IN THE UNITED STATES DISTRICT COURT
FOR THE SOUTHERN DISTRICT OF TEXAS
HOUSTON DIVISION

WESTERNGECO L.L.C.,	§	
	§	
Plaintiff,	§	
	§	
V.	§	**CIVIL ACTION NO. 4:09-cv-01827**
	§	
ION GEOPHYSICAL CORPORATION,	§	**Judge Keith P. Ellison**
FUGRO-GEOTEAM, INC.,	§	
FUGRO-GEOTEAM AS,	§	
FUGRO NORWAY MARINE SERVICES	§	
AS, FUGRO, INC., FUGRO (USA), INC. and	§	
GEOSERVICES, INC.,	§	
	§	**JURY TRIAL DEMANDED**
Defendants.	§	

ION'S FINAL INVALIDITY CONTENTIONS

In accordance with the parties' agreement, the Court's *Markman* ruling, and the Court's Local Patent Rules (particularly P.R. 3-3), Defendant ION Geophysical Corporation ("ION"), submits its Final Invalidity Contentions identifying prior art and other grounds that invalidate the asserted claims of U.S. Patent Nos. 6,691,038 ("the '038 patent"), 6,932,017 ("the '017 patent"), 7,080,607 ("the '607 patent"), 7,162,967 ("the '967 patent"), and 7,293,520 ("the '520 patent) (collectively, "WesternGeco's asserted patents" or "WesternGeco's patents-in-suit"). Attached as part of ION's Final Invalidity Contentions are claim charts in accordance with P.R. 3-3(c), outlining in detail the basis for ION's contentions at the present time that the asserted claims of WesternGeco's patents-in-suit are invalid on various grounds under Title 35.

I. INTRODUCTION

ION's Final Invalidity Contentions address the Claims of WesternGeco's patents-in-suit asserted against ION in the Disclosures of Asserted Claims and Final Infringement Contentions ("FICS") submitted by WesternGeco, L.L.C. ("WesternGeco"). WesternGeco asserts that ION infringes claims 1-7, 10-11, 13-17, 20-32, 35-36, 38-42, and 45-50 of the '038 patent; claims 1-9 and 16 of the '017 patent; claims 1-9 and 15 of the '607 patent; claims 1, 4-10, and 15 of the '967 patent, and claims 1-3, 6-20, and 23-34 of the '520 patent. Finally, ION does not accept WesternGeco's allegation that all asserted claims of the '017, '967, '607, and '520 patents are entitled to a priority date of October 1, 1998. As such, upon a determination of the actual priority date of the patents-in-suit, ION reserves the right to supplement its Final Invalidity Contentions with prior art based on the then-established priority dates.

Where a feature of a prior art reference is not specifically identified in the attached claim charts as corresponding to a claim limitation, the lack of specific identification should not be regarded as a concession by ION that the prior art reference does not embody the claim limitation when the reference is properly interpreted from the perspective of one skilled in the relevant art. WesternGeco has not identified which elements of the asserted claims (or combinations thereof) it contends were not known to one of ordinary skill in the art at the time of the alleged inventions of WesternGeco's patents-in-suit. For any claim limitation that WesternGeco alleges is not disclosed in a particular prior art reference, ION reserves the right to prove that such limitation is either inherent in the reference or obvious to one of ordinary skill in the art at the relevant time, or that the limitation is disclosed in one or more other prior art references that, when combined, renders the asserted claims obvious under 35 U.S.C. § 103.

The prior art references produced by ION in connection with these contentions are representative of the state of the prior art pertinent to invalidity. ION reserves the right to identify other prior art or to supplement its disclosures or contentions under the following circumstances:

(i) ION reserves the right to amend these contentions and disclosures as new information becomes available.

(ii) ION has not yet completed its discovery from WesternGeco. Such discovery may include information that affects the disclosures and contentions herein.

(iii) ION has also not yet completed its discovery from third parties who may \ have information concerning additional prior art. Such discovery may include information that affects the disclosures and contentions herein.

The attached claim charts cite particular teachings and/or disclosures of the prior art as applied to features of the asserted claims. However, persons of ordinary skill in the art may view an item of prior art in the context of other publications, literature, products, and technical knowledge. Thus, ION also reserves the right to rely on non-cited portions of the prior art references, related file histories, other publications or testimony as aids in understanding and interpreting the cited portions, as providing context to the art, and as additional evidence that the prior art discloses a claim element. ION further reserves the right to rely on non-cited portions of the prior art references, related file histories, other publications, and testimony to establish that a person of ordinary skill in the art would have been motivated to combine certain of the cited references to render the asserted claims obvious. ION also reserves the right to rely upon, and incorporates herein by reference the invalidity contentions and prior art disclosed by WesternGeco and/or the Fugro Defendants.

These Final Invalidity Contentions are not an admission by ION that the accused products (including any current or past version of these products) are covered by or infringe the asserted claims of WesternGeco's patents-in-suit, particularly when these claims are properly construed.

II. IDENTIFICATION OF PRIOR ART

Pursuant to P.R. 3-3(a), ION provides the following list of prior art references that it contends anticipate (pursuant to 35 U.S.C. § 102) and/or render obvious (pursuant to 35 U.S.C. § 103) the asserted claims of WesternGeco's patents-in-suit. The following identification of references, the identification of references in Section III and the attached claim charts are to be considered as a whole, and all contentions made among them are to be considered as a whole. In the event the identification of references in Section III and/or a claim chart provides a contention based on a reference not identified in this Section, that contention nevertheless is to be considered as part of these Final Invalidity Contentions.

NO.	PRIOR ART REFERENCE	DATES
1.	International Patent Application No. WO 97/11395 ("Olivier '395")	Filing Date: September 20, 1996 Published: March 27, 1997
2.	International Patent Application No. WO 2000/20895 ("Hillesund '895")	Filing Date: September 28, 1999 Published: April 13, 2000
3.	U.S. Patent No. 5,790,472 ("Workman '472 patent")	Filing Date: December 20, 1996 Issued: August 4, 1998 Country of Origin: United States
4.	U.S. Patent No. 4,404,664 ("Zachariadis '664 patent")	Filing Date: December 31, 1980 Issued: September 13, 1983 Country of Origin: United States
5.	U.S. Patent No. 5,546,882 ("'882 patent")	Filing Date: July 7, 1995 Issued: August 20, 1996 Country of Origin: Norway
6.	U.S. Patent No. 5,200,930 ("'930 patent")	Filing Date: January 24, 1992 Issued: April 6, 1993 Country of Origin: United States
7.	Patent Cooperation Treaty Published Application No. WO 98/28636 ("Bittleston '636 application")	Filing Date: December 19, 1997 Published: July 2, 1998
8.	Kalman, R.E., 1960, "A New Approach to Linear Filtering and Prediction Problems," Trans of ASME-J of Basic Engineering,	Date of Publication: 1960

WesternGeco Ex. 2033, pg. 4
IPR2015-00567
ION v WesternGeco

NO.	PRIOR ART REFERENCE	DATES
	vol. 82 (series D). A copy of this reference is attached as Exhibit 18.	
9.	ION's 35 U.S.C. § 102(f) prior art	

III. SPECIFIC PRELIMINARY INVALIDITY CONTENTIONS

A. Anticipation Under 35 U.S.C. § 102

1. General Comments

In accordance with P.R. 3-3(b) and (c), ION identifies the references in Section 2 below as anticipating the asserted claims of the WesternGeco patents-in-suit under one or more provisions of 35 U.S.C. § 102. The references are also identified in the claim charts attached hereto. The claim charts identify specific aspects of the cited prior art references that correspond to the respective claim limitations. However, the claim charts are exemplary only and include at least one citation to an anticipatory reference for each limitation of the respective asserted claim. Thus, although ION has identified at least one citation per claim limitation present in a reference, each and every disclosure of the same limitation in the same reference is not necessarily identified in the charts. A reference may contain additional support for a particular claim limitation. Persons of ordinary skill in the art generally read a prior art reference as a whole and in the context of other publications and literature, physical embodiments and knowledge in the field of art.

ION thus reserves the right to rely on non-cited portions of the prior art references and on other publications and expert testimony to provide context, and as aids to understanding and interpreting the portions that are cited. To the extent any limitation is deemed not to be precisely met by an item of prior art, any purported differences are such that the claimed subject matter as a whole would have been obvious to one skilled in the art at the time of the alleged invention in view of the state of the art and knowledge of those skilled in the art. Where ION cites to a particular figure in a prior art reference, the citation should be understood to encompass the caption and description of the figure and any text relating to the figure in the reference in addition to the figure itself. Conversely, where a cited portion of text refers to a figure, the citation should be understood to include the figure as well.

Where the anticipatory reference is a prior art product or physical embodiment, the attached claim charts may include citations to other materials in order to establish certain aspects of the prior art product or physical embodiment. Such citations do not diminish the anticipatory nature of the prior art product or physical embodiment. At minimum, citations to additional prior art references establish the obviousness of the respective claims, and the motivation to combine a prior art product or physical embodiment with a prior art reference discussing that prior art product or physical embodiment is self-evident.

As noted above, the identification of anticipatory references, the identification of prior art references in Section II above, and the associated claim charts, are to be considered as a whole, and all contentions made among them are to be considered. Thus, in the event the identification of references in Section II and/or a claim chart provides an anticipation contention not identified below – or vice versa – that contention is nevertheless to be considered as part of these Final Invalidity Contentions. ION may also rely on the United States Patent and Trademark Office's characterizations of the teachings in and the effects of the prior art, as well as the admissions, statements, representations, and characterizations made by WesternGeco, the named inventor, or others substantively involved in the preparation or prosecution of the WesternGeco patents-in-suit. Those statements may include admissions, statements, representations, and characterizations concerning the prior art during the prosecution of relevant patent applications, including reexamination, or any related U.S. or foreign patent applications.

2. Specific Anticipation Contentions

The following prior art references anticipate the respectively identified claims of the WesternGeco patents-in-suit, as set forth in the following claim chart exhibits:

1. '038 Patent - International Patent Application No. WO 2000/20895 ("Hillesund '895"). *See* Exhibit 1.
2. '017 Patent - U.S. Patent No. 5,790,472 ("Workman '472 patent"). *See* Exhibit 2.
3. '607 Patent - U.S. Patent No. 5,790,472 ("Workman '472 patent"). *See* Exhibit 3.
4. '967 Patent - U.S. Patent No. 5,200,930 ("'930 patent"). *See* Exhibit 4.
5. ION's 35 U.S.C. § 102(f) prior art. *See* Exhibit 5.

B. Obviousness Under 35 U.S.C. § 103

1. General Comments

In accordance with P.R. 3-3(b) and (c), ION identifies the following combination of references as rendering the asserted claims of the WesternGeco patents-in-suit obvious under 35 U.S.C. § 103. ION also identifies and incorporates by reference the combinations identified in the referenced claim charts attached hereto. The attached claim charts demonstrate the obviousness of the asserted claim and identify specific disclosures or aspects of each reference in the combination that correspond to the respective claim limitations. For each identified combination, the full teachings of the references should be considered. The claim charts are exemplary only, and include at least one citation to one or more of those references for each claim limitation. Thus, although ION has identified at least one citation per claim limitation present in a combination of references, each and every disclosure of the same limitation in the same combination of references is not necessarily identified in the chart. That is, a combination of references may contain additional support for a particular claim limitation. Persons of ordinary skill in the art generally read a prior art reference as a whole and in the context of other publications and literature.

ION thus reserves the right to rely on non-cited portions of the prior art references and on other publications and expert testimony to provide context and as aids to understanding and interpreting the portions that are cited. To the extent any limitation is deemed not to be exactly met by a combination of references, then any purported differences are such that the claimed subject matter as a whole would have been obvious to one skilled in the art at the time of the alleged invention, in view of the state of the art and knowledge of those skilled in the art. Where ION cites to a particular figure in a prior art reference, the citation should be understood to encompass the caption and description of the figure and any text relating to the figure in the reference, in addition to the figure itself. Conversely, where a cited portion of text refers to a figure, the citation should be understood to include the figure as well.

Where the combination of references includes a prior art product or physical embodiment, the Section 103 claim charts may also include citations to other materials in order to establish certain aspects of the prior art product or physical embodiment. Such citations do not diminish the disclosure of the prior art product or physical embodiment. At minimum, however, citations to additional prior art references establish the obviousness of the respective claims, and the motivation to combine a prior art product or physical embodiment with a prior art reference discussing that prior art product or physical embodiment is self-evident and/or obvious to persons of ordinary skill in the relevant art at the time of the alleged inventions of the WesternGeco patents-in-suit.

Where a combination is directed to a dependent claim, but not the independent claim from which the dependent claim depends, it should be understood that the claim chart for the combination incorporates the claim chart for first-identified prior art reference in the combination. As an example, claim 2 of the '038 patent depends from claim 1. For a contention that dependent claim 2 is obvious over the combination of Reference X and Reference Y, the claim chart showing that Reference X anticipates claim 1 should be understood as being incorporated into the obviousness claim chart. In other words, the chart for the primary reference of a combination is incorporated by reference into any obviousness chart that identifies the primary reference.

The following identification of combinations, the identification of references in Section II, and associated claim charts, are to be considered as a whole, and all contentions made among them are to be considered. Thus, in the event the identification of references in Section II and/or a claim chart provides an obviousness contention not identified below – or vice versa – that contention is nevertheless to be considered as part of these Final Invalidity Contentions.

In establishing obviousness under Section 103, ION may also rely on the United States Patent and Trademark Office's characterizations of the teachings in and the effects of the prior art. ION may further rely on the admissions, statements, representations, and characterizations made by WesternGeco, the named inventor, or others substantively involved in the preparation or prosecution of the WesternGeco patents-in-suit, including admissions, statements, representations, and characterizations concerning the prior art during the prosecution of relevant patent applications, including reexamination, or any related U.S. or foreign patent applications.

2. "Motivation to Combine"

For each combination of references identified below and/or in an attached claim chart, ION hereby identifies a "motivation" for one of ordinary skill in the art at the time of the alleged invention of the WesternGeco patents-in-suit to combine those references. The "motivation" to combine is identified in view of the Supreme Court decision in *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398 (2007), and is not limited to any specific test or analytical framework for determining obviousness (such as the "teaching, suggestion, or motivation" test).

It would have been obvious for a person of ordinary skill in the art at the time of the purported invention to combine each of the prior-art elements of the respective combinations identified below with other prior-art elements of those respective combinations to create a device or method having the ability to control both the depth and lateral position of marine seismic streamers using streamer positioning devices controlled by a control system that is either located on the towing vessel or the streamer positioning device or both anticipating every limitation of the asserted claims of the WesternGeco patents-in-suit. A person of ordinary skill would have found it obvious at the time of the purported invention to combine these elements, because the elements would predictably perform their known prior-art functions in said device or method to control the position of marine seismic streamers, the combination of elements would entail a simple substitution of one known element for another to achieve predictable results, and/or the combination would have been obvious to try.

Each of the combinations identified below and/or in the attached claim charts relies on the substitution or incorporation of elements that were known in the prior art, as described in the cited references. All of the art cited below would have been art that one of skill in the art would have been aware of or referred to in addressing the problem claimed to be addressed by the WesternGeco patents-in-suit, as well as other problems and/or market demands prior to the date of the purported invention, providing a reason for combining that art in the manner described below. Also, as noted above, the combination of the familiar elements claimed in the WesternGeco patents-in-suit according to known methods would have been obvious because it does no more than yield predictable results. The references disclosed herein describe methods that were known to offer what the WesternGeco patents-in-suit assert are improvements over the prior art. As such, one of skill in the art would have been motivated to combine them in the manner disclosed in these Final Invalidity Contentions.

While not necessary, a motivation to combine may also be found in the references themselves. One of ordinary skill in the art would be motivated to combine a reference that refers to, or otherwise explicitly invites combination with, another reference.

The references identified below also describe the elements of the asserted claims in sufficient detail – whether the structure and function or just the function with the structure known to one of ordinary skill in the art. In each instance, a person of ordinary skill in the art could have modified the device using the substituted or incorporated elements, and the results of the substitutions and incorporations would have been predictable. Where substitutions or combinations have been made, each of the substituted or combined elements is similar to the original elements and provides similar functionality and/or enhancement. It would have been predictable to one skilled in the art that the modified device or system, *i.e.*, the device or system resulting from the combined teachings of the applied references, could be substituted or incorporated into the original devices or systems and used to provide the claimed structure or functionality without altering the purpose of the original devices or systems, or their elements. Further, the references demonstrate that a person of ordinary skill in the art already knew how the substituted or incorporated elements would operate and how they would be made.

Furthermore, the WesternGeco patents-in-suit are directed generally to control systems for positioning marine seismic streamers, and persons working in the field of marine seismic technology would be aware of the research and development that had been done in the field.

Among other things, the control systems ensure proper positioning of seismic streamers towed behind vessels, which is vital to accurate marine seismic surveys. That is, while the streamers are towed behind a vessel, the control system, including streamer positioning devices, allow the user to maintain desired streamer positioning. These and other attributes of the control systems for marine seismic streamers were well known prior to 1998. For example, it was known that to complete accurate marine surveys one needed the ability to control the positioning of the marine streamers.

Thus, at a minimum, the technology and state of the marine seismic streamer control system industry was such that— to the extent the claimed combinations might be viewed as not already existing by that time—they led inevitably to combinations such as those claimed in the WesternGeco patents-in-suit. Indeed, by the time of the alleged invention of the WesternGeco patents-in-suit, demands known to the design community or present in the marketplace, and the background knowledge possessed by a person having ordinary skill in the art, all provided readily apparent reason to combine the known elements in the fashion claimed by the WesternGeco patents-in-suit. Combinations of the individual claimed features, which have been known to the marine seismic streamer control system and marine survey communities prior to the alleged invention of the WesternGeco patents-in-suit, would have been within the ordinary creativity of one skilled in the art at the time of the purported invention, and would therefore have been obvious under 35 U.S.C. § 103.

Although ION has identified the above "motivations" to combine, additional "motivations" to combine may exist. Persons of ordinary skill in the art generally read a prior art reference as a whole and in the context of other publications and literature, physical embodiments and knowledge in the field of art. ION reserves the right to rely on such additional "motivations" to combine.

3. Specific Obviousness Contentions

The following combinations of prior art references render the respectively identified claims of the WesternGeco patents-in-suit obvious under 35 U.S.C. § 103:

1. '038 Patent - International Patent Application No. WO 2000/20895 ("Hillesund '895"). *See* Exhibit 6.

2. '038 Patent - International Patent Application No. WO 297/11395 ("Olivier '395"). *See* Exhibit 7.

3. '038 Patent - International Patent Application No. WO 2000/20895 ("Hillesund '895") & U.S. Patent No. 5,200,930 ("'930 patent"). *See* Exhibit 8.

4. '038 Patent - International Patent Application No. WO 2000/20895 ("Hillesund '895") & U.S. Patent No. 5,546,882 ("'882 Patent"). *See* Exhibit 9.

5. '017 Patent - U.S. Patent No. 5,790,472 ("Workman '472 patent. *See* Exhibit 10.

6. '017 Patent - U.S. Patent No. 5,790,472 ("Workman '472 patent") & Kalman, R.E., 1960, "*A New approach to Linear Filtering and Prediction Problems*," Trans of ASME-J. of Basic Engineering, vol. 82 (Series D). *See* Exhibit 11.

7. '967 Patent - U.S. Patent No. 5,790,472 ("Workman '472 patent") & International Patent Application No. WO 98/28636 ("Bittleston '636 application"). *See* Exhibit 12.

8. '607 Patent - U.S. Patent No. 5,790,472 ("Workman '472 patent") & Kalman, R.E., 1960, "*A New approach to Linear Filtering and Prediction Problems*," Trans of ASME-J. of Basic Engineering, vol. 82 (Series D). *See* Exhibit 13.

9. '607 Patent - U.S. Patent No. 5,790,472 ("Workman '472 patent") & International Patent Application No. WO 98/28636 ("Bittleston '636 application"). *See* Exhibit 14.

10. '967 Patent - U.S. Patent No. 4,404,664 ("Zachariadis '664 patent") & International Patent Application No. WO 297/11395 ("Olivier '395"). *See* Exhibit 15.

11. '607 Patent - U.S. Patent No. 5,790,472 ("Workman '472 patent. *See* Exhibit 16.

12. '017 Patent - U.S. Patent No. 5,790,472 ("Workman '472 patent"), Kalman, R.E., 1960, "*A New approach to Linear Filtering and Prediction Problems*," Trans of ASME-J. of Basic Engineering, vol. 82 (Series D), and U.S. Patent No. 4,404,664 ("Zachariadis '664 patent"). *See* Exhibit 17.

ION also contends, in the alternative, that each of the anticipatory references identified above in Section III.A.2 and in the attached claim charts render all of the asserted claims obvious when standing alone and when considered in view of the knowledge of one skilled in the art at the time of the alleged inventions of the WesternGeco patents-in-suit. Thus, for any claim or claim element that is shown in a claim chart as being anticipated, ION also contends, in the alternative, that the claim or claim element is rendered obvious in view of the same identified disclosure in each of the anticipatory references identified herein. In other words, for all of the anticipatory references identified above, ION contends, in the alternative, that each of the respective anticipatory references renders each asserted claim obvious on its own without the need to combine the identified anticipatory reference with any other reference.

Alternatively, should WesternGeco assert that a given claim element is missing from a given anticipatory reference, ION reserves the right to argue that it would have been obvious to combine the reference with any one of the above-mentioned obviousness references to provide the purportedly missing element.

IV. <u>INVALIDITY UNDER 35 U.S.C. § 112</u>

Pursuant to P.R. 3-3(d), ION identifies exemplary bases for invalidating the asserted claims of the WesternGeco patents-in-suit for indefiniteness, lack of an adequate written description, lack of enablement, and/or failure to disclose the best mode. ION does not address the failure of any ancestor application to support the asserted claims here as required for the claims to gain benefit of any filing date(s) of any ancestor application. As such, upon determination that any of WesternGeco's asserted priority dates for the WesternGeco patents-in-suit are inapplicable, ION reserves the right to supplement its contentions based on additional prior art dated after the alleged priority dates. Further, ION reserves the right to assert invalidity based on any and all other grounds not referenced herein and not required to be disclosed in these contentions.

Each asserted claim of the WesternGeco patents-in-suit is invalid under 35 U.S.C. § 112 for failure to particularly point out and distinctly claim the subject matter the inventor regards as the alleged invention(s) and thus are fatally indefinite. Further, each asserted claim is invalid under 35 U.S.C. § 112 in that the specification does not set forth the alleged invention(s) so as to enable a person skilled in the art to make and use them without undue experimentation. For example, in a number of internal feasibility reports, development plans, specifications, tests, and other documents predating the filing of the WesternGeco patents-in-suit (*e.g.*, WG00009017-9125; WG00001520-1611; WG00008668-754; WG00008560-667; WG00011673-780; WG00001728-48; WG00063947-82; WG00011781-826; WG00008050-294; WG00011936-59; WG00008351-559; WG0361080-84; WG00013052-85; and WG0062727-43), WesternGeco identifies a number of "requirements" that are not disclosed in the patents-in suit. Moreover, each asserted claim is invalid under 35 U.S.C. § 112 for failing to disclose the preferred embodiment.

WesternGeco's asserted claims are invalid for failing to disclose the best mode. As set forth above, WesternGeco failed to disclose certain "requirements" in the patents-in-suit. Invalidity based on failure to disclose the best mode is a fact intensive inquiry that requires discovery on the inventor(s) state of mind at the time of invention and patenting. ION reserves the right to supplement its best mode contentions upon further discovery from WesternGeco. Subject to ION's right to supplement, the named inventors of the WesternGeco patents-in-suit knew of a preferred mode that was better than the mode disclosed in the WesternGeco patents-in-suit but concealed this preferred mode from the public. The disclosures in the WesternGeco patents-in-suit were not adequate enough to enable one skilled in the pertinent art to practice the best mode.

Although the claims of the WesternGeco patents-in-suit appear to require a particular structure, the corresponding written description in the patents is inadequate under Section 112 because it does not enable persons skilled in the art to make and use the alleged inventions without undue experimentation. For example, '017 patent claim 1 requires "calculating desired changes in the orientation" of the wings. Persons skilled in the art could not determine from reading the patent specification the limits, if any, imposed on the changes to the wing's orientation.

Similar indefiniteness issues exist in the asserted independent claims of the '017, '038 and '607 patents and thus all dependent claims as well. Furthermore, many of the asserted dependent claims of the WesternGeco patents-in-suit also suffer from similar indefiniteness issues. Each asserted claim is also invalid under 35 U.S.C. § 112 because the written description does not reflect that the inventors were in possession of the claimed invention(s).

Based on WesternGeco's Infringement Contentions it appears that WesternGeco is asserting a meaning and scope for the bolded language that goes beyond any written description support in the specifications of the patents-in-suit and results in a claim scope that is not enabled by the specifications. However, because WesternGeco's Infringement Contentions are not entirely clear as to these issues, in view of the fact that WesternGeco has not yet provided proposed claim constructions for any claim term, and in view of the fact that the Court has not construed these terms yet, ION reserves its right to supplement, modify or change its identification of asserted claims that are invalid under 35 U.S.C. § 112.

Moreover, the asserted claims are invalid for lack of an adequate written description to the extent that they are construed to contradict and/or fail to require the required, non-optional alleged attributes of the alleged "inventions" identified in the patents-in-suit. Such asserted claims fail to comply with the written description requirement, as their scope would exceed the scope of the alleged "invention" as set forth in the specifications of the patents-in-suit. Further, to the extent that the asserted claims are construed or asserted to encompass species or embodiments that are not described in the specification, the claims lack an adequate written description in the specification and fail to satisfy the enablement requirement. The asserted claims encompass combinations of features, and arrangements of features or re-arrangements of features, which were not disclosed in the specification. Accordingly, the asserted claims lack an adequate written description in the specification pursuant to Section 112.

By way of example, under WesternGeco's apparent construction of the asserted claims (to which ION does not accede), the claims lack an adequate written description in the specification, and fail to disclose in sufficient detail as to enable one skilled in the pertinent art to make and use the features of the accused products.

A. <u>'038 Patent</u>

Claims 4, 14, 19, 29, and 39 of the '038 patent are invalid for failing to comply with 35 U.S.C. § 112(1), because the specification does not describe "desired streamer position" and/or "desired positions" in a manner sufficient to enable a person of ordinary skill in the art to practice the invention without undue experimentation. In addition, those terms render the claims insolubly ambiguous, not amenable to construction, and fail to notify the public of the scope of the patentee's right to exclude.

Claims 22, 25, 47, and 50 of the '038 patent are invalid for failing to comply with 35 U.S.C. § 112(1), because the specification does not describe "optimal path" and/or "optimal coverage" in a manner sufficient to enable a person of ordinary skill in the art to practice the invention without undue experimentation. In addition, those terms render the claims insolubly ambiguous, not amenable to construction, and fail to notify the public of the scope of the patentee's right to exclude.

Claims 1-7, 10-11, 13-17, 20-32, 35-36, 38-42, and 45-50 of the '038 patent are invalid for failing to comply with 35 U.S.C. § 112(1), because the specification does not describe "active streamer positioning device" in a manner sufficient to enable a person of ordinary skill in the art to practice the invention without undue experimentation. In addition, that term renders the claims insolubly ambiguous, not amenable to construction, and fails to notify the public of the scope of the patentee's right to exclude.

Claims 29-32, 48, 49, 50 are invalid for failing to comply with 35 U.S.C. § 112(2) because the claims include the term "the master controller," which does not have an antecedent basis in the claims or the claims upon which they depend. Because it lacks an antecedent basis, that term renders the claims insolubly ambiguous, not amenable to construction, and fails to notify the public of the scope of the patentee's right to exclude.

B. '017 Patent

Claim 16 of the '017 patent is invalid as indefinite because it fails to meet the requirements of 35 U.S.C. § 112(6). The specification does not recite a structure corresponding to the claimed "means for obtaining a predicted position of the streamer positioning devices" sufficient to indicate the claimed structure to a person of ordinary skill in the art. As a result, the claim is rendered insolubly ambiguous, not amenable to construction, and insufficient to notify the public of the scope of the patentee's right to exclude.

Claim 16 of the '017 patent is invalid as indefinite because it fails to meet the requirements of 35 U.S.C. § 112(6). The specification does not recite a structure corresponding to the claimed "means for obtaining an estimated velocity of the streamer positioning devices" sufficient to indicate the claimed structure to a person of ordinary skill in the art. As a result, the claim is rendered insolubly ambiguous, not amenable to construction, and insufficient to notify the public of the scope of the patentee's right to exclude.

Claim 16 of the '017 patent is invalid as indefinite because it fails to meet the requirements of 35 U.S.C. § 112(6). The specification does not recite a structure corresponding to the claimed "means for calculating desired changes in the orientations of the respective wings of at least some of the streamer positioning devices using said predicted position and said estimated velocity" sufficient to indicate the claimed structure to a person of ordinary skill in the art. As a result, the claim is rendered insolubly ambiguous, not amenable to construction, and insufficient to notify the public of the scope of the patentee's right to exclude.

Claim 16 of the '017 patent is invalid as indefinite because it fails to meet the requirements of 35 U.S.C. § 112(6). The specification does not recite structure corresponding to the claimed "means for actuating the wing motors to produce said desired changes in wing orientation" sufficient to indicate the claimed structure to a person of ordinary skill in the art. As a result, the claim is rendered insolubly ambiguous, not amenable to construction, and insufficient to notify the public of the scope of the patentee's right to exclude.

Claims 1-9 and 16 of the '017 patent are invalid for failing to comply with 35 U.S.C. § 112(1), because the specification does not describe "desired changes" in a manner sufficient to enable a person of ordinary skill in the art to practice the invention without undue experimentation. In addition, this term renders the claims insolubly ambiguous, not amenable to construction, and fails to notify the public of the scope of the patentee's right to exclude.

Claim 7 of the '017 patent is invalid for failing to comply with 35 U.S.C. § 112(1), because the specification does not describe "global control system" in a manner sufficient to enable a person of ordinary skill in the art to practice the invention without undue experimentation. In addition, this term renders the claims insolubly ambiguous, not amenable to construction, and fails to notify the public of the scope of the patentee's right to exclude.

Claim 8 of the '017 patent is invalid for failing to comply with 35 U.S.C. § 112(1), because the specification does not describe "streamer separation mode" in a manner sufficient to enable a person of ordinary skill in the art to practice the invention without undue experimentation. In addition, this term renders the claims insolubly ambiguous, not amenable to construction, and fails to notify the public of the scope of the patentee's right to exclude.

Finally, dependent claims 3, 4, and 6 of the '017 patent are invalid for failing to specify a further limitation of the subject matter claimed in violation of 35 U.S.C. § 112(4) because the terms "water referenced towing velocity that compensates for the speed and heading of marine currents," "said estimated velocity is compensated of relative movement between said seismic survey vessel and said streaming positioning devices," and/or "regulated to prevent the wing from stalling" are inherent aspects of the invention as claimed by the respective claims on which those claims depend.

Claims 1-9 and 16 of the '017 patent are invalid for failing to comply with 35 U.S.C. § 112(1), because the specification does not describe a "streamer positioning device" that can control the streamer position both laterally and vertically in a manner sufficient to enable a person of ordinary skill in the art to practice the invention without undue experimentation.

C. <u>'607 Patent</u>

Claims 1-9 and 15 of the '607 patent are invalid for failing to comply with 35 U.S.C. § 112(1), because the specification does not describe "desired changes" in a manner sufficient to enable a person of ordinary skill in the art to practice the invention without undue experimentation. In addition, this term renders the claims insolubly ambiguous, not amenable to construction, and fails to notify the public of the scope of the patentee's right to exclude.

Claim 7 of the '607 patent is invalid for failing to comply with 35 U.S.C. § 112(1), because the specification does not describe "global control system," "feather angle mode," and/or "turn control mode" in a manner sufficient to enable a person of ordinary skill in the art to practice the invention without undue experimentation. In addition, those terms render the claims insolubly ambiguous, not amenable to construction, and fail to notify the public of the scope of the patentee's right to exclude.

Claim 8 of the '607 patent is invalid for failing to comply with 35 U.S.C. § 112(1), because the specification does not describe "global control system" and/or "streamer separation mode" in a manner sufficient to enable a person of ordinary skill in the art to practice the invention without undue experimentation. In addition, those terms render the claims insolubly ambiguous, not amenable to construction, and fail to notify the public of the scope of the patentee's right to exclude.

Dependent claims 3, 4, and 6 of the '607 patent are invalid for failing to specify a further limitation of the subject matter claimed in violation of 35 U.S.C. § 112(4) because the terms "water referenced towing velocity that compensates for the speed and heading of marine currents," "said estimated velocity is compensated of relative movement between said seismic survey vessel and said streaming positioning devices," or "regulated to prevent the wing from stalling" are inherent aspects of the invention as claimed by the respective claims on which those claims depend.

Claims 1-9 and 15 of the '607 patent are invalid for failing to comply with 35 U.S.C. § 112(1), because the specification does not describe a "streamer positioning device" that can control the streamer position both laterally and vertically in a manner sufficient to enable a person of ordinary skill in the art to practice the invention without undue experimentation.

Claims 1, 4-10, and 15 are invalid as indefinite under 35 U.S.C. § 112(2) because "desired changes in 'position' of one or more of the streamer positioning devices" as stated in this claims 1 and 15 is fundamentally ambiguous. "Position" can plausibly mean the desired changes in the location coordinates of the streamer positioning devices, or it can plausibly mean the desired changes in the angles of the wings on the streamer positioning device.

D. <u>'967 Patent</u>

Claims 4, 5, and 8 of the '967 patent are invalid for failing to comply with 35 U.S.C. § 112(1), because the specification does not describe "desired vertical depth," "desired horizontal displacement," or "desired forces" in a manner sufficient to enable a person of ordinary skill in the art to practice the invention without undue experimentation. In addition, those terms render the claims insolubly ambiguous, not amenable to construction, and fail to notify the public of the scope of the patentee's right to exclude.

Claims 1-10 and 15 of the '967 patent are invalid for failing to comply with 35 U.S.C. § 112(1), because the specification does not describe "global control system" and/or "local control system" in a manner sufficient to enable a person of ordinary skill in the art to practice the invention without undue experimentation. In addition, those terms render the claims insolubly ambiguous, not amenable to construction, and fail to notify the public of the scope of the patentee's right to exclude.

Claim 5 of the '967 patent is invalid as indefinite under 35 U.S.C. § 112(2) because "deviation between the desired horizontal displacement and the actual horizontal displacement" is insoluably ambiguous. The usual and ordinary meaning of horizontal displacement is a difference between desired and actual positions. The '967 patent offers an implicit definition of displacement as "the magnitude and direction of the displacement between the actual horizontal position and the desired horizontal position of the bird." Thus, displacement is a difference between actual and desired horizontal positions. Claim 5 states deviation as "magnitude and direction of the deviation between the desired horizontal displacement and actual horizontal displacement." Thus, "deviation" in this claim 5 is a difference-of-a-difference.

Claim 7, 8, 9, and 10 of the '967 patent are invalid for failing to comply with 35 U.S.C. § 112(1) because the specification does not describe "adjusting the wing using the local control system is regulated to prevent the positioning device from stalling" in a manner sufficient to enable a person of ordinary skill in the art to practice the invention without undue experimentation.

Claim 8 of the '967 patent is invalid for failing to comply with 35 U.S.C. § 112(1), because the specification does not describe "feather angle mode" and/or "turn control mode" in a manner sufficient to enable a person of ordinary skill in the art to practice the invention without undue experimentation. In addition, those terms render the claims insolubly ambiguous, not amenable to construction, and fail to notify the public of the scope of the patentee's right to exclude.

Claim 9 of the '967 patent is invalid for failing to comply with 35 U.S.C. § 112(1), because the specification does not describe "streamer separation mode" in a manner sufficient to enable a person of ordinary skill in the art to practice the invention without undue experimentation. In addition, this term renders the claims insolubly ambiguous, not amenable to construction, and fails to notify the public of the scope of the patentee's right to exclude.

Dependent Claim 7 of the '967 patent is invalid for failing to specify a further limitation of the subject matter claimed in violation of 35 U.S.C. § 112(4) because the term "regulated to prevent the positioning device from stalling" is an inherent aspect of the invention as claimed by the respective claims on which that claim depends.

Claims 1, 4-10, and 15 of the '967 patent are invalid for failing to comply with 35 U.S.C. § 112(1), because the specification does not describe a "streamer positioning device" that can control the streamer position both laterally and vertically in a manner sufficient to enable a person of ordinary skill in the art to practice the invention without undue experimentation.

E. <u>'520 Patent</u>

Claims 1-3, 6-20, and 23-34 of the '520 patent are invalid for failing to comply with 35 U.S.C. § 112(1), because the specification does not describe "feather angle mode," "turn control mode," and/or "streamer separation mode" in a manner sufficient to enable a person of ordinary skill in the art to practice the invention without undue experimentation. In addition, those terms render the claims insolubly ambiguous, not amenable to construction, and fail to notify the public of the scope of the patentee's right to exclude.

Additionally, claims 1 and 18 of the '520 patent are invalid for failing to comply with 35 U.S.C. § 112(1), because the specification does not describe how to control the streamer positioning devices with a control system configured to operate in one or more control modes selected from a feather angle mode, a turn control mode, and a streamer separation mode and does not describe a control system configured to use a control mode selected from a feather angle mode, a turn control mode, a streamer separation mode, and two or more of these modes in a manner sufficient to enable a person of ordinary skill in the art to practice the inventions without undue experimentation. None of the claims depending from claims 1 or 18 further define the non-enabled portions of claims 1 and 18, and thus are invalid under § 112(1) as well.

Dependent Claims 3, 4, and 6 of the '520 patent are invalid for failing to specify a further limitation of the subject matter claimed in violation of 35 U.S.C. § 112(4) because the terms "water referenced towing velocity that compensates for the speed and heading of marine currents," "said estimated velocity is compensated of relative movement between said seismic survey vessel and said streaming positioning devices," or "regulated to prevent the wing from stalling" are inherent aspects of the invention as claimed by the respective claims on which those claims depend.

Claims 1-3, 6-20, and 23-34 of the '520 patent are invalid for failing to comply with 35 U.S.C. § 112(1), because the specification does not describe a "streamer positioning device" that can control the streamer position both laterally and vertically in a manner sufficient to enable a person of ordinary skill in the art to practice the invention without undue experimentation.

V. DOCUMENT PRODUCTION ACCOMPANYING PRELIMINARY INVALIDITY CONTENTIONS

Pursuant to Patent Rule 3-4(a), ION previously provided documents within its respective possession, custody, or control showing the operation of any aspects or elements of its respective Accused Instrumentalities identified by WesternGeco in its Infringement Contentions.

Nothing in these disclosures shall be treated as an admission by ION that WesternGeco's Infringement Contentions comply with the requirements of the Court's Patent Local Rules or reasonably or adequately show the operation of the Accused Instrumentalities identified by WesternGeco in its Infringement Contentions. ION expressly reserves the right to revise, amend, and/or supplement these disclosures and accompanying document production.

In accordance with Patent Rule 3-4(b), ION is providing under separate cover each item of prior art within its respective possession, custody, or control identified pursuant to Patent Rule 3-3(a) above and that has not yet been produced in this matter. ION expressly reserves the right to revise, amend, and/or supplement these disclosures and accompanying document production.

In accordance with patent Rule 3-4(c), ION previously provided documents summarizing the revenue received from the sales of the Accused Instrumentalities. ION expressly reserves the right to revise, amend, and/or supplement these disclosures and accompanying document production.

Dated: February 3, 2012

Respectfully submitted,

/s/ David Burgert
David L. Burgert
ATTORNEY IN CHARGE
State Bar No. 03378300
Federal I.D. No. 2084
dburgert@porterhedges.com
Ray T. Torgerson
State Bar No. 24003067
Federal I.D. No. 22846
rtorgerson@porterhedges.com
PORTER HEDGES LLP
1000 Main Street, 36th Floor
Houston, Texas 77002-6336
Telephone: (713) 226-6668
Facsimile: (713) 226-6268

ATTORNEYS FOR DEFENDANT
ION GEOPHYSICAL CORPORATION

CERTIFICATE OF SERVICE

The undersigned hereby certifies that on the 3rd day of February, 2012, the foregoing was served pursuant to the Federal Rules of Civil Procedure to the following:

Lee L. Kaplan, Esq.
SMYSER KAPLAN & VESELKA, L.L.P.
700 Louisiana, Suite 2300
Houston, TX 77002
Tel: 713-221-2323
Fax: 713-221-2320
E-mail: lkaplan@skv.com

Timothy K. Gilman, Esq.
Simeon G. Papacostas, Esq.
Gregg F. LoCascio, P.C.
KIRKLAND & ELLIS LLP
601 Lexington Avenue
New York, NY 10022
Tel: 212-446-4689
Main: 212-446-4800
Fax: 212-446-4900
E-mail: tgilman@kirkland.com
E-mail: spapacostas@kirkland.com

Gregg F. LoCascio, Esq.
KIRKLAND & ELLIS LLP
655 Fifteenth Street, N.W.
Washington, D.C. 20005
Tel: 202-879-5290
Fax: 202-879-5200
E-mail: glocascio@kirkland.com

ATTORNEYS FOR PLAINTIFF WESTERNGECO L.L.C.

Gordon T. Arnold, Esq.
ARNOLD & KNOBLOCH LLP
4900 Woodway, Suite 900
Houston, TX 77056
Telephone: 713-972-1649
Facsimile: 713-972-1180
Email: GArnold@arnold-iplaw.com

John M. Elsley, Esq.
Rachel de Cordova, Esq.
ROYSTON, RAYZOR, VICKERY & WILLIAMS, L.L.P.
711 Louisiana, Suite 500
Houston, TX 77002
Telephone: 713-224-8380
Facsimile: 713-225-9945
Email: John.Elsley@roystonlaw.com
Email: rachel.decordova@roystonlaw.com

ATTORNEYS FOR DEFENDANTS, FUGRO-GEOTEAM, INC., FUGRO, INC., FUGRO (USA), INC., AND FUGRO GEOSERVICES, INC.

/s/ David Burgert
David Burgert

EXHIBIT 1

EXHIBIT 1

Anticipation of U.S. Patent No. 6,691,038 (the "Zajac '038 patent") by International Patent Application WO 2000/20895 ("Hillesund '895 Application")

U.S. Patent No. 6,691,038 Asserted Claims	**Citations from Hillesund '895 Application**
1. A seismic streamer array tracking and positioning system comprising:	The Hillesund WO 00/20895 International Application discloses this limitation. *See, e.g.,* Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.,* Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention".
a towing vessel for towing a seismic array;	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers ...").
an array comprising a plurality of seismic streamers;	The Hillesund '895 reference discloses this limitation. *See, e.g.,* Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers ...").
an active streamer positioning device (ASPD) attached to at least one seismic streamer for positioning the seismic streamer relative to other seismic streamers within the array;	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") *See, e.g.,* Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to 'relative' positioning of streamers ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle … . The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change". The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn …. In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers."). The '038 patent discloses that this limitation was well known to one skilled in the art prior to and at the time of the invention. *See, e.g.*, '038 patent, Col. 1, ll. 25-56 (discussing the known prior art including attaching control apparatuses to seismic streamers to position streamers).
and a master controller for issuing positioning commands to each ASPD to adjust a vertical and horizontal position of a first streamer relative to a second streamer within the array for maintaining a specified array geometry.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("In the preferred embodiment of the present invention, the control system for the birds 18 is distributed between a global control system 22 located on or near the seismic survey vessel 10 and a local control system located within or near the birds 18. The global control system 22 is typically connected to the seismic survey

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	vessel's navigation system and obtains estimates of system wide parameters, such as the vessel's towing direction and velocity and current direction and velocity, from the vessel's navigation system."). *See, e.g.*, Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global control system 22 preferably transmits, at regular intervals (such as every five seconds) a desired horizontal force 42 and a desired vertical force 44 to the local control system 36."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2; particularly in regard to the limitation of "specified array geometry" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn .... In extreme

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers.").
2. The apparatus of claim 1 further comprising: an environmental sensor for sensing environmental factors which influence the path of the towed array.	The Hillesund '895 application discloses this limitation. *See* Claim 1 Analysis. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers.") *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The "water-referenced" towing velocity and crosscurrent velocity could alternatively be determined using flowmeters or other types of water velocity sensors attached directly to the birds 18. Although these types of sensors are typically quite expensive, one advantage of this type of velocity determination system is that the sensed in-line and cross-line velocities will be inherently compensated for the speed and heading of marine currents acting on said streamer positioning device and for relative movements between the vessel 10 and the bird 18.").

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
3. The apparatus of claim 1 further comprising:	The Hillesund '895 application discloses this limitation. See Claim 1 Analysis.
a tracking system for tracking the streamer positions versus time during a seismic data acquisition run and storing the positions versus time in a legacy database for repeating the positions versus time in a subsequent data acquisition;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 7, Paragraph 1 ("In the preferred embodiment of the present invention, the global control system 22 monitors the actual positions of each of the birds 18 and is programmed with the desired positions of or the desired minimum separations between the seismic streamers 12."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system.")
and an array geometry tracking system for tracking the array geometry versus time during a seismic data acquisition run and storing the array geometry versus time in a legacy database for repeating the array geometry versus time in a subsequent data acquisition run.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle. The feather could be input either manually, through use of a current meter, or through use of an estimated value based on the average horizontal bird forces. Only when the crosscurrent velocity is very small will the feather angle be set to zero and the desired streamer positions be in precise alignment with the towing direction. The turn control mode is used when ending one pass and

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn. The vessel navigation system will typically notify the global control system 22 when to start throwing the streamers 12 out, and when to start straightening the streamers. In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers.").
4. The apparatus of claim 3 wherein the master controller compares the positions of the streamers versus time and the array geometry versus time to a desired streamer position and array geometry versus time and issues positioning commands to the ASPDs to maintain the desired streamer position and array geometry versus time.	The Hillesund '895 application discloses this limitation. *See* Claim 3 Analysis. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	global control system 22 located on the seismic survey vessel 10 and the local control system 36 located on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required.").
5. The apparatus of claim 4 wherein the master controller factors in environmental factors into the positioning commands to compensate for environmental influences on the positioning of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See* Claim 4 Analysis. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").
6. The apparatus of claim 4 wherein the master controller compensates for maneuverability in the positioning commands to compensate for maneuverability influences on the positioning of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See* Claim 4 Analysis. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array.").

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	See, e.g., Hillesund '895 at p. 8, Paragraph 3 ("The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system.").
10. The apparatus of claim 1 wherein the array geometry comprises a plurality of streamers positioned at a uniform depth.	The Hillesund '895 application discloses this limitation. *See* Claim 1 Analysis. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.")
11. The apparatus of claim 1 wherein the array geometry comprises a plurality of streamers positioned at a plurality of depths for varying temporal resolution of the array.	The Hillesund '895 application discloses this limitation. *See* Claim 1 Analysis. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") *See, e.g.*, Hillesund '895 at p. 19, Paragraph 2 ("In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible")
13. The apparatus of claim 4 wherein the array geometry is tracked via satellite and communicated to the master controller.	The Hillesund '895 application discloses this limitation. *See* Claim 4 Analysis.

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	See, e.g., Hillesund '895 at p. 6, Paragraph 2 ("The global control system 22 is typically connected to the seismic survey vessel's navigation system and obtains estimates of system wide parameters, such as the vessel's towing direction and velocity and current direction and velocity, from the vessel's navigation system."). *See, e.g.*, Hillesund '895 at p. 7, Paragraph 1 ("Alternatively, or additionally, satellite-based global positioning system equipment can be used to determine the positions of the equipment.").
14. A seismic streamer array tracking and positioning system comprising:	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.*, Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention".
a towing vessel for towing a seismic array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …").
a seismic streamer array comprising a plurality of seismic streamers; an active streamer positioning device (ASPD) attached to each seismic streamer for positioning each seismic streamer;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …"). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.")

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
a master controller for issuing vertical and horizontal positioning commands to each ASPD for maintaining a specified array geometry;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("In the preferred embodiment of the present invention, the control system for the birds 18 is distributed between a global control system 22 located on or near the seismic survey vessel 10 and a local control system located within or near the birds 18. The global control system 22 is typically connected to the seismic survey vessel's navigation system and obtains estimates of system wide parameters, such as the vessel's towing direction and velocity and current direction and velocity, from the vessel's navigation system."). *See, e.g.*, Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global control system 22 preferably transmits, at regular intervals (such as every five seconds) a desired horizontal force 42 and a desired vertical force 44 to the local control system 36."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. ..."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2; particularly in regard to the limitation of "specified array geometry" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change". ... Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn .... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. …")
an environmental sensor for sensing environmental factors which influence the towed path of the towed array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers.") *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically *acquire* the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. …") *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The "water-referenced" towing velocity and crosscurrent velocity could alternatively be determined using flowmeters or other types of water velocity sensors attached directly to the birds 18. Although these types of sensors are typically quite expensive, one advantage of this type of velocity determination system is that the sensed in-line and cross-line velocities will be inherently compensated for the speed and heading of marine currents acting on said streamer positioning device and for relative movements between the vessel 10 and the bird 18.").
a tracking system for tracking the streamer horizontal and vertical positions versus time during a seismic data acquisition run;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 7, Paragraph 1 ("In the preferred embodiment of the present invention, the global control system 22 monitors the actual positions of each of the birds ...").

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	See, e.g., Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system.")
an array geometry tracking system for tracking the array geometry versus time during a seismic data acquisition run, wherein the master controller compares the vertical and horizontal positions of the streamers versus time and the array geometry versus time to desired streamer positions and array geometry versus time and issues positioning commands to the ASPDs to maintain the desired streamer positions and array geometry versus time.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to the limitation of "maintain the desired streamer positions and array geometry versus time." ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. ... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers ...").

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
15. The apparatus of claim 14 wherein the master controller factors in environmental measurements into the positioning commands to compensate for environmental influences on the positions of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See* Claim 14 Analysis. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").
16. The apparatus of claim 14 wherein the master controller compensates for maneuverability in the positioning commands to compensate for maneuverability influences on the positioning of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See* Claim 14 Analysis. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array."). A Person Having Ordinary Skill In The Art at the time of the invention would find this limitation to be inherent in the invention. To "compensate for maneuverability influences" it would be necessary to take into account various maneuverability factors, including, but not necessarily limited to, cable diameter, array type, deployed configuration, vessel type, device type, etc. which are part of the basis for the behavior of the streamers. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The force and

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system.").
20. A seismic streamer array tracking and positioning system comprising:	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.,* Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention."
a towing vessel for towing a seismic array;	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …").
a seismic streamer array comprising a plurality of seismic streamers;	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …").
an active streamer positioning device (ASPD) attached to each seismic streamer for vertically and horizontally positioning each seismic streamer relative to the array;	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") *See, e.g.,* Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to the limitation of "positioning each seismic streamer relative to the array". ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change". The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode.... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth ..."). The '038 patent discloses that this limitation was well known to one skilled in the art prior to and at the time of the invention. *See, e.g.*, '038 patent, Col. 1, ll. 25-56 (discussing the known prior art including attaching control apparatuses to seismic streamers to position streamers).
and a master controller for issuing positioning commands to each ASPD for maintaining a specified array path.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("In the preferred embodiment of the present invention, the control system for the birds 18 is distributed between a global control system 22 located on or near the seismic survey vessel 10 and a local control system located within or near the birds ..."). *See, e.g.*, Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global control system 22 preferably transmits, at regular intervals (such as every five seconds) a desired horizontal force 42 and a desired vertical force 44 to the local control system 36."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2; particularly in regard to the limitation of "specified array path" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle … The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. … In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers.").
21. The apparatus of claim 20 wherein the master controller issues positioning commands to the towing vessel for maintaining a specified array path.	The Hillesund '895 application discloses this limitation. *See* Claim 20 Analysis. See, e.g., Hillesund '895 at p. 6, Paragraph 2 ("The global control system 22 is typically connected to the seismic survey vessel's navigation system and obtains estimates of system wide parameters, such as the vessel's towing direction and velocity and current direction and velocity, from the vessel's navigation system.")

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	In addition, Persons Having Ordinary Skill In The Art will readily recognize that the seismic survey vessel's navigation system is typically utilized to steer the vessel in routine seismic acquisition operations ("auto-pilot").
22. The apparatus of claim 20 further comprising:	The Hillesund '895 application discloses this limitation. See Claim 20 Analysis.
a processor for calculating an optimal path for the seismic array for optimal coverage during seismic data acquisition over a seismic field;	The Hillesund '895 application discloses this limitation. *See* Claim 20 Analysis. *See, e.g.*, Hillesund '895, Fig 4. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").
a streamer behavior prediction processor which predicts array behavior;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").
and wherein the master controller compensates for predicted streamer behavior in issuing vertical and horizontal positioning commands to the towing vessel and the ASPDs for positioning the array along the optimal path.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").
23. The apparatus of claim 22 wherein the master controller compensates for environmental factors in the positioning commands.	The Hillesund '895 application discloses this limitation. *See* Claim 22 Analysis. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").
24. The apparatus of claim 23 wherein the master controller compensates for maneuverability factors in the positioning commands.	The Hillesund '895 application discloses this limitation. *See* Claim 23 Analysis. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array."). This limitation is inherent. It would be necessary to take into account some maneuverability factors such as cable diameter, array type, deployed configuration which are part of the basis for the behavior of the streamers to be able to implement the invention of Claim 23. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system.").
25. A seismic streamer array tracking and positioning system comprising:	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.*, Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention."
a towing vessel for towing a seismic array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …").
a seismic streamer array comprising a plurality of seismic streamers;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …").
an active streamer positioning device (ASPD) attached to each seismic streamer for vertically and horizontally positioning each seismic streamer relative to the array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to 'relative' positioning of streamers ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle …. The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change". The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn .... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers."). The '038 patent discloses that this limitation was well known to one skilled in the art prior to and at the time of the invention. *See, e.g.*, '038 patent, Col. 1, ll. 25-56 (discussing the known prior art including attaching control apparatuses to seismic streamers to position streamers).
a master controller for issuing positioning commands to each ASPD and to the towing vessel for maintaining an optimal path, wherein the master controller further comprises a processor for calculating an optimal path for the seismic array for optimal coverage during seismic data acquisition over a seismic field, and a streamer behavior prediction processor which predicts array behavior, wherein the master controller compensates for predicted streamer behavior in issuing positioning commands to the towing vessel and the ASPDs for positioning the array along the optimal path, wherein the master	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("In the preferred embodiment of the present invention, the control system for the birds 18 is distributed between a global control system 22 located on or near the seismic survey vessel 10 and a local control system located within or near the birds 18. The global control system 22 is typically connected to the seismic survey vessel's navigation system and obtains estimates of system wide parameters, such as the vessel's towing direction and velocity and current direction and velocity, from the vessel's navigation system."). *See, e.g.*, Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global control system 22 preferably transmits, at regular intervals (such as every five seconds) a desired horizontal force 42 and a desired vertical force 44 to the local control system 36.").

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
controller compensates for environmental and maneuverability factors in the positioning commands.	*See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn .... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	streamers."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices."). *See, e.g.*, Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array.").
26. A method for tracking and positioning a seismic streamer array comprising:	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.*, Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention."
for towing a seismic array comprising a plurality of seismic streamers;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	towing eight marine seismic streamers ...").
attaching an active streamer positioning device (ASPD) each seismic streamer for positioning the seismic streamer relative to other seismic streamers within the array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to 'relative' positioning of streamers ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn .... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers."). The '038 patent discloses that this limitation was well known to one skilled in the art prior to and at the time of the invention. *See, e.g.*, '038 patent, Col. 1, ll. 25-56 (discussing the known prior art including attaching control apparatuses to seismic streamers to position streamers).
and issuing vertical and horizontal positioning commands to each ASPD for maintaining a specified array geometry.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2; particularly in regard to the limitation of "specified array geometry" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. ... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers.").
27. The method of claim 26 further comprising: providing an environmental sensor for sensing environmental factors which influence the path of the towed array.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers.

