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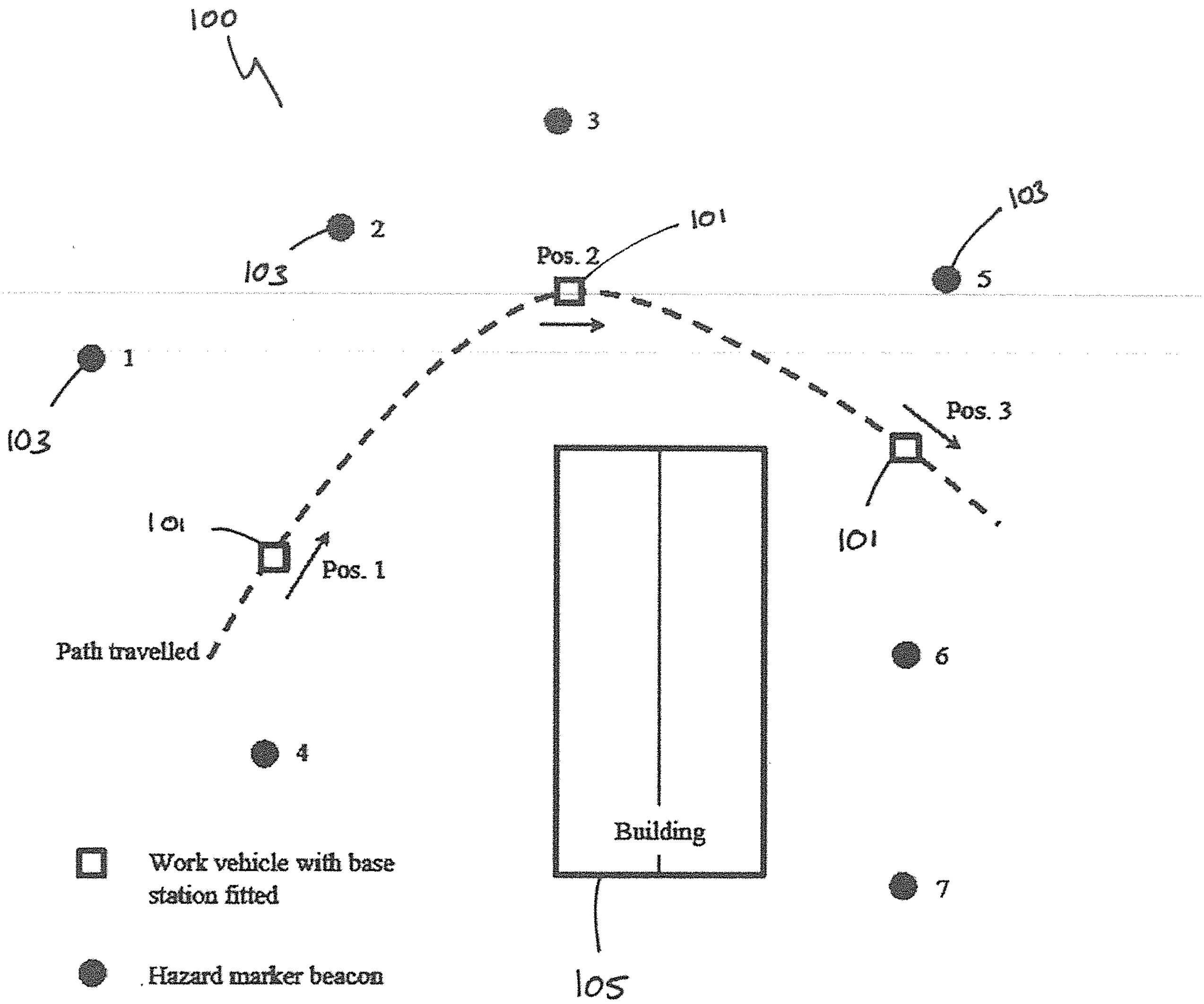
100
3
2
103
101
Pos. 2
103
5
1
103
Pos. 3
101
101
Pos. 1
Path travelled
6
4
Building
Work vehicle with base station fitted
Hazard marker beacon
7
105

Figure 1

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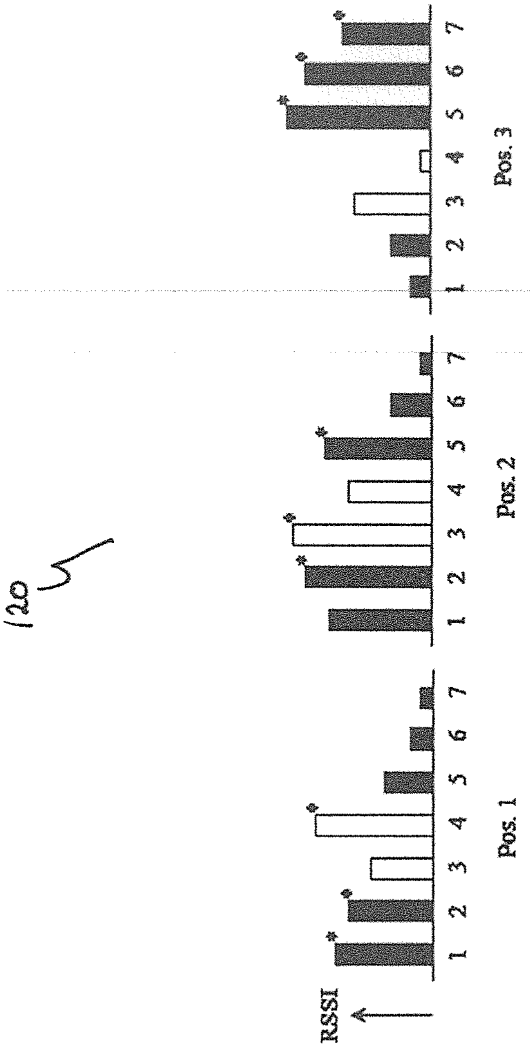

