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Schreder

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[54] **AUTOMOBILE NAVIGATION GUIDANCE, CONTROL AND SAFETY SYSTEM**

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[51] **Int. Cl.**[6] **G08G 1/123**

[52] **U.S. Cl.** **340/995**; 340/988; 364/449

[58] **Field of Search** 340/995, 990, 340/988, 905, 438, 439, 435, 903; 364/449, 436; 180/282

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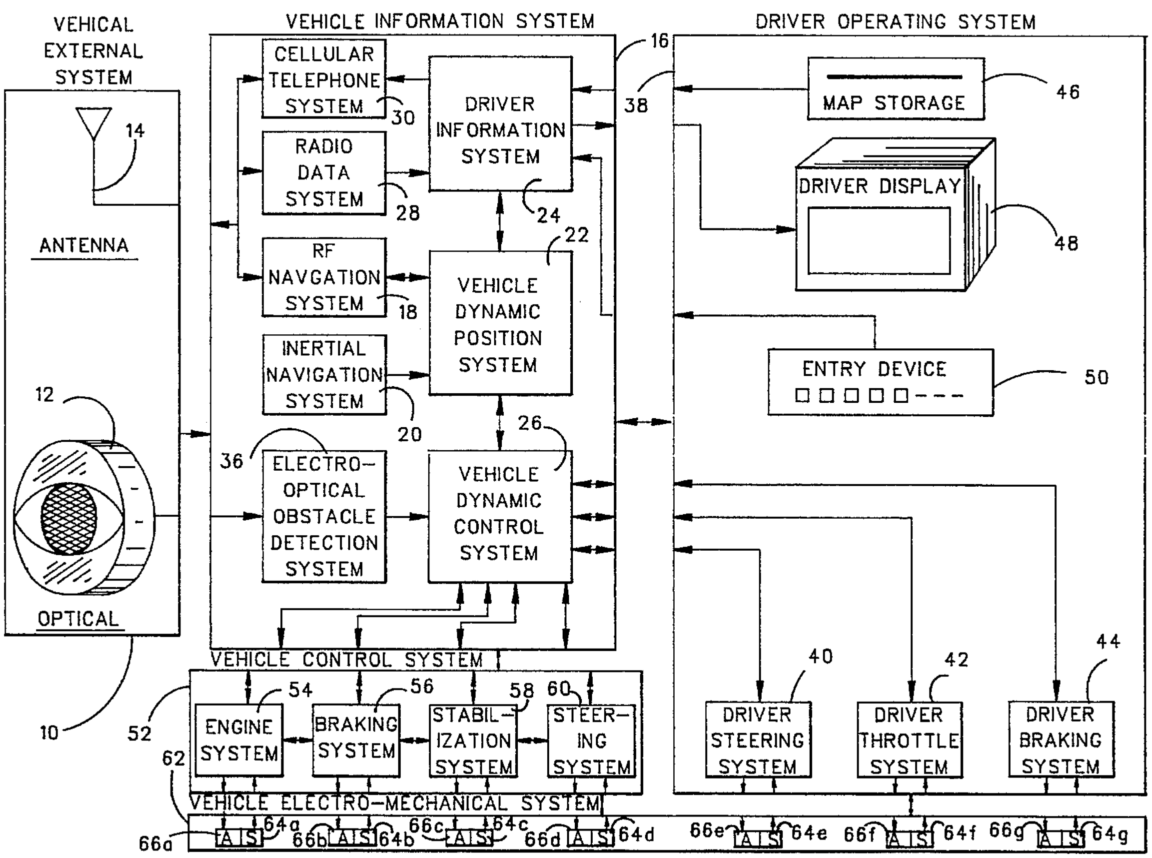
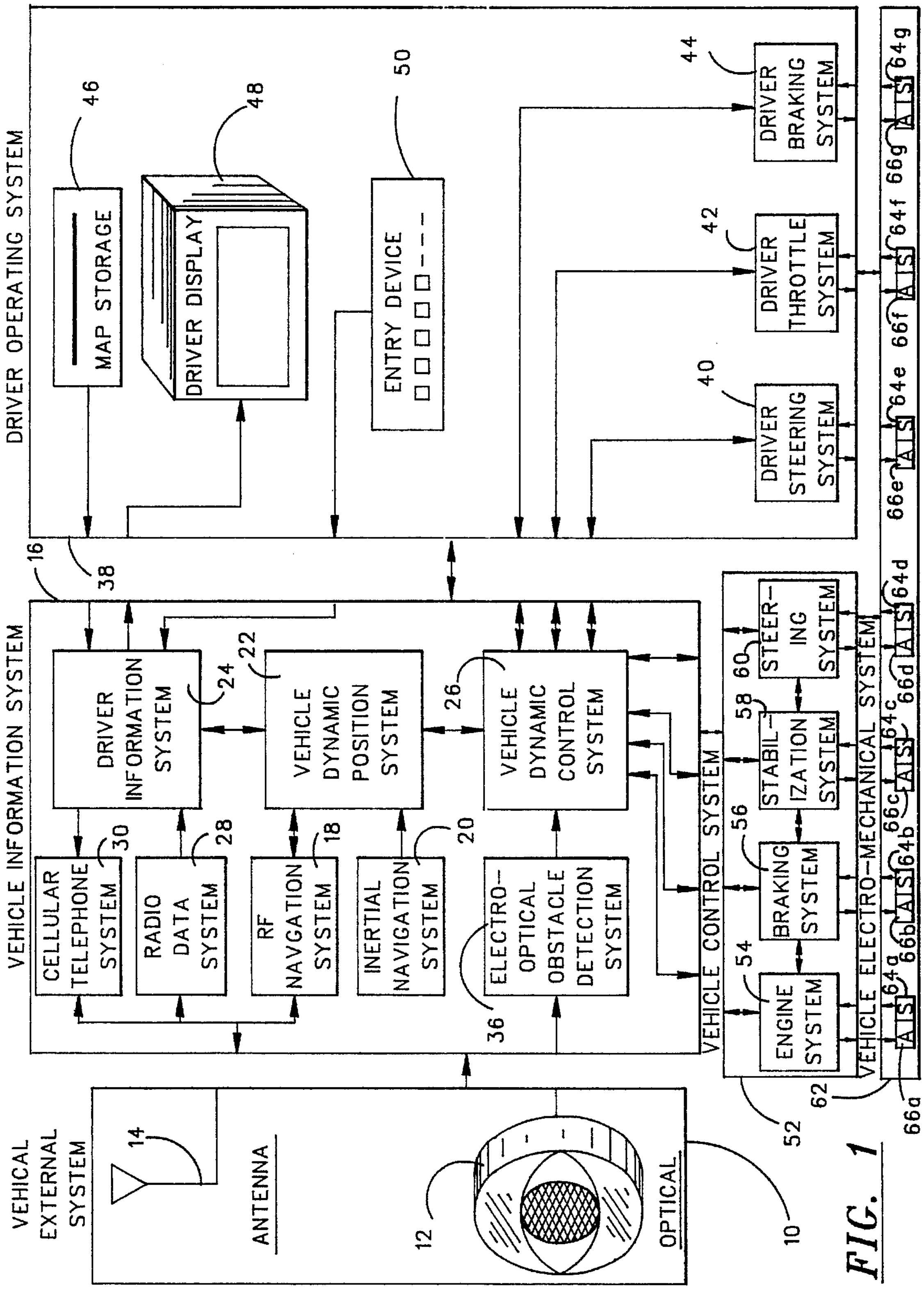
[57] **ABSTRACT**

