TECH LINK

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Acquisition Technology Snapshots

Door Generator and Navigation System

Several PGS Ramform vessels now have paravanes (or "doors") equipped with generators to power navigation sensors. These navigation sensors, GPS receivers and acoustic ranging units, are used to enhance the streamer positioning in terms of accuracy and reliability (refer to **Figure 1**).

Relative positions for towed seismic streamers are established using magnetic compasses placed along each streamer, acoustic networks covering either part or all of the streamer spread, or a combination of these methods. Absolute coordinates for each receiver location can only be established using one of more precisely known reference positions, for example, GPS sensors on head or tail buoys. Traditionally, acoustic networks have been used to link the streamer fronts (the forwardmost point on each streamer) to the vessel. This objective, however, is complicated by the wake of the vessel, which is not an ideal environment for acoustic ranging. Wider streamer spreads mean longer ranges, which compounds the problem.

To overcome the difficulties described above, floats with surface and sub-surface navigation sensors have been towed between the streamer fronts, but this is logistically unattractive. An attractive alternative is to use the paravanes as platforms for the navigation equipment. Paravanes are used to maintain streamer separation, and represent the outermost component of any towed streamer spread. Vertical foils are kept in position by a float at the top (refer to **Figure 2**). The largest paravanes used in operation have foils with a height of 10 m, suspended below cylindrical floats more than 9 m in length. Tension in the "superwide" towing rope can exceed 20 tons.

Electrical power is necessary if navigation sensors are mounted on the paravanes, which presents a technology challenge. Access to the paravane for repair and maintenance is difficult, both alongside the vessel (refer to **Figure 3**) and under tow. A "2 x 100%" solution was designed in order to improve the redundancy of the system. In other words, it was decided that each paravane

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Summary

Two PGS technology innovations are described that are helping to improve the quality and efficiency of PGS towed streamer operations.

PGS has installed GPS receivers and acoustic ranging units on the paravanes of several Ramform vessels. The resultant benefit is improved streamer positioning accuracy. A solution to the associated power requirements has been the development of a unique generator technology that is mounted on each paravane.

On the source side, PGS has been developing an "air leak" model that provides an understanding of the physics of air leaks in air guns, and the associated effects upon source output. Threshold tables specific to each air gun in the air gun arrays can now be developed as a complement to traditional "drop out" tables used during towed streamer survey QC.

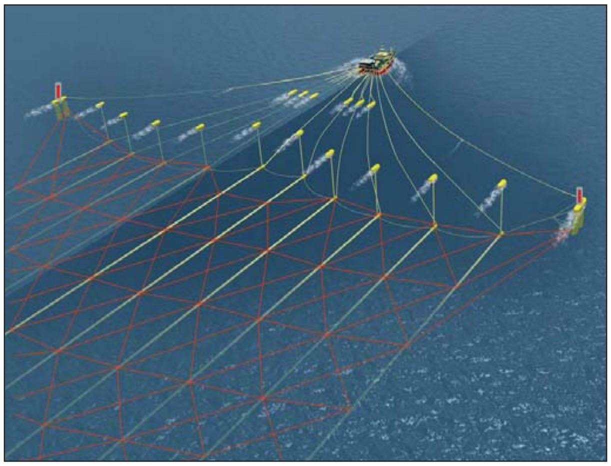

Figure 1: Schematic illustration of the full acoustic network deployed behind a PGS Ramform vessel.

Door Generator and Navigation System

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would be equipped with two generators and navigation sensor systems.

Unlike available off-the-shelf hydro-powered generators, the PGS paravane generators had to be custom-designed to deliver optimum performance at typical seismic towing speeds of 4 to 5 knots. This meant that the propeller's torque and RPM had to be tailored to match the characteristics of the gear and motor at these relatively slow speeds.

After the first prototype production generator was built, an in-sea tow testing delivered 210 Watts at 5 knots towing speed, which is typically 3-4 times more than off-the-shelf generators.

Figure 2: Baro48 paravane. Note the personnel.

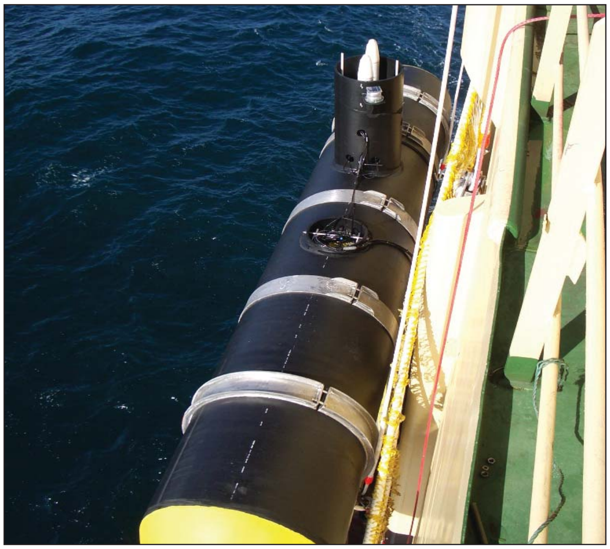

Figure 3: Baro45 paravane alongside a Ramform vessel.

