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(54) **Title:** GNSS RECEIVER USING SIGNALS OF OPPORTUNITY AND ASSISTANCE INFORMATION TO REDUCE THE TIME TO FIRST FIX

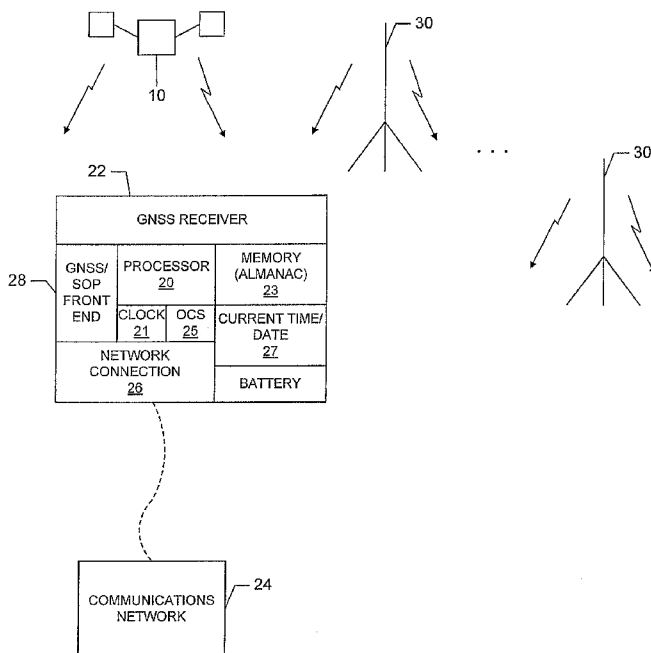


FIG. 1

(57) **Abstract:** A GNSS receiver reduces the time to first fix by utilizing the properties of existing radiated signals of opportunity, such as AM or FM radio signals, television signals and so forth, to reduce the uncertainties associated with oscillator frequency and phase, and further utilizing an Almanac and battery backed-up date and time to determine the satellites in view and reduce the uncertainties associated with Doppler. The receiver may use multiple signals of opportunity to determine the city or local area in which the receiver is located based on the set of frequencies of the signals, and also to reduce search uncertainties for oscillator frequency by estimating an offset based on the differences between the frequencies of the respective signals of opportunity at the receiver and the nominal broadcast frequencies of the signals.

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GNSS RECEIVER USING SIGNALS OF OPPORTUNITY AND ASSISTANCE INFORMATION TO REDUCE THE TIME TO FIRST FIX

CROSS-REFERENCE TO RELATED APPLICATIONS

5 The present application claims the benefit of U.S. Provisional Patent Application Serial No. 61/055,189, which was filed on May 22, 2008, by Jonathan Ladd and Patrick Fenton for a GNSS RECEIVER USING SIGNALS OF OPPORTUNITY AND ASSISTANCE INFORMATION TO REDUCE THE TIME TO FIRST FIX and is hereby incorporated by reference.

10 BACKGROUND OF THE INVENTION

Field of the Invention

The invention relates generally to GNSS receivers and methods of operating the GNSS receivers to reduce both time to first fix and receiver radio frequency (RF) bandwidth.

Background Information

15 When acquiring GNSS satellite signals, receivers perform searches that involve uncertainties related to satellite selection, Doppler frequency and receiver oscillator frequency. Generally, the search involves cycling through all possible satellite selections, and for each satellite successively trying possible frequencies and code phase delays in an attempt to obtain frequency and code lock with the satellite
20 signal. At each combination of frequency and code phase delay, the receiver determines correlation power to check if the satellite signal has been acquired. the

process must be performed for each satellite in the search strategy, since each satellite transmits a unique code and is associated with a different relative motion with respect to the receiver. This exhaustive search is thus time consuming.

The uncertainties related to satellite selection could be solved by use of a valid Almanac of orbiting satellites, the true time of day from a clock driven by the receiver oscillator, and an approximate location of the receiver. From the Almanac, the time and the position information, the receiver can determine the satellites in view and compute their expected Doppler frequency offsets. However most receivers, after a power down cycle, do not maintain a valid position or a sufficiently accurate time.