Figure 2

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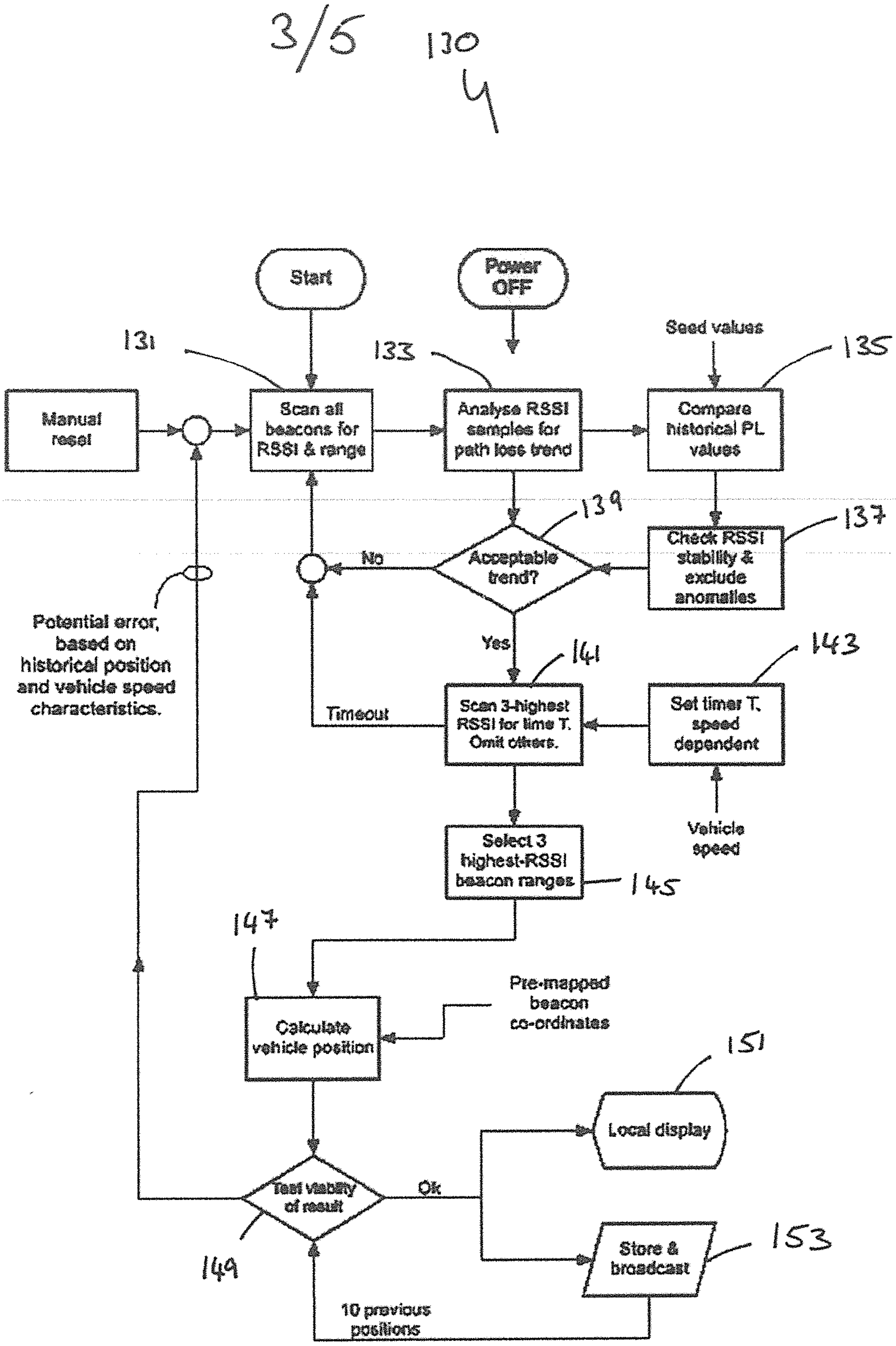
130
Start
Power OFF
Seed values
131
133
135
Manual reset
Scan all beacons for RSSI & range
Analyse RSSI samples for path loss trend
Compare historical PL values
139
137
No
Acceptable trend?
Check RSSI stability & exclude anomalies
Potential error, based on historical position and vehicle speed characteristics.
Yes
141
143
Timeout
Scan 3-highest RSSI for time T. Omit others.
Set timer T, speed dependent
Vehicle speed
Select 3 highest-RSSI beacon ranges
145
147
Pre-mapped beacon co-ordinates
Calculate vehicle position
151
Local display
Test viability of result
Ok
Store & broadcast
153
149
10 previous positions