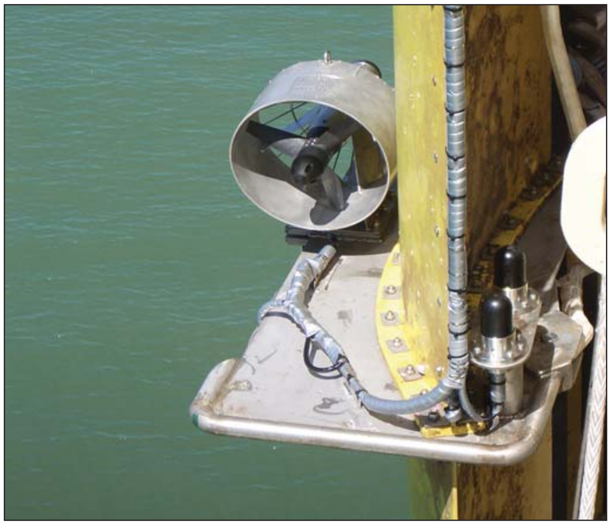

Figure 4: Baro48 paravane on a PGS Ramform vessel a generator and acoustic pingers mounted.

As reliability was an essential factor for the paravane generators, a 5 year design lifetime was established in the early development phase. The generator's motor is a brushless type with high lifetime expectancy, and the connected gear is ruggedly designed. In order to reduce the risk of water intrusion into the generator house, the torque from the propeller is transferred through a magnetic coupling. This approach allows the gear and motor to be hermetically sealed, and also separates the gear and motor (dry side) from the propeller (wet side), thus enabling easy replacement in the field of either side of the coupling (refer to **Figure 5**).

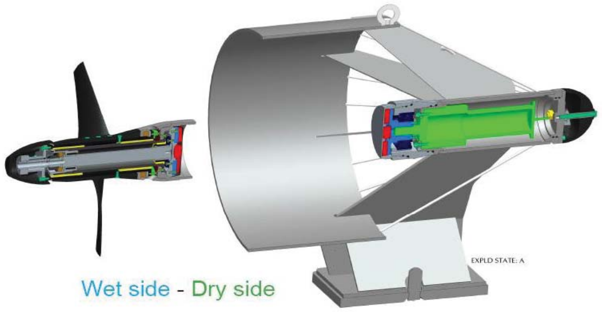

Figure 5: 3D schematic that illustrates a cross-section and the wet/dry sides of the PGS deflector generator.

The system's "combibox" is mounted in a recessed hole in the paravane's float. The unit contains the charging electronics for each generator, and lithium-ion batteries to increase the reliability of the 24 Volt DC output current. Each generator is coupled to a separate charger, and battery pack as part of the "2 x 100%" design philosophy.

The combibox contains a status surveillance system with a radio link to the mother vessel. The voltage from each generator, status for each battery pack, measured

Figure 6: PGS paravane generator combibox.

combibox operational temperature, and values from a water intrusion sensor is sent via radio every four seconds.

The navigation equipment installed is Seatrack RGPS pods and DigiRANGE acoustic units. There are two complete installations of these units on each paravane, in case one should fail. The two RGPS units are put in a small tower at the top of the float, as high as possible above the waterline. Conversely, depth below the water line is an advantage for the acoustic transducers (refer also to **Figure 4**). The zone between the paravane and the streamers is important, and will ideally be affected by minimal turbulence. Consequently, the transducers are placed on the inside of the aftmost (rear) foil, while the cans with the electronics necessary to trigger the acoustics, and the radio antennas all are placed together within the paravane float.

Overall, two fixed points at the front of the outer streamers provides an excellent baseline for the acoustic network. Experience shows that magnetic compasses are no longer required to help an acoustic network solution to converge, vessel heading is no longer relevant to the acoustic network, and time-consuming gyro calibrations can be skipped.

Geophysical Implications of Source Air Leaks

An analysis of PGS' marine operations reveals that air leaks from the seismic source continue to be a major component of total technical downtime. Air leaks can affect the source emission wavefield, so the current practice is to abort or scratch any sail lines in which an air leak occurs. Unfortunately, this practice is indiscriminate, and takes no account of the geophysical effects of any particular air leak. The ability to distinguish between destructive and insignificant air leaks could save many hours of unnecessary downtime each year. A sensitive air leak detection tool was developed some years ago, and is already in use across the PGS fleet. This tool has been very successful in detecting even very small leaks, and identifying their position in the source array. Experience with this system demonstrated that it was important to quantify air leak effects, and to develop acceptability thresholds for survey execution.