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	See, e.g., Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.,* Hillesund '895 at p. 8, Paragraph 3 ("The "water-referenced" towing velocity and crosscurrent velocity could alternatively be determined using flowmeters or other types of water velocity sensors attached directly to the birds 18. Although these types of sensors are typically quite expensive, one advantage of this type of velocity determination system is that the sensed in-line and cross-line velocities will be inherently compensated for the speed and heading of marine currents acting on said streamer positioning device and for relative movements between the vessel 10 and the bird 18.").
28. The method of claim 26 further comprising: providing a tracking system for tracking the streamer positions versus time during a seismic data acquisition run and storing the positions versus time in a legacy database for repeating the positions versus time in a subsequent data acquisition; and providing an array geometry tracking system for tracking the array geometry versus time during a seismic data acquisition run and storing the array geometry versus time in a legacy database for repeating the array geometry versus time in a subsequent data acquisition run.	The Hillesund '895 application discloses this limitation. *See* Claim 26 Analysis. *See, e.g.,* Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.,* Hillesund '895 at p. 7, Paragraph 1 ("In the preferred embodiment of the present invention, the global control system 22 monitors the actual positions of each of the birds 18 and is programmed with the desired positions of or the desired minimum separations between the seismic streamers 12."). *See, e.g.,* Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system.") In regard to "array geometry tracking system," *see, e.g.*, Hillesund '895 at p. 18, Paragraph 3 to p. 19, Paragraph 2 ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle. The feather could be input either manually, through use of a current meter, or through use of an estimated value based on the average horizontal bird forces. Only when the crosscurrent velocity is very small will the feather angle be set to zero and the desired streamer positions be in precise alignment with the towing direction. The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change". The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn. The vessel navigation system will typically notify the global control system 22 when to start throwing the streamers 12 out, and when to start straightening the streamers. In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers.").
29. The method of claim 28 wherein the master controller compares the positions of the streamers versus time and the array geometry versus time to a desired streamer position and array geometry versus time and issues positioning commands to the ASPDs to maintain the desired streamer position and array geometry versus time.	The Hillesund '895 application discloses this limitation. *See* Claim 28 Analysis. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required.").
30. The method of claim 29 wherein the master controller factors in environmental factors into the positioning commands to compensate for environmental influences on the positioning of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See* Claim 29 Analysis. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity.").

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	See, e.g., Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").
31. The method of claim 30 wherein the master controller compensates for maneuverability in the positioning commands to compensate for maneuverability influences on the positioning of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See* Claim 30 Analysis. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array."). A Person Having Ordinary Skill In The Art at the time of the invention would find this limitation to be inherent in the invention. To "compensate for maneuverability influences" it would be necessary to take into account various maneuverability factors, including, but not necessarily limited to, cable diameter, array type, deployed configuration, vessel type, device type, etc. which are part of the basis for the behavior of the streamers. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system.").
35. The method of claim 26 wherein the array geometry comprises a plurality of streamers positioned at a uniform depth.	The Hillesund '895 application discloses this limitation. *See* Claim 26 Analysis. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.")

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
36. The method of claim 26 wherein the array geometry comprises a plurality of streamers positioned at a plurality of depths for varying temporal resolution of the array.	The Hillesund '895 application discloses this limitation. *See* Claim 26 Analysis. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") *See, e.g.*, Hillesund '895 at p. 19, Paragraph 2 ("In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible")
38. The method of claim 29 wherein the array geometry is tracked via satellite and communicated to the master controller.	The Hillesund '895 application discloses this limitation. *See* Claim 29 Analysis. See, e.g., Hillesund '895 at p. 7, Paragraph 1 ("The horizontal positions of the birds 18 can be derived, for instance, using the types of acoustic positioning systems ... Alternatively, or additionally, satellite-based global positioning system equipment can be used to determine the positions of the equipment.")
39. A method for tracking and positioning a seismic streamer array comprising:	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.*, Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention."

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
towing a seismic array comprising a plurality of seismic streamers from a towing vessel;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …"). *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …").
attaching an active streamer positioning device (ASPD) to each seismic streamer for positioning each seismic streamer;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to "positioning" of streamers ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. …") In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. ..."). The '038 patent discloses that this limitation was well known to one skilled in the art prior to and at the time of the invention. *See, e.g.*, '038 patent, Col. 1, ll. 25-56 (discussing the known prior art including attaching control apparatuses to seismic streamers to position streamers).
issuing positioning commands from a master controller to each ASPD to adjust vertical and horizontal position of a first streamer relative to a second streamer in the array for maintaining a specified array	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("In the preferred embodiment of the present invention, the control system for the birds 18 is distributed between a global control system 22 located on or near the seismic survey vessel 10 and a local

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
geometry;	control system located within or near the birds 18."). *See, e.g.*, Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global control system 22 preferably transmits, at regular intervals (such as every five seconds) a desired horizontal force 42 and a desired vertical force 44 to the local control system 36."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2; particularly in regard to the limitation of "maintaining a specified array geometry" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn .... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers.").
sensing environmental factors which influence the towed path of the towed array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers.") *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The "water-referenced" towing velocity and crosscurrent velocity could alternatively be determined using flowmeters or other types of water velocity sensors attached directly to the birds 18. Although these types of sensors are typically quite expensive, one advantage of this type of velocity determination system is that the sensed in-line and cross-line velocities will be inherently compensated for the speed and heading of marine currents acting on said streamer positioning device and for relative movements between the vessel 10 and the bird 18.").
tracking the streamer positions versus time during a seismic data acquisition run;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 7, Paragraph 1 ("In the preferred embodiment of the present invention, the global control system 22 monitors the actual positions of each of the birds 18 and is programmed with the desired positions of or the desired minimum separations between the seismic streamers 12."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system.")
tracking the array geometry versus time during a seismic data acquisition run, wherein the master controller compares the positions of the streamers versus time and the array geometry versus time to desired streamer positions and array geometry versus time and issues positioning commands to the ASPDs to maintain the desired streamer positions and array geometry versus time.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required.").
40. The method of claim 39 wherein the master controller factors in environmental measurements into the positioning commands to compensate for environmental influences on the positions of the	The Hillesund '895 application discloses this limitation. *See* Claim 39 Analysis. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
streamers and the array geometry.	from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").
41. The method of claim 39 wherein the master controller compensates for maneuverability in the positioning commands to compensate for maneuverability influences on the positioning of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See* Claim 39 Analysis. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array."). A Person Having Ordinary Skill In The Art at the time of the invention would find this limitation to be inherent in the invention. To "compensate for maneuverability influences" it would be necessary to take into account various maneuverability factors, including, but not necessarily limited to, cable diameter, array type, deployed configuration, vessel type, device type, etc. which are part of the basis for the behavior of the streamers. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system.").

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
45. A method for tracking and positioning seismic streamer array comprising:	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.*, Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention."
towing a seismic array comprising a plurality of seismic streamers;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …").
attaching an active streamer positioning device (ASPD) attached to each seismic streamer for positioning each seismic streamer;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer ...") *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to "positioning each seismic streamer" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle …. The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. … Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	after the completion of the turn .... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth ..."). The '038 patent discloses that this limitation was well known to one skilled in the art prior to and at the time of the invention. *See, e.g.*, '038 patent, Col. 1, ll. 25-56 (discussing the known prior art, including attaching control apparatuses to seismic streamers to position streamers).
and issuing vertical and horizontal positioning commands to each ASPD for maintaining a specified array path.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("In the preferred embodiment of the present invention, the control system for the birds 18 is distributed between a global control system 22 located on or near the seismic survey vessel 10 and a local control system located within or near the birds ..."). *See, e.g.*, Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global control system 22 preferably transmits, at regular intervals (such as every five seconds) a desired horizontal force 42 and a desired vertical force 44 to the local control system 36."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19,

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	Paragraph 2; particularly in regard to the limitation of "specified array path" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change". The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. ... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers.").
46. The method of claim 45 wherein a master controller issues positioning commands to the towing vessel for maintaining a specified array path.	The Hillesund '895 application discloses this limitation. *See* Claim 45 Analysis. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("The global control system 22 is typically connected to the seismic survey vessel's navigation system and obtains estimates of system wide parameters, such as the vessel's towing direction and velocity and current direction and velocity, from the vessel's navigation system.") In addition, Persons Having Ordinary Skill In The Art will readily recognize that the seismic survey vessel's navigation system is typically utilized to steer the vessel in routine seismic acquisition operations ("auto-pilot").

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
47. The method of claim 45 further comprising: calculating an optimal path for the seismic array for optimal coverage during seismic data acquisition over a seismic field;	The Hillesund '895 application discloses this limitation. *See* Claim 45 Analysis. *See, e.g.*, Hillesund '895, Fig 4. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").
predicting array behavior;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig 4. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").
and compensating for predicted streamer behavior in issuing positioning commands to the towing vessel and the ASPDs for positioning the array along the optimal path.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("In the preferred embodiment of the present invention, the control system for the birds 18 is distributed between a global control system 22 located on or near the seismic survey vessel 10 and a local control system located within or near the birds 18. The global control system 22 is typically connected to the seismic survey vessel's navigation system and obtains estimates of system wide parameters, such as the vessel's towing direction and velocity and current direction and velocity, from the vessel's navigation system."). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices."). *See, e.g.*, Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	control system 22 preferably transmits, at regular intervals (such as every five seconds) a desired horizontal force 42 and a desired vertical force 44 to the local control system 36."). *See, e.g.,* Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required."). *See, e.g.,* Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2; particularly in regard to the limitation of "specified array geometry" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn .... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers.").
48. The method of claim 47 wherein the master controller compensates for environmental factors in the positioning commands.	The Hillesund '895 application discloses this limitation. *See* Claims 15, 30, and 40 Analyses. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity.").
49. The method of claim 48 wherein the master controller compensates for maneuverability factors in the positioning commands.	The Hillesund '895 application discloses this limitation. *See* Claims 16, 31, and 41 Analyses. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array.").

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	A Person Having Ordinary Skill In The Art at the time of the invention would find this limitation to be inherent in the invention. To "compensate for maneuverability influences" it would be necessary to take into account various maneuverability factors, including, but not necessarily limited to, cable diameter, array type, deployed configuration, vessel type, device type, etc. which are part of the basis for the behavior of the streamers. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system.").
50. A method for tracking and positioning a seismic streamer array comprising:	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.*, Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention".
towing a seismic array comprising a plurality of seismic streamers;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …").
attaching an active streamer positioning device (ASPD) attached to each seismic streamer for positioning each seismic streamer;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer ...") *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to "positioning each seismic streamer" ("The inventive control system will primarily operate

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	in two different *control modes*: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep *each streamer* in a straight line offset from the towing direction by a certain feather angle ... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. ...") The '038 patent discloses that this limitation was well known to one skilled in the art prior to and at the time of the invention. *See, e.g.*, '038 patent, Col. 1, ll. 25-56 (discussing the known prior art, including attaching control apparatuses to seismic streamers to position streamers).
issuing horizontal and vertical positioning commands to each ASPD and to the towing vessel for maintaining an optimal path, calculating an optimal path for the seismic array for optimal coverage during seismic data acquisition over a seismic field, and a behavior prediction processor which predicting array behavior, wherein the master controller compensates for predicted streamer behavior in issuing positioning commands to the towing vessel and the ASPDs for positioning the array along the optimal path, wherein the master controller compensates for environmental and maneuverability factors in the positioning commands.	The Hillesund '895 application discloses this limitation. See, e.g., Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global control system 22 preferably transmits, at regular intervals (such as every five seconds) a desired horizontal force 42 and a desired vertical force 44 to the local control system 36."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 located on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required.").

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	See, e.g., Hillesund '895 at p. 6, Paragraph 3 ("To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and *behavior-predictive* model-based control logic to properly control the streamer positioning devices."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system."). *See also* Claims 1, 2, 5, 6, 21, 22, and 25 Analyses.

EXHIBIT 2

EXHIBIT 2

Anticipation of U.S. Patent No. 6,932,017 (the "Hillesund '017 patent") Based On
U.S. Patent 5,790,472 ("Workman '472 patent")

U.S. Patent No. 6,932,017 Asserted Claims	Citations from '472 prior-art
1. A method of controlling the positions of marine seismic streamers in an array of such streamers being towed by a seismic survey vessel, the streamers having respective streamer positioning devices disposed therealong and each streamer positioning device having a wing and a wing motor for changing the orientation of the wing so as to steer the streamer positioning device laterally, said method comprising the steps of:	U.S. Patent 5,790,472 (Adaptive Control of Marine Seismic Streamers; Workman & Chambers; assigned to Western Atlas; 1998) discloses this claim preamble. The limitation of "marine seismic streamers in an array of such streamers being towed by a seismic survey vessel" is disclosed in the Workman '472 patent. The limitation of "streamer positioning devices disposed therealong and each streamer positioning device having a wing and a wing motor for changing the orientation of the wing" is disclosed in the Workman '472 patent. The limitation "to steer the streamer positioning device laterally" is disclosed in the Workman '472 patent. *See, e.g.,* Workman '472 at Col. 2, ll. 32-33 ("... the prior art discloses a series of discrete devices for locating and controlling the positions of streamer cables ...") and Col. 2, ll. 45-47 ("The present invention is an improved system for controlling the position and shape of marine seismic streamer cables"). *See, e.g.,* Workman '472 at Col. 3, ll. 33-43 ("As known to those skilled in the art, components of the marine seismic data acquisition system 05, on the vessel 11, may include ... a network solution system 10 for determining the position of the streamer cables 13 and seismic sources 12, and a streamer cable controller 16 for controlling the streamer positioning devices"). *See, e.g.,* Workman '472 at Col. 1, ll. 17-19 ("Due to the increasing use of marine 3-D seismic data, multi-cable marine surveys are now commonplace"). *See, e.g.,* Workman '472 at Col. 1, l. 45 ("Streamer positioning devices are well known in the art"). *See, e.g.,* Workman '472 at Col. 3, ll. 14-20 ("As known to

U.S. Patent No. 6,932,017 Asserted Claims	Citations from '472 prior-art
	those skilled in the art, streamer positioning devices 14, for example birds and tail buoys, may be attached to the exterior of the streamer cables 13 for adjusting the vertical and lateral positions of the streamer cables 13. The streamer cables 13 include electrical or optical cables for connecting the streamer positioning devices 14 to individual control and logging systems"). *See, e.g.*, Workman '472 at Col. 1, ll. 55-61 (describes lateral positioning with wings). A wing motor to move a wing is inherent in this invention because of the need for dynamic control to implement this invention.
obtaining a predicted position of the streamer positioning devices;	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 2, ll. 15-18 ("These devices and methods may then be used to determine the real time position of the seismic sources and seismic streamer cables by computing a network solution to a Kalman filter, as disclosed by U.S. Pat. No. 5,353,223"). Prediction is a fundamental aspect of Kalman filtering technology. A person Having Ordinary Skill In The Art will understand that the disclosed Kalman filter is a well-known prior art technology that is used to obtain a predicted position.
obtaining an estimated velocity of the streamer positioning devices;	Given "a predicted position of the streamer positioning devices," then a Person Having Ordinary Skill In The Art will understand that it is inherent that velocities are necessarily obtained from differences in positions over known time intervals based on fundamental concepts of marine navigation known for generations. In marine seismic navigation systems at the time of invention, solutions for positions are typically available several times per minute which necessarily yields estimates of velocities several times per minute as simple differences of positions. *See, e.g.*, Workman '472 at Col. 2, ll. 15-18 ("These devices and methods may then be used to determine the real time position of the seismic sources and seismic streamer cables by computing a network solution to a Kalman filter, as disclosed by U.S. Pat. No. 5,353,223").

U.S. Patent No. 6,932,017 Asserted Claims	Citations from '472 prior-art
	Estimation is a fundamental aspect of Kalman filtering technology. A person Having Ordinary Skill In The Art will understand that the disclosed Kalman filter is a well-known prior art technology that is used to obtain an estimated velocity.
for at least some of the streamer positioning devices, calculating desired changes in the orientation of their wings using said predicted position and said estimated velocity;	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 3, ll. 42-43 ("… and a streamer cable controller 16 for controlling the streamer positioning devices 14"). *See* also, e.g., FIG. 2 *See, e.g.*, Workman '472 at Col. 3, ll. 59-62 ("… includes a streamer control processor 40 for … calculating a position correction to reposition the streamer cables 13") *See, e.g.*, Workman '472 at Col. 4, ll. 17-21 "The streamer control processor 40 is connected to the streamer device controller 16. When the streamer cables 13 need to be repositioned, the position correction is used by the streamer device controller 16 to adjust the streamer positioning devices 14 and reposition the streamer cables 13." Given "predicted positions and estimated velocities", a Person Having Ordinary Skill in the Art will understand that it is inherent that the "orientation of their wings" for the streamer positioning devices necessarily must be calculated to be able to implement any change in streamer position or motion whatsoever.
and actuating the wing motors to produce said desired changes in wing orientation.	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 1, ll. 55-57 ("For example, devices to control the lateral positioning of streamer cables by using camber-adjustable hydrofoils or angled wings are disclosed …") This limitation is also inherent. Given a desire to reposition the streamers, then a Person Having Ordinary Skill In The Art will understand that to change the "wing orientation" for the streamer positioning devices will necessarily require the action of a motor.

U.S. Patent No. 6,932,017 Asserted Claims	Citations from '472 prior-art
8. A method as claimed in claim 7, in which said global control system is further configured into a streamer separation mode, wherein said global control system attempts to direct said streamer positioning device to maintain a minimum separation distance between adjacent streamers.	The Workman '472 patent discloses this limitation of "streamer separation mode". *See, e.g.*, Workman '472 at Col. 1, ll. 33-35 ("The ability to control the position and shape of the streamer cables is desirable for preventing the entanglement of the streamer cables …"). *See, e.g.*, Workman '472 at Col. 3, ll. 58-67 ("In the present embodiment of the invention, the marine seismic data acquisition system 05 also includes a streamer control processor 40 for deciding when the streamer cables 13 should be repositioned and for calculating a position correction to reposition the streamer cables 13. Also in the present embodiment of the invention, threshold parameters are established for determining when the streamer cables should be repositioned. Threshold parameters may include a plurality of values for: minimum allowable separations between streamer cables 13 …") *See, e.g.*, Workman '472 at Col. 4, ll. 8-35 (discloses streamer control processor).
16. Apparatus for controlling the positions of marine seismic streamer in an array of such streamers being towed by a seismic survey vessel, the streamers having respective streamer positioning devices disposed therealong and each streamer positioning device having a wing and a wing motor for changing the horizontal orientation of the wing so as to steer the streamer positioning device laterally, said apparatus comprising:	U.S. Patent 5,790,472 (Adaptive Control of Marine Seismic Streamers; Workman & Chambers; assigned to Western Atlas; 1998) discloses this claim preamble. The limitation of "marine seismic streamers in an array of such streamers being towed by a seismic survey vessel" is disclosed in the Workman '472 patent. The limitation of "streamer positioning devices disposed therealong and each streamer positioning device having a wing and a wing motor for changing the orientation of the wing" is disclosed in the Workman '472 patent. The limitation "to steer the streamer positioning device laterally" is disclosed in the Workman '472 patent. *See, e.g.*, Workman '472 at Col. 1, ll. 55-61 (describes lateral positioning with wings). A wing motor to move a wing is inherent in this invention because of the need for dynamic control to implement this invention. *See, e.g.*, Workman '472 at Col. 2, ll. 32-33 ("… the prior

U.S. Patent No. 6,932,017 Asserted Claims	Citations from '472 prior-art
	art discloses a series of discrete devices for locating and controlling the positions of streamer cables ...") and Col. 2, ll. 45-47 ("The present invention is an improved system for controlling the position and shape of marine seismic streamer cables"). *See, e.g.,* Workman '472 at Col. 3, ll. 33-43 ("As known to those skilled in the art, components of the marine seismic data acquisition system 05, on the vessel 11, may include … a network solution system 10 for determining the position of the streamer cables 13 and seismic sources 12, and a streamer cable controller 16 for controlling the streamer positioning devices"). *See, e.g.,* Workman '472 at Col. 1, ll. 17-19 ("Due to the increasing use of marine 3-D seismic data, multi-cable marine surveys are now commonplace"). *See, e.g.,* Workman '472 at Col. 1, l. 45 ("Streamer positioning devices are well known in the art"). *See, e.g.,* Workman '472 at Col. 3, ll. 14-20 ("As known to those skilled in the art, streamer positioning devices 14, for example birds and tail buoys, may be attached to the exterior of the streamer cables 13 for adjusting the vertical and lateral positions of the streamer cables 13. The streamer cables 13 include electrical or optical cables for connecting the streamer positioning devices 14 to individual control and logging systems").
means for obtaining a predicted position of the streamer positioning devices;	Under 35 U.S.C. § 112, ¶ 6, the Workman '472 patent discloses structure that performs the claimed function of obtaining a predicted position of the streamer positioning devices and that is either identical to the structure identified by the Court or equivalent structure. *See, e.g.,* As shown in Figure 2, the marine seismic data acquisition system 05 comprises a streamer control processor 40 and a streamer cable controller 16. *See, e.g.,* Workman '472 at Col. 3, ll. 33-34 and ll. 42-44 ("As known to those skilled in the art, components of the marine seismic data acquisition system 05, on the vessel

U.S. Patent No. 6,932,017 Asserted Claims	Citations from '472 prior-art
	11, may include … a streamer cable controller 16 for controlling the streamer positioning devices 14."). *See, e.g.,* Workman '472 at Col. 3, ll. 58-62 ("… the marine seismic data acquisition system 05 also includes a streamer control processor 40 for deciding when the streamer cables 13 should be repositioned and for calculating a position correction to reposition the streamer cables 13.") *See, e.g.,* Workman '472 at Col. 2, ll. 15-19 which discloses "prediction" in a Kalman filter. ("These devices and methods may then be used to determine the real time position of the seismic sources and seismic streamer cables by computing a network solution to a Kalman filter, as disclosed by U.S. Pat. No. 5,353,223"). Prediction is a fundamental aspect of Kalman filtering technology. A PHOSITA will understand that the disclosed Kalman filter is a well-known prior-art technology that is used to obtain a predicted position and that such filtering technology is implemented using algorithms software.
means for obtaining an estimated velocity of the streamer positioning devices,	Under 35 U.S.C. § 112, ¶ 6, the Workman '472 patent discloses structure that performs the claimed function of obtaining an estimated velocity of the streamer positioning devices and that is either identical to the structure identified by the Court or equivalent structure. The '017 specification states that "The towing velocity and crosscurrent velocity are preferably "water-referenced" values that are calculated from the vessel speed and heading values and the current speed and heading values, as well as any relative movement between the seismic survey vessel 10 and the bird 18 (such as while the vessel is turning). Alternatively, the global control system 22 could provide the local control system with the horizontal velocity and water in-flow angle. The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system. The "water-referenced" towing velocity and crosscurrent velocity could alternatively be determined using

U.S. Patent No. 6,932,017 Asserted Claims	Citations from '472 prior-art
	flowmeters or other types of water velocity sensors attached directly to the birds 18." *See, e.g.,* As shown in Figure 2, the marine seismic data acquisition system 05 comprises a streamer control processor 40 and a streamer cable controller 16. *See, e.g.,* Workman '472 at Col. 2, ll. 15-18; at Col. 4, l. 8; and "prediction" in a Kalman filter at Col. 2., ll. 15-19. The aforementioned disclosed structure performs the function of: "These devices and methods may then be used to determine the real time position of the seismic sources and seismic streamer cables by computing a network solution to a Kalman filter, as disclosed by U.S. Pat. No. 5,353,223"). Given "a predicted position of the streamer positioning devices," then a Person Having Ordinary Skill In The Art will understand that it is inherent that velocities are necessarily obtained from differences in positions over known time intervals based on fundamental concepts of marine navigation known for generations. In marine seismic navigation systems at the time of invention, solutions for positions are typically available several times per minute which necessarily yields estimates velocities several times per minute as simple differences of positions. Estimation is a fundamental aspect of Kalman filtering technology. A person Having Ordinary Skill In The Art will understand that the disclosed Kalman filter is a well-known prior art technology that is used to obtain an estimated velocity.
means for calculating desired changes in the orientations of the respective wings of at least some of the streamer positioning devices using said predicted position and said estimated velocity;	Under 35 U.S.C. § 112, ¶ 6, the Workman '472 patent discloses structure that performs the claimed function of calculating desired changes in the orientations of the respective wings of at least some of the streamer positioning devices using said predicted position and said estimated velocity and that is either identical to the structure identified by the Court or equivalent structure. The Workman '472 patent discloses a global control system for performing the recited function. The Workman '472 patent discloses a structure to perform this function

U.S. Patent No. 6,932,017 Asserted Claims	Citations from '472 prior-art
	comprised of a streamer cable controller and a streamer control processor. *See, e.g.,* As shown in Figure 2, the marine seismic data acquisition system 05 comprises a streamer control processor 40 and a streamer cable controller 16. *See, e.g.,* Workman '472 at Col. 3, ll. 42-43 ("... and a streamer cable controller 16 for controlling the streamer positioning devices 14"). *See* also, e.g., FIG. 2 *See, e.g.,* Workman '472 at Col. 3, ll. 59-62 ("... includes a streamer control processor 40 for ... calculating a position correction to reposition the streamer cables 13") *See, e.g.,* Workman '472 at Col. 4, ll. 17-21 "The streamer control processor 40 is connected to the streamer device controller 16. When the streamer cables 13 need to be repositioned, the position correction is used by the streamer device controller 16 to adjust the streamer positioning devices 14 and reposition the streamer cables 13." This claim limitation "calculating desired changes in the orientation of their wings using said predicted position and said estimated velocity" is also an inherent aspect of the invention. Given "predicted positions and estimated velocities," it is inherently necessary that the "orientation of their wings" for the streamer positioning devices must be calculated to be able to implement any change in streamer position or motion whatsoever.
and means for actuating the wing motors to produce said desired changes in wing orientation.	Under 35 U.S.C. § 112, ¶ 6, the Workman '472 patent discloses structure that performs the claimed function of actuating the wing motors to produce said desired changes in wing orientation and that is either identical to the structure identified by the Court or equivalent structure. *See, e.g.,* Workman '472 at Col. 1, ll. 55-57 ("For example, devices to control the lateral positioning of streamer cables by using camber-adjustable hydrofoils or angled wings are disclosed ...") This claim limitation "actuating the wing motors to

U.S. Patent No. 6,932,017 Asserted Claims	Citations from '472 prior-art
	produce said desired changes in wing orientation" is also an inherent aspect of the invention. Given a desire to reposition the streamers, it is necessary that the "wing orientation" for the streamer positioning devices will need to be altered, which necessarily requires the action of a motor.

2661705v2

EXHIBIT 3

EXHIBIT 3

U.S. Patent No. 7,080,607 (the "'607 patent") Is Anticipated By
U.S. Patent 5,790,472 (Workman '472)

U.S. Patent No. 7,080,607 Asserted Claims	**Citations from prior-art**
1. A method comprising: (a) towing an a [sic] array of streamers each having a plurality of streamer positioning devices there along;	U.S. Patent 5,790,472 (Adaptive Control of Marine Seismic Streamers; Workman & Chambers; assigned to Western Atlas; 1998) discloses this limitation *See, e.g.*, Workman '472 at Col. 2, ll. 32-33 ("... the prior art discloses a series of discrete devices for locating and controlling the positions of streamer cables ...") and Col. 2, ll. 45-47 ("The present invention is an improved system for controlling the position and shape of marine seismic streamer cables"). *See, e.g.*, Workman '472 at Col. 1, ll. 17-19 ("Due to the increasing use of marine 3-D seismic data, multi-cable marine surveys are now commonplace") *See, e.g.*, Workman '472 at Col. 1, l. 45 ("Streamer positioning devices are well known in the art") *See, e.g.*, Workman '472 at Col. 3, ll. 14-20 ("As known to those skilled in the art, streamer positioning devices 14, for example birds and tail buoys, may be attached to the exterior of the streamer cables 13 for adjusting the vertical and lateral positions of the streamer cables 13. The streamer cables 13 include electrical or optical cables for connecting the streamer positioning devices 14 to individual control and logging systems").
(b) predicting positions of at least some of the streamer positioning devices;	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 2, ll. 15-18 ("These devices and methods may then be used to determine the real time position of the seismic sources and seismic streamer cables by computing a network solution to a Kalman filter, as disclosed by U.S. Pat. No. 5,353,223" [prediction is a fundamental aspect of Kalman filtering technology]).

U.S. Patent No. 7,080,607 Asserted Claims	Citations from prior-art
(c) using the predicted positions to calculate desired changes in position of one or more of the streamer positioning devices; and	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 3, ll. 42-43 ("... and a streamer cable controller 16 for controlling the streamer positioning devices 14"). *See* also, e.g., FIG. 2 *See, e.g.*, Workman '472 at Col. 3, ll. 59-62 ("... includes a streamer control processor 40 for ... calculating a position correction to reposition the streamer cables 13") *See, e.g.*, Workman '472 at Col. 4, ll. 17-21 "The streamer control processor 40 is connected to the streamer device controller 16. When the streamer cables 13 need to be repositioned, the position correction is used by the streamer device controller 16 to adjust the streamer positioning devices 14 and reposition the streamer cables 13." This claim limitation "calculate desired changes in position of one or more of the streamer positioning devices" is also an inherent aspect of the invention. Given "predicted positions," it is inherently necessary that "desired changes in position" for the streamer positioning devices must be calculated to be able to implement any change in streamer position or motion whatsoever.
(d) implementing at least some of the desired changes.	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 1, ll. 55-57 ("For example, devices to control the lateral positioning of streamer cables by using camber-adjustable hydrofoils or angled wings are disclosed ...") This claim limitation "actuating the wing motors to produce said desired changes in wing orientation" is also an inherent aspect of the invention. Given a desire to reposition the streamers, it is inherently necessary that the "wing orientation" for the streamer positioning devices will need to be altered, which inherently requires the action of a motor.

U.S. Patent No. 7,080,607 Asserted Claims	Citations from prior-art
8. A method as claimed in claim 7, in which said global control system is further configured into a streamer separation mode, wherein said global control system attempts to direct said streamer positioning device to maintain a minimum separation distance between adjacent streamers.	The Workman '472 patent discloses this limitation of streamer separation mode. *See, e.g.*, Workman '472, Col. 1, ll. 33-35 ("The ability to control the position and shape of the streamer cables is desirable for preventing the entanglement of the streamer cables …"). *See, e.g.*, Workman '472, Col. 3, ll. 65-67 (Threshold parameters may include a plurality of values for: minimum allowable separations between streamer cables …").
15. An array of seismic streamers towed by a towing vessel comprising:	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 1, ll. 17-19 ("Due to the increasing use of marine 3-D seismic data, multi-cable marine surveys are now commonplace") *See, e.g.*, FIG. 1 which discloses a towing vessel.
(a) a plurality of streamer positioning devices on or inline with each streamer;	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 2, ll. 32-33 ("… the prior art discloses a series of discrete devices for locating and controlling the positions of streamer cables ...") and Col. 2, ll. 45-47 ("The present invention is an improved system for controlling the position and shape of marine seismic streamer cables"). *See, e.g.*, Workman '472 at Col. 1, l. 45 ("Streamer positioning devices are well known in the art") *See, e.g.*, Workman '472 at Col. 3, ll. 14-20 ("As known to those skilled in the art, streamer positioning devices 14, for example birds and tail buoys, may be attached to the exterior of the streamer cables 13 for adjusting the vertical and lateral positions of the streamer cables 13. The streamer cables 13 include electrical or optical cables for connecting the streamer positioning devices 14 to individual control and logging systems").

U.S. Patent No. 7,080,607 Asserted Claims	**Citations from prior-art**
(b) a prediction unit adapted to predict positions of at least some of the streamer positioning devices; and	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 2, ll. 15-18 ("These devices and methods may then be used to determine the real time position of the seismic sources and seismic streamer cables by computing a network solution to a Kalman filter, as disclosed by U.S. Pat. No. 5,353,223") *[prediction is a fundamental aspect of Kalman filtering technology]. [annotation added]*
(c) a control unit adapted to use the predicted positions to calculate desired changes in positions of one or more of the streamer positioning devices.	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 3, ll. 42-43 ("... and a streamer cable controller 16 for controlling the streamer positioning devices 14"). *See* also, e.g., FIG. 2 *See, e.g.*, Workman '472 at Col. 3, ll. 59-62 ("... includes a streamer control processor 40 for ... calculating a position correction to reposition the streamer cables 13") *See, e.g.*, Workman '472 at Col. 4, ll. 17-21 "The streamer control processor 40 is connected to the streamer device controller 16. When the streamer cables 13 need to be repositioned, the position correction is used by the streamer device controller 16 to adjust the streamer positioning devices 14 and reposition the streamer cables 13." This claim limitation "calculate desired changes in position of one or more of the streamer positioning devices" is also an inherent aspect of the invention. Given "predicted positions," it is inherently necessary that "desired changes in position" for the streamer positioning devices must be calculated to be able to implement any change in streamer position or motion whatsoever.

EXHIBIT 4

EXHIBIT 4

U.S. Patent No. 7,162,967 (the "967 patent") Is Anticipated By
U.S. Patent 5,200,930 (Rouquette, '930)

U.S. Patent No. 7,162,967 Asserted Claims	Citations from prior-art
1. A method comprising: (a) towing an array of streamers each having a plurality of streamer positioning devices there along, at least one of the streamer positioning devices having a wing;	U.S. Patent 5,200,930 (Two-Wire Multi-Channel Streamer Communication System; Rouquette; assigned to The Laitram Corp.; issued 1993) discloses this limitation. *See, e.g.,* Rouquette '930 at Col. 1, ll. 13-17 ("In a marine seismic survey, a surveying vessel tows one or more seismic cables or streamers. Each streamer is outfitted with … position control devices … such as cable leveling birds …") *See, e.g.,* Rouquette '930, Col. 2, ll. 49-52 ("FIG. 1 is side view of a seismic surveying vessel towing a streamer outfitted with sensing and streamer control devices in communication with a controller aboard the vessel in accordance with the invention") *See, e.g.,* Rouquette '930 at FIG. 1 which depicts wings on birds.
(b) transmitting from a global control system location information to at least one local control system on the at least one streamer positioning devices having a wing; and	The Rouquette '930 patent discloses this limitation. *See, e.g.,* Rouquette '930 patent, FIG. 2 *See, e.g.,* Rouquette '930, Col. 3, ll. 23-31 ("These and other objects are achieved by the present invention, which provides a multi-channel, two-wire communication system for sending commands and data requests to and receiving data [f]rom many positioning sensors and cable-leveling devices distributed along a seismic streamer. The apparatus of the invention includes a central controller comprising an intelligent modem that can scan the many streamer devices for cable-positioning data each seismic shot interval."). *See, e.g.,* Rouquette '930, Col. 4, ll. 6-11 ("Distributed along the length of the streamer 22 are … outboard devices, such as cable leveling birds 26A-B … For brevity, all such devices are hereinafter referred to generally as sensors"); Col. 4, ll. 16-18 ("The sensors 24, 26, and 28 are all in communication with a

U.S. Patent No. 7,162,967 Asserted Claims	Citations from prior-art
	central controller 38 on board the vessel 20."); Col. 4, ll. 34-36 ("Communication between the sensors and the on-board controller is effected over one or more two-wire lines running through the streamer …"); Col. 4, ll. 39-41 ("An outboard bird 44, clamped to the streamer 40 by a collar (not shown), communicates with the on-board controller …")
(c) adjusting the wing using the local control system.	The Rouquette '930 patent discloses this limitation. Col. 4, ll. 45-47 ("Control signals are received by the bird electronics 50 to control the wings of the bird and, thereby, the depth of the streamer.").
4. The method as claimed in claim 1, wherein the global control system transmits a desired vertical depth for the at least one streamer positioning device and the local control system calculates magnitude and direction of the deviation between the desired vertical depth and actual depth.	The Roqutte '930 patent discloses this limitation *See, e.g.*, Rouquette at Col. 4, ll. 34-47 ("a bird 26 can also communicate heading and depth data to the on-board controller 38 for use in predicting the shape of the streamer … Communication between the sensors and the on-board controller is effected over one or more two-wire lines running through the streamer … Control signals are received by the bird electronics 50 to control the wings of the bird and, thereby, the depth of the streamer.") A Person Having Ordinary Skill In The Art will recognize that it is inherent in the invention to utilize a "desired vertical depth" as a necessary component of any attempt to control depth. It is inherent to "calculate magnitude and direction of the deviation between the desired vertical depth and the actual depth" as a necessary step in any attempt to control depth.
15. An array of seismic streamers towed by a towing vessel comprising:	Rouquette '930 discloses this claim preamble. *See, e.g.*, Rouquette '930 at Col. 1, ll. 13-17 ("In a marine seismic survey, a surveying vessel tows one or more seismic cables or streamers. Each streamer is outfitted with … position control devices … such as cable leveling birds …")

U.S. Patent No. 7,162,967 Asserted Claims	Citations from prior-art
(a) a plurality of streamer positioning devices on or inline with each streamer, at least one of the streamer positioning devices having a wing;	Rouquette '930 discloses this claim preamble. *See, e.g.*, Rouquette '930 at Col. 1, ll. 13-17 ("In a marine seismic survey, a surveying vessel tows one or more seismic cables or streamers. Each streamer is outfitted with … position control devices … such as cable leveling birds …") *See, e.g.*, Rouquette '930, Col. 2, ll. 49-52 ("FIG. 1 is side view of a seismic surveying vessel towing a streamer outfitted with sensing and streamer control devices in communication with a controller aboard the vessel in accordance with the invention") *See, e.g.*, Rouquette '930 at FIG. 1 which depicts wings on birds.
(b) a global control system transmitting location information to at least one local control system on the at least one streamer positioning device having a wing, the local control system adjusting the wing.	The Rouquette '930 patent discloses this limitation. *See, e.g.*, Rouquette '930 patent, FIG. 2 *See, e.g.*, Rouquette '930, Col. 3, ll. 23-31 ("These and other objects are achieved by the present invention, which provides a multi-channel, two-wire communication system for sending commands and data requests to and receiving data [f]rom many positioning sensors and cable-leveling devices distributed along a seismic streamer. The apparatus of the invention includes a central controller comprising an intelligent modem that can scan the many streamer devices for cable-positioning data each seismic shot interval."). *See, e.g.*, Rouquette '930, Col. 4, ll. 6-11 ("Distributed along the length of the streamer 22 are … outboard devices, such as cable leveling birds 26A-B … For brevity, all such devices are hereinafter referred to generally as sensors"); Col. 4, ll. 16-18 ("The sensors 24, 26, and 28 are all in communication with a central controller 38 on board the vessel 20."); Col. 4, ll. 34-36 ("Communication between the sensors and the on-board controller is effected over one or more two-wire lines running through the streamer …"); Col. 4, ll. 39-41 ("An outboard bird 44, clamped to the streamer 40 by a collar (not shown), communicates with the on-board controller …") *See, e.g.*, Rouquette '930, Col. 4, ll. 45-47 ("Control signals are received by the bird electronics 50 to control the wings of the bird and, thereby, the depth of the streamer.").

EXHIBIT 5

EXHIBIT 6

35 USC § 102(f) Prior Art

This chart identifies the claims for which ION claims inventorship. Such prior art includes ION's proprietary positioning devices, which were disclosed to WesternGeco during the mid-1990s discussions and meetings pursuant to a nondisclosure agreement. Evidence of such invention is found in ION's disclosures pursuant to Patent Rule 3-2(a)(1)-(2).

U.S. Patent No. 6,932,017 (the "'017 patent")

U.S. Patent No. 6,932,017 Asserted Claims	§ 102(f) Prior Art
1. A method of controlling the positions of marine seismic streamers in an array of such streamers being towed by a seismic survey vessel, the streamers having respective streamer positioning devices disposed therealong and each streamer positioning device having a wing and a wing motor for changing the orientation of the wing so as to steer the streamer positioning device laterally, said method comprising the steps of:	DigiCOURSE, a company later acquired by ION, was approached by GECO—and more specifically, Simon Bittleston (an inventor of the '017 patent)—to develop a proprietary streamer positioning device that, among other things, could control both the lateral and vertical position of a streamer as claimed herein. Accordingly, the DigiCOURSE engineers who developed this streamer positioning device are the true inventors, or at least co-inventors, of the invention claimed herein.
obtaining a predicted position of the streamer positioning devices;	
obtaining an estimated velocity of the streamer positioning devices;	
for at least some of the streamer positioning devices, calculating desired changes in the orientation of their wings using said predicted position and said estimated velocity;	
and actuating the wing motors to produce said desired changes in wing orientation.	

1725677v1

U.S. Patent No. 6,932,017 **Asserted Claims**	**§ 102(f) Prior Art**
2. A method as claimed in claim 1, wherein said estimated velocity is calculated using a vessel speed received from said seismic survey vessel's navigation system.	*See* Claim 1 Analysis.
3. A method as claimed in claim 2, in which said estimated velocity is a water referenced towing velocity that compensates for the speed and heading of marine currents acting on said streamer positioning devices.	*See* Claim 1 Analysis.
4. A method as claimed in claim 3, in which said estimated velocity is compensated for relative movement between said seismic survey vessel and said streamer positioning devices.	*See* Claim 1 Analysis.
5. A method as claimed in claim 4, in which said step of calculating a desired change in wing orientation further uses an estimate of the crosscurrent velocity at the respective streamer positioning device.	*See* Claim 1 Analysis.
6. A method as claimed in claim 5, in which said step of calculating a desired change in wing orientation is regulated to prevent the wing from stalling.	*See* Claim 1 Analysis.

EXHIBIT 6

U.S. Patent No. 6,932,017 Asserted Claims	§ 102(f) Prior Art
7. A method as claimed in claim 6, in which said step of calculating a desired change in wing orientation is regulated by a global control system located on or near said seismic survey vessel that is configured into a feather angle mode, wherein said global control system attempts to direct the streamer positioning devices to maintain each of said streamers in a straight line offset from the towing direction of said marine seismic vessel by a certain feather angle, and into a turn control mode, wherein said global control system directs said streamer positioning devices to generate a force in the opposite direction of a turn at the beginning of the turn.	*See* Claim 1 Analysis.
8. A method as claimed in claim 7, in which said global control system is further configured into a streamer separation mode, wherein said global control system attempts to direct said streamer positioning device to maintain a minimum separation distance between adjacent streamers	*See* Claim 1 Analysis.
9. A method as claimed in claim 8, further including the step of displaying the position of said streamer positioning devices on said seismic survey vessel.	*See* Claim 1 Analysis.
16. Apparatus for controlling the positions of marine seismic streamer in an array of such streamers being towed by a seismic survey vessel, the streamers having respective streamer positioning devices disposed therealong and each streamer positioning device having a	*See* Claim 1 Analysis.

U.S. Patent No. 6,932,017 Asserted Claims	§ 102(f) Prior Art
wing and a wing motor for changing the horizontal orientation of the wing so as to steer the streamer positioning device laterally, said apparatus comprising:	
means for obtaining a predicted position of the streamer positioning devices;	
means for obtaining an estimated velocity of the streamer positioning devices,	
means for calculating desired changes in the orientations of the respective wings of at least some of the streamer positioning devices using said predicted position and said estimated velocity;	
and means for actuating the wing motors to produce said desired changes in wing orientation.	

EXHIBIT 6

U.S. Patent No. 6,691,607 (the "'607 patent")

U.S. Patent No. 6,691,607 Asserted Claims	**§ 102(f) Prior Art**
1. A method comprising: (a) towing an a array of streamers each having a plurality of streamer positioning devices there along;	DigiCOURSE, a company later acquired by ION, was approached by GECO—and more specifically, Simon Bittleston (an inventor of the '017 patent)—to develop a proprietary streamer positioning device that, among other things, could control both the lateral and vertical position of a streamer as claimed herein. Accordingly, the DigiCOURSE engineers who developed this streamer positioning device are the true inventors, or at least co-inventors, of the invention claimed herein.
(b) predicting positions of at least some of the streamer positioning devices;	
(c) using the predicted positions to calculate desired changes in position of one or more of the streamer positioning devices; and	
(d) implementing at least some of the desired changes.	
2. A method as claimed in claim 1, comprising estimating velocity of at least some of the streamer positioning devices, wherein said estimated velocity is calculated using a vessel speed received from a navigation system on said seismic survey vessel.	*See* Claim 1 Analysis.
3. A method as claimed in claim 2, in which said estimated velocity is a water referenced towing velocity that compensates for the speed and heading of marine currents acting on said streamer positioning devices.	*See* Claim 1 Analysis.

1725677v1

U.S. Patent No. 6,691,607 Asserted Claims	§ 102(f) Prior Art
4. A method as claimed in claim 3, in which said estimated velocity is compensated for relative movement between said seismic survey vessel and said streamer positioning devices.	*See* Claim 1 Analysis.
5. A method as claimed in claim 2, in which said step of using the predicted positions to calculate desired changes in position of one or more of the streamer positioning devices further uses an estimate of the crosscurrent velocity at the respective streamer positioning device.	*See* Claim 1 Analysis.
6. A method as claimed in claim 5, in which said step of using the predicted positions to calculate desired changes in position of one or more of the streamer positioning devices is regulated to prevent the positioning device from stalling.	*See* Claim 1 Analysis.
7. A method as claimed in claim 6, in which said step of using the predicted positions to calculate desired changes in position of one or more of the streamer positioning devices is regulated by a global control system located on or near a seismic survey vessel that is configured into a feather angle mode, wherein said global control system attempts to direct the streamer positioning devices to maintain each of said streamers in a straight line offset from the towing direction of said marine seismic vessel by a certain feather angle, and into a turn control mode, wherein said global control	*See* Claim 1 Analysis.

U.S. Patent No. 6,691,607 Asserted Claims	§ 102(f) Prior Art
system directs said streamer positioning devices to generate a force in the opposite direction of a turn at the beginning of the turn.	
8. A method as claimed in claim 7, in which said global control system is further configured into a streamer separation mode, wherein said global control system attempts to direct said streamer positioning device to maintain a minimum separation distance between adjacent streamers.	*See* Claim 1 Analysis.
9. A method as claimed in claim 8, further including the step of displaying the position of said streamer positioning devices on said seismic survey vessel.	*See* Claim 1 Analysis.
15. An array of seismic streamers towed by a towing vessel comprising:	DigiCOURSE, a company later acquired by ION, was approached by GECO—and more specifically, Simon Bittleston (an inventor of the '017 patent)—to develop a proprietary streamer positioning device that, among other things, could control both the lateral and vertical position of a streamer as claimed herein. Accordingly, the DigiCOURSE engineers who developed this streamer positioning device are the true inventors, or at least co-inventors, of the invention claimed herein.
(a) a plurality of streamer positioning devices on or inline with each streamer;	The '607 patent discloses that this limitation was well known to one skilled in the art prior to and at the time of invention. *See, e.g.*, '607 patent, Col. 1, ll. 10-23 (discussing the known prior art including a vessel for towing an array of seismic streamers that have a plurality of positioning devices). *See, e.g.*, '607, Fig. 1.

U.S. Patent No. 6,691,607 Asserted Claims	**§ 102(f) Prior Art**
(b) a prediction unit adapted to predict positions of at least some of the streamer positioning devices; and	
(c) a control unit adapted to use the predicted positions to calculate desired changes in positions of one or more of the streamer positioning devices.	

EXHIBIT 6

U.S. Patent No. 7,162,967 (the "967 patent")

U.S. Patent No. 7,162,967 Asserted Claims	**§ 102(f) Prior Art**
1. A method comprising: (a) towing an array of streamers each having a plurality of streamer positioning devices there along, at least one of the streamer positioning devices having a wing;	DigiCOURSE, a company later acquired by ION, was approached by GECO—and more specifically, Simon Bittleston (an inventor of the '017 patent)—to develop a proprietary streamer positioning device that, among other things, could control both the lateral and vertical position of a streamer as claimed herein. Accordingly, the DigiCOURSE engineers who developed this streamer positioning device are the true inventors, or at least co-inventors, of the invention claimed herein.
(b) transmitting from a global control system location information to at least one local control system on the at least one streamer positioning devices having a wing; and	
(c) adjusting the wing using the local control system.	
4. The method as claimed in claim 1, wherein the global control system transmits a desired vertical depth for the at least one streamer positioning device and the local control system calculates magnitude and direction of the deviation between the desired vertical depth and actual depth.	*See* Claim 1 Analysis.
5. The method as claimed in claim 1, wherein the global control system transmits a desired horizontal displacement for the at least one streamer positioning device and the local control system calculates magnitude and direction of the deviation between the desired horizontal displacement and	*See* Claim 1 Analysis.

U.S. Patent No. 7,162,967 Asserted Claims	§ 102(f) Prior Art
actual horizontal displacement.	
6. The method as claimed in claim 1, comprising calculating velocity of at least one of the streamer positioning devices, wherein the calculating velocity comprises at least one of a) using a vessel speed received from a navigation system on a seismic survey vessel; b) compensating for the speed and heading of marine currents acting on the at least one streamer positioning device; and c) compensating for relative movement between the seismic survey vessel and the at least one streamer positioning device.	*See* Claim 1 Analysis.
7. The method as claimed in claim 6, in which said step of adjusting the wing using the local control system is regulated to prevent the positioning device from stalling.	*See* Claim 1 Analysis.
8. The method as claimed in claim 7, in which said step of using the location information to calculate desired forces on the at least one streamer positioning device is regulated by the global control system located on or near a seismic survey vessel that is configured into a feather angle mode, wherein the global control system attempts to direct the streamer positioning devices to maintain each of the streamers in a straight line offset from the towing direction of the marine seismic vessel by a certain feather	*See* Claim 1 Analysis.

U.S. Patent No. 7,162,967 Asserted Claims	§ 102(f) Prior Art
angle, and into a turn control mode, wherein the global control system directs the streamer positioning devices to generate a force in the opposite direction of a turn at the beginning of the turn.	
9. The method as claimed in claim 8, which said global control system is further configured into a streamer separation mode, wherein said global control system attempts to direct said streamer positioning device to maintain a minimum separation distance between adjacent streamers.	*See* Claim 1 Analysis.
10. The method as claimed in claim 9, further including the step of displaying the position of said streamer positioning devices on said seismic survey vessel.	*See* Claim 1 Analysis.
15. An array of seismic streamers towed by a towing vessel comprising:	The '967 patent discloses that this limitation was well known to one skilled in the art prior to and at the time of invention. *See, e.g.*, '967 patent, Col. 1, ll. 10-23 (discussing the known prior art including a vessel for towing an array of seismic streamers that have a plurality of positioning devices). *See, e.g.*, '967, Fig. 1.
(a) a plurality of streamer positioning devices on or inline with each streamer, at least one of the streamer positioning devices having a wing;	DigiCOURSE, a company later acquired by ION, was approached by GECO—and more specifically, Simon Bittleston (an inventor of the '017 patent)—to develop a proprietary streamer positioning device that, among other things, could control both the lateral and vertical position of a streamer as claimed herein. Accordingly, the DigiCOURSE engineers who developed this streamer positioning device are the true

U.S. Patent No. 7,162,967 Asserted Claims	§ 102(f) Prior Art
	inventors, or at least co-inventors, of the invention claimed herein.
(b) a global control system transmitting location information to at least one local control system on the at least one streamer positioning device having a wing, the local control system adjusting the wing.	

EXHIBIT 6

U.S. Patent No. 7,293,520 (the "'520 patent")

U.S. Patent No. 7,293,520 Asserted Claims	**§ 102(f) Prior Art**
1. A method comprising: (a) towing an array of streamers each having a plurality of streamer positioning devices there along contributing to steering the streamers;	DigiCOURSE, a company later acquired by ION, was approached by GECO—and more specifically, Simon Bittleston (an inventor of the '017 patent)—to develop a proprietary streamer positioning device that, among other things, could control both the lateral and vertical position of a streamer as claimed herein. Accordingly, the DigiCOURSE engineers who developed this streamer positioning device are the true inventors, or at least co-inventors, of the invention claimed herein.
(b) controlling the streamer positioning devices with a control system configured to operate in one or more control modes selected from a feather angle mode, a turn control mode, and a streamer separation mode.	
2. The method of claim 1 wherein the control mode is the feather angle mode, and the controlling comprises the control system attempting to keep each streamer in a straight line offset from a towing direction by a feather angle.	*See* Claim 1 Analysis.
3. The method of claim 2 comprising inputting the feather angle manually.	*See* Claim 1 Analysis.
6. The method of claim 1 wherein the towing comprises ending one pass, turning a towing vessel having the streamers attached thereto while throwing out the streamers before beginning another pass, with the control mode in the turn control mode during the turning and throwing out.	*See* Claim 1 Analysis.

1725677v1

U.S. Patent No. 7,293,520 Asserted Claims	§ 102(f) Prior Art
7. The method of claim 6 comprising turning during a 3D seismic survey.	*See* Claim 1 Analysis.
8. The method of claim 6 comprising turning during a line change.	*See* Claim 1 Analysis.
9. The method of claim 6 comprising commanding each streamer positioning device to generate a force in an opposite direction of the turning,	*See* Claim 1 Analysis.
10. The method of claim 6 comprising separating adjacent streamers by depth during the turning mode to avoid possible entanglement during the turning.	*See* Claim 1 Analysis.
11. The method of claim 10 comprising returning adjacent streamers to a common depth after the completion of the turning.	*See* Claim 1 Analysis.
12. The method of claim 6 comprising notifying the control system, via a vessel navigation system, when to start throwing the streamers out, and when to start straightening the streamers.	*See* Claim 1 Analysis.
13. The method of claim 1 wherein the control mode is the streamer separation mode, the control system attempting to minimize the risk of entanglement of the streamers.	*See* Claim 1 Analysis.

U.S. Patent No. 7,293,520 Asserted Claims	§ 102(f) Prior Art
14. The method of claim 13 comprising the control system attempting to maximize distance between adjacent streamers.	*See* Claim 1 Analysis.
15. The method of claim 13 comprising separating the streamers in depth.	*See* Claim 1 Analysis.
16. The method of claim 15 wherein the array of streamers comprises two streamers, and comprising positioning the two streamers as far away from each other as possible.	*See* Claim 1 Analysis.
17. The method of claim 15 wherein the array of streamers comprises three or more streamers, the array comprising one port-most streamer, one starboard-most streamer and at least one inner streamer and comprising positioning the port-most and starboard-most streamers as far away form each other as possible.	*See* Claim 1 Analysis.
18. An apparatus comprising: (a) an array of streamers each having a plurality of streamer positioning devices there along;	*See* Claim 1 Analysis.
(b) a control system configured to use a control mode selected from a feather angle mode, a turn control mode, a streamer separation mode, and two or more of these modes.	

U.S. Patent No. 7,293,520 Asserted Claims	§ 102(f) Prior Art
19. The apparatus of claim 18 wherein the control mode is the feather angle mode, and the controlling comprises the control system attempting to keep each streamer in a straight line offset from a towing direction by a feather angle.	*See* Claim 1 Analysis.
20. The apparatus of claim 19 comprising inputting the feather angle manually.	*See* Claim 1 Analysis.
23. The apparatus of claim 18 wherein the towing comprises ending one pass, turning a towing vessel having the streamers attached thereto while throwing out the streamers before beginning another pass, with the control mode in the turn control mode during the turning and throwing out.	*See* Claim 1 Analysis.
24. The apparatus of claim 23 comprising turning during a 3D seismic survey.	*See* Claim 1 Analysis.
25. The apparatus of claim 23 comprising turning during a line change.	*See* Claim 1 Analysis.
26. The apparatus of claim 23 comprising commanding each streamer positioning device to generate a force in an opposite direction of the turning, and then commanding each streamer positioning device to go to a position defined by the feather angle control mode.	*See* Claim 1 Analysis.

U.S. Patent No. 7,293,520 Asserted Claims	**§ 102(f) Prior Art**
27. The apparatus of claim 23 comprising separating adjacent streamers by depth during the turning mode to avoid possible entanglement during the turning.	*See* Claim 1 Analysis.
28. The apparatus of claim 27 comprising returning adjacent streamers to a common depth after the completion of the turning.	*See* Claim 1 Analysis.
29. The apparatus of claim 23 comprising notifying the control system, via a vessel navigation system, when to start throwing the streamers out, and when to start straightening the streamers.	*See* Claim 1 Analysis.
30. The apparatus of claim 18 wherein the control mode is the streamer separation mode, the control system attempting to minimize the risk of entanglement of the streamers.	*See* Claim 1 Analysis.
31. The apparatus of claim 30 comprising the control system attempting to maximize distance between adjacent streamers.	*See* Claim 1 Analysis.
32. The apparatus of claim 30 comprising separating the streamers in depth.	*See* Claim 1 Analysis.
33. The apparatus of claim 32 wherein the array of streamers comprises two streamers, and comprising positioning the two streamers as far away	*See* Claim 1 Analysis.

U.S. Patent No. 7,293,520 Asserted Claims	§ 102(f) Prior Art
from each other as possible.	
34. The apparatus of claim 32 wherein the array of streamers comprises three or more streamers, the array comprising one port-most streamer, one starboard-most streamer and at least one inner streamer and comprising positioning the port-most and starboard-most streamers as far away from each other as possible.	*See* Claim 1 Analysis.