An automobile is equipped with an inertial measuring unit, an RF GPS satellite navigation unit and a local area digitized street map system for precise electronic positioning and route guidance between departures and arrivals, is equipped with RF receivers to monitor updated traffic condition information for dynamic rerouting guidance with a resulting reduction in travel time, traffic congestion and pollution emissions, is also equipped with vehicular superceding controls substantially activated during unstable vehicular conditions sensed by the inertial measuring unit to improve the safe operation of the automobile so as to reduce vehicular accidents, and is further equipped with telecommunications through which emergency care providers are automatically notified of the precise location of the automobile in the case of an accident so as to improve the response time of road-side emergency care.

4 Claims, 2 Drawing Sheets




DRIVER OPERATING SYSTEM
MAP STORAGE
46
DRIVER DISPLAY
48
ENTRY DEVICE
50
DRIVER BRAKING SYSTEM
44
DRIVER THROTTLE SYSTEM
42
DRIVER STEERING SYSTEM
40
VEHICLE INFORMATION SYSTEM
16
38
DRIVER INFORMATION SYSTEM
24
VEHICLE DYNAMIC POSITION SYSTEM
22
VEHICLE DYNAMIC CONTROL SYSTEM
26
CELLULAR TELEPHONE SYSTEM
30
RADIO DATA SYSTEM
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RF NAVGATION SYSTEM
18
INERTIAL NAVIGATION SYSTEM
20
ELECTRO-OPTICAL OBSTACLE DETECTION SYSTEM
36
VEHICLE CONTROL SYSTEM
ENGINE SYSTEM
54
BRAKING SYSTEM
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STABIL-IZATION SYSTEM
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STEER-ING SYSTEM
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VEHICLE ELECTRO-MECHANICAL SYSTEM
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AIS
64a 64b 64c 64d 64e 64f 64g
66a 66b 66c 66d 66e 66f 66g
VEHICAL EXTERNAL SYSTEM
14
ANTENNA
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OPTICAL
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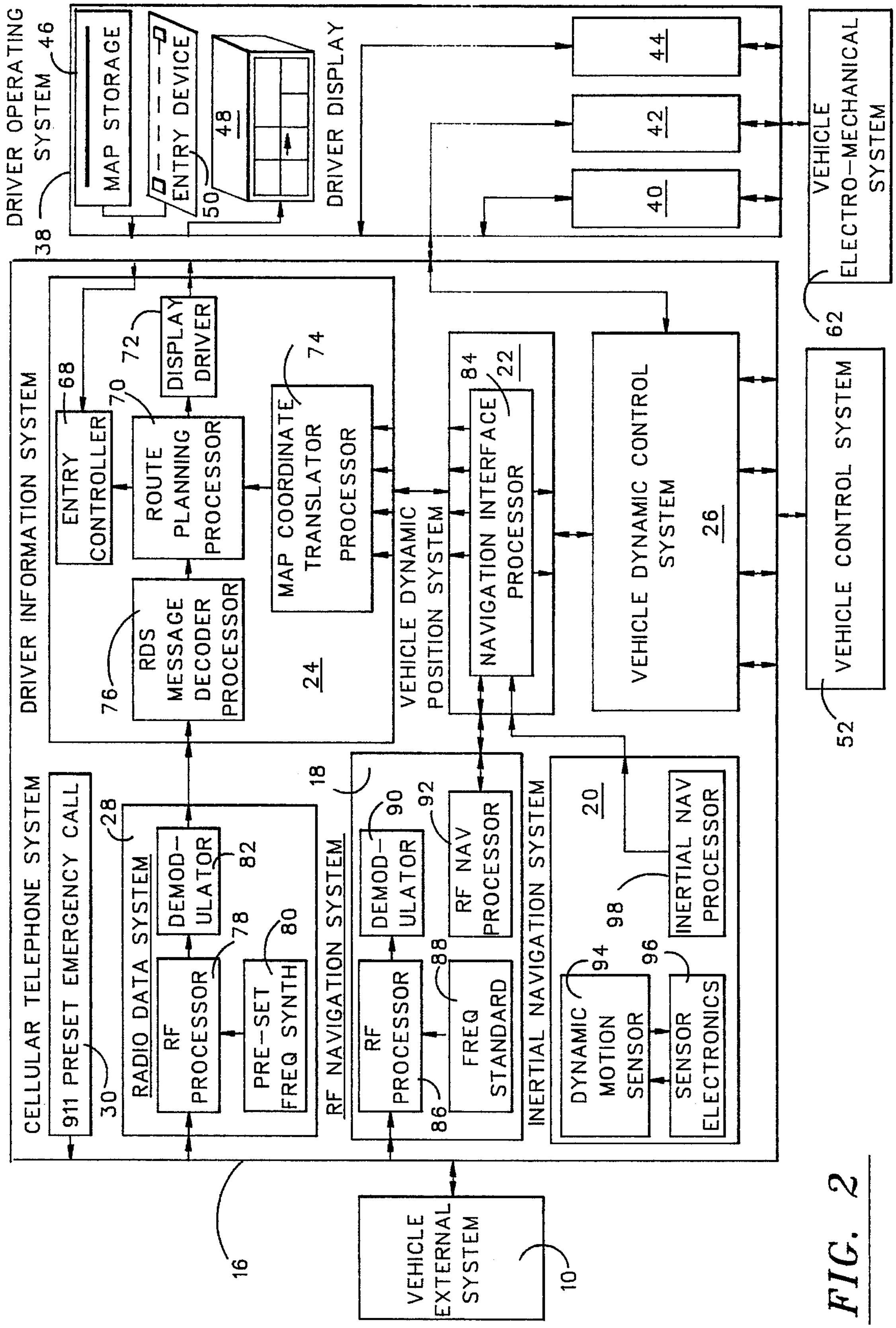
FIG. 1