Without the Almanac, accurate time and also a valid position, the receiver must cycle through all possible satellites in its search strategy, as discussed above. Even with the Almanac, and sufficiently accurate time and position information, the search is still subject to clock frequency uncertainties, which makes even a more limited search strategy time consuming. Further, if the receiver has moved during power down, the retained position may no longer be sufficiently valid for the computation of satellites in view and/or expected Doppler frequency.

The uncertainties related to Doppler frequency and receiver oscillator frequency require that the searches are extended by $\pm 4\text{kHz}$ for Doppler and $\pm 12\text{kHz}$ for oscillator frequency. The magnitude of the oscillator frequency uncertainty is a function of the type of oscillator or timing crystal used in the receiver. The more precise (and usually more costly) the oscillator is, the less uncertainty there is in its generated frequency. The typical oscillators used in GNSS receivers have between 5 to 10 parts per million (ppm) frequency uncertainty due to temperature and aging affects, and 10 ppm equates to additional $\pm 16\text{kHz}$ Doppler uncertainty.

Contending with either or both of the Doppler and oscillator frequency and phase uncertainties results in a longer time to first fix (TTFF), which is the time required by a GNSS receiver to achieve a position solution and typically involves acquiring and tracking the signals from at least four GNSS satellites. The oscillator
5 frequency uncertainty further requires a wider radio frequency (RF) bandwidth for tracking, which adversely affects the tracking of weaker satellite signals due to increased susceptibility to RF interfering signals.

To reduce the TTFF, known prior GPS receivers, such as the receiver described in United States Patent 5,663,735 to Eshenbach, may utilize data that are
10 modulated onto special purpose radio signals, such as, for example, time announcements that are modulated onto National Institute of Standards and Technology (NIST) radio signals. The GPS receivers utilize the time announcements to determine a transition time between two data bits modulated onto a GPS satellite signal that is being acquired and, in turn, determine GPS time. Further, the GPS
15 receivers may also use frequency information that is modulated onto the NIST radio signal to remove the uncertainty in the receiver oscillator frequency, although the phase uncertainties of the oscillator driven clock remain. One of the problems with such GPS receivers, however, is that the NIST radio signals may not be available at certain locations. Further, even if NIST radio signals are available, the content
20 modulated onto the signals does not provide information that the GPS receiver can use directly to estimate its location.

SUMMARY OF THE INVENTION

A GNSS receiver utilizes the properties of existing radiated signals of opportunity, such as AM or FM radio signals, television signals and so forth, to reduce the uncertainties associated with oscillator frequency and the oscillator driven clock phase uncertainty. Further, the GNSS receiver utilizes assistance in the form of a stored Almanac orbiting satellite and battery backed-up date and time, to reduce the uncertainties associated with Doppler.

The GNSS receiver may also use the properties of multiple signals of opportunity to determine the city or local area in which the receiver is located in order to provide a sufficiently accurate position estimate (to within 100 kilometers) to enable the use of the Almanac. The receiver may, for example, determine the city or local area based on the set of signal frequencies, as discussed in more detail below.

Once the city or local area in which the GNSS receiver is located is known, the GNSS receiver may use the nominal or published frequencies of the local signals of opportunity to determine an estimate of oscillator frequency offset. The GNSS receiver thus determines the difference between the frequency of a signal of opportunity at the remote receiver and the nominal frequency of the signal of opportunity, and uses the difference as an estimate of the oscillator frequency offset, to eliminate or at least substantially reduce the associated $\pm 12\text{kHz}$ search uncertainty.

In addition, the GNSS receiver may use the city or area location information and the stored time and date to enter the stored Almanac, and determine the satellites in view thereby reducing the exhaustive satellite search to searching only for the satellites currently visible. Further, the receiver can also compute associated

estimated Doppler offsets, to eliminate or at