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Hoffberg

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(54) **MOBILE COMMUNICATION DEVICE**

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(60) Provisional application No. 60/072,757, filed on Jan. 27, 1998.

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(52) **U.S. Cl.** **340/905**; 340/995.1; 340/539.17; 340/995.13; 370/351; 701/117; 701/119
(58) **Field of Search** 340/995.1, 995.13, 340/905, 825.22, 539.17; 701/117, 119; 380/271; 370/351

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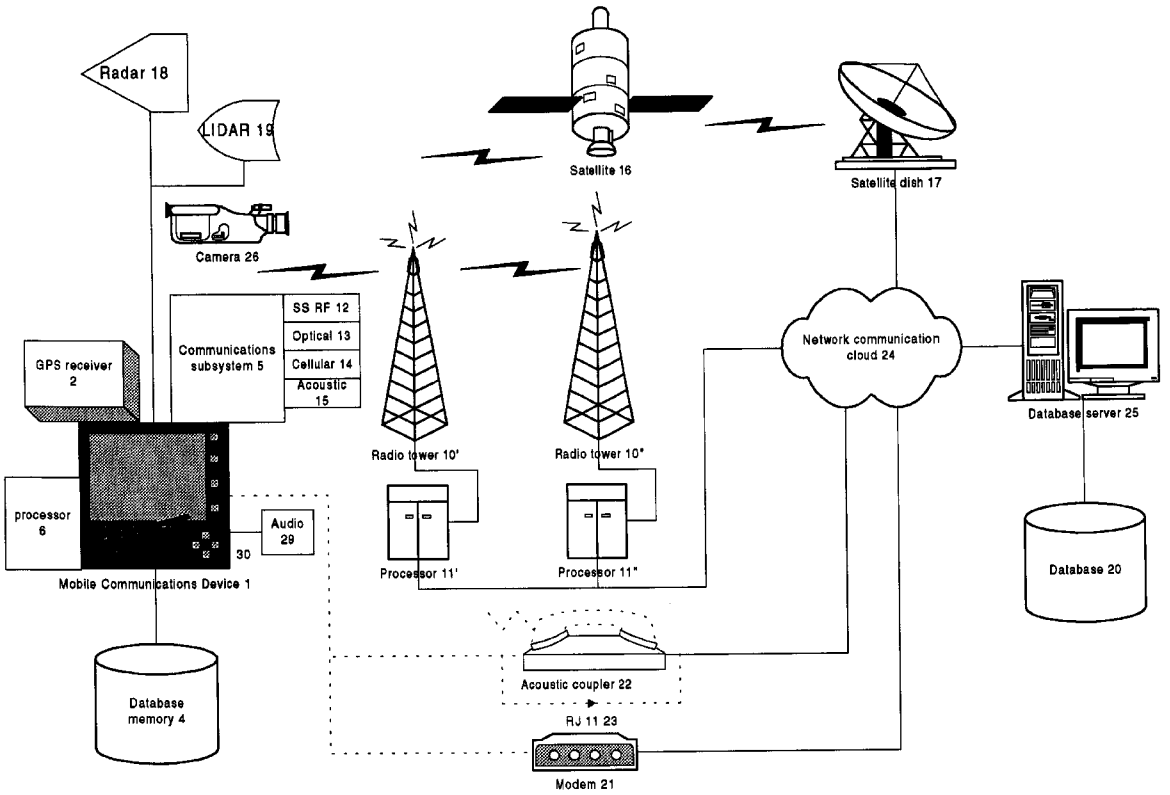
(57) **ABSTRACT**

A mobile communications device comprising a location sensing system, producing a location output; a memory, storing a set of locations and associated events; a telecommunications device, communicating event and location information between a remote system and said memory; and a processor, processing said location output in conjunction with said stored locations and associated events in said memory, to determine a priority thereof.

16 Claims, 2 Drawing Sheets



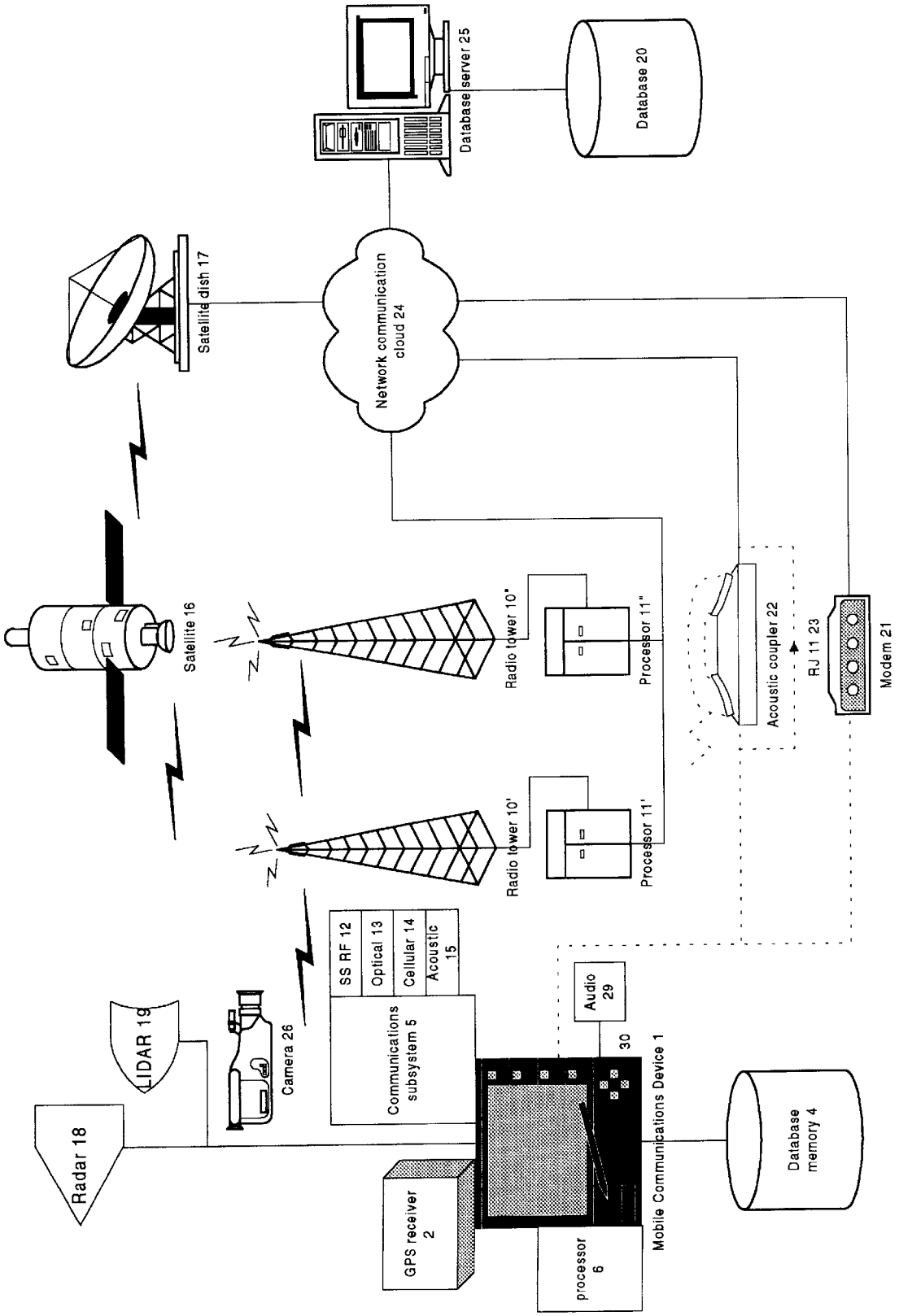

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Fig. 1

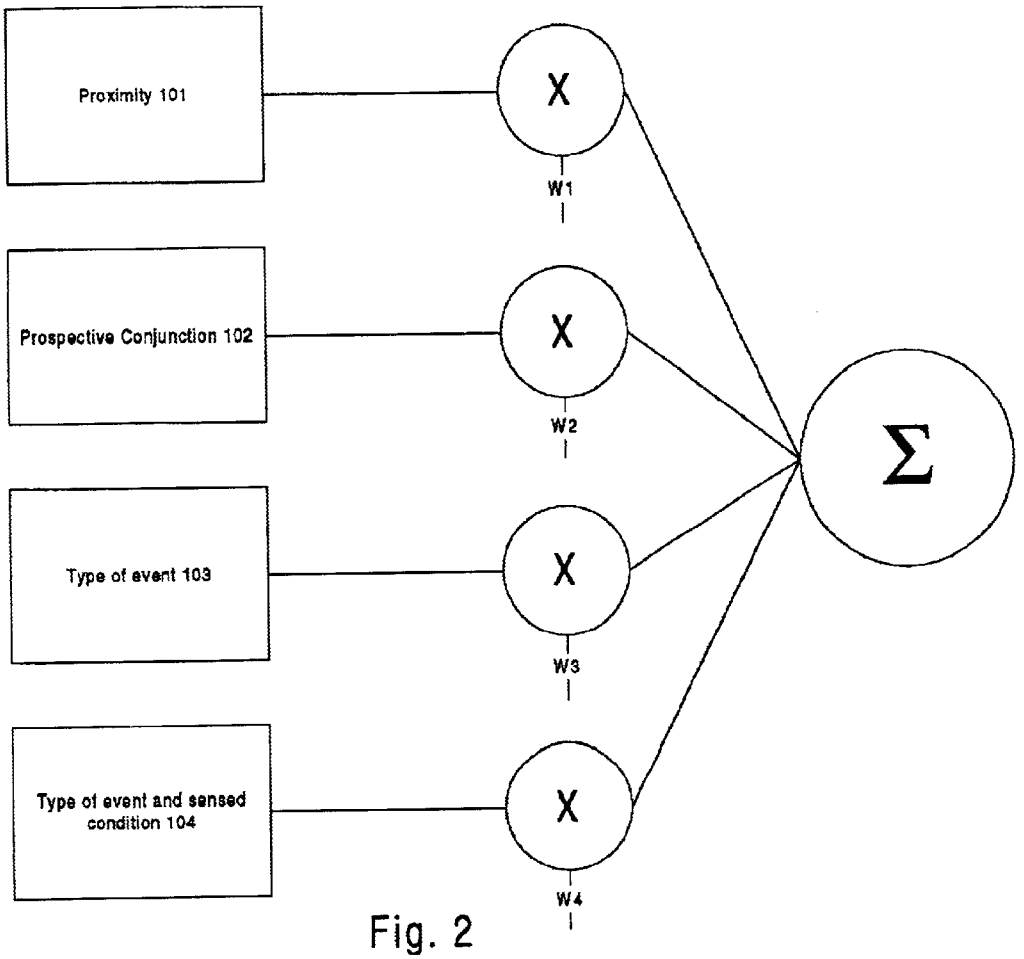
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Fig. 2

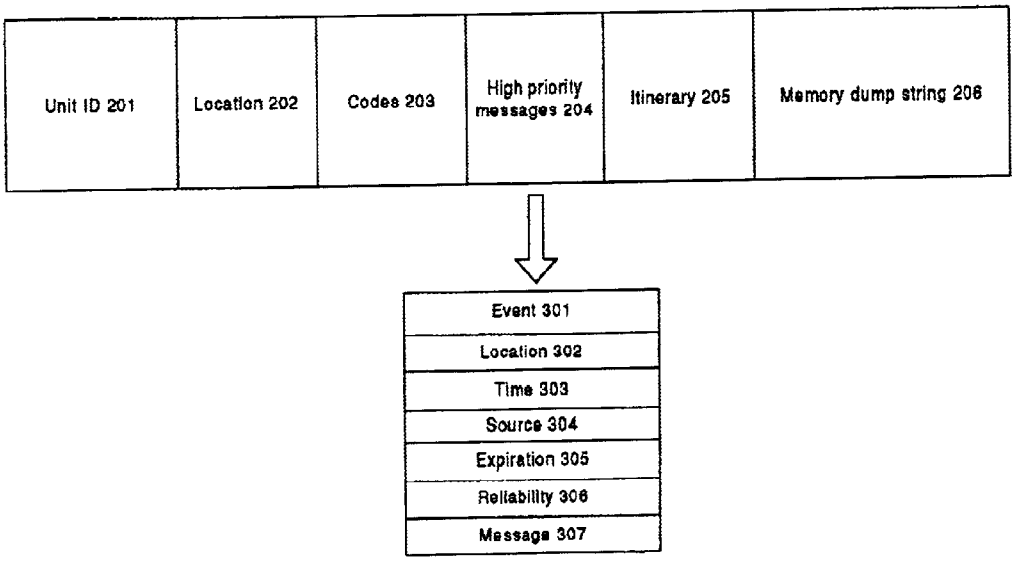
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Fig. 3

MOBILE COMMUNICATION DEVICE

This application is a continuation of U.S. patent application Ser. No. 09/236,184, filed Jan. 25, 1999, now issued as U.S. Pat. No. 6,252,544 on Jun. 26, 2001, which claimed benefit of priority from U.S. Provisional Patent Application No. 60/072,757, filed Jan. 27, 1998.