PGS has consequently had an on-going project to improve our understanding of air leaks. Two separate field tests at the PGS test barge facility in western Norway were conducted. A variety of different air leak scenarios were created, and then their effect upon the wavefield of a sub-array of air guns was measured. The ultimate aim was to develop an accurate air leak model by improved our understanding of the physics and nature of these events.

An air leak causes a stream of bubbles to rise from the leak position, forming an aerated plume of water, which stretches rearwards as the source is towed forwards (refer to **Figure 7**). This has a significant effect on the source signature in the near-field, and also affects the far-field

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Figure 7: Example of an air leak plume behind a sub-array of air guns being towed through the water..

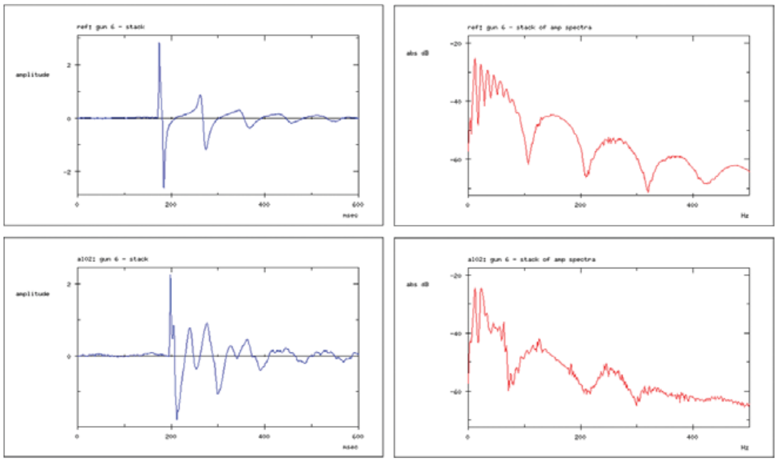

Figure 8: Effect of an air leak on the far-field signature of a single air gun, and its associated amplitude spectrum. Upper: No leak. Lower: With an air leak.

Shell criteria		
2x150	2x100	2x150
2x60	90	150 (+sp)
20	60	70
40	20	40
60	40	20
100 (+sp)	70	2x70
2x250	250 (+sp)	2x250
3090G - 2000psi - 6m dpth - 10m ss		

Figure 9: Air leak acceptability map for the 3090 in³ source array at 6 m depth. A red colour indicates that the air leak is unacceptable at that gun position.

Geophysical Implications of Source Air Leaks

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source signature in a very different way. In general, the guns immediately behind the leak are affected the most, so the position of the air leak in a full source array is a key parameter for determining the overall effect on the source wavefield. **Figure 8** shows an example of a far-field signature measurement and its associated amplitude spectrum for a single air gun in the absence of an air leak (top), and in the presence of an air leak (bottom).

An air leak produces a variety of physical effects on the source output. There is short period energy emission from the air leak bubbles themselves. The ghost notch in the amplitude spectrum of the overall air gun array is shifted to a lower frequency because of the increased travel time through the aerated water of the air leak plume. Also, the apparent magnitude of the ghost reflection is reduced, which can be attributed to absorption, scattering and multiple reflections in the air plume. In addition to these effects, the gun in the position of the air leak may show reduced output and a different bubble period because of reduced gun pressure in that position.

The next step in the PGS project was to create an air leak model for use in conjunction with the PGS Nucleus air gun modeling package to predict the effects of air leaks. A variety of the criteria commonly used to assess the geophysical effect of air gun "drop outs" upon the signature and spectrum were tested, resulting in a "traffic light" acceptability map that can be produced for any PGS air gun array and any attribute criteria to show the gun positions at which air leaks have an unacceptable effect. It was decided that a very conservative approach should be taken when producing such maps, and that they would be calculated for an extremely large air leak in each scenario. Thus, a high confidence can be placed upon the resultant thresholds. An example is given in **Figure 9**, based upon the 3090 in³ source array and the "Shell" criteria set (peak-to-bubble ratio > 15.00, average spectral deviation < 1.20 dB from ideal, and absolute maximum spectral deviation < 1.70 dB from ideal).

As observed in **Figure 9**, the acceptability map is a schematic of the three sub-arrays of the array, with gun sizes marked for each gun position. The sub-arrays are aligned in the vertical direction, with the front of the sub-array at the top of the plot. The PGS Nucleus package is being correspondingly enhanced to incorporate this new functionality.

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