DRIVER OPERATING SYSTEM
38
46
MAP STORAGE
ENTRY DEVICE
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40
VEHICLE ELECTRO-MECHANICAL SYSTEM
62
DRIVER INFORMATION SYSTEM
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ENTRY CONTROLLER
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DISPLAY DRIVER
ROUTE PLANNING PROCESSOR
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MAP COORDINATE TRANSLATOR PROCESSOR
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RDS MESSAGE DECODER PROCESSOR
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VEHICLE DYNAMIC POSITION SYSTEM
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NAVIGATION INTERFACE PROCESSOR
VEHICLE DYNAMIC CONTROL SYSTEM
26
VEHICLE CONTROL SYSTEM
52
CELLULAR TELEPHONE SYSTEM
911 PRESET EMERGENCY CALL
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28
RADIO DATA SYSTEM
DEMOD-ULATOR
82
78
80
RF PROCESSOR
PRE-SET FREQ SYNTH
18
RF NAVIGATION SYSTEM
90
92
DEMOD-ULATOR
RF NAV PROCESSOR
88
RF PROCESSOR
FREQ STANDARD
86
INERTIAL NAVIGATION SYSTEM
20
INERTIAL NAV PROCESSOR
98
94
96
DYNAMIC MOTION SENSOR
SENSOR ELECTRONICS
16
VEHICLE EXTERNAL SYSTEM
10

FIG. 2

AUTOMOBILE NAVIGATION GUIDANCE, CONTROL AND SAFETY SYSTEM

FIELD OF INVENTION

The present invention relates to inertial navigation, automobile control, three dimensional satellite positioning, vehicular traffic management, automobile telecommunications, automobile radio data systems, traffic monitoring systems, local area digitized traffic maps, route guidance systems, road side emergency care and pollution control. More specifically, the present invention relates to integrating, adapting and improving various technologies and methods to provide a comprehensive vehicular route guidance, control and safety system for reducing travel time, pollution emissions, traffic accidents and road side emergency care response time.

BACKGROUND OF THE INVENTION

Modern automobile travel has long been plagued by excessive traffic congestion and resulting air pollution from continually increasing automobile use. Drivers have long sought optimum travel routes to minimize drive time, and governmental agencies have sought to reduce air pollutants, as is well known. Local area radio and TV stations have transmitted "sig-alerts" to inform drivers of blocked or congested traffic routes so that drivers familiar with various routes to their respective destinations can alter enroute their planned route to minimize drive time which is often unproductive and represents an aggregate burden on society. Such "sig-alerts" disadvantageously require real-time receptions by the drivers prior to entering the congested traffic area. Such "sig-alerts" are often missed when drivers are not tuned into the transmitting station at the proper time. Moreover, drivers tend to learn and routinely follow the same route day after day without becoming familiar with alternate routes even in the face of heavy recurring congestion. Road side signs have also long been used to warn drivers and redirect traffic during road construction or traffic congestion. For example, posted detour signs and electronic road-side billboards have been used to suggest or require alternative routes. Some electronic billboards have been posted on main traffic arteries, warning of pending traffic blockage or congestion. However, these signs and billboards also suffer from being posted too near to the point of congestion or blockage preventing meaningful re-evaluation of the planned route and alteration of that route, primarily because of the required close proximal relationship between the sign location and the point of congestion or blockage. There exists a continuing need to improve the reception of accurate traffic congestion and alternative route information.

Local area radio and TV stations have broadcasted predicted pollution levels, that is, "smog alerts" with a view of altering driver use, such as increased car pooling or collective rapid transit use on days of expected high pollution levels, to minimize and reduce those levels. "Smog alerts" suffer from the same disadvantages as "sig-alerts" in that drivers may not be informed in time to take alternative actions. Moreover, the independent nature of human beings and their respective differing destinations tend to defeat an appropriate communal response to such "smog alerts". There also exists a need to continually reduce automobile travel time and the resulting environmental pollutants by optimizing the travel time or travel distance of vehicles between departure locations and arrival destinations.

Governmental agencies have provided emergency care services in response to road side vehicular accidents, as is well known. Governmental agencies have adopted the well known "911" emergency call method through which road accidents are reported and followed by the dispatching of emergency care services including police, fire and paramedic services using dedicated emergency RF radio systems. Such RF radio systems and methods often require the reporting of the accident by private citizens who are typically either witnesses to the accident or are involved in the accident. However, such systems and methods fail when such victims are incapacitated by injury, or when such witnesses are unable to quickly locate an operating phone especially in remote areas. Moreover, critical time is often lost when searching for a telephone to place the "911" call on a remote telephone. Further still, misinformation may be inadvertently given by those reporting victims and witnesses unfamiliar with the location of the accident thereby directing the emergency care provider to the wrong location. There exists a continuing need to more expeditiously provide accurate vehicular traffic accident information to emergency care providers.

Drivers have heretofore operated automobiles in their daily lives but nonetheless do at times operate their respective vehicles at excessive speeds or when exceeding other safe operating conditions resulting in accidents. Modern day automobiles have been adapted with increasingly sophisticated vehicular electronic controls including power steering, four-wheel steering, anti-lock braking, engine governing, automatic transmission, cruise control, and suspensions lifting controls. Additionally, modern automobiles have been increasingly adapted with electro-mechanical sensing and control using electronic processing, including the use of microprocessor based electronic systems. The increased sophistication of electronic vehicular sensing and control is well suited for microcomputer processing. The accuracy, sensitivity and operational speed of electronic controls are known to far exceed that of the human mind. There exists a continuing need to adapt and improve real-time vehicular dynamic motion and operating condition sensing and control for corrective vehicular control to maintain as best possible the automobile within safe operating limits. These adaptions and improvements are well suited for automatic processing capabilities of modern day micro-electronics.

Automobiles have also been adapted with experimental local area digitized road map systems which display a map portion of interest. The driver can locate departure and destination points on the map, and then visually follow the displayed map respecting the current position of the vehicle, as the driver travels toward the desired destination point. The map systems display a cursor to locate the current position of the moving vehicle on the displayed map. The portion of the map that is displayed is periodically adjusted to keep the current position cursor in the center of the displayed map portion. The map systems use a compass and a wheel sensor odometer to move the current position from one location to another as the vehicle travels on the road. The use of such map display systems requires the driver to repetitively study the map and then mentally and repetitively determine and select travel routes diverting attention away from the safe operation of the vehicle. The display of the digitized map with a current position cursor tends to increase traffic accidents, rather than promote safe operation. Also, the compass and wheel odometer technology causes map position error drifts over distance, requiring recalibration after traveling only a few miles. Moreover, the use of such map systems disadvantageously requires the entry of the departure point each time the driver begins a new route.

Additionally, the digitized map systems do not perform route guidance indicating a route through which the driver should take to reach a particular destination point. The digitized map systems are not dynamically updated with current traffic information, such as detours for road construction, blocked routes due to accidents, and delayed travel times due to heavy traffic congestion. Furthermore, such map systems do not provide route guidance based upon varying requirements, such as, least route time, least travel distance, cost-effective least traffic stops and turns, nor a combination thereof, nor based upon dynamic updated current traffic conditions. There exists a continuing need to improve digitized map systems with a driver friendly interface which reduces diversion away from the safe attentive operation of the vehicle to promote accident free dynamic route guidance vehicular operation.

While the aforementioned "sig-alerts", "smog-alerts", "911", detour signs, electronic billboard and digitized map systems and methods have had some success, there exists a wide range of technologies that have disadvantageously not been applied in a comprehensive integrated manner to significantly improve route guidance, reduce pollution, improve vehicular control and increase safety associated with the common automobile experience. For example, it is known that gyro based inertial navigation systems have been used to generate three-dimensional position information, including exceedingly accurate acceleration and velocity information over a relatively short travel distance, and that GPS satellite positioning systems can provide three-dimensional vehicular positioning and epoch timing, with the inertial system being activated when satellite antenna reception is blocked during "drop out" for continuous precise positioning. It is also known that digitized terrain maps can be electronically correlated to current vehicular transient positions, as have been applied to military styled transports and weapons. For another example, it is also known that digitally encoded information is well suited to RF radio transmission within specific transmission carrier bands, and that automobiles have been adapted to received AM radio, FM radio, and cellular telecommunication RF transmissions. For yet another example, it is further known that automobile electronic processing has been adapted to automatically control braking, steering, suspension and engine operation, for example, anti-lock braking, four-wheel directional steering, dynamic suspension stiffening during turns and high speed, engine governors limiting vehicular speed, and cruise control for maintaining a desired velocity. For still another example, traffic monitors, such as road embedded magnetic traffic light sensor loops and road surface traffic flow meters have been used to detect traffic flow conditions. While these sensors, meters, elements, systems and controls have served limited specific purposes, the prior art has disadvantageously failed to integrate them in a comprehensive fashion to provide a complete dynamic route guidance, dynamic vehicular control, and safety improvement system.

Recently, certain experimental integrated vehicular dynamic guidance systems have been proposed. Motorola has disclosed an Intelligent Vehicle Highway System in block diagram form in copyright dated 1993 brochure. Delco Electronics has disclosed another Intelligent Vehicle Highway System also in block diagram form in Automotive News published on Apr. 12 1993. These systems use compass technology for vehicular positioning. However, displacement wheel sensors are plagued by tire slippage, tire wear and are relatively inaccurate requiring recalibration of the current position. Compasses are inexpensive, but suffer from drifting particularly when driving on a straight road for extended periods. Compasses can sense turns, and the system may then be automatically recalibrated to the current position based upon sensing a turn and correlating that turn to the nearest turn on a digitized map, but such recalibration is still prone to errors during excessive drifts. Moreover, digitized map systems with the compass and wheel sensor positioning methods operate in two dimensions on a three-dimensional road terrain injecting further errors between the digitized map position and the current vehicular position due to a failure to sense distance traveled in the vertical dimension.

These Intelligent Vehicle Highway Systems appear to use GPS satellite reception to enhance vehicular tracking on digitized road maps as part of a guidance and control system. These systems use GPS to determine when drift errors become excessive and to indicate that recalibration is necessary. However, the GPS reception is not used for automatic accurate recalibration of current vehicular positioning, even though C-MIGITS and like devices have been used for GPS positioning, inertial sensing and epoch time monitoring, which can provide accurate continuous positioning.

These Intelligent Vehicle Highway Systems use the compass and wheel sensors for vehicular positioning for route guidance, but do not use accurate GPS and inertial route navigation and guidance and do not use inertial measuring units for dynamic vehicular control. Even though dynamic electronic vehicular control, for example, anti-lock braking, anti-skid steering, and electronic control suspension have been contemplated by others, these systems do not appear to functionally integrate these dynamic controls with an accurate inertial route guidance system having an inertial measuring unit well suited for dynamic motion sensing. There exists a need to further integrate and improve these guidance systems with dynamic vehicular control and with improved navigation in a more comprehensive system.

These Intelligent Vehicle Highway Systems also use RF receivers to receive dynamic road condition information for dynamic route guidance, and contemplate infrastructure traffic monitoring, for example, a network for road magnetic sensing loops, and contemplate the RF broadcasting of dynamic traffic conditions for dynamic route guidance. The disclosed two-way RF communication through the use of a transceiver suggests a dedicated two-way RF radio data system. While two-way RF communication is possible, the flow of necessary information between the vehicles and central system appears to be exceedingly lopsided. The flow of information from the vehicles to a central traffic radio data control system may be far less than the required information from traffic radio data control system to the vehicles. It seems that the amount of broadcasted dynamic traffic flow information to the vehicles would be far greater than the information transmitted from the vehicles to the central traffic control center. For example, road side incident or accident emergency messages to a central system may occur far less than the occurrences of congested traffic points on a digitized map having a large number of road coordinate points.

Conserving bandwidth capacity is an objective of RF communication systems. The utilization of existing infrastructure telecommunications would seem cost-effective. AT&T has recently suggested improving the existing cellular communication network with high speed digital cellular communication capabilities. This would enable the use of cellular telecommunications for the purpose of transmitting digital information encoding the location of vehicular incidents and accidents. It then appears that a vehicular radio data system would be cost-effectively used for unidirectional

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