FIELD OF THE INVENTION

The present invention relates to the field of communications devices, and more particularly to mobile telecommunications devices having position detection and event storage memory.

BACKGROUND OF THE INVENTION

A number of devices are known which provide mobile telecommunication capabilities. Further, known position detection systems employ the known Global Positioning System (GPS), Global Orbiting Navigational System (GLONASS), Loran, RF triangulation, inertial frame reference and Cellular Telephone base site, e.g., time difference of arrival (TDOA) or nearest antenna proximity systems. Known GPS mobile systems include memory to record location, time and event type, and some systems may be integrated with global information systems, to track path, speed, etc. Known Differential GPS (DGPS) systems include mobile telecommunication functionality to communicate between distant units, typically to allow very precise relative position measurements, in the presence of substantial absolute position errors, or to calibrate the position of a mobile transceiver based on a relative position with respect to a fixed transceiver having a known location. These systems do not typically intercommunicate event information between units. Thus, the communications streams relate to position information only. However, known weather balloon transceiver systems, for example, do transmit both position and weather information to a base station.

Many electronic location determination systems are available, or have been proposed, to provide location information to a user equipped with a location determination receiver. Ground-based location determination systems, such as Loran, Omega, TACAN, Decca, U.S. Airforce Joint Tactical Information Distribution System (JTIDS Relnav), or U.S. Army Position Location and Reporting System (PLRS), use the intersection of hyperbolic surfaces to provide location information. A representative ground system is LORAN-C discussed in LORAN-C User Handbook, Department of Transportation, U.S. Coast Guard, Commandant Instruction M16562.3, May 1990, which is incorporated by reference herein. LORAN-C provides a typical location accuracy of approximately 400 meters. A limitation of a LORAN-C location determination system is that not all locations in the northern hemisphere, and no locations in the southern hemisphere, are covered by LORAN-C. A second limitation of LORAN-C is that the typical accuracy of approximately 400 meters is insufficient for many applications. A third limitation of LORAN-C is that weather, local electronic signal interference, poor crossing angles, closely spaced time difference hyperbolas, and skywaves (multipath interference) frequently cause the accuracy to be significantly worse than 400 meters.

Other ground-based location determination devices use systems that were developed primarily for communications, such as cellular telephone, FM broadcast, and AM broadcast. Some cellular telephone systems provide estimates of location, using comparison of signal strengths from three or more sources. FM broadcast systems having subcarrier signals can provide estimates of location by measuring the phases of the subcarrier signals. Kelley et al. in U.S. Pat. No. 5,173,710 disclose a system that allows determination of a location of a vehicle. FM subcarrier signals are received from three FM radio stations with known locations but unknown relative phases by signal processors at the vehicle as well as at a fixed station having a known location. The fixed station processor determines the relative phase of the signals transmitted by the three FM radio stations and transmits the relative phase information to the vehicle. The vehicle processor determines its location from the FM subcarrier signal phases and from the relative phase information it receives. A limitation of cellular systems and FM subcarrier systems for location determination is that they are limited to small regions, with diameters of the order of 20–50 km.

Satellite-based location determination systems such as GPS and GLONASS, use the intersection of spherical surface areas to provide location information with a typical (selective availability) accuracy of 100 meters, anywhere on or near the surface of the earth. These systems may also be used to obtain positional accuracies within 1 centimeter. The satellite-based location determination systems include satellites having signal transmitters to broadcast location information and control stations on earth to track and control the satellites. Location determination receivers process the signals transmitted from the satellites and provide location information to the user.

The Global Positioning System (GPS) is part of a satellite navigation system developed by the United States Defense Department under its NAVSTAR satellite program. A fully operational GPS includes up to 24 satellites approximately uniformly dispersed around six circular orbits with four satellites each, the orbits being inclined at an angle of 55°, relative to the equator, and being separated from each other by multiples of 60° longitude. The orbits have radii of 26,560 kilometers and are approximately circular. The orbits are non-geosynchronous, with 0.5 sidereal day (11.967 hours) orbital time intervals, so that the satellites move with time, relative to the Earth below. Theoretically, four or more GPS satellites will have line of sight to most points on the Earth's surface, and line of sight access to three or more such satellites can be used to determine an observer's position anywhere on the Earth's surface, 24 hours per day. Each satellite carries a cesium or rubidium atomic clock to provide timing information for the signals transmitted by the satellites. Internal clock correction is provided for each satellite clock.

A second configuration for global positioning is GLONASS, placed in orbit by the former Soviet Union and now maintained by the Russian Republic. GLONASS also uses 24 satellites, distributed approximately uniformly in three orbital planes of eight satellites each. Each orbital plane has a nominal inclination of 64.8° relative to the equator, and the three orbital planes are separated from each other by multiples of 120° longitude. The GLONASS circular orbits have smaller radii, about 25,510 kilometers, and a satellite period of revolution of 8/17 of a sidereal day (11.26 hours). A GLONASS satellite and a GPS satellite will thus complete 17 and 16 revolutions, respectively, around the Earth every 8 sidereal days. The signal frequencies of both GPS and GLONASS are in L-band (1 to 2 GHz).

Because the signals from the satellites pass through the troposphere for only a short distance, the accuracy of satellite location determination systems such as GPS or GLONASS is largely unaffected by weather or local anoma-

lies. A limitation of GLONASS is that it is not clear that the Russian Republic has the resources to complete and to maintain the system for full world wide 24 hour coverage.

The inherent accuracy of the GPS position measured by a commercial GPS receiver is approximately 20 meters. However, the United States Government currently intentionally degrades the accuracy of GPS computed positions for commercial users with Selective Availability, SA. With SA, the GPS position accuracy of a commercial GPS receiver is approximately 100 meters. However, higher accuracy is available with the use of secret decryption codes.

Differential Global Positioning System, DGPS, is a technique for enhancing the accuracy of the GPS position, and of course may be applied to GLONASS as well. The DGPS comprises the Global Positioning System together with a GPS reference station receiver situated at a known position. DGPS error correction information is derived by taking the difference between the measurements made by the GPS reference station and the expected measurement at the known position of the reference station. DGPS error correction information can be in the form of GPS satellite pseudorange offsets or GPS position offsets. If GPS position offsets are used, the GPS satellites used in the calculation of the GPS position must be included as part of the DGPS error correction information. A processor in a "differential-ready" GPS receiver applies the DGPS error correction information to enhance the GPS position to an accuracy in the range of 10 meters to a less than one meter.

Two types of DGPS exist, postprocessed and realtime. In postprocessed systems, the DGPS error correction information and a user's GPS position information are processed after the user has completed his data acquisition. In realtime systems, the DGPS error correction information is transmitted to the GPS user in a DGPS telemetry stream, e.g., a radio wave signal, and processed by a differential-ready GPS receiver as the application progresses. Realtime processing is desirable for many applications because the enhanced accuracy of DGPS is available to the GPS user while in the field. Realtime broadcast of DGPS error correction information is available from many sources, both public and private, including Coast Guard RDF beacon and commercially operated FM broadcast subcarriers. A DGPS radio wave receiver is required to receive the DGPS radio wave signal containing the DGPS error correction information, and pass the DGPS error corrections to the differential-ready GPS receiver.

Many applications of GPS including mineral surveying, mapping, adding attributes or features to maps, finding sites on a map, vehicle navigation, airplane navigation, marine navigation, field asset management, geographical information systems, and others require the enhanced accuracy that is available with DGPS. For instance, a 20 to 100 meter error could lead to unintentional trespassing, make the return to an underground asset difficult, or put a user on the wrong block while walking or driving in a city. These applications require a computer to store and process data, retain databases, perform calculations, display information to a user, and take input from a user entry. For instance, the user may need to store a map database, display a map, add attributes to features on the map, and store these attributes for geographical information. The user may also need to store and display locations or calculate range and bearing to another location.

GPS is typically used by many professionals engaged in navigation and surveying fields such as marine navigation, aircraft piloting, seismology, boundary surveying, and other applications where accurate location is required or where the cost of GPS is small compared to the cost of a mistake in determining location. Some mobile professionals in the utilities, insurance, ranching, prospecting, ambulance driving, trucking, delivery, police, fire, real estate, forestry, and other mobile applications use GPS to save time in their work. GPS is also used for personal travel such as hiking, biking, horseback riding, yachting, fishing, driving in personal cars, and other travel activities. To enhance the usefulness of GPS a number of sources have integrated maps into the output, or provide a global information system (GIS) to process the GPS output. Thus, it is known to sort and display proximate map features and/or attributes in the same coordinate system as the position information.

As disclosed in U.S. Pat. No. 5,528,248, incorporated herein by reference, a satellite location determination system using Global Positioning System (GPS) satellite signal transmitters receives a spread spectrum L1 carrier signal having a frequency=1575.42 MHz. The L1 signal from each satellite signal transmitter is binary phase shift key (BPSK) modulated by a Coarse/Acquisition (C/A) pseudo-random noise (PRN) code having a clock or chip rate of f**0**=1.023 MHz. Location information is transmitted at a rate of 50 baud. The PRN codes allow use of a plurality of GPS satellite signal transmitters for determining an observer's position and for providing location information. A signal transmitted by a particular GPS satellite is selected by generating and correlating the PRN code for that particular satellite signal transmitter with a GPS signal received from that satellite. All C/A PRN codes used for GPS satellite signals are known and are stored and/or generated in a GPS receiver. A bit stream from the GPS satellite signal transmitter includes an ephemeris location of the GPS satellite signal transmitter, an almanac location for all GPS satellites, and correction parameters for ionospheric signal propagation delay, and clock time of the GPS satellite signal transmitter. Accepted methods for generating the C/A-code are set forth in the document GPS Interface Control Document ICD-GPS-200, published by Rockwell International Corporation, Satellite Systems Division, Revision A, 26 Sep. 1984, which is incorporated by reference herein.

Energy on a single carrier frequency from all of the satellites is transduced by the receiver at a point close to Earth. The satellites from which the energy originated are identified by modulating the carrier transmitted from each satellite with pseudorandom type signals. In one mode, referred to as the coarse/acquisition (C/A) mode, the pseudorandom signal is a gold code sequence having a chip rate of 1.023 MHz; there are 1,023 chips in each gold code sequence, such that the sequence is repeated once every millisecond (the chipping rate of a pseudorandom sequence is the rate at which the individual pulses in the sequence are derived and therefore is equal to the code repetition rate divided by the number of members in the code; one pulse of the noise code is referred to as a chip).

The 1.023 MHz gold code sequence chip rate enables the position of the receiver responsive to the signals transmitted from four of the satellites to be determined to an accuracy of approximately 60 to 300 meters.

There is a second mode, referred to as the precise or protected (P) mode, wherein pseudorandom codes with chip rates of 10.23 MHz are transmitted with sequences that are extremely long, so that the sequences repeat no more than once per week. In the P mode, the position of the receiver can be determined to an accuracy of approximately 16 to 30 meters. However, the P mode requires Government classified information about how the receiver is programmed and is intended for use only by authorized receivers. Hence,

civilian and/or military receivers that are apt to be obtained by unauthorized users are not responsive to the P mode.

To enable the receivers to separate the C/A signals received from the different satellites, the receiver includes a plurality of different locally derived gold code sources, each of which corresponds with the gold code sequence transmitted from one of the satellites in the field of the receiver. The locally derived and the transmitted gold code sequences are cross correlated with each other over one millisecond, gold code sequence intervals. The phase of the locally derived gold code sequences vary on a chip-by-chip basis, and then within a chip, until the maximum cross correlation function is obtained. Since the cross correlation for two gold code sequences having a length of 1,023 bits is approximately 16 times as great as the cross correlation function of any of the other combinations of gold code sequences, it is relatively easy to lock the locally derived gold code sequence onto the same gold code sequence that was transmitted by one of the satellites.

The gold code sequences from at least four of the satellites in the field of view of the receiver are separated in this manner by using a single channel that is sequentially responsive to each of the locally derived gold code sequences or by using parallel channels that are simultaneously responsive to the different gold code sequences. After four locally derived gold code sequences are locked in phase with the gold code sequences received from four satellites in the field of view of the receiver, the position of the receiver can be determined to an accuracy of approximately 60 to 300 meters.

The approximately 60 to 300 meter accuracy of GPS is determined by (1) the number of satellites transmitting signals to which the receiver is effectively responsive, (2) the variable amplitudes of the received signals, and (3) the magnitude of the cross correlation peaks between the received signals from the different satellites.

In response to reception of multiple pseudorange noise (PRN) signals, there is a common time interval for some of the codes to likely cause a degradation in time of arrival measurements of each received PRN due to the cross correlations between the received signals. The time of arrival measurement for each PRN is made by determining the time of a peak amplitude of the cross correlation between the received composite signal and a local gold code sequence that is identical to one of the transmitted PRN. When random noise is superimposed on a received PRN, increasing the averaging time of the cross correlation between the signal and a local PRN sequence decreases the average noise contribution to the time of arrival error. However, because the cross correlation errors between the received PRN's are periodic, increasing the averaging time increases both signal and the cross correlation value between the received PRN's alike and time of arrival errors are not reduced.

The GPS receiver may incorporate a Kalman filter, which is adaptive and therefore automatically modifies its threshold of acceptable data perturbations, depending on the velocity of the vehicle (GPS antenna). This optimizes system response and accuracy of the GPS system. Generally, when the vehicle increases velocity by a specified amount, the GPS Kalman filter will raise its acceptable noise threshold. Similarly, when the vehicle decreases its velocity by a specified amount, the GPS Kalman filter will lower its acceptable noise threshold.

Extremely accurate GPS receivers depend on phase measurements of the radio carriers that they receive from various orbiting GPS satellites. Less accurate GPS receivers simply develop the pseudoranges to each visible satellite based on the time codes being sent. Within the granularity of a single time code, the carrier phase can be measured and used to compute range distance as a multiple of the fundamental carrier wavelength. GPS signal transmissions are on two synchronous, but separate, carrier frequencies "L1" and "L2", with wavelengths of nineteen and twenty-four centimeters, respectively. Thus within nineteen or twenty-four centimeters, the phase of the GPS carrier signal will change 360° (2 π radians). However, the number of whole cycle (360°) carrier phase shifts between a particular GPS satellite and the GPS receiver must be resolved. At the receiver, every cycle will appear essentially the same, over a short time frame. Therefore there is an "integer ambiguity" in the calculation. The resolution of this integer ambiguity is therefore a calculation-intensive arithmetic problem to be solved by GPS receivers. The traditional approaches to such integer ambiguity resolution have prevented on-the-fly solution measurement updates for moving GPS receivers with centimeter accurate outputs. Very often, such highly accurate GPS receivers have required long periods of motionlessness to produce a first and subsequent position fix.

There are numerous prior art methods for resolving integer ambiguities. These include integer searches, multiple antennas, multiple GPS observables, motion-based approaches, and external aiding. Search techniques often require significant computation time and are vulnerable to erroneous solutions or when only a few satellites are visible. More antennas can improve reliability considerably. If carried to an extreme, a phased array of antennas results, whereby the integers are completely unambiguous and searching is unnecessary. But for economy, reduced size, complexity and power consumption, the minimum number of antennas required to quickly and unambiguously resolve the integers, even in the presence of noise, is preferred.

One method for integer resolution is to make use of the other observables that modulate a GPS timer. The pseudorandom code imposed on the GPS satellite transmission can be used as a coarse indicator of differential range, although it is very susceptible to multipath problems. Differentiating the L1 and L2 carriers in phase sensitive manner provides a longer effective wavelength, and reduces the search space, i.e., an ambiguity distance increased from 19 or 24 centimeters to about 456 centimeters. However, dual frequency receivers are expensive because they are more complicated. Motion-based integer resolution methods make use of additional information provided by platform or satellite motion. But such motion may not always be present when it is needed. Another prior art technique for precision attitude determination and kinematic positioning is described by Hatch, in U.S. Pat. No. 4,963,889, incorporated herein by reference, which employs two spaced antennas, moveable with respect to each other. Knight, U.S. Pat. No. 5,296,861, incorporated herein by reference, provides a method of reducing the mathematical intensity of integer ambiguity resolution. See also, U.S. Pat. No. 5,471,218, incorporated herein by reference.

Direct range measurements, combined with the satellite geometry, may also allow the correct integer carrier phase ambiguities to be determined for a plurality of satellites tracked at two or more sites. The use of additional sensors, such as a laser level, electronic distance meter, a compass, a tape, etc., provide valuable constraints that limit the number of possible integer ambiguities that need to be considered in a search for the correct set.

Many systems using handheld computers, having software and databases defining maps and running standard

operating systems, have been coupled to GPS Smart Antennas. Wireless, infrared, serial, parallel, and PCMCIA interfaces have been used to interconnect the handheld computer and the GPS Smart Antenna. Differential-ready GPS Smart Antennas having an input to receive signals representative of DGPS error corrections are also commercially available. Further, GPS receivers and Differential-ready GPS Smart Antennas which are self contained, built onto a type II PCMCIA card (PC Card), and/or having serial data communications ports (RS-232 or RS-422) are commercially available. See, U.S. Pat. No. 5,276,451, and U.S. Pat. No. 5,210,540, assigned to Pioneer Electronic Corporation.

There are several different types of vehicle navigational systems. The first system makes use of stored map displays wherein the maps of a predetermined area are stored in the in-vehicle computer and displayed to the vehicle operator or driver. The maps, combined with information describing the location where the vehicle started and where it is to go, will highlight the direction and the driver will have to read the display and follow the route. One such stored map display system was offered by General Motors on their 1994 Oldsmobile, using Global Positioning System (GPS) satellites and dead reckoning techniques, and likely map matching to determine a precise location. The vehicle has radio receivers for receiving data from satellites, giving the location of the receiver expressed in latitude and longitude. The driver enters details of the desired destination into an on-board or in-vehicle computer in the form of specific address, a road intersection, etc. The stored map is displayed, allowing the operator to pinpoint the desired destination. The on-board computer then seeks to calculate the most efficient route, displaying the distance to, and the direction of, each turn using graphics and a voice prompt.

Other known systems employ speech recognition as a user input. For example, another system, described in U.S. Pat. No. 5,274,560 does not use GPS and has no sensing devices connected to the vehicle. The routing information is contained in a device that is coupled to a CD player in the vehicle's audio system. Commands are entered into the system via a microphone and the results are outputted through the vehicle's speakers. The vehicle operator spells out the locations and destinations, letter by letter. The system confirms the locations by repeating whole words. Once the system has received the current location and destination, the system develops the route and calculates the estimated time. The operator utilizes several specific performance commands, such as "Next", and the system then begins to give segment by segment route directions.

Still another system, such as the Siemens Ali-Scout™ system, requires that the driver key-in the destination address coordinates into the in-vehicle computer. A compass located in the vehicle then gives a "compass" direction to the destination address. Such a compass direction is shown in graphics as an arrow on a display unit, indicating the direction the driver should go. Along the side of the road are several infrared beacon sites which transmit data information to a properly equipped vehicle relative to the next adjacent beacon site. From all of the information received, the in-vehicle computer selects the desired beacon data information to the next beacon and displays a graphic symbol for the vehicle operator to follow and the distance to the desired destination. In this system, there is no map to read; both a simple graphic symbol and a segment of the route is displayed, and a voice prompt telling the vehicle operator when to turn and when to continue in the same direction is enunciated. Once the program begins, there is minimal operator feedback required.

U.S. Pat. No. 4,350,970, describes a method for traffic management in a routing and information system for motor vehicle traffic. The system has a network of stationary routing stations each located in the vicinity of the roadway, which transmit route information and local information concerning its position to passing vehicles. The trip destination address is loaded by the vehicle operator into an onboard device in the vehicle and by dead reckoning techniques, a distance and direction graphic message is displayed. The first routing station which the vehicle passes transmits a message to the vehicle with route data to the next routing station. The vehicle receives the message and as it executes the several vector distances in the message, it accumulates time and distance which it then transmits to the second routing station when it is interrogated by the second routing station. In this manner, traffic management is updated in real time and the vehicles are always routed the "best way". Of course, the best way may be the shortest way, the less traveled way the cheapest way or any combination of these plus other criteria. See also, U.S. patent application Ser. No. 08/258241, filed on Aug. 3, 1994.

U.S. Pat. No. 5,668,880, incorporated herein by reference, relates to an intervehicle data communication device.

Systems which integrate GPS, GLONASS, LORAN or other positioning systems into vehicular guidance systems are well known, and indeed navigational purposes were prime motivators for the creation of these systems. Radar, laser, acoustic and visual sensors have all been applied to vehicular guidance and control, as well. For example, U.S. Pat. No. 4,757,450 relates to a reflected beam system for detecting a preceding vehicle, in order to allow control over intervehicular spacing. U.S. Pat. No. 4,833,469 relates to an obstacle proximity sensor, employing, e.g., a radar beam to determine distance and relative velocity of an obstacle. U.S. Pat. No. 5,600,561 relates to a vehicle distance data processor which computes a velocity vector based on serialtimepoints. U.S. Pat. No. 4,552,456 relates to an optical pulse radar for an automobile. U.S. Pat. No. 4,543,577 relates to a moving obstacle detection system for a vehicle, using Doppler radar. U.S. Pat. No. 4,349,823 relates to an automotive radar system for monitoring objects in front of the vehicle. U.S. Pat. No. 5,473,538 relates to a collision judging system for a vehicle, triggered by a braking event and determining a distance to an obstacle in front of the vehicle. U.S. Pat. No. 4,168,499 relates to an anti-collision radar system. U.S. Pat. No. 4,626.850 relates to a vehicle detection and collision avoidance apparatus, using an acoustic sensor. U.S. Pat. No. 4,028,662 relates to a passing vehicle signaling apparatus, to detect adjacent vehicles during a lane change. U.S. Pat. No. 5,541,590 relates to a vehicle crash predictive and evasive system, employing neural networks. U.S. Pat. No. 5,646,612 relates to a vehicle collision avoidance system, using an infrared imaging system. U.S. Pat. No. 5,285,523 relates to a neural network system for recognizing driving conditions and controlling the vehicle in dependence thereon. U.S. Pat. No. 5,189,619 relates to an artificial intelligence based adaptive vehicle control system. U.S. Pat. No. 5,162,997 relates to a driver-adaptive automobile control system. U.S. Pat. No. 3,689,882 relates to an anti-collision radar system for detecting obstacles or on-coming vehicles.

U.S. Pat. No. 4,855,915 relates to a vehicle which may be autonomously guided using optically reflective materials. U.S. Pat. No. 5,347,456 relates to an intelligent roadway reference system for controlling lateral position of a vehicle, using magnetic sensors. U.S. Pat. No. 5,189,612 relates to an autonomous vehicle guidance system employing buried

magnetic markers. U.S. Pat. No. 5,039,979 relates to a roadway alarm system employing metallized painted divider lines. U.S. Pat. No. 4,239,415 relates to a method for installing an electromagnetic sensor loop in a highway. U.S. Pat. No. 4,185,265 relates to a vehicular magnetic coded signaling apparatus which transmits binary signals using magnetic signposts. U.S. Pat. No. 5,687,215 relates to a vehicular emergency message system. U.S. Pat. No. 5,550,055 relates to a position monitoring system for vehicles, for example in case they are stolen. U.S. Pat. No. 5,563,071 relates to a system for time and/or event logging of an event, employing differential GPS. U.S. Pat. No. 5,701,328 relates to a chirped spread spectrum positioning system.

U.S. Pat. Nos. 5,689,269, 5,119,504, 5,678,182, 5,621,793, 5.673,305, 5,043,736, 5,684,860, 5,625,668, 5,602,739, 5,544,225, 5,461,365, 5,299,132, 5,301,368, 5,633,872, 5,563,607, 5,382,957, 5,638,078, 5,630,206, 5,610,815, 4,677,555, 4,700,301, 4,807,131, 4,963,889, 5,030,957, 5,144,317, 5,148,179, 5,247,306, 5,296,861, 5,347,286, 5,359,332, 5,442,363, 5,451,964, expressly incorporated herein by reference, relate to systems which employ GPS and telecommunication functionality. Such systems are often employed in differential global positioning system (DGPS) and vehicular security and tracking applications.

Typical "secure" encryption systems include the Rivest-Shamir-Adelman algorithm (RSA), the Diffie-Hellman algorithm (DH), the Data Encryption Standard (DES), elliptic curve encryption algorithms, so-called PGP algorithm, and other known algorithms. U.S. Pat. Nos. 4,200,770, 4,218,582, 4,405,829, 4,424,414 and 4,424,415, expressly incorporated herein by reference, relate to RSA-type encryption systems. Other cryptographic system patents include U.S. Pat. Nos. 4,658,094 and 4,797,920, incorporated herein by reference. See also:

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U.S. Pat. No. 5,519,718, incorporated herein by references, relates to a mobile bidirectional pager communication scheme.

U.S. Pat. No. 5,218,620, incorporated herein by references, relates to a spread spectrum communication device.

U.S. Pat. Nos. 3,161,871; 3,568,161; 3,630,079; 3,664,701; 3,683,114; 3,769,710; 3,771,483; 3,772,688; 3,848,254; 3,922,673; 3,956,797; 3,986,119; 3,993,955; 4,002,983; 4,010,619; 4,024,382; 4,077,005; 4,084,323; 4,114,155; 4,152,693; 4,155,042; 4,168,576; 4,229,620; 4,229,737; 4,235,441; 4,240,079; 4,244,123; 4,274,560; 4,313,263; 4,323,921; 4,333,238; 4,359,733; 4,369,426; 4,384,293; 4,393,270; 4,402,049; 4,403,291; 4,428,057; 4,437,151; 4,445,118; 4,450,477; 4,459,667; 4,463,357; 4,471,273; 4,472,663; 4,485,383; 4,492,036; 4,508,999; 4,511,947; 4,514,665; 4,518,902; 4,521,885; 4,523,450; 4,529,919; 4,547,778; 4,550,317; 4,555,651; 4,564,085; 4,567,757; 4,571,847; 4,578,678; 4,591,730; 4,596,988; 4,599,620; 4,600,921; 4,602,279; 4,613,867; 4,622,557; 4,630,685; 4,633,966; 4,637,488; 4,638,445; 4,644,351; 4,644,368; 4,646,096; 4,647,784; 4,651,157; 4,652,884; 4,654,879; 4,656,463; 4,656,476; 4,659,970; 4,667,203; 4,673,936; 4,674,048; 4,677,555; 4,677,686; 4,678,329; 4,679,147; 4,680,715; 4,682,953; 4,684,247; 4,688,244; 4,690,610; 4,691,149; 4,691,385; 4,697,281; 4,701,760; 4,701,934; 4,703,444; 4,706,772; 4,709,195; 4,713,767; 4,718,080; 4,722,410; 4,727,492; 4,727,962; 4,728,922; 4,730,690; 4,731,613; 4,740,778; 4,741,245; 4,741,412; 4,743,913; 4,744,761; 4,750,197; 4,751,512; 4,751,983; 4,754,280; 4,754,283; 4,755,905; 4,758,959; 4,761,742; 4,772,410; 774,671; 4,774,672; 4,776,750; 4,777,818; 4,781,514; 4,785,463; 4,786,164; 4,790,402; 4,791,572; 4,792,995; 4,796,189; 4,796,191; 4,799,062; 4,804,893; 4,804,937; 4,807,714; 4,809,005; 4,809,178; 4,812,820; 4,812,845; 4,812,991; 4,814,711; 4,815,020; 4,815,213; 4,818,171; 4,819,053; 4,819,174; 4,819,195; 4,819,860; 4,821,294; 4,821,309; 4,823,901; 4,825,457; 4,829,372; 4,829,442; 4,831,539; 4,833,477; 4,837,700; 4,839,835; 4,846,297; 4,847,862; 4,849,731; 4,852,146; 4,860,352; 4,861,220; 4,864,284; 4,864,592; 4,866,450; 4,866,776; 4,868,859; 4,868,866; 4,869,635; 4,870,422; 4,876,659; 4,879,658; 4,882,689; 4,882,696; 4,884,348; 4,888,699; 4,888,890; 4,891,650; 4,891,761; 4,894,655; 4,894,662; 4,896,370; 4,897,642; 4,899,285; 4,901,340; 4,903,211; 4,903,212; 4,904,983; 4,907,159; 4,908,629; 4,910,493; 4,910,677; 4,912,475; 4,912,643; 4,912,645; 4,914,609; 4,918,425; 4,918,609; 4,924,402; 4,924,417; 4,924,699; 4,926,336; 4,928,105; 4,928,106; 4,928,107; 4,932,910; 4,937,751; 4,937,752; 4,939,678; 4,943,925; 4,945,501; 4,947,151; 4,949,268; 4,951,212; 4,954,837; 4,954,959; 4,963,865; 4,963,889; 4,968,981; 4,970,652; 4,972,431; 4,974,170; 4,975,707; 4,976,619; 4,977,679; 4,983,980; 4,986,384; 4,989,151; 4,991,304; 4,996,645; 4,996,703; 5,003,317; 5,006,855; 5,010,491; 5,014,206; 5,017,926; 5,021,792; 5,021,794; 5,025,261; 5,030,957; 5,030,957; 5,031,104; 5,036,329; 5,036,537; 5,041,833; 5,043,736; 5,043,902; 5,045,861; 5,046,011; 5,046,130; 5,054,110; 5,055,851; 5,056,106; 5,059,969; 5,061,936; 5,065,326; 5,067,082; 5,068,656; 5,070,404; 5,072,227; 5,075,693; 5,077,557; 5,081,667; 5,083,256; 5,084,822; 5,086,390; 5,087,919; 5,089,826; 5,097,269; 5,101,356; 5,101,416; 5,102,360; 5,103,400; 5,103,459; 5,109,399; 5,115,223; 5,117,232; 5,119,102; 5,119,301; 5,119,504; 5,121,326; 5,122,803; 5,122,957; 5,124,915; 5,126,748; 5,128,874; 5,128,979; 5,144,318; 5,146,231; 5,148,002; 5,148,179; 5,148,452; 5,153,598; 5,153,836; 5,155,490; 5,155,491; 5,155,591; 5,155,688; 5,155,689; 5,157,691; 5,161,886; 5,168,452; 5,170,171; 5,172,321; 5,175,557; 5,177,685; 5,184,123; 5,185,610; 5,185,761; 5,187,805; 5,192,957; 5,193,215; 5,194,871; 5,202,829; 5,208,756; 5,210,540; 5,210,787; 5,218,367; 5,220,507; 5,220,509; 5,223,844; 5,225,842; 5,228,695; 5,228,854; 5,245,537; 5,247,440; 5,257,195;

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SUMMARY OF THE INVENTION

The present invention provides a mobile telecommunications device having a position detector, which may be absolute, relative or other type, a memory for storing events in conjunction with locations, and a transmitter or receiver for communicating information stored or to be stored in the memory.

The aforementioned references, each incorporated by reference, relate to methods and apparatus which may be used as part of, or in conjunction with the present invention. Therefore, it is understood that the present invention may integrate other systems, or be integrated in other systems, having complementary, synergistic or related in some way. For example, common sensors, antennas, processors, memory, communications hardware, subsystems and the like may provide a basis for combination, even if the functions are separate.

The position detector is preferably a GPS or combined GPS-GLONASS receiver, although a cellular telephone position detection system (e.g., Enhanced 911 type system) may also be employed. According to aspects of the present invention, a positional accuracy tolerance of 100 up to 1000 meters may be acceptable, achievable with either type system. However, for such purposes as pothole reporting, positional accuracies of 1 to 3 meters are preferred. These may be obtained through a combination of techniques, and therefore the inherent accuracy of any one technique need not meet the overall system requirement.

The position detector may also be linked to a mapping system and possibly a dead reckoning system, in order to pinpoint a position with a geographic landmark. Thus, while precise absolute coordinate measurements of position may be used, it may also be possible to obtain useful data at reduced cost by applying certain presumptions to available data. In an automotive system, steering angle, compass direction, and wheel revolution information may be available, thereby giving a rough indication of position from a known starting point. When this information is applied to a mapping system, a relatively precise position may be estimated. Therefore, the required precision of another positioning system used in conjunction need not be high, in order to provide high reliability position information. For example, where it is desired to map potholes, positional accuracy of 10 cm may be desired, far more precise than might be available from a normal GPS receiver mounted in a moving automobile. However, when combined with other data, location and identification of such events is possible. Further, while the system may include or tolerate inaccuracies. it is generally desired that the system have high precision, as compensation for inaccuracies may be applied.

The system provides a memory for storing events and respective locations. Preferably, further information is also

stored, such as a time of the event, its character or nature, and other quantitative or qualitative aspects of the information or its source and/or conditions of acquisition. This memory may be a solid state memory or module, rotating magnetic and/or optical memory devices, or other known types of memory.

The events to be stored may be detected locally, such as through a detector for radar and/or laser emission source, radio scanner, traffic or road conditions (mechanical vehicle sensors, visual and/or infrared imaging, radar or LIDAR analysis, acoustic sensors, or the like), places of interest which may be selectively identified, itinerary stops, and/or fixed locations. The events may also be provided by a remote transmitter, with no local event detection. Therefore, while means for identifying events having associated locations is a part of the system as a whole, such means need not be included in every apparatus embodying the invention.

Radar detectors typically are employed to detect operating emitters of X (10.5 GHz), K (25 GHz) and Ka (35 GHz) radar emissions from traffic control devices or law enforcement a personnel for detecting vehicle speed by the Doppler effect. These systems typically operate as superheterodyne receivers which sweep one or more bands, and detect a wave having an energy significantly above background. As such, these types of devices are subject to numerous sources of interference, accidental, intentional, and incidental. A known system, Safety Warning System (SWS) licensed by Safety Warning System L.C., Englewood Fla., makes use of such radar detectors to specifically warn motorists of identified road hazards. In this case, one of a set of particular signals is modulated within a radar band by a transmitter operated near the roadway. The receiver decodes the transmission and warns the driver of the hazard.

LIDAR devices emit an infrared laser signal, which is then reflected off a moving vehicle and analyzed for delay, which relates to distance. Through successive measurements, a sped can be calculated. A LIDAR detector therefore seeks to detect the characteristic pulsatile infrared energy.

Police radios employ certain restricted frequencies, and in some cases, police vehicles continuously transmit a signal. While certain laws restrict interception of messages sent on police bands, it is believed that the mere detection and localization of a carrier wave is not and may not be legally restricted. These radios tend to operate below 800 MHz, and thus a receiver may employ standard radio technologies.

Potholes and other road obstructions and defects have two characteristics. First, they adversely effect vehicles which encounter them. Second, they often cause a secondary effect of motorists seeking to avoid a direct encounter or damage, by slowing or executing an evasive maneuver. These obstructions may therefore be detected in three ways; first, by analyzing the suspension of the vehicle for unusual shocks indicative of such vents; second, by analyzing speed and steering patterns of the subject vehicle and possibly surrounding vehicles; and third, by a visual, ultrasonic, or other direct sensor for detecting the pothole or other obstruction. Such direct sensors are known; however, their effectiveness is limited, and therefore an advance mapping of such potholes and other road obstructions greatly facilitates avoiding vehicle damage and executing unsafe or emergency evasive maneuvers. An advance mapping may also be useful in remediating such road hazards, as well.

Traffic jams occur for a variety of reasons. Typically, the road carries traffic above a threshold, and for some reason the normal traffic flow patterns are disrupted. Therefore, there is a dramatic slowdown in the average vehicle speed, and a reduced throughput. Because,of the reduced throughput, even after the cause of the disruption has abated, the roadways may take minutes to hours to return to normal. Therefore, it is typically desired to have advance.warnings of disruptions, which include accidents, icing, rain, sun glare, lane closures, road debris, police action, exits and entrances, and the like, in order to allow the driver to avoid the involved region or plan accordingly. Abnormal traffic patterns may be detected by comparing a vehicle speed to the speed limit or a historical average speed, by a visual evaluation of traffic conditions, or by broadcast road advisories. High traffic conditions are associated with braking of traffic, which in turn results in deceleration and the illumination of brake lights. Brake lights may be determined by both the specific level of illumination and the center brake light, which is not normally illuminated. Deceleration may be detected by an optical, radar or LIDAR sensor for detecting the speed and/or acceleration state of nearby vehicles.

While a preferred embodiment of the present invention employs one or more sensors, broadcast advisories, including those from systems according to or compatible with the present invention, provide a valuable source of information relating to road conditions and information of interest at a particular location. Therefore, the sensors need not form a part of the core. system. Further, some or all of the required sensors may be integrated with the vehicle electronics ("vetronics"), and therefore the sensors may be provided separately or as options. It is therefore an aspect of an embodiment of the invention to integrate the transceiver, and event database into a vetronics system, preferably using a digital vetronics data bus to communicate with existing systems, such as speed sensors, antilock brake sensors, cruise control, automatic traction system, suspension, engine, transmission, and other vehicle systems.

The radio used for the communications subsystem can be radio frequency AM, FM, spread spectrum, microwave, light (infrared, visible, UV) or laser or maser beam (millimeter wave, infrared, visible), or for short distance communications, acoustic or other communications may be employed. The system preferably employs an intelligent transportation system (ITS) or Industrial, Scientific and Medical (ISM) allocated band, such as the 915 MHz, 2.4 MHz or 5.8 GHz band. (The 2.350–2.450 GHz band corresponds to the emission of microwave ovens, and thus the band suffers from potentially significant interference). The 24.125 GHz band, corresponding to K-band police radar, may also be available; however, transmit power in this band is restricted, e.g., less than about 9 mW. The signal may be transmitted through free space or in paths including fiber optics, waveguides, cables or the like. The communication may be short or medium range omnidirectional, line of sight, reflected (optical, radio frequency, retroreflector designs), satellite, secure or non-secure, or other modes of communications between two points, that the application or state-of-the-art may allow. The particular communications methodology is not critical to the invention, although a preferred embodiment employs a spread spectrum microwave transmission.

A number of Dedicated Short Range Communications (DSRC) systems have been proposed or implemented in order to provide communications between vehicles and roadside systems. These DSRC systems traditionally operate in the f900 MHz band for toll collection, while the FCC has recently made available 75 MHz in the 5.850–5.925 GHz range for such purposes, on a co-primary basis with micro-

wave communications, satellite uplinks, government radar, and other uses. However, spectrum is also available in the so-called U-NII band, which encompasses 5.15–5.25 GHz (indoors, 50 mW) and 5.25–5.35 (outdoors, 250 mW). At such frequencies, the preferred semiconductor technology for the radio-frequency circuits is Silicon Germanium, available as a biCMOS heterojunction bipolar transistor process from IBM (CommQuest Technologies Division). Gallium Arsenide processes may also operate in this band. Silicon processes are preferred in the 900 MHz band and below.

A Japanese ITS ("ETC") proposal provides a 5.8 GHz full duplex interrogation system with a half duplex transponder, operating at about 1 megabit per second transmission rates.

It is noted that the present technology has the capability for streamlining transportation systems, by communicating traffic conditions almost immediately and quickly allowing decisions to be made by drivers to minimize congestion and avoid unnecessary slowdowns. A particular result of the implementation of this technology will be a reduction in vehicular air pollution, as a result of reduced traffic jams and other inefficient driving patterns. To further the environmental protection aspect of the invention, integration of the database with cruise control and driver information systems may reduce inefficient vehicle speed fluctuations, by communicating to the driver or controlling the vehicle at an efficient speed. As a part of this system, therefore, adaptive speed limits and intelligent traffic flow control devices may be provided. For example, there is no need for fixed time traffic lights if the intersection is monitored for actual traffic conditions. By providing intervehicle communications and identification, such an intelligent system is easier to implement. Likewise, the 55 miles per hour speed limit that was initially presented in light of the "oil crisis" in the 1970's, and parts of which persist today even in light of relatively low petroleum pricing and evidence that the alleged secondary health and safety benefit is marginal or non-existent, may be eliminated in favor of a system which employs intelligence to optimize the traffic flow patterns based on actual existing conditions, rather than a static set of rules which are applied universally and without intelligence.

The communications device may be a transmitter, receiver or transceiver, transmitting event information, storing received event information, or exchanging event information, respectively. Thus, while the system as a whole typically involves a propagation of event information between remote databases, each system embodying the invention need not perform all functions.

In a retroreflector design system, signal to noise ratio is improved by spatial specificity, and typically coherent detection. An interrogation signal is emitted, which is modulated and redirected back toward its source, within a relatively wide range, by a receiver. Thus, while the receiver may be "passive", the return signal has a relatively high amplitude (as compared to non-retroreflective designs under comparable conditions) and the interrogator can spatially discriminate and coherently detect the return signal. Both optical and RF retroreflector systems exist.

In a preferred embodiment, the communications device employs an unlicensed band, such as 900 MHz (902–928 MHz), FRS, 49 MHz, 27 MHz, 2.4–2.5 GHz, 5.4 GHz, 5.8 GHz, etc. Further, in order to provide noise immunity and band capacity, spread spectrum RF techniques are preferred.

In one embodiment, communications devices are installed in automobiles. Mobile GPS receivers in the vehicles provide location information to the communications devices. These GPS receivers may be integral or separate from the communications devices. Event detectors, such as police radar and laser (LIDAR) speed detectors, traffic and weather condition detectors, road hazard detectors (pot holes, debris, accidents, ice, mud and rock slides, drunk drivers, etc.), traffic speed detectors (speedometer reading, sensors for detecting speed of other vehicles), speed limits, checkpoints, toll booths, etc., may be provided as inputs to the system, or appropriate sensors integrated therein. The system may also serve as a beacon to good Samaritans, emergency workers and other motorists in the event of accident, disablement, or other status of the host vehicle.

It is noted that at frequencies above about 800 MHz, the transmitter signal may be used as a part of a traffic radar system. Therefore, the transmitted signal may serve both as a communications stream and a sensor emission.

Functions similar to those of the Cadillac (GM) On-Star system may also be implemented, as well as alarm and security systems, garage door opening and "smart home" integration.

The memory stores information describing the event as well as the location of the event. Preferably, the memory is not organized as a matrix of memory addresses corresponding to locations, e.g., a "map", but rather in a record format having explicitly describing the event and location. making storage of the sparse matrix more efficient and facilitating indexing and sorting on various aspects of each data record. Additional information, such as the time of the event, importance of the event, expiration time of the event, source and reliability of the event information, and commercial and/or advertising information associated with the event may be stored. The information in the memory is processed to provide a useful output, which may be a simple alphanumeric, voice (audible) or graphic output or the telecommunications system. In any case, the output is preferably presented in a sorted order according to pertinence, which is a combination of the abstract importance of the event and proximity, with "proximity" weighted higher than "importance". Once a communication or output cycle is initiated, it may continue until the entire memory is output, or include merely output a portion of the contents.

In outputting information directly to a human user, thresholds are preferably applied to limit output to events which are of immediate consequence and apparent importance. For example, if the communications device is installed in a vehicle, and the information in the memory indicates that a pothole, highway obstruction, or police radar "trap" is ahead, the user is informed. Events in the opposite direction (as determined by a path or velocity record extracted from the position detector) are not output, nor are such events far away. On the other hand, events such as road icing, flooding, or the like, are often applicable to all nearby motorists, and are output regardless of direction of travel, unless another communications device with event detector indicates that the event would not affect the local communications device or the vehicle in which it is installed.

The system preferably ages event data intelligently, allowing certain types of events to expire or decrease in importance. A traffic accident event more than 12 hours old is likely stale, and therefore would not be output, and preferably is purged; however, locations which are the site of multiple accidents may be tagged as hazardous, and the hazard event output to the user as appropriate.

A temporal analysis may also be applied to the event data, and therefore diurnal variations and the like accounted for. Examples of this type of data include rush hour traffic, sun glare (adjusted for season, etc.), vacation routes, and the like.

Thus, user outputs are provided based on proximity, importance, and optionally other factors, such as direction, speed (over or under speed limit), time-of-day, date or season (e.g., sun glare), freshness of event recordation, and the like.

In communicating data to another communications device, typically it is desired to transmit (or exchange) all of the memory or all of a "public" portion of the memory, with the received information sorted and processed by the receiving unit and relevant information persistently stored in the memory. After exchange, conflicts may be resolved by a further exchange of information. An error detection and correction (EDC) protocol may be employed, to assure accurate data transmission.

Since the communication bandwidth is necessarily limited, and the communications channels subject to noise and crowding, it is often important to prioritize transmissions. It is noted that, without a complete communication of the memory, it is difficult to determine which events a communications partner is aware of, so that an initial communication may include an identification of the partners as well as recent encounters with other partners, to eliminate redundant communications, where possible. Vehicles traveling in the same direction will often be in close proximity longer than vehicles traveling in opposite directions. Further, the information of relevance to a vehicle traveling in the same direction will differ from the information of relevance to a vehicle traveling in the opposite direction. Thus, in addition to an identification of the communications device, the recent path and proposed path and velocity should also be exchanged. Based on this information, the data is prioritized and sorted, formatted and transmitted. Since the communications channel will likely vary in dependence on distance between partners, the communications protocol may be adaptive, providing increased data rate with decreasing distance, up to the channel capacity. Further, when the vehicles are relatively close, a line-of-sight communications scheme may be implemented, such as infrared (e.g., IRdA), while at larger distances (and/or for all distances) a spread spectrum 915 MHz, 2.4 GHz or 5.825 GHz RF communications scheme implemented.

Where multiple communications devices are present within a common communications region, these may be pooled, allowing transmissions from one transmitter to many receivers. In addition, within a band, multiple channels may be allocated, allowing multiple communications sessions. In this case, a single arbitration and control channel is provided to identify communications devices and communications parameters. Preferably, a communications device has the capability to monitor multiple channels simultaneously, and optionally to transmit on multiple channels simultaneously, where channel congestion is low. The channels are typically frequency division. Where such frequency division channels are defined, communications may be facilitated by so-called "repeaters", which may itself be a mobile transceiver according to the present invention. Preferably, such a repeater unit itself monitors the data stream, and may even process the data stream based on its internal parameters before passing it on.

In order to assure data integrity and optimize data bandwidth, both forward and retrospective error correction are applied. Data is preferably packetized, with each packet including error detection and correction information. Successful receipt of each packet is acknowledged on a reverse channel, optionally interspersed with corresponding data packets traveling in the reverse direction (e.g., full duplex communications). Where the data error rate (raw or corrected) is unacceptably high, one or more "fallback" modes may be implemented, such as reduced data rates, more fault tolerant modulation schemes, and extended error correction and detection codes. Transmitter power may also be modulated within acceptable limits.

A central repository of event data may be provided, such as on the Internet or an on-line database. In this case, event information may be administered remotely, and local storage minimized or eliminated. Communications with the central database may be conducted by cellular telephone, cellular data packet devices (CDPD), PCS, GSM, satellite (Iridium™, etc.) or in other communications bands and other communications schemes.

Alternately, or in addition, the communications device may include a telephone modem (digital to analog modulator-demodulator) for exchanging event information over telephone communications lines. The device according to the present invention may either be plugged into a wall jack, use acoustic coupling (advantageous, for example, for pay-telephones) or communicate wirelessly with a base unit, such as while parked in a garage or service station. Where primary event information storage is remote from the device, preferably local storage is based on an itinerary (route) and frequently traveled areas, with less frequently traveled and not prospectively traveled routes stored remotely. This allows consolidated update of memory by a large number of sources, with statistical error detection and correction of errant event information. The itinerary information may be programmed in conjunction with the GPS system and mapping software.

According to one embodiment of the invention, the functions are integrated into a single device, including police radar and LIDAR detectors, user output, memory, central processor, GPS receiver and RF transceiver. Accessory inputs and outputs may also be provided, including means for alphanumeric, graphic (still or motion) or voice message communication between communications devices. Event information is communicated as packets including full event information as well as error correction and detection codes. The packet size is preferably large enough to minimize the impact of communications protocol overhead while small enough to minimize the efficiency loss resulting from full packet retransmissions. For example, a control channel is provided with 256 bit packets, while a set of regular communications channels is provided with 512 bit packets. Event information may span multiple packets or be consolidated within packets. The data is preferably compressed using a dictionary lookup, run length encoding, and/or model-based vector quantization method. Thus, since transceivers will typically be within 2000 meters from each other, relative position may be relayed in an offset format, with a grid size based on GPS precision and required accuracy, e.g., about 50–100 meters. The encoding may be adaptive, based, for example. on stored map information, with information representation density highest on traveled routes and lower in desolate areas. Thus, a sort of differential-corrected positional coding may be established between units.

By integrating functions, efficiencies are achieved. Thus, a single central processor, memory, program store and user interface will suffice for all functions. Further, the power supply and housing are also consolidated. While GPS and telecommunication antennas will be distinct, other portions of the system may also be integrated. In a device intended for vehicular applications, the GPS and other functions may be available to other vehicular systems, or the required data received from other systems. For example, the Cadillac (GM) On-Star system might supply GPS signals to the communications device according to the present invention, or vice versa.

Communication between communications devices may also employ the cellular telephone network, for example utilizing excess capacity in a local or regional communication mode rather than linked to the public switched telecommunications network (PSTN). Thus, the system may include or encompass a typical cellular (AMPS, IS-136, IS-95, CDPD, PCS and/or GSM) type telecommunications device, or link to an external telecommunications device.

Even where the cellular telephony infrastructure is not involved, mobile hardware may be reused for the present invention. For example, the output of a mobile cellular transceiver may be "upconverted" to, for example, 900 MHz or 2.4 GHz, and retransmitted. While this is somewhat inefficient in terms of power and complexity, it allows use of existing cellular devices (with software reprogramming and data interfacing) in conjunction with a relatively simple upconversion transmitter.

According to the present invention, messages are passed between a network of free roving devices. In order to maintain network integrity, spurious data must be excluded. Thus, in order to prevent a "hacker" or miscreant (e.g., overzealous police official) from intentionally contaminating the dispersed database, or an innocent person from transmitting corrupted data, the ultimate source of event data is recorded. When corrupt or erroneous data is identified, the source is also identified. The corrupting source is then transmitted or identified to the central database, whereupon, units in the field may be programmed to ignore the corrupt unit, or to identify its location as a possible event to be aware of.

Preferably, data is transmitted digitally, and may be encrypted. Encryption codes may be of a public-key/private key variety, with key lookup (e.g., by a cellular telephony or CDPD-type arrangement to a central database) either before each data exchange, or on a global basis with published updates. In fact, corrupt or unauthorized units may be deactivated by normal and authorized units within the network, thus inhibiting "hacking" of the network. Thus, a subscription based system is supported.

Techniques corresponding to the Firewire (IEEE 1394) copy protection scheme may be implemented, and indeed the system according to the present invention may implement or incorporate the IEEE 1394 interface standard. While the event database is generally not intended to be copy-protected, the IEEE 1394 key management scheme may be useful for implementing subscription schemes and for preventing tampering.

One way to subsidize a subscription-based system is through advertising revenue. Therefore, the "events" may also include messages targeted to particular users, either by location, demographics, origin, time, or other factors. Thus, a motel or restaurant might solicit customers who are close by (especially in the evening), or set up transponders along highways at desired locations. Travelers would then receive messages appropriate to time and place. While the user of the system according to the present invention will typically be a frequent motorist or affluent, the system may also provide demographic codes, which allow a customized response to each unit. Since demographic information is personal, and may indicate traveler vulnerability, this information is preferably not transmitted as an open message and is preferably not decodable by unauthorized persons. In fact, the demographic codes may be employed to filter received information, rather than to broadcast interests.

Commercial messages may be stored in memory, and therefore need not be displayed immediately upon receipt. Further, such information may be provided on a so-called "smart card" or PC Card device, with messages triggered by location, perceived events, time and/or other factors. In turn, the presentation of commercial messages may be stored for verification by an auditing agency, thus allowing accounting for advertising fees on an "impression" basis.

The communications device may also receive data through broadcasts, such as using FM sidebands, paging channels, satellite transmission and the like. Thus, locationally or temporally distant information need not be transmitted between mobile units.

While low power or micropower design is desirable, in an automobile environment, typically sufficient power is continuously available to support sophisticated and/or power hungry electronic devices; thus, significant design freedom is provided to implement the present invention using available technologies.

These and other objects will become clear through a review of the drawings and detailed description of the preferred embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings show:

FIG. **1** is a block diagram of a preferred embodiment of a communications system according to the present invention;

FIG. **2** is a schematic diagram showing the prioritization scheme; and

FIG. **3** is a block diagram representing a message format.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** shows a block diagram of an communications device embodiment of the present nvention. The mobile communications device **1** includes, as necessary elements, a location ensing system **2**, producing a location output **3**; a memory **4**, storing a set of locations and associated events; a telecommunications subsystem **5**, communicating event and location information between a remote system and the memory **4**; and a processor **6**, processing the location output in conjunction with the stored locations and associated events in the memory **4**, to determine a priority thereof.

The location sensing system **2** comprises a known GPS receiver, which produces data that is analyzed by the processor **6**. In an alternate embodiment, the GPS receiver includes its own processor and outputs coordinate positions, e.g., Cartesian coordinates, latitude and longitude, to the communications device processor **6**, e.g., through a serial port or data bus, such as PC card, Universal serial Bus (USB), Firewire (IEEE 1394), peripheral connect interface (PCI), or other bus, such as that present within an automobile for communication of signals between subsystems. The location sensing system may also determine a position based on the GLONASS system, LORAN, inertial reference, cellular base stations **10'**, **10"**, triangulation with fixed radio sources, such as FM radio and television stations, environmental markers and/or transponders, or the like.

The communications subsystem **5** is a 900 MHz digital spread spectrum radio transceiver **12**, operating unlicensed according to FCC regulations for this type of equipment. The system may alternately or additionally communicate in other unlicensed bands, such as 27 MHz, 49 MHz, FRS band, 2.4–2.5 GHz, 5.4 GHz, 5.8 GHz using various known modulation schemes and data communication protocols. Further, licensed radio bands may also be used, including

FM radio sidebands (88–108 MHz), television PRO channel, cellular telephony channels, DECT, PCS and GSM channels, and the like. Likewise, satellite systems **16**, **17** may be used to communicate with the mobile communications device **1**. Thus, for example, instead of direct communication between mobile units, the existing cellular telephony **10'**, **10"** infrastructure may be used to provide intercell, local, and/or regional communications between units, controlled by cellular telephone switching processors **11'**, **11"**. These communications may be given a lower priority than voice communications on the cellular telephone network, and therefore may use otherwise excess bandwidth, thus allowing reduced costs and reduced user fees or subscription rates. Further, this scheme allows use of existing cellular telephones **14**, as or instead of an integrated communications subsystem operating according to a different standard. For example, cellular telephones may be present in the vehicle for voice communications purposes, and therefore simultaneously with a system according to the present invention. In this case, the communications device need only have a data communications transceiver for interfacing with a cellular communication device, e.g., AMPS, IS-95, IS-136, CDPD, DECT, GSM and PCS, and need not integrate the radio frequency communication device components. In a variant embodiment, a cellular-type telephone is controlled to operate outside the (AMPS) cellular telephone channels, in the 900 MHz band. It is noted that existing cellar communications system do not support high bandwidth data communications when using a single channel. On the other hand, the modifications to a digital cellular communications device to allocate a full time division multiplexed (TDM) channel to as single transceiver are theoretically simple, and allow relatively high data rates. Thus, slightly modified transceivers may be employed. Such modified transceivers may also be used for other high bandwidth mobile requirements, such as mobile video-conferencing, and the like.

The memory **4** may be of any standard type, for example, static random access memory, dynamic random access memory, ferroelectric memory, magnetic domain memory (e.g., diskette, hard disk), non-volatile semiconductor memory (e.g., UV-EPROM, EEPROM, Flash, non-standard electrically erasable programmable non-volatile memory), optically readable memory (e.g., R-CDROM, RW-CDROM, R-DVD, etc.), scanning/tunneling micromechanical memory systems, and the like. Preferably, common memory devices, such as 72 or 168 pin dynamic RAM single inline memory modules (SIMMs) are employed, at least for a volatile portion of the memory, allowing simple upgrades and industry standard compatibility.

While the preferred embodiment includes a radio frequency transceiver for transmitting event data and receiving event data, embodiments are also possible which either transmit or receive the relevant data, but not both. For example, regulations may limit certain transmissions or relevant event sensors, e.g., radar detectors in trucks. In these cases, a receive only embodiment may be appropriate. Further, while radio frequency communications are preferred, due to their range, data capacity and availability, optical communications systems **13**, e.g., infrared LED's and laser diodes, acoustic communication **15**, passive backscatter communications (employing an RF transceiver such as the spread spectrum transceiver **12**), and the like may also be employed in conjunction or in substitution of a radio frequency system. Optical communication systems **13** may employ various detectors, including optical homodyne detectors, or other coherent optical detectors, or other types of optical sensors, such as PIDs, CCDs, silicon photodiodes, and the like.

Under some circumstances, a wired link between units may be appropriate. For example, a central database **20** may provide consolidated and reliable data. The relevant portion of the database **20** may be downloaded by telephone through a modem **21**, either through a physical connection **23** (e.g., RJ-11 or RJ-12 jack) or through an acoustic coupler **22**, through the public switched telephone network, Internet or other network **24**, to a database server **25**. The memory **4** of the mobile unit may also be uploaded to the central database **20**, after processing by the database server **25**, during the same connection or session.

Thus, according to the present invention, the public switched telephone network **24** may be involved both during intermittent mass data communications with a central database **20**, and also using, for example, cellular telephony **14**, for the normal operation of the system (e.g., communications between mobile units).

The processor **6** analyzes the information stored in memory **4** to provide a prioritized output. Thus, the memory may store information relating to a relatively large number of events, without overwhelming the capacity of a human user or communications partner. Priority may be based on a number of factors, including proximity of a stored location to a sensed location or a spatial-temporal proximity of a stored location to a loci of an itinerary **101**, a prospective conjunction **102** of a sensed location with a stored location, a type of event **103**, a type of event and a sensed condition associated with the mobile communications device **104**, or other factors or a combination of factors. Neural networks, fuzzy logic and/or traditional logic paradigms may also be employed to prioritize the outputs. These logical paradigms are provided in known manner, and, especially in the case of neural network-based systems, a training aspect may be supplied with the system to allow it to adapt to the preferences and capabilities of the user. Thus, for a human user, events which are forthcoming and important are output, while past events and those in the distant future, if at all, are low priority. On the other hand, for communications with other devices, the prioritization is primarily in consideration of the fact that the communication between units may be only short lived; therefore, the data is communicated in order to priority, preferably of the recipient device. In an adaptive device, if the user believes that the information from the device is inappropriate, a simple input is provided, which is later analyzed to alter the information presentation algorithm. Likewise, if an information alert retrospectively turns out to be erroneous in a predictable manner, i.e., relating to a route not taken, the system may internally adjust the algorithm without user input.

In order to sort the priorities, the intended recipient may, for example, identify itself **201** and communicate its location **202** an itinerary or intended or prospective path **205**. High priority messages **204** and various codes **203** may be interspersed through the communication string. The transmitting unit then outputs data **206** in order of the computed or predicted importance of the event and the time before the recipient encounters the event. Static events, such as fixed location radar emission sources, which may, for example, indicate a source for interference with a radar detector, or a speed detection/control device, may be transmitted as well.

Therefore, it is noted that the present invention provides a means for mapping events and for analyzing their significance. Thus, this embodiment does not merely rely on processed sensor outputs to supply information to the user; rather, sensor outputs may be filtered based on past experience with the particular location in question. If a particular user does not have direct experience with a location, then the

experience of others at that location may be substituted or combined to improve analysis of the sensor signal. Therefore, the signal analysis from the sensor need not be subjected to a relatively high threshold to avoid false alarms. A low threshold is acceptable because other information is employed to determine the nature of the physical elements which give rise to the event and sensor activation.

It is noted that, in the case of "false alarms", the response of the unit is to detect the event, e.g., radar signal, correlate it with a stored "false alarm" event, and suppress an alarm or modify the alarm signal. Thus, information stored in memory and/or transmitted between units, may signify an important alarm or a suppression of an erroneous alarm. In this context is apparent that the integrity of the database structure, especially from corruption by the very sources of alarms which are intended to be detected, is important. To the extent that the environment responds to the existence and deployment of the system according to the present invention, for example by detecting transmissions between units to identify and locate units, and thereby alter the nature of an event to be detected, the present system may also be adaptive, in terms of its function and signature spectral patterns. In one aspect, the system may employ a so-called "FLASH" upgradable memory, which controls system, operation. Therefore, periodically, the system operation may be altered. The communications may selectively occur on a plurality of bands, using a plurality of protocols. Thus, for example, the system may have tri-band capability, e.g., 900 MHz, 2.4 GHz and 5.8 GHz. The mapping feature of the present invention may also be used to identify the locations of such monitoring sites. The system may also mask its transmissions as other, more common types of transmissions or environmental sources of emissions. A direct sequence spread spectrum technique maybe employed which is difficult to detect without knowing the spread spectrum sequence seed. Of course, an aspect of the present invention is open communications, which as a matter of course are not securely encrypted and which would identify the transponder and its location. This problem may be addressed, in part, relying on laws which prevent unauthorized eavesdropping and unauthorized interception and decryption of communications, unauthorized "copying" of copyright works and defeating of copy protection schemes thereof, control over availability of authorized transceivers, and patent protection of the design and implementation.

Thus, in a preferred design, all communications are direct sequence spread spectrum over a wide band, with medium to high security codes, e.g., 10 bits or greater length chip sequence and 12 bits or greater data encryption, and more preferably 16 bit or greater chip sequence and 16 bit or greater data encryption. The chip sequence of the control and arbitration channel, which must be available to all compatible units, may be adaptive or changing, for example following a formula based on time, location, and/or an arbitrary authorization code provided with a subscription update. Further, the chip sequence may vary based on selective availability (SA) deviancies in GPS data, or based on the identity of satellites in view of the receiver. While such information might be available to "pirates", miscreants, hackers and scofflaws, the algorithm for generating the chip sequence might be held as confidential, and thus the system unusable without specific authorization and incompatible with equipment without such algorithm. Such systems employing secure encryption with open access have been employed in satellite television (General Instrument Video-Cipher II) and the like. It is noted that, in order to mask a message in a spread spectrum signal, multiple active channels may be employed, one or more of which transmits the desired data and the remainder transmitting noise or masking data.

Employing 2.4 or 5.8 GHz communications bands, data rates of 10 megabits per second (MBPS) are possible, although lower rates, such as 0.5–1.0 MBPS may be preferred to reduce loss due to interference or adverse communications conditions and maintain availability of simultaneous communications on multiple channels within the band in a small geographic area.

Where mobile devices are traveling parallel and at similar speeds, or both are stopped, an extended communications session may be initiated. In this case, the data prioritization will be weighted to completely exchange a public portion of the database, although emphasis will still be placed on immediately forthcoming events, if anticipated. On the other hand, where computed or user-input trajectories indicate a likely brief encounter, the immediate past events are weighted most heavily.

In order to analyze temporal relevance, the memory **4** preferably stores an event identifier **301**, a location **302**, a time of detection of an event **303**, a source of the event information **304**, an encoding for a likely expiration of the event **305**, a reliability indicator for the event **306**, and possibly a message associated with the event **307** including other information. These data fields may each be transmitted or received to describe the event, or selectively transmitted based on the nature of the event or an initial exchange between units specifying the information which will be communicated.

For example, in a radar detector embodiment, mobile police radar "traps" are often relocated, so that a particular location of one event should not be perpetuated beyond its anticipated or actual relevance. In this case, expirations may be stored, or calculated based on a "type" of event according to a set of rules. False alarms, due to security systems, traffic control and monitoring systems, and the like, may also be recorded, to increase the reliability any warnings provided.

Likewise, traffic jams often resolve after minutes or hours, and, while certain road regions may be prone to traffic jams, especially at certain hours of the day and/or days of the week, abnormal condition information should not persist indefinitely.

The preferred embodiment according to the present invention provides an event detector, which, in turn is preferably a police radar **18** and LIDAR **19** detector. Other detected events may include speed of vehicle, traffic conditions, weather conditions, road conditions, road debris or potholes, site designation, sources of radio signals or interference or false alarms for other event detectors, and particular vehicles, such as drunk drivers or unmarked police cars (possibly by manual event input). The event detector may include, for example, a sensor, such as a camera **26**, which may analyze traffic control indicia (such as speed limits, cautions, traffic lights). The event may also include a commercial message or advertisement, received, for example from a fixed antenna beside a road, which, for example, is stored as the message **307**. Such a commercial message **307** may be presented immediately or stored for future output. The received message, whether commercial or not, may be a static or motion graphic image, text or sound message. The user output of the system **27** may thus be visual, such as a graphic or alphanumeric (text) display, indicator lights or LED's **28**, audible alerts or spoken voice through an audio transducer **29**.

The camera is, for example, a color, monochrome or infrared charge coupled device (CCD) or complementary

metal oxide silicon field effect transistor (CMOS) imager, having resolution of CIF (common interchange format), QCIF (quarter common interchange format), NTSC (national television standards committee), PAL (phase-alternate line), or other standard, and preferably images using NTSC format and transmits, if at all, as QCIF. Image communication may be, for example H.261 or H.263, using H.324+ (using mobile communications extensions) or H.323 protocol. The imager may also be incorporated as part of a mobile videoconferencing system, although a dual imager system (one for imaging persons and the other for imaging road conditions) may be implemented. Other ITU standards, e.g., T.120, may be employed for data communications, although the particular nature of the data communications channel(s) may compel other communications protocols.

In order to maintain the integrity of the database stored in memory **4**, **20**, it may be useful to store the originator of a record, i.e., its source **304**. Thus, if event information from that origin is deemed unreliable, all records from that source may be purged, and future messages ignored or "flagged". As stated above, even the proximity of an unreliable or modified unit may be detrimental to system operation. Therefore, where the location of such a unit is known, other units in proximity may enter into a silent mode. Further, normal units may transmit a "kill" message to the unreliable unit, causing it to cease functioning (at least in a transmit mode) until the problem is rectified or the unit reauthorized.

The unit is preferably tamper-proof, for example, codes necessary for unit activation and operation are corrupted or erased if an enclosure to the unit is opened. Thus, techniques such as employed in the General Instrument VideoCipher II and disclosed in Kaish et al., U.S. Pat. No. 4,494,114, may be employed.

The communications subsystem preferably employs an error correction/error detection protocol, with forward error correction and confirmation of received data packet. The scheme may be adaptive to the quality of the communication channel(s), with the packet length, encoding scheme, transmit power, bandwidth allocation, data rate and modulation scheme varied in an adaptive scheme to optimize the communication between units. In many cases, units engaged in communication will exchange information bidirectionally. In that case, a full duplex communication protocol is preferred; on the other hand, where communication is unidirectional, greater data communication rates may be achieved employing the available bandwidth and applying it to the single communication session.

In some instances, it may be desired to maintain privacy of communications. In that case, two possibilities are available; spread spectrum communications, preferably direct sequence spread spectrum communications is employed, to limit eavesdropping possibilities. Second, the data itself may be encrypted, using, for example, a DES, PGP, elliptic keys, or RSA type encryption scheme. Keys may be supplied or exchanged in advance, negotiated between partners, or involve a public key-private key encryption algorithm. For example, the spread spectrum communications chip sequence may be based on an encrypted code.

In order to provide flexibility in financing the communications devices, the commercial messages **307** discussed above may be employed. Further, by circulating authorization tokens or codes **203**, a subscription service may be provided. Thus, in a simplest subscription scheme, the communications device has a timer function, which may be a simple clock or GPS referenced. The user must input an authorization code periodically in order for the device to continue operating. Thus, similarly to satellite television receivers and some addressable cable television decoders, failure to provide the authorization code, which may be entered, e.g., by telephone communication or through a keypad **30**, renders the device temporarily or permanently inoperative. In order to reduce the burden of reauthorizations, the authorization codes or tokens may be passed through the communications "cloud" **24**, so that devices **1**, if used, will eventually receive the authorization data. Conversely, a code **203** may be circulated which specifically deactivates a certain device **1**, for example for non-payment of the subscription fee or misuse of the device (e.g., in an attempt to corrupt other users databases). The authorization process is preferably integral to the core operation of the system, making bypassing authorization difficult.

Where a number of communications devices are in proximity, a multi-party communication session may be initiated. For example, the communications subsystem may have simultaneous multi-channel capability, allowing each unit to transmit on a separate channel or use a shared channel. Where the number of channels or channel capacity is insufficient, units may take turns transmitting event information on the same channel (e.g., according to estimated priority), or time division multiplex (TDM) the channel(s). Preferably, the communication scheme involves a number of channels within a band, e.g., 1 common control channel and 24 data communications channels. Since some communication sessions may be relatively short, e.g., limited to a few seconds, a data communications channel preferably has a maximum capacity of tens of kilobits per second or higher. In some cases, hundreds of kilobits, or megabit range bandwidths are achievable, especially with a small number of channels (e.g., one channel). Thus, for example, a DSSS spread spectrum transceiver operating in the 2.5 GHz band might have a usable bandwidth of 10 megabits per second, even while sharing the same band with other transceivers in close proximity. Where necessary, directional antennas or phased arrays may be employed to provide spatial discrimination.

The system preferably has advanced ability to detect channel conditions. Thus, where communications are interrupted by physical limitations in the channel, the impairment to the communications channel is detected and the communications session paused until the impairment abates. This, in turn, will allow other units, which might not be subject to the impairment, to use the same channel during this interval. The channel impairment may be detected by a feedback protocol between communications partners, or by means of symmetric antennas and communications systems, by which an impairment of a received signal may be presumed to affect the transmitted signal as well. The latter requires a high degree of standardization of equipment design and installation for effectiveness.

It is particularly noted that, where the events to be detected and the communications subsystem operate in the same band, structures may be shared between the communications and event detection systems, but this also increases the possibilities for interference.

As one embodiment of the invention, the processor may be provided as a standard personal digital assistant (PDA) with a PC Card or PCMCIA slot for receiving a standard GPS receiver module. The PDA, in turn has memory, which may include random access memory, flash memory, and rotating magnetic memory (hard disk), for example. The PDA also includes a data communications port, which sends data to and controls the communications subsystem, which

may be, for example, model interfacing with, e.g., a cellular telephone or CDPD system. The PDA has a processing system which is capable of running applications written in general purpose, high level languages such as C. The PDA may operate under a standard operating system, such as Microsoft Windows CE, or a proprietary operating system. A software application written in a high level language can normally be ported to run in the PDA processing system. Thus, the basic elements of the hardware platform are all available without customization. In a preferred embodiment, an event sensor is provided, such as a police radar and laser speed detection equipment system (e.g., "radar detector") is provided. This may employ a modified commercially available radar detector, to produce a serial data stream or parallel signal set. For example, radar detectors providing an alphanumeric display often transmit data to the display controller by means of a serial data signal. This signal may be intercepted and interfaced with a serial port or custom port of the PDA.

Optionally, the GPS Smart Antenna is "differential-ready" to apply differential GPS (DGPS) error correction information to improve accuracy of a GPS determined location. The application program for the PDA may be provided in a semiconductor memory cartridge or stored on hard disk.

The PDA **30** includes the processing system, including a microprocessor, memory, pre-coded program instructions and data stored in memory, a microprocessor bus for addresses, data, and control, an interrupt bus for interrupt signals, and associated hardware, operates in a conventional manner to receive digital signals, process information, and issue digital signals. A user interface in the PDA includes a visual display or audible output to present signals received from the processing system to a user, a user entry system to issue signals from the user to the processing system. The user interface may include one or more push keys, toggle switches, proximity switches, trackballs, joysticks or pressure sensitive keys, a touch-sensitive display screen, microphones or a combination of any of the above used together or with other similar type user input methods. The PDA sends digital signals representing addresses, data, and commands to the memory device and receives digital signals representing instructions and data from the memory. A PDA interface electrically connects the processing system to a GPS Smart Antenna. If the PDA and GPS are not integrated, a preferred interface comprises a computer-standard low to medium speed serial data interface, such as RS-232, RS-422, or USB, through a cabled interface for connection to the GPS Smart Antenna.

The GPS Smart Antenna system includes a GPS receiver antenna to receive GPS satellite signals from GPS satellite transmitters, a GPS frequency downconverter to downconvert the approximately 1.575 GHz frequency of the L1 GPS satellite signals to a lower frequency (LF) signal that is suitable for digital processing, and to issue the LF to a GPS processor. The GPS processor demodulates and decodes the LF signal and provides location information for at least one of (i) location of the GPS antenna, (ii), GPS satellite pseudoranges between the GPS satellites and the GPS antenna, (iii) rate of change of location of the GPS antenna, (iv) heading of the GPS antenna, and (v) time to a GPS interface. Optionally, the GPS Smart Antenna and GPS processor are differential-ready. An optional input select switch, controlled by the GPS processor upon a request from the PDA, allows a single serial interface to receive either a control signal from the PDA or a DGPS error correction signal from an optional DGPS radiowave receiver. Alternately, a DGPS-type system may be coordinated between multiple mobile receivers, top provide high relative position accuracy, even where the absolute position accuracy is low. Since the event position calculations are based on the relative position frame, the effect is to accurately position the events with respect to the vehicle.

The user device may display, for example, map features according to a coordinate system such as latitude and longitude. The display may also include an indication of the location of the GPS receiver, an itinerary, proposed route, and indications of the location of various events. By correlating the GPS with a stored map, the absolute location of the vehicle may be determined by map matching techniques. In accordance with the present invention, these events are derived from the event detector or the memory. Other communications devices may also be located on the display.

The user entry system has both touchscreen keys and press keys in the present embodiment. With a touchscreen, a user enters a request by touching a designated portion overlying a visual display with his finger (or soft pointer, such as a plastic pen). The touchscreen senses the touch and causes a digital signal to be sent to the processing system indicating where the touch was made. Switches such as rotary switches, toggle switches, or other switches can equally well be applied. An advantage of the touchscreen is that a label or a placement of the touchscreen, and a corresponding function of the touchscreen, may be changed by the computer controlling the display any number of times without changing electrical or mechanical hardware. In the present embodiment, zoom keys may be employed change scale and resolution of a map on the display. Zooming in decreases the scale, so that the map is viewed with greater resolution over a lesser area of the map. Zooming out increases the scale, so that a greater area of the map is viewed with lesser resolution. A map orientation key selects an orientation of a direction on the map with a direction on the visual display, for example, orientations of north up or current ground track up. It is noted that these map functions are generally known, and known techniques may be generally applied for such map functions. According to the present invention, in addition to normal map functions, the event data may be overlayed on the map to provide additional dimensions of display data. Further, by providing these data, which are dynamic, the map system becomes useful even to travelers who are well aware of the geography and layout of the region being traveled.

A 900 MHz spread spectrum communications system operates as follows. The RF receiver includes an antenna, low noise amplifier (LNA) with a noise temperature below 80 degrees Kelvin and a helical bandpass filter to cancel the image frequency noise. The filtered signal is then downconverted to an intermediate frequency (IF) of about 70 MHz, which is the result of mixing the filtered received signal with a local oscillator signal of between about 832–858 MHz at about 17 dbm. Of course, other tuning frequencies may be selected, for example, to avoid interference with other equipment. The local oscillator thus operates at about 850 MHz and is locked to a reference of 10.625 MHz. The 70 MHz IF frequency is amplified and filtered by a SAW filter **906** with a bandwidth of 1.5–10 MHz, depending on the data signal bandwidth. The IF is then demodulated to baseband, employing a demodulator using an inverse sequence from the transmitted spread spectrum sequence. Thus, in a frequency hopping embodiment, the demodulator synthesizes a signal having the appropriate frequency sequence. In a direct sequence spread spectrum embodiment, the demodulator provides the appropriate pseudorandom code sequence to demodulate the received signal. Time synchronization may

be effected by using the timing functions of the GPS receiver. The demodulated signal is then decoded into messages, which are typically digital bitstreams.

In a 2.4 GHz system, the RF semiconductor technology will typically include gallium arsenide integrated circuits. In a 5.8 GHz system, the RF section semiconductors are preferably silicon germanium. Once demodulated to below about 1 GHz, standard silicon technologies may be employed.

The baseband demodulator may also comprise a digital radio, employing a digital signal processor, receiving a digitized IF signal and outputting a data stream. In this case, it may be preferred to digitize at an IF frequency below 70 MHz. For example, with a data stream having a bandwidth of 1.5 MHz, the preferred IF is 2–10 MHz, with quadrature digitization of the analog signal at that IF. The IF signal may be processed in parallel with a plurality of demodulators, allowing multiple signals to be received simultaneously.

In the 900 MHz embodiment, a PLL, such as a 1.1 gigahertz PLL frequency synthesizer, Part No. MC145190 available from Motorola Semiconductors, Phoenix, Ariz., may be used to generate the first IF. This frequency synthesizer, referenced to the 9.6 megahertz reference frequency, generates a local oscillator signal of approximately 860 megahertz. This PLL synthesizer chip produces a locked stable output signal which is low pass filtered to produce a variable voltage to control voltage control oscillator. VCO is, for example, Part No. MQC505-900 operating at approximately 860 megahertz and available from Murata of Tokyo, Japan. The feedback through sense keeps synthesizer chip stable to produce a stable, fixed course output. A second PLL produces a fine control frequency. The second PLL includes a synthesizer chip, e.g., Part No. MC145170 available from Motorola Semiconductor of Phoenix, Ariz. This PLL frequency synthesizer chip has digital controls for control by a microcontroller. The output of the fine synthesizer chip is low pass filtered to produce a variable DC voltage to control avoltage controlled oscillator, e.g., Part No. MQC309-964, operating within the 900 megahertz band. The fine adjust frequency is band pass filtered with an SAW band pass filter with a center frequency of approximately 38 megahertz. The band pass filter is, for example. Part No. SAF38.9MZR80Z also available from Murata of Tokyo, Japan. The output of the second PLL is controlled in accordance with the output frequency desired based on the frequency of the hop transmitted at the current time. By adjusting the fine frequency, which would be mixed with the coarse frequency, the output frequency in the 900 megahertz band is produced with very little phase noise, very little phase jitter and extremely narrow noise skirt. Thus, this double loop system serves to demodulate the signal to a low IF frequency or to baseband.

There has thus been shown and described novel communications devices and systems and methods which fulfill all the objects and advantages sought therefor. Many changes, modifications, variations, combinations, subcombinations and other uses and applications of the subject invention will, however, become apparent to those skilled in the art after considering this specification and the accompanying drawings which disclose the preferred embodiments thereof. All such changes, modifications, variations and other uses and applications which do not depart from the spirit and scope of the invention are deemed to be covered by the invention, which is to be limited only by the claims which follow.

What is claimed is:

1. An information collection system comprising:

a plurality of mobile units each having a wireless communication device, each mobile unit being associated with a vehicle, means for determining a location of the vehicle, and an output for presenting traffic-related information communicated through the wireless communication device to a user; and

a central monitoring station adapted for transmitting data to and receiving data from at least one of the mobile units,

wherein the wireless communication device of a mobile unit communicates traffic information with the central monitoring station, and communicates prioritized traffic information directly with a corresponding mobile unit in a self-organizing communication network.

2. The system of claim **1** in which the central monitoring station generates a map of traffic conditions based on information transmitted from mobile units installed in vehicles.

3. The system of claim **2** in which the information displayed at the mobile unit is traffic information.

4. An information collection system of claim **3**,

wherein information received by the central monitoring station from the plurality of mobile units includes position and velocity data.

5. The information collection system recited in claim **1** wherein the means that determines location of a vehicle is a Global Positioning Satellite (GPS) system.

6. The information collection system recited in claim **1** wherein the central monitoring station includes a warning generation system which transmits warnings to mobile units installed in vehicles about to enter traffic jams.

7. The information collection system recited in claim **1** wherein the central monitoring station includes a warning generation system which transmits warnings to an Intelligent Vehicle Highway System (IVHS).

8. The information collection system recited in claim **1** wherein communications between mobile units comprise prioritized communications of a plurality of events.

9. The information collection system recited in claim **1** wherein a mobile unit communicates with the central monitoring station through a wireless cellular communications network.

10. The information collection system recited in claim **1**, further comprising an environmental condition sensor, wherein mobile units communicate a sensed environmental condition and a location thereof.

11. The information collection system recited in claim **1** further comprising a graphic user interface.

12. The information collection system recited in claim **1** wherein communications comprise geographically relevant advertisements.

13. An automated traffic mapping system comprising:

a plurality of mobile units installed in vehicles in traffic, each said mobile unit having both a wireless communication device and apparatus that determines location of a vehicle on which it is installed;

processing means in each of said mobile units, said processing means communicating prioritized traffic information to other vehicle mobile units in a self-organizing communication network in a region via said wireless communication device and receiving traffic information from other mobile units in said region via said wireless communication device and processing said location information to evaluate local traffic of said region; and

a central monitoring station receiving location information from a plurality of said mobile units.

14. The automated traffic mapping system recited in claim **13**, further comprising an environmental condition sensor,

wherein mobile units map a sensed environmental condition and a location thereof.

15. A computer implemented method of automated traffic mapping comprising the steps of:

receiving at a central monitoring station information from a plurality of mobile units installed on vehicles;

generating a map of traffic conditions at the central station and transmitting traffic information to the mobile units;

receiving and displaying the traffic information at the mobile units; and

communicating prioritized traffic information by communications which hop between mobile units in a self-organizing communication network.

16. The computer implemented method of automated traffic mapping recited in claim **15**, wherein said communications which hop from one or more mobile units to the central monitoring station are implemented as a store and forward architecture.

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