EXHIBIT 6

EXHIBIT 6

U.S. Patent No. 6,691,038 (the "Zajac '038 patent") Is Obvious In View of International Patent Application WO 2000/20895 ("Hillesund '895 Application")

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
1. A seismic streamer array tracking and positioning system comprising:	The Hillesund WO 00/20895 International Application discloses this limitation. *See, e.g.*, Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.*, Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention".
a towing vessel for towing a seismic array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers ...").
an array comprising a plurality of seismic streamers;	The Hillesund '895 reference discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers ...").
an active streamer positioning device (ASPD) attached to at least one seismic streamer for positioning the seismic streamer relative to other seismic streamers within the array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to 'relative' positioning of streamers ("The inventive control system will primarily operate

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle … . The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change". The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn …. In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers."). The '038 patent discloses that this limitation was well known to one skilled in the art prior to and at the time of the invention. *See, e.g.*, '038 patent, Col. 1, ll. 25-56 (discussing the known prior art including attaching control apparatuses to seismic streamers to position streamers).
and a master controller for issuing positioning commands to each ASPD to adjust a vertical and horizontal position of a first streamer relative to a second streamer within the array for maintaining a specified array geometry.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("In the preferred embodiment of the present invention, the control system for the birds 18 is distributed between a global control system 22 located on or near the seismic survey vessel 10 and a local control system located within or near the birds 18. The global

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	control system 22 is typically connected to the seismic survey vessel's navigation system and obtains estimates of system wide parameters, such as the vessel's towing direction and velocity and current direction and velocity, from the vessel's navigation system."). *See, e.g.*, Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global control system 22 preferably transmits, at regular intervals (such as every five seconds) a desired horizontal force 42 and a desired vertical force 44 to the local control system 36."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2; particularly in regard to the limitation of "specified array geometry" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	as possible after the completion of the turn .... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers.").
2. The apparatus of claim 1 further comprising: an environmental sensor for sensing environmental factors which influence the path of the towed array.	The Hillesund '895 application discloses this limitation. *See* Claim 1 Analysis. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers.") *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The "water-referenced" towing velocity and crosscurrent velocity could alternatively be determined using flowmeters or other types of water velocity sensors attached directly to the birds 18. Although these types of sensors are typically quite expensive, one advantage of this type of velocity determination system is that the sensed in-line and cross-line velocities will be inherently compensated for the speed and heading of marine currents acting on said streamer positioning device and for relative movements

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	between the vessel 10 and the bird 18.").
3. The apparatus of claim 1 further comprising:	The Hillesund '895 application discloses this limitation. See Claim 1 Analysis.
a tracking system for tracking the streamer positions versus time during a seismic data acquisition run and storing the positions versus time in a legacy database for repeating the positions versus time in a subsequent data acquisition;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 7, Paragraph 1 ("In the preferred embodiment of the present invention, the global control system 22 monitors the actual positions of each of the birds 18 and is programmed with the desired positions of or the desired minimum separations between the seismic streamers 12."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system.") Persons Having Ordinary Skill In The Art at the time of invention would have recognized that tracking streamer positions and storing the positions in a legacy database, including the times during acquisition, was obvious and had been in widespread industry standard practice since the late 1980's. Industry standards (such as the so-called UKOOA navigation database standards) have existed and been used since the early 1990's. It is also obvious to a Person Having Ordinary Skill In The Art that streamer positions in such a database can be repeatedly utilized.

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
and an array geometry tracking system for tracking the array geometry versus time during a seismic data acquisition run and storing the array geometry versus time in a legacy database for repeating the array geometry versus time in a subsequent data acquisition run.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle. The feather could be input either manually, through use of a current meter, or through use of an estimated value based on the average horizontal bird forces. Only when the crosscurrent velocity is very small will the feather angle be set to zero and the desired streamer positions be in precise alignment with the towing direction. The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn. The vessel navigation system will typically notify the global control system 22 when to start throwing the streamers 12 out, and when to start straightening the streamers. In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers."). Persons Having Ordinary Skill In The Art at the time of invention would have recognized that tracking the array geometry and storing the array geometry in a legacy database, including the times during acquisition, was obvious and had been in widespread industry standard practice since the late 1980's. Industry standards (such as the so-called UKOOA navigation database standards) have existed and been used since the early 1990's. It is also obvious to a Person Having Ordinary Skill In The Art that the array geometry in such a database can be repeatedly utilized.
4. The apparatus of claim 3 wherein the master controller compares the positions of the streamers versus time and the array geometry versus time to a desired streamer position and array geometry versus time and issues positioning commands to the ASPDs to maintain the desired streamer position and array geometry versus time.	The Hillesund '895 application discloses this limitation. *See* Claim 3 Analysis. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 located on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required.").

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
5. The apparatus of claim 4 wherein the master controller factors in environmental factors into the positioning commands to compensate for environmental influences on the positioning of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See* Claim 4 Analysis. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").
6. The apparatus of claim 4 wherein the master controller compensates for maneuverability in the positioning commands to compensate for maneuverability influences on the positioning of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See* Claim 4 Analysis. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system."). At the time of the invention it was obvious to a Person Having Ordinary Skill In The Art at the time of the invention that to "compensate for maneuverability influences" it would be necessary to take into account various maneuverability factors,

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application
	including, but not necessarily limited to, cable diameter, array type, deployed configuration, vessel type, device type, etc. which are part of the basis for the behavior of the streamers. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system.").
10. The apparatus of claim 1 wherein the array geometry comprises a plurality of streamers positioned at a uniform depth.	The Hillesund '895 application discloses this limitation. *See* Claim 1 Analysis. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") Persons Having Ordinary Skill in The Art will recognize that deploying 'a plurality of streamers at a uniform depth' has been the most obvious and common industry practice since the 1980's.

11. The apparatus of claim 1 wherein the array geometry comprises a plurality of streamers positioned at a plurality of depths for varying temporal resolution of the array.	The Hillesund '895 application discloses this limitation. *See* Claim 1 Analysis. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") *See, e.g.*, Hillesund '895 at p. 19, Paragraph 2 ("In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the

	global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible") Persons Having Ordinary Skill in The Art will recognize that deploying 'a plurality of streamers positioned at a plurality of depths' has been obvious and has been selectively utilized in industry practice since the 1980's. In addition to other industry practitioners, a predecessor company of WesternGeco utilized so-called "over-under" streamer acquisition selectively since before the priority date for the '038 patent.
13. The apparatus of claim 4 wherein the array geometry is tracked via satellite and communicated to the master controller.	The Hillesund '895 application discloses this limitation. *See* Claim 4 Analysis. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("The global control system 22 is typically connected to the seismic survey vessel's navigation system and obtains estimates of system wide parameters, such as the vessel's towing direction and velocity and current direction and velocity, from the vessel's navigation system."). *See, e.g.*, Hillesund '895 at p. 7, Paragraph 1 ("Alternatively, or additionally, satellite-based global positioning system equipment can be used to determine the positions of the equipment.").
14. A seismic streamer array tracking and positioning system comprising:	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.*, Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention".
a towing vessel for towing a seismic array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers ...").

a seismic streamer array comprising a plurality of seismic streamers; an active streamer positioning device (ASPD) attached to each seismic streamer for positioning each seismic streamer;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …"). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.")
a master controller for issuing vertical and horizontal positioning commands to each ASPD for maintaining a specified array geometry;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("In the preferred embodiment of the present invention, the control system for the birds 18 is distributed between a global control system 22 located on or near the seismic survey vessel 10 and a local control system located within or near the birds 18. The global control system 22 is typically connected to the seismic survey vessel's navigation system and obtains estimates of system wide parameters, such as the vessel's towing direction and velocity and current direction and velocity, from the vessel's navigation system."). *See, e.g.*, Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global control system 22 preferably transmits, at regular intervals (such as every five seconds) a desired horizontal force 42 and a desired vertical force 44 to the local control system 36."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. …"). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2; particularly in regard to the limitation of "specified array geometry" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line

	offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change". ... Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn .... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. ...")
an environmental sensor for sensing environmental factors which influence the towed path of the towed array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers.") *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically *acquire* the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. ...") *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The "water-referenced" towing velocity and crosscurrent velocity could alternatively be determined using flowmeters or other types of water velocity sensors attached directly to the birds 18. Although these types of sensors are typically quite expensive, one advantage of this type of velocity determination system is that the sensed in-line and cross-line velocities will be inherently compensated for the speed and heading of marine currents acting on said streamer positioning device and for relative movements between the vessel 10 and the bird 18.").
a tracking system for tracking the streamer horizontal and vertical positions versus time during a seismic data acquisition run;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers

	12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 7, Paragraph 1 ("In the preferred embodiment of the present invention, the global control system 22 monitors the actual positions of each of the birds ..."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system.")
an array geometry tracking system for tracking the array geometry versus time during a seismic data acquisition run, wherein the master controller compares the vertical and horizontal positions of the streamers versus time and the array geometry versus time to desired streamer positions and array geometry versus time and issues positioning commands to the ASPDs to maintain the desired streamer positions and array geometry versus time.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to the limitation of "maintain the desired streamer positions and array geometry versus time." ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. ... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers ...").

15. The apparatus of claim 14 wherein the master controller factors in environmental measurements into the positioning commands to compensate for environmental influences on the positions of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See* Claim 14 Analysis. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").
16. The apparatus of claim 14 wherein the master controller compensates for maneuverability in the positioning commands to compensate for maneuverability influences on the positioning of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See* Claim 14 Analysis. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array."). A Person Having Ordinary Skill In The Art at the time of the invention would find this limitation to be inherent in the invention. To "compensate for maneuverability influences" it would be necessary to take into account various maneuverability factors, including, but not necessarily limited to, cable diameter, array type, deployed configuration, vessel type, device type, etc. which are part of the basis for the behavior of the streamers. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system.").

	At the time of the invention it was obvious to a Person Having Ordinary Skill In The Art at the time of the invention that to "compensate for maneuverability influences" it would be necessary to take into account various maneuverability factors, including, but not necessarily limited to, cable diameter, array type, deployed configuration, vessel type, device type, etc. which are part of the basis for the behavior of the streamers.
17. The apparatus of claim 14 further comprising: a monitor for determining the status of each streamer, wherein the master controller adjusts the array geometry to compensate for a failed streamer.	The Hillesund '895 application discloses this limitation. A Person Having Ordinary Skill In The Art will recognize that it was obvious common practice at the time of the invention to monitor the status of each streamer. They will also recognize that it was obvious common practice to compensate for failed streamers to the maximum extent that towing capabilities of a given vessel allowed.
20. A seismic streamer array tracking and positioning system comprising:	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.*, Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention."
a towing vessel for towing a seismic array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …").
a seismic streamer array comprising a plurality of seismic streamers;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …").

an active streamer positioning device (ASPD) attached to each seismic streamer for vertically and horizontally positioning each seismic streamer relative to the array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to the limitation of "positioning each seismic streamer relative to the array". ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change". The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode.... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth ..."). The '038 patent discloses that this limitation was well known to one skilled in the art prior to and at the time of the invention. *See, e.g.*, '038 patent, Col. 1, ll. 25-56 (discussing the known prior art including attaching control apparatuses to seismic streamers to position streamers).
and a master controller for issuing positioning commands to each ASPD for maintaining a specified array path.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("In the preferred embodiment of the present invention, the control system for the birds 18 is distributed between a global control system 22 located on or near the seismic survey vessel 10 and a local control system located within or near the birds ...").

	See, e.g., Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global control system 22 preferably transmits, at regular intervals (such as every five seconds) a desired horizontal force 42 and a desired vertical force 44 to the local control system 36."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2; particularly in regard to the limitation of "specified array path" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle … The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. … In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers.").

21. The apparatus of claim 20 wherein the master controller issues positioning commands to the towing vessel for maintaining a specified array path.	The Hillesund '895 application discloses this limitation. *See* Claim 20 Analysis. See, e.g., Hillesund '895 at p. 6, Paragraph 2 ("The global control system 22 is typically connected to the seismic survey vessel's navigation system and obtains estimates of system wide parameters, such as the vessel's towing direction and velocity and current direction and velocity, from the vessel's navigation system.") In addition, Persons Having Ordinary Skill In The Art will readily recognize that the seismic survey vessel's navigation system is typically utilized to steer the vessel in routine seismic acquisition operations ("auto-pilot").
22. The apparatus of claim 20 further comprising:	The Hillesund '895 application discloses this limitation. See Claim 20 Analysis.
a processor for calculating an optimal path for the seismic array for optimal coverage during seismic data acquisition over a seismic field;	The Hillesund '895 application discloses this limitation. *See* Claim 20 Analysis. *See, e.g.*, Hillesund '895, Fig 4. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices."). A Person Having Ordinary Skill In The Art will recognize that calculating an "optimal path for the seismic array for optimal coverage" has been obvious common commercial practice since before the priority date of the '038 patent. Commercial software for this calculation was available.
a streamer behavior prediction processor which predicts array behavior;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").

and wherein the master controller compensates for predicted streamer behavior in issuing vertical and horizontal positioning commands to the towing vessel and the ASPDs for positioning the array along the optimal path.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices."). At the time of the invention of the '038 patent, a Person Having Ordinary Skill In The Art would have found it obvious to position the array along the optimal path, using various technologies including neural-networks and behavior-predictive model based control logic.
23. The apparatus of claim 22 wherein the master controller compensates for environmental factors in the positioning commands.	The Hillesund '895 application discloses this limitation. *See* Claim 22 Analysis. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").
24. The apparatus of claim 23 wherein the master controller compensates for maneuverability factors in the positioning commands.	The Hillesund '895 application discloses this limitation. *See* Claim 23 Analysis. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array.").

	This limitation is inherent. It would be necessary to take into account some maneuverability factors such as cable diameter, array type, deployed configuration which are part of the basis for the behavior of the streamers to be able to implement the invention of Claim 23. *See, e.g.,* Hillesund '895 at p. 8, Paragraph 3 ("The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system."). At the time of the invention it was obvious to a Person Having Ordinary Skill In The Art at the time of the invention that to "compensate for maneuverability influences" it would be necessary to take into account various maneuverability factors, including, but not necessarily limited to, cable diameter, array type, deployed configuration, vessel type, device type, etc. which are part of the basis for the behavior of the streamers.
25. A seismic streamer array tracking and positioning system comprising:	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.,* Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention."
a towing vessel for towing a seismic array;	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …").
a seismic streamer array comprising a plurality of seismic streamers;	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …").
an active streamer positioning device (ASPD) attached to each seismic streamer for vertically and horizontally positioning each	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18

seismic streamer relative to the array;	may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") *See, e.g.,* Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to 'relative' positioning of streamers ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change". The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn .... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers."). The '038 patent discloses that this limitation was well known to one skilled in the art prior to and at the time of the invention. *See, e.g.,* '038 patent, Col. 1, ll. 25-56 (discussing the known prior art including attaching control apparatuses to seismic streamers to position streamers).

a master controller for issuing positioning commands to each ASPD and to the towing vessel for maintaining an optimal path, wherein the master controller further comprises a processor for calculating an optimal path for the seismic array for optimal coverage during seismic data acquisition over a seismic field, and a streamer behavior prediction processor which predicts array behavior, wherein the master controller compensates for predicted streamer behavior in issuing positioning commands to the towing vessel and the ASPDs for positioning the array along the optimal path, wherein the master controller compensates for environmental and maneuverability factors in the positioning commands.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("In the preferred embodiment of the present invention, the control system for the birds 18 is distributed between a global control system 22 located on or near the seismic survey vessel 10 and a local control system located within or near the birds 18. The global control system 22 is typically connected to the seismic survey vessel's navigation system and obtains estimates of system wide parameters, such as the vessel's towing direction and velocity and current direction and velocity, from the vessel's navigation system."). *See, e.g.*, Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global control system 22 preferably transmits, at regular intervals (such as every five seconds) a desired horizontal force 42 and a desired vertical force 44 to the local control system 36."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible

	entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn .... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers."). *See, e.g.,* Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.,* Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices."). *See, e.g.,* Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array."). A Person Having Ordinary Skill In The Art at the time of the '038 invention would have recognized that calculating an "optimal path for the seismic array for optimal coverage" was obvious common commercial practice. ION predecessor companies, among others, offered commercial software for this calculation at this time.

26. A method for tracking and positioning a seismic streamer array comprising:	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.*, Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention."
for towing a seismic array comprising a plurality of seismic streamers;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers ...").
attaching an active streamer positioning device (ASPD) each seismic streamer for positioning the seismic streamer relative to other seismic streamers within the array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to 'relative' positioning of streamers ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode

	adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn .... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers."). The '038 patent discloses that this limitation was well known to one skilled in the art prior to and at the time of the invention. *See, e.g.*, '038 patent, Col. 1, ll. 25-56 (discussing the known prior art including attaching control apparatuses to seismic streamers to position streamers).
and issuing vertical and horizontal positioning commands to each ASPD for maintaining a specified array geometry.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2; particularly in regard to the limitation of "specified array geometry" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. ... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position

	information that will direct the bird 18 to the midpoint position between its adjacent streamers.").
27. The method of claim 26 further comprising: providing an environmental sensor for sensing environmental factors which influence the path of the towed array.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The "water-referenced" towing velocity and crosscurrent velocity could alternatively be determined using flowmeters or other types of water velocity sensors attached directly to the birds 18. Although these types of sensors are typically quite expensive, one advantage of this type of velocity determination system is that the sensed in-line and cross-line velocities will be inherently compensated for the speed and heading of marine currents acting on said streamer positioning device and for relative movements between the vessel 10 and the bird 18.").
28. The method of claim 26 further comprising: providing a tracking system for tracking the streamer positions versus time during a seismic data acquisition run and storing the positions versus time in a legacy database for repeating the positions versus time in a subsequent data acquisition; and providing an array geometry tracking system for tracking the array geometry versus time during a seismic data acquisition run and	The Hillesund '895 application discloses this limitation. *See* Claim 26 Analysis. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 7, Paragraph 1 ("In the preferred

storing the array geometry versus time in a legacy database for repeating the array geometry versus time in a subsequent data acquisition run.	embodiment of the present invention, the global control system 22 monitors the actual positions of each of the birds 18 and is programmed with the desired positions of or the desired minimum separations between the seismic streamers 12."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system.") In regard to "array geometry tracking system," *see, e.g.*, Hillesund '895 at p. 18, Paragraph 3 to p. 19, Paragraph 2 ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle. The feather could be input either manually, through use of a current meter, or through use of an estimated value based on the average horizontal bird forces. Only when the crosscurrent velocity is very small will the feather angle be set to zero and the desired streamer positions be in precise alignment with the towing direction. The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change". The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn. The vessel navigation system will typically notify the global control system 22 when to start throwing the streamers 12 out, and when to start straightening the streamers. In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will

	typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers."). Persons Having Ordinary Skill In The Art at the time of invention would have recognized that tracking streamer positions and storing the positions in a legacy database, including the times during acquisition, was obvious and had been in widespread industry standard practice since the late 1980's. Industry standards (such as the so-called UKOOA navigation database standards) have existed and been used since the early 1990's. It is also obvious to a Person Having Ordinary Skill In The Art that streamer positions in such a database can be repeatedly utilized.
29. The method of claim 28 wherein the master controller compares the positions of the streamers versus time and the array geometry versus time to a desired streamer position and array geometry versus time and issues positioning commands to the ASPDs to maintain the desired streamer position and array geometry versus time.	The Hillesund '895 application discloses this limitation. *See* Claim 28 Analysis. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required.").
30. The method of claim 29 wherein the master controller factors in environmental factors into the positioning commands to compensate for environmental influences on the positioning of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See* Claim 29 Analysis. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading

	(degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").
31. The method of claim 30 wherein the master controller compensates for maneuverability in the positioning commands to compensate for maneuverability influences on the positioning of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See* Claim 30 Analysis. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array."). A Person Having Ordinary Skill In The Art at the time of the invention would find this limitation to be inherent in the invention. To "compensate for maneuverability influences" it would be necessary to take into account various maneuverability factors, including, but not necessarily limited to, cable diameter, array type, deployed configuration, vessel type, device type, etc. which are part of the basis for the behavior of the streamers. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system."). At the time of the invention it was obvious to a Person Having Ordinary Skill In The Art at the time of the invention that to "compensate for maneuverability influences" it would be necessary to take into account various maneuverability factors, including, but not necessarily limited to, cable diameter, array type, deployed configuration, vessel type, device type, etc. which are part of the basis for the behavior of the streamers.

32. The method of claim 26 further comprising: providing a monitor for determining the status of each streamer, wherein the master controller adjusts the array geometry to compensate for a failed streamer.	Person Having Ordinary Skill In The Art will recognize that it was obvious common practice at the time of the invention to monitor the status of each streamer. They will also recognize that it was obvious common practice to compensate for failed streamers to the maximum extent that towing capabilities of a given vessel allowed.
35. The method of claim 26 wherein the array geometry comprises a plurality of streamers positioned at a uniform depth.	The Hillesund '895 application discloses this limitation. *See* Claim 26 Analysis. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") Persons Having Ordinary Skill in The Art will recognize that deploying 'a plurality of streamers at a uniform depth' has been the most obvious and common industry practice since the 1980's.
36. The method of claim 26 wherein the array geometry comprises a plurality of streamers positioned at a plurality of depths for varying temporal resolution of the array.	The Hillesund '895 application discloses this limitation. *See* Claim 26 Analysis. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") *See, e.g.*, Hillesund '895 at p. 19, Paragraph 2 ("In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be

	separated in depth and the outermost streamers will be positioned as far away from each other as possible") Persons Having Ordinary Skill in The Art will recognize that deploying 'a plurality of streamers positioned at a plurality of depths' has been obvious and has been selectively utilized in industry practice since the 1980's. In addition to other industry practitioners, a predecessor company of WesternGeco utilized so-called "over-under" streamer acquisition selectively since before the priority date for the '038 patent.
38. The method of claim 29 wherein the array geometry is tracked via satellite and communicated to the master controller.	The Hillesund '895 application discloses this limitation. *See* Claim 29 Analysis. See, e.g., Hillesund '895 at p. 7, Paragraph 1 ("The horizontal positions of the birds 18 can be derived, for instance, using the types of acoustic positioning systems ... Alternatively, or additionally, satellite-based global positioning system equipment can be used to determine the positions of the equipment.")
39. A method for tracking and positioning a seismic streamer array comprising:	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.*, Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention."
towing a seismic array comprising a plurality of seismic streamers from a towing vessel;	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers ..."). *See, e.g.,* Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers ...").

attaching an active streamer positioning device (ASPD) to each seismic streamer for positioning each seismic streamer;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to "positioning" of streamers ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. ...") In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. ..."). The '038 patent discloses that this limitation was well known to one skilled in the art prior to and at the time of the invention. *See, e.g.*, '038 patent, Col. 1, ll. 25-56 (discussing the known prior art including attaching control apparatuses to seismic streamers to position streamers).
issuing positioning commands from a master controller to each ASPD to adjust vertical and horizontal position of a first streamer relative to a second streamer in the array for maintaining a specified array geometry;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("In the preferred embodiment of the present invention, the control system for the birds 18 is distributed between a global control system 22 located on or near the seismic survey vessel 10 and a local control system located within or near the birds 18."). *See, e.g.*, Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global control system 22 preferably transmits, at regular intervals (such as every five seconds) a desired horizontal force 42 and a desired vertical force 44 to the local control system 36."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers

	12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required."). *See, e.g.,* Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2; particularly in regard to the limitation of "maintaining a specified array geometry" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn .... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers.").
sensing environmental factors which influence the towed path of the towed array;	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers.") *See, e.g.,* Hillesund '895 at p. 8, Paragraph 1 ("The global control

	system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.,* Hillesund '895 at p. 8, Paragraph 3 ("The "water-referenced" towing velocity and crosscurrent velocity could alternatively be determined using flowmeters or other types of water velocity sensors attached directly to the birds 18. Although these types of sensors are typically quite expensive, one advantage of this type of velocity determination system is that the sensed in-line and cross-line velocities will be inherently compensated for the speed and heading of marine currents acting on said streamer positioning device and for relative movements between the vessel 10 and the bird 18.").
tracking the streamer positions versus time during a seismic data acquisition run;	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.,* Hillesund '895 at p. 7, Paragraph 1 ("In the preferred embodiment of the present invention, the global control system 22 monitors the actual positions of each of the birds 18 and is programmed with the desired positions of or the desired minimum separations between the seismic streamers 12."). *See, e.g.,* Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system.") Persons Having Ordinary Skill In The Art at the time of invention would have recognized that tracking streamer positions and

	storing the positions in a legacy database, including the times during acquisition, was obvious and had been in widespread industry standard practice since the late 1980's. Industry standards (such as the so-called UKOOA navigation database standards) have existed and been used since the early 1990's. It is also obvious to a Person Having Ordinary Skill In The Art that streamer positions in such a database can be repeatedly utilized.
tracking the array geometry versus time during a seismic data acquisition run, wherein the master controller compares the positions of the streamers versus time and the array geometry versus time to desired streamer positions and array geometry versus time and issues positioning commands to the ASPDs to maintain the desired streamer positions and array geometry versus time.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required.").
40. The method of claim 39 wherein the master controller factors in environmental measurements into the positioning commands to compensate for environmental influences on the positions of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See* Claim 39 Analysis. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side

	control required to property position the streamers. To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").
41. The method of claim 39 wherein the master controller compensates for maneuverability in the positioning commands to compensate for maneuverability influences on the positioning of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See* Claim 39 Analysis. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array."). A Person Having Ordinary Skill In The Art at the time of the invention would find this limitation to be inherent in the invention. To "compensate for maneuverability influences" it would be necessary to take into account various maneuverability factors, including, but not necessarily limited to, cable diameter, array type, deployed configuration, vessel type, device type, etc. which are part of the basis for the behavior of the streamers. *See, e.g.,* Hillesund '895 at p. 8, Paragraph 3 ("The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system."). At the time of the invention it was obvious to a Person Having Ordinary Skill In The Art at the time of the invention that to "compensate for maneuverability influences" it would be necessary to take into account various maneuverability factors, including, but not necessarily limited to, cable diameter, array type, deployed configuration, vessel type, device type, etc. which are part of the basis for the behavior of the streamers.
42. The method of claim 39 further comprising: determining the status of each streamer, wherein the master controller adjusts the array geometry to compensate for a failed streamer.	The Hillesund '895 application discloses this limitation. A Person Having Ordinary Skill In The Art will recognize that it was obvious common practice at the time of the invention to monitor the status of each streamer. They will also recognize that it was obvious common practice to compensate for failed streamers to the maximum extent that towing capabilities of a given vessel allowed.

45. A method for tracking and positioning seismic streamer array comprising:	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.,* Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention."
towing a seismic array comprising a plurality of seismic streamers;	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …").
attaching an active streamer positioning device (ASPD) attached to each seismic streamer for positioning each seismic streamer;	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer ...") *See, e.g.,* Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to "positioning each seismic streamer" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle …. The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. … Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn …. In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In

	this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth …"). The '038 patent discloses that this limitation was well known to one skilled in the art prior to and at the time of the invention. *See, e.g.*, '038 patent, Col. 1, ll. 25-56 (discussing the known prior art, including attaching control apparatuses to seismic streamers to position streamers).
and issuing vertical and horizontal positioning commands to each ASPD for maintaining a specified array path.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("In the preferred embodiment of the present invention, the control system for the birds 18 is distributed between a global control system 22 located on or near the seismic survey vessel 10 and a local control system located within or near the birds …"). *See, e.g.*, Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global control system 22 preferably transmits, at regular intervals (such as every five seconds) a desired horizontal force 42 and a desired vertical force 44 to the local control system 36."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2; particularly in regard to the limitation of "specified array path" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle …. The turn control mode is used when ending one pass and beginning another

	pass during a 3D seismic survey, sometimes referred to as a "line change". The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. ... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers.").
46. The method of claim 45 wherein a master controller issues positioning commands to the towing vessel for maintaining a specified array path.	The Hillesund '895 application discloses this limitation. *See* Claim 45 Analysis. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("The global control system 22 is typically connected to the seismic survey vessel's navigation system and obtains estimates of system wide parameters, such as the vessel's towing direction and velocity and current direction and velocity, from the vessel's navigation system.") In addition, Persons Having Ordinary Skill In The Art will readily recognize that the seismic survey vessel's navigation system is typically utilized to steer the vessel in routine seismic acquisition operations ("auto-pilot").
47. The method of claim 45 further comprising: calculating an optimal path for the seismic array for optimal coverage during seismic data acquisition over a seismic field;	The Hillesund '895 application discloses this limitation. *See* Claim 45 Analysis. *See, e.g.*, Hillesund '895, Fig 4. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").

predicting array behavior;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig 4. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").
and compensating for predicted streamer behavior in issuing positioning commands to the towing vessel and the ASPDs for positioning the array along the optimal path.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("In the preferred embodiment of the present invention, the control system for the birds 18 is distributed between a global control system 22 located on or near the seismic survey vessel 10 and a local control system located within or near the birds 18. The global control system 22 is typically connected to the seismic survey vessel's navigation system and obtains estimates of system wide parameters, such as the vessel's towing direction and velocity and current direction and velocity, from the vessel's navigation system."). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices."). *See, e.g.*, Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global control system 22 preferably transmits, at regular intervals (such as every five seconds) a desired horizontal force 42 and a desired vertical force 44 to the local control system 36."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required.").

	See, e.g., Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2; particularly in regard to the limitation of "specified array geometry" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn .... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers.").
48. The method of claim 47 wherein the master controller compensates for environmental factors in the positioning commands.	The Hillesund '895 application discloses this limitation. *See* Claims 15, 30, and 40 Analyses. *See, e.g.,* Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").

	See, e.g., Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity.").
49. The method of claim 48 wherein the master controller compensates for maneuverability factors in the positioning commands.	The Hillesund '895 application discloses this limitation. *See* Claims 16, 31, and 41 Analyses. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array."). A Person Having Ordinary Skill In The Art at the time of the invention would find this limitation to be inherent in the invention. To "compensate for maneuverability influences" it would be necessary to take into account various maneuverability factors, including, but not necessarily limited to, cable diameter, array type, deployed configuration, vessel type, device type, etc. which are part of the basis for the behavior of the streamers. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system.").
50. A method for tracking and positioning a seismic streamer array comprising:	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.*, Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention".

towing a seismic array comprising a plurality of seismic streamers;	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …").
attaching an active streamer positioning device (ASPD) attached to each seismic streamer for positioning each seismic streamer;	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer ...") *See, e.g.,* Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to "positioning each seismic streamer" ("The inventive control system will primarily operate in two different *control modes*: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep *each streamer* in a straight line offset from the towing direction by a certain feather angle … In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. …") The '038 patent discloses that this limitation was well known to one skilled in the art prior to and at the time of the invention. *See, e.g.,* '038 patent, Col. 1, ll. 25-56 (discussing the known prior art, including attaching control apparatuses to seismic streamers to position streamers).
issuing horizontal and vertical positioning commands to each ASPD and to the towing vessel for maintaining an optimal path, calculating an optimal path for the seismic array for optimal coverage during seismic data acquisition over a seismic field, and a behavior	The Hillesund '895 application discloses this limitation. See, e.g., Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired

prediction processor which predicting array behavior, wherein the master controller compensates for predicted streamer behavior in issuing positioning commands to the towing vessel and the ASPDs for positioning the array along the optimal path, wherein the master controller compensates for environmental and maneuverability factors in the positioning commands.	positions."). *See, e.g.*, Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global control system 22 preferably transmits, at regular intervals (such as every five seconds) a desired horizontal force 42 and a desired vertical force 44 to the local control system 36."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 located on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required."). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and *behavior-predictive* model-based control logic to properly control the streamer positioning devices."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously

	during operation of the control system."). *See also* Claims 1, 2, 5, 6, 21, 22, and 25 Analyses.

2662753v1

EXHIBIT 7

EXHIBIT 7

U.S. Patent No. 6,691,038 (the " '038 patent") Is Obvious In View of International Patent Application WO 97/11395 ("Olivier '395 Application")

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Olivier '395 Application
1. A seismic streamer array tracking and positioning system comprising:	The Olivier International Application WO 97/11395 discloses a system for tracking and positioning seismic arrays.
a towing vessel for towing a seismic array;	The Olivier '395 application discloses this limitation. *See, e.g.*, Olivier '395 at p.1, l. 24; to p. 2, l. 2 ("In marine seismic exploration, an underwater cable, commonly referred to as a streamer cable, is towed through the water by a vessel such as a surface ship.")
an array comprising a plurality of seismic streamers;	The Olivier '395 application discloses this limitation. *See, e.g.*, Olivier '395 at p. 7, ll. 14-15 ("In addition, although only a single cable 11 is shown, the towing vessel 10 may tow a plurality of cables simultaneously.")
an active streamer positioning device (ASPD) attached to at least one seismic streamer for positioning the seismic streamer relative to other seismic streamers within the array;	The Olivier '395 application discloses this limitation. *See, e.g.* Olivier '395 at p. 4, ll. 23-26 ("The external devices of an underwater cable arrangement according to the present invention can perform a wide variety of functions, including but not limited to sensing the head of the cable, performing acoustic ranging, and controlling the depth of the position of the cable in the water."). For a plurality of cables, a Person Having Ordinary Skill In The Art at the time of the invention would have found it obvious that positioning of any one streamer may be relative to other streamer(s). *See*, e.g., Olivier '395 at p. 7, ll. 14-15 ("In addition, although only a single cable 11 is shown, the towing vessel 10 may tow a plurality of cables simultaneously.")

2662513v1

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Olivier '395 Application
	See, e.g. Olivier '395 at p. 13, ll. 7-21 ("Figures 7 through 17 illustrate another example of an external device according to the present invention. This embodiment is a depth control device 70 which is capable of controlling the depth beneath the water surface of the underwater cable 20. In addition, it may be used to steer the cable 20 to control the horizontal position of the cable 20 within the water. Figure 7 is a side elevation showing the depth control device 70 as it would appear when being towed through the water to the left in the figure.").
and a master controller for issuing positioning commands to each ASPD to adjust a vertical and horizontal position of a first streamer relative to a second streamer within the array for maintaining a specified array geometry.	The Olivier '395 application discloses this limitation, including in particular, a controller aboard the towing vessel. *See, e.g.* Olivier '395 at p. 24, ll. 6-11 ("Data representing the times of transmission and the times of reception of acoustic pulses are usually transmitted by the ranging devices over a communications link through the cable to a controller aboard the towing vessel. The transit times of pulses between pairs of ranging devices and therefore the distances between pairs of locations on the cable, the towing vessel, or the seismic source, can be determined. From this collection of distances, the shape of the cable (and of hydrophones in the cable) can be estimated."). For a plurality of cables, a Person Having Ordinary Skill In The Art at the time of the invention would have found it obvious that positioning of any one streamer may be relative to other streamer(s). *See,* e.g., Olivier '395 at P. 7, ll. 14-15 ("In addition, although only a single cable 11 is shown, the towing vessel 10 may tow a plurality of cables simultaneously."). The Olivier '395 application inherently discloses this information. The Olivier '395 reference discloses a controller contained on the towing vessel and said controller sends and receives commands and communications from the external devices.

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Olivier '395 Application
2. The apparatus of claim 1 further comprising: an environmental sensor for sensing environmental factors which influence the path of the towed array.	The Olivier '395 application discloses this limitation. *See* Claim 1 Analysis. *See, e.g.* Olivier '395 at p. 47, l. 24; to p. 48, l. 2 ("Optionally, the depth control device may also include a conventional temperature sensor 426, used for reporting the temperature to the towing vessel or to temperature-compensate the data reported by the other sensors. Signal conditioning circuitry 427 converts the raw temperature sensor signal into a signal to be input into the microprocessor.").
10. The apparatus of claim 1 wherein the array geometry comprises a plurality of streamers positioned at a uniform depth.	*See* Claim 1 Analysis. *See, e.g.* Olivier '395 at p. 23, ll. 1-2 ("In addition, based on the input signal from the depth sensor 142, the controller 140 can control the pitch actuator 135 to maintain the depth control device 70 at a constant depth"). Persons Having Ordinary Skill in The Art at the time of the invention would have found it obvious to recognize that deploying "a plurality of streamers at a uniform depth" had been the most common industry practice since the 1980's. The Olivier '395 application discloses that the controller has the ability to maintain the depth control devices, and therefore necessarily also maintain the streamers at a uniform depth.
11. The apparatus of claim 1 wherein the array geometry comprises a plurality of streamers positioned at a plurality of depths for varying temporal resolution of the array.	*See* Claim 1 Analysis. The Olivier '395 application discloses that the controller has the ability to control the depth control devices, and therefore the streamers, in a variety of manners, which would include varying depths. *See, e.g.* Olivier '395 at p. 22, ll. 22-23 ("The controller 140 can control the operation of the depth control device 70 in a variety of manners"). It was obvious to Persons Having Ordinary Skill in The Art at the time of the invention that deploying 'a plurality of streamers

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Olivier '395 Application
	positioned at a plurality of depths' had been selectively utilized in industry practice since the 1980's. In addition to other industry practitioners, a predecessor company of WesternGeco utilized so-called "over-under" streamer acquisition selectively since before the priority date for the '038 patent. The Olivier '395 application discloses that the controller has the ability to control the depth control devices, and therefore the streamers, in a variety of manners, which would include varying depths.
20. A seismic streamer array tracking and positioning system comprising:	The Olivier '395 application discloses a system for tracking and positioning a seismic streamer array.
a towing vessel for towing a seismic array;	The Olivier '395 application discloses this limitation. See, e.g., Olivier '395 at P.1, l. 24; to P. 2, l. 2 ("In marine seismic exploration, an underwater cable, commonly referred to as a streamer cable, is towed through the water by a vessel such as a surface ship.")
a seismic streamer array comprising a plurality of seismic streamers;	The Olivier '395 application discloses this limitation. See, e.g., Olivier '395 at p. 7, ll. 14-15 ("In addition, although only a single cable 11 is shown, the towing vessel 10 may tow a plurality of cables simultaneously.")
an active streamer positioning device (ASPD) attached to each seismic streamer for vertically and horizontally positioning each seismic streamer relative to the array;	The Olivier '395 application discloses this limitation. *See, e.g.* Olivier '395 at p. 4, ll. 23-26 ("The external devices of an underwater cable arrangement according to the present invention can perform a wide variety of functions, including but not limited to sensing the head of the cable, performing acoustic ranging, and controlling the depth of the position of the cable in the water."). For a plurality of cables, a Person Having Ordinary Skill In The Art at the time of the invention would have found it obvious that

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Olivier '395 Application
	positioning of any one streamer may be relative to other streamer(s). See, e.g., Olivier '395 at p. 7, ll. 14-15 ("In addition, although only a single cable 11 is shown, the towing vessel 10 may tow a plurality of cables simultaneously.") *See, e.g.* Olivier '395 at p. 13, ll. 7-21 ("Figures 7 through 17 illustrate another example of an external device according to the present invention. This embodiment is a depth control device 70 which is capable of controlling the depth beneath the water surface of the underwater cable 20. In addition, it may be used to steer the cable 20 to control the horizontal position of the cable 20 within the water. Figure 7 is a side elevation showing the depth control device 70 as it would appear when being towed through the water to the left in the figure.").
and a master controller for issuing positioning commands to each ASPD for maintaining a specified array path.	The Olivier '395 application discloses this limitation, including in particular, a controller aboard the towing vessel. *See, e.g.* Olivier '395 at p. 24, ll. 6-11 ("Data representing the times of transmission and the times of reception of acoustic pulses are usually transmitted by the ranging devices over a communications link through the cable to a controller aboard the towing vessel. The transit times of pulses between pairs of ranging devices and therefore the distances between pairs of locations on the cable, the towing vessel, or the seismic source, can be determined. From this collection of distances, the shape of the cable (and of hydrophones in the cable) can be estimated."). A Person Having Ordinary Skill In The Art at the time of the invention would have found it obvious that towing seismic streamers by a vessel involves moving the streamer array over the water bottom along a path, and involves moving the seismic streamer array along a path through the water.
21. The apparatus of claim 20 wherein the master controller issues positioning commands to the towing vessel for maintaining a specified array path.	The Olivier '395 application inherently discloses this limitation, in particular a controller contained on the towing vessel and said controller sends and receives commands and communications from the external devices. *See also, e.g.*, FIG. 1 *See* Claim 20 Analysis.

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Olivier '395 Application
	See, e.g. Olivier '395 at p. 24, ll. 6-11. At the time of the invention, a Person Having Ordinary Skill In The Art would have found it obvious that "maintaining a specified array path" is undertaken dominantly by steering commands to the "towing vessel" so as to "maintain[ing] a specified array path". It is recognized that "maintaining a specified array path" is largely determined by the towing motion of the towing vessel, with the effects of cross currents and ASPD steering being smaller. Further, a Person Having Ordinary Skill In The Art at the time of the invention would have found obvious and common commercial practice to have navigation controller systems control the steering of seismic towing vessels.
26. A method for tracking and positioning a seismic streamer array comprising:	The Olivier '395 application discloses a method for tracking and positioning a seismic array through the use of various external devices.
for towing a seismic array comprising a plurality of seismic streamers;	The Olivier '395 application discloses this limitation. *See, e.g.*, Olivier '395 at P.1, l. 24; to P. 2, l. 2 ("In marine seismic exploration, an underwater cable, commonly referred to as a streamer cable, is towed through the water by a vessel such as a surface ship.") *See, e.g.*, Olivier '395 at P. 7, ll. 14-15 ("In addition, although only a single cable 11 is shown, the towing vessel 10 may tow a plurality of cables simultaneously.")
attaching an active streamer positioning device (ASPD) each seismic streamer for positioning the seismic streamer relative to other seismic streamers within the array;	The Olivier '395 application discloses this limitation. *See, e.g.* '395 Olivier at p. 4, ll. 23-26 ("The external devices of an underwater cable arrangement according to the present invention can perform a wide variety of functions, including but not limited to sensing the head of the cable, performing acoustic ranging, and controlling the depth of the position of the cable in

2662513v1

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Olivier '395 Application
	the water."). For a plurality of cables, a Person Having Ordinary Skill In The Art at the time of the invention would have found it obvious that positioning of any one streamer may be relative to other streamer(s). *See*, e.g., Olivier '395 at p. 7, ll. 14-15 ("In addition, although only a single cable 11 is shown, the towing vessel 10 may tow a plurality of cables simultaneously."). *See, e.g.* Olivier '395 at p. 13, ll. 7-21 ("Figures 7 through 17 illustrate another example of an external device according to the present invention. This embodiment is a depth control device 70 which is capable of controlling the depth beneath the water surface of the underwater cable 20. In addition, it may be used to steer the cable 20 to control the horizontal position of the cable 20 within the water. Figure 7 is a side elevation showing the depth control device 70 as it would appear when being towed through the water to the left in the figure.").
and issuing vertical and horizontal positioning commands to each ASPD for maintaining a specified array geometry.	The Olivier '395 application discloses this limitation. *See, e.g.* Olivier '395 at p. 13, ll. 7-21 ("Figures 7 through 17 illustrate another example of an external device according to the present invention. This embodiment is a depth control device 70 which is capable of controlling the depth beneath the water surface of the underwater cable 20. In addition, it may be used to steer the cable 20 to control the horizontal position of the cable 20 within the water. Figure 7 is a side elevation showing the depth control device 70 as it would appear when being towed through the water to the left in the figure."). The Olivier '395 reference discloses a controller contained on the towing vessel and said controller sends and receives commands and communications from the external devices. *See, e.g.* Olivier '395 at p. 22, l. 22; to p. 23, l. 2 ("The controller 140 can control the operation of the depth control device 70 in a variety of manners. For example, based on the input signal from the attitude sensor 144, which indicates the roll angle of the inner sleeve 71 with respect to the horizontal, the Hall effect sensors 143, and the encoder for the roll actuator 130, the controller 140 can control the roll actuator 130 so as to maintain

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Olivier '395 Application
	the roll angle of the wings constant with respect to the horizontal. In addition, based on the input signal from the depth sensor 142, the controller 140 can control the pitch actuator 135 to maintain the depth control device 70 at a constant depth."). *See, also, e.g.* Olivier '395 at p. 21, ll. 3-18 ("The Hall effect sensors 143 are used to sense the position of the wings 120 with respect to the inner sleeve 71 in roll and pitch. A first one of the Hall effect sensors 143 generates a signal when the collar 111 is at reference rotational position with respect to the inner sleeve 71, while a second one of the Hall effect sensors 143 generates a signal when the collar 111 is at reference position in the lengthwise direction of the inner sleeve 71. The reference position in the lengthwise direction corresponds to a predetermined reference angle of attack of the wings 120. Unillustrated magnetic member, such as magnetic pellets, may be mounted on the collar 111 or the wings 120 for sensing by the Hall effect sensors 143. By counting the number of rotations of the roll actuator 130 since the generation of an output signal by the first Hall effect sensor 143, the controller 140 can calculate the current rotational angle of the collar 111 and the wings 120 with respect to the reference rotational position. Based on the angle with respect to the horizontal determined by the output of the attitude sensor 144, the controller 140 can determine the current roll angle of the wings 120 about the longitudinal axis of the cable 20 with respect to the horizontal. Similarly, by counting the number of rotations of the pitch actuator 135 since the generation of an output signal by the second Hall effect sensor 143, the controller 140 can calculate the angle of attack of the wings 120.").
27. The method of claim 26 further comprising: providing an environmental sensor for sensing environmental factors which influence the path of the towed array.	The Olivier '395 application discloses this limitation. *See, e.g.* Olivier '395 at P. 47, l. 24; to P. 48, l. 2 ("Optionally, the depth control device may also include a conventional temperature sensor 426, used for reporting the temperature to the towing vessel or to temperature-compensate the data reported by the other sensors. Signal conditioning circuitry 427 converts the raw temperature sensor signal into a signal to be input into the microprocessor."). *See* Claim 26 Analysis.

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Olivier '395 Application
35. The method of claim 26 wherein the array geometry comprises a plurality of streamers positioned at a uniform depth.	The Olivier '395 application discloses this limitation. *See* Claim 26 Analysis.
Olivier '395 application discloses that the controller has the lity to maintain the depth control devices, and therefore essarily also maintain the streamers at a uniform depth: , *e.g.* Olivier '395 at P. 23, ll. 1-2 ("In addition, based on the ut signal from the depth sensor 142, the controller 140 can trol the pitch actuator 135 to maintain the depth control ice 70 at a constant depth"). sons Having Ordinary Skill in The Art at the time of the ention would have found it obvious to recognize that loying "a plurality of streamers at a uniform depth" had been most common industry practice since the 1980's.	
The method of claim 26 wherein the array geometry prises a plurality of streamers positioned at a plurality of ths for varying temporal resolution of the array.	The Olivier '395 application discloses this limitation. *See* Claim 26 Analysis. The Olivier '395 application discloses that the controller has tl ability to control the depth control devices, and therefore the streamers, in a variety of manners, which would include varyir depths: *See, e.g.* Olivier '395 at 22, ll. 22-23 ("The controller 140 can control the operation of the depth control device 70 in variety of manners"). It was obvious to Persons Having Ordinary Skill in The Art at the time of the invention that deploying 'a plurality of streame positioned at a plurality of depths' had been selectively utilize in industry practice since the 1980's. In addition to other industry practitioners, a predecessor company of WesternGecc utilized so-called "over-under" streamer acquisition selectivel

	since before the priority date for the '038 patent.
A method for tracking and positioning seismic streamer array prising:	The Olivier '395 application discloses a method for tracking ai positioning a seismic array through the use of various external devices.
ing a seismic array comprising a plurality of seismic amers;	The Olivier '395 application discloses this limitation. *See*, e.g., Olivier '395 at P.1, l. 24; to P. 2, l. 2 ("In marine seismic exploration, an underwater cable, commonly referred t as a streamer cable, is towed through the water by a vessel suc as a surface ship.") *See*, e.g., Olivier '395 at P. 7, ll. 14-15 ("In addition, although only a single cable 11 is shown, the towing vessel 10 may tow plurality of cables simultaneously.")
ching an active streamer positioning device (ASPD) attached ach seismic streamer for positioning each seismic streamer;	The Olivier '395 application discloses this limitation. *See, e.g.* Olivier '395 at p. 4, ll. 23-26 ("The external devices c an underwater cable arrangement according to the present invention can perform a wide variety of functions, including bı not limited to sensing the head of the cable, performing acoust ranging, and controlling the depth of the position of the cable i the water."). *See, e.g.* Olivier '395 at p. 13, ll. 7-21 ("Figures 7 through 17 illustrate another example of an external device according to tł present invention. This embodiment is a depth control device 7 which is capable of controlling the depth beneath the water surface of the underwater cable 20. In addition, it may be used steer the cable 20 to control the horizontal position of the cabl 20 within the water. Figure 7 is a side elevation showing the depth control device 70 as it would appear when being towed through the water to the left in the figure.").
issuing vertical and horizontal positioning commands to h ASPD for maintaining a specified array path.	The Olivier '395 application discloses this limitation. *See, e.g.* Olivier '395 at p. 13, ll. 7-21 ("Figures 7 through 17 illustrate another example of an external device according to tł present invention. This embodiment is a depth control device 7

which is capable of controlling the depth beneath the water surface of the underwater cable 20. In addition, it may be used steer the cable 20 to control the horizontal position of the cabl(20 within the water. Figure 7 is a side elevation showing the depth control device 70 as it would appear when being towed through the water to the left in the figure.").

See, e.g. Olivier '395 at p. 22, l. 22; to p. 23, l. 2 ("The control 140 can control the operation of the depth control device 70 in variety of manners. For example, based on the input signal fro the attitude sensor 144, which indicates the roll angle of the inner sleeve 71 with respect to the horizontal, the Hall effect sensors 143, and the encoder for the roll actuator 130, the controller 140 can control the roll actuator 130 so as to mainta the roll angle of the wings constant with respect to the horizontal. In addition, based on the input signal from the dept sensor 142, the controller 140 can control the pitch actuator 13 to maintain the depth control device 70 at a constant depth.").

See, also, e.g. Olivier '395 at p. 21, ll. 3-18 ("The Hall effect sensors 143 are used to sense the position of the wings 120 wi respect to the inner sleeve 71 in roll and pitch. A first one of th Hall effect sensors 143 generates a signal when the collar 111 at reference rotational position with respect to the inner sleeve 71, while a second one of the Hall effect sensors 143 generate signal when the collar 111 is at reference position in the lengthwise direction of the inner sleeve 71. The reference position in the lengthwise direction corresponds to a predetermined reference angle of attack of the wings 120. Unillustrated magnetic member, such as magnetic pellets, may be mounted on the collar 111 or the wings 120 for sensing by t Hall effect sensors 143. By counting the number of rotations o the roll actuator 130 since the generation of an output signal b the first Hall effect sensor 143, the controller 140 can calculat the current rotational angle of the collar 111 and the wings 12(with respect to the reference rotational position. Based on the angle with respect to the horizontal determined by the output o the attitude sensor 144, the controller 140 can determine the current roll angle of the wings 120 about the longitudinal axis the cable 20 with respect to the horizontal. Similarly, by counting the number of rotations of the pitch actuator 135 sinc the generation of an output signal by the second Hall effect sensor 143, the controller 140 can calculate the angle of attack the wings 120.").

EXHIBIT 8

EXHIBIT 8

U.S. Patent No. 6,691,038 (the "'038 patent") Is Obvious In View of International Patent Application WO 2000/20895 ("Hillesund '895 Application") and U.S. Patent 5,200,930 ("Rouquette '930")

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
1. A seismic streamer array tracking and positioning system comprising:	The Hillesund WO 00/20895 International Application discloses this limitation. *See, e.g.*, Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.*, Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention".
a towing vessel for towing a seismic array;	The Hillesund '895 application and Rouquette patent disclose this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1. ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers ..."). *See, e.g.*, Rouquette '930 at Col. 1, ll. 13-14 ("In a marine seismic survey, a surveying vessel tows one or more seismic cables or streamers")
an array comprising a plurality of seismic streamers;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1. ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers ...").

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
an active streamer positioning device (ASPD) attached to at least one seismic streamer for positioning the seismic streamer relative to other seismic streamers within the array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3to p. 19, Paragraph 2 particularly in regard to 'relative' positioning of streamers ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle ... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change". The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn ... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers."). The '930 patent discloses this limitation. *See, e.g.*, '930, Fig. 1. *See, e.g.*, '930 patent, Col. 2, ll. 49-52 ("FIG. 1 is side view of a seismic surveying vessel towing a streamer outfitted with sensing and streamer control devices in communication with a controller aboard the vessel in accordance with the invention") *See, e.g.*, '930 patent Col. 4, ll. 6-13 ("Distributed along the length of the streamer 22 are in-streamer sensors 24A-D, such as compasses and depth sensors, and outboard devices, such as cable-leveling birds 26A-B and acoustic ranging transceivers 28A-B. For brevity, all such devices are hereinafter referred to generally as sensors. The outboard sensors are connected to the streamer 22 by means of collars 27 clamped around the streamer.") The '038 patent discloses that this limitation was well known to one skilled in the art prior to and at the time of the invention. *See, e.g.*, '038 patent, Col. 1, ll. 25-56 (discussing the known prior art including attaching control apparatuses to seismic streamers to position streamers).
and a master controller for issuing positioning commands to each ASPD to adjust a vertical and horizontal position of a first streamer relative to a second streamer within the array for maintaining a specified array geometry.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("In the preferred embodiment of the present invention, the control system for the birds 18 is distributed between a global control system 22 located on or near the seismic survey vessel 10 and a local control system located within or near the birds 18. The global control system 22 is typically connected to the seismic survey vessel's navigation system and obtains estimates of system wide parameters, such as the vessel's towing direction and velocity and current direction and velocity, from the vessel's navigation system.").

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	See, e.g., Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global control system 22 preferably transmits, at regular intervals (such as every five seconds) a desired horizontal force 42 and a desired vertical force 44 to the local control system 36."). *See, e.g.,* Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required."). *See, e.g.,* Hillesund '895 at p. 18, Paragraph 3to p. 19, Paragraph 2 particularly in regard to 'specified array geometry' ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle ... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change". The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn ... In extreme weather conditions, the inventive control system may

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers."). The Rouquette '930 patent discloses this limitation. *See, e.g.*, '930 patent, Figs. 1 & 2. *See, e.g.*, Rouquette '930, Col. 3, ll. 23-31 ("These and other objects are achieved by the present invention, which provides a multi-channel, two-wire communication system for sending commands and data requests to and receiving data [f]rom many positioning sensors and cable-leveling devices distributed along a seismic streamer. The apparatus of the invention includes a central controller comprising an intelligent modem that can scan the many streamer devices for cable-positioning data each seismic shot interval."). See, e.g., Rouquette '930, Col. 4, ll. 6-11 ("Distributed along the length of the streamer 22 are … outboard devices, such as cable leveling birds 26A-B … For brevity, all such devices are hereinafter referred to generally as sensors"); Col. 4, ll. 16-18 ("The sensors 24, 26, and 28 are all in communication with a central controller 38 on board the vessel 20."); Col. 4, ll. 34-36 ("Communication between the sensors and the on-board controller is effected over one or more two-wire lines running through the streamer …"); Col. 4, ll. 39-41 ("An outboard bird 44, clamped to the streamer 40 by a collar (not shown), communicates with the on-board controller …");

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	Col. 4, ll. 45-47 ("Control signals are received by the bird electronics 50 to control the wings of the bird and, thereby, the depth of the streamer.").
2. The apparatus of claim 1 further comprising: an environmental sensor for sensing environmental factors which influence the path of the towed array.	The Hillesund '895 application discloses this limitation. *See* Claim 1 Analysis. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The "water-referenced" towing velocity and crosscurrent velocity could alternatively be determined using flowmeters or other types of water velocity sensors attached directly to the birds 18. Although these types of sensors are typically quite expensive, one advantage of this type of velocity determination system is that the sensed in-line and cross-line velocities will be inherently compensated for the speed and heading of marine currents acting on said streamer positioning device and for relative movements between the vessel 10 and the bird 18."). The Rouquette '930 patent discloses this limitation. *See, e.g.*, Rouquette '930, Col. 4, ll. 25-28 ("Outfitted with heading sensors and depths sensors, a bird 26 can also communicate heading and depth data to the on-board controller 38 for use in predicting the shape of the streamer 22.").