Figure 3

26 07 17

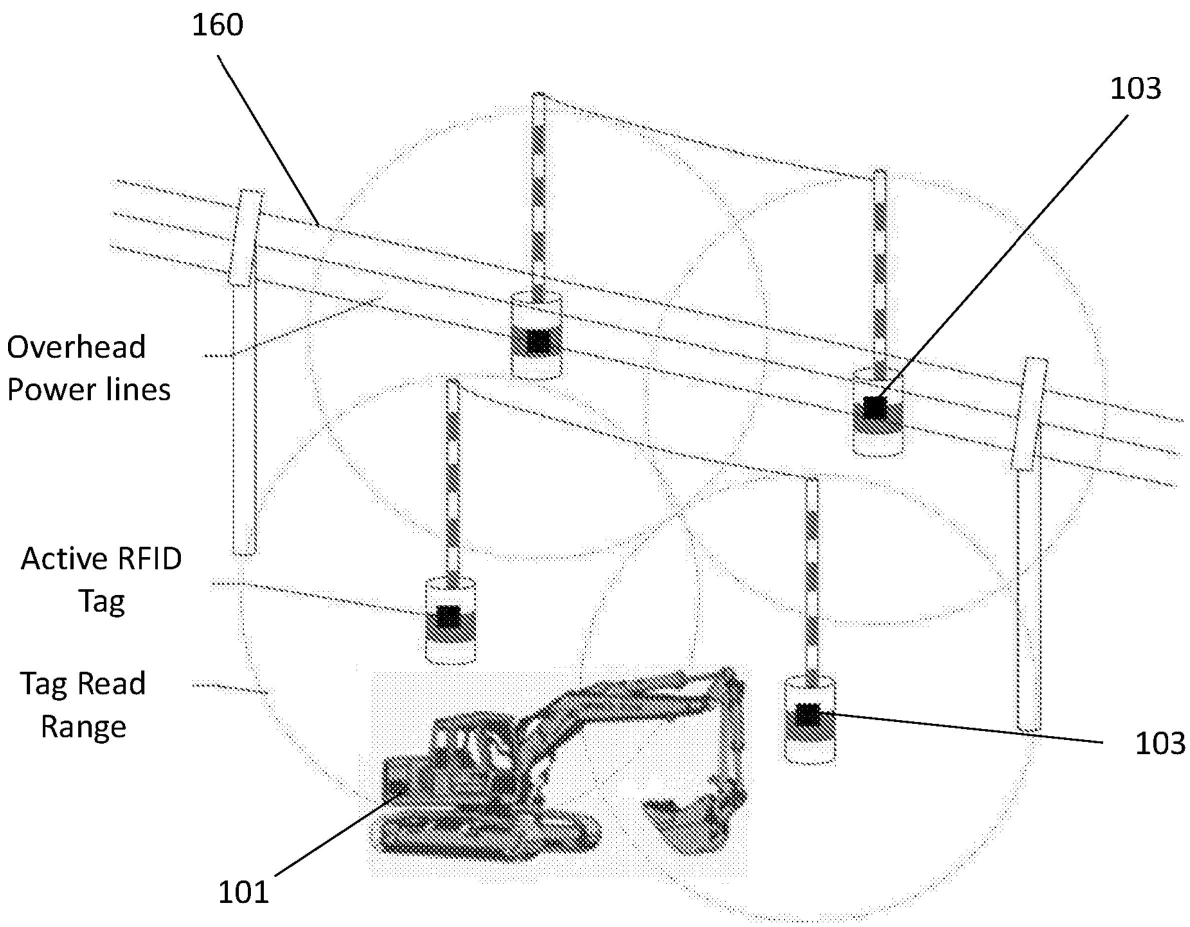

Figure 4

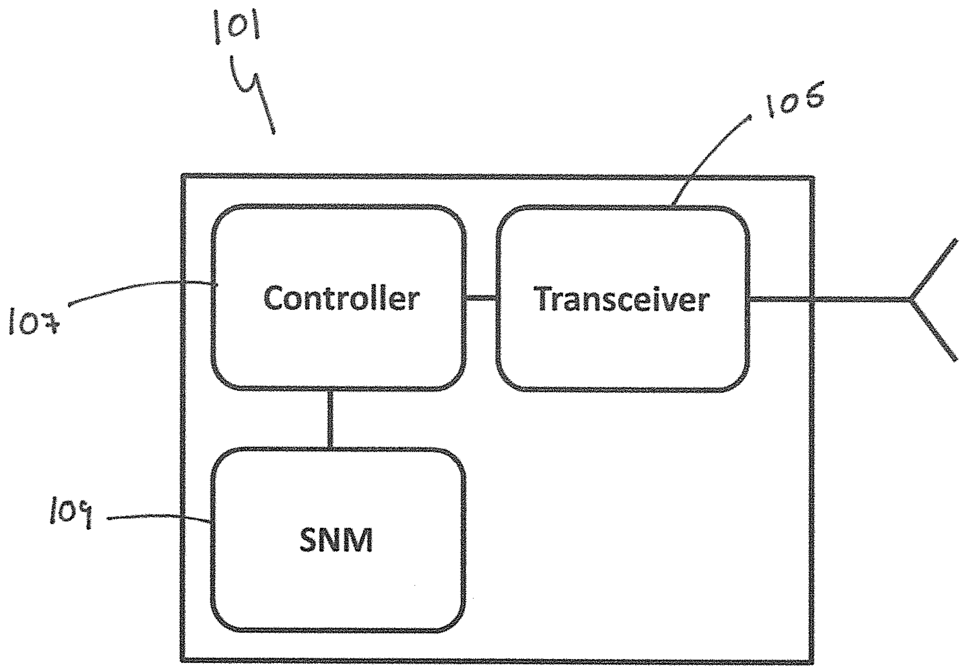

Figure 5

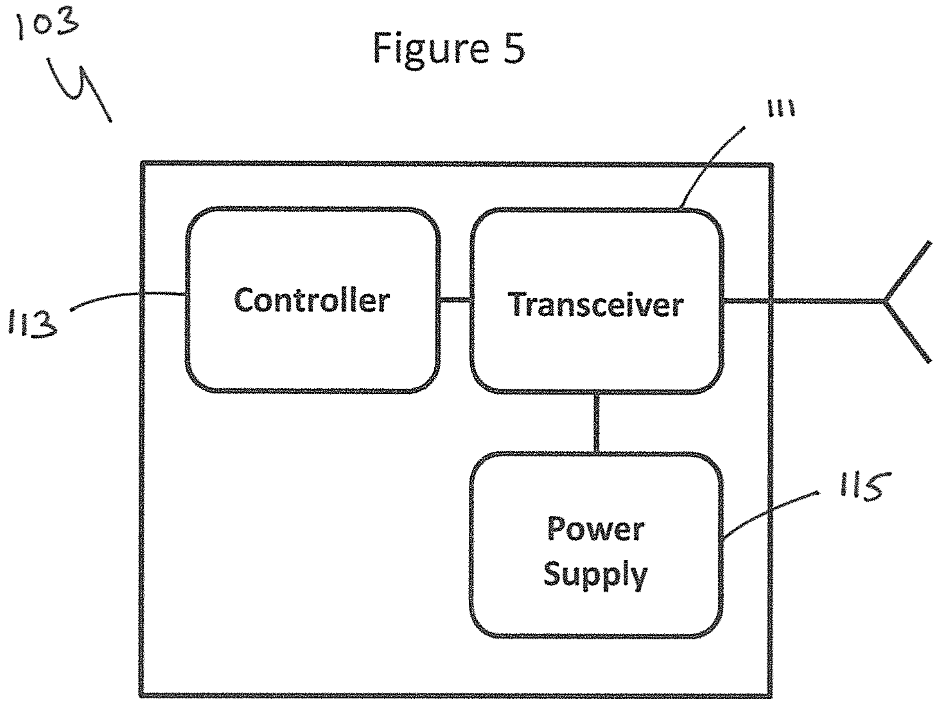

Figure 6

RADIO LOCATOR SYSTEM

FIELD OF THE INVENTION

This invention relates to a radio locator system and in particular to a radio locator system for providing accurate locational, navigational and situational awareness in a defined geometric space.