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	See, e.g., Rouquette '930, Col. 4, ll. 47-51 ("The bird electronics also measure various operating parameters, such as depth, heading, wing angle, temperature, and battery status, and send such data to the controller upon request.").
3. The apparatus of claim 1 further comprising:	The Hillesund '895 application discloses this limitation.
a tracking system for tracking the streamer positions versus time during a seismic data acquisition run and storing the positions versus time in a legacy database for repeating the positions versus time in a subsequent data acquisition;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 7, Paragraph 1 ("In the preferred embodiment of the present invention, the global control system 22 monitors the actual positions of each of the birds 18 and is programmed with the desired positions of or the desired minimum separations between the seismic streamers 12."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system.") Persons Having Ordinary Skill In The Art at the time of invention would have recognized that tracking streamer positions and storing the positions in a legacy database, including the times during acquisition, was obvious and had been in widespread industry standard practice since the late 1980's. Industry standards (such as the so-called UKOOA navigation database standards) have existed and been used since the early

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	1990's. It is also obvious to a Person Having Ordinary Skill In The Art that streamer positions in such a database can be repeatedly utilized.
and an array geometry tracking system for tracking the array geometry versus time during a seismic data acquisition run and storing the array geometry versus time in a legacy database for repeating the array geometry versus time in a subsequent data acquisition run.	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895 at p. 18, Paragraph 3 to p. 19, Paragraph 2 ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle. The feather could be input either manually, through use of a current meter, or through use of an estimated value based on the average horizontal bird forces. Only when the crosscurrent velocity is very small will the feather angle be set to zero and the desired streamer positions be in precise alignment with the towing direction. The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change". The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn. The vessel navigation system will typically notify the global control system 22 when to start throwing the streamers 12 out, and when to start straightening the streamers. In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers."). Persons Having Ordinary Skill In The Art at the time of invention would have recognized that tracking the array geometry and storing the array geometry in a legacy database, including the times during acquisition, was obvious and had been in widespread industry standard practice since the late 1980's. Industry standards (such as the so-called UKOOA navigation database standards) have existed and been used since the early 1990's. It is also obvious to a Person Having Ordinary Skill In The Art that the array geometry in such a database can be repeatedly utilized.
4. The apparatus of claim 3 wherein the master controller compares the positions of the streamers versus time and the array geometry versus time to a desired streamer position and array geometry versus time and issues positioning commands to the ASPDs to maintain the desired streamer position and array geometry versus time.	The Hillesund '895 application discloses this limitation. *See* Claim 3 Analysis. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 located on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	magnitude of total desired force required.").
5. The apparatus of claim 4 wherein the master controller factors in environmental factors into the positioning commands to compensate for environmental influences on the positioning of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See* Claims 4 and 2 Analyses. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").
6. The apparatus of claim 4 wherein the master controller compensates for maneuverability in the positioning commands to compensate for maneuverability influences on the positioning of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See* Claim 4 Analysis. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array."). At the time of the invention it was obvious to a Person Having Ordinary Skill In The Art at the time of the invention that to

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	"compensate for maneuverability influences" it would be necessary to take into account various maneuverability factors, including, but not necessarily limited to, cable diameter, array type, deployed configuration, vessel type, device type, etc. which are part of the basis for the behavior of the streamers. *See, e.g.,* Hillesund '895 at p. 8, Paragraph 3 ("The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system.").
7. The apparatus of claim 1 further comprising: a monitor for determining the status of each streamer, wherein the master controller adjusts the array geometry to compensate for a failed streamer.	*See* Claim 1 Analysis. Person Having Ordinary Skill In The Art will recognize that it was obvious common practice at the time of the invention to monitor the status of each streamer. They will also recognize that it was obvious common practice to compensate for failed streamers to the maximum extent that towing capabilities of a given vessel allowed.
10. The apparatus of claim 1 wherein the array geometry comprises a plurality of streamers positioned at a uniform depth.	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") Persons Having Ordinary Skill in The Art will recognize that deploying 'a plurality of streamers at a uniform depth' has been the most obvious and common industry practice since the 1980's. *See* Claim 1 Analysis, *generally.*

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
11. The apparatus of claim 1 wherein the array geometry comprises a plurality of streamers positioned at a plurality of depths for varying temporal resolution of the array.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") *See, e.g.*, Hillesund '895 at p. 19, Paragraph 2 ("In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible") Persons Having Ordinary Skill in The Art will recognize that deploying 'a plurality of streamers positioned at a plurality of depths' has been obvious and has been selectively utilized in industry practice since the 1980's. In addition to other industry practitioners, a predecessor company of WesternGeco utilized so-called "over-under" streamer acquisition selectively since before the priority date for the '038 patent. *See* Claim 1 Analysis, *generally*.
13. The apparatus of claim 4 wherein the array geometry is tracked via satellite and communicated to the master controller.	The Hillesund '895 application discloses this limitation. *See* Claim 4 Analysis. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("The global control system 22 is typically connected to the seismic survey vessel's navigation system and obtains estimates of system wide parameters, such as the vessel's towing direction and velocity and current direction and velocity, from the vessel's navigation system.").

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	See, e.g., Hillesund '895 at p. 7, Paragraph 1 ("Alternatively, or additionally, satellite-based global positioning system equipment can be used to determine the positions of the equipment.").
14. A seismic streamer array tracking and positioning system comprising:	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.*, Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention".
a towing vessel for towing a seismic array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …").
a seismic streamer array comprising a plurality of seismic streamers; an active streamer positioning device (ASPD) attached to each seismic streamer for positioning each seismic streamer;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …"). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.")
a master controller for issuing vertical and horizontal positioning commands to each ASPD for	The Hillesund '895 application discloses this limitation.

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
maintaining a specified array geometry;	*See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("In the preferred embodiment of the present invention, the control system for the birds 18 is distributed between a global control system 22 located on or near the seismic survey vessel 10 and a local control system located within or near the birds 18. The global control system 22 is typically connected to the seismic survey vessel's navigation system and obtains estimates of system wide parameters, such as the vessel's towing direction and velocity and current direction and velocity, from the vessel's navigation system."). *See, e.g.*, Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global control system 22 preferably transmits, at regular intervals (such as every five seconds) a desired horizontal force 42 and a desired vertical force 44 to the local control system 36."). See, e.g., Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. …"). See, e.g., Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2; particularly in regard to the limitation of "specified array geometry" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle … The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change". … Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn … In extreme weather conditions, the inventive control system may

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. ...")
an environmental sensor for sensing environmental factors which influence the towed path of the towed array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. ...") See, e.g., Hillesund '895 at p. 8, Paragraph 3 ("The "water-referenced" towing velocity and crosscurrent velocity could alternatively be determined using flowmeters or other types of water velocity sensors attached directly to the birds 18. Although these types of sensors are typically quite expensive, one advantage of this type of velocity determination system is that the sensed in-line and cross-line velocities will be inherently compensated for the speed and heading of marine currents acting on said streamer positioning device and for relative movements between the vessel 10 and the bird 18.").
a tracking system for tracking the streamer horizontal and vertical positions versus time during a seismic data acquisition run;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 7, Paragraph 1 ("In the preferred embodiment of the present invention, the global control system 22 monitors the actual positions of each of the birds ..."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system.")
an array geometry tracking system for tracking the array geometry versus time during a seismic data acquisition run, wherein the master controller compares the vertical and horizontal positions of the streamers versus time and the array geometry versus time to desired streamer positions and array geometry versus time and issues positioning commands to the ASPDs to maintain the desired streamer positions and array geometry versus time.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to the limitation of "... maintain the desired streamer positions and array geometry versus time" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change". The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. ... In extreme weather conditions, the

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers ....").
15. The apparatus of claim 14 wherein the master controller factors in environmental measurements into the positioning commands to compensate for environmental influences on the positions of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices."). *See also* Claim 14 Analysis.
16. The apparatus of claim 14 wherein the master controller compensates for maneuverability in the positioning commands to compensate for maneuverability influences on the positioning of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array."). At the time of the invention it was obvious to a Person Having

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	Ordinary Skill In The Art at the time of the invention that to "compensate for maneuverability influences" it would be necessary to take into account various maneuverability factors, including, but not necessarily limited to, cable diameter, array type, deployed configuration, vessel type, device type, etc. which are part of the basis for the behavior of the streamers. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system.").
17. The apparatus of claim 14 further comprising: a monitor for determining the status of each streamer, wherein the master controller adjusts the array geometry to compensate for a failed streamer.	A Person Having Ordinary Skill In The Art will recognize that it was obvious common practice at the time of the invention to monitor the status of each streamer. They will also recognize that it was obvious common practice to compensate for failed streamers to the maximum extent that towing capabilities of a given vessel allowed.
20. A seismic streamer array tracking and positioning system comprising:	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.*, Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention".
a towing vessel for towing a seismic array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers ...").

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
a seismic streamer array comprising a plurality of seismic streamers;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers ...").
an active streamer positioning device (ASPD) attached to each seismic streamer for vertically and horizontally positioning each seismic streamer relative to the array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to the limitation of "positioning each seismic streamer relative to the array". ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. ... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth ..."). The '038 patent discloses that this limitation was well known to one skilled in the art prior to and at the time of the invention.

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	See, e.g., '038 patent, Col. 1, ll. 25-56 (discussing the known prior art including attaching control apparatuses to seismic streamers to position streamers).
and a master controller for issuing positioning commands to each ASPD for maintaining a specified array path.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("In the preferred embodiment of the present invention, the control system for the birds 18 is distributed between a global control system 22 located on or near the seismic survey vessel 10 and a local control system located within or near the birds ..."). *See, e.g.*, Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global control system 22 preferably transmits, at regular intervals (such as every five seconds) a desired horizontal force 42 and a desired vertical force 44 to the local control system 36."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2; particularly in regard to the limitation of "specified array path" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle ... . The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change". The turn control mode consists of

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. ... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers."). A Person Having Ordinary Skill In The Art will recognize that towing seismic streamers by a vessel involves moving the streamer array over the water bottom along a path, and involves moving the seismic streamer array along a path through the water. Further, see also Hillesund '895, p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions. ...")
21. The apparatus of claim 20 wherein the master controller issues positioning commands to the towing vessel for maintaining a specified array path.	The Hillesund '895 application discloses this limitation. *See* Claim 20 Analysis. *See, e.g.,* Hillesund '895 at p. 6, Paragraph 2 ("The global *control system* 22 is typically connected to the seismic survey vessel's navigation system and obtains estimates of system wide parameters, such as the vessel's towing direction and velocity and current direction and velocity, from the vessel's navigation

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	system.") A Person Having Ordinary Skill In The Art will recognize that "maintaining a specified array path" is undertaken dominantly by steering commands to the "towing vessel" so as to "maintain[ing] a specified array path." It is recognized that "maintaining a specified array path" is largely determined by the towing motion of the towing vessel, with the effects of cross currents and ASPD steering being smaller. Further, a Person Having Ordinary Skill In The Art will recognize that it has been common commercial practice to have navigation controller systems control the steering of seismic towing vessels since before the priority date of '038 patent.
22. The apparatus of claim 20 further comprising:	The Hillesund '895 application discloses this limitation. See Claim 20 Analysis.
a processor for calculating an optimal path for the seismic array for optimal coverage during seismic data acquisition over a seismic field;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig 4. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices."). A Person Having Ordinary Skill In The Art will recognize that calculating an "optimal path for the seismic array for optimal coverage" has been obvious common commercial practice since before the priority date of the '038 patent. Commercial software for this calculation was available.

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
a streamer behavior prediction processor which predicts array behavior;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").
and wherein the master controller compensates for predicted streamer behavior in issuing vertical and horizontal positioning commands to the towing vessel and the ASPDs for positioning the array along the optimal path.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices."). At the time of the invention of the '038 patent, a Person Having Ordinary Skill In The Art would have found it obvious to position the array along the optimal path, using various technologies including neural-networks and behavior-predictive model based control logic. See Claim 1 Analysis.
23. The apparatus of claim 22 wherein the master controller compensates for environmental factors in the positioning commands.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity.").

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	See, e.g., Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices."). *See also* Claims 2, 5, and 22 Analyses.
24. The apparatus of claim 23 wherein the master controller compensates for maneuverability factors in the positioning commands.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array."). At the time of the invention it was obvious to a Person Having Ordinary Skill In The Art at the time of the invention that to "compensate for maneuverability influences" it would be necessary to take into account various maneuverability factors, including, but not necessarily limited to, cable diameter, array type, deployed configuration, vessel type, device type, etc. which are part of the basis for the behavior of the streamers. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system."). *See also* Claims 6 and 22 Analyses.
25. A seismic streamer array tracking and positioning system comprising:	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.*, Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention".
a towing vessel for towing a seismic array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …").
a seismic streamer array comprising a plurality of seismic streamers;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …").
an active streamer positioning device (ASPD) attached to each seismic streamer for vertically and horizontally positioning each seismic streamer relative to the array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to 'relative' positioning of streamers ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle …

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn .... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers."). The '038 patent discloses that this limitation was well known to one skilled in the art prior to and at the time of the invention. *See, e.g.*, '038 patent, Col. 1, ll. 25-56 (discussing the known prior art including attaching control apparatuses to seismic streamers to position streamers).
a master controller for issuing positioning commands to each ASPD and to the towing vessel for maintaining an optimal path, wherein the master controller further comprises a processor for calculating an optimal path for the seismic array for optimal coverage during seismic	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("In the preferred embodiment of the present invention, the control system for the birds 18 is distributed between a global control system 22 located on or near the seismic survey vessel 10 and a local control system located within or near the birds 18. The global control system 22 is typically connected to the seismic survey

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
data acquisition over a seismic field, and a streamer behavior prediction processor which predicts array behavior, wherein the master controller compensates for predicted streamer behavior in issuing positioning commands to the towing vessel and the ASPDs for positioning the array along the optimal path, wherein the master controller compensates for environmental and maneuverability factors in the positioning commands.	vessel's navigation system and obtains estimates of system wide parameters, such as the vessel's towing direction and velocity and current direction and velocity, from the vessel's navigation system."). *See, e.g.*, Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global control system 22 preferably transmits, at regular intervals (such as every five seconds) a desired horizontal force 42 and a desired vertical force 44 to the local control system 36."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change". The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn ... .In extreme

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices."). *See, e.g.*, Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array."). A Person Having Ordinary Skill In The Art at the time of the '038 invention would have recognized that calculating an "optimal path for the seismic array for optimal coverage" was

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	obvious common commercial practice. ION predecessor companies, among others, offered commercial software for this calculation at this time.
26. A method for tracking and positioning a seismic streamer array comprising:	The Hillesund '895 application and the Roquette '930 patent disclose this limitation. *See, e.g.*, Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.*, Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention."
for towing a seismic array comprising a plurality of seismic streamers;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …").
attaching an active streamer positioning device (ASPD) each seismic streamer for positioning the seismic streamer relative to other seismic streamers within the array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to 'relative' positioning of streamers ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	.... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change". The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn .... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers."). The '038 patent discloses that this limitation was well known to one skilled in the art prior to and at the time of the invention. *See, e.g.,* '038 patent, Col. 1, ll. 25-56 (discussing the known prior art including attaching control apparatuses to seismic streamers to position streamers). The Rouquette '930 patent discloses this limitation. *See, e.g.,* Rouquette '930, Fig. 1. *See, e.g.,* Rouquette '930, Col. 2, ll. 49-52 ("FIG. 1 is side view of a seismic surveying vessel towing a streamer outfitted with sensing and streamer control devices in communication with a controller aboard the vessel in accordance with the invention") *See, e.g.,* Rouquette '930 Col. 4, ll. 6-13 ("Distributed along the

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	length of the streamer 22 are in-streamer sensors 24A-D, such as compasses and depth sensors, and outboard devices, such as cable-leveling birds 26A-B and acoustic ranging transceivers 28A-B. For brevity, all such devices are hereinafter referred to generally as sensors. The outboard sensors are connected to the streamer 22 by means of collars 27 clamped around the streamer.")
and issuing vertical and horizontal positioning commands to each ASPD for maintaining a specified array geometry.	The Hillesund '895 application and the Roquette '930 patent disclose this limitation. *See, e.g.,* Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2; particularly in regard to the limitation of "specified array geometry" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle ... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change". The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. ... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers."). The Rouquette '930 patent discloses this limitation.

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	See, e.g., Rouquette '930, Figs. 1 and 2 *See, e.g.*, Rouquette '930, Col. 3, ll. 23-31 ("These and other objects are achieved by the present invention, which provides a multi-channel, two-wire communication system for sending commands and data requests to and receiving data [f]rom many positioning sensors and cable-leveling devices distributed along a seismic streamer. The apparatus of the invention includes a central controller comprising an intelligent modem that can scan the many streamer devices for cable-positioning data each seismic shot interval."). *See, e.g.*, Rouquette '930, Col. 4, ll. 45-47 ("Control signals are received by the bird electronics 50 to control the wings of the bird and, thereby, the depth of the streamer.").
27. The method of claim 26 further comprising: providing an environmental sensor for sensing environmental factors which influence the path of the towed array.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The "water-referenced" towing velocity and crosscurrent velocity could alternatively be determined using flowmeters or other types of water velocity sensors attached directly to the birds 18. Although these types of sensors are typically quite expensive, one advantage of this type of velocity determination system is that

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	the sensed in-line and cross-line velocities will be inherently compensated for the speed and heading of marine currents acting on said streamer positioning device and for relative movements between the vessel 10 and the bird 18."). The Rouquette '930 patent discloses this limitation. *See, e.g.*, Rouquette '930, Col. 4, ll. 25-28 ("Outfitted with heading sensors and depths sensors, a bird 26 can also communicate heading and depth data to the on-board controller 38 for use in predicting the shape of the streamer 22."). *See, e.g.*, Rouquette '930, Col. 4, ll. 47-51 ("The bird electronics also measure various operating parameters, such as depth, heading, wing angle, temperature, and battery status, and send such data to the controller upon request.").
28. The method of claim 26 further comprising: providing a tracking system for tracking the streamer positions versus time during a seismic data acquisition run and storing the positions versus time in a legacy database for repeating the positions versus time in a subsequent data acquisition; and providing an array geometry tracking system for tracking the array geometry versus time during a seismic data acquisition run and storing the array geometry versus time in a legacy database for repeating the array geometry versus time in a subsequent data acquisition run.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 7, Paragraph 1 ("In the preferred embodiment of the present invention, the global control system 22 monitors the actual positions of each of the birds 18 and is programmed with the desired positions of or the desired minimum separations between the seismic streamers 12."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system.")

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	Persons Having Ordinary Skill In The Art at the time of invention would have recognized that tracking streamer positions and storing the positions in a legacy database, including the times during acquisition, was obvious and had been in widespread industry standard practice since the late 1980's. Industry standards (such as the so-called UKOOA navigation database standards) have existed and been used since the early 1990's. It is also obvious to a Person Having Ordinary Skill In The Art that streamer positions in such a database can be repeatedly utilized. In regard to "array geometry tracking system," *also see, e.g.*, Hillesund '895 at p. 18, Paragraph 3 to p. 19, Paragraph 2 ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle. The feather could be input either manually, through use of a current meter, or through use of an estimated value based on the average horizontal bird forces. Only when the crosscurrent velocity is very small will the feather angle be set to zero and the desired streamer positions be in precise alignment with the towing direction. The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change". The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn. The vessel navigation system will typically notify the global control system 22 when to start throwing the streamers 12 out, and when to start straightening the streamers.

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers.").
29. The method of claim 28 wherein the master controller compares the positions of the streamers versus time and the array geometry versus time to a desired streamer position and array geometry versus time and issues positioning commands to the ASPDs to maintain the desired streamer position and array geometry versus time.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required.").
30. The method of claim 29 wherein the master controller factors in environmental factors into the positioning commands to compensate for environmental influences on the positioning of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").
31. The method of claim 30 wherein the master controller compensates for maneuverability in the positioning commands to compensate for maneuverability influences on the positioning of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array."). At the time of the invention it was obvious to a Person Having Ordinary Skill In The Art at the time of the invention that to "compensate for maneuverability influences" it would be necessary to take into account various maneuverability factors, including, but not necessarily limited to, cable diameter, array type, deployed configuration, vessel type, device type, etc. which are part of the basis for the behavior of the streamers. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system.").
32. The method of claim 26 further comprising: providing a monitor for determining the status of each streamer, wherein the master controller adjusts the array geometry	Person Having Ordinary Skill In The Art will recognize that it was obvious common practice at the time of the invention to monitor the status of each streamer. They will also recognize that it was obvious common practice to compensate for failed streamers to the maximum extent that towing capabilities of a

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
to compensate for a failed streamer.	given vessel allowed.
35. The method of claim 26 wherein the array geometry comprises a plurality of streamers positioned at a uniform depth.	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") Persons Having Ordinary Skill in The Art will recognize that deploying 'a plurality of streamers at a uniform depth' has been the most obvious and common industry practice since the 1980's. *See* Claim 1 Analysis, *generally.*
36. The method of claim 26 wherein the array geometry comprises a plurality of streamers positioned at a plurality of depths for varying temporal resolution of the array.	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") *See, e.g.,* Hillesund '895 at p. 19, Paragraph 2 ("In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible")

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	Persons Having Ordinary Skill in The Art will recognize that deploying 'a plurality of streamers positioned at a plurality of depths' has been obvious and has been selectively utilized in industry practice since the 1980's. In addition to other industry practitioners, a predecessor company of WesternGeco utilized so-called "over-under" streamer acquisition selectively since before the priority date for the '038 patent. *See* Claim 1 Analysis, *generally*.
38. The method of claim 29 wherein the array geometry is tracked via satellite and communicated to the master controller.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 1 ("Alternatively, or additionally, satellite-based global positioning system equipment can be used to determine the positions of the equipment."). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("The global control system 22 is typically connected to the seismic survey vessel's navigation system and obtains estimates of system wide parameters, such as the vessel's towing direction and velocity and current direction and velocity, from the vessel's navigation system.").
39. A method for tracking and positioning a seismic streamer array comprising:	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.*, Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention".
towing a seismic array comprising a plurality of seismic streamers from a	The Hillesund '895 application discloses this limitation. The Hillesund '895 application discloses this limitation.

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
towing vessel;	*See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers ..."). *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers ...").
attaching an active streamer positioning device (ASPD) to each seismic streamer for positioning each seismic streamer;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to "positioning" of streamers ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. ...") The '038 patent discloses that this limitation was well known to one skilled in the art prior to and at the time of the invention. *See, e.g.*, '038 patent, Col. 1, ll. 25-56 (discussing the known prior art including attaching control apparatuses to seismic streamers to position streamers).
issuing positioning commands from a master controller to each ASPD to adjust vertical and horizontal position of a first streamer relative to a second streamer in the array for maintaining a specified array geometry;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("In the preferred embodiment of the present invention, the control system for the birds 18 is distributed between a global control system 22 located on or near the seismic survey vessel 10 and a local control system located within or near the birds 18.").

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	See, e.g., Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global control system 22 preferably transmits, at regular intervals (such as every five seconds) a desired horizontal force 42 and a *desired vertical force* 44 to the local control system 36."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2; particularly in regard to the limitation of "maintaining a specified array geometry" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change". ... Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn .... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	bird 18 to the midpoint position between its adjacent streamers.").
sensing environmental factors which influence the towed path of the towed array;	The Hillesund '895 application and Roquette '930 patent disclose this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The "water-referenced" towing velocity and crosscurrent velocity could alternatively be determined using flowmeters or other types of water velocity sensors attached directly to the birds 18. Although these types of sensors are typically quite expensive, one advantage of this type of velocity determination system is that the sensed in-line and cross-line velocities will be inherently compensated for the speed and heading of marine currents acting on said streamer positioning device and for relative movements between the vessel 10 and the bird 18."). The Rouquette '930 patent discloses this limitation. *See, e.g.*, Rouquette '930, Col. 4, ll. 25-28 ("Outfitted with heading sensors and depths sensors, a bird 26 can also communicate heading and depth data to the on-board controller 38 for use in predicting the shape of the streamer 22.").

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	See, e.g., Rouquette '930, Col. 4, ll. 47-51 ("The bird electronics also measure various operating parameters, such as depth, heading, wing angle, temperature, and battery status, and send such data to the controller upon request.").
tracking the streamer positions versus time during a seismic data acquisition run;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 7, Paragraph 1 ("In the preferred embodiment of the present invention, the global control system 22 monitors the actual positions of each of the birds …"). Persons Having Ordinary Skill In The Art at the time of invention would have recognized that tracking streamer positions and storing the positions in a legacy database, including the times during acquisition, was obvious and had been in widespread industry standard practice since the late 1980's. Industry standards (such as the so-called UKOOA navigation database standards) have existed and been used since the early 1990's. It is also obvious to a Person Having Ordinary Skill In The Art that streamer positions in such a database can be repeatedly utilized.
tracking the array geometry versus time during a seismic data acquisition run, wherein the master controller compares the positions of the streamers versus time and the array geometry versus time to desired streamer positions and array geometry versus time and issues positioning commands to the ASPDs to maintain the desired streamer positions and array geometry versus	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The global

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
time.	control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required.").
40. The method of claim 39 wherein the master controller factors in environmental measurements into the positioning commands to compensate for environmental influences on the positions of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").
41. The method of claim 39 wherein the master controller compensates for maneuverability in the positioning commands to compensate for maneuverability influences on the positioning of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array."). At the time of the invention it was obvious to a Person Having

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	Ordinary Skill In The Art at the time of the invention that to "compensate for maneuverability influences" it would be necessary to take into account various maneuverability factors, including, but not necessarily limited to, cable diameter, array type, deployed configuration, vessel type, device type, etc. which are part of the basis for the behavior of the streamers. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system.").
42. The method of claim 39 further comprising: determining the status of each streamer, wherein the master controller adjusts the array geometry to compensate for a failed streamer.	The Hillesund '895 application discloses this limitation. A Person Having Ordinary Skill In The Art will recognize that it was obvious common practice at the time of the invention to monitor the status of each streamer. They will also recognize that it was obvious common practice to compensate for failed streamers to the maximum extent that towing capabilities of a given vessel allowed.
45. A method for tracking and positioning seismic streamer array comprising:	The Hillesund '895 application and the Roquette '930 patent disclose this limitation. *See* Claim 1 Analysis.
towing a seismic array comprising a plurality of seismic streamers;	The Hillesund '895 application discloses this limitation. *See* Claim 1 Analysis.
attaching an active streamer positioning device (ASPD) attached to each seismic streamer for positioning each seismic streamer;	The Hillesund '895 application discloses this limitation. *See* Claims 1 and 26 Analyses.
and issuing vertical and horizontal positioning commands to each ASPD for maintaining a specified	The Hillesund '895 application discloses this limitation. *See* Claims 1 and 26 Analyses.

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
array path.	
46. The method of claim 45 wherein a master controller issues positioning commands to the towing vessel for maintaining a specified array path.	The Hillesund '895 application discloses this limitation. *See* Claims 1, 21, and 45 Analyses.
47. The method of claim 45 further comprising: calculating an optimal path for the seismic array for optimal coverage during seismic data acquisition over a seismic field;	The Hillesund '895 application discloses this limitation. *See* Claims 1, 22, and 45 Analyses.
predicting array behavior;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig 4. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").
and compensating for predicted streamer behavior in issuing positioning commands to the towing vessel and the ASPDs for positioning the array along the optimal path.	The Hillesund '895 application discloses this limitation. *See* Claims 1, 21, 22, and 45 Analyses.
48. The method of claim 47 wherein the master controller compensates for environmental factors in the positioning commands.	The Hillesund '895 application discloses this limitation. *See* Claims 15, 30, and 40 Analyses.

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
49. The method of claim 48 wherein the master controller compensates for maneuverability factors in the positioning commands.	The Hillesund '895 application discloses this limitation. *See* Claims 16, 31, and 41 Analyses.
50. A method for tracking and positioning a seismic streamer array comprising:	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.*, Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention".
towing a seismic array comprising a plurality of seismic streamers;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …").
attaching an active streamer positioning device (ASPD) attached to each seismic streamer for positioning each seismic streamer;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer ...") *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to "positioning each seismic streamer" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle …

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. …") The '038 patent discloses that this limitation was well known to one skilled in the art prior to and at the time of the invention. *See, e.g.*, '038 patent, Col. 1, ll. 25-56 (discussing the known prior art, including attaching control apparatuses to seismic streamers to position streamers).
issuing horizontal and vertical positioning commands to each ASPD and to the towing vessel for maintaining an optimal path, calculating an optimal path for the seismic array for optimal coverage during seismic data acquisition over a seismic field, and a behavior prediction processor which predicting array behavior, wherein the master controller compensates for predicted streamer behavior in issuing positioning commands to the towing vessel and the ASPDs for positioning the array along the optimal path, wherein the master controller compensates for environmental and maneuverability factors in the positioning commands.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global control system 22 preferably transmits, at regular intervals (such as every five seconds) a desired horizontal force 42 and a desired vertical force 44 to the local control system 36."). See, e.g., Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 located on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required.").

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Hillesund '895 Application and Rouquette '930
	See, e.g., Hillesund '895 at p. 6, Paragraph 3 ("To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system."). *See also* Claims 1, 2, 5, 6, 21, 22, and 25 Analyses.

2662748v1

EXHIBIT 9

EXHIBIT 9

U.S. Patent No. 6,691,038 (the " '038 patent") Is Obvious In View of International Patent Application WO 2000/20895 ("Hillesund '895 Application") and U.S. Patent 5,546,882 ("Kuche '882")

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Prior Art
1. A seismic streamer array tracking and positioning system comprising:	The Hillesund WO 00/20895 International Application discloses this limitation. *See, e.g.*, Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.*, Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention".
a towing vessel for towing a seismic array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers ...").
an array comprising a plurality of seismic streamers;	The Hillesund '895 reference discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers ...").
an active streamer positioning device (ASPD) attached to at least one seismic streamer for positioning the seismic streamer relative to other seismic streamers within the array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to 'relative' positioning of

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Prior Art
	streamers ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle … . The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change". The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn …. In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers."). The '038 patent discloses that this limitation was well known to one skilled in the art prior to and at the time of the invention. *See, e.g.,* '038 patent, Col. 1, ll. 25-56 (discussing the known prior art including attaching control apparatuses to seismic streamers to position streamers).
and a master controller for issuing positioning commands to each ASPD to adjust a vertical and horizontal position of a first streamer relative to a second streamer within the array for maintaining a specified	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895 at p. 6, Paragraph 2 ("In the preferred embodiment of the present invention, the control system for the birds 18 is distributed between a global control system 22 located on or near the seismic survey vessel 10 and a local

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Prior Art
array geometry.	control system located within or near the birds 18. The global control system 22 is typically connected to the seismic survey vessel's navigation system and obtains estimates of system wide parameters, such as the vessel's towing direction and velocity and current direction and velocity, from the vessel's navigation system."). *See, e.g.*, Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global control system 22 preferably transmits, at regular intervals (such as every five seconds) a desired horizontal force 42 and a desired vertical force 44 to the local control system 36."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2; particularly in regard to the limitation of "specified array geometry" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Prior Art
	during the turn and will be returned to a common depth as soon as possible after the completion of the turn .... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers.").
2. The apparatus of claim 1 further comprising: an environmental sensor for sensing environmental factors which influence the path of the towed array.	The Hillesund '895 application discloses this limitation. *See* Claim 1 Analysis. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers.") *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The "water-referenced" towing velocity and crosscurrent velocity could alternatively be determined using flowmeters or other types of water velocity sensors attached directly to the birds 18. Although these types of sensors are typically quite expensive, one advantage of this type of velocity determination system is that the sensed in-line and cross-line velocities will be inherently compensated for the speed and heading of marine currents acting

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Prior Art
	on said streamer positioning device and for relative movements between the vessel 10 and the bird 18.").
3. The apparatus of claim 1 further comprising:	The Hillesund '895 application discloses this limitation. See Claim 1 Analysis.
a tracking system for tracking the streamer positions versus time during a seismic data acquisition run and storing the positions versus time in a legacy database for repeating the positions versus time in a subsequent data acquisition;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 7, Paragraph 1 ("In the preferred embodiment of the present invention, the global control system 22 monitors the actual positions of each of the birds 18 and is programmed with the desired positions of or the desired minimum separations between the seismic streamers 12."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system.") Persons Having Ordinary Skill In The Art at the time of invention would have recognized that tracking streamer positions and storing the positions in a legacy database, including the times during acquisition, was obvious and had been in widespread industry standard practice since the late 1980's. Industry standards (such as the so-called UKOOA navigation database standards) have existed and been used since the early 1990's. It is also obvious to a Person Having Ordinary Skill In The Art that streamer positions in such a database can be repeatedly utilized.

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Prior Art
and an array geometry tracking system for tracking the array geometry versus time during a seismic data acquisition run and storing the array geometry versus time in a legacy database for repeating the array geometry versus time in a subsequent data acquisition run.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle. The feather could be input either manually, through use of a current meter, or through use of an estimated value based on the average horizontal bird forces. Only when the crosscurrent velocity is very small will the feather angle be set to zero and the desired streamer positions be in precise alignment with the towing direction. The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn. The vessel navigation system will typically notify the global control system 22 when to start throwing the streamers 12 out, and when to start straightening the streamers. In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Prior Art
	streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers."). Persons Having Ordinary Skill In The Art at the time of invention would have recognized that tracking the array geometry and storing the array geometry in a legacy database, including the times during acquisition, was obvious and had been in widespread industry standard practice since the late 1980's. Industry standards (such as the so-called UKOOA navigation database standards) have existed and been used since the early 1990's. It is also obvious to a Person Having Ordinary Skill In The Art that the array geometry in such a database can be repeatedly utilized.
4. The apparatus of claim 3 wherein the master controller compares the positions of the streamers versus time and the array geometry versus time to a desired streamer position and array geometry versus time and issues positioning commands to the ASPDs to maintain the desired streamer position and array geometry versus time.	The Hillesund '895 application discloses this limitation. *See* Claim 3 Analysis. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 located on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required.").

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Prior Art
5. The apparatus of claim 4 wherein the master controller factors in environmental factors into the positioning commands to compensate for environmental influences on the positioning of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See* Claim 4 Analysis. *See, e.g.,* Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.,* Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").
6. The apparatus of claim 4 wherein the master controller compensates for maneuverability in the positioning commands to compensate for maneuverability influences on the positioning of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See* Claim 4 Analysis. *See, e.g.,* Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array."). *See, e.g.,* Hillesund '895 at p. 8, Paragraph 3 ("The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system."). At the time of the invention it was obvious to a Person Having Ordinary Skill In The Art at the time of the invention that to "compensate for maneuverability influences" it would be necessary to take into account various maneuverability factors,

U.S. Patent No. 6,691,038 Asserted Claims	Citations from Prior Art
	including, but not necessarily limited to, cable diameter, array type, deployed configuration, vessel type, device type, etc. which are part of the basis for the behavior of the streamers. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system.").
10. The apparatus of claim 1 wherein the array geometry comprises a plurality of streamers positioned at a uniform depth.	The Hillesund '895 application discloses this limitation. *See* Claim 1 Analysis. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") Persons Having Ordinary Skill in The Art will recognize that deploying 'a plurality of streamers at a uniform depth' has been the most obvious and common industry practice since the 1980's.

11. The apparatus of claim 1 wherein the array geometry comprises a plurality of streamers positioned at a plurality of depths for varying temporal resolution of the array.	The Hillesund '895 application discloses this limitation. *See* Claim 1 Analysis. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") *See, e.g.*, Hillesund '895 at p. 19, Paragraph 2 ("In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the

	global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible") Persons Having Ordinary Skill in The Art will recognize that deploying 'a plurality of streamers positioned at a plurality of depths' has been obvious and has been selectively utilized in industry practice since the 1980's. In addition to other industry practitioners, a predecessor company of WesternGeco utilized so-called "over-under" streamer acquisition selectively since before the priority date for the '038 patent.
13. The apparatus of claim 4 wherein the array geometry is tracked via satellite and communicated to the master controller.	The Hillesund '895 application and the Kuche '882 patent disclose this limitation. *See* Claim 4 Analysis. *See, e.g.,* Hillesund '895 at p. 6, Paragraph 2 ("The global control system 22 is typically connected to the seismic survey vessel's navigation system and obtains estimates of system wide parameters, such as the vessel's towing direction and velocity and current direction and velocity, from the vessel's navigation system."). *See, e.g.,* Hillesund '895 at p. 7, Paragraph 1 ("Alternatively, or additionally, satellite-based global positioning system equipment can be used to determine the positions of the equipment."). The Kuche '882 patent discloses this limitation of using satellites to track the streamer array, and communicating the satellite navigation data along a streamer. *See,* e.g., Kuche '882, Col. 1, ll. 3-11 (disclosing an apparatus to use satellites, specifically global positioning system ("GPS"), to track streamer positions). *See,* e.g., Col. 2, ll. 3-6 and ll. 13-15 ("The drawing shows a buoy or float 1 at the sea surface and preferably provided with a GPS receiver 1A with an associated antenna 1B so as to serve as a reference position in a seismic assembly being towed. ... in particular signal or data transmission between the buoy 1 and the streamer 4")

14. A seismic streamer array tracking and positioning system comprising:	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.*, Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention".
a towing vessel for towing a seismic array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …").
a seismic streamer array comprising a plurality of seismic streamers; an active streamer positioning device (ASPD) attached to each seismic streamer for positioning each seismic streamer;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …"). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.")
a master controller for issuing vertical and horizontal positioning commands to each ASPD for maintaining a specified array geometry;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("In the preferred embodiment of the present invention, the control system for the birds 18 is distributed between a global control system 22 located on or near the seismic survey vessel 10 and a local control system located within or near the birds 18. The global control system 22 is typically connected to the seismic survey vessel's navigation system and obtains estimates of system wide parameters, such as the vessel's towing direction and velocity and current direction and velocity, from the vessel's navigation system."). *See, e.g.*, Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global control system 22 preferably transmits, at regular intervals (such as every

	five seconds) a desired horizontal force 42 and a desired vertical force 44 to the local control system 36."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. ..."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2; particularly in regard to the limitation of "specified array geometry" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change". ... Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn .... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. ...")
an environmental sensor for sensing environmental factors which influence the towed path of the towed array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers.") *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically *acquire* the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. ...") *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The "water-

	referenced" towing velocity and crosscurrent velocity could alternatively be determined using flowmeters or other types of water velocity sensors attached directly to the birds 18. Although these types of sensors are typically quite expensive, one advantage of this type of velocity determination system is that the sensed in-line and cross-line velocities will be inherently compensated for the speed and heading of marine currents acting on said streamer positioning device and for relative movements between the vessel 10 and the bird 18.").
a tracking system for tracking the streamer horizontal and vertical positions versus time during a seismic data acquisition run;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 7, Paragraph 1 ("In the preferred embodiment of the present invention, the global control system 22 monitors the actual positions of each of the birds ..."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system.")
an array geometry tracking system for tracking the array geometry versus time during a seismic data acquisition run, wherein the master controller compares the vertical and horizontal positions of the streamers versus time and the array geometry versus time to desired streamer positions and array geometry versus time and issues positioning commands to the ASPDs to maintain the desired streamer positions and array geometry versus time.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to the limitation of "maintain the desired streamer positions and array geometry versus time." ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control

	mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. ... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers ...").
15. The apparatus of claim 14 wherein the master controller factors in environmental measurements into the positioning commands to compensate for environmental influences on the positions of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See* Claim 14 Analysis. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").
16. The apparatus of claim 14 wherein the master controller compensates for maneuverability in the positioning commands to compensate for maneuverability influences on the positioning of the	The Hillesund '895 application discloses this limitation. *See* Claim 14 Analysis. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal

streamers and the array geometry.	forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array."). A Person Having Ordinary Skill In The Art at the time of the invention would find this limitation to be inherent in the invention. To "compensate for maneuverability influences" it would be necessary to take into account various maneuverability factors, including, but not necessarily limited to, cable diameter, array type, deployed configuration, vessel type, device type, etc. which are part of the basis for the behavior of the streamers. *See, e.g.,* Hillesund '895 at p. 8, Paragraph 3 ("The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system."). At the time of the invention it was obvious to a Person Having Ordinary Skill In The Art at the time of the invention that to "compensate for maneuverability influences" it would be necessary to take into account various maneuverability factors, including, but not necessarily limited to, cable diameter, array type, deployed configuration, vessel type, device type, etc. which are part of the basis for the behavior of the streamers.
17. The apparatus of claim 14 further comprising: a monitor for determining the status of each streamer, wherein the master controller adjusts the array geometry to compensate for a failed streamer.	The Hillesund '895 application discloses this limitation. A Person Having Ordinary Skill In The Art will recognize that it was obvious common practice at the time of the invention to monitor the status of each streamer. They will also recognize that it was obvious common practice to compensate for failed streamers to the maximum extent that towing capabilities of a given vessel allowed.
20. A seismic streamer array tracking and positioning system comprising:	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.,* Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention."

a towing vessel for towing a seismic array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …").
a seismic streamer array comprising a plurality of seismic streamers;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …").
an active streamer positioning device (ASPD) attached to each seismic streamer for vertically and horizontally positioning each seismic streamer relative to the array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to the limitation of "positioning each seismic streamer relative to the array". ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle …. The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change". The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode.… In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth ..."). The '038 patent discloses that this limitation was well known to one skilled in the art prior to and at the time of the invention.

	See, e.g., '038 patent, Col. 1, ll. 25-56 (discussing the known prior art including attaching control apparatuses to seismic streamers to position streamers).
and a master controller for issuing positioning commands to each ASPD for maintaining a specified array path.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("In the preferred embodiment of the present invention, the control system for the birds 18 is distributed between a global control system 22 located on or near the seismic survey vessel 10 and a local control system located within or near the birds ..."). *See, e.g.*, Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global control system 22 preferably transmits, at regular intervals (such as every five seconds) a desired horizontal force 42 and a desired vertical force 44 to the local control system 36."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2; particularly in regard to the limitation of "specified array path" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle ... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. ... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode

	that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers.").
21. The apparatus of claim 20 wherein the master controller issues positioning commands to the towing vessel for maintaining a specified array path.	The Hillesund '895 application discloses this limitation. *See* Claim 20 Analysis. See, e.g., Hillesund '895 at p. 6, Paragraph 2 ("The global control system 22 is typically connected to the seismic survey vessel's navigation system and obtains estimates of system wide parameters, such as the vessel's towing direction and velocity and current direction and velocity, from the vessel's navigation system.") In addition, Persons Having Ordinary Skill In The Art will readily recognize that the seismic survey vessel's navigation system is typically utilized to steer the vessel in routine seismic acquisition operations ("auto-pilot").
22. The apparatus of claim 20 further comprising:	The Hillesund '895 application discloses this limitation. See Claim 20 Analysis.
a processor for calculating an optimal path for the seismic array for optimal coverage during seismic data acquisition over a seismic field;	The Hillesund '895 application discloses this limitation. *See* Claim 20 Analysis. *See, e.g.*, Hillesund '895, Fig 4. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices."). A Person Having Ordinary Skill In The Art will recognize that calculating an "optimal path for the seismic array for optimal coverage" has been obvious common commercial practice since before the priority date of the '038 patent. Commercial software

	for this calculation was available.
a streamer behavior prediction processor which predicts array behavior;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").
and wherein the master controller compensates for predicted streamer behavior in issuing vertical and horizontal positioning commands to the towing vessel and the ASPDs for positioning the array along the optimal path.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices."). At the time of the invention of the '038 patent, a Person Having Ordinary Skill In The Art would have found it obvious to position the array along the optimal path, using various technologies including neural-networks and behavior-predictive model based control logic.
23. The apparatus of claim 22 wherein the master controller compensates for environmental factors in the positioning commands.	The Hillesund '895 application discloses this limitation. *See* Claim 22 Analysis. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. To compensate for these localized current fluctuations, the inventive control

	system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").
24. The apparatus of claim 23 wherein the master controller compensates for maneuverability factors in the positioning commands.	The Hillesund '895 application discloses this limitation. *See* Claim 23 Analysis. *See, e.g.,* Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array."). This limitation is inherent. It would be necessary to take into account some maneuverability factors such as cable diameter, array type, deployed configuration which are part of the basis for the behavior of the streamers to be able to implement the invention of Claim 23. *See, e.g.,* Hillesund '895 at p. 8, Paragraph 3 ("The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system."). At the time of the invention it was obvious to a Person Having Ordinary Skill In The Art at the time of the invention that to "compensate for maneuverability influences" it would be necessary to take into account various maneuverability factors, including, but not necessarily limited to, cable diameter, array type, deployed configuration, vessel type, device type, etc. which are part of the basis for the behavior of the streamers.
25. A seismic streamer array tracking and positioning system comprising:	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.,* Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention."
a towing vessel for towing a seismic array;	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown

	towing eight marine seismic streamers …").
a seismic streamer array comprising a plurality of seismic streamers;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …").
an active streamer positioning device (ASPD) attached to each seismic streamer for vertically and horizontally positioning each seismic streamer relative to the array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to 'relative' positioning of streamers ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle …. The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change". The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn …. In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner

	streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers."). The '038 patent discloses that this limitation was well known to one skilled in the art prior to and at the time of the invention. *See, e.g.*, '038 patent, Col. 1, ll. 25-56 (discussing the known prior art including attaching control apparatuses to seismic streamers to position streamers).
a master controller for issuing positioning commands to each ASPD and to the towing vessel for maintaining an optimal path, wherein the master controller further comprises a processor for calculating an optimal path for the seismic array for optimal coverage during seismic data acquisition over a seismic field, and a streamer behavior prediction processor which predicts array behavior, wherein the master controller compensates for predicted streamer behavior in issuing positioning commands to the towing vessel and the ASPDs for positioning the array along the optimal path, wherein the master controller compensates for environmental and maneuverability factors in the positioning commands.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("In the preferred embodiment of the present invention, the control system for the birds 18 is distributed between a global control system 22 located on or near the seismic survey vessel 10 and a local control system located within or near the birds 18. The global control system 22 is typically connected to the seismic survey vessel's navigation system and obtains estimates of system wide parameters, such as the vessel's towing direction and velocity and current direction and velocity, from the vessel's navigation system."). *See, e.g.*, Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global control system 22 preferably transmits, at regular intervals (such as every five seconds) a desired horizontal force 42 and a desired vertical force 44 to the local control system 36."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control

	system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn .... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").

	See, e.g., Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array."). A Person Having Ordinary Skill In The Art at the time of the '038 invention would have recognized that calculating an "optimal path for the seismic array for optimal coverage" was obvious common commercial practice. ION predecessor companies, among others, offered commercial software for this calculation at this time.
26. A method for tracking and positioning a seismic streamer array comprising:	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.*, Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention."
for towing a seismic array comprising a plurality of seismic streamers;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers ...").
attaching an active streamer positioning device (ASPD) each seismic streamer for positioning the seismic streamer relative to other seismic streamers within the array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to 'relative' positioning of streamers ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control

	mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn .... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers."). The '038 patent discloses that this limitation was well known to one skilled in the art prior to and at the time of the invention. *See, e.g.*, '038 patent, Col. 1, ll. 25-56 (discussing the known prior art including attaching control apparatuses to seismic streamers to position streamers).
and issuing vertical and horizontal positioning commands to each ASPD for maintaining a specified array geometry.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2; particularly in regard to the limitation of "specified array geometry" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. ... In extreme weather conditions, the inventive control

	system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers.").
27. The method of claim 26 further comprising: providing an environmental sensor for sensing environmental factors which influence the path of the towed array.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The "water-referenced" towing velocity and crosscurrent velocity could alternatively be determined using flowmeters or other types of water velocity sensors attached directly to the birds 18. Although these types of sensors are typically quite expensive, one advantage of this type of velocity determination system is that the sensed in-line and cross-line velocities will be inherently compensated for the speed and heading of marine currents acting on said streamer positioning device and for relative movements between the vessel 10 and the bird 18.").
28. The method of claim 26 further comprising: providing a tracking system for tracking the streamer positions versus time during a seismic data acquisition run and	The Hillesund '895 application discloses this limitation. *See* Claim 26 Analysis. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control

storing the positions versus time in a legacy database for repeating the positions versus time in a subsequent data acquisition; and providing an array geometry tracking system for tracking the array geometry versus time during a seismic data acquisition run and storing the array geometry versus time in a legacy database for repeating the array geometry versus time in a subsequent data acquisition run.	system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 7, Paragraph 1 ("In the preferred embodiment of the present invention, the global control system 22 monitors the actual positions of each of the birds 18 and is programmed with the desired positions of or the desired minimum separations between the seismic streamers 12."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system.") In regard to "array geometry tracking system," *see, e.g.*, Hillesund '895 at p. 18, Paragraph 3 to p. 19, Paragraph 2 ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle. The feather could be input either manually, through use of a current meter, or through use of an estimated value based on the average horizontal bird forces. Only when the crosscurrent velocity is very small will the feather angle be set to zero and the desired streamer positions be in precise alignment with the towing direction. The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change". The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn. The vessel navigation system will typically

	notify the global control system 22 when to start throwing the streamers 12 out, and when to start straightening the streamers. In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers."). Persons Having Ordinary Skill In The Art at the time of invention would have recognized that tracking streamer positions and storing the positions in a legacy database, including the times during acquisition, was obvious and had been in widespread industry standard practice since the late 1980's. Industry standards (such as the so-called UKOOA navigation database standards) have existed and been used since the early 1990's. It is also obvious to a Person Having Ordinary Skill In The Art that streamer positions in such a database can be repeatedly utilized.
29. The method of claim 28 wherein the master controller compares the positions of the streamers versus time and the array geometry versus time to a desired streamer position and array geometry versus time and issues positioning commands to the ASPDs to maintain the desired streamer position and array geometry versus time.	The Hillesund '895 application discloses this limitation. *See* Claim 28 Analysis. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required.").

30. The method of claim 29 wherein the master controller factors in environmental factors into the positioning commands to compensate for environmental influences on the positioning of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See* Claim 29 Analysis. *See, e.g.,* Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.,* Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").
31. The method of claim 30 wherein the master controller compensates for maneuverability in the positioning commands to compensate for maneuverability influences on the positioning of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See* Claim 30 Analysis. *See, e.g.,* Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array."). A Person Having Ordinary Skill In The Art at the time of the invention would find this limitation to be inherent in the invention. To "compensate for maneuverability influences" it would be necessary to take into account various maneuverability factors, including, but not necessarily limited to, cable diameter, array type, deployed configuration, vessel type, device type, etc. which are part of the basis for the behavior of the streamers. *See, e.g.,* Hillesund '895 at p. 8, Paragraph 3 ("The force and

	velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system."). At the time of the invention it was obvious to a Person Having Ordinary Skill In The Art at the time of the invention that to "compensate for maneuverability influences" it would be necessary to take into account various maneuverability factors, including, but not necessarily limited to, cable diameter, array type, deployed configuration, vessel type, device type, etc. which are part of the basis for the behavior of the streamers.
32. The method of claim 26 further comprising: providing a monitor for determining the status of each streamer, wherein the master controller adjusts the array geometry to compensate for a failed streamer.	Person Having Ordinary Skill In The Art will recognize that it was obvious common practice at the time of the invention to monitor the status of each streamer. They will also recognize that it was obvious common practice to compensate for failed streamers to the maximum extent that towing capabilities of a given vessel allowed.
35. The method of claim 26 wherein the array geometry comprises a plurality of streamers positioned at a uniform depth.	The Hillesund '895 application discloses this limitation. *See* Claim 26 Analysis. *See, e.g.,* Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") Persons Having Ordinary Skill in The Art will recognize that deploying 'a plurality of streamers at a uniform depth' has been the most obvious and common industry practice since the 1980's.
36. The method of claim 26 wherein the array geometry comprises a plurality of streamers positioned at a plurality of depths for varying temporal resolution of the array.	The Hillesund '895 application discloses this limitation. *See* Claim 26 Analysis. *See, e.g.,* Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and

	horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") *See, e.g.*, Hillesund '895 at p. 19, Paragraph 2 ("In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible") Persons Having Ordinary Skill in The Art will recognize that deploying 'a plurality of streamers positioned at a plurality of depths' has been obvious and has been selectively utilized in industry practice since the 1980's. In addition to other industry practitioners, a predecessor company of WesternGeco utilized so-called "over-under" streamer acquisition selectively since before the priority date for the '038 patent.
38. The method of claim 29 wherein the array geometry is tracked via satellite and communicated to the master controller.	The Hillesund '895 application and the Kuche '882 patent disclose this limitation. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 1 ("Alternatively, or additionally, satellite-based global positioning system equipment can be used to determine the positions of the equipment."). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("The global control system 22 is typically connected to the seismic survey vessel's navigation system and obtains estimates of system wide parameters, such as the vessel's towing direction and velocity and current direction and velocity, from the vessel's navigation system."). The Kuche '882 patent discloses this limitation of using satellites to track the streamer array, and communicating the satellite navigation data along a streamer. *See,* e.g., Kuche '882, Col. 1, ll. 3-11 (disclosing an apparatus to use satellites, specifically global positioning system ("GPS"), to track streamer positions) *See,* e.g., Col. 2, ll. 3-6 and ll. 13-15 ("The drawing shows a buoy or float 1 at the sea surface and preferably provided with a GPS receiver 1A with an associated antenna 1B so as to serve as a

	reference position in a seismic assembly being towed. ... in particular signal or data transmission between the buoy 1 and the streamer 4") *See,* e.g., Kuche '882, Col. 1, ll. 3-11 (disclosing an apparatus to use satellites, specifically global positioning system ("GPS"), to track streamer positions; further, *see,* e.g., Col. 2, ll. 13-15 (" ... in particular signal or data transmission between the [GPS satellite navigation] buoy 1 and the streamer 4")
39. A method for tracking and positioning a seismic streamer array comprising:	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.,* Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention."
towing a seismic array comprising a plurality of seismic streamers from a towing vessel;	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers ..."). *See, e.g.,* Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers ...").
attaching an active streamer positioning device (ASPD) to each seismic streamer for positioning each seismic streamer;	The Hillesund '895 application discloses this limitation. *See, e.g.,* Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer 12 between the deflector 16 and the tail buoy 20 in both the vertical (depth) and horizontal directions.") *See, e.g.,* Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to "positioning" of streamers ("The

	inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. ...") In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. ..."). The '038 patent discloses that this limitation was well known to one skilled in the art prior to and at the time of the invention. *See, e.g.*, '038 patent, Col. 1, ll. 25-56 (discussing the known prior art including attaching control apparatuses to seismic streamers to position streamers).
issuing positioning commands from a master controller to each ASPD to adjust vertical and horizontal position of a first streamer relative to a second streamer in the array for maintaining a specified array geometry;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("In the preferred embodiment of the present invention, the control system for the birds 18 is distributed between a global control system 22 located on or near the seismic survey vessel 10 and a local control system located within or near the birds 18."). *See, e.g.*, Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global control system 22 preferably transmits, at regular intervals (such as every five seconds) a desired horizontal force 42 and a desired vertical force 44 to the local control system 36."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2; particularly in regard to the limitation of "maintaining a specified array geometry" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control

	mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn .... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers.").
sensing environmental factors which influence the towed path of the towed array;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers.") *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The "water-

	referenced" towing velocity and crosscurrent velocity could alternatively be determined using flowmeters or other types of water velocity sensors attached directly to the birds 18. Although these types of sensors are typically quite expensive, one advantage of this type of velocity determination system is that the sensed in-line and cross-line velocities will be inherently compensated for the speed and heading of marine currents acting on said streamer positioning device and for relative movements between the vessel 10 and the bird 18.").
tracking the streamer positions versus time during a seismic data acquisition run;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 7, Paragraph 1 ("In the preferred embodiment of the present invention, the global control system 22 monitors the actual positions of each of the birds 18 and is programmed with the desired positions of or the desired minimum separations between the seismic streamers 12."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system.") Persons Having Ordinary Skill In The Art at the time of invention would have recognized that tracking streamer positions and storing the positions in a legacy database, including the times during acquisition, was obvious and had been in widespread industry standard practice since the late 1980's. Industry standards (such as the so-called UKOOA navigation database standards) have existed and been used since the early 1990's. It is also obvious to a Person Having Ordinary Skill In The Art that streamer positions in such a database can be repeatedly utilized.

tracking the array geometry versus time during a seismic data acquisition run, wherein the master controller compares the positions of the streamers versus time and the array geometry versus time to desired streamer positions and array geometry versus time and issues positioning commands to the ASPDs to maintain the desired streamer positions and array geometry versus time.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required.").
40. The method of claim 39 wherein the master controller factors in environmental measurements into the positioning commands to compensate for environmental influences on the positions of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See* Claim 39 Analysis. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").

41. The method of claim 39 wherein the master controller compensates for maneuverability in the positioning commands to compensate for maneuverability influences on the positioning of the streamers and the array geometry.	The Hillesund '895 application discloses this limitation. *See* Claim 39 Analysis. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array."). A Person Having Ordinary Skill In The Art at the time of the invention would find this limitation to be inherent in the invention. To "compensate for maneuverability influences" it would be necessary to take into account various maneuverability factors, including, but not necessarily limited to, cable diameter, array type, deployed configuration, vessel type, device type, etc. which are part of the basis for the behavior of the streamers. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system."). At the time of the invention it was obvious to a Person Having Ordinary Skill In The Art at the time of the invention that to "compensate for maneuverability influences" it would be necessary to take into account various maneuverability factors, including, but not necessarily limited to, cable diameter, array type, deployed configuration, vessel type, device type, etc. which are part of the basis for the behavior of the streamers.
42. The method of claim 39 further comprising: determining the status of each streamer, wherein the master controller adjusts the array geometry to compensate for a failed streamer.	The Hillesund '895 application discloses this limitation. A Person Having Ordinary Skill In The Art will recognize that it was obvious common practice at the time of the invention to monitor the status of each streamer. They will also recognize that it was obvious common practice to compensate for failed streamers to the maximum extent that towing capabilities of a given vessel allowed.
45. A method for tracking and positioning seismic streamer array comprising:	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer

	positioning devices attached to the streamer cables. *See, e.g.*, Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention."
towing a seismic array comprising a plurality of seismic streamers;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …").
attaching an active streamer positioning device (ASPD) attached to each seismic streamer for positioning each seismic streamer;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer ...") *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to "positioning each seismic streamer" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle …. The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. … Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn …. In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth …"). The '038 patent discloses that this limitation was well known to one skilled in the art prior to and at the time of the invention.

	See, e.g., '038 patent, Col. 1, ll. 25-56 (discussing the known prior art, including attaching control apparatuses to seismic streamers to position streamers).
and issuing vertical and horizontal positioning commands to each ASPD for maintaining a specified array path.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("In the preferred embodiment of the present invention, the control system for the birds 18 is distributed between a global control system 22 located on or near the seismic survey vessel 10 and a local control system located within or near the birds ..."). *See, e.g.*, Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global control system 22 preferably transmits, at regular intervals (such as every five seconds) a desired horizontal force 42 and a desired vertical force 44 to the local control system 36."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2; particularly in regard to the limitation of "specified array path" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change". The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. ... In extreme weather

	conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers.").
46. The method of claim 45 wherein a master controller issues positioning commands to the towing vessel for maintaining a specified array path.	The Hillesund '895 application discloses this limitation. *See* Claim 45 Analysis. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("The global control system 22 is typically connected to the seismic survey vessel's navigation system and obtains estimates of system wide parameters, such as the vessel's towing direction and velocity and current direction and velocity, from the vessel's navigation system.") In addition, Persons Having Ordinary Skill In The Art will readily recognize that the seismic survey vessel's navigation system is typically utilized to steer the vessel in routine seismic acquisition operations ("auto-pilot").
47. The method of claim 45 further comprising: calculating an optimal path for the seismic array for optimal coverage during seismic data acquisition over a seismic field;	The Hillesund '895 application discloses this limitation. *See* Claim 45 Analysis. *See, e.g.*, Hillesund '895, Fig 4. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").
predicting array behavior;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig 4. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("To compensate for these localized current fluctuations, the inventive control system

	utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices.").
and compensating for predicted streamer behavior in issuing positioning commands to the towing vessel and the ASPDs for positioning the array along the optimal path.	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 2 ("In the preferred embodiment of the present invention, the control system for the birds 18 is distributed between a global control system 22 located on or near the seismic survey vessel 10 and a local control system located within or near the birds 18. The global control system 22 is typically connected to the seismic survey vessel's navigation system and obtains estimates of system wide parameters, such as the vessel's towing direction and velocity and current direction and velocity, from the vessel's navigation system."). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices."). *See, e.g.*, Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global control system 22 preferably transmits, at regular intervals (such as every five seconds) a desired horizontal force 42 and a desired vertical force 44 to the local control system 36."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2; particularly in regard to the limitation of "specified array geometry" ("The inventive control system will primarily operate in two different control modes: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep each streamer in a straight line

	offset from the towing direction by a certain feather angle .... The turn control mode is used when ending one pass and beginning another pass during a 3D seismic survey, sometimes referred to as a "line change." The turn control mode consists of two phases. In the first part of the turn, every bird 18 tries to "throw out" the streamer 12 by generating a force in the opposite direction of the turn. In the last part of the turn, the birds 18 are directed to go to the position defined by the feather angle control mode. By doing this, a tighter turn can be achieved and the turn time of the vessel and equipment can be substantially reduced. Typically during the turn mode adjacent streamers will be depth separated to avoid possible entanglement during the turn and will be returned to a common depth as soon as possible after the completion of the turn .... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. In this control mode, the global control system 22 attempts to maximize the distance between adjacent streamers. The streamers 12 will typically be separated in depth and the outermost streamers will be positioned as far away from each other as possible. The inner streamers will then be regularly spaced between these outermost streamers, i.e. each bird 18 will receive desired horizontal forces 42 or desired horizontal position information that will direct the bird 18 to the midpoint position between its adjacent streamers.").
48. The method of claim 47 wherein the master controller compensates for environmental factors in the positioning commands.	The Hillesund '895 application discloses this limitation. *See* Claims 15, 30, and 40 Analyses. *See, e.g.,* Hillesund '895 at p. 6, Paragraph 3 ("Localized current fluctuations can dramatically influence the magnitude of the side control required to property position the streamers. To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and behavior-predictive model-based control logic to properly control the streamer positioning devices."). *See, e.g.,* Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be

	estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity.").
49. The method of claim 48 wherein the master controller compensates for maneuverability factors in the positioning commands.	The Hillesund '895 application discloses this limitation. *See* Claims 16, 31, and 41 Analyses. *See, e.g.*, Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array."). A Person Having Ordinary Skill In The Art at the time of the invention would find this limitation to be inherent in the invention. To "compensate for maneuverability influences" it would be necessary to take into account various maneuverability factors, including, but not necessarily limited to, cable diameter, array type, deployed configuration, vessel type, device type, etc. which are part of the basis for the behavior of the streamers. *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system.").
50. A method for tracking and positioning a seismic streamer array comprising:	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 *generally*, which discloses a system wherein a towing vessel tows a seismic array comprised of a plurality of seismic streamers. Actual positions are determined for this array, and positions are controlled by seismic streamer positioning devices attached to the streamer cables. *See, e.g.*, Hillesund '895 at p. 4, Paragraph titled "Summary of the Invention".
towing a seismic array comprising a plurality of seismic streamers;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895, Fig. 1. *See also* Hillesund '895 at p. 5, Paragraph 1 ("In Figure 1, a seismic survey vessel 10 is shown towing eight marine seismic streamers …").

attaching an active streamer positioning device (ASPD) attached to each seismic streamer for positioning each seismic streamer;	The Hillesund '895 application discloses this limitation. *See, e.g.*, Hillesund '895 at p. 6, Paragraph 1 ("Preferably the birds 18 are both vertically and horizontally steerable. These birds 18 may, for instance, be located at regular intervals along the streamer, such as every 200 to 400 meters. The vertically and horizontally steerable birds 18 can be used to constrain the shape of the seismic streamer ...") *See, e.g.*, Hillesund '895 at p. 18, Paragraph 3, to p. 19, Paragraph 2 particularly in regard to "positioning each seismic streamer" ("The inventive control system will primarily operate in two different *control modes*: a feather angle control mode and a turn control mode. In the feather angle control mode, the global control system 22 attempts to keep *each streamer* in a straight line offset from the towing direction by a certain feather angle ... In extreme weather conditions, the inventive control system may also operate in a streamer separation control mode that attempts to minimize the risk of entanglement of the streamers. ...") The '038 patent discloses that this limitation was well known to one skilled in the art prior to and at the time of the invention. *See, e.g.*, '038 patent, Col. 1, ll. 25-56 (discussing the known prior art, including attaching control apparatuses to seismic streamers to position streamers).
issuing horizontal and vertical positioning commands to each ASPD and to the towing vessel for maintaining an optimal path, calculating an optimal path for the seismic array for optimal coverage during seismic data acquisition over a seismic field, and a behavior prediction processor which predicting array behavior, wherein the master controller compensates for predicted streamer behavior in issuing positioning commands to the towing vessel and the ASPDs for	The Hillesund '895 application discloses this limitation. See, e.g., Hillesund '895 at p. 7, Paragraph 2 ("The global control system 22 preferably maintains a dynamic model of each of the seismic streamers 12 and utilizes the desired and actual positions of the birds 18 to regularly calculate updated desired vertical and horizontal forces the birds should impart on the seismic streamers 12 to move them from their actual positions to their desired positions."). *See, e.g.*, Hillesund '895 at p. 10, Paragraph 3 ("During operation of the streamer positioning control system, the global control system 22 preferably transmits, at regular intervals (such as every five seconds) a desired horizontal force 42 and a desired vertical

positioning the array along the optimal path, wherein the master controller compensates for environmental and maneuverability factors in the positioning commands.	force 44 to the local control system 36."). *See, e.g.*, Hillesund '895 at p. 18, Paragraph 2 ("The inventive control system is based on shared responsibilities between the global control system 22 located on the seismic survey vessel 10 and the local control system 36 located on the bird 18. The global control system 22 is tasked with monitoring the positions of the streamers 12 and providing desired forces or desired position information to the local control system 36. The local control system 36 within each bird 18 is responsible for adjusting the wing splay angle to rotate the bird to the proper position and for adjusting the wing common angle to produce the magnitude of total desired force required."). *See, e.g.*, Hillesund '895 at p. 6, Paragraph 3 ("To compensate for these localized current fluctuations, the inventive control system utilizes a distributed processing control architecture and *behavior-predictive* model-based control logic to properly control the streamer positioning devices."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 1 ("The global control system 22 will typically acquire the following parameters from the vessel's navigation system: vessel speed (m/s), vessel heading (degrees), current speed (m/s), current heading (degrees), and the location of each of the birds in the horizontal plane in a vessel fixed coordinate system. Current speed and heading can also be estimated based on the average forces acting on the streamers 12 by the birds 18. The global control system 22 will preferably send the following values to the local bird controller: demanded vertical force, demanded horizontal force, towing velocity, and crosscurrent velocity."). *See, e.g.*, Hillesund '895 at p. 7, Paragraph 3 ("The global control system 22 preferably calculates the desired vertical and horizontal forces based on the behavior of each streamer and also takes into account the behavior of the complete streamer array."). *See, e.g.*, Hillesund '895 at p. 8, Paragraph 3 ("The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system."). *See also* Claims 1, 2, 5, 6, 21, 22, and 25 Analyses.

EXHIBIT 10

EXHIBIT 10

U.S. Patent No. 6,932,017 (the "Hillesund '017 patent") Is Obvious In View of
U.S. Patent 5,790,472 ("Workman '472 patent")

U.S. Patent No. 6,932,017 Asserted Claims	**Citations from '472 prior-art**
1. A method of controlling the positions of marine seismic streamers in an array of such streamers being towed by a seismic survey vessel, the streamers having respective streamer positioning devices disposed therealong and each streamer positioning device having a wing and a wing motor for changing the orientation of the wing so as to steer the streamer positioning device laterally, said method comprising the steps of:	U.S. Patent 5,790,472 (Adaptive Control of Marine Seismic Streamers; Workman & Chambers; assigned to Western Atlas; 1998) discloses this claim preamble. The limitation of "marine seismic streamers in an array of such streamers being towed by a seismic survey vessel" is disclosed in the Workman '472 patent. The limitation of "streamer positioning devices disposed therealong and each streamer positioning device having a wing and a wing motor for changing the orientation of the wing" is disclosed in the Workman '472 patent. The limitation "to steer the streamer positioning device laterally" is disclosed in the Workman '472 patent. *See, e.g.,* Workman '472 at Col. 2, ll. 32-33 ("... the prior art discloses a series of discrete devices for locating and controlling the positions of streamer cables ...") and Col. 2, ll. 45-47 ("The present invention is an improved system for controlling the position and shape of marine seismic streamer cables"). *See, e.g.,* Workman '472 at Col. 3, ll. 33-43 ("As known to those skilled in the art, components of the marine seismic data acquisition system 05, on the vessel 11, may include ... a network solution system 10 for determining the position of the streamer cables 13 and seismic sources 12, and a streamer cable controller 16 for controlling the streamer positioning devices"). *See, e.g.,* Workman '472 at Col. 1, ll. 17-19 ("Due to the increasing use of marine 3-D seismic data, multi-cable marine surveys are now commonplace"). *See, e.g.,* Workman '472 at Col. 1, l. 45 ("Streamer

U.S. Patent No. 6,932,017 Asserted Claims	Citations from '472 prior-art
	positioning devices are well known in the art"). *See, e.g.*, Workman '472 at Col. 3, ll. 14-20 ("As known to those skilled in the art, streamer positioning devices 14, for example birds and tail buoys, may be attached to the exterior of the streamer cables 13 for adjusting the vertical and lateral positions of the streamer cables 13. The streamer cables 13 include electrical or optical cables for connecting the streamer positioning devices 14 to individual control and logging systems"). *See, e.g.*, Workman '472 at Col. 1, ll. 55-61 (describes lateral positioning with wings). A wing motor to move a wing is inherent in this invention because of the need for dynamic control to implement this invention. In the event that a wing motor is not considered inherent, then it is obvious based on Workman '472 at Col. 1, ll. 27-61.
obtaining a predicted position of the streamer positioning devices;	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 2, ll. 15-18 ("These devices and methods may then be used to determine the real time position of the seismic sources and seismic streamer cables by computing a network solution to a Kalman filter, as disclosed by U.S. Pat. No. 5,353,223"). Prediction is a fundamental aspect of Kalman filtering technology. A person Having Ordinary Skill In The Art will understand that the disclosed Kalman filter is a well-known prior art technology that is used to obtain a predicted position.
obtaining an estimated velocity of the streamer positioning devices;	Given "a predicted position of the streamer positioning devices," then a Person Having Ordinary Skill In The Art will understand that it is inherent that velocities are necessarily obtained from differences in positions over known time intervals based on fundamental concepts of marine navigation known for generations. In marine seismic navigation systems at the time of invention,

U.S. Patent No. 6,932,017 Asserted Claims	Citations from '472 prior-art
	solutions for positions are typically available several times per minute which necessarily yields estimates of velocities several times per minute as simple differences of positions. *See, e.g.*, Workman '472 at Col. 2, ll. 15-18 ("These devices and methods may then be used to determine the real time position of the seismic sources and seismic streamer cables by computing a network solution to a Kalman filter, as disclosed by U.S. Pat. No. 5,353,223"). Estimation is a fundamental aspect of Kalman filtering technology. A person Having Ordinary Skill In The Art will understand that the disclosed Kalman filter is a well-known prior art technology that is used to obtain an estimated velocity.
for at least some of the streamer positioning devices, calculating desired changes in the orientation of their wings using said predicted position and said estimated velocity;	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 3, ll. 42-43 ("... and a streamer cable controller 16 for controlling the streamer positioning devices 14"). *See* also, e.g., FIG. 2 *See, e.g.*, Workman '472 at Col. 3, ll. 59-62 ("... includes a streamer control processor 40 for ... calculating a position correction to reposition the streamer cables 13") *See, e.g.*, Workman '472 at Col. 4, ll. 17-21 "The streamer control processor 40 is connected to the streamer device controller 16. When the streamer cables 13 need to be repositioned, the position correction is used by the streamer device controller 16 to adjust the streamer positioning devices 14 and reposition the streamer cables 13." Given "predicted positions and estimated velocities", a Person Having Ordinary Skill in the Art will understand that it is inherent that the "orientation of their wings" for the streamer positioning devices necessarily must be calculated to be able to implement any change in streamer position or motion whatsoever.

U.S. Patent No. 6,932,017 Asserted Claims	Citations from '472 prior-art
and actuating the wing motors to produce said desired changes in wing orientation.	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 1, ll. 55-57 ("For example, devices to control the lateral positioning of streamer cables by using camber-adjustable hydrofoils or angled wings are disclosed …") This limitation is also inherent. Given a desire to reposition the streamers, then a Person Having Ordinary Skill In The Art will understand that to change the "wing orientation" for the streamer positioning devices will necessarily require the action of a motor. It would have been obvious to one of ordinary skill in the art to have used an actuator or motor to produce the desired changes.
8. A method as claimed in claim 7, in which said global control system is further configured into a streamer separation mode, wherein said global control system attempts to direct said streamer positioning device to maintain a minimum separation distance between adjacent streamers.	The Workman '472 patent discloses this limitation of "streamer separation mode". *See, e.g.*, Workman '472 at Col. 1, ll. 33-35 ("The ability to control the position and shape of the streamer cables is desirable for preventing the entanglement of the streamer cables …"). *See, e.g.*, Workman '472 at Col. 3, ll. 58-67 ("In the present embodiment of the invention, the marine seismic data acquisition system 05 also includes a streamer control processor 40 for deciding when the streamer cables 13 should be repositioned and for calculating a position correction to reposition the streamer cables 13. Also in the present embodiment of the invention, threshold parameters are established for determining when the streamer cables should be repositioned. Threshold parameters may include a plurality of values for: minimum allowable separations between streamer cables 13 …") *See, e.g.*, Workman '472 at Col. 4, ll. 8-35 (discloses streamer control processor).
16. Apparatus for controlling	U.S. Patent 5,790,472 (Adaptive Control of Marine

U.S. Patent No. 6,932,017 Asserted Claims	Citations from '472 prior-art
the positions of marine seismic streamer in an array of such streamers being towed by a seismic survey vessel, the streamers having respective streamer positioning devices disposed therealong and each streamer positioning device having a wing and a wing motor for changing the horizontal orientation of the wing so as to steer the streamer positioning device laterally, said apparatus comprising:	Seismic Streamers; Workman & Chambers; assigned to Western Atlas; 1998) discloses this claim preamble. The limitation of "marine seismic streamers in an array of such streamers being towed by a seismic survey vessel" is disclosed in the Workman '472 patent. The limitation of "streamer positioning devices disposed therealong and each streamer positioning device having a wing and a wing motor for changing the orientation of the wing" is disclosed in the Workman '472 patent. The limitation "to steer the streamer positioning device laterally" is disclosed in the Workman '472 patent. *See, e.g.*, Workman '472 at Col. 1, ll. 55-61 (describes lateral positioning with wings). A wing motor to move a wing is inherent in this invention because of the need for dynamic control to implement this invention. *See, e.g.*, Workman '472 at Col. 2, ll. 32-33 ("... the prior art discloses a series of discrete devices for locating and controlling the positions of streamer cables ...") and Col. 2, ll. 45-47 ("The present invention is an improved system for controlling the position and shape of marine seismic streamer cables"). *See, e.g.*, Workman '472 at Col. 3, ll. 33-43 ("As known to those skilled in the art, components of the marine seismic data acquisition system 05, on the vessel 11, may include ... a network solution system 10 for determining the position of the streamer cables 13 and seismic sources 12, and a streamer cable controller 16 for controlling the streamer positioning devices"). *See, e.g.*, Workman '472 at Col. 1, ll. 17-19 ("Due to the increasing use of marine 3-D seismic data, multi-cable marine surveys are now commonplace"). *See, e.g.*, Workman '472 at Col. 1, l. 45 ("Streamer positioning devices are well known in the art"). *See, e.g.*, Workman '472 at Col. 3, ll. 14-20 ("As known to those skilled in the art, streamer positioning devices 14, for

U.S. Patent No. 6,932,017 Asserted Claims	Citations from '472 prior-art
	example birds and tail buoys, may be attached to the exterior of the streamer cables 13 for adjusting the vertical and lateral positions of the streamer cables 13. The streamer cables 13 include electrical or optical cables for connecting the streamer positioning devices 14 to individual control and logging systems"). In the event that a wing motor is not considered inherent, then it is obvious based on Workman '472 at Col. 1, ll. 27-61.
means for obtaining a predicted position of the streamer positioning devices;	Under 35 U.S.C. § 112, ¶ 6, the Workman '472 patent discloses structure that performs the claimed function of obtaining a predicted position of the streamer positioning devices and that is either identical to the structure identified by the Court or equivalent structure. *See, e.g.,* As shown in Figure 2, the marine seismic data acquisition system 05 comprises a streamer control processor 40 and a streamer cable controller 16. *See, e.g.,* Workman '472 at Col. 3, ll. 33-34 and ll. 42-44 ("As known to those skilled in the art, components of the marine seismic data acquisition system 05, on the vessel 11, may include … a streamer cable controller 16 for controlling the streamer positioning devices 14."). *See, e.g.,* Workman '472 at Col. 3, ll. 58-62 ("… the marine seismic data acquisition system 05 also includes a streamer control processor 40 for deciding when the streamer cables 13 should be repositioned and for calculating a position correction to reposition the streamer cables 13.") *See, e.g.,* Workman '472 at Col. 2, ll. 15-19 which discloses "prediction" in a Kalman filter. The aforementioned disclosed structure performs the function of: ("These devices and methods may then be used to determine the real time position of the seismic sources and seismic streamer cables by computing a network solution to a Kalman filter, as disclosed by U.S. Pat. No. 5,353,223").

U.S. Patent No. 6,932,017 Asserted Claims	Citations from '472 prior-art
	Prediction is a fundamental aspect of Kalman filtering technology. A PHOSITA will understand that the disclosed Kalman filter is a well-known prior-art technology that is used to obtain a predicted position and that such filtering technology is implemented using algorithms software.
means for obtaining an estimated velocity of the streamer positioning devices,	Under 35 U.S.C. § 112, ¶ 6, the Workman '472 patent discloses structure that performs the claimed function of obtaining an estimated velocity of the streamer positioning devices and that is either identical to the structure identified by the Court or equivalent structure. The '017 specification states that "The towing velocity and crosscurrent velocity are preferably "water-referenced" values that are calculated from the vessel speed and heading values and the current speed and heading values, as well as any relative movement between the seismic survey vessel 10 and the bird 18 (such as while the vessel is turning). Alternatively, the global control system 22 could provide the local control system with the horizontal velocity and water in-flow angle. The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system. The "water-referenced" towing velocity and crosscurrent velocity could alternatively be determined using flowmeters or other types of water velocity sensors attached directly to the birds 18." *See, e.g.*, As shown in Figure 2, the marine seismic data acquisition system 05 comprises a streamer control processor 40 and a streamer cable controller 16. *See, e.g.,* Workman '472 at Col. 2, ll. 15-18; at Col. 4, l. 8; and "prediction" in a Kalman filter at Col. 2., ll. 15-19. The aforementioned disclosed structure performs the function of: "These devices and methods may then be used to determine the real time position of the seismic sources and seismic streamer cables by computing a network solution to a Kalman filter, as disclosed by U.S. Pat. No.

U.S. Patent No. 6,932,017 Asserted Claims	Citations from '472 prior-art
	5,353,223"). Given "a predicted position of the streamer positioning devices," then a Person Having Ordinary Skill In The Art will understand that it is inherent that velocities are necessarily obtained from differences in positions over known time intervals based on fundamental concepts of marine navigation known for generations. In marine seismic navigation systems at the time of invention, solutions for positions are typically available several times per minute which necessarily yields estimates velocities several times per minute as simple differences of positions. Estimation is a fundamental aspect of Kalman filtering technology. A person Having Ordinary Skill In The Art will understand that the disclosed Kalman filter is a well-known prior art technology that is used to obtain an estimated velocity.
means for calculating desired changes in the orientations of the respective wings of at least some of the streamer positioning devices using said predicted position and said estimated velocity;	Under 35 U.S.C. § 112, ¶ 6, the Workman '472 patent discloses structure that performs the claimed function of calculating desired changes in the orientations of the respective wings of at least some of the streamer positioning devices using said predicted position and said estimated velocity and that is either identical to the structure identified by the Court or equivalent structure. The Workman '472 patent discloses a global control system for performing the recited function. The Workman '472 patent discloses a structure to perform this function comprised of a streamer cable controller and a streamer control processor. *See, e.g.,* As shown in Figure 2, the marine seismic data acquisition system 05 comprises a streamer control processor 40 and a streamer cable controller 16. *See, e.g.,* Workman '472 at Col. 3, ll. 42-43 ("... and a streamer cable controller 16 for controlling the streamer positioning devices 14"). *See* also, e.g., FIG. 2

U.S. Patent No. 6,932,017 Asserted Claims	Citations from '472 prior-art
	See, e.g., Workman '472 at Col. 3, ll. 59-62 ("... includes a streamer control processor 40 for ... calculating a position correction to reposition the streamer cables 13") *See, e.g.*, Workman '472 at Col. 4, ll. 17-21 "The streamer control processor 40 is connected to the streamer device controller 16. When the streamer cables 13 need to be repositioned, the position correction is used by the streamer device controller 16 to adjust the streamer positioning devices 14 and reposition the streamer cables 13." This claim limitation "calculating desired changes in the orientation of their wings using said predicted position and said estimated velocity" is also an inherent aspect of the invention. Given "predicted positions and estimated velocities", it is inherently necessary that the "orientation of their wings" for the streamer positioning devices must be calculated to be able to implement any change in streamer position or motion whatsoever.
and means for actuating the wing motors to produce said desired changes in wing orientation.	Under 35 U.S.C. § 112, ¶ 6, the Workman '472 patent discloses structure that performs the claimed function of actuating the wing motors to produce said desired changes in wing orientation and that is either identical to the structure identified by the Court or equivalent structure. *See, e.g.*, Workman '472 at Col. 1, ll. 55-57 ("For example, devices to control the lateral positioning of streamer cables by using camber-adjustable hydrofoils or angled wings are disclosed ...") This claim limitation "actuating the wing motors to produce said desired changes in wing orientation" is also an inherent aspect of the invention. Given a desire to reposition the streamers, it is necessary that the "wing orientation" for the streamer positioning devices will need to be altered, which necessarily requires the action of a motor. Even assuming that a motor would not be inherent in the

U.S. Patent No. 6,932,017 Asserted Claims	Citations from '472 prior-art
	'472 patent's disclosure, the streamer cable controller 16 controls the streamer positioning devices, or birds, to produce a desired change in the wing orientation. Col. 3, ll. 30-45; col. 4, ll. 8-21. That necessarily occurs via some type of actuator, and it would have been obvious to one of ordinary skill in the art to have used an actuator or motor.

EXHIBIT 11

EXHIBIT 11

U.S. Patent No. 6,932,017 (the "Hillesund '017 patent") Is Obvious In View of Workman '472 and Kalman Reference

U.S. Patent No. 6,932,017 Asserted Claims	**Citations from the prior-art**
1. A method of controlling the positions of marine seismic streamers in an array of such streamers being towed by a seismic survey vessel, the streamers having respective streamer positioning devices disposed therealong and each streamer positioning device having a wing and a wing motor for changing the orientation of the wing so as to steer the streamer positioning device laterally, said method comprising the steps of:	U.S. Patent 5,790,472 (Adaptive Control of Marine Seismic Streamers; Workman & Chambers; assigned to Western Atlas; 1998) discloses this claim preamble. The limitation of "marine seismic streamers in an array of such streamers being towed by a seismic survey vessel" is disclosed in the Workman '472 patent. The limitation of "streamer positioning devices disposed therealong and each streamer positioning device having a wing and a wing motor for changing the orientation of the wing" is disclosed in the Workman '472 patent. The limitation "to steer the streamer positioning device laterally" is disclosed in the Workman '472 patent. *See, e.g.,* Workman '472 at Col. 2, ll. 32-33 ("... the prior art discloses a series of discrete devices for locating and controlling the positions of streamer cables ...") and Col. 2, ll. 45-47 ("The present invention is an improved system for controlling the position and shape of marine seismic streamer cables"). *See, e.g.,* Workman '472 at Col. 3, ll. 33-43 ("As known to those skilled in the art, components of the marine seismic data acquisition system 05, on the vessel 11, may include ... a network solution system 10 for determining the position of the streamer cables 13 and seismic sources 12, and a streamer cable controller 16 for controlling the streamer positioning devices"). *See, e.g.,* Workman '472 at Col. 1, ll. 17-19 ("Due to the increasing use of marine 3-D seismic data, multi-cable marine surveys are now commonplace"). *See, e.g.,* Workman '472 at Col. 1, l. 45 ("Streamer positioning devices are well known in the art").

U.S. Patent No. 6,932,017 Asserted Claims	**Citations from the prior-art**
	See, e.g., Workman '472 at Col. 3, ll. 14-20 ("As known to those skilled in the art, streamer positioning devices 14, for example birds and tail buoys, may be attached to the exterior of the streamer cables 13 for adjusting the vertical and lateral positions of the streamer cables 13. The streamer cables 13 include electrical or optical cables for connecting the streamer positioning devices 14 to individual control and logging systems"). *See, e.g.*, Workman '472 at Col. 1, ll. 55-61 (describes lateral positioning with wings). A wing motor to move a wing is inherent in this invention because of the need for dynamic control to implement this invention. In the event that a wing motor is not considered inherent, then it is obvious based on Workman '472 at Col. 1, ll. 27-61.
obtaining a predicted position of the streamer positioning devices;	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 2, ll. 15-18 ("These devices and methods may then be used to determine the real time position of the seismic sources and seismic streamer cables by computing a network solution to a Kalman filter, as disclosed by U.S. Pat. No. 5,353,223"). Kalman, R.E., 1960, "A New approach to Linear Filtering and Prediction Problems," Trans of ASME-J. of Basic Engineering, vol. 82 (Series D), pp. 35-36 discloses the limitation of "prediction." *See, e.g.*, p. 36, bottom of right hand column in section "Optimal Estimation," first paragraph: "we have a prediction problem. Since our treatment will be general enough to include these and similar problems, we shall use hereafter the collective term estimation." Prediction is a fundamental aspect of Kalman filtering technology. A Person Having Ordinary Skill In The Art will understand that the disclosed Kalman filter is a well-known prior art technology that is obvious to use to obtain a predicted position.

U.S. Patent No. 6,932,017 Asserted Claims	Citations from the prior-art
obtaining an estimated velocity of the streamer positioning devices;	Given "a predicted position of the streamer positioning devices," then a Person Having Ordinary Skill In The Art will understand that it is obvious that velocities are readily obtained from differences in positions over known time intervals based on fundamental concepts of marine navigation known for generations. In marine seismic navigation systems at the time of invention, solutions for positions are typically available several times per minute which yields estimates of velocities several times per minute as simple differences of positions. *See, e.g.*, Workman '472 at Col. 2, ll. 15-18 ("These devices and methods may then be used to determine the real time position of the seismic sources and seismic streamer cables by computing a network solution to a Kalman filter, as disclosed by U.S. Pat. No. 5,353,223"). Kalman, R.E., 1960, "A New approach to Linear Filtering and Prediction Problems," Trans of ASME-J. of Basic Engineering, vol. 82 (Series D), pp. 35-36 discloses the limitation of "prediction." *See, e.g.*, p. 36, bottom of right hand column in section "Optimal Estimation," first paragraph: "we have a prediction problem. Since our treatment will be general enough to include these and similar problems, we shall use hereafter the collective term estimation." Estimation is a fundamental aspect of Kalman filtering technology. A person Having Ordinary Skill In The Art will understand that the disclosed Kalman filter is a well-known prior art technology that is obvious to use to obtain an estimated velocity.
for at least some of the streamer positioning devices, calculating desired changes in the orientation of their wings using said predicted position and said estimated velocity;	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 3, ll. 42-43 ("... and a streamer cable controller 16 for controlling the streamer positioning devices 14"). *See* also, e.g., FIG. 2 *See, e.g.*, Workman '472 at Col. 3, ll. 59-62 ("... includes a streamer control processor 40 for ... calculating a position

U.S. Patent No. 6,932,017 Asserted Claims	Citations from the prior-art
	correction to reposition the streamer cables 13") *See, e.g.*, Workman '472 at Col. 4, ll. 17-21 "The streamer control processor 40 is connected to the streamer device controller 16. When the streamer cables 13 need to be repositioned, the position correction is used by the streamer device controller 16 to adjust the streamer positioning devices 14 and reposition the streamer cables 13." Given "predicted positions and estimated velocities", a Person Having Ordinary Skill in the Art will understand that it is inherent that the "orientation of their wings" for the streamer positioning devices necessarily must be calculated to be able to implement any change in streamer position or motion whatsoever.
and actuating the wing motors to produce said desired changes in wing orientation.	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 1, ll. 55-57 ("For example, devices to control the lateral positioning of streamer cables by using camber-adjustable hydrofoils or angled wings are disclosed …") This limitation is also inherent. Given a desire to reposition the streamers, then a Person Having Ordinary Skill In The Art will understand that to change the "wing orientation" for the streamer positioning devices will necessarily require the action of a motor. It would have been obvious to one of ordinary skill in the art to have used an actuator or motor to produce the desired changes.

U.S. Patent No. 6,932,017 Asserted Claims	Citations from the prior-art
8. A method as claimed in claim 7, in which said global control system is further configured into a streamer separation mode, wherein said global control system attempts to direct said streamer positioning device to maintain a minimum separation distance between adjacent streamers.	The Workman '472 patent discloses this limitation of "streamer separation mode". *See, e.g.*, Workman '472 at Col. 1, ll. 33-35 ("The ability to control the position and shape of the streamer cables is desirable for preventing the entanglement of the streamer cables …"). *See, e.g.*, Workman '472 at Col. 3, ll. 58-67 ("In the present embodiment of the invention, the marine seismic data acquisition system 05 also includes a streamer control processor 40 for deciding when the streamer cables 13 should be repositioned and for calculating a position correction to reposition the streamer cables 13. Also in the present embodiment of the invention, threshold parameters are established for determining when the streamer cables should be repositioned. Threshold parameters may include a plurality of values for: minimum allowable separations between streamer cables 13 …") *See, e.g.*, Workman '472 at Col. 4, ll. 8-35 (discloses streamer control processor).
16. Apparatus for controlling the positions of marine seismic streamer in an array of such streamers being towed by a seismic survey vessel, the streamers having respective streamer positioning devices disposed therealong and each streamer positioning device having a wing and a wing motor for changing the horizontal orientation of the wing so as to steer the streamer positioning device laterally, said apparatus comprising:	U.S. Patent 5,790,472 (Adaptive Control of Marine Seismic Streamers; Workman & Chambers; assigned to Western Atlas; 1998) discloses this claim preamble. The limitation of "marine seismic streamers in an array of such streamers being towed by a seismic survey vessel" is disclosed in the Workman '472 patent. The limitation of "streamer positioning devices disposed therealong and each streamer positioning device having a wing and a wing motor for changing the orientation of the wing" is disclosed in the Workman '472 patent. The limitation "to steer the streamer positioning device laterally" is disclosed in the Workman '472 patent. *See, e.g.*, Workman '472 at Col. 1, ll. 55-61 (describes lateral positioning with wings). A wing motor to move a wing is inherent in this invention because of the need for

U.S. Patent No. 6,932,017 Asserted Claims	Citations from the prior-art
	dynamic control to implement this invention. *See, e.g.*, Workman '472 at Col. 2, ll. 32-33 ("… the prior art discloses a series of discrete devices for locating and controlling the positions of streamer cables ...") and Col. 2, ll. 45-47 ("The present invention is an improved system for controlling the position and shape of marine seismic streamer cables"). *See, e.g.*, Workman '472 at Col. 3, ll. 33-43 ("As known to those skilled in the art, components of the marine seismic data acquisition system 05, on the vessel 11, may include … a network solution system 10 for determining the position of the streamer cables 13 and seismic sources 12, and a streamer cable controller 16 for controlling the streamer positioning devices"). *See, e.g.*, Workman '472 at Col. 1, ll. 17-19 ("Due to the increasing use of marine 3-D seismic data, multi-cable marine surveys are now commonplace"). *See, e.g.*, Workman '472 at Col. 1, l. 45 ("Streamer positioning devices are well known in the art"). *See, e.g.*, Workman '472 at Col. 3, ll. 14-20 ("As known to those skilled in the art, streamer positioning devices 14, for example birds and tail buoys, may be attached to the exterior of the streamer cables 13 for adjusting the vertical and lateral positions of the streamer cables 13. The streamer cables 13 include electrical or optical cables for connecting the streamer positioning devices 14 to individual control and logging systems"). In the event that a wing motor is not considered inherent, then it is obvious based on Workman '472 at Col. 1, ll. 27-61.
means for obtaining a predicted position of the streamer positioning devices;	Under 35 U.S.C. § 112, ¶ 6, the Workman '472 patent discloses structure that performs the claimed function of obtaining a predicted position of the streamer positioning devices and that is either identical to the structure identified by the Court or equivalent structure.

U.S. Patent No. 6,932,017 Asserted Claims	Citations from the prior-art
	See, e.g., As shown in Figure 2, the marine seismic data acquisition system 05 comprises a streamer control processor 40 and a streamer cable controller 16. *See, e.g.*, Workman '472 at Col. 3, ll. 33-34 and ll. 42-44 ("As known to those skilled in the art, components of the marine seismic data acquisition system 05, on the vessel 11, may include … a streamer cable controller 16 for controlling the streamer positioning devices 14."). *See, e.g.*, Workman '472 at Col. 3, ll. 58-62 ("… the marine seismic data acquisition system 05 also includes a streamer control processor 40 for deciding when the streamer cables 13 should be repositioned and for calculating a position correction to reposition the streamer cables 13.") *See, e.g.*, Workman '472 at Col. 2, ll. 15-19 which discloses "prediction" in a Kalman filter. The aforementioned disclosed structure performs the function of: ("These devices and methods may then be used to determine the real time position of the seismic sources and seismic streamer cables by computing a network solution to a Kalman filter, as disclosed by U.S. Pat. No. 5,353,223"). Prediction is a fundamental aspect of Kalman filtering technology. A PHOSITA will understand that the disclosed Kalman filter is a well-known prior-art technology that is used to obtain a predicted position and that such filtering technology is implemented using algorithms software. *See, e.g.*, Workman '472 at Col. 2, ll. 15-19 which discloses "prediction" in a Kalman filter ("These devices and methods may then be used to determine the real time position of the seismic sources and seismic streamer cables by computing a network solution to a Kalman filter, as disclosed by U.S. Pat. No. 5,353,223"). Kalman, R.E., 1960, "A New approach to Linear Filtering and Prediction Problems," Trans of ASME-J. of Basic

U.S. Patent No. 6,932,017 Asserted Claims	Citations from the prior-art
	Engineering, vol. 82 (Series D), pp. 35-35 discloses the limitation of "prediction." *See, e.g.*, p. 36, bottom of right hand column in section "Optimal Estimation," first paragraph: "we have a prediction problem. Since our treatment will be general enough to include these and similar problems, we shall use hereafter the collective term estimation."
means for obtaining an estimated velocity of the streamer positioning devices,	Under 35 U.S.C. § 112, ¶ 6, the Workman '472 patent discloses structure that performs the claimed function of obtaining an estimated velocity of the streamer positioning devices and that is either identical to the structure identified by the Court or equivalent structure. The '017 specification states that "The towing velocity and crosscurrent velocity are preferably "water-referenced" values that are calculated from the vessel speed and heading values and the current speed and heading values, as well as any relative movement between the seismic survey vessel 10 and the bird 18 (such as while the vessel is turning). Alternatively, the global control system 22 could provide the local control system with the horizontal velocity and water in-flow angle. The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system. The "water-referenced" towing velocity and crosscurrent velocity could alternatively be determined using flowmeters or other types of water velocity sensors attached directly to the birds 18." *See, e.g.,* As shown in Figure 2, the marine seismic data acquisition system 05 comprises a streamer control processor 40 and a streamer cable controller 16. *See, e.g.,* Workman '472 at Col. 2, ll. 15-18; at Col. 4, l. 8; and "prediction" in a Kalman filter at Col. 2., ll. 15-19. The aforementioned disclosed structure performs the

U.S. Patent No. 6,932,017 Asserted Claims	Citations from the prior-art
	function of: "These devices and methods may then be used to determine the real time position of the seismic sources and seismic streamer cables by computing a network solution to a Kalman filter, as disclosed by U.S. Pat. No. 5,353,223"). Given "a predicted position of the streamer positioning devices," then a Person Having Ordinary Skill In The Art will understand that it is inherent that velocities are necessarily obtained from differences in positions over known time intervals based on fundamental concepts of marine navigation known for generations. In marine seismic navigation systems at the time of invention, solutions for positions are typically available several times per minute which necessarily yields estimates velocities several times per minute as simple differences of positions. Estimation is a fundamental aspect of Kalman filtering technology. A person Having Ordinary Skill In The Art will understand that the disclosed Kalman filter is a well-known prior art technology that is used to obtain an estimated velocity. Kalman, R.E., 1960, "A New approach to Linear Filtering and Prediction Problems," Trans of ASME-J. of Basic Engineering, vol. 82 (Series D), pp. 35-35 discloses the limitation of "prediction." *See, e.g.*, p. 36, bottom of right hand column in section "Optimal Estimation," first paragraph: "we have a prediction problem. Since our treatment will be general enough to include these and similar problems, we shall use hereafter the collective term estimation."
means for calculating desired changes in the orientations of the respective wings of at least some of the streamer positioning devices using said predicted position and said estimated velocity;	Under 35 U.S.C. § 112, ¶ 6, the Workman '472 patent discloses structure that performs the claimed function of calculating desired changes in the orientations of the respective wings of at least some of the streamer positioning devices using said predicted position and said estimated velocity and that is either identical to the structure identified by the Court or equivalent structure. The Workman '472 patent discloses a global control

U.S. Patent No. 6,932,017 Asserted Claims	Citations from the prior-art
	system for performing the recited function. The Workman '472 patent discloses a structure to perform this function comprised of a streamer cable controller and a streamer control processor. *See, e.g.,* As shown in Figure 2, the marine seismic data acquisition system 05 comprises a streamer control processor 40 and a streamer cable controller 16. *See, e.g.,* Workman '472 at Col. 3, ll. 42-43 ("... and a streamer cable controller 16 for controlling the streamer positioning devices 14"). *See* also, e.g., FIG. 2 *See, e.g.,* Workman '472 at Col. 3, ll. 59-62 ("... includes a streamer control processor 40 for ... calculating a position correction to reposition the streamer cables 13") *See, e.g.,* Workman '472 at Col. 4, ll. 17-21 "The streamer control processor 40 is connected to the streamer device controller 16. When the streamer cables 13 need to be repositioned, the position correction is used by the streamer device controller 16 to adjust the streamer positioning devices 14 and reposition the streamer cables 13." This claim limitation "calculating desired changes in the orientation of their wings using said predicted position and said estimated velocity" is also an inherent aspect of the invention. Given "predicted positions and estimated velocities", it is inherently necessary that the "orientation of their wings" for the streamer positioning devices must be calculated to be able to implement any change in streamer position or motion whatsoever.
and means for actuating the wing motors to produce said desired changes in wing orientation.	Under 35 U.S.C. § 112, ¶ 6, the Workman '472 patent discloses structure that performs the claimed function of actuating the wing motors to produce said desired changes in wing orientation and that is either identical to the

U.S. Patent No. 6,932,017 Asserted Claims	Citations from the prior-art
	structure identified by the Court or equivalent structure. *See, e.g.*, Workman '472 at Col. 1, ll. 55-57 ("For example, devices to control the lateral positioning of streamer cables by using camber-adjustable hydrofoils or angled wings are disclosed ...") This claim limitation "actuating the wing motors to produce said desired changes in wing orientation" is also an inherent aspect of the invention. Given a desire to reposition the streamers, it is necessary that the "wing orientation" for the streamer positioning devices will need to be altered, which necessarily requires the action of a motor. Even assuming that a motor would not be inherent in the '472 patent's disclosure, the streamer cable controller 16 controls the streamer positioning devices, or birds, to produce a desired change in the wing orientation. Col. 3, ll. 30-45; col. 4, ll. 8-21. That necessarily occurs via some type of actuator, and it would have been obvious to one of ordinary skill in the art to have used an actuator or motor.

EXHIBIT 12

EXHIBIT 12

U.S. Patent No. 7,162,967 (the "967 patent") Is Obvious Based on the Combination of International Application WO 98/28636 (Bittleston '636) and U.S. Patent 5,790,472 (Workman '472)

U.S. Patent No. 7,162,967 Asserted Claims	Citations from prior-art
1. A method comprising: (a) towing an array of streamers each having a plurality of streamer positioning devices there along, at least one of the streamer positioning devices having a wing;	PCT Application WO 98/28636 (Control Devices for Controlling the Position of a Marine Seismic Streamer; Bittleston; published 2 July, 1998) discloses these limitations. *See, e.g.*, Bittleston '636 at p. 1, ll. 5-7 ("In order to perform a 3D seismic survey, a plurality of such streamers are towed at about 5 knots behind a seismic survey vessel") *See, e.g.*, Bittleston '636 at p. 1, ll. 14-15 ("control devices known as birds, attached to each streamer at intervals of 200 to 300 meters, are used.") *See, e.g.*, Bittleston '636 at FIGS. 1, 3-5 (figures depict wings) *See, e.g.*, Bittleston '636 at p. 4, 2nd Paragraph ("The bird 10 is provided with two opposed control surfaces, or wings, 24, typically moulded from a fibre-reinforced plastics material, which project horizontally outwardly from the body"). U.S. Patent 5,790,472 (Adaptive Control of Marine Seismic Streamers; Workman & Chambers; assigned to Western Atlas; 1998) discloses these limitations. *See, e.g.*, Workman '472 at Col. 1, ll. 17-19 ("Due to the increasing use of marine 3-D seismic data, multi-cable marine surveys are now commonplace"). *See, e.g.*, Workman '472 at Col. 1, l. 45 ("Streamer positioning devices are well known in the art"). Further, see, e.g., Col. 1, ll. 46-61 which references several prior art streamer positioning devices with at least one wing. *See, e.g.*, Workman '472 at Col. 2, ll. 32-33 ("... the prior art discloses a series of discrete devices for locating and controlling the positions of streamer cables ...").

U.S. Patent No. 7,162,967 Asserted Claims	Citations from prior-art
(b) transmitting from a global control system location information to at least one local control system on the at least one streamer positioning devices having a wing; and	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 3, ll. 58-62 ("the marine seismic data acquisition system 05 also includes a streamer control processor 40 for deciding when the streamer cables 13 should be repositioned and for calculating a position correction to reposition the streamer cables 13"). *See, e.g.*, Workman '472 at Col 4, ll. 8-21. ("The streamer control processor 40 is connected to the network solution system 10, the seismic binning system 30, the streamer positioning control devices 14, and the seismic data recording system 18 and receives the real time signal outputs of these systems. The streamer control processor 40 evaluates these real time signals and the threshold parameters from the terminal 32 to determine when the streamer cables 13 need to be repositioned and to calculate the position correction required to keep the streamer cables 13 within the threshold parameters. The streamer control processor 40 is connected to the streamer device controller 16. When the streamer cables 13 need to be repositioned, the position correction is used by the streamer device controller 16 to adjust the streamer positioning devices 14 and reposition the streamer cables 13.") A Person Having Ordinary Skill In The Art will find this limitation obvious from the Bittleston '636 application. *See, e.g.*, FIG. 2 where the inputs 35, 37, and 38 obviously must come from a global control system. *See, e.g.*, Bittleston '636 at p. 4, last Paragraph which discloses a local controller: ("The greater part of the length of the body 12 of the bird 10 is flexible, the only rigid parts being the connectors 20, 22, and a short central section which houses the control system") *See, e.g.*, Bittleston '636 at page 5, Paragraph 3 which discloses a local controller and communication with a global controller: ("The control system 26 is schematically illustrated in Figure 2, and comprises a microprocessor-based control circuit 34 having respective inputs 35 to 39 to receive control signals representative of desired depth, actual depth, desired lateral position, actual lateral position and roll angle of the bird 10")

U.S. Patent No. 7,162,967 Asserted Claims	Citations from prior-art
(c) adjusting the wing using the local control system.	The Bittleston '636 application discloses this limitation. *See, e.g.*, Bittleston '636 at p. 6, ll. 8-10 ("The control circuit 34 then adjusts each of the wings 24 independently by means of the stepper motors 48, 50 so as to start to achieve the calculated … wing angular positions"). *See, e.g.*, Bittleston '636 at p. 4, last Paragraph which discloses a local controller: ("The greater part of the length of the body 12 of the bird 10 is flexible, the only rigid parts being the connectors 20, 22, and a short central section which houses the control system"). [emphasis added] *See, e.g.*, Bittleston '636 at FIG. 2 which discloses a local control system within the bird: ("Figure 2 is a simple schematic of a control system forming part of the streamer control device of Figure 1"). The Workman '472 patent discloses this limitation as prior art *See, e.g.*, Workman '472 at Col. 1, ll. 55-57 ("For example, devices to control the lateral positioning of streamer cables by using camber-adjustable hydrofoils or angled wings are disclosed")
4. The method as claimed in claim 1, wherein the global control system transmits a desired vertical depth for the at least one streamer positioning device and the local control system calculates magnitude and direction of the deviation between the desired vertical depth and actual depth.	The Bittleston '636 application discloses this limitation. *See* claim 1 Analysis. *See, e.g.*, Bittleston '636 at p. 6, ll. 1-2, where a local control system receives desired depth information from a global control system: ("In operation, the control circuit 34 receives between its inputs 35 and 36 a signal indicative of the difference between the actual and desired depths of the bird 10") Further, *see, e.g.* Bittleston '636 at p. 6, ll. 4-8 ("These … difference signals are used by the control circuit 34 to calculate the roll angle of the bird 10 and the respective angular positions of the wings 24 which together will produce the … vertical force (upwardly or downwardly) … required to move the bird 10 to the desired depth").

U.S. Patent No. 7,162,967 Asserted Claims	Citations from prior-art
	See, e.g., Bittleston '636 at page 5, Paragraph 3 which discloses a local controller and communication with a global controller: ("The control system 26 is schematically illustrated in Figure 2, and comprises a microprocessor-based control circuit 34 having respective inputs 35 to 39 to receive control signals representative of desired depth, actual depth, … of the bird 10").
5. The method as claimed in claim 1, wherein the global control system transmits a desired horizontal displacement for the at least one streamer positioning device and the local control system calculates magnitude and direction of the deviation between the desired horizontal displacement and actual horizontal displacement.	The Bittleston '636 application discloses this limitation. *See* claim 1 Analysis. *See, e.g.*, Bittleston '636 at p. 6, ll. 1-4, and FIG. 2, where a local control system receives desired lateral position information 37 and receives actual lateral position 38 from a global control system: ("In operation, the control circuit 34 receives … between its inputs 37 and 38 a signal indicative of the difference between the actual and desired lateral positions of the bird 10.") Further, *see, e.g.* Bittleston '636 at p. 6, ll. 4-8 ("These … difference signals are used by the control circuit 34 to calculate the roll angle of the bird 10 and the respective angular positions of the wings 24 which together will produce the … lateral force (left or right) required to move the bird 10 to the desired … lateral position"). *See, e.g.*, Bittleston '636 at page 5, 3rd Paragraph which discloses a local controller and communication with a global controller: ("The control system 26 is schematically illustrated in Figure 2, and comprises a microprocessor-based control circuit 34 having respective inputs 35 to 39 to receive control signals representative of … desired lateral position, actual lateral position, … of the bird 10").
6. The method as claimed in claim 1, comprising calculating velocity of at least one of the streamer positioning devices, wherein the calculating velocity comprises at least one of a) using a	At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art that velocities of the streamer positioning devices are readily calculated from the successive positions of said streamer positioning devices at a series of time. (a.) At the time of the invention, it was obvious to a Person

U.S. Patent No. 7,162,967 Asserted Claims	Citations from prior-art
vessel speed received from a navigation system on a seismic survey vessel; b) compensating for the speed and heading of marine currents acting on the at least one streamer positioning device; and c) compensating for relative movement between the seismic survey vessel and the at least one streamer positioning device.	Having Ordinary Skill In The Art that "calculating velocity of at least one of the streamer positioning devices" *must* include the "vessel speed" as the major component because the vessel is towing the streamers and the streamer positioning devices. It is also obvious to a Person Having Ordinary Skill In The Art that the "calculating velocity" involves a vector which by definition must include direction as well as speed. Thus in addition to the "vessel speed" it is required to also have information regarding vessel heading, course, and track-made-good.) At the time of the invention, it was also obvious to a Person Having Ordinary Skill In The Art that it was routine navigational practice to obtain vessel speed in any of several ways within the prior-art. For example, satellite navigation or radio-navigation systems can routinely provide vessel position and speed. Additionally, Doppler sonar speed logs or electromagnetic speed logs are well-known commercially available prior-art devices which can provide vessel speed through the water. (b.) At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art to utilize long-standing prior-art navigational techniques to "compensate for the speed and heading of marine currents". (c.) At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art that the vector combination of the relative velocity vector ("relative movement between the seismic survey vessel and the at least one streamer positioning device.") and vessel velocity (referenced to the water as in claim 3.) to obtain a velocity "compensated for relative movement" is obvious application of well-known prior-art in the vector analysis of velocities.
7. The method as claimed in claim 6, in which said step of adjusting the wing using the local control system is regulated to prevent the positioning device from stalling.	At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art to regulate wing angles to prevent stalling, given complete information about the relative geometry of the wings and water flow over the wings, including the geometric or effective angle-of-attack.

U.S. Patent No. 7,162,967 Asserted Claims	Citations from prior-art
8. The method as claimed in claim 7, in which said step of using the location information to calculate desired forces on the at least one streamer positioning device is regulated by the global control system located on or near a seismic survey vessel that is configured into a feather angle mode, wherein the global control system attempts to direct the streamer positioning devices to maintain each of the streamers in a straight line offset from the towing direction of the marine seismic vessel by a certain feather angle, and into a turn control mode, wherein the global control system directs the streamer positioning devices to generate a force in the opposite direction of a turn at the beginning of the turn.	*See* Claim 7 Analysis. It would have been the at least one streamer positioning device is regulated by the global control system located on or near a seismic survey vessel that is configured into a feather angle mode, wherein the global control system attempts to direct the streamer positioning devices to maintain each of the streamers in a straight line offset from the towing direction of the marine seismic vessel by a certain feather angle, and into a turn control mode, wherein the global control system directs the streamer positioning devices to generate a force in the opposite direction of a turn at the beginning of the turn. At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art to describe various equivalent modes of operation for multiple streamers having lateral control. Various modes of operation of seismic streamers had been publicly recognized within the seismic industry since the 1970's and 1980's, and became widely recognized in commercial practice by the early 1990's. The limitation of "a feather angle mode wherein … maintain each of said streamers in a straight line offset from the towing direction of said marine seismic vessel by a certain feather angle" was recognized as obvious from the time of the first commercial use of multiple streamers. This concept of desiring to tow streamers straight and parallel with constant feather angle was widely recognized and employed as commercial practice by the early 1990's. At the time of the invention, the limitation of "a feather angle mode wherein … maintain each of said streamers in a straight line offset from the towing direction of said marine seismic vessel by a certain feather angle" was obvious. At the time of the invention, it was also obvious to operate streamers in circles (so-called circle-shoots). It was known to persons of ordinary skill in the art by at least before 1995 that global control systems were used to control the streamer positing devices, and that such control systems were located at or near the vessel. Using global control systems to direct the streamer positioning devices to maintain each of the streamers in a straight line offset from the towing direction of the marine seismic vessel by a certain feather angle, and to generate a force in the opposite direction of a turn at the beginning of the turn were also well known in the art at that time, making this obvious in light

U.S. Patent No. 7,162,967 Asserted Claims	Citations from prior-art
	of the cited combination.
9. The method as claimed in claim 8, which said global control system is further configured into a streamer separation mode, wherein said global control system attempts to direct said streamer positioning device to maintain a minimum separation distance between adjacent streamers.	The Workman '472 patent discloses this streamer separation mode. *See* claim 8 Analysis. *See, e.g.*, Workman '472, Col. 1, ll. 33-35 ("The ability to control the position and shape of the streamer cables is desirable for preventing the entanglement of the streamer cables"). *See, e.g.*, Workman '472, Col. 3, ll. 65-67 ("Threshold parameters may include a plurality of values for: minimum allowable separations between streamer cables"). At the time of the invention it was obvious to a Person Having Ordinary Skill In The Art that "streamer separation mode" exemplified commonsense commercial practice. It was obvious that avoiding entanglement of multiple streamers was the primary goal and mode of operation since the earliest multi-streamer 3D seismic surveys in the late 1980's and early 1990's.
10. The method as claimed in claim 9, further including the step of displaying the position of said streamer positioning devices on said seismic survey vessel.	*See* Claim 9 Analysis. At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art that displaying the positions of the streamer positioning devices (and of the entire streamer) was necessarily common commercial practice. Such displays utilized many different forms of computer graphics devices and display algorithms.
15. An array of seismic streamers towed by a towing vessel comprising:	The Bittleston '636 application discloses this limitation. *See, e.g.*, Bittleston '636 at p. 1, ll. 5-7 ("In order to perform a 3D seismic survey, a plurality of such streamers are towed at about 5 knots behind a seismic survey vessel, ...") This limitation is disclosed in the Workman '472 patent.

U.S. Patent No. 7,162,967 Asserted Claims	Citations from prior-art
	See, e.g., Workman '472 at Col. 1, ll. 17-19 ("Due to the increasing use of marine 3-D seismic data, multi-cable marine surveys are now commonplace"). *See, e.g.*, FIG. 1 which discloses a towing vessel.
(a) a plurality of streamer positioning devices on or inline with each streamer, at least one of the streamer positioning devices having a wing;	The Bittleston '636 application discloses this limitation. *See, e.g.*, Bittleston '636 at p. 1, ll. 14-15 ("control devices known as birds, attached to each streamer at intervals of 200 to 300 meters, are used.") *See, e.g.*, Bittleston '636 at FIGS. 1, 3-5 (figures depict wings) *See, e.g.*, Bittleston '636 at p. 4, 2nd Paragraph ("The bird 10 is provided with two opposed control surfaces, or wings, 24, typically moulded from a fibre-reinforced plastics material, which project horizontally outwardly from the body"). This limitation is disclosed in the Workman '472 patent. *See, e.g.*, Workman '472 at Col. 1, l. 45 ("Streamer positioning devices are well known in the art"). Further, see, e.g., Col. 1, ll. 46-61 which references several prior art streamer positioning devices with at least one wing. *See, e.g.*, Workman '472 at Col. 2, ll. 32-33 ("the prior art discloses a series of discrete devices for locating and controlling the positions of streamer cables").
(b) a global control system transmitting location information to at least one local control system on the at least one streamer positioning device having a wing, the local control system adjusting the wing.	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 3, ll. 58-62 ("the marine seismic data acquisition system 05 also includes a streamer control processor 40 for deciding when the streamer cables 13 should be repositioned and for calculating a position correction to reposition the streamer cables 13"). *See, e.g.*, Workman '472 at Col 4, ll. 8-21. ("The streamer control

U.S. Patent No. 7,162,967 Asserted Claims	Citations from prior-art
	processor 40 is connected to the network solution system 10, the seismic binning system 30, the streamer positioning control devices 14, and the seismic data recording system 18 and receives the real time signal outputs of these systems. The streamer control processor 40 evaluates these real time signals and the threshold parameters from the terminal 32 to determine when the streamer cables 13 need to be repositioned and to calculate the position correction required to keep the streamer cables 13 within the threshold parameters. The streamer control processor 40 is connected to the streamer device controller 16. When the streamer cables 13 need to be repositioned, the position correction is used by the streamer device controller 16 to adjust the streamer positioning devices 14 and reposition the streamer cables 13.") A Person Having Ordinary Skill In The Art will find this limitation obvious from the Bittleston '636 application. *See, e.g.,* FIG. 2 where the inputs 35, 37, and 38 obviously must come from a global control system. *See, e.g.,* Bittleston '636 at p. 5, Paragraph 3 which discloses a local controller and communication with a global controller: ("The control system 26 is schematically illustrated in Figure 2, and comprises a microprocessor-based control circuit 34 having respective inputs 35 to 39 to receive control signals representative of desired depth, actual depth, desired lateral position, actual lateral position and roll angle of the bird 10") *See, e.g.,* Bittleston '636 at p. 4, last Paragraph which discloses a local controller: ("The greater part of the length of the body 12 of the bird 10 is flexible, the only rigid parts being the connectors 20, 22, and a short central section which houses the control system"). *See, e.g.,* Bittleston '636 at p. 5, Paragraph 4 ("The control circuit 34 has two control outputs 44, 46, connected to control respective electrical stepper motors 48, 50, each of which is drivingly connected to a respective one of the wings 24."). *See, e.g.,* Bittleston '636 at p. 6, ll. 8-10 ("The control circuit 34 then adjusts each of the wings 24 independently by means of the stepper motors 48, 50 so as to start to achieve the calculated ... wing angular positions").

EXHIBIT 13

EXHIBIT 13

U.S. Patent No. 7,080,607 (the "'607 patent") Is Obvious In View of
U.S. Patent 5,790,472 (Workman '472) and Kalman Reference

U.S. Patent No. 7,080,607 Asserted Claims	**Citations from prior-art**
1. A method comprising: (a) towing an a [sic] array of streamers each having a plurality of streamer positioning devices there along;	U.S. Patent 5,790,472 (Adaptive Control of Marine Seismic Streamers; Workman & Chambers; assigned to Western Atlas; 1998) discloses this limitation *See, e.g.,* Workman '472 at Col. 2, ll. 32-33 ("... the prior art discloses a series of discrete devices for locating and controlling the positions of streamer cables") and Col. 2, ll. 45-47 ("The present invention is an improved system for controlling the position and shape of marine seismic streamer cables"). *See, e.g.,* Workman '472 at Col. 1, ll. 17-19 ("Due to the increasing use of marine 3-D seismic data, multi-cable marine surveys are now commonplace") *See, e.g.,* Workman '472 at Col. 1, l. 45 ("Streamer positioning devices are well known in the art") *See, e.g.,* Workman '472 at Col. 3, ll. 14-20 ("As known to those skilled in the art, streamer positioning devices 14, for example birds and tail buoys, may be attached to the exterior of the streamer cables 13 for adjusting the vertical and lateral positions of the streamer cables 13. The streamer cables 13 include electrical or optical cables for connecting the streamer positioning devices 14 to individual control and logging systems").
(b) predicting positions of at least some of the streamer positioning devices;	The Workman '472 patent discloses this limitation. *See, e.g.,* Workman '472 at Col. 2, ll. 15-18 ("These devices and methods may then be used to determine the real time position of the seismic sources and seismic streamer cables by computing a network solution to a Kalman filter, as disclosed by U.S. Pat. No. 5,353,223" Kalman, R.E., 1960, "A New approach to Linear Filtering and Prediction Problems," Trans of ASME-J. of Basic Engineering, vol. 82

U.S. Patent No. 7,080,607 Asserted Claims	Citations from prior-art
	(Series D), pp. 35-35 discloses the limitation of "prediction." *See, e.g.*, p. 36, bottom of right hand column in section "Optimal Estimation," first paragraph: "we have a *prediction* problem. Since our treatment will be general enough to include these and similar problems, we shall use hereafter the collective term estimation." Prediction is a fundamental aspect of Kalman filtering technology. A Person Having Ordinary Skill In The Art will understand that the disclosed Kalman filter is a well-known prior art technology that is obvious to use to obtain a predicted position.
(c) using the predicted positions to calculate desired changes in position of one or more of the streamer positioning devices; and	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 3, ll. 42-43 ("and a streamer cable controller 16 for controlling the streamer positioning devices 14"). *See* also, e.g., FIG. 2 *See, e.g.*, Workman '472 at Col. 3, ll. 59-62 ("includes a streamer control processor 40 for ... calculating a position correction to reposition the streamer cables 13") *See, e.g.*, Workman '472 at Col. 4, ll. 17-21 ("The streamer control processor 40 is connected to the streamer device controller 16. When the streamer cables 13 need to be repositioned, the position correction is used by the streamer device controller 16 to adjust the streamer positioning devices 14 and reposition the streamer cables 13.") This claim limitation "calculate desired changes in position of one or more of the streamer positioning devices" is also an inherent aspect of the invention. Given "predicted positions," it is inherently necessary that "desired changes in position" for the streamer positioning devices must be calculated to be able to implement any change in streamer position or motion whatsoever.
(d) implementing at least some of the desired changes.	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 1, ll. 55-57 ("For example, devices to control the lateral positioning of streamer cables by using camber-

U.S. Patent No. 7,080,607 Asserted Claims	Citations from prior-art
	adjustable hydrofoils or angled wings are disclosed") This claim limitation "actuating the wing motors to produce said desired changes in wing orientation" is also an inherent aspect of the invention. Given a desire to reposition the streamers, it is inherently necessary that the "wing orientation" for the streamer positioning devices will need to be altered, which inherently requires the action of a motor, or equivalent.
8. A method as claimed in claim 7, in which said global control system is further configured into a streamer separation mode, wherein said global control system attempts to direct said streamer positioning device to maintain a minimum separation distance between adjacent streamers.	The Workman '472 patent discloses the streamer separation mode. *See, e.g.*, Workman '472, Col. 1, ll. 33-35 ("The ability to control the position and shape of the streamer cables is desirable for preventing the entanglement of the streamer cables"). *See, e.g.*, Workman '472, Col. 3, ll. 65-67 (Threshold parameters may include a plurality of values for: minimum allowable separations between streamer cables").
15. An array of seismic streamers towed by a towing vessel comprising:	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 1, ll. 17-19 ("Due to the increasing use of marine 3-D seismic data, multi-cable marine surveys are now commonplace") *See, e.g.*, FIG. 1 which discloses a towing vessel.
(a) a plurality of streamer positioning devices on or inline with each streamer;	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 2, ll. 32-33 ("the prior art discloses a series of discrete devices for locating and controlling the positions of streamer cables") and Col. 2, ll. 45-47 ("The present invention is an improved system for controlling the position and shape of marine seismic streamer cables").

U.S. Patent No. 7,080,607 Asserted Claims	Citations from prior-art
	See, e.g., Workman '472 at Col. 1, l. 45 ("Streamer positioning devices are well known in the art") *See, e.g.*, Workman '472 at Col. 3, ll. 14-20 ("As known to those skilled in the art, streamer positioning devices 14, for example birds and tail buoys, may be attached to the exterior of the streamer cables 13 for adjusting the vertical and lateral positions of the streamer cables 13. The streamer cables 13 include electrical or optical cables for connecting the streamer positioning devices 14 to individual control and logging systems").
(b) a prediction unit adapted to predict positions of at least some of the streamer positioning devices; and	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 2, ll. 15-18 ("These devices and methods may then be used to determine the real time position of the seismic sources and seismic streamer cables by computing a network solution to a Kalman filter, as disclosed by U.S. Pat. No. 5,353,223" Kalman, R.E., 1960, "A New approach to Linear Filtering and Prediction Problems," Trans of ASME-J. of Basic Engineering, vol. 82 (Series D), pp. 35-35 discloses the limitation of "prediction." *See, e.g.*, p. 36, bottom of right hand column in section "Optimal Estimation," first paragraph: "we have a *prediction* problem. Since our treatment will be general enough to include these and similar problems, we shall use hereafter the collective term estimation." Prediction is a fundamental aspect of Kalman filtering technology. A Person Having Ordinary Skill In The Art will understand that the disclosed Kalman filter is a well-known prior art technology that is obvious to use to obtain a predicted position.
(c) a control unit adapted to use the predicted positions to calculate desired changes in positions of one or more of the streamer	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 3, ll. 42-43 ("and a streamer cable controller 16 for controlling the streamer positioning devices 14"). *See* also, e.g., FIG. 2

U.S. Patent No. 7,080,607 Asserted Claims	Citations from prior-art
positioning devices.	*See, e.g.,* Workman '472 at Col. 3, ll. 59-62 ("includes a streamer control processor 40 for … calculating a position correction to reposition the streamer cables 13") *See, e.g.,* Workman '472 at Col. 4, ll. 17-21 ("The streamer control processor 40 is connected to the streamer device controller 16. When the streamer cables 13 need to be repositioned, the position correction is used by the streamer device controller 16 to adjust the streamer positioning devices 14 and reposition the streamer cables 13.") This claim limitation "calculate desired changes in position of one or more of the streamer positioning devices" is also an inherent aspect of the invention. Given "predicted positions," it is inherently necessary that "desired changes in position" for the streamer positioning devices must be calculated to be able to implement any change in streamer position or motion whatsoever.

EXHIBIT 14

EXHIBIT 14

U.S. Patent No. 7,080,607 (the "'607 patent") Is Obvious In View of International Application WO 98/28636 (Bittleston '636) and U.S. Patent 5,790,472 (Workman '472)

U.S. Patent No. 7,080,607 Asserted Claims	Citations from prior-art
1. A method comprising: (a) towing an a *[sic]* array of streamers each having a plurality of streamer positioning devices there along;	PCT Application WO 98/28636 (Control Devices for Controlling the Position of a Marine Seismic Streamer; Bittleston; published 2 July, 1998) and U.S. Patent 5,790,472 disclose this limitation. *See, e.g.*, Bittleston '636 at p. 1, ll. 5-7 ("In order to perform a 3D seismic survey, a plurality of such streamers are towed at about 5 knots behind a seismic survey vessel") *See, e.g.*, Bittleston '636 at p. 1, ll. 14-15 ("control devices known as birds, attached to each streamer at intervals of 200 to 300 meters, are used.") *See, e.g.*, Workman '472 at Col. 2, ll. 32-33 ("the prior art discloses a series of discrete devices for locating and controlling the positions of streamer cables") and Col. 2, ll. 45-47 ("The present invention is an improved system for controlling the position and shape of marine seismic streamer cables"). *See, e.g.*, Workman '472 at Col. 1, ll. 17-19 ("Due to the increasing use of marine 3-D seismic data, multi-cable marine surveys are now commonplace") *See, e.g.*, Workman '472 at Col. 1, l. 45 ("Streamer positioning devices are well known in the art") *See, e.g.*, Workman '472 at Col. 3, ll. 14-20 ("As known to those skilled in the art, streamer positioning devices 14, for example birds and tail buoys, may be attached to the exterior of the streamer cables 13 for adjusting the vertical and lateral positions of the streamer cables 13. The streamer cables 13 include electrical or optical cables for connecting the streamer positioning devices 14 to individual control and logging systems").
(b) predicting positions of at least some of the streamer positioning devices;	The Bittleston '636 application and the Workman '472 patent disclose this limitation. *See, e.g.*, Bittleston '636 at p. 5, 11-14 ("The control system 26 is schematically illustrated in Figure 2, and comprises a microprocessor-based control circuit 34 having respective inputs 35 to 39 to receive control signals

U.S. Patent No. 7,080,607 Asserted Claims	Citations from prior-art
	representative of … actual lateral position") in conjunction with p. 5, ll. 18-20 ("The lateral position signals are typically derived from a position determining system of the kind described in our US Patent No 4,992,990 or our International patent Application No WO9621163.") *See, e.g.*, Workman '472 at Col. 2, ll. 15-18 ("These devices and methods may then be used to determine the real time position of the seismic sources and seismic streamer cables by computing a network solution to a Kalman filter, as disclosed by U.S. Pat. No. 5,353,223") Prediction is a fundamental aspect of Kalman filtering technology. A Person Having Ordinary Skill In The Art will understand that the disclosed Kalman filter is a well-known prior art technology that is obvious to use to obtain a predicted position.
(c) using the predicted positions to calculate desired changes in position of one or more of the streamer positioning devices; and	The Bittleston '636 application and the Workman '472 patent disclose this limitation. *See, e.g.*, Bittleston '636 at p. 5, ll. 11-14 ("The control system 26 is schematically illustrated in Figure 2, and comprises a microprocessor-based control circuit 34 having respective inputs 35 to 39 to receive control signals representative of … actual lateral position"). Further at p. 6, ll. 1-8 ("In operation, the control circuit 34 receives … between its inputs 37 and 38 a signal indicative of the difference between the actual and desired lateral positions of the bird 10 … difference signals are used by the control circuit 34 to calculate the respective angular positions of the wings 24 which together will produce the … lateral force (left or right) required to move the bird 10 to the desired … lateral position."). *See also, e.g.*, FIG. 2 of Bittleston '636. *See, e.g.*, Workman '472 at Col. 3, ll. 42-43 ("a streamer cable controller 16 for controlling the streamer positioning devices 14"). *See* also, e.g., FIG. 2 *See, e.g.*, Workman '472 at Col. 3, ll. 59-62 ("includes a streamer control processor 40 for … calculating a position correction to reposition the streamer cables 13") *See, e.g.*, Workman '472 at Col. 4, ll. 17-21 ("The streamer control processor 40 is connected to the streamer device controller 16. When the streamer cables 13 need to be repositioned, the position correction is used by the streamer device controller 16 to adjust the streamer positioning devices 14 and reposition the streamer cables 13.")

U.S. Patent No. 7,080,607 Asserted Claims	Citations from prior-art
	It is obvious to a Person Having Ordinary Skill In The Art that, given "predicted positions", it is necessary that "desired changes in position" for the streamer positioning devices must be calculated to be able to implement any change in streamer position or motion whatsoever.
(d) implementing at least some of the desired changes.	The Bittleston '636 application and the Workman '472 patent disclose this limitation. *See, e.g.,* Bittleston '636 at p. 6, ll. 8-10 ("The control circuit 34 then adjusts each of the wings 24 independently by means of the stepper motors 48, 50 so as to start to achieve the calculated … wing angular positions"). *See, e.g.,* Workman '472 at Col. 1, ll. 55-57 ("For example, devices to control the lateral positioning of streamer cables by using camber-adjustable hydrofoils or angled wings are disclosed") This claim limitation "actuating the wing motors to produce said desired changes in wing orientation" is also an inherent aspect of the invention. Given a desire to reposition the streamers, it is inherently necessary that the "wing orientation" for the streamer positioning devices will need to be altered, which inherently requires the action of a motor or actuator.
2. A method as claimed in claim 1, comprising estimating velocity of at least some of the streamer positioning devices, wherein said estimated velocity is calculated using a vessel speed received from a navigation system on said seismic survey vessel.	The Workman '472 patent discloses this limitation. *See, e.g.,* Workman '472 at Col. 3, ll. 33-50 ("As known to those skilled in the art, components of the marine seismic data acquisition system 05, on the vessel 11, may include a vessel positioning system 20 for determining the position of the vessel 11 by satellite navigation, … a network solution system 10 for determining the position of the streamer cables") At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art that this limitation was commercially available prior-art. It was obvious to use commercially available navigation systems, including satellites, to determine vessel speed (and track-made-good); and to use commercially available Kalman filter based navigation systems, or equivalents, which can estimate velocities of locations along a streamer, such as a streamer positioning device. At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art that the "estimated velocity" of the streamer positioning devices *must* include the "vessel speed" as the major component because the vessel is

U.S. Patent No. 7,080,607 Asserted Claims	Citations from prior-art
	towing the streamers and the streamer positioning devices. It is also obvious to a Person Having Ordinary Skill In The Art that the "estimated velocity" is a vector which by definition must include direction as well as speed. Thus in addition to the "vessel speed" it is required to also have information regarding heading, course, and track-made-good.
3. A method as claimed in claim 2, in which said estimated velocity is a water referenced towing velocity that compensates for the speed and heading of marine currents acting on said streamer positioning devices.	At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art to utilize the vector combination of the towing velocity vector and current velocity to obtain a "water referenced towing velocity". Further it was obvious that this limitation was disclosed in long-standing navigational prior-art discloses techniques for "dead reckoning" which "compensate for the speed and heading of marine currents." At the time of the invention, it was also obvious to a Person Having Ordinary Skill In The Art to utilize commercially available prior-art devices and methods such as Doppler sonar current meters or electromagnetic speed logs that can directly provide vessel speed and course through the water. Workman '472 discloses this limitation. *See, e.g.*, Workman '472 at Col 1, ll. 28-34 which recognizes the need to compensate for the effect of marine currents on streamers, and the attached streamer positioning devices. ("A natural consequence of towing such streamer cable configurations in a marine environment is that currents, wind, and wave action will deflect the streamer cables from their intended paths. Streamer cable drift is a continuing problem for marine seismic surveys. … The ability to control the position and shape of the streamer cables is desirable") Then, further, *see, e.g.*, Workman '472 at Col. 2, ll. 45-47 which discloses a solution to this problem ("The present invention is an improved system for controlling the position and shape of marine seismic streamer cables.")
4. A method as claimed in claim 3, in which said estimated velocity is compensated for relative movement between said seismic survey vessel and said streamer positioning devices.	The Workman '472 patent discloses this limitation. See, e.g., Workman '472 at Col. 3, ll. 33-50 ("As known to those skilled in the art, components of the marine seismic data acquisition system 05, on the vessel 11, may include a vessel positioning system 20 for determining the position of the vessel 11 by satellite navigation, … a network solution system 10 for determining the position of the streamer cables")

U.S. Patent No. 7,080,607 Asserted Claims	Citations from prior-art
	At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art that this limitation was commercially available prior-art. It was obvious to use commercially available navigation systems, including satellites, to determine vessel speed (and track-made-good); to use commercially available acoustic and streamer compass based streamer navigation systems; and to use commercially available Kalman filter based navigation systems, or equivalents, which readily estimate velocities of locations along a streamer, such as a streamer positioning device. Then having vessel velocity and streamer positioning device velocity, this obviously gives relative movement. At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art that the vector combination of the relative velocity vector ("relative movement between said seismic survey vessel and said streamer positioning devices.") and vessel velocity (referenced to the water as in claim 3) to obtain a "velocity [that] is compensated" for the streamer positioning devices is a simple application of well-known prior-art in the vector analysis of velocities.
5. A method as claimed in claim 2, in which said step of using the predicted positions to calculate desired changes in position of one or more of the streamer positioning devices further uses an estimate of the crosscurrent velocity at the respective streamer positioning device.	At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art to use commercially available Doppler sonar speed logs or electromagnetic speed logs to provide vessel speed through the water which can be used in classical prior-art navigation to compare with radio-navigation or satellite positions of the vessel to determine crosscurrents. At the time of the invention it was obvious to a Person Having Ordinary Skill In The Art that it is possible to calculate a desired change in wing orientation only if an "estimate of the cross-current velocity" is available, *i.e.*, only if the so-called angle-of-attack of the wings relative to water flow were available, rather than simply the angle of the wings relative to the streamer axis. Then given the complete geometry information including the crosscurrent and the angle-of-attack, the relationships of forces and wing angles and wing shapes are obvious as well-known prior-art.

U.S. Patent No. 7,080,607 Asserted Claims	Citations from prior-art
6. A method as claimed in claim 5, in which said step of using the predicted positions to calculate desired changes in position of one or more of the streamer positioning devices is regulated to prevent the positioning device from stalling.	At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art to regulate wing angles to prevent stalling, given complete information about the relative geometry of the wings and water flow over the wings, including the so-called angle-of-attack.
7. A method as claimed in claim 6, in which said step of using the predicted positions to calculate desired changes in position of one or more of the streamer positioning devices is regulated by a global control system located on or near a seismic survey vessel that is configured into a feather angle mode, wherein said global control system attempts to direct the streamer positioning devices to maintain each of said streamers in a straight line offset from the towing direction of said marine seismic vessel by a certain feather angle, and into a turn control mode, wherein said global control system directs said streamer positioning devices to generate a force in the opposite direction of a turn at the beginning of the turn.	The Workman '472 patent discloses a control system and a mode of streamer operation. *See, e.g.*, Workman '472 at Col. 3, ll. 58-67 ("In the present embodiment of the invention, the marine seismic data acquisition system 05 also includes a streamer control processor 40 for deciding when the streamer cables 13 should be repositioned and for calculating a position correction to reposition the streamer cables 13. Also in the present embodiment of the invention, threshold parameters are established for determining when the streamer cables should be repositioned. Threshold parameters may include a plurality of values for: minimum allowable separations between streamer cables 13") *See, generally, e.g.*, Workman '472 at Col. 4, ll. 8-35 (generally discloses streamer control processor). See, e.g., Workman '472 at Col. 4, ll. ("The streamer control processor 40 is connected to the streamer device controller 16. When the streamer cables 13 need to be repositioned, the position correction is used by the streamer device controller 16 to adjust the streamer positioning devices") At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art to describe various modes of operation for multiple streamers having lateral control. Various modes of operation of seismic streamers had been publicly recognized within the seismic industry since the 1970's and 1980's, and became widely recognized in commercial practice by the early 1990's. The limitation of "a feather angle mode wherein … maintain each of said streamers in a straight line offset from the towing direction of said marine seismic vessel by a certain feather angle" was recognized from the time of the first commercial use of multiple streamers. This concept of desiring to tow streamers straight and parallel with constant feather angle was widely recognized and employed as commercial practice by the early 1990's. At the time of the invention, the limitation of "a feather angle mode wherein …

U.S. Patent No. 7,080,607 Asserted Claims	Citations from prior-art
	maintain each of said streamers in a straight line offset from the towing direction of said marine seismic vessel by a certain feather angle" was obvious. At the time of the invention, it was also obvious to operate streamers in circles (so-called circle-shoots).
8. A method as claimed in claim 7, in which said global control system is further configured into a streamer separation mode, wherein said global control system attempts to direct said streamer positioning device to maintain a minimum separation distance between adjacent streamers.	The Workman '472 patent discloses the streamer separation mode. *See, e.g.*, Workman '472, Col. 1, ll. 33-35 ("The ability to control the position and shape of the streamer cables is desirable for preventing the entanglement of the streamer cables …"). *See, e.g.*, Workman '472, Col. 3, ll. 65-67 (Threshold parameters may include a plurality of values for: minimum allowable separations between streamer cables …"). At the time of the invention it was obvious to a Person Having Ordinary Skill In The Art that "streamer separation mode" exemplified commonsense commercial practice. It was obvious that avoiding entanglement of multiple streamers was the primary goal and mode of operation since the earliest multi-streamer 3D seismic surveys in the late 1980's and early 1990's.
9. A method as claimed in claim 8, further including the step of displaying the position of said streamer positioning devices on said seismic survey vessel.	At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art that displaying the positions of the streamer positioning devices (and of the entire streamer) was necessarily common commercial practice. Such displays utilized many different forms of computer graphics devices and display algorithms.
15. An array of seismic streamers towed by a towing vessel comprising:	The Bittleston '636 application and the Workman '472 patent disclose this limitation. *See, e.g.*, Bittleston '636 at p. 1, ll. 5-7 ("In order to perform a 3D seismic survey, a plurality of such streamers are towed at about 5 knots behind a seismic survey vessel") *See, e.g.*, Workman '472 at Col. 1, ll. 17-19 ("Due to the increasing use of marine 3-D seismic data, multi-cable marine surveys are now commonplace")

U.S. Patent No. 7,080,607 Asserted Claims	Citations from prior-art
	See, e.g., Workman '472 FIG. 1 which discloses a towing vessel.
(a) a plurality of streamer positioning devices on or inline with each streamer;	The Bittleston '636 application and the Workman '472 patent disclose this limitation. *See, e.g.*, '636 Bittleston at p. 1, ll. 14-15 ("control devices known as birds, attached to each streamer at intervals of 200 to 300 meters, are used.") *See, e.g.*, Workman '472 at Col. 2, ll. 32-33 ("... the prior art discloses a series of discrete devices for locating and controlling the positions of streamer cables") and Col. 2, ll. 45-47 ("The present invention is an improved system for controlling the position and shape of marine seismic streamer cables"). *See, e.g.*, Workman '472 at Col. 1, l. 45 ("Streamer positioning devices are well known in the art") *See, e.g.*, Workman '472 at Col. 3, ll. 14-20 ("As known to those skilled in the art, streamer positioning devices 14, for example birds and tail buoys, may be attached to the exterior of the streamer cables 13 for adjusting the vertical and lateral positions of the streamer cables 13. The streamer cables 13 include electrical or optical cables for connecting the streamer positioning devices 14 to individual control and logging systems").
(b) a prediction unit adapted to predict positions of at least some of the streamer positioning devices; and	The Bittleston '636 application and the Workman '472 patent disclose this limitation. *See, e.g.*, '636 Bittleston, at p. 5, ll. 11-14 ("The control system 26 is schematically illustrated in Figure 2, and comprises a microprocessor-based control circuit 34 having respective inputs 35 to 39 to receive control signals representative of ... actual lateral position"). *See also, e.g.*, FIG. 2 of Bittleston '636. *See, e.g.*, Workman '472 at Col. 2, ll. 15-18 ("These devices and methods may then be used to determine the real time position of the seismic sources and seismic streamer cables by computing a network solution to a Kalman filter, as disclosed by U.S. Pat. No. 5,353,223")

U.S. Patent No. 7,080,607 Asserted Claims	Citations from prior-art
	Prediction is a fundamental aspect of Kalman filtering technology. A Person Having Ordinary Skill In The Art will understand that the disclosed Kalman filter is a well-known prior art technology that is obvious to use to obtain a predicted position.
(c) a control unit adapted to use the predicted positions to calculate desired changes in positions of one or more of the streamer positioning devices.	The Bittleston '636 application and the Workman '472 patent disclose this limitation. *See, e.g.*, Bittleston '636 at p. 5, ll. 11-14 ("The control system 26 is schematically illustrated in Figure 2, and comprises a microprocessor-based control circuit 34 having respective inputs 35 to 39 to receive control signals representative of … actual lateral position"). Further at p. 6, ll. 1-8 ("In operation, the control circuit 34 receives … between its inputs 37 and 38 a signal indicative of the difference between the actual and desired lateral positions of the bird 10 … difference signals are used by the control circuit 34 to calculate the respective angular positions of the wings 24 which together will produce the … lateral force (left or right) required to move the bird 10 to the desired … lateral position."). *See also, e.g.*, FIGS. 2, and 3-5 of Bittleston '636. *See, e.g.*, Workman '472 at Col. 3, ll. 42-43 ("and a streamer cable controller 16 for controlling the streamer positioning devices 14"). *See* also, e.g., FIG. 2 *See, e.g.*, Workman '472 at Col. 3, ll. 59-62 ("includes a streamer control processor 40 for … calculating a position correction to reposition the streamer cables 13") *See, e.g.*, Workman '472 at Col. 4, ll. 17-21 ("The streamer control processor 40 is connected to the streamer device controller 16. When the streamer cables 13 need to be repositioned, the position correction is used by the streamer device controller 16 to adjust the streamer positioning devices 14 and reposition the streamer cables 13.") It is obvious to a Person Having Ordinary Skill In The Art that, given "predicted positions," it is necessary that "desired changes in position" for the streamer positioning devices must be calculated to be able to implement any change in streamer position or motion whatsoever.

EXHIBIT 15

EXHIBIT 15

U.S. Patent No. 7,162,967 (the "967 patent") Is Obvious in View of International Patent Application WO 97/11395 (Olivier '395) and U.S. Patent 4,404,664 (Zachariadis '664)

U.S. Patent No. 7,162,967 Asserted Claims	Citations from prior-art
1. A method comprising: (a) towing an array of streamers each having a plurality of streamer positioning devices there along, at least one of the streamer positioning devices having a wing;	U.S. Patent 4,404,664 (System for Laterally Positioning a Towed Marine Cable and Method of Using Same; Zachariadis; assigned to Mobil Oil; 1983) in combination with PCT Patent Application WO 97/11395 (Coil Support Device for an Underwater Cable; Olivier; assigned to Laitram Co.; published 1997) discloses this limitation. *See, e.g.,* Zachariadis '664, Claim 1, (Col. 13, l. 6) to (Col. 14, l. 2) ("A system for controlling the lateral position of a marine cable being towed by a vessel and having adjustable control surfaces affixed to said marine cable at a plurality of spaced-apart positions along said cable for varying lateral thrust to said cable in response to control signals from the vessel") *See, e.g.,* Zachariadis '664, Col. 3, ll. 16-18 ("a plurality of remotely controlled, lateral positioning devices are mounted at selected points along the length of the cable"). *See, e.g.,* Zachariadis '664, claim 1, Col. 13, ll. 13-14 ("a motor associated with each control surface for rotating said control surface"). *See, e.g.,* Zachariadis'664, Col. 1, ll. 41-43 ("Lateral positioning of a towed cable comprises two basic aspects: determining the existing position of the cable and moving it to a desired position"). *See, generally,* Zachariadis '664, Col. 1, l. 41 to col. 2, l. 68. Olivier '395 discloses the limitation of "an array of streamers being towed by a seismic survey vessel". *See, e.g.,* Olivier '395 at p.1, l. 24; to p. 2, l. 2 ("In marine seismic exploration, an underwater cable, commonly referred to as a streamer cable, is towed through the water by a vessel such as a surface ship.")

U.S. Patent No. 7,162,967 Asserted Claims	Citations from prior-art
	See, e.g., Olivier '395 at p. 7, ll. 13-15 ("... there is no restriction on the number or type of devices which are attached to the cable 11. In addition, although only a single cable 11 is shown, the towing vessel 10 may tow a plurality of cables simultaneously.") *See, e.g.,* Olivier FIG. 1 which discloses a plurality of streamer positioning devices. *See, e.g.,* Olivier, FIGS. 7-8 which disclose wings.
(b) transmitting from a global control system location information to at least one local control system on the at least one streamer positioning devices having a wing; and	The Zachariadis '664 patent and Olivier '395 application disclose this limitation. *See, generally,* Zachariadis '664, Col. 3, l. 43 to Col. 4, l. 4. *See, e.g.,* Zachariadis '664, Col. 3, l. 43-44 ("It is a further object to control the lateral positioning devices of such as system through the use of a computer.") *See, e.g.,* Zachariadis '664 Col. 3, l. 55 ("Transmissions means are provided"); and *see, e.g.,* '664 Zachariadis, Col. 3, ll. 58-66 ("Suitable circuitry in each lateral positioning device senses and examines the coded control signal ... In the selected lateral positioning device, circuitry further decodes the coded control signal. Motor actuation means are controlled by the decoder means ... and operate motor means for the adjustment of the lateral positioning control surfaces [wings]"). At the time of invention, given the state of the art of control systems, it would have been obvious to a Person Having Ordinary Skill In The Art to provide "a global control system located on or near said seismic vessel" to control/regulate multiple streamer positioning devices, each with their own local controller. The Olivier '395 application discloses a local control system and communication, such as from a global control system. *See* Figures 33-35 and *generally* pp. 44-48.

U.S. Patent No. 7,162,967 Asserted Claims	Citations from prior-art
(c) adjusting the wing using the local control system.	This limitation is disclosed in the Zachariadis '664 patent and Olivier '395 application. *See, e.g.*, Zachariadis '664, claim 1; col. 13, l. 13 to col. 14, l. 2 ("a motor associated with each control surface for rotating said control surface … to a second position at which a desired lateral thrust is imparted to said cable, receiving means … to cause said motor to rotate said control surface of said second position") At the time of the invention it was obvious to a Person Having Ordinary Skill In The Art that wing motors were commercially available prior-art, as found, for example, in depth birds from multiple commercial suppliers. The Olivier '395 reference discloses this limitation. *See e.g.*, Olivier '395 at p. 19 ll. 5-6 ("The actuators for operating the wing unit 110 include one which will be referred to as a roll actuator 130 and another which will be referred to as a pitch actuator 135.") *See e.g.*, Olivier '395 at p. 47, ll. 5-10 ("In a depth-keeping mode of operation, the microprocessor 304 executes a PID (proportional-integral-differential) or other control algorithm and determines whether the wing positions need to be changed. If so, the microprocessor 304 sends appropriate signals to the motors 410, 411 of the roll and/or pitch actuator through buffers 412, 413 (possibly including D/A converters) which convert the low-level logic signals from the microprocessor into higher level motor signals sufficient to drive the motors.")
4. The method as claimed in claim 1, wherein the global control system transmits a desired vertical depth for the at least one streamer positioning device and the local control system calculates magnitude and direction of the deviation between the desired vertical	The Zachariadis '664 patent discloses this limitation. *See generally, e.g.*, Col. 3, l. 43 to Col. 4, l.4 *See, e.g.*, Zachariadis, '664 at Col. 4, ll. 51-57 ("The aforesaid control signal is generated … in direct response to the aforesaid vessel and lateral positioning device coordinate signals. Transmission means are provided for converting the coded control signals into a form suitable for transmitting through conductors in

U.S. Patent No. 7,162,967 Asserted Claims	Citations from prior-art
depth and actual depth.	the seismic cable.") *See, e.g.*, Zachariadis, '664 at Col. 1, ll. 47-50 ("U.S. Pat. Nos. 3,605,674 to Weese … discloses several variations of a remotely controlled device for laterally or laterally and vertically positioning a streamer").
5. The method as claimed in claim 1, wherein the global control system transmits a desired horizontal displacement for the at least one streamer positioning device and the local control system calculates magnitude and direction of the deviation between the desired horizontal displacement and actual horizontal displacement.	The Zachariadis '664 patent discloses this limitation. S*ee generally, e.g.*, Col. 3, l. 43 to Col. 4, l. 4 *See, e.g.*, Zachariadis, '664 at Col. 4, ll. 51-57 ("The aforesaid control signal is generated … in direct response to the aforesaid vessel and lateral positioning device coordinate signals. Transmission means are provided for converting the coded control signals into a form suitable for transmitting through conductors in the seismic cable.") *See, e.g.*, Zachariadis, '664 at Col. 1, ll. 47-50 ("U.S. Pat. Nos. 3,605,674 to Weese … discloses several variations of a remotely controlled device for laterally or laterally and vertically positioning a streamer …").
6. The method as claimed in claim 1, comprising calculating velocity of at least one of the streamer positioning devices, wherein the calculating velocity comprises at least one of a) using a vessel speed received from a navigation system on a seismic survey vessel; b) compensating for the speed and heading of marine currents acting on the at least one streamer positioning device; and c) compensating for relative movement between the seismic survey vessel and the at least one streamer positioning	At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art that velocities of the streamer positioning devices are readily calculated from the successive positions of said streamer positioning devices at a series of time. (a.) At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art that "calculating velocity of at least one of the streamer positioning devices" *must* include the "vessel speed" as the major component because the vessel is towing the streamers and the streamer positioning devices. It is also obvious to a Person Having Ordinary Skill In The Art that the "calculating velocity" involves a vector which by definition must include direction as well as speed. Thus in addition to the "vessel speed" it is required to also have information regarding vessel heading, course, and track-made-good.) At the time of the invention, it was also obvious to a Person Having Ordinary Skill In The Art that it was routine navigational

U.S. Patent No. 7,162,967 Asserted Claims	Citations from prior-art
device.	practice to obtain vessel speed in any of several ways within the prior-art. For example, satellite navigation or radio-navigation systems can routinely provide vessel position and speed. Additionally, Doppler sonar speed logs or electromagnetic speed logs are well-known commercially available prior-art devices which can provide vessel speed through the water. (b.) At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art to utilize long-standing prior-art navigational techniques to "compensate for the speed and heading of marine currents". (c.) At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art that the vector combination of the relative velocity vector ("relative movement between the seismic survey vessel and the at least one streamer positioning device.") and vessel velocity (referenced to the water as in claim 3.) to obtain a velocity "compensated for relative movement" is obvious application of well-known prior-art in the vector analysis of velocities.
7. The method as claimed in claim 6, in which said step of adjusting the wing using the local control system is regulated to prevent the positioning device from stalling.	At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art to regulate wing angles to prevent stalling, given complete information about the relative geometry of the wings and water flow over the wings, including the geometric or effective angle-of-attack.
8. The method as claimed in claim 7, in which said step of using the location information to calculate desired forces on the at least one streamer positioning device is regulated by the global control system located on or near a seismic survey vessel that is configured into a feather angle mode, wherein the global control system attempts to direct the	These limitations are disclosed in the Zachariadis '664 patent and Olivier '395 application. *See, generally*, Zachariadis '664, Col. 3, l. 43 to Col. 4, l. 4. *See, e.g.*, Zachariadis '664, Col. 3, l. 43-44 ("It is a further object to control the lateral positioning devices of such as system through the use of a computer.") *See, e.g.*, Zachariadis '664 Col. 3, l. 55 ("Transmissions means are provided"); and *see, e.g.*, '664 Zachariadis, Col. 3, ll. 58-66 ("Suitable circuitry in each lateral positioning device senses and

U.S. Patent No. 7,162,967 Asserted Claims	Citations from prior-art
streamer positioning devices to maintain each of the streamers in a straight line offset from the towing direction of the marine seismic vessel by a certain feather angle, and into a turn control mode, wherein the global control system directs the streamer positioning devices to generate a force in the opposite direction of a turn at the beginning of the turn.	examines the coded control signal ... In the selected lateral positioning device, circuitry further decodes the coded control signal. Motor actuation means are controlled by the decoder means ... and operate motor means for the adjustment of the lateral positioning control surfaces"). At the time of invention, given the state of the art of control systems, it would have been obvious to a Person Having Ordinary Skill In The Art to provide "a global control system located on or near said seismic vessel" to control/regulate multiple streamer positioning devices, each with their own local controller. The Olivier '395 application discloses a local control system and communication, such as from a global control system. *See* Figures 33-35 and *generally* pp. 44-48. At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art to describe various equivalent modes of operation for multiple streamers having lateral control. Various modes of operation of seismic streamers had been publicly recognized within the seismic industry since the 1970's and 1980's, and became widely recognized in commercial practice by the early 1990's. The limitation of "a feather angle mode wherein ... maintain each of said streamers in a straight line offset from the towing direction of said marine seismic vessel by a certain feather angle" was recognized as obvious from the time of the first commercial use of multiple streamers. This concept of desiring to tow streamers straight and parallel with constant feather angle was widely recognized and employed as commercial practice by the early 1990's. At the time of the invention, the limitation of "a feather angle mode wherein ... maintain each of said streamers in a straight line offset from the towing direction of said marine seismic vessel by a certain feather angle" was obvious. At the time of the invention, it was also obvious to operate streamers in circles (so-called circle-shoots). The Zachariadis '664 patent discloses the limitation of a "feather angle mode". *See, e.g.*, Zachariadis '664 at Col. 12, ll. 53-57 ("It should also be realized that the adjustments of said lateral positioning devices to position the cable in a straight line along a heading from the towing vessel can be accomplished automatically by a suitably sized and

U.S. Patent No. 7,162,967 Asserted Claims	Citations from prior-art
	programmed computer.").
9. The method as claimed in claim 8, which said global control system is further configured into a streamer separation mode, wherein said global control system attempts to direct said streamer positioning device to maintain a minimum separation distance between adjacent streamers.	This limitation is disclosed in Zachariadis '664. *See, e.g.,* Claim 7 Analysis, and *see, generally*, Zachariadis '664, Col. 3, l. 43 to Col. 4, l. 4 At the time of the invention it was obvious to a Person Having Ordinary Skill In The Art that "streamer separation mode" exemplified commonsense commercial practice. It was obvious that avoiding entanglement of multiple streamers was the primary goal and mode of operation since the earliest multi-streamer 3D seismic surveys in the late 1980's and early 1990's.
10. The method as claimed in claim 9, further including the step of displaying the position of said streamer positioning devices on said seismic survey vessel.	This limitation is disclosed in the Zachariadis '664 patent. *See, e.g.*, Zachariadis '664, Abstract, ll. 11-13 ("... visual display of the relative position of each lateral positioning device with respect to the vessel ..."). *See, e.g.*, Zachariadis '664, Col. 3, ll. 29-33 ("The coordinate signals are provided to a display matrix of a suitable device ... for display of the relative positions of the vessel and lateral positioning devices ...") *See, e.g.*, Zachariadis '664, Col. 5, ll. 58-61 ("A simple plot of the X and Y coordinates of the ship and the lateral positioning devices is provided on a suitable visual display device"). *See, e.g.*, Zachariadis '664, Col. 4, ll. 28-30 ("FIG. 5 illustrates a visual display of the coordinates of the vessel and selected points along the towed cable as determined by the equipment of FIG. 2"); and said equipment is disclosed at, e.g., Col. 4, ll. 20-21 ("FIG. 2 illustrates in block diagram form the cable ... positioning equipment of the invention"). *See, e.g.*, Zachariadis '664, Col. 8, ll. 60-64 ("In addition to the location of the marine vessel and the lateral positioning devices,

U.S. Patent No. 7,162,967 Asserted Claims	Citations from prior-art
	the locations of various … may also be displayed"). *See, e.g.,* Zachariadis '664, Col. 3, ll. 31-33 ("display of the relative positions of the vessel and the lateral positioning devices with respect to the selected heading.") At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art that displaying the positions of the streamer positioning devices (and of the entire streamer) was necessarily common commercial practice. Such displays utilized many different forms of computer graphics devices and display algorithms.
15. An array of seismic streamers towed by a towing vessel comprising:	The Olivier '395 application discloses this limitation. *See, e.g.,* Olivier '395 at p.1, l. 24; to p. 2, l. 2 ("In marine seismic exploration, an underwater cable, commonly referred to as a streamer cable, is towed through the water by a vessel such as a surface ship.") *See, e.g.,* Olivier '395 at p. 7, ll. 14-15 ("In addition, although only a single cable 11 is shown, the towing vessel 10 may tow a plurality of cables simultaneously.")
(a) a plurality of streamer positioning devices on or inline with each streamer, at least one of the streamer positioning devices having a wing;	This limitation is disclosed in the Zachariadis '664 patent and Olivier '395 application. *See, e.g.,* Zachariadis '664, Col. 3, ll. 16-18 ("a plurality of remotely controlled, lateral positioning devices are mounted at selected points along the length of the cable"). *See, e.g.,* Olivier '395 at p. 7, ll. 13-15 ("there is no restriction on the number or type of devices which are attached to the cable 11. In addition, although only a single cable 11 is shown, the towing vessel 10 may tow a plurality of cables simultaneously.") *See, e.g.,* Olivier FIG. 1 which discloses a plurality of streamer positioning devices.

U.S. Patent No. 7,162,967 Asserted Claims	Citations from prior-art
	See, e.g., Olivier, FIGS. 7-8 which disclose wings.
(b) a global control system transmitting location information to at least one local control system on the at least one streamer positioning device having a wing, the local control system adjusting the wing.	This limitation of is disclosed in the Zachariadis '664 patent and Olivier '395 application. *See, generally*, Zachariadis '664, Col. 3, l. 43 to Col. 4, l. 4. *See, e.g.*, Zachariadis '664, Col. 3, l. 43-44 ("It is a further object to control the lateral positioning devices of such as system through the use of a computer.") *See, e.g.*, Zachariadis '664 Col. 3, l. 55 ("Transmissions means are provided"); and *see, e.g.*, '664 Zachariadis, Col. 3, ll. 58-66 ("Suitable circuitry in each lateral positioning device senses and examines the coded control signal ... In the selected lateral positioning device, circuitry further decodes the coded control signal. Motor actuation means are controlled by the decoder means ... and operate motor means for the adjustment of the lateral positioning control surfaces"). *See, e.g.*, Zachariadis '664, claim 1; col. 13, l. 13 to col. 14, l. 2 ("a motor associated with each control surface for rotating said control surface ... to a second position at which a desired lateral thrust is imparted to said cable, receiving means ... to cause said motor to rotate said control surface of said second position") At the time of invention, given the state of the art of control systems, it would have been obvious to a Person Having Ordinary Skill In The Art to provide "a global control system located on or near said seismic vessel" to control/regulate multiple streamer positioning devices, each with their own local controller. The Olivier '395 application discloses a local control system and communication, such as from a global control system. *See* Figures 33-35 and *generally* pp. 44-48. The Olivier '395 reference discloses the limitation of the "local control system adjusting the wing". *See e.g.*, Olivier '395 at p. 19 ll. 5-6 ("The actuators for operating the wing unit 110 include one which will be referred to as a roll

U.S. Patent No. 7,162,967 Asserted Claims	Citations from prior-art
	actuator 130 and another which will be referred to as a pitch actuator 135.") *See e.g.*, Olivier '395 at p. 47, ll. 5-10 ("In a depth-keeping mode of operation, the microprocessor 304 executes a PID (proportional-integral-differential) or other control algorithm and determines whether the wing positions need to be changed. If so, the microprocessor 304 sends appropriate signals to the motors 410, 411 of the roll and/or pitch actuator through buffers 412, 413 (possibly including D/A converters) which convert the low-level logic signals from the microprocessor into higher level motor signals sufficient to drive the motors.") At the time of the invention it was obvious to a Person Having Ordinary Skill In The Art that wing motors were commercially available prior-art, as found, for example, in depth birds from multiple commercial suppliers.

EXHIBIT 16

EXHIBIT 16

U.S. Patent No. 7,080,607 (the "'607 patent") Is Obvious In View of U.S. Patent 5,790,472 (Workman '472)

U.S. Patent No. 7,080,607 Asserted Claims	**Citations from prior-art**
1. A method comprising: (a) towing an a [sic] array of streamers each having a plurality of streamer positioning devices there along;	U.S. Patent 5,790,472 (Adaptive Control of Marine Seismic Streamers; Workman & Chambers; assigned to Western Atlas; 1998) discloses this limitation *See, e.g.,* Workman '472 at Col. 2, ll. 32-33 ("the prior art discloses a series of discrete devices for locating and controlling the positions of streamer cables") and Col. 2, ll. 45-47 ("The present invention is an improved system for controlling the position and shape of marine seismic streamer cables"). *See, e.g.,* Workman '472 at Col. 1, ll. 17-19 ("Due to the increasing use of marine 3-D seismic data, multi-cable marine surveys are now commonplace") *See, e.g.,* Workman '472 at Col. 1, l. 45 ("Streamer positioning devices are well known in the art") *See, e.g.,* Workman '472 at Col. 3, ll. 14-20 ("As known to those skilled in the art, streamer positioning devices 14, for example birds and tail buoys, may be attached to the exterior of the streamer cables 13 for adjusting the vertical and lateral positions of the streamer cables 13. The streamer cables 13 include electrical or optical cables for connecting the streamer positioning devices 14 to individual control and logging systems").
(b) predicting positions of at least some of the streamer positioning devices;	The Workman '472 patent discloses this limitation. *See, e.g.,* Workman '472 at Col. 2, ll. 15-18 ("These devices and methods may then be used to determine the real time position of the seismic sources and seismic streamer cables by computing a network solution to a Kalman filter, as disclosed by U.S. Pat. No. 5,353,223") Prediction is a fundamental aspect of Kalman filtering technology. A Person Having Ordinary Skill In The Art will understand that the disclosed Kalman filter is a well-known prior art technology that is obvious to use to obtain a predicted position. At the time of the invention, Kalman filtering, including a prediction step, was common commercial practice.

U.S. Patent No. 7,080,607 Asserted Claims	Citations from prior-art
(c) using the predicted positions to calculate desired changes in position of one or more of the streamer positioning devices; and	The Workman '472 patent discloses this limitation. *See, e.g.,* Workman '472 at Col. 3, ll. 42-43 ("and a streamer cable controller 16 for controlling the streamer positioning devices 14"). *See* also, e.g., FIG. 2 *See, e.g.,* Workman '472 at Col. 3, ll. 59-62 ("includes a streamer control processor 40 for … calculating a position correction to reposition the streamer cables 13") *See, e.g.,* Workman '472 at Col. 4, ll. 17-21 ("The streamer control processor 40 is connected to the streamer device controller 16. When the streamer cables 13 need to be repositioned, the position correction is used by the streamer device controller 16 to adjust the streamer positioning devices 14 and reposition the streamer cables 13.") This claim limitation "calculate desired changes in position of one or more of the streamer positioning devices" is also an inherent aspect of the invention. Given "predicted positions", it is inherently necessary that "desired changes in position" for the streamer positioning devices must be calculated to be able to implement any change in streamer position or motion whatsoever.
(d) implementing at least some of the desired changes.	The Workman '472 patent discloses this limitation. *See, e.g.,* Workman '472 at Col. 1, ll. 55-57 ("For example, devices to control the lateral positioning of streamer cables by using camber-adjustable hydrofoils or angled wings are disclosed") This claim limitation "actuating the wing motors to produce said desired changes in wing orientation" is also an inherent aspect of the invention. Given a desire to reposition the streamers, it is inherently necessary that the "wing orientation" for the streamer positioning devices will need to be altered, which inherently requires the action of a motor, or equivalent.

U.S. Patent No. 7,080,607 Asserted Claims	Citations from prior-art
8. A method as claimed in claim 7, in which said global control system is further configured into a streamer separation mode, wherein said global control system attempts to direct said streamer positioning device to maintain a minimum separation distance between adjacent streamers.	The Workman '472 patent discloses the streamer separation mode. *See, e.g.*, Workman '472, Col. 1, ll. 33-35 ("The ability to control the position and shape of the streamer cables is desirable for preventing the entanglement of the streamer cables"). *See, e.g.*, Workman '472, Col. 3, ll. 65-67 (Threshold parameters may include a plurality of values for: minimum allowable separations between streamer cables").
15. An array of seismic streamers towed by a towing vessel comprising:	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 1, ll. 17-19 ("Due to the increasing use of marine 3-D seismic data, multi-cable marine surveys are now commonplace") *See, e.g.*, FIG. 1 which discloses a towing vessel.
(a) a plurality of streamer positioning devices on or inline with each streamer;	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 2, ll. 32-33 ("the prior art discloses a series of discrete devices for locating and controlling the positions of streamer cables") and Col. 2, ll. 45-47 ("The present invention is an improved system for controlling the position and shape of marine seismic streamer cables"). *See, e.g.*, Workman '472 at Col. 1, l. 45 ("Streamer positioning devices are well known in the art") *See, e.g.*, Workman '472 at Col. 3, ll. 14-20 ("As known to those skilled in the art, streamer positioning devices 14, for example birds and tail buoys, may be attached to the exterior of the streamer cables 13 for adjusting the vertical and lateral positions of the streamer cables 13. The streamer cables 13 include electrical or optical cables for connecting the streamer positioning devices 14 to individual control and logging systems").

U.S. Patent No. 7,080,607 Asserted Claims	Citations from prior-art
(b) a prediction unit adapted to predict positions of at least some of the streamer positioning devices; and	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 2, ll. 15-18 ("These devices and methods may then be used to determine the real time position of the seismic sources and seismic streamer cables by computing a network solution to a Kalman filter, as disclosed by U.S. Pat. No. 5,353,223") Prediction is a fundamental aspect of Kalman filtering technology. A Person Having Ordinary Skill In The Art will understand that the disclosed Kalman filter is a well-known prior art technology that is obvious to use to obtain a predicted position. At the time of the invention, Kalman filtering, including a prediction step, was common commercial practice.
(c) a control unit adapted to use the predicted positions to calculate desired changes in positions of one or more of the streamer positioning devices.	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 3, ll. 42-43 ("and a streamer cable controller 16 for controlling the streamer positioning devices 14"). *See* also, e.g., FIG. 2 *See, e.g.*, Workman '472 at Col. 3, ll. 59-62 ("includes a streamer control processor 40 for … calculating a position correction to reposition the streamer cables 13") *See, e.g.*, Workman '472 at Col. 4, ll. 17-21 ("The streamer control processor 40 is connected to the streamer device controller 16. When the streamer cables 13 need to be repositioned, the position correction is used by the streamer device controller 16 to adjust the streamer positioning devices 14 and reposition the streamer cables 13.") This claim limitation "calculate desired changes in position of one or more of the streamer positioning devices" is also an inherent aspect of the invention. Given "predicted positions", it is inherently necessary that "desired changes in position" for the streamer positioning devices must be calculated to be able to implement any change in streamer position or motion whatsoever.

2665791v1

EXHIBIT 17

EXHIBIT O-6xxxx

U.S. Patent No. 6,932,017 (the "Hillesund '017 patent") Is Obvious In View of U.S. Patent 5,790,472 (Workman '472), U.S. Patent 4,404,664 (Zachariadis '664), and Kalman Ref

U.S. Patent No. 6,932,017 Asserted Claims	**Citations from prior-art**
1. A method of controlling the positions of marine seismic streamers in an array of such streamers being towed by a seismic survey vessel, the streamers having respective streamer positioning devices disposed therealong and each streamer positioning device having a wing and a wing motor for changing the orientation of the wing so as to steer the streamer positioning device laterally, said method comprising the steps of:	U.S. Patent 5,790,472 (Adaptive Control of Marine Seismic Streamers; Workman & Chambers; assigned to Western Atlas; 1998) discloses this claim preamble. The limitation of "marine seismic streamers in an array of such streamers being towed by a seismic survey vessel" is disclosed in the Workman '472 patent. The limitation of "streamer positioning devices disposed therealong and each streamer positioning device having a wing and a wing motor for changing the orientation of the wing" is disclosed in the Workman '472 patent. The limitation "to steer the streamer positioning device laterally" is disclosed in the Workman '472 patent. *See, e.g.,* Workman '472 at Col. 2, ll. 32-33 ("the prior art discloses a series of discrete devices for locating and controlling the positions of streamer cables") and Col. 2, ll. 45-47 ("The present invention is an improved system for controlling the position and shape of marine seismic streamer cables"). *See, e.g.,* Workman '472 at Col. 3, ll. 33-43 ("As known to those skilled in the art, components of the marine seismic data acquisition system 05, on the vessel 11, may include … a network solution system 10 for determining the position of the streamer cables 13 and seismic sources 12, and a streamer cable controller 16 for controlling the streamer positioning devices"). *See, e.g.,* Workman '472 at Col. 1, ll. 17-19 ("Due to the increasing use of marine 3-D seismic data, multi-cable marine surveys are now commonplace"). *See, e.g.,* Workman '472 at Col. 1, l. 45 ("Streamer

U.S. Patent No. 6,932,017 Asserted Claims	Citations from prior-art
	positioning devices are well known in the art"). *See, e.g.*, Workman '472 at Col. 3, ll. 14-20 ("As known to those skilled in the art, streamer positioning devices 14, for example birds and tail buoys, may be attached to the exterior of the streamer cables 13 for adjusting the vertical and lateral positions of the streamer cables 13. The streamer cables 13 include electrical or optical cables for connecting the streamer positioning devices 14 to individual control and logging systems"). *See, e.g.*, Workman '472 at Col. 1, ll. 55-61 (describes lateral positioning with wings). A Person Having Ordinary Skill In The Art will readily understand that a wing motor to move a wing is obvious. U.S. Patent 4,404,664 (System for Laterally Positioning a Towed Marine Cable and Method of Using Same; Zachariadis; assigned to Mobil Oil; 1983) discloses this claim. *See, e.g.*, Zachariadis '664, Claim 1, (Col. 13, l. 6) to (Col. 14, l. 2) ("A system for controlling the lateral position of a marine cable being towed by a vessel and having adjustable control surfaces affixed to said marine cable at a plurality of spaced-apart positions along said cable for varying lateral thrust to said cable in response to control signals from the vessel, the improvement comprising: (a) a motor associated with each control surface for rotating said control surface from a neutral position at which no lateral thrust is imparted to said cable to a second position at which a desired lateral thrust is imparted to said cable, (b) receiving means associated with each control surface for decoding the control signals from said vessel and producing a first electric current of magnitude and direction necessary to cause said motor to rotate said control surface of said second position") *See, e.g.*, Zachariadis'664, Col. 1, ll. 41-43 ("Lateral positioning of a towed cable comprises two basic aspects: determining the existing position of the cable and moving it to a desired position").

U.S. Patent No. 6,932,017 Asserted Claims	Citations from prior-art
	See, generally, Zachariadis '664, Col. 1, l. 41 to col. 2, l. 68. The limitation of "streamer positioning devices disposed therealong and each streamer positioning device having a wing and a wing motor for changing the orientation of the wing" is disclosed in the Zachariadis '664 patent. *See, e.g.,* Zachariadis '664, Col. 3, ll. 16-18 ("a plurality of remotely controlled, lateral positioning devices are mounted at selected points along the length of the cable"). *See, e.g.,* Zachariadis '664, claim 1, Col. 13, ll. 13-14 ("a motor associated with each control surface [wing] for rotating said control surface"). The limitation "to steer the streamer positioning device laterally" is disclosed in the Zachariadis '664 patent. *See, e.g.,* Zachariadis '664, Abstract ("Coded digital commands are generated and transmitted to each lateral positioning device for adjustment of its control surfaces whereby the lateral thrust produced the device as it is towed through the water is varied and the horizontal position of the portion of the cable to either side of the device controlled") *See, e.g.,* Zachariadis '664, Col. 3, ll. 3-5 ("It is an object of th[e] invention to provide a system for controlling the lateral position of a cable being towed through the water."). *See, e.g.,* Zachariadis '664, Col. 1, ll. 41-43 ("Lateral positioning of a towed cable comprises two basic aspects: determining the existing position of the cable and moving it to a desired position").

U.S. Patent No. 6,932,017 Asserted Claims	Citations from prior-art
obtaining a predicted position of the streamer positioning devices;	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 2, ll. 15-18 ("These devices and methods may then be used to determine the real time position of the seismic sources and seismic streamer cables by computing a network solution to a Kalman filter, as disclosed by U.S. Pat. No. 5,353,223"). Kalman, R.E., 1960, "A New approach to Linear Filtering and Prediction Problems," Trans of ASME-J. of Basic Engineering, vol. 82 (Series D), pp. 35-35 discloses the limitation of "prediction." *See, e.g.*, p. 36, bottom of right hand column in section "Optimal Estimation," first paragraph: "we have a prediction problem. Since our treatment will be general enough to include these and similar problems, we shall use hereafter the collective term estimation." At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art that this limitation was commercially available prior-art, utilizing several different technologies to obtain predicted positions along streamers, including the positions of any streamer positioning devices disposed therealong. Since the 1980's, some commercial streamer navigation systems have utilized Kalman Filter technology, which includes a 'prediction' step as integral to the technology. Kalman filter technology was widely known prior-art at the time of the invention.
obtaining an estimated velocity of the streamer positioning devices;	Given "a predicted position of the streamer positioning devices," then it is obvious to a Person Having Ordinary Skill In The Art that velocities are readily obtained from differences in positions over known time intervals based on fundamental historical concepts of marine navigation. In marine seismic navigation systems at the time of invention, solutions for positions are typically available several times per minute which yields estimates of velocities several times per minute as simple differences of positions.

U.S. Patent No. 6,932,017 Asserted Claims	Citations from prior-art
	At the time of the invention, it was also obvious to a Person Having Ordinary Skill In The Art to use commercially available current meters, based on acoustic Doppler measurements, or other technologies; or to use commercially available Kalman filter based navigation systems which can estimate velocities of locations along a streamer, such as at streamer positioning devices. Workman '472 discloses this limitation. *See, e.g.*, Workman '472 at Col. 2, ll. 15-18 ("These devices and methods may then be used to determine the real time position of the seismic sources and seismic streamer cables by computing a network solution to a Kalman filter, as disclosed by U.S. Pat. No. 5,353,223"). Kalman, R.E., 1960, "A New approach to Linear Filtering and Prediction Problems," Trans of ASME-J. of Basic Engineering, vol. 82 (Series D), pp. 35-35 discloses the limitation of "prediction." *See, e.g.*, p. 36, bottom of right hand column in section "Optimal Estimation," first paragraph: "we have a prediction problem. Since our treatment will be general enough to include these and similar problems, we shall use hereafter the collective term estimation." Estimation is a fundamental aspect of Kalman filtering technology. A person Having Ordinary Skill In The Art will understand that the disclosed Kalman filter is a well-known prior art technology that is obvious to use to obtain an estimated velocity.
for at least some of the streamer positioning devices, calculating desired changes in the orientation of their wings using said predicted position and said estimated velocity;	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 3, ll. 42-43 ("and a streamer cable controller 16 for controlling the streamer positioning devices 14"). *See* also, e.g., FIG. 2 *See, e.g.*, Workman '472 at Col. 3, ll. 59-62 ("includes a streamer control processor 40 for … calculating a position

U.S. Patent No. 6,932,017 Asserted Claims	Citations from prior-art
	correction to reposition the streamer cables 13") *See, e.g.*, Workman '472 at Col. 4, ll. 17-21 ("The streamer control processor 40 is connected to the streamer device controller 16. When the streamer cables 13 need to be repositioned, the position correction is used by the streamer device controller 16 to adjust the streamer positioning devices 14 and reposition the streamer cables 13.") At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art to "calculate desired changes in the orientation of their wings" based on various available technologies. These obvious technologies could have included various control theory techniques; and could have involved the calculation of wing orientation from position and velocity utilizing the relationships of forces on the wing and wing orientation or angle. These relationships of forces and wing angles and wing shapes were well-known long-standing prior-art, available from the technologies of aerodynamics and/or the hydrodynamics of rudders.
and actuating the wing motors to produce said desired changes in wing orientation.	The Workman '472 patent discloses this limitation. *See, e.g.*, Workman '472 at Col. 1, ll. 55-57 ("For example, devices to control the lateral positioning of streamer cables by using camber-adjustable hydrofoils or angled wings are disclosed") This limitation is disclosed in the Zachariadis '664 patent. *See, e.g.*, Zachariadis '664, claim 1; col. 13, l. 13 to col. 14, l. 2 ("a motor associated with each control surface for rotating said control surface ... to a second position at which a desired lateral thrust is imparted to said cable, receiving means ... to cause said motor to rotate said control surface of said second position") At the time of the invention it was obvious to a Person Having Ordinary Skill In The Art that wing motors were commercially available prior-art, as found, for example, in

U.S. Patent No. 6,932,017 Asserted Claims	Citations from prior-art
	depth birds from multiple commercial suppliers.
2. A method as claimed in claim 1, wherein said estimated velocity is calculated using a vessel speed received from said seismic survey vessel's navigation system.	At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art that "calculating velocity of at least one of the streamer positioning devices" must include the "vessel speed" as the major component because the vessel is towing the streamers and the streamer positioning devices. It is also obvious to a Person Having Ordinary Skill In The Art that the "calculating velocity" involves a vector which by definition must include direction as well as speed. Thus in addition to the "vessel speed" it is required to also have information regarding vessel heading, course, and/or track-made-good. At the time of the invention, it was also obvious to a Person Having Ordinary Skill In The Art that it was routine navigational practice to obtain vessel speed in any of several ways within the prior-art. For example, satellite navigation or radio-navigation systems can routinely provide vessel position and speed. Additionally Doppler sonar speed logs or electromagnetic speed logs are well-known commercially available prior-art devices which can provide vessel speed through the water.
3. A method as claimed in claim 2, in which said estimated velocity is a water referenced towing velocity that compensates for the speed and heading of marine currents acting on said streamer positioning devices.	At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art to utilize the vector combination of the towing velocity vector and current velocity to obtain a "water referenced towing velocity". Further it was obvious that this limitation was disclosed in long-standing navigational prior-art discloses techniques for "dead reckoning" which "compensate for the speed and heading of marine currents." At the time of the invention, it was also obvious to a Person Having Ordinary Skill In The Art to utilize commercially available prior-art devices and methods such as Doppler sonar current meters or electromagnetic speed logs that can directly provide vessel speed and course

U.S. Patent No. 6,932,017 Asserted Claims	Citations from prior-art
	through the water.
4. A method as claimed in claim 3, in which said estimated velocity is compensated for relative movement between said seismic survey vessel and said streamer positioning devices.	At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art that the vector combination of the relative velocity vector ("relative movement between said seismic survey vessel and said streamer positioning devices.") and vessel velocity (referenced to the water as in claim 3.) to obtain a "velocity [that] is compensated" is application of well-known prior-art in the vector analysis of velocities.
5. A method as claimed in claim 4, in which said step of calculating a desired change in wing orientation further uses an estimate of the crosscurrent velocity at the respective streamer positioning device.	At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art to use commercially available Doppler sonar speed logs or electromagnetic speed logs to provide vessel speed through the water which can be used in classical prior-art navigation to compare with radio-navigation or satellite positions of the vessel to determine crosscurrents. At the time of the invention it was obvious to a Person Having Ordinary Skill In The Art that it is possible to calculate a desired change in wing orientation" only if an "estimate of the cross-current velocity" is available, *i.e.*, only if the so-called angle-of-attack of the wings relative to water flow were available, rather than simply the angle of the wings relative to the streamer axis. Then, given the complete geometry information including the crosscurrent and the angle-of-attack, the relationships of forces and wing angles and wing shapes are obvious as well-known prior-art.

U.S. Patent No. 6,932,017 Asserted Claims	Citations from prior-art
6. A method as claimed in claim 5, in which said step of calculating a desired change in wing orientation is regulated to prevent the wing from stalling.	At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art to regulate wing angles to prevent stalling, given complete information about the relative geometry of the wings and water flow over the wings, including the so-called angle-of-attack.
7. A method as claimed in claim 6, in which said step of calculating a desired change in wing orientation is regulated by a global control system located on or near said seismic survey vessel that is configured into a feather angle mode, wherein said global control system attempts to direct the streamer positioning devices to maintain each of said streamers in a straight line offset from the towing direction of said marine seismic vessel by a certain feather angle, and into a turn control mode, wherein said global control system directs said streamer positioning devices to generate a force in the opposite direction of a turn at the beginning of the turn.	The limitation of "calculating a desired change in wing orientation is regulated by a global control system located on or near said seismic survey vessel" is disclosed in the Zachariadis '664 patent. *See, generally*, Zachariadis '664, Col. 3, l. 43 to Col. 4, l. 4. *See, e.g.*, Zachariadis '664, Col. 3, l. 43-44 ("It is a further object to control the lateral positioning devices of such as system through the use of a computer.") *See, e.g.*, Zachariadis '664 Col. 3, l. 55 ("Transmissions means are provided") *See, e.g.*, '664 Zachariadis, Col. 3, ll. 58-66 ("Suitable circuitry in each lateral positioning device senses and examines the coded control signal … In the selected lateral positioning device, circuitry further decodes the coded control signal. Motor actuation means are controlled by the decoder means … and operate motor means for the adjustment of the lateral positioning control surfaces"). At the time of invention, given the state of the art of control systems, it would have been obvious to a Person Having Ordinary Skill In The Art to provide "a global control system located on or near said seismic vessel" to control/regulate multiple streamer positioning devices, each with their own local controller. At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art to describe various equivalent modes of operation for multiple streamers

U.S. Patent No. 6,932,017 Asserted Claims	Citations from prior-art
	having lateral control. Various modes of operation of seismic streamers had been publicly recognized within the seismic industry since the 1970's and 1980's, and became widely recognized in commercial practice by the early 1990's. The limitation of "a feather angle mode wherein … maintain each of said streamers in a straight line offset from the towing direction of said marine seismic vessel by a certain feather angle" was recognized as obvious from the time of the first commercial use of multiple streamers. This concept of desiring to tow streamers straight and parallel with constant feather angle was widely recognized and employed as commercial practice by the early 1990's. At the time of the invention, the limitation of "a feather angle mode wherein … maintain each of said streamers in a straight line offset from the towing direction of said marine seismic vessel by a certain feather angle" was obvious. At the time of the invention, it was also obvious to operate streamers in circles (so-called circle-shoots). The Zachariadis '664 patent discloses the limitation of a "feather angle mode." See, e.g., Zachariadis '664 at Col. 12, ll. 53-57 ("It should also be realized that the adjustments of said lateral positioning devices to position the cable in a straight line along a heading from the towing vessel can be accomplished automatically by a suitably sized and programmed computer.").
8. A method as claimed in claim 7, in which said global control system is further configured into a streamer separation mode, wherein said global control system attempts to direct said streamer positioning device to maintain a minimum separation distance between adjacent streamers.	The Workman '472 patent discloses this limitation of "streamer separation mode." *See, e.g.*, Workman '472 at Col. 1, ll. 33-35 ("The ability to control the position and shape of the streamer cables is desirable for preventing the entanglement of the streamer cables"). *See, e.g.*, Workman '472 at Col. 3, ll. 58-67 ("In the present embodiment of the invention, the marine seismic data acquisition system 05 also includes a streamer control processor 40 for deciding when the streamer cables 13

U.S. Patent No. 6,932,017 Asserted Claims	Citations from prior-art
	should be repositioned and for calculating a position correction to reposition the streamer cables 13. Also in the present embodiment of the invention, threshold parameters are established for determining when the streamer cables should be repositioned. Threshold parameters may include a plurality of values for: minimum allowable separations between streamer cables 13") *See, e.g.,* Workman '472 at Col. 4, ll. 8-35 (discloses streamer control processor). The limitation of a global control system is disclosed in Zachariadis '664. See, e.g., Claim 7 Analysis, and *see, generally*, Zachariadis '664, Col. 3, l. 43 to Col. 4, l. 4 At the time of the invention it was obvious to a Person Having Ordinary Skill In The Art that "streamer separation mode" exemplified commonsense commercial practice. It was obvious that avoiding entanglement of multiple streamers was the primary goal and mode of operation since the earliest multi-streamer 3D seismic surveys in the late 1980's and early 1990's.
9. A method as claimed in claim 8, further including the step of displaying the position of said streamer positioning devices on said seismic survey vessel.	This limitation is disclosed in the Zachariadis '664 patent. *See, e.g.,* Zachariadis '664, Abstract, ll. 11-13 ("visual display of the relative position of each lateral positioning device with respect to the vessel"). *See, e.g.,* Zachariadis '664, Col. 3, ll. 29-33 ("The coordinate signals are provided to a display matric of a suitable device … for display of the relative positions of the vessel and lateral positioning devices") *See, e.g.,* Zachariadis '664, Col. 5, ll. 58-61 ("A simple plot of the X and Y coordinates of the ship and the lateral positioning devices is provided on a suitable visual display device"). *See, e.g.,* Zachariadis '664, Col. 4, ll. 28-30 ("FIG. 5

U.S. Patent No. 6,932,017 Asserted Claims	Citations from prior-art
	illustrates a visual display of the coordinates of the vessel and selected points along the towed cable as determined by the equipment of FIG. 2"); and said equipment is disclosed at, e.g., Col. 4, ll. 20-21 ("FIG. 2 illustrates in block diagram form the cable … positioning equipment of the invention"). *See, e.g.,* Zachariadis '664, Col. 8, ll. 60-64 ("In addition to the location of the marine vessel and the lateral positioning devices, the locations of various … may also be displayed"). *See, e.g.,* Zachariadis '664, Col. 3, ll. 31-33 ("display of the relative positions of the vessel and the lateral positioning devices with respect to the selected heading.") At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art that displaying the positions of the streamer positioning devices (and of the entire streamer) was necessarily common commercial practice. Such displays utilized many different forms of computer graphics devices and display algorithms.
16. Apparatus for controlling the positions of marine seismic streamer in an array of such streamers being towed by a seismic survey vessel, the streamers having respective streamer positioning devices disposed therealong and each streamer positioning device having a wing and a wing motor for changing the horizontal orientation of the wing so as to steer the streamer positioning device laterally, said apparatus comprising:	Workman '472 discloses this claim preamble. The limitation of "marine seismic streamers in an array of such streamers being towed by a seismic survey vessel" is disclosed in the Workman '472 patent. The limitation of "streamer positioning devices disposed therealong and each streamer positioning device having a wing and a wing motor for changing the orientation of the wing" is disclosed in the Workman '472 patent. The limitation "to steer the streamer positioning device laterally" is disclosed in the Workman '472 patent. *See, e.g.,* Workman '472 at Col. 1, ll. 55-61 (describes lateral positioning with wings). A Person Having Ordinary Skill In The Art will readily understand that a wing motor to move a wing is obvious.

U.S. Patent No. 6,932,017 Asserted Claims	Citations from prior-art
	See, e.g., Workman '472 at Col. 2, ll. 32-33 ("the prior art discloses a series of discrete devices for locating and controlling the positions of streamer cables") and Col. 2, ll. 45-47 ("The present invention is an improved system for controlling the position and shape of marine seismic streamer cables"). *See, e.g.*, Workman '472 at Col. 3, ll. 33-43 ("As known to those skilled in the art, components of the marine seismic data acquisition system 05, on the vessel 11, may include … a network solution system 10 for determining the position of the streamer cables 13 and seismic sources 12, and a streamer cable controller 16 for controlling the streamer positioning devices"). *See, e.g.*, Workman '472 at Col. 1, ll. 17-19 ("Due to the increasing use of marine 3-D seismic data, multi-cable marine surveys are now commonplace"). *See, e.g.*, Workman '472 at Col. 1, l. 45 ("Streamer positioning devices are well known in the art"). *See, e.g.*, Workman '472 at Col. 3, ll. 14-20 ("As known to those skilled in the art, streamer positioning devices 14, for example birds and tail buoys, may be attached to the exterior of the streamer cables 13 for adjusting the vertical and lateral positions of the streamer cables 13. The streamer cables 13 include electrical or optical cables for connecting the streamer positioning devices 14 to individual control and logging systems"). The Zachariadis '664 patent discloses this claim preamble. *See, e.g.*, Zachariadis '664, Claim 1, (Col. 13, l. 6) to (Col. 14, l. 2) ("A system for controlling the lateral position of a marine cable being towed by a vessel and having adjustable control surfaces affixed to said marine cable at a plurality of spaced-apart positions along said cable for varying lateral thrust to said cable in response to control signals from the vessel, the improvement comprising: (a) a motor associated with each control surface for rotating said control surface from a neutral position at which no lateral

U.S. Patent No. 6,932,017 Asserted Claims	Citations from prior-art
	thrust is imparted to said cable to a second position at which a desired lateral thrust is imparted to said cable, (b) receiving means associated with each control surface for decoding the control signals from said vessel and producing a first electric current of magnitude and direction necessary to cause said motor to rotate said control surface of said second position") *See, e.g.*, Zachariadis '664, Col. 1, ll. 41-43 ("Lateral positioning of a towed cable comprises two basic aspects: determining the existing position of the cable and moving it to a desired position"). *See, generally*, Zachariadis '664, Col. 1, l. 41 to col. 2, l. 68. The limitation of "streamer positioning devices disposed therealong and each streamer positioning device having a wing and a wing motor for changing the orientation of the wing" is disclosed in the '664 Zachariadis patent. *See, e.g.*, Zachariadis '664, Col. 3, ll. 16-18 ("a plurality of remotely controlled, lateral positioning devices are mounted at selected points along the length of the cable"). *See, e.g.*, Zachariadis '664, claim 1, Col. 13, ll. 13-14 ("a motor associated with each control surface [wing] for rotating said control surface"). The limitation "to steer the streamer positioning device laterally" is disclosed in the Zachariadis '664 patent. *See. e.g.*, Zachariadis '664, Abstract ("Coded digital commands are generated and transmitted to each lateral positioning device for adjustment of its control surfaces whereby the lateral thrust produced the device as it is towed through the water is varied and the horizontal position of the portion of the cable to either side of the device controlled") *See, e.g.*, Zachariadis '664, Col. 3, ll. 3-5 ("It is an object of th[e] invention to provide a system for controlling the lateral position of a cable being towed through the

U.S. Patent No. 6,932,017 Asserted Claims	Citations from prior-art
	water."). *See, e.g.*, Zachariadis '664, Col. 1, ll. 41-43 ("Lateral positioning of a towed cable comprises two basic aspects: determining the existing position of the cable and moving it to a desired position").
means for obtaining a predicted position of the streamer positioning devices;	Under 35 U.S.C. § 112, ¶ 6, the cited priori art discloses structure that performs the claimed function of obtaining a predicted position of the streamer positioning devices and that is either identical to the structure identified by the Court or equivalent structure. The Workman '472 patent discloses a structure to perform this function comprised of a streamer cable controller and a streamer control processor. *See, e.g.*, Workman '472 at Col. 3, ll. 33-34 and ll. 42-44 ("As known to those skilled in the art, components of the marine seismic data acquisition system 05, on the vessel 11, may include … a streamer cable controller 16 for controlling the streamer positioning devices 14."). *See, e.g.*, Workman '472 at Col. 3, ll. 58-62 ("the marine seismic data acquisition system 05 also includes a streamer control processor 40 for deciding when the streamer cables 13 should be repositioned and for calculating a position correction to reposition the streamer cables 13.") *See, e.g.*, Workman '472 at Col. 2, ll. 15-19 which discloses "prediction" in a Kalman filter. The aforementioned disclosed structure performs the function of: ("These devices and methods may then be used to determine the real time position of the seismic sources and seismic streamer cables by computing a network solution to a Kalman filter, as disclosed by U.S. Pat. No. 5,353,223"). Kalman, R.E., 1960, "A New approach to Linear Filtering and Prediction Problems," Trans of ASME-J. of Basic Engineering, vol. 82 (Series D), pp. 35-35 discloses the limitation of "prediction."

U.S. Patent No. 6,932,017 Asserted Claims	Citations from prior-art
	See, e.g., p. 36, bottom of right hand column in section "Optimal Estimation," first paragraph: "we have a prediction problem. Since our treatment will be general enough to include these and similar problems, we shall use hereafter the collective term estimation." At the time of the invention, a structure to perform this function was obvious to a Person Having Ordinary Skill In The Art, This structure was commercially available prior-art, utilizing several different technologies to obtain predicted positions along streamers, including the positions of any streamer positioning devices disposed therealong. Since the 1980's, some commercial streamer navigation systems have utilized Kalman Filter technology, which includes a 'prediction' step as integral to the technology. Kalman filter technology was widely known prior-art at the time of the invention.
means for obtaining an estimated velocity of the streamer positioning devices,	Under 35 U.S.C. § 112, ¶ 6, the cited prior art discloses structure that performs the claimed function of obtaining an estimated velocity of the streamer positioning devices and that is either identical to the structure identified by the Court or equivalent structure. The '017 specification states that "The towing velocity and crosscurrent velocity are preferably "water-referenced" values that are calculated from the vessel speed and heading values and the current speed and heading values, as well as any relative movement between the seismic survey vessel 10 and the bird 18 (such as while the vessel is turning). Alternatively, the global control system 22 could provide the local control system with the horizontal velocity and water in-flow angle. The force and velocity values are delivered by the global control system 22 as separate values for each bird 18 on each streamer 12 continuously during operation of the control system. The "water-referenced" towing velocity and crosscurrent velocity could alternatively be determined using flowmeters or other types of water velocity sensors attached directly to the birds 18."

The Workman '472 patent discloses a structure to perform this function comprised of a streamer cable controller and a streamer control processor.

See, e.g., Workman '472 at Col. 2, ll. 15-18; at Col. 4, l. 8; and "prediction" in a Kalman filter at Col. 2., ll. 15-19. The aforementioned disclosed structure performs the function of: "These devices and methods may then be used to determine the real time position of the seismic sources and seismic streamer cables by computing a network solution to a Kalman filter, as disclosed by U.S. Pat. No. 5,353,223").

Given "a predicted position of the streamer positioning devices," then a Person Having Ordinary Skill In The Art will understand that velocities are readily obtained from differences in positions over known time intervals based on fundamental concepts of marine navigation known for generations. In marine seismic navigation systems at the time of invention, solutions for positions are typically available several times per minute which obviously yields estimates velocities several times per minute as simple differences of positions.

At the time of the invention, it was obvious to a Person Having Ordinary Skill In The Art to use commercially available current meters, based on acoustic Doppler measurements, or other techniques; or to use commercially available Kalman filter based navigation systems which can estimate velocities of locations along a streamer, such as a streamer positioning device.

Kalman, R.E., 1960, "A New approach to Linear Filtering and Prediction Problems," Trans of ASME-J. of Basic Engineering, vol. 82 (Series D), pp. 35-35 discloses the limitation of "prediction."

See, e.g., p. 36, bottom of right hand column in section "Optimal Estimation," first paragraph: "we have a prediction problem. Since our treatment will be general enough to include these and similar problems, we shall use hereafter the collective term estimation."

Estimation is a fundamental aspect of Kalman filtering technology. A person Having Ordinary Skill In The Art will understand that the disclosed Kalman filter is a well-

known prior art technology that is used to obtain an estimated velocity.	
means for calculating desired changes in the orientations of the respective wings of at least some of the streamer positioning devices using said predicted position and said estimated velocity;	Under 35 U.S.C. § 112, ¶ 6, the cited prior art discloses structure that performs the claimed function of calculating desired changes in the orientations of the respective wings of at least some of the streamer positioning devices using said predicted position and said estimated velocity and that is either identical to the structure identified by the Court or equivalent structure. The Workman '472 patent discloses a structure to perform this function comprised of a streamer cable controller and a streamer control processor. *See, e.g.*, Workman '472 at Col. 3, ll. 42-43 ("and a streamer cable controller 16 for controlling the streamer positioning devices 14"). *See* also, e.g., FIG. 2 *See, e.g.*, Workman '472 at Col. 3, ll. 59-62 ("includes a streamer control processor 40 for ... calculating a position correction to reposition the streamer cables 13") *See, e.g.*, Workman '472 at Col. 4, ll. 17-21 ("The streamer control processor 40 is connected to the streamer device controller 16. When the streamer cables 13 need to be repositioned, the position correction is used by the streamer device controller 16 to adjust the streamer positioning devices 14

	and reposition the streamer cables 13.") At the time of the invention, structures to perform this function were obvious to a Person Having Ordinary Skill In The Art. These structures could have included various control theory techniques; and could have involved the calculation of wing orientation from position and velocity utilizing the relationships of forces on the wing and wing orientation or angle. These relationships of forces and wing angles and wing shapes were well-known long-standing prior-art, available from the technologies of aerodynamics and/or the hydrodynamics of rudders.
and means for actuating the wing motors to produce said desired changes in wing orientation.	Under 35 U.S.C. § 112, ¶ 6, the Workman '472 patent discloses structure that performs the claimed function of actuating the wing motors to produce said desired changes in wing orientation and that is either identical to the structure identified by the Court or equivalent structure. The Workman '472 discloses a structure to perform this function. *See, e.g.,* Workman '472 at Col. 1, ll. 55-57 ("For example, devices to control the lateral positioning of streamer cables by using camber-adjustable hydrofoils or angled wings are disclosed") The claimed function is "actuating the wing motors to produce said desired changes in wing orientation". The Court has given a construction of "motor driver;

	and equivalents thereof". The Zachariadis '664 patent discloses structures to perform this function. *See, e.g.*, Zachariadis '664, claim 1; col. 13, l. 13 to col. 14, l. 2 ("a motor associated with each control surface for rotating said control surface … to a second position at which a desired lateral thrust is imparted to said cable, receiving means … to cause said motor to rotate said control surface of said second position") At the time of the invention it was obvious to a Person Having Ordinary Skill In The Art that wing motors were commercially available prior-art structures to perform this function, as found, for example, in depth birds from multiple commercial suppliers.

2666111v1

EXHIBIT 18

A New Approach to Linear Filtering and Prediction Problems[1]

R. E. KALMAN
Research Institute for Advanced Study,[2]
Baltimore, Md.

The classical filtering and prediction problem is re-examined using the Bode-Shannon representation of random processes and the "state transition" method of analysis of dynamic systems. New results are:

(1) The formulation and methods of solution of the problem apply without modification to stationary and nonstationary statistics and to growing-memory and infinite-memory filters.

(2) A nonlinear difference (or differential) equation is derived for the covariance matrix of the optimal estimation error. From the solution of this equation the coefficients of the difference (or differential) equation of the optimal linear filter are obtained without further calculations.

(3) The filtering problem is shown to be the dual of the noise-free regulator problem.

The new method developed here is applied to two well-known problems, confirming and extending earlier results.

The discussion is largely self-contained and proceeds from first principles; basic concepts of the theory of random processes are reviewed in the Appendix.

Introduction

AN IMPORTANT class of theoretical and practical problems in communication and control is of a statistical nature. Such problems are: (i) Prediction of random signals; (ii) separation of random signals from random noise; (iii) detection of signals of known form (pulses, sinusoids) in the presence of random noise.

In his pioneering work, Wiener [1][3] showed that problems (i) and (ii) lead to the so-called Wiener-Hopf integral equation; he also gave a method (spectral factorization) for the solution of this integral equation in the practically important special case of stationary statistics and rational spectra.

Many extensions and generalizations followed Wiener's basic work. Zadeh and Ragazzini solved the finite-memory case [2]. Concurrently and independently of Bode and Shannon [3], they also gave a simplified method [2] of solution. Booton discussed the nonstationary Wiener-Hopf equation [4]. These results are now in standard texts [5-6]. A somewhat different approach along these main lines has been given recently by Darlington [7]. For extensions to sampled signals, see, e.g., Franklin [8], Lees [9]. Another approach based on the eigenfunctions of the Wiener-Hopf equation (which applies also to nonstationary problems whereas the preceding methods in general don't), has been pioneered by Davis [10] and applied by many others, e.g., Shinbrot [11], Blum [12], Pugachev [13], Solodovnikov [14].

In all these works, the objective is to obtain the specification of a linear dynamic system (Wiener filter) which accomplishes the prediction, separation, or detection of a random signal.[4]

[1] This research was supported in part by the U. S. Air Force Office of Scientific Research under Contract AF 49 (638)-382.

[2] 7212 Bellona Ave.

[3] Numbers in brackets designate References at end of paper.

[4] Of course, in general these tasks may be done better by nonlinear filters. At present, however, little or nothing is known about how to obtain (both theoretically and practically) these nonlinear filters.

Contributed by the Instruments and Regulators Division and presented at the Instruments and Regulators Conference, March 29– April 2, 1959, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

 Manuscript received at ASME Headquarters, February 24, 1959. Paper No. 59—IRD-11.

Present methods for solving the Wiener problem are subject to a number of limitations which seriously curtail their practical usefulness:

(1) The optimal filter is specified by its impulse response. It is not a simple task to synthesize the filter from such data.

(2) Numerical determination of the optimal impulse response is often quite involved and poorly suited to machine computation. The situation gets rapidly worse with increasing complexity of the problem.

(3) Important generalizations (e.g., growing-memory filters, nonstationary prediction) require new derivations, frequently of considerable difficulty to the nonspecialist.

(4) The mathematics of the derivations are not transparent. Fundamental assumptions and their consequences tend to be obscured.

This paper introduces a new look at this whole assemblage of problems, sidestepping the difficulties just mentioned. The following are the highlights of the paper:

(5) *Optimal Estimates and Orthogonal Projections.* The Wiener problem is approached from the point of view of conditional distributions and expectations. In this way, basic facts of the Wiener theory are quickly obtained; the scope of the results and the fundamental assumptions appear clearly. It is seen that all statistical calculations and results are based on first and second order averages; no other statistical data are needed. Thus difficulty (4) is eliminated. This method is well known in probability theory (see pp. 75–78 and 148–155 of Doob [15] and pp. 455–464 of Loève [16]) but has not yet been used extensively in engineering.

(6) *Models for Random Processes.* Following, in particular, Bode and Shannon [3], arbitrary random signals are represented (up to second order average statistical properties) as the output of a linear dynamic system excited by independent or uncorrelated random signals ("white noise"). This is a standard trick in the engineering applications of the Wiener theory [2–7]. The approach taken here differs from the conventional one only in the way in which linear dynamic systems are described. We shall emphasize the concepts of *state* and *state transition;* in other words, linear systems will be specified by systems of first-order difference (or differential) equations. This point of view is

natural and also necessary in order to take advantage of the simplifications mentioned under (5).

(7) *Solution of the Wiener Problem.* With the state-transition method, a single derivation covers a large variety of problems: growing and infinite memory filters, stationary and nonstationary statistics, etc.; difficulty (3) disappears. Having guessed the "state" of the estimation (i.e., filtering or prediction) problem correctly, one is led to a nonlinear difference (or differential) equation for the covariance matrix of the optimal estimation error. This is vaguely analogous to the Wiener-Hopf equation. Solution of the equation for the covariance matrix starts at the time t_0 when the first observation is taken; at each later time t the solution of the equation represents the covariance of the optimal prediction error given observations in the interval (t_0, t). From the covariance matrix at time t we obtain at once, without further calculations, the coefficients (in general, time-varying) characterizing the optimal linear filter.

(8) *The Dual Problem.* The new formulation of the Wiener problem brings it into contact with the growing new theory of control systems based on the "state" point of view [17–24]. It turns out, *surprisingly,* that the Wiener problem is the *dual* of the noise-free optimal regulator problem, which has been solved previously by the author, using the state-transition method to great advantage [18, 23, 24]. The mathematical background of the two problems is identical—this has been suspected all along, but until now the analogies have never been made explicit.

(9) *Applications.* The power of the new method is most apparent in theoretical investigations and in numerical answers to complex practical problems. In the latter case, it is best to resort to machine computation. Examples of this type will be discussed later. To provide some feel for applications, two standard examples from nonstationary prediction are included; in these cases the solution of the nonlinear difference equation mentioned under (7) above can be obtained even in closed form.

For easy reference, the main results are displayed in the form of theorems. Only Theorems 3 and 4 are original. The next section and the Appendix serve mainly to review well-known material in a form suitable for the present purposes.

Notation Conventions

Throughout the paper, we shall deal mainly with *discrete* (or *sampled)* dynamic systems; in other words, signals will be observed at equally spaced points in time *(sampling instants).* By suitable choice of the time scale, the constant intervals between successive sampling instants *(sampling periods)* may be chosen as unity. Thus variables referring to time, such as t, t_0, τ, T will always be integers. The restriction to discrete dynamic systems is not at all essential (at least from the engineering point of view); by using the discreteness, however, we can keep the mathematics rigorous and yet elementary. Vectors will be denoted by small bold-face letters: **a**, **b**, ..., **u**, **x**, **y**, ... A *vector* or more precisely an *n-vector* is a set of n numbers x_1, ... x_n; the x_i are the *co-ordinates* or *components* of the vector **x**.

Matrices will be denoted by capital bold-face letters: **A**, **B**, **Q**, **Φ**, **Ψ**, ...; they are $m \times n$ arrays of elements a_{ij}, b_{ij}, q_{ij},... The *transpose* (interchanging rows and columns) of a matrix will be denoted by the prime. In manipulating formulas, it will be convenient to regard a vector as a matrix with a single column.

Using the conventional definition of matrix multiplication, we write the *scalar product* of two n-vectors **x**, **y** as

$$\mathbf{x'y} = \sum_{i=1}^{n} x_i y_i = \mathbf{y'x}$$

The scalar product is clearly a scalar, i.e., not a vector, quantity. Similarly, the quadratic form associated with the $n \times n$ matrix **Q** is,

$$\mathbf{x'Qx} = \sum_{i,j=1}^{n} x_i q_{ij} x_j$$

We define the expression **xy'** where **x'** is an m-vector and **y** is an n-vector to be the $m \times n$ matrix with elements $x_i y_j$.

We write $E(\mathbf{x}) = E\mathbf{x}$ for the expected value of the random vector **x** (see Appendix). It is usually convenient to omit the brackets after E. This does not result in confusion in simple cases since constants and the operator E commute. Thus $E\mathbf{xy'}$ = matrix with elements $E(x_i y_j)$; $E\mathbf{x}E\mathbf{y'}$ = matrix with elements $E(x_i)E(y_j)$.

For ease of reference, a list of the principal symbols used is given below.

Optimal Estimates

t	time in general, present time.
t_0	time at which observations start.
$x_1(t)$, $x_2(t)$	basic random variables.
$y(t)$	observed random variable.
$x_1^*(t_1\|t)$	optimal estimate of $x_1(t_1)$ given $y(t_0)$, ..., $y(t)$.
L	loss function (non random function of its argument).
ε	estimation error (random variable).

Orthogonal Projections

$\mathcal{Y}(t)$	linear manifold generated by the random variables $y(t_0)$, ..., $y(t)$.
$\bar{x}(t_1\|t)$	orthogonal projection of $x(t_1)$ on $\mathcal{Y}(t)$.
$\tilde{x}(t_1\|t)$	component of $x(t_1)$ orthogonal to $\mathcal{Y}(t)$.

Models for Random Processes

$\mathbf{\Phi}(t+1; t)$	transition matrix
$\mathbf{Q}(t)$	covariance of random excitation

Solution of the Wiener Problem

$\mathbf{x}(t)$	basic random variable.
$\mathbf{y}(t)$	observed random variable.
$\mathcal{Y}(t)$	linear manifold generated by $\mathbf{y}(t_0)$, ..., $\mathbf{y}(t)$.
$\mathcal{Z}(t)$	linear manifold generated by $\tilde{\mathbf{y}}(t\|t-1)$.
$\mathbf{x}^*(t_1\|t)$	optimal estimate of $\mathbf{x}(t_1)$ given $\mathcal{Y}(t)$.
$\tilde{\mathbf{x}}(t_1\|t)$	error in optimal estimate of $\mathbf{x}(t_1)$ given $\mathcal{Y}(t)$.

Optimal Estimates

To have a concrete description or the type of problems to be studied, consider the following situation. We are given signal $x_1(t)$ and noise $x_2(t)$. Only the sum $y(t) = x_1(t) + x_2(t)$ can be observed. Suppose we have observed and know exactly the values of $y(t_0)$, ..., $y(t)$. What can we infer from this knowledge in regard to the (unobservable) value of the signal at $t = t_1$, where t_1 may be less than, equal to, or greater than t? If $t_1 < t$, this is a *data-smoothing (interpolation)* problem. If $t_1 = t$, this is called *filtering.* If $t_1 > t$, we have a *prediction* problem. Since our treatment will be general enough to include these and similar problems, we shall use hereafter the collective term *estimation.*

As was pointed out by Wiener [1], the natural setting of the estimation problem belongs to the realm of probability theory and statistics. Thus signal, noise, and their sum will be random variables, and consequently they may be regarded as random processes. From the probabilistic description of the random processes we can determine the probability with which a particular sample of the signal and noise will occur. For any given set of measured values $\eta(t_0)$, ..., $\eta(t)$ of the random variable $y(t)$ one can then also determine, in principle, the probability of simultaneous occurrence of various values $\xi_1(t)$ of the random variable $x_1(t_1)$. This is the conditional probability distribution function

$$Pr[x_1(t_1) \le \xi_1 | y(t_0) = \eta(t_0), \ldots, y(t) = \eta(t)] = F(\xi_1) \quad (1)$$

Evidently, $F(\xi_1)$ represents all the information which the measurement of the random variables $y(t_0), ..., y(t)$ has conveyed about the random variable $x_1(t_1)$. Any statistical estimate of the random variable $x_1(t_1)$ will be some function of this distribution and therefore a (nonrandom) function of the random variables $y(t_0), ..., y(t)$. This statistical estimate is denoted by $X_1(t_1|t)$, or by just $X_1(t_1)$ or X_1 when the set of observed random variables or the time at which the estimate is required are clear from context.

Suppose now that X_1 is given as a fixed function of the random variables $y(t_0), ..., y(t)$. Then X_1 is itself a random variable and its actual value is known whenever the actual values of $y(t_0), ..., y(t)$ are known. In general, the actual value of $X_1(t_1)$ will be different from the (unknown) actual value of $x_1(t_1)$. To arrive at a rational way of determining X_1, it is natural to assign a *penalty* or *loss* for incorrect estimates. Clearly, the loss should be a (i) positive, (ii) nondecreasing function of the *estimation error* $\varepsilon = x_1(t_1) - X_1(t_1)$. Thus we define a *loss function* by

$$L(0) = 0$$

$$L(\varepsilon_2) \ge L(\varepsilon_1) \ge 0 \quad \text{when} \quad \varepsilon_2 \ge \varepsilon_1 \ge 0 \quad (2)$$

$$L(\varepsilon) = L(-\varepsilon)$$

Some common examples of loss functions are: $L(\varepsilon) = a\varepsilon^2$, $a\varepsilon^4$, $a|\varepsilon|$, $a[1 - \exp(-\varepsilon^2)]$, etc., where a is a positive constant.

One (but by no means the only) natural way of choosing the random variable X_1 is to require that this choice should minimize the average loss or risk

$$E\{L[x_1(t_1) - X_1(t_1)]\} = E[E\{L[x(t_1) - X_1(t_1)]|y(t_0), \ldots, y(t)\}] \quad (3)$$

Since the first expectation on the right-hand side of (3) does not depend on the choice of X_1 but only on $y(t_0), ..., y(t)$, it is clear that minimizing (3) is equivalent to minimizing

$$E\{L[x_1(t_1) - X_1(t_1)]|y(t_0), ..., y(t)\} \quad (4)$$

Under just slight additional assumptions, optimal estimates can be characterized in a simple way.

Theorem 1. *Assume that L is of type* (2) *and that the conditional distribution function* $F(\xi)$ *defined by* (1) *is:*

(*A*) *symmetric about the mean* $\bar{\xi}$:

$$F(\xi - \bar{\xi}) = 1 - F(\bar{\xi} - \xi)$$

(*B*) *convex for* $\xi \le \bar{\xi}$:

$$F(\lambda\xi_1 + (1 - \lambda)\xi_2) \le \lambda F(\xi_1) + (1 - \lambda)F(\xi_2)$$

for all $\xi_1, \xi_2 \le \bar{\xi}$ *and* $0 \le \lambda \le 1$

Then the random variable $x_1^*(t_1|t)$ *which minimizes the average loss* (3) *is the conditional expectation*

$$x_1^*(t_1|t) = E[x_1(t_1)|y(t_0), \ldots, y(t)] \quad (5)$$

Proof: As pointed out recently by Sherman [25], this theorem follows immediately from a well-known lemma in probability theory.

Corollary. *If the random processes* $\{x_1(t)\}$, $\{x_2(t)\}$, and $\{y(t)\}$ *are gaussian, Theorem 1 holds.*

Proof: By Theorem 5, (*A*) (see Appendix), conditional distributions on a gaussian random process are gaussian. Hence the requirements of Theorem 1 are always satisfied.

In the control system literature, this theorem appears sometimes in a form which is more restrictive in one way and more general in another way:

Theorem 1-a. *If* $L(\varepsilon) = \varepsilon^2$, *then Theorem 1 is true without assumptions* (*A*) and (*B*).

Proof: Expand the conditional expectation (4):

$$E[x_1^2(t_1)|y(t_0), \ldots, y(t)] - 2X_1(t_1)E[x_1(t_1)|y(t_0), \ldots, y(t)] + X_1^2(t_1)$$

and differentiate with respect to $X_1(t_1)$. This is not a completely rigorous argument; for a simple rigorous proof see Doob [15], pp. 77–78.

Remarks. (*a*) As far as the author is aware, it is not known what is the most general class of random processes $\{x_1(t)\}$, $\{x_2(t)\}$ for which the conditional distribution function satisfies the requirements of Theorem 1.

(*b*) Aside from the note of Sherman, Theorem 1 apparently has never been stated explicitly in the control systems literature. In fact, one finds many statements to the effect that loss functions of the general type (2) cannot be conveniently handled mathematically.

(*c*) In the sequel, we shall be dealing mainly with vector-valued random variables. In that case, the estimation problem is stated as: Given a vector-valued random process $\{\mathbf{x}(t)\}$ and observed random variables $\mathbf{y}(t_0), ..., \mathbf{y}(t)$, where $\mathbf{y}(t) = \mathbf{M}\mathbf{x}(t)$ ($\mathbf{M}$ being a singular matrix; in other words, not all co-ordinates of $\mathbf{x}(t)$ can be observed), find an estimate $\mathbf{X}(t_1)$ which minimizes the expected loss $E[L(\|\mathbf{x}(t_1) - \mathbf{X}(t_1)\|)]$, $\| \; \|$ being the norm of a vector.

Theorem 1 remains true in the vector case also, provided we re- quire that the conditional distribution function of the n co-ordi- nates of the vector $\mathbf{x}(t_1)$,

$$Pr[x_1(t_1) \le \xi_1, \ldots, x_n(t_1) \le \xi_n | \mathbf{y}(t_0), \ldots, \mathbf{y}(t)] = F(\xi_1, \ldots, \xi_n)$$

be symmetric with respect to the n variables $\xi_1 - \bar{\xi}_1, \ldots, \xi_n - \bar{\xi}_n$ and convex in the region where all of these variables are negative.

Orthogonal Projections

The explicit calculation of the optimal estimate as a function of the observed variables is, in general, impossible. There is an important exception: The processes $\{x_1(t)\}$, $\{x_2(t)\}$ are gaussian.

On the other hand, if we attempt to get an optimal estimate under the restriction $L(\varepsilon) = \varepsilon^2$ and the additional requirement that the estimate be a linear function of the observed random variables, we get an estimate which is identical with the optimal estimate in the gaussian case, without the assumption of linearity or quadratic loss function. This shows that results obtainable by linear estimation can be bettered by nonlinear estimation only when (i) the random processes are nongaussian and even then (in view of Theorem 5, (*C*)) only (ii) by considering at least third-order probability distribution functions.

In the special cases just mentioned, the explicit solution of the estimation problem is most easily understood with the help of a geometric picture. This is the subject of the present section.

Consider the (real-valued) random variables $y(t_0), \ldots, y(t)$. The set of all linear combinations of these random variables with real coefficients

$$\sum_{i=t_0}^{t} a_i y(i) \quad (6)$$

forms a *vector space (linear manifold)* which we denote by $\mathcal{Y}(t)$. We regard, abstractly, any expression of the form (6) as "point" or "vector" in $\mathcal{Y}(t)$; this use of the word "vector" should not be confused, of course, with "vector-valued" random variables, etc. Since we do not want to fix the value of t (i.e., the total number of possible observations), $\mathcal{Y}(t)$ should be regarded as a finite-dimensional subspace of the space of all possible observations.

Given any two vectors u, v in $\mathcal{Y}(t)$ (i.e., random variables expressible in the form (6)), we say that u and v are *orthogonal* if $Euv = 0$. Using the Schmidt orthogonalization procedure, as described for instance by Doob [15], p. 151, or by Loève [16], p. 459, it is easy to select an *orthonormal basis* in $\mathcal{Y}(t)$. By this is meant a set of vectors $e_{t_0}, \ldots, e_t$ in $\mathcal{Y}(t)$ such that any vector in $\mathcal{Y}(t)$ can be expressed as a unique linear combination of $e_{t_0}, \ldots, e_t$ and

$$\left.\begin{aligned} Ee_ie_j = \delta_{ij} &= 1 \quad \text{if} \quad i = j \\ &= 0 \quad \text{if} \quad i \neq j \end{aligned}\right\} \quad (i, j = t_0, \ldots, t) \tag{7}$$

Thus any vector $\bar{x}$ in $\mathcal{Y}(t)$. is given by

$$\bar{x} = \sum_{i=t_0}^{t} a_i e_i$$

and so the coefficients a_i can be immediately determined with the aid of (7):

$$E\bar{x}e_j = E\left(\sum_{i=t_0}^{t} a_i e_i\right)e_j = \sum_{i=t_0}^{t} a_i Ee_ie_j = \sum_{i=t_0}^{t} a_i \delta_{ij} = a_j \tag{8}$$

It follows further that any random variable x (not necessarily in $\mathcal{Y}(t)$) can be uniquely decomposed into two parts: a part $\bar{x}$ in $\mathcal{Y}(t)$ and a part $\tilde{x}$ orthogonal to $\mathcal{Y}(t)$ (i.e., orthogonal to every vector in $\mathcal{Y}(t)$). In fact, we can write

$$x = \bar{x} + \tilde{x} = \sum_{i=t_0}^{t} (Exe_i)e_i + \tilde{x} \tag{9}$$

Thus $\bar{x}$ is uniquely determined by equation (9) and is obviously a vector in $\mathcal{Y}(t)$. Therefore $\tilde{x}$ is also uniquely determined; it remains to check that it is orthogonal to $\mathcal{Y}(t)$:

$$E\tilde{x}e_i = E(x - \bar{x})e_i = Exe_i - E\bar{x}e_i$$

Now the co-ordinates of $\bar{x}$ with respect to the basis $e_{t_0}, \ldots, e_t$ are given either in the form $E\bar{x}e_i$ (as in (8)) or in the form Exe_i (as in (9)). Since the co-ordinates are unique, $Exe_i = E\bar{x}e_i$ ($i = t_0, \ldots, t$); hence $E\tilde{x}e_i = 0$ and $\tilde{x}$ is orthogonal to every base vector e_i; and therefore to $\mathcal{Y}(t)$. We call $\bar{x}$ the *orthogonal projection* of x on $\mathcal{Y}(t)$.

There is another way in which the orthogonal projection can be characterized: $\bar{x}$ is that vector in $\mathcal{Y}(t)$ (i.e., that *linear* function of the random variables $y(t_0), \ldots, y(t)$) which minimizes the quadratic loss function. In fact, if $\bar{w}$ is any other vector in $\mathcal{Y}(t)$, we have

$$E(x - \bar{w})^2 = E(\tilde{x} + \bar{x} - \bar{w})^2 = E[(x - \bar{x}) + (\bar{x} - \bar{w})]^2$$

Since $\tilde{x}$ is orthogonal to every vector in $\mathcal{Y}(t)$ and in particular to $\bar{x} - \bar{w}$ we have

$$E(x - \bar{w})^2 = E(x - \bar{x})^2 + E(\bar{x} - \bar{w})^2 \geq E(x - \bar{x})^2 \tag{10}$$

This shows that, if $\bar{w}$ also minimizes the quadratic loss, we must have $E(\bar{x} - \bar{w})^2 = 0$ which means that the random variables $\bar{x}$ and $\bar{w}$ are equal (except possibly for a set of events whose probability is zero).

These results may be summarized as follows:

Theorem 2. Let $\{x(t)\}$, $\{y(t)\}$ *random processes with zero mean (i.e.,* $Ex(t) = Ey(t) = 0$ *for all* t*). We observe* $y(t_0), \ldots, y(t)$.

If either

(*A*) *the random processes* $\{x(t)\}$, $\{y(t)\}$ *are gaussian; or*

(*B*) *the optimal estimate is restricted to be a linear function of the observed random variables and* $L(\varepsilon) = \varepsilon^2$;

then

$$\begin{aligned} x^*(t_1|t) &= \textit{optimal estimate of } x(t_1) \text{ given } y(t_0), \ldots, y(t) \\ &= \textit{orthogonal projection } \bar{x}(t_1|t) \textit{ of } x(t_1) \text{ on } \mathcal{Y}(t). \end{aligned} \tag{11}$$

These results are well-known though not easily accessible in the control systems literature. See Doob [15], pp. 75–78, or Pugachev [26]. It is sometimes convenient to denote the orthogonal projection by

$$\bar{x}(t_1 \mid t) \equiv x^*(t_1 \mid t) = \hat{E}[x(t_1) \mid \mathcal{Y}(t)]$$

The notation $\hat{E}$ is motivated by part (*b*) of the theorem: If the stochastic processes in question are gaussian, then orthogonal projection is actually identical with conditional expectation.

Proof. (*A*) This is a direct consequence of the remarks in connection with (10).

(*B*) Since $x(t)$, $y(t)$ are random variables with zero mean, it is clear from formula (9) that the orthogonal part $\tilde{x}(t_1|t)$ of $x(t_1)$ with respect to the linear manifold $\mathcal{Y}(t)$ is also a random variable with zero mean. Orthogonal random variables with zero mean are uncorrelated; if they are also gaussian then (by Theorem 5 (*B*)) they are independent. Thus

$$\begin{aligned} 0 = E\tilde{x}(t_1|t) &= E[\tilde{x}(t_1|t)|y(t_0), \ldots, y(t)] \\ &= E[x(t_1) - \bar{x}(t_1|t)|y(t_0), \ldots, y(t)] \\ &= E[x(t_1)|y(t_0), \ldots, y(t)] - \bar{x}(t_1|t) = 0 \end{aligned}$$

Remarks. (*d*) A rigorous formulation of the contents of this section as $t \to \infty$ requires some elementary notions from the theory of Hilbert space. See Doob [15] and Loève [16].

(*e*) The physical interpretation of Theorem 2 is largely a matter of taste. If we are not worried about the assumption of gaussianness, part (*A*) shows that the orthogonal projection is the optimal estimate for all reasonable loss functions. If we do worry about gaussianness, even if we are resigned to consider only linear estimates, we know that orthogonal projections are *not* the optimal estimate for many reasonable loss functions. Since in practice it is difficult to ascertain to what degree of approximation a random process of physical origin is gaussian, it is hard to decide whether Theorem 2 has very broad or very limited significance.

(*f*) Theorem 2 is immediately generalized for the case of vector-valued random variables. In fact, we define the linear manifold $\mathcal{Y}(t)$ generated by $\mathbf{y}(t_0), \ldots, \mathbf{y}(t)$ to be the set of all linear combinations

$$\sum_{i=t_0}^{t} \sum_{j=1}^{m} a_{ij} y_j(i)$$

of all m co-ordinates of each of the random vectors $\mathbf{y}(t_0), \ldots, \mathbf{y}(t)$. The rest of the story proceeds as before.

(*g*) Theorem 2 states in effect that the optimal estimate under conditions (*A*) or (*B*) is a linear combination of all previous observations. In other words, the optimal estimate can be regarded as the output of a linear filter, with the input being the actually occurring values of the observable random variables; Theorem 2 gives a way of computing the impulse response of the optimal filter. As pointed out before, knowledge of this impulse response is not a complete solution of the problem; for this reason, no explicit formulas for the calculation of the impulse response will be given.

Models for Random Processes

In dealing with physical phenomena, it is not sufficient to give an empirical description but one must have also some idea of the underlying causes. Without being able to separate in some sense causes and effects, i.e., without the assumption of causality, one can hardly hope for useful results.

It is a fairly generally accepted fact that primary macroscopic sources of random phenomena are independent gaussian processes.[5] A well-known example is the noise voltage produced in a resistor due to thermal agitation. In most cases, *observed* random phenomena are not describable by independent random variables. The statistical dependence (correlation) between random signals observed at different times is usually explained by the presence of a dynamic system between the primary random source and the observer. *Thus a random function of time may be thought of as the output of a dynamic system excited by an independent gaussian random process.*

An important property of gaussian random signals is that they remain gaussian after passing through a linear system (Theorem 5 (*A*)). Assuming independent gaussian primary random sources, if the observed random signal is also gaussian, we may assume that the dynamic system between the observer and the primary source is *linear*. This conclusion may be forced on us also because of lack of detailed knowledge of the statistical properties of the observed random signal: Given any random process with known first and second-order averages, we can find a gaussian random process with the same properties (Theorem 5 (*C*)). Thus gaussian distributions and linear dynamics are natural, mutually plausible assumptions particularly when the statistical data are scant.

How is a dynamic system (linear or nonlinear) described? The fundamental concept is the notion of the *state*. By this is meant, intuitively, some quantitative information (a set of numbers, a function, etc.) which is the least amount of data one has to know about the past behavior of the system in order to predict its future behavior. The dynamics is then described in terms of *state transitions*, i.e., one must specify how one state is transformed into another as time passes.

A *linear* dynamic system may be described in general by the vector differential equation

$$\left.\begin{aligned} d\mathbf{x}/dt &= \mathbf{F}(t)\mathbf{x} + \mathbf{D}(t)\mathbf{u}(t) \\ \text{and} \qquad & \\ \mathbf{y}(t) &= \mathbf{M}(t)\mathbf{x}(t) \end{aligned}\right\} \qquad (12)$$

where $\mathbf{x}$ is an n-vector, the *state* of the system (the components x_i of $\mathbf{x}$ are called *state variables*); $\mathbf{u}(t)$ is an m-vector ($m \leq n$) representing the *inputs* to the system; $\mathbf{F}(t)$ and $\mathbf{D}(t)$ are $n \times n$, respectively, $n \times m$ matrices. If all coefficients of $\mathbf{F}(t)$, $\mathbf{D}(t)$, $\mathbf{M}(t)$ are constants, we say that the dynamic system (12) is *time-invariant* or *stationary*. Finally, $\mathbf{y}(t)$ is a *p-vector* denoting the outputs of the system; $\mathbf{M}(t)$ is an $n \times p$ matrix; $p \leq n$

The physical interpretation of (12) has been discussed in detail elsewhere [18, 20, 23]. A look at the block diagram in Fig. 1 may be helpful. This is not an ordinary but a matrix block diagram (as revealed by the fat lines indicating signal flow). The integrator in

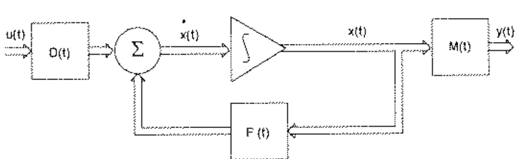

Fig 1. Matrix block diagram of the general linear continuous-dynamic system

[5] The probability distributions will be gaussian because macroscopic random effects may be thought of as the superposition of very many microscopic random effects; under very general conditions, such aggregate effects tend to be gaussian, regardless of the statistical properties of the microscopic effects. The assumption of independence in this context is motivated by the fact that microscopic phenomena tend to take place much more rapidly than macroscopic phenomena; thus primary random sources would appear to be independent on a macroscopic time scale.

Fig. 1 actually stands for n integrators such that the output of each is a state variable; $\mathbf{F}(t)$ indicates how the outputs of the integrators are fed back to the inputs of the integrators. Thus $f_{ij}(t)$ is the coefficient with which the output of the jth integrator is fed back to the input of the ith integrator. It is not hard to relate this formalism to more conventional methods of linear system analysis.

If we assume that the system (12) is stationary and that $\mathbf{u}(t)$ is constant during each sampling period, that is

$$\mathbf{u}(t + \tau) = \mathbf{u}(t); \quad 0 \leq \tau < 1, \quad t = 0, 1, \ldots \qquad (13)$$

then (12) can be readily transformed into the more convenient discrete form.

$$\mathbf{x}(t + 1) = \mathbf{\Phi}(1)\mathbf{x}(t) + \mathbf{\Delta}(1)\mathbf{u}(t); \quad t = 0, 1, \ldots$$

where [18, 20]

$$\mathbf{\Phi}(1) = \exp \mathbf{F} = \sum_{i=0}^{\infty} \mathbf{F}^i/i! \quad (\mathbf{F}^0 = \text{unit matrix})$$

and

$$\mathbf{\Delta}(1) = \left(\int_0^1 \exp \mathbf{F}\tau d\tau\right) \mathbf{D}$$

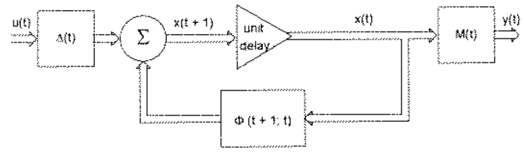

Fig 2. Matrix block diagram of the general linear discrete-dynamic system

See Fig. 2. One could also express exp $\mathbf{F}\tau$ in closed form using Laplace transform methods [18, 20, 22, 24]. If $\mathbf{u}(t)$ satisfies (13) but the system (12) is nonstationary, we can write analogously

$$\left.\begin{aligned} \mathbf{x}(t + 1) &= \mathbf{\Phi}(t + 1; t) + \mathbf{\Delta}(t)\mathbf{u}(t) \\ \mathbf{y}(t) &= \mathbf{M}(t)\mathbf{x}(t) \end{aligned}\right\} \quad t = 0, 1, \ldots \qquad (14)$$

but of course now $\mathbf{\Phi}(t + 1; t)$, $\mathbf{\Delta}(t)$ cannot be expressed in general in closed form. Equations of type (14) are encountered frequently also in the study of complicated sampled-data systems [22]. See Fig. 2

$\mathbf{\Phi}(t + 1; t)$ is the *transition matrix* of the system (12) or (14). The notation $\mathbf{\Phi}(t_2; t_1)$ (t_2, t_1 = integers) indicates transition from time t_1 to time t_2. Evidently $\mathbf{\Phi}(t; t) = \mathbf{I}$ = unit matrix. If the system (12) is stationary then $\mathbf{\Phi}(t + 1; t) = \mathbf{\Phi}(t + 1 - t) = \mathbf{\Phi}(1)$ = const. Note also the product rule: $\mathbf{\Phi}(t; s)\mathbf{\Phi}(s; r) = \mathbf{\Phi}(t; r)$ and the inverse rule $\mathbf{\Phi}^{-1}(t; s) = \mathbf{\Phi}(s; t)$, where t, s, r are integers. In a stationary system, $\mathbf{\Phi}(t; \tau) = \exp \mathbf{F}(t - \tau)$.

As a result of the preceding discussion, we shall represent random phenomena by the model

$$\mathbf{x}(t + 1) = \mathbf{\Phi}(t + 1; t)\mathbf{x}(t) + \mathbf{u}(t) \qquad (15)$$

where $\{\mathbf{u}(t)\}$ is a vector-valued, independent, gaussian random process, with zero mean, which is completely described by (in view of Theorem 5 (*C*))

$$E\mathbf{u}(t) = \mathbf{0} \quad \text{for all } t;$$

$$E\mathbf{u}(t)\mathbf{u}'(s) = \mathbf{0} \quad \text{if } t \neq s$$

$$E\mathbf{u}(t)\mathbf{u}'(t) = \mathbf{G}(t).$$

Of course (Theorem 5 (*A*)), $\mathbf{x}(t)$ is then also a gaussian random process with zero mean, but it is no longer independent. In fact, if we consider (15) in the steady state (assuming it is a stable system), in other words, if we neglect the initial state $\mathbf{x}(t_0)$, then

$$x(t) = \sum_{r=-\infty}^{t-1} \mathbf{\Phi}(t; r+1)\mathbf{u}(r).$$

Therefore if $t \geq s$ we have

$$E\mathbf{x}(t)\mathbf{x}'(s) = \sum_{r=-\infty}^{s-1} \mathbf{\Phi}(t; r+1)\mathbf{Q}(r)\mathbf{\Phi}'(s; r+1).$$

Thus if we assume a linear dynamic model and know the statistical properties of the gaussian random excitation, it is easy to find the corresponding statistical properties of the gaussian random process $\{\mathbf{x}(t)\}$.

In real life, however, the situation is usually reversed. One is given the covariance matrix $E\mathbf{x}(t)\mathbf{x}'(s)$ (or rather, one attempts to estimate the matrix from limited statistical data) and the problem is to get (15) and the statistical properties of $\mathbf{u}(t)$. This is a subtle and presently largely unsolved problem in experimentation and data reduction. As in the vast majority of the engineering literature on the Wiener problem, we shall find it convenient to start with the model (15) and regard the problem of obtaining the model itself as a separate question. To be sure, the two problems *should* be optimized jointly if possible; the author is not aware, however, of any study of the *joint* optimization problem.

In summary, the following assumptions are made about random processes:

Physical random phenomena may be thought of as *due to primary random sources exciting dynamic systems. The primary sources are assumed to be independent gaussian random processes with zero mean; the dynamic systems will be linear. The random processes are therefore described by models such as* (15). *The question of how the numbers specifying the model are obtained from experimental data will not be considered.*

Solution of the Wiener problem

Let us now define the principal problem of the paper.

Problem I. *Consider the dynamic model*

$$\mathbf{x}(t+1) = \mathbf{\Phi}(t+1; t)\mathbf{x}(t) + \mathbf{u}(t) \quad (16)$$

$$\mathbf{y}(t) = \mathbf{M}(t)\mathbf{x}(t) \quad (17)$$

where $\mathbf{u}(t)$ *is an independent gaussian random process of n-vectors with zero mean,* $\mathbf{x}(t)$ *is an n-vector,* $\mathbf{y}(t)$ *is a p-vector* ($p \leq n$), $\mathbf{\Phi}(t+1; t)$, $\mathbf{M}(t)$ *are* $n \times n$, *resp.* $p \times n$, *matrices whose elements are nonrandom functions of time.*

Given the observed values of $\mathbf{y}(t_0)$, ..., $\mathbf{y}(t)$ *find an estimate* $\mathbf{x}^*(t_1|t)$ *of* $\mathbf{x}(t_1)$ *which minimizes the expected loss.* (See Fig. 2, where $\mathbf{\Delta}(t) = \mathbf{I}$.)

This problem includes as a special case the problems of filtering, prediction, and data smoothing mentioned earlier. It includes also the problem of reconstructing all the state variables of a linear dynamic system from noisy observations of some of the state variables ($p < n!$).

From Theorem 2-*a* we know that the solution of Problem I is simply the orthogonal projection of $\mathbf{x}(t_1)$ on the linear manifold $\mathcal{Y}(t)$ generated by the observed random variables. As remarked in the Introduction, this is to be accomplished by means of a linear (not necessarily stationary!) dynamic system of the general form (14). With this in mind, we proceed as follows.

Assume that $\mathbf{y}(t_0)$, ..., $\mathbf{y}(t-1)$ have been measured, i.e., that $\mathcal{Y}(t-1)$ is known. Next, at time t, the random variable $\mathbf{y}(t)$ is measured. As before let $\tilde{\mathbf{y}}(t|t-1)$ be the component of $\mathbf{y}(t)$ orthogonal to $\mathcal{Y}(t-1)$. If $\tilde{\mathbf{y}}(t|t-1) \equiv 0$, which means that the values of all components of this random vector are zero for almost every possible event, then $\mathcal{Y}(t)$ is obviously the same as $\mathcal{Y}(t-1)$ and therefore the measurement of $\mathbf{y}(t)$ does not convey any additional information. This is not likely to happen in a physically meaningful situation. In any case, $\tilde{\mathbf{y}}(t|t-1)$ generates a linear manifold (possibly 0) which we denote by $\mathcal{Z}(t)$. By definition, $\mathcal{Y}(t-1)$ and $\mathcal{Z}(t)$ taken together are the same manifold as $\mathcal{Y}(t)$, and every vector in $\mathcal{Z}(t)$ is orthogonal to every vector in $\mathcal{Y}(t-1)$.

Assuming by induction that $\mathbf{x}^*(t_1 - 1|t-1)$ is known, we can write:

$$\begin{aligned}\mathbf{x}^*(t_1|t) &= \hat{E}[\mathbf{x}(t_1)|\mathcal{Y}(t)] = \hat{E}[\mathbf{x}(t_1)|\mathcal{Y}(t-1)] + \hat{E}[\mathbf{x}(t_1)|\mathcal{Z}(t)] \\ &= \mathbf{\Phi}(t+1; t)\,\mathbf{x}^*(t_1 - 1|t-1) + \hat{E}[\mathbf{u}(t_1 - 1)|\mathcal{Y}(t-1)] \\ &\quad + \hat{E}[\mathbf{x}(t_1)|\mathcal{Z}(t)] \end{aligned} \quad (18)$$

where the last line is obtained using (16).

Let $t_1 = t + s$, where s is any integer. If $s \geq 0$, then $\mathbf{u}(t_1 - 1)$ is independent of $\mathcal{Y}(t-1)$. This is because $\mathbf{u}(t_1 - 1) = \mathbf{u}(t + s - 1)$ is then independent of $\mathbf{u}(t-2)$, $\mathbf{u}(t-3)$, ... and therefore by (16–17), independent of $\mathbf{y}(t_0)$, ..., $\mathbf{y}(t-1)$, hence independent of $\mathcal{Y}(t-1)$. Since, for all t, $\mathbf{u}(t_0)$ has zero mean by assumption, it follows that $\mathbf{u}(t_1 - 1)$ ($s \geq 0$) is orthogonal to $\mathcal{Y}(t-1)$. Thus if $s \geq 0$, the second term on the right-hand side of (18) vanishes; if $s < 0$, considerable complications result in evaluating this term. We shall consider only the case $t_1 \geq t$. Furthermore, it will suffice to consider in detail only the case $t_1 = t + 1$ since the other cases can be easily reduced to this one.

The last term in (18) must be a linear operation on the random variable $\tilde{\mathbf{y}}(t|t-1)$:

$$\hat{E}[\mathbf{x}(t+1)|\mathcal{Z}(t)] = \mathbf{\Delta}^*(t)\,\tilde{\mathbf{y}}(t|t-1) \quad (19)$$

where $\mathbf{\Delta}^*(t)$ is an $n \times p$ matrix, and the star refers to "optimal filtering".

The component of $\mathbf{y}(t)$ lying in $\mathcal{Y}(t-1)$ is $\bar{\mathbf{y}}(t|t-1) = \mathbf{M}(t)\mathbf{x}^*(t|t-1)$. Hence

$$\tilde{\mathbf{y}}(t|t-1) = \mathbf{y}(t) - \bar{\mathbf{y}}(t|t-1) = \mathbf{y}(t) - \mathbf{M}(t)\mathbf{x}^*(t|t-1). \quad (20)$$

Combining (18-20) (see Fig. 3) we obtain

$$\mathbf{x}^*(t+1|t) = \mathbf{\Phi}^*(t+1; t)\mathbf{x}^*(t|t-1) + \mathbf{\Delta}^*(t)\mathbf{y}(t) \quad (21)$$

where

$$\mathbf{\Phi}^*(t+1; t) = \mathbf{\Phi}(t+1; t) - \mathbf{\Delta}^*(t)\mathbf{M}(t) \quad (22)$$

Thus optimal estimation is performed by a linear dynamic system of the same form as (14). The state of the estimator is the previous estimate, the input is the last measured value of the observable random variable $\mathbf{y}(t)$, the transition matrix is given by (22). Notice that physical realization of the optimal filter requires only (*i*) the model of the random process (*ii*) the operator $\mathbf{\Delta}^*(t)$.

The estimation error is also governed by a linear dynamic system. In fact,

$$\begin{aligned}\tilde{\mathbf{x}}(t+1|t) &= \mathbf{x}(t+1) - \mathbf{x}^*(t+1|t) \\ &= \mathbf{\Phi}(t+1; t)\mathbf{x}(t) + \mathbf{u}(t) - \mathbf{\Phi}^*(t+1; t)\mathbf{x}^*(t|t-1) \\ &\quad - \mathbf{\Delta}^*(t)\mathbf{M}(t)\mathbf{x}(t)\end{aligned}$$

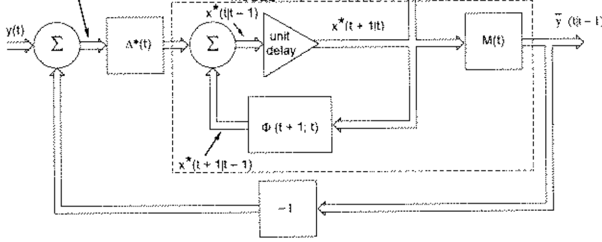

Fig. 3 Matrix block diagram of optimal filter

$$= \mathbf{\Phi}^*(t+1;t)\,\tilde{\mathbf{x}}(t|t-1) + \mathbf{u}(t) \qquad (23)$$

Thus $\mathbf{\Phi}^*$ is also the transition matrix of the linear dynamic system governing the error.

From (23) we obtain at once a recursion relation for the covariance matrix $\mathbf{P}^*(t)$ of the optimal error $\tilde{\mathbf{x}}(t|t-1)$. Noting that $\mathbf{u}(t)$ is independent of $\mathbf{x}(t)$ and therefore of $\tilde{\mathbf{x}}(t|t-1)$ we get

$$\begin{aligned}
\mathbf{P}^*(t+1) &= E\,\tilde{\mathbf{x}}(t+1|t)\,\tilde{\mathbf{x}}'(t+1|t) \\
&= \mathbf{\Phi}^*(t+1;t)E\,\tilde{\mathbf{x}}(t|t-1)\,\tilde{\mathbf{x}}'(t|t-1)\mathbf{\Phi}^{*\prime}(t+1;t) + \mathbf{Q}(t) \\
&= \mathbf{\Phi}^*(t+1;t)E\,\tilde{\mathbf{x}}(t|t-1)\,\tilde{\mathbf{x}}'(t|t-1)\mathbf{\Phi}'(t+1;t) + \mathbf{Q}(t) \\
&= \mathbf{\Phi}^*(t+1;t)\mathbf{P}^*(t)\mathbf{\Phi}'(t+1;t) + \mathbf{Q}(t) \qquad (24)
\end{aligned}$$

where $\mathbf{Q}(t) = E\mathbf{u}(t)\mathbf{u}'(t)$.

There remains the problem of obtaining an explicit formula for $\mathbf{\Delta}^*$ (and thus also for $\mathbf{\Phi}^*$). Since,

$$\tilde{\mathbf{x}}(t+1)|Z(t)) = \mathbf{x}(t+1) - \hat{E}\,[\mathbf{x}(t+1)|Z(t)]$$

is orthogonal to $\tilde{\mathbf{y}}(t|t-1)$, it follows that by (19) that

$$\begin{aligned}
0 &= E[\mathbf{x}(t+1) - \mathbf{\Delta}^*(t)\,\tilde{\mathbf{y}}(t|t-1)]\,\tilde{\mathbf{y}}'(t|t-1) \\
&= E\mathbf{x}(t+1)\,\tilde{\mathbf{y}}'(t|t-1) - \mathbf{\Delta}^*(t)E\,\tilde{\mathbf{y}}(t|t-1)\,\tilde{\mathbf{y}}'(t|t-1).
\end{aligned}$$

Noting that $\tilde{\mathbf{x}}(t+1|t-1)$ is orthogonal to $Z(t)$, the definition of $\mathbf{P}(t)$ given earlier, and (17), it follows further

$$\begin{aligned}
0 &= E\,\tilde{\mathbf{x}}(t+1|t-1)\,\tilde{\mathbf{y}}'(t|t-1) - \mathbf{\Delta}^*(t)\mathbf{M}(t)\mathbf{P}^*(t)\mathbf{M}'(t) \\
&= E[\mathbf{\Phi}(t+1;t)\,\tilde{\mathbf{x}}(t|t-1) + \mathbf{u}(t|t-1)]\,\tilde{\mathbf{x}}'(t|t-1)\mathbf{M}'(t) \\
&\qquad - \mathbf{\Delta}^*(t)\mathbf{M}(t)\mathbf{P}^*(t)\mathbf{M}'(t).
\end{aligned}$$

Finally, since $\mathbf{u}(t)$ is independent of $\mathbf{x}(t)$,

$$0 = \mathbf{\Phi}(t+1;t)\mathbf{P}^*(t)\mathbf{M}'(t) - \mathbf{\Delta}^*(t)\mathbf{M}(t)\mathbf{P}^*(t)\mathbf{M}'(t).$$

Now the matrix $\mathbf{M}(t)\mathbf{P}^*(t)\mathbf{M}'(t)$will be positive definite and hence invertible whenever $\mathbf{P}^*(t)$ is positive definite, provided that none of the rows of $\mathbf{M}(t)$ are linearly dependent at any time, in other words, that none of the observed scalar random variables $y_1(t)$, ..., $y_m(t)$, is a linear combination of the others. Under these circumstances we get finally:

$$\mathbf{\Delta}^*(t) = \mathbf{\Phi}(t+1;t)\mathbf{P}^*(t)\mathbf{M}'(t)[\mathbf{M}(t)\mathbf{P}^*(t)\mathbf{M}'(t)]^{-1} \qquad (25)$$

Since observations start at t_0, $\tilde{\mathbf{x}}(t_0|t_0-1) = \mathbf{x}(t_0)$; to begin the iterative evaluation of $\mathbf{P}^*(t)$ by means of equation (24), we must obviously specify $\mathbf{P}^*(t_0) = E\mathbf{x}(t_0)\mathbf{x}'(t_0)$. Assuming this matrix is positive definite, equation (25) then yields $\mathbf{\Delta}^*(t_0)$; equation (22) $\mathbf{\Phi}^*(t_0+1;t_0)$, and equation (24) $\mathbf{P}^*(t_0+1)$, completing the cycle. If now $\mathbf{Q}(t)$ is positive definite, then all the $\mathbf{P}^*(t)$ will be positive definite and the requirements in deriving (25) will be satisfied at each step.

Now we remove the restriction that $t_1 = t+1$. Since $\mathbf{u}(t)$ is orthogonal to $\mathcal{Y}(t)$, we have

$$\mathbf{x}^*(t+1|t) = \hat{E}\,[\mathbf{\Phi}(t+1;t)\mathbf{x}(t) + \mathbf{u}(t)|\mathcal{Y}(t)] = \mathbf{\Phi}(t+1;t)\mathbf{x}^*(t|t)$$

Hence if $\mathbf{\Phi}(t+1;t)$ has an inverse $\mathbf{\Phi}(t;t+1)$ (which is always the case when $\mathbf{\Phi}$ is the transition matrix of a dynamic system describable by a differential equation) we have

$$\mathbf{x}^*(t|t) = \mathbf{\Phi}(t;t+1)\mathbf{x}^*(t+1|t)$$

If $t_1 \geq t+1$, we first observe by repeated application of (16) that

$$\mathbf{x}(t+s) = \mathbf{\Phi}(t+s;t+1)\mathbf{x}(t+1) + \sum_{r1}^{s-1} \mathbf{\Phi}(t+s;t+r)\mathbf{u}(t+r) \qquad (s \geq 1)$$

Since $\mathbf{u}(t+s-1)$, …, $\mathbf{u}(t+1)$ are all orthogonal to $\mathcal{Y}(t)$,

$$\begin{aligned}
\mathbf{x}^*(t+s|t) &= \hat{E}\,[\mathbf{x}(t+s)|\mathcal{Y}(t)] \\
&= \hat{E}\,[\mathbf{\Phi}(t+s;t+1)\mathbf{x}(t+1)|\mathcal{Y}(t)] \\
&= \mathbf{\Phi}(t+s;t+1)\mathbf{x}^*(t+1|t) \qquad (s \geq 1)
\end{aligned}$$

If $s < 0$, the results are similar, but $\mathbf{x}^*(t-s|t)$ will have $(1-s)(n-p)$ co-ordinates.

The results of this section may be summarized as follows:

Theorem 3. (*Solution of the Wiener Problem*)

Consider Problem I. The optimal estimate $\mathbf{x}^*(t+1|t)$ *of* $\mathbf{x}(t+1)$ *given* $\mathbf{y}(t_0)$, ..., $\mathbf{y}(t)$ *is generated by the linear dynamic system*

$$\mathbf{x}^*(t+1|t) = \mathbf{\Phi}^*(t+1;t)\mathbf{x}^*(t|t-1) + \mathbf{\Delta}^*(t)\mathbf{y}(t) \qquad (21)$$

The estimation error is given by

$$\tilde{\mathbf{x}}(t+1|t) = \mathbf{\Phi}^*(t+1;t)\,\tilde{\mathbf{x}}(t|t-1) + \mathbf{u}(t) \qquad (23)$$

The covariance matrix of the estimation error is

$$\text{cov}\;\tilde{\mathbf{x}}(t|t-1) = E\,\tilde{\mathbf{x}}(t|t-1)\,\tilde{\mathbf{x}}'(t|t-1) = \mathbf{P}^*(t) \qquad (26)$$

The expected quadratic loss is

$$\sum_{i=1}^{n} E\tilde{x}_i^{\,2}(t\,|\,t-1) = \text{trace}\;\mathbf{P}^*(t) \qquad (27)$$

The matrices $\mathbf{\Delta}^*(t)$, $\mathbf{\Phi}^*(t+1;t)$, $\mathbf{P}^*(t)$ *are generated by the recursion relations*

$$\left.\begin{aligned}
\mathbf{\Delta}^*(t) &= \mathbf{\Phi}(t+1;t)\mathbf{P}^*(t)\mathbf{M}'(t)[\mathbf{M}(t)\mathbf{P}^*(t)\mathbf{M}'(t)]^{-1} && (28)\\
\mathbf{\Phi}^*(t+1;t) &= \mathbf{\Phi}(t+1;t) - \mathbf{\Delta}^*(t)\mathbf{M}(t) && (29)\\
\mathbf{P}^*(t+1) &= \mathbf{\Phi}^*(t+1;t)\mathbf{P}^*(t)\mathbf{\Phi}'(t+1;t) + \mathbf{Q}(t) && (30)
\end{aligned}\right\}\; t \geq t_0$$

In order to carry out the iterations, one must specify the covariance $\mathbf{P}^*(t_0)$ *of* $\mathbf{x}(t_0)$ *and the covariance* $\mathbf{Q}(t)$ *of* $\mathbf{u}(t)$. *Finally, for any* $s \geq 0$, *if* $\mathbf{\Phi}$ *is invertible*

$$\begin{aligned}
\mathbf{x}^*(t+s|t) &= \mathbf{\Phi}(t+s;t+1)\mathbf{x}^*(t+1)|t) \\
&= \mathbf{\Phi}(t+s;t+1)\mathbf{\Phi}^*(t+1;t)\mathbf{\Phi}(t;t+s-1) \times \mathbf{x}^*(t+s-1|t-1) \\
&\quad + \mathbf{\Phi}(t+s;t+1)\mathbf{\Delta}^*(t)\mathbf{y}(t) \qquad (31)
\end{aligned}$$

so that the estimate $\mathbf{x}^*(t+s|t)$ $(s \geq 0)$ *is also given by a linear dynamic system of the type* (21).

Remarks. (*h*) Eliminating $\mathbf{\Delta}^*$ and $\mathbf{\Phi}^*$ from (28–30), a nonlinear difference equation is obtained for $\mathbf{P}^*(t)$:

$$\begin{aligned}
\mathbf{P}^*(t+1) = \mathbf{\Phi}(t+1;t)\{&\mathbf{P}^*(t) - \mathbf{P}^*(t)\mathbf{M}'(t)[\mathbf{M}(t)\mathbf{P}^*(t)\mathbf{M}'(t)]^{-1} \\
&\times \mathbf{P}^*(t)\mathbf{M}(t)\}\mathbf{\Phi}'(t+1;t) + \mathbf{Q}(t) \qquad t \geq t_0 \qquad (32)
\end{aligned}$$

This equation is linear only if $\mathbf{M}(t)$ is invertible but then the problem is trivial since all components of the random vector $\mathbf{x}(t)$ are observable $\mathbf{P}^*(t+1) = \mathbf{Q}(t)$. Observe that equation (32) plays a role in the present theory analogous to that of the Wiener-Hopf equation in the conventional theory.

Once $\mathbf{P}^*(t)$ has been computed via (32) starting at $t = t_0$, the explicit specification of the optimal linear filter is immediately available from formulas (29-30). Of course, the solution of Equation (32), or of its differential-equation equivalent, is a much simpler task than solution of the Wiener-Hopf equation.

(*i*) The results stated in Theorem 3 do not resolve completely Problem I. Little has been said, for instance, about the physical significance of the assumptions needed to obtain equation (25), the convergence and stability of the nonlinear difference equation (32), the stability of the optimal filter (21), etc. This can actually be done in a completely satisfactory way, but must be left to a future paper. In this connection, the principal guide and tool turns out to be the duality theorem mentioned briefly in the next section. See [29].

(*j*) By letting the sampling period (equal to one so far) approach zero, the method can be used to obtain the specification of a differential equation for the optimal filter. To do this, i.e., to pass from equation (14) to equation (12), requires computing the logarithm $\mathbf{F}^*$ of the matrix $\mathbf{\Phi}^*$. But this can be done only if $\mathbf{\Phi}^*$ is nonsingular—which is easily seen *not* to be the case. This is because it is sufficient for the optimal filter to have $n - p$ state variables, rather than n, as the formalism of equation (22) would seem to imply. By appropriate modifications, therefore, equation (22) can be reduced to an equivalent set of only $n - p$ equations whose transition matrix is nonsingular. Details of this type will be covered in later publications.

(*k*) The dynamic system (21) is, in general, nonstationary. This is due to two things: (1) The time dependence of $\mathbf{\Phi}(t + 1; t)$ and $\mathbf{M}(t)$; (2) the fact that the estimation starts at $t = t_0$ and improves as more data are accumulated. If $\mathbf{\Phi}$, $\mathbf{M}$ are constants, it can be shown that (21) becomes a stationary dynamic system in the limit $t \to \infty$. This is the case treated by the classical Wiener theory.

(*l*) It is noteworthy that the derivations given are not affected by the nonstationarity of the model for $\mathbf{x}(t)$ or the finiteness of available data. In fact, as far as the author is aware, the only explicit recursion relations given before for the growing-memory filter are due to Blum [12]. However, his results are much more complicated than ours.

(*m*) By inspection of Fig. 3 we see that the optimal filter is a feedback system, and that the signal after the first summer is white noise since $\tilde{\mathbf{y}}(t|t-1)$ is obviously an orthogonal random process. This corresponds to some well-known results in Wiener filtering, see, e.g., Smith [28], Chapter 6, Fig. 6–4. However, this is apparently the first *rigorous* proof that every Wiener filter is realizable by means of a feedback system. Moreover, it will be shown in another paper that such a filter is always *stable*, under very mild assumptions on the model (16–17). See [29].

The Dual Problem

Let us now consider another problem which is conceptually very different from optimal estimation, namely, the noise-free regulator problem. In the simplest cases, this is:

Problem II. *Consider the dynamic system*

$$\mathbf{x}(t+1) = \hat{\mathbf{\Phi}}(t+1; t)\mathbf{x}(t) + \hat{\mathbf{M}}(t)\mathbf{u}(t) \qquad (33)$$

where $\mathbf{x}(t)$ is an n-vector, $\mathbf{u}(t)$ is an m-vector ($m \le n$), $\hat{\mathbf{\Phi}}$, $\hat{\mathbf{M}}$ are $n \times n$ resp. $n \times m$ matrices whose elements are nonrandom functions of time. Given any state $\mathbf{x}(t)$ at time t, we are to find a sequence $\mathbf{u}(t)$, ..., $\mathbf{u}(T)$ of control vectors which minimizes the performance index

$$V[\mathbf{x}(t)] = \sum_{\tau=t}^{T+1} \mathbf{x}'(\tau)\mathbf{Q}(\tau)\mathbf{x}(\tau)$$

Where $\hat{\mathbf{Q}}(t)$ is a positive definite matrix whose elements are nonrandom functions of time. See Fig. 2, where $\mathbf{\Delta} = \hat{\mathbf{M}}$ and $\mathbf{M} = \mathbf{I}$.

Probabilistic considerations play no part in Problem II; it is implicitly assumed that every state variable can be measured exactly at each instant t, $t + 1$, ..., T. It is customary to call $T \ge t$ the *terminal time* (it may be infinity).

The first general solution of the noise-free regulator problem is due to the author [18]. The main result is that the optimal control vectors $\mathbf{u}^*(t)$ are nonstationary linear functions of $\mathbf{x}(t)$. After a change in notation, the formulas of the Appendix, Reference [18] (see also Reference [23]) are as follows:

$$\mathbf{u}^*(t) = -\hat{\mathbf{\Delta}}^*(t)\mathbf{x}(t) \qquad (34)$$

Under optimal control as given by (34), the "closed-loop" equations for the system are (see Fig. 4)

$$\mathbf{x}(t+1) = \hat{\mathbf{\Phi}}^*(t+1; t)\mathbf{x}(t)$$

and the minimum performance index at time t is given by

$$V^*[\mathbf{x}(t)] = \mathbf{x}'(t)\mathbf{P}^*(t-1)\mathbf{x}(t)$$

The matrices $\hat{\mathbf{\Delta}}^*(t)$, $\hat{\mathbf{\Phi}}^*(t+1; t)$, $\hat{\mathbf{P}}^*(t)$ are determined by the recursion relations:

$$\left.\begin{aligned} \hat{\mathbf{\Delta}}^*(t) &= [\hat{\mathbf{M}}'(t)\hat{\mathbf{P}}^*(t)\hat{\mathbf{M}}(t)]^{-1}\hat{\mathbf{M}}'(t)\hat{\mathbf{P}}^*(t)\hat{\mathbf{\Phi}}(t+1; t) && (35)\\ \hat{\mathbf{\Phi}}^*(t+1; t) &= \hat{\mathbf{\Phi}}(t+1; t) - \hat{\mathbf{M}}(t)\hat{\mathbf{\Delta}}^*(t) && (36)\\ \hat{\mathbf{P}}^*(t-1) &= \hat{\mathbf{\Phi}}'(t+1; t)\hat{\mathbf{P}}^*(t)\hat{\mathbf{\Phi}}^*(t+1; t) + \hat{\mathbf{Q}}(t) && (37) \end{aligned}\right\} t \le T$$

Initially we must set $\hat{\mathbf{P}}^*(T) = \hat{\mathbf{Q}}(T+1)$.

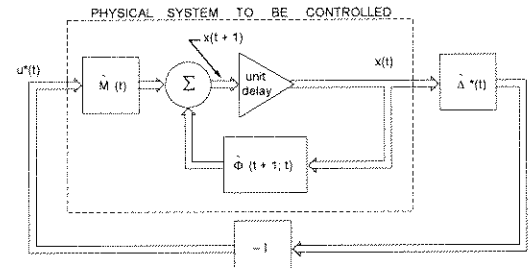

Fig. 4 Matrix block diagram of optimal controller

Comparing equations (35–37) with (28–30) and Fig. 3 with Fig. 4 we notice some interesting things which are expressed precisely by

Theorem 4. (*Duality Theorem*) *Problem I and Problem II are duals of each other in the following sense:*

Let $\tau \ge 0$. Replace every matrix $\mathbf{X}(t) = \mathbf{X}(t_0 + \tau)$ in (28–30) by $\hat{\mathbf{X}}'(t) = \hat{\mathbf{X}}'(T - \tau)$. Then One has (35–37). Conversely, replace every matrix $\hat{\mathbf{X}}(T - \tau)$ in (35–37) by $\mathbf{X}'(t_0 + \tau)$. Then one has (28–30).

Proof. Carry out the substitutions. For ease of reference, the dualities between the two problems are given in detail in Table 1.

Table 1

	Problem I	Problem II
1	$\mathbf{x}(t)$ (unobservable) state variables of random process.	$\mathbf{x}(t)$ (observable) state variables of plant to be regulated.
2	$\mathbf{y}(t)$ observed random variables.	$\mathbf{u}(t)$ control variables
3	t_0 first observation.	T last control action.
4	$\mathbf{\Phi}(t_0 + \tau + 1; t_0 + \tau)$ transition matrix.	$\hat{\mathbf{\Phi}}(T - \tau + 1; T - \tau)$ transition matrix.
5	$\mathbf{P}^*(t_0 + \tau)$ covariance of optimized estimation error.	$\hat{\mathbf{P}}^*(T - \tau)$ matrix of quadratic form for performance index under optimal regulation.
6	$\mathbf{\Delta}^*(t_0 + \tau)$ weighting of observation for optimal estimation.	$\hat{\mathbf{\Delta}}^*(T - \tau)$ weighting of state for optimal control.
7	$\mathbf{\Phi}^*(t_0 + \tau + 1; t_0 + \tau)$ transition matrix for optimal estimation error.	$\hat{\mathbf{\Phi}}^*(T - \tau + 1; T - \tau)$ transition matrix under optimal regulation.
8	$\mathbf{M}(t_0 + \tau)$ effect of state on observation.	$\hat{\mathbf{M}}(T - \tau)$ effect of control vectors on state.
9	$\mathbf{Q}(t_0 + \tau)$ covariance of random excitation.	$\hat{\mathbf{Q}}(T - \tau)$ matrix of quadratic form defining error criterion.

Remarks. (*n*) The *mathematical* significance of the duality between Problem I and Problem II is that both problems reduce to the solution of the Wiener-Hopf-like equation (32).

(*o*) The *physical* significance of the duality is intriguing. Why are observations and control dual quantities?

Recent research [29] has shown that the essence of the Duality Theorem lies in the duality of constraints at the output (represented by the matrix $\hat{\mathbf{M}}(t)$ in Problem I) and constraints at the input (represented by the matrix $\hat{\mathbf{M}}(t)$ in Problem II).

(p) Applications of Wiener's methods to the solution of noise-free regulator problem have been known for a long time; see the recent textbook of Newton, Gould, and Kaiser [27]. However, the connections between the two problems, and in particular the duality, have apparently never been stated precisely before.

(q) The duality theorem offers a powerful tool for developing more deeply the theory (as opposed to the computation) of Wiener filters, as mentioned in Remark (i). This will be published elsewhere [29].

Applications

The power of the new approach to the Wiener problem, as expressed by Theorem 3, is most obvious when the data of the problem are given in numerical form. In that case, one simply performs the numerical computations required by (28–30). Results of such calculations, in some cases of practical engineering interest, will be published elsewhere.

When the answers are desired in closed analytic form, the iterations (28–30) may lead to very unwieldy expressions. In a few cases, $\mathbf{\Delta}^*$ and $\mathbf{\Phi}^*$ can be put into "closed form." Without discussing here how (if at all) such closed forms can be obtained, we now give two examples indicative of the type of results to be expected.

Example 1. Consider the problem mentioned under "Optimal Estimates." Let $x_1(t)$ be the signal and $x_2(t)$ the noise. We assume the model:

$$x_1(t+1) = \phi_{11}(t+1;t)x_1(t) + u_1(t)$$

$$x_2(t+1) = u_2(t)$$

$$y_1(t) = x_1(t) + x_2(t)$$

The specific data for which we desire a solution of the estimation problem are as follows:

1 $t_1 = t + 1$; $t_0 = 0$
2 $Ex_1^2(0) = 0$, i.e., $x_1(0) = 0$
3 $Eu_1^2(t) = a^2$, $Eu^2(t) = b^2$, $Eu_1(t)\,u_2(t) = 0$ (for all t)
4 $\phi_{11}(t+1;t) = \phi_{11} =$ const.

A simple calculation shows that the following matrices satisfy the difference equations (28–30), for all $t \geq t_0$:

$$\mathbf{\Delta}^*(t) = \begin{bmatrix} \phi_{11}C(t) \\ 0 \end{bmatrix}$$

$$\mathbf{\Phi}^*(t+1;t) = \begin{bmatrix} \phi_{11}[1-C(t)] & 0 \\ 0 & 0 \end{bmatrix}$$

$$\mathbf{P}^*(t+1) = \begin{bmatrix} a^2 + \phi_{11}{}^2 b^2 C(t) & 0 \\ 0 & b^2 \end{bmatrix}$$

where $$C(t+1) = 1 - \frac{b^2}{a^2 + b^2 + \phi_{11}{}^2 b^2 C(t)} \qquad t \geq 0 \tag{38}$$

Since it was assumed that $x_1(0) = 0$, neither $x_1(1)$ nor $x_2(1)$ can be predicted from the measurement of $y_1(0)$. Hence the measurement at time $t = 0$ is useless, which shows that we should set $C(0) = 0$. This fact, with the iterations (38), completely determines the function $C(t)$. The nonlinear difference equation (38) plays the role of the Wiener-Hopf equation.

If $b^2/a^2 << 1$, then $C(t) \approx 1$ which is essentially pure prediction. If $b^2/a^2 >> 1$, then $C(t) \approx 0$, and we depend mainly on $x_1^*(t|t-1)$ for the estimation of $x_1^*(t+1|t)$ and assign only very small weight to the measurement $y_1(t)$; this is what one would expect when the measured data are very noisy.

In any case, $x_2^*(t|t-1) = 0$ at all times; one cannot predict independent noise! This means that ϕ^*_{12} can be set equal to zero. The optimal predictor is a first-order dynamic system. See Remark (j).

To find the stationary Wiener filter, let $t = \infty$ on both sides of (38), solve the resulting quadratic equation in $C(\infty)$, etc.

Example 2. A number or particles leave the origin at time $t_0 = 0$ with random velocities; after $t = 0$, each particle moves with a constant (unknown) velocity. Suppose that the position of one of these particles is measured, the data being contaminated by stationary, additive, correlated noise. What is the optimal estimate of the position and velocity of the particle at the time of the last measurement?

Let $x_1(t)$ be the position and $x_2(t)$ the velocity of the particle; $x_3(t)$ is the noise. The problem is then represented by the model,

$$x_1(t+1) = x_1(t) + x_2(t)$$

$$x_2(t+1) = x_2(t)$$

$$x_3(t+1) = \phi_{33}(t+1;t)x_3(t) + u_3(t)$$

$$y_1(t) = x_1(t) + x_3(t)$$

and the additional conditions

1 $t_1 = t$; $t_0 = 0$
2 $Ex_1^2(0) = Ex_2(0) = 0$, $Ex_2^2(0) = a^2 > 0$;
3 $Eu_3(t) = 0$, $Eu_3^2(t) = b^2$.
4 $\phi_{33}(t+1;t) = \phi_{33} =$ const.

According to Theorem 3, $\mathbf{x}^*(t|t)$ is calculated using the dynamic system (31).

First we solve the problem of predicting the position and velocity of the particle one step ahead. Simple considerations show that

$$\mathbf{P}^*(1) = \begin{bmatrix} a^2 & a^2 & 0 \\ a^2 & a^2 & 0 \\ 0 & 0 & b^2 \end{bmatrix} \quad \text{and} \quad \mathbf{\Delta}^*(0) = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$

It is then easy to check by substitution into equations (28–30) that

$$\mathbf{P}^*(t) = \frac{b^2}{C_1(t-1)} \times \begin{bmatrix} t^2 & t & -\phi_{33}t(t-1) \\ t & 1 & -\phi_{33}(t-1) \\ -\phi_{33}t(t-1) & -\phi_{33}(t-1) & \phi_{33}{}^2(t-1)^2 + C_1(t-1) \end{bmatrix}$$

is the correct expression for the covariance matrix of the prediction error $\tilde{\mathbf{x}}(t|t-1)$ for all $t \geq 1$, provided that we define

$$C_1(0) = b^2/a^2$$
$$C_1(t) = C_1(t-1) + [t - \phi_{33}(t-1)]^2, \quad t \geq 1$$

It is interesting to note that the results just obtained are valid also when ϕ_{33} depends on t. This is true also in Example 1. In conventional treatments of such problems there *seems* to be an essential difference between the cases of stationary and nonstationary noise. This misleading impression created by the conventional theory is due to the very special *methods* used in solving the Wiener-Hopf equation.

Introducing the abbreviation

$$C_2(0) = 0$$
$$C_2(t) = t - \phi_{33}(t-1), \quad t \geq 1$$

and observing that

$$\text{cov}\,\tilde{\mathbf{x}}(t+1|t) = \mathbf{P}^*(t+1) = \mathbf{\Phi}(t+1;t)[\text{cov}\,\tilde{\mathbf{x}}(t|t)]\mathbf{\Phi}'(t+1;t) + \mathbf{Q}(t)$$

the matrices occurring in equation (31) and the covariance matrix of $\tilde{\mathbf{x}}(t|t)$ are found after simple calculations. We have, for all $t \geq 0$,

$$\mathbf{\Phi}(t; t+1)\mathbf{\Delta}^*(t) = \frac{1}{C_1(t)}\begin{bmatrix} tC_2(t) \\ C_2(t) \\ C_1(t) - tC_2(t) \end{bmatrix}$$

$\mathbf{\Phi}(t; t+1)\mathbf{\Phi}^*(t+1; t)\mathbf{\Phi}(t+1; t)$

$$= \frac{1}{C_1(t)}\begin{bmatrix} C_1(t) - tC_2(t) & C_1(t) - tC_3(t) & -\phi_{33}tC_2(t) \\ -C_2(t) & C_1(t) - C_2(t) & -\phi_{33}C_2(t) \\ -C_1(t) + tC_2(t) & -C_1(t) + tC_2(t) & +\phi_{33}tC_2(t) \end{bmatrix}$$

and

$$\text{cov } \tilde{\mathbf{x}}(t|t) = E\tilde{\mathbf{x}}(t|t)\tilde{\mathbf{x}}'(t|t) = \frac{b^2}{C_1(t)}\begin{bmatrix} t^2 & t & -t^2 \\ t & 1 & -t \\ -t^2 & -t & t^2 \end{bmatrix}$$

To gain some insight into the behavior of this system, let us examine the limiting case $t \to \infty$ of a large number of observations. Then $C_1(t)$ obeys approximately the differential equation

$$dC_1(t)/dt \approx C_2^2(t) \qquad (t >> 1)$$

from which we find

$$C_1(t) \approx (1 - \phi_{33})^2 t^3/3 + \phi_{33}(1 - \phi_{33})t^2 + \phi_{33}^2 t + b^2/a^2 \qquad (t >> 1) \qquad (39)$$

Using (39), we get further,

$$\mathbf{\Phi}^{-1}\mathbf{\Phi}^*\mathbf{\Phi} \approx \begin{bmatrix} 1 & 1 & 0 \\ 0 & 1 & 0 \\ -1 & -1 & 0 \end{bmatrix} \text{ and } \mathbf{\Phi}^{-1}\mathbf{\Delta}^* \approx \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \qquad (t >> 1)$$

Thus as the number of observations becomes large, we depend almost exclusively on $x_1^*(t|t)$ and $x_2^*(t|t)$ to estimate $x_1^*(t+1|t+1)$ and $x_2^*(t+1|t+1)$. Current observations are used almost exclusively to estimate the noise

$$x_3^*(t|t) \approx y_1^*(t) - x_1^*(t|t) \qquad (t >> 1)$$

One would of course expect something like this since the problem is analogous to fitting a straight line to an increasing number of points.

As a second check on the reasonableness of the results given, observe that the case $t >> 1$ is essentially the same as prediction based on continuous observations. Setting $\phi_{33} = 0$, we have

$$E\tilde{x}_1^2(t|t) \approx \frac{a^2b^2t^2}{b^2 + a^2t^3/3} \qquad (t >> 1; \phi_{33} = 0)$$

which is identical with the result obtained by Shinbrot [11], Example 1, and Solodovnikov [14], Example 2, in their treatment of the Wiener problem in the finite-length, continuous-data case, using an approach entirely different from ours.

Conclusions

This paper formulates and solves the Wiener problem from the "state" point of view. On the one hand, this leads to a very general treatment including cases which cause difficulties when attacked by other methods. On the other hand, the Wiener problem is shown to be closely connected with other problems in the theory of control. Much remains to be done to exploit these connections.

References

1 N. Wiener, "The Extrapolation, Interpolation and Smoothing of Stationary Time Series," John Wiley & Sons, Inc., New York, N.Y., 1949.

2 L. A. Zadeh and J. R. Ragazzini, "An Extension of Wiener's Theory of Prediction," *Journal of Applied Physics*, vol. 21, 1950, pp. 645–655.

3 H. W. Bode and C. E. Shannon, "A Simplified Derivation of Linear Least-Squares Smoothing and Prediction Theory," *Proceedinqs IRE*, vol. 38, 1950, pp. 417–425.

4 R. C. Booton, "An Optimization Theory for Time-Varying Linear Systems With Nonstationary Statistical Inputs," *Proceedings IRE*, vol. 40, 1952, pp. 977–981.

5 J. H. Laning and R. H. Battin, "Random Processes in Automatic Control," McGraw-Hill Book Company, Inc., New York, N. Y., 1956.

6 W. B. Davenport, Jr., and W. L. Root, "An Introduction to the Theory of Random Signals and Noise," McGraw-Hill Book Company, Inc., New York, N. Y., 1958.

7 S. Darlington, "Linear Least-Squares Smoothing and Prediction, With Applications," *Bell System Tech. Journal*, vol. 37, 1958, pp.1221–1294.

8 G. Franklin, "The Optimum Synthesis of Sampled-Data Systems" Doctoral dissertation, Dept. of Elect. Engr., Columbia University, 1955.

9 A. B. Lees, "Interpolation and Extrapolation of Sampled Data," *Trans. IRE Prof. Grou.p on Information Theory*, IT-2, 1956, pp. 173–175.

10 R. C. Davis. "On the Theory of Prediction of Nonstationary Stochastic Processes," *Journal of Applied Physics*, vol. 23. 1952, pp. 1047–1053.

11 M. Shinbrot, "Optimization of Time-Varying Linear Systems With Nonstationary Inputs," TRANS. ASME, vol. 80, 1958. pp. 457–462.

12 M. Blum, "Recursion Formulas for Growing Memory Digital Filters," *Trans. IRE Prof. Group on Information Theory*. IT-4. 1958, pp. 24–30.

13 V. S. Pugachev, "The Use of Canonical Expansions of Random Functions in Determining an Optimum Linear System," *Automatics and Remote Control* (USSR), vol. 17, 1956, pp. 489–499; translation pp. 545–556.

14 V. V. Solodovnikov and A. M. Batkov. "On the Theory of Self-Optimizing Systems (in German and Russian)," Proc. Heidelberg Conference on Automatic Control, 1956. pp. 308–323.

15 J. L. Doob, "Stochastic Processes," John Wiley & Sons, Inc., New York, N. Y., 1955.

16 M. Loève, "Probability Theory," Van Nostrand Company, Inc., New York, N. Y., 1955.

17 R. E. Bellman, I. Glicksberg, and O. A. Gross, "Some Aspects of the Mathematical Theory of Control Processes," RAND Report R-313, 1958, 244 pp.

18 R. E. Kalman and R. W. Koepcke, "Optimal Synthesis of Linear Sampling Control Systems Using Generalized Performance Indexes," TRANS. ASME, vol. 80, 1958, pp. 1820–1826.

19 J. E. Bertram, "Effect of Quantization in Sampled-Feedback Systems," *Trans. AIEE*, vol. 77, II, 1958, pp. 177–182.

20 R. E. Kalman and J. E. Bertram, "General Synthesis Procedure for Computer Control of Single and Multi-Loop Linear Systems" *Trans. AIEE*, vol. 77, II, 1958, pp. 602–609.

21 C. W. Merriam, III, "A Class of Optimum Control Systems," *Journal of the Franklin Institute*, vol. 267, 1959, pp. 267–281.

22 R. E. Kalman and J. E. Bertram, "A Unified Approach to the Theory of Sampling Systems," *Journal of the Franklin Institute*, vol. 267, 1959, pp. 405–436.

23 R. E. Kalman and R. W. Koepcke, "The Role of Digital Computers in the Dynamic Optimization of Chemical Reactors," Proc. Western Joint Computer Conference, 1959, pp. 107–116.

24 R. E. Kalman, "Dynamic Optimization of Linear Control Systems, I. Theory," to appear.

25 S. Sherman, "Non-Mean-Square Error Criteria," *Trans. IRE Prof. Group on Information Theory*, IT-4, 1958, pp. 125–126.

26 V. S. Pugachev, "On a Possible General Solution of the Problem of Determining Optimum Dynamic Systems," *Automatics and Remote Control* (USSR), vol. 17, 1956, pp. 585–589.

27 G. C. Newton, Jr., L. A. Gould, and J. F. Kaiser, "Analytical Design of Linear Feedback Controls," John Wiley & Sons, Inc., New York, N. Y., 1957.

28 O. J. M. Smith, "Feedback Control Systems," McGraw-Hill Book Company, Inc., New York, N. Y., 1958.

29 R. E. Kalman, "On the General Theory of Control Systems," Proceedings First International Conference on Automatic Control, Moscow, USSR, 1960.

APPENDIX
RANDOM PROCESSES: BASIC CONCEPTS

For convenience of the reader, we review here some elementary definitions and facts about probability and random processes. Everything is presented with the utmost possible simplicity; for greater depth and breadth, consult Laning and Battin [5] or Doob [15].

A *random variable* is a function whose values depend on the outcome of a chance event. The *values* of a random variable may be any convenient mathematical entities; real or complex numbers, vectors, etc. For simplicity, we shall consider here only real-valued random variables, but this is no real restriction. Random variables will be denoted by $x, y, \ldots$ and their values by $\xi, \eta, \ldots$. Sums, products, and functions of random variables are also random variables.

A random variable x can be explicitly defined by stating the probability that x is less than or equal to some real constant ξ. This is expressed symbolically by writing

$$Pr(x \le \xi) = F_x(\xi);\ F_x(-\infty) = 0,\ F_x(+\infty) = 1$$

$F_x(\xi)$ is called the *probability distribution function* of the random variable x. When $F_x(\xi)$ is differentiable with respect to ξ, then $f_x(\xi) = dF_x(\xi)/d\xi$ is called the *probability density function* of x.

The *expected value* (*mathematical expectation, statistical average, ensemble average, mean*, etc., are commonly used synonyms) of any nonrandom function $g(x)$ of a random variable x is defined by

$$Eg(x) = E[g(x)] = \int_{-\infty}^{\infty} g(\xi)dF_x(\xi) = \int_{-\infty}^{\infty} g(\xi)f_x(\xi)d\xi \qquad (40)$$

As indicated, it is often convenient to omit the brackets after the symbol E. A sequence of random variables (finite or infinite)

$$\{x(t)\} = \ldots, x(-1), x(0), x(1), \ldots \qquad (41)$$

is called a *discrete* (or *discrete-parameter*) *random* (or *stochastic*) *process*. One particular set of observed values of the random process (41)

$$\ldots, \xi(-1), \xi(0), \xi(1), \ldots$$

is called a *realization* (or a *sample function*) of the process. Intuitively, a random process is simply a set of random variables which are indexed in such a way as to bring the notion of time into the picture.

A random process is *uncorrelated* if

$$Ex(t)x(s) = Ex(t)Ex(s) \qquad (t \ne s)$$

If, furthermore,

$$Ex(t)x(s) = 0 \qquad (t \ne s)$$

then the random process is *orthogonal*. Any uncorrelated random process can be changed into orthogonal random process by replacing $x(t)$ by $x'(t) = x(t) - Ex(t)$ since then

$$Ex'(t)x'(s) = E[x(t) - Ex(t)]\cdot[x(s) - Ex(s)] = Ex(t)x(s) - Ex(t)Ex(s) = 0$$

It is useful to remember that, if a random process is orthogonal, then

$$E[x(t_1) + x(t_2) + \ldots]^2 = Ex^2(t_1) + Ex^2(t_2) + \ldots \ (t_1 \ne t_2 \ne \ldots)$$

If $\mathbf{x}$ is a vector-valued random variable with components $x_1, \ldots, x_n$ (which are of course random variables), the matrix

$$[E(x_i - Ex_i)(x_j - Ex_j)] = E(\mathbf{x} - E\mathbf{x})(\mathbf{x}' - E\mathbf{x}') = \text{cov}\ \mathbf{x} \qquad (42)$$

is called the *covariance matrix of* x.

A random process may be specified explicitly by stating the probability of simultaneous occurrence of any finite number of events of the type

$x(t_1) \le \xi_1, \ldots, x(t_n) \le \xi_n$; $(t_1 \ne \ldots \ne t_n)$, i.e.,

$$Pr[(x(t_1) \le \xi_1, \ldots, x(t_n) \le \xi_n)] = F_{x(t_1), \ldots, x(t_n)}(\xi_1, \ldots, \xi_n) \qquad (43)$$

where $F_{x(t_1), \ldots, x(t_n)}$ is called the *joint probability distribution function* of the random variables $x(t_1), \ldots, x(t_n)$. The *joint probability density function* is then

$$f_{x(t_1), \ldots, x(t_n)}(\xi_1, \ldots, \xi_n) = \partial^n F_{n(t_1), \ldots, x(t_n)}/\partial\xi_1, \ldots, \partial\xi_n$$

provided the required derivatives exist. The expected value $Eg[x(t_1), \ldots, x(t_n)]$ of any nonrandom function of n random variables is defined by an n-fold integral analogous to (40).

A random process is *independent* if for any finite $t_1 \ne \ldots \ne t_n$, (43) is equal to the product of the first-order distributions

$$Pr[x(t_1) \le \xi_1] \ldots Pr[x(t_n) \le \xi_n]$$

If a set of random variables is independent, then they are obviously also uncorrelated. The converse is not true in general. For a set of more than 2 random variables to be independent, it is not sufficient that any pair of random variables be independent.

Frequently it is of interest to consider the probability distribution of a random variable $x(t_{n+1})$ of a random process given the actual values $\xi(t_1), \ldots, \xi(t_n)$ with which the random variables $x(t_1), \ldots, x(t_n)$ have occurred. This is denoted by

$$Pr[x(t_{n+1}) \le \xi_{n+1} | x(t_1) = \xi_1, \ldots, x(t_n) = \xi_n] = \frac{\int_{-\infty}^{\xi_{n+1}} f_{x(t_1),\ldots,x(t_{n+1})}(\xi_1,\ldots,\xi_{n+1})d\xi_{n+1}}{f_{x(t_1),\ldots,x(t_n)}(\xi_1,\ldots,\xi_n)} \qquad (44)$$

which is called the *conditional probability distribution function* of $x(t_{n+1})$ given $x(t_1), \ldots, x(t_n)$. The *conditional expectation*

$$E\{g[x(t_{n+1})] | x(t_1), \ldots, x(t_n)\}$$

is defined analogously to (40). The conditional expectation is a random variable; it follows that

$$E[E\{g[x(t_{n+1})] | x(t_1), \ldots, x(t_n)\}] = E\{g[x(t_{n+1})]\}$$

In all cases of interest in this paper, integrals of the type (40) or (44) need never be evaluated explicitly, only the *concept* of the expected value is needed.

A random variable x is *gaussian* (or *normally distributed*) if

$$f_x(\xi) = \frac{1}{[2\pi E(x - Ex)^2]^{1/2}} \exp\left[-\frac{1}{2}\frac{(\xi - Ex)^2}{E(x - Ex)^2}\right]$$

which is the well-known bell-shaped curve. Similarly, a random vector $\mathbf{x}$ is *gaussian* if

$$f_x(\xi) = \frac{1}{(2\pi)^{n/2}(\det \mathbf{C})^{1/2}} \exp\left[-\frac{1}{2}(\boldsymbol{\xi} - E\mathbf{x})'\mathbf{C}^{-1}(\boldsymbol{\xi} - E\mathbf{x})\right]$$

where $\mathbf{C}^{-1}$ is the inverse of the covariance matrix (42) of $\mathbf{x}$. A *gaussian random process* is defined similarly.

The importance of gaussian random variables and processes is largely due to the following facts:

Theorem 5. (*A*) *Linear functions (and therefore conditional expectations) on a gaussian random process are gaussian random variables.*

(*B*) *Orthogonal gaussian random variables are independent.*

(*C*) *Given any random process with means* $Ex(t)$ *and covariances* $Ex(t)x(s)$, *there exists a unique gaussian random process with the same means and covariances.*

Explanation of this transcription, John Lukesh, 20 January 2002.

Using a photo copy of R. E. Kalman's 1960 paper from an original of the ASME "Journal of Basic Engineering", March 1960 issue, I did my best to make an accurate version of this rather significant piece, in an up-to-date computer file format. For this I was able to choose page formatting and type font spacings that resulted in a document that is a close match to the original. (All pages start and stop at about the same point, for example; even most individual lines of text do.) I used a recent version of Word for Windows and a recent Hewlett Packard scanner with OCR (optical character recognition) software. The OCR software is very good on plain text, even distinguishing between italic versus regular characters quite reliably, but it does not do well with subscripts, superscripts, and special fonts, which were quite prevalent in the original paper. And I found there was no point in trying to work from the OCR results for equations. A lot of manual labor was involved.

Since I wanted to make a faithful reproduction of the original, I did not make any changes to correct (what I believed were) mistakes in it. For example, equation (32) has a $\mathbf{P}^*(t)\mathbf{M}(t)$ product that should be reversed, I think. I left this, and some other things that I thought were mistakes in the original, as is. (I didn't find very many other problems with the original.) There may, *of course*, be problems with my transcription. The plain text OCR results, which didn't require much editing, are pretty accurate I think. But the subscripts etc and the equations which I copied essentially manually, are suspect. I've reviewed the resulting document quite carefully, several times finding mistakes in what I did each time. The last time there were five, four cosmetic and one fairly inconsequential. There are probably more. I would be very pleased to know about it if any reader of this finds some of them; jlukesh@deltanet.com.