BACKGROUND TO THE INVENTION

In recent years it has become common practice to use devices which utilise satellite navigation systems such as GPS, GLONASS or BEIDOU to navigate on land, sea and air. These devices have become widely available in both the industrial and commercial markets, and are used by pedestrians navigating city streets, motorists navigating roads and aircraft navigating the airways. The accuracy of these satellite systems range from 7 to 10 metres for GLONASS and 3 to 4 metres for GPS. This accuracy is typically more than sufficient for the tasks described previously; however in environments such as building sites or near cliff edges or electrical systems, or any environment containing potential hazards, this relatively small inaccuracy could have potentially fatal consequences.

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Furthermore whilst the accuracy of the satellite navigation systems themselves may be a cause for concern there are also environmental factors which impact on the accuracy of these systems. For example in urban environments the signal will be subject to propagation anomalies such as blocking, attenuation and/or multipath propagation anomalies which may greatly affect the accuracy of the system, this may manifest in location jittering, where the device jumps between a number of locations rapidly using reflected signals. This inaccuracy further increases the risk in the hazardous environments described previously.

Therefore there exists a need to obviate or mitigate the problems described above by providing a system which allows for increased spatial awareness and positional intelligence relative to identifiable objects such as hazards present in different environments and which also minimises the effects of propagation anomalies which doesn’t require GPS or any other satellite navigation system for navigation.

SUMMARY OF THE INVENTION

Accordingly a first aspect of the invention provides a system for providing locational awareness in a geometric space as recited in claim 1.

Preferably, said one or more characteristics of the secondary signal comprises the RSSI (received signal strength indicator).

Ideally, the master device is configured to alter one or more characteristics of the primary signal in order to determine the nearest slave devices.

Preferably, the master device is configured to transmit the primary signal with one or more characteristics set in order to establish communication with a maximal number of slave devices in the geometric space, preferably by transmitting said primary signal with a maximal range.

Ideally, the master device is configured to alter one or more characteristics of the primary signal such as to establish communication with at least a pre-defined number of slave devices, preferably by reducing the range of said primary signal from an initial, preferably maximal, range.

Preferably, the pre-defined number comprises the three nearest slave devices relative to the master device, and wherein the master device is operable to calculate its location relative to said at least three nearest slave devices using trilateration.

Ideally, the pre-defined number comprises four proximal slave devices wherein the master device is operable to calculate its location using quadrilateration.

Preferably, said one or more characteristic of the primary signal being altered comprises the transmission power.

Ideally, the primary signal is transmitted at periodic intervals.

Preferably, the timing of the periodic intervals at which the master device is configured to transmit the primary signal is determined by programming the controller to transmit for a set number of clock cycles [T],

Optionally, wherein the timing of the periodic intervals at which the master device is configured to transmit the primary signal is determined by monitoring one or more characteristics of the master device and varying the timing of clock cycles based on changes of this characteristic.

Ideally, the characteristics of the master device which are monitored comprise the speed and/or acceleration and/or heading and/or altitude.

Preferably, said secondary signal comprises an identifying signal.

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Ideally, the information provided by the secondary signal comprises the distance of the slave device relative to the master device and/or the time elapsed between transmission of the primary signal and receival of the secondary signal and/or the signal strength of the secondary signal and/or the frequency of the secondary signal.

Preferably, said master device comprises a transceiver such as an RF transceiver coupled to a controller such as a microcontroller or processor or microprocessor.

Ideally, said slave device comprises a transceiver.

Preferably, said slave device comprises a controller such as a microcontroller or processor or microprocessor.

Ideally, said x and y axis are defined in respect of latitude and longitude.

Preferably, where said z axis is defined in respect of altitude, wherein said z axis extends at a 90° angle relative to the x and y axis.

Preferably, the data defining the location of one more identifiable objects comprises location information identifying one or more hazards in the geometric space such as electrical cabling or water pipes.

Ideally, said slave device includes a satellite navigation module which is configured to obtain mapping information via a satellite navigation system such as GPS or GLONASS.

Preferably, the master device is configured to issue an alert upon determination that its location is proximal to one or more objects in said geometric space.

Ideally, said master device is configured to issue said alert by activating one or more audio, haptic and/or visual alarms.

A second aspect of the invention provides a method for determining the nearest slave devices for location calculations by a master device within a defined geometric space as recited in claim 24.

Preferably, said method further comprises determining if a desired trend in the one or more characteristics of the secondary signal(s) is present.

Ideally, said trend comprises an increase or decrease in one or more characteristics of the secondary signal.

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Preferably, said desired characteristic of the secondary signal comprises the Received Signal Strength Indicator (RSSI) of the secondary signals.

Ideally, said method further comprises altering one or more characteristics of said primary signal to determine the most robust secondary signals received.

Preferably, the method further comprises calculating the location of the mater device within the geometric space using the most robust secondary signals received from the plurality of slave devices.

Ideally, the characteristic of the primary signal being altered is the transmission power.

BRIEF DESCRIPTION OF THE DRAWINGS

An embodiment of the invention is now described by way of example and with reference to the accompanying drawings where like numerals may be used to denote like parts and in which:

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Figure 1 is a diagram showing an embodiment of an RF device locator system in situ;
Figure 2 is a bar graph showing one characteristic of a signal received by a master device from a plurality of slave devices at a plurality of positions previously shown in figure 1;
Figure 3 is a flow chart illustrating the operation of the RF device locator system of Figure 1;
Figure 4 is a diagram showing an embodiment of the RF locator system in situ;
Figure 5 is a schematic diagram of an embodiment of the master device;
Figure 6 is a schematic diagram of an embodiment of the slave device(s).

DETAILED DESCRIPTION

Referring now to Figure 1 of the drawings, there is shown, generally indicated by the reference numeral 100, a diagram showing an RF device locator system embodying one aspect of the invention. The system comprises at least one master device 101 and a plurality of slave devices 103. The slave devices 103 are typically positioned such as to define a geometric space. The slave devices 103 may be positioned such as to define an area and/or a volume. The master device 101 is configured to transmit a primary signal which the slave devices 103 are operable to receive and transmit a secondary signal in response. The master device 101 is configured to receive the plurality of secondary signals from the slave devices 103 and using data provided by the secondary signal(s), determine its position in the defined geometric space. Preferably the master device 101 is configured to determine its position relative to one or more identifiable objects 160 (as shown in Figure 4). The preferred system incorporates at least three slave devices 103.

In figure 1 several slave devices 103 are shown indicated with reference numerals 1 to 7. A building 105 is also shown. The building 105 prevents optimum LOS (Line Of Sight) communication between the master device 101 and one or more of the slave devices 103, depending on the position of the master device 101 as it moves from Pos. 1 to Pos. 3, this reduces or otherwise alters the signal strength received at various positions. The primary signal may be transmitted at periodic intervals and typically comprises an interrogation signal. The secondary signal from the plurality of slave devices 105 is typically sent in response to the primary signal. Preferably the secondary signal comprises an identifying signal which allows the master device 101 to determine which slave device 103 it is communicating with. In an alternative embodiment the slave devices 103 may be configured to transmit the secondary signal at periodic intervals.

The master device 101 is configured to monitor the plurality of secondary signals and using information provided by these determine its position, typically relative to one or more identifiable objects 160. The information provided by the secondary signal typically comprises mapping information regarding the location of the slave devices 103 and/or the identifiable objects. The mapping information may include cartesian coordinates as defined by a map or geographical co-ordinates such as the longitude, latitude and altitude of the slave device 103 and/or the distance of the slave device 103 relative to the master device 101 and/or the distance of the slave device 103 to the identifiable objects 160 in the defined geometric space. The identifiable objects 160 typically comprise hazards such as electrical wiring and/or sheer edges or any other hazard. Additionally the information provided by the secondary signal may comprise the time elapsed between transmission of the primary signal and receival of the secondary signal and/or the signal strength of the secondary signal or any other suitable information.

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The master device 101 typically comprises a transceiver 104 such as an RF transceiver or other wireless device(s) for receiving and transmitting wireless signals, which is coupled to a controller 107 such as a microcontroller or processor or microprocessor or any other suitably programmed or configured data processing device. Optionally the master device 101 may be programmed with mapping information regarding the defined geometric space in which it is, or will be, located. Optionally, the master device 101 incorporates a satellite navigation module 109 which is configured to obtain Satellite navigation data via GPS or GLONASS or any other suitable navigation system.

The master device 101 is typically mobile e.g. carried by a vehicle, as is shown in Figure 1, and may be carried by a person or installed in the vehicle as is convenient. The timing of the periodic intervals at which the master device 101 is typically configured to transmit the primary signal may be determined by programming the controller 107 to transmit for a set number of clock cycles [T], and/or, by monitoring one or more characteristics of the master device 101 and varying the timing of clock cycles based on changes of this characteristic. To this end, the characteristics of the master device 101 which may be monitored comprise the speed and/or acceleration and/or heading and/or altitude, or any other suitable characteristic relating to its motion and/or location. Preferably, the characteristic being monitored comprises the speed at which the master device 101 is moving, this is particularly beneficial where the master device 101 is mounted upon or coupled to a moving object such as a vehicle. To this end, the master device 101 may calculate one or more of the desired characteristics based on the change in distance measurements received between periodic sampling of the secondary signal of the slave devices 103. Alternatively, the desired characteristic of the vehicle may be provided by coupling the master device 101 via wired or wireless means to the vehicle, with the master device 101 being operable to obtain the desired characteristic information from one or more gauges or sensors or other indicative devices provided on the vehicle or person. Further alternatively the master device 101 may be able to calculate one or more desired characteristics using the satellite navigation module 109.

The slave device 103 typically comprises a radio frequency device such as an RF transceiver 111; however it may alternatively comprise a transponder or any other suitable wireless device(s) for receiving and transmitting wireless signals. Further alternatively, the slave device 103 may comprise an RFID tag or any other suitable device capable of communicating wirelessly with the master device 101. The slave device 103 is typically a fixed device (i.e. at a fixed location during use, e.g. mounted on a post or other suitable object), however it may alternatively comprise a mobile device which is carried by or mounted on a person or vehicle. The slave device 103 typically comprises a controller 113 such as a microcontroller or processor or microprocessor or any other suitably programmed or configured data processing device.

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The slave device 103 is preferably programmed with mapping information regarding the geometric space in which it is positioned. Preferably the mapping information comprises data indicative of the location of the slave device 103 and/or the identifiable objects 160 in the defined geometric space. Preferably the slave device 103 is configured to transmit the mapping information within the secondary signal. Typically the mapping information comprises data defining a map and/or data defining the location of objects on the map. The map typically has a reference point, such as a point of origin, defined in relation to the defined geometric space. The reference point typically comprises a specific location indicated as (0, 0) on the x and y axis respectively. The x-axis is to be understood as comprising a longitudinal axis which extends substantially parallel to the equator. The y-axis is to be understood as comprising a lateral axis which extends substantially perpendicular to the equator. Each slave device 103, also typically has respective x and y co-ordinate values relative to the initial reference point within the pre-defined map. Additionally the identifiable objects 160 are also plotted on the pre-defined map and have respective pre defined co-ordinates within the map. Further additionally the pre-defined map may comprise a z axis. The z-axis is to be understood as comprising the axis which extends at an approximately 90° angle relative to both the x and y axis. Typically the slave devices 103 and identifiable objects 160 each have pre-determined z co-ordinates. Additionally or alternatively, the slave devices 103 may be programed with locational information regarding the defined geometric space where longtitude, latitude and/or altitude are defined by the x, y and z axis respectively. In a preferable embodiment the mapping information comprises pre-determined values for the slave devices 103 and objects 160 in terms of lattitude, longtiude and/or altitude. In a further alternative embodiment the slave device 103 may incoporate a satellite navigation module which is configured to obtain Satellite navigation data via GPS or GLONASS or any other suitable navigation system. Further alternatively, the slave devices 103 may incoporate a barometer, where the slave device 103 is operable to determine its altitude using the barometer in-use.

The mapping information may also include additional information regarding the identifiable objects 160. Where the identifiable object 160 comprises a hazard, the mapping information may also comprise; data defining any one or more of the type of hazard; specific parameters of the hazard such as voltage etc. Advantageously, the secondary signal transmitted in response to the primary signal by the slave device 103 preferably comprises data indicative of the mapping information provided in the slave device 103.

In an alternative embodiment the master device 101 may be interchanged with at least one of the slave device(s) 103 or vice versa. The slave device 103 typically incorporates a power supply 115 such as a battery however it may alternatively be coupled to an energy harvesting means (not shown) such as a photovoltaic array and/or a piezoelectric generator and/or an aerofoil-powered generator or any other suitable energy harvesting means. Further alternatively the slave device 103 may be coupled to a mains power supply. In a preferred embodiment the slave device 103 incorporates a rechargeable battery such as a NiMh or LiPo or any other suitable rechargeable battery.

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Typically the primary and/or secondary signal(s) are transmitted on an ISM (Industrial, Scientific and Medical) radio band. Preferably the carrier frequency of the primary and/or secondary signal comprises 2.4 to 2.5 GHz. Alternatively the carrier frequency may range from 5.725 to 5.875 GHz, or any other suitable radio band.

In figure 1 the master device 101 is shown carried by a moving object such as a vehicle. The master device 101 is configured to determine its location using data indicative of locational information provided by the secondary signals received from the plurality of slave devices 103. The master device 101 is further configured to communicate with any slave devices 103 in the vicinity to obtain mapping information regarding any identifiable objects 160 in close proximity. To obtain the most accurate location calculation, the most robust signals (e.g. the signal received from one or more slave device with relatively high signal strength compared to the respective signal received from the or each other slave device) from the plurality of slave devices 103 are used. To obtain the most robust secondary signals one or more characteristics of the secondary signals transmitted from the plurality of slave devices 103 in response to the primary signal from the master device 101 may be monitored and compared, with the signals having the most desirable characteristics being used for locational awareness calculations. In a preferred embodiment the characteristic being monitored is the received signal strength (RSSI) however it may alternatively comprise any other suitable characteristic of the secondary signal. Advantageously, the master device is configured to determine its location relative to one or more identifiable objects 160 including its direction of travel relative to the one or more objects 160. Alternatively the master device may determines its location using a satellite navigation module (not shown) incorporated therein

In a first embodiment shown in figures 1 and 2, the secondary signal from three, preferably only three, slave devices 103 is used to calculate the location of the master device 101 via trilateration. Trilateration allows the master device 101 to determine its location relative to at least three slave devices 103. To this end the master device 101 may be programmed or otherwise configured to perform any conventional trilateration algorithm(s) on location information from the respective three signals. Advantageously, the secondary signal incorporates data indicative of locational information regarding the slave device 103 and any identifiable objects 160 in the geometric space, the master device 101 is operable to determine its location relative to one or more identifiable objects 160 using trilateration also. Advantageously whilst more than three values can be used to obtain the locational awareness information with added redundancy, three values are all that are required and by only using the strongest signal received from three slave devices 103, accurate positioning of the master device 101 can be calculated at the fastest rate and at minimum power requirements.

The characteristic of the secondary signal being monitored in figures 1 and 2 is the received signal strength (RSSI), however other characteristics previously mentioned could also be used here. At Pos. 1, the highest values received of RSSI are from slave devices 1, 2, 4 this shows the effect that the building 105 has on the signal being received from the obstructed slave devices 103 and in particular slave devices 5, 6 and 7. Therefore the master device 101 uses the secondary signal from slave devices 1, 2, 4 to determine its location at Pos.1. At Pos. 2, the highest RSSI values received are from slave devices 2, 3, 5 again this shows the effect that the building 105 has on the signal being received as the vehicle incorporating the master device 101 moves along the path shown. The secondary signals from these devices would be used to calculate location of the master device 101 at Pos.2. At Pos. 3, the highest RSSI values received are from slave devices 5, 6, 7 showing that as the vehicle incorporating the master device 101 is now on the opposite side of the building 105 with the signals received from the slave devices 1, 2, 3 and 4 being subject to significant propagation anomalies such as those mentioned previously.

As well as monitoring and comparing characteristics of the secondary signal to determine the most suitable slave device 103 for calculating the location of the master device 101 in the defined geometric space, additionally or alternatively, one or more characteristics of the primary signal transmitted from the master device 101 may be altered to determine the secondary signals with the most desirable characteristics to use for location calculations. Initially the master device 101 may transmit the primary signal with characteristics such that the signal transmits at its widest range establishing communication with the maximum number of slave devices 103 in proximity. Characteristics of the primary signal may subsequently be altered such as to limit its range and thereby reduce the number of available secondary signals received by the master device 101, as without receiving the primary signal, slave devices 103 located at the edges of the defined space will not transmit a secondary signal in response. Typically characteristics of the primary signal 101 may be altered such that the master device is in communication with a pre-defined number of proximal slave devices 103 at any location. In a preferable embodiment the master device 101 is configured to

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establish communication with at least three and/or four slave devices 103. The master device 101 may then calculate its location using the secondary signals received from the pre-defined number of proximal slave devices 103 at that location. As the master device 101 moves within an area it is configured to select the slave devices 103 for location calculation by increasing and decreasing the transmission power of the signal such that the master device remains in communication with the nearest slave devices 103 at various locations. At any one time within the defined space the master device 101 is in communication with at least three slave devices 103, advantageously this provides the master device 101 with a reference point at all times in the geometric space. Preferably the characteristic of the primary signal being varied is the transmission power however additionally or alternatively the amplitude and/or frequency or any other suitable characteristic may be varied. Other factors which may affect the range of the primary signal include the transmit and receive antenna gain, receiver sensitivity (use a low-noise amplifier to increase), any losses deliberately introduced to the signal path.

In a preferred embodiment the master device 101 comprises a Nanotron® radio, typically incorporating characteristic varying functionality, typically comprising transmission power varying functionality. Alternatively, the master device 101 may incorporate an attenuator (not shown) which is configured to alter one or more characteristics of the primary signal to determine the secondary signals with the most desirable characteristics to use for location calculations. Typically the master device 101 and/or attenuator may be configured to reduce the power or amplitude or any other suitable characteristic of the primary signal such as to limit the range of the primary signal, thereby restricting the slave devices 103 which may receive the primary signal to those in close proximity. In a preferred embodiment the attenuator comprises a PIN diode however it may alternatively comprise any other suitable attenuator. In a preferable embodiment the transmission power may be varied between at least -30dBm to +30 dBm. In a preferred embodiment the transmission power is typically varied between -22 to +16 dBm.

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In preferred embodiment, the master device 101 is operable to continuously communicate with the slave devices 103 until it determines that the location calculated remains the same for a set number of clock cycles, whereupon it will enter a rest mode. In rest mode the master device 101 may be configured to re- calculate its position at set time intervals, if any change in location information is determined then the system will restart, and begin scanning at maximum range as described previously. Advantageously, the master device 101 is typically configured to store information from each slave device 103 which it detects thereby allowing the master device 101 to re-use this historical information when in proximity to these slave devices 103 reducing both time and power requirements necessary to determine location information.

The master device 101 typically calculates its location using the secondary signals from three or four slave devices 103. Advantageously where the master device 101 is in communication with at least four slave devices 103 it may calculate its location using quadrilateration. To this end the master device 101 may be programmed or otherwise configured to perform any conventional quadrilateration algorithm(s) on location information from the respective four signals. Advantageously, quadrilateration allows the master device 101 to determine its location within a geometric volume. Quadrilateration is to be understood to mean, that where the master device 101 is in communication with at least four slaves devices 103 with each slave device providing data indicative of locational information regarding the defined geometric volume, the master device 101 is operable to plot its location within a 3D model using the Cartesian co-ordinates provided by the mapping information incorporated within the slave device 103 as defined in relation to the pre-defined map having x, y and in this case z axis. Advantageously, this allows the master device 101 to determine its location within the defined geometric volume relative to the slave devices 103 and/or identifiable objects 160. This is particularly advantageous in geometric spaces where identifiable objects 160, comprising hazards may be located at specific heights in-use, as it will allow vehicles which have the master device 101 coupled thereto to determine how close they are to a particular hazard 16 at any given time, at any location within the space. This is in comparison to the use of at least three secondary signals and trilateration to calculate the location of the master device 101 as this method provides locational information on the x and y axis as defined by the pre-defined map.

Typically the signals received from the slave device 103 may undergo one or more signal processing techniques such as filtering to ensure any rogue signals are removed to allow for accurate location calculations. Optionally the signals may undergo transversal, Kalman or any other similar filtering method. The characteristics of the primary signal which may be altered may comprise the signal strength and/or signal power and/or frequency and/or amplitude and/or any other suitable characteristic.

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Referring now to figure 3 there is shown a flowchart illustrating an example of the operation of the RF locator system of Figures 1 and 2. Initially after start-up all slave devices in the system are scanned and their characteristics such as range and/or RSSI values are stored for processing 131. In this embodiment the characteristic used is RSSI however this is interchangeable with other signal characteristics described previously. The RSSI values are then analysed 133 and, may if available be compared with historical RSSI values for the area 135, advantageously the use of historical values may save processing time upon initiation of the system 130. Following the analysis of the RSSI values at 133 and possibly 135 the values are then typically verified for stability with any anomalies being removed to ensure data accuracy 137.

Following the analysis of the RSSI values at 133, 135 and 137 the values are then assessed as to whether there is an acceptable trend present, in that three strong RSSI values have been obtained from at least 3 slave devices 103, if this is not the case then the steps of 131, 135, 138 and 139 may be repeated sequentially until an acceptable trend is found. If an acceptable trend is determined at 139 then the three slave devices with the highest RSSI values only, will be scanned for a set period of time T before waiting for a number of cycles before scanning again, the duration of the time period T which may be programmed to correspond to a number of clock cycles or alternatively it may be dependent upon the speed of the vehicle 101 (as shown in figure 1), where a clock 143 may be coupled to the master device 101 and where the faster the speed of vehicle 101 the more regular the periods of T and the fewer wait cycles. Subsequent to determination of the desired RSSI values 145, the vehicles 101 position may be calculated 147. This may be achieved using co-ordinates provided by the secondary signal from at least three of the slave devices 103.

Once the vehicle’s 101 position has been determined, it is tested to ensure its viability 149, if this is found to be correct then the position may be displayed on a display 151 and/or it may stored within the master device 101 and broadcast 153 to the slave devices 103 where again the viability of the results may be tested to ensure the accuracy of the location information 149. If the result of the vehicle location test determines that the vehicle is near a hazard 160 it is configured to alert the user typically by one or more audio and/or visual alarms (not shown) Typically the audio alarms may comprise a sounder or buzzer or any other suitable audio alarm. The visual alarm may comprise one or more LEDs or displays or any other suitable visual alarm. If the result of the vehicle location test is found to be in error then the system 130 will reset and a new scanning 131 will occur along with the previously described steps being repeated.

Figure 4 shows an example of the master device 101 being coupled to a vehicle, with a plurality of slave devices 103 located nearby. In this embodiment the master device 101 is operable to calculate its location via trilateration with the four slave devices 103 shown providing mapping information regarding the defined geometric area. As the mapping information provided by the slave devices 103 contains information regarding potential hazards 160 in the area, the master device will be alerted to the identifiably object 160, in this case comprising overhead cabling, upon entering into close proximity.

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In the described embodiments the system 100 is typically provided upon land with the master device 101 typically coupled to a land vehicle or person, with the slave devices 103 positioned within or around a geometric space. In alternative embodiments the system may be provided upon water or in the air. For example the master device 101 may be coupled to a ship or plane or drone with the slave devices 103 being located on the sea using a flotation device or in the air using an airborne device.

A second aspect of the invention is embodied by a method for determining a plurality of proximal slave devices 103 for calculation of location information by the master device 101 within the defined geometric space, the method comprising:

Transmitting a primary signal from the master device 101;
Receiving the transmitted signal at a plurality of slave devices 103;
Transmitting a respective secondary signal in response to the primary signal from the slave devices 103;
Receiving the secondary signal at the master device 101;
Calculating the location of the master device 101 within the geometric space using the secondary signals received from the plurality of nearest slave devices 103.

CLAIMS

1. A system for providing locational awareness in a geometric space comprising:

A master device;
A plurality of slave devices;
Said master device being operable to transmit a primary signal;
Said slave devices being operable to receive said primary signal and transmit a secondary signal in response;
Wherein said master device is configured to receive said plurality of secondary signals;
Wherein said master device is configured to monitor and compare one or more characteristics of the secondary signals received from the plurality of slave devices to determine the at least three nearest slave devices relative to the master device at any one time,
Wherein said master device is configured to determine its location relative to said at least three nearest slave devices in said geometric space using data provided by the one or more secondary signals;
Wherein said slave devices are programmed with mapping information comprising data defining a map of the geometric space in which they are positioned and the location of one or more objects within said geometric space on said map;
Wherein said data defining a map comprises a pre-defined map having Cartesian co-ordinates wherein a reference point is defined in relation to the defined geometric space;
Wherein the location of the slave devices and the identifiable objects are also defined on said map in relation to said reference point along x, y and z axis; and;
Wherein said mapping information is incorporated within said secondary signal.

2. The system as claimed in claim 1, wherein said one or more characteristics of the secondary signal comprises the RSSI (received signal strength indicator).

3. The system as claimed in any claim 1, wherein the master device is configured to alter one or more characteristics of the primary signal in order to determine the nearest slave devices.

4. The system as claimed in any preceding claim, wherein the master device is configured to transmit the primary signal with one or more characteristics to establish communication with the maximum number of slave devices in the geometric space.

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5. The system as claimed in claims 3 to 4, wherein the master device is configured to alter one or more characteristics of the primary signal such as to establish communication with at least a pre-defined number of slave devices,.

6. The system as claimed in claim 5, wherein the pre-defined number comprises the three nearest slave devices relative to the master device at any one time and wherein the master device is operable to calculate its location relative to said at least three nearest slave devices using trilateration.

7. The system as claimed in claim 5, wherein the pre-defined number comprises four proximal slave devices wherein the master device is operable to calculate its location using quadrilateration.

8. The system as claimed in claims 5 to 7, wherein the characteristic of the primary signal being altered comprises the transmission power.

9. The system as claimed in any preceding claim, wherein the primary signal is transmitted at periodic intervals.

10. The system as claimed in claim 9, wherein the timing of the periodic intervals at which the master device is configured to transmit the primary signal is determined by programming the controller to transmit for a set number of clock cycles [T].

11. The system as claimed in claim 9, wherein the timing of the periodic intervals at which the master device is configured to transmit the primary signal is determined by monitoring one or more characteristics of the master device and varying the timing of clock cycles based on changes of this characteristic.

12. The system as claimed in claim 11, wherein the characteristics of the master device which are monitored comprise the speed and/or acceleration and/or heading and/or altitude.

13. The system as claimed in any preceding claim, wherein said secondary signal comprises an identifying signal.

14. The system as claimed in any preceding claim, wherein the information provided by the secondary signal may comprise the distance of the slave device relative to the master device and/or the time elapsed between transmission of the primary signal and receival of the secondary signal and/or the signal strength of the secondary signal and/or the frequency of the secondary signal.

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15. The system as claimed in any preceding claim, wherein said master device comprises a transceiver such as an RF transceiver which is coupled to a controller such as a microcontroller or processor or microprocessor.

16. The system as claimed in any preceding claim, wherein said slave device comprises a transceiver.

17. The system as claimed in claim 16, wherein said slave device comprises a controller such as a microcontroller or processor or microprocessor.

18. The system as claimed in claim 1, wherein said x and y axis are defined in respect of latitude and longitude.

19. The system as claimed in claim 1, where said z axis is defined in respect of altitude, wherein said z axis extends at a 90° angle relative to the x and y axis.

20. The system as claimed in any claims any preceding claim, wherein the data defining the location of one more identifiable objects comprising contains location information identifying one or more hazards in the geometric area such as electrical cabling or water pipes.

21. The system as claimed in any preceding claim, wherein said slave device includes a satellite navigation module which is configured to obtain mapping information via a satellite navigation system such as GPS or GLONASS.

22. The system as claimed in any preceding claim, wherein the master device is configured to issue an alert upon determination that its location is proximal to one or more objects in said geometric space.

23. The system as claimed in claim 22, wherein said master device is configured to issue said alert by activating one or more audio, haptic and/or visual alarms.

24. A method for determining the nearest slave devices for location calculations by a master device within a defined geometric space as per the system of claim 1, the method comprising the steps of;

    Transmitting a primary signal from the master device;
    Receiving the transmitted signal at a plurality of slave devices;
    Transmitting a respective secondary signal in response to the primary signal from the slave devices;
    Receiving the secondary signal(s) at the master device;

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Comparing one or more characteristics of the secondary signals received from the plurality of slave devices;

Determining the at least three nearest slave devices relative to the master device at any one time;

Calculating the location of the master device within the geometric space using the secondary signals received from the at least three nearest slave devices;

Wherein said slave devices are programmed with mapping information comprising data defining a map of the geometric space in which they are positioned and the location of one or more objects within said geometric space on said map;

Wherein said data defining a map comprises a pre-defined map having Cartesian co-ordinates wherein a reference point is defined in relation to the defined geometric space;

wherein the location of the slave devices and the identifiable objects are also defined on said map in relation to said reference point along x, y and z axis; and;

Wherein said mapping information is incorporated within said secondary signal.

25. The method as claimed in claim 24, wherein said method further comprises determining if a desired trend in the one or more characteristics of the secondary signal(s) is present.

26. The method as claimed in claim 24 wherein said trend comprises an increase or decrease in one or more characteristics of the secondary signal.

27. The method as claimed in claims 24 to 26, wherein said desired characteristic of the secondary signal comprises the Received Signal Strength Indicator (RSSI) of the secondary signals.

28. The method as claimed in any preceding claim, wherein said method further comprises altering one or more characteristics of said primary signal to determine the most robust secondary signals received.

29. The method as claimed in claim 28, wherein the method further comprises calculating the location of the mater device within the geometric space using the most robust secondary signals received from the plurality of slave devices.

30. The method as claimed in claims 28 to 29, wherein the characteristic of the primary signal being altered is the transmission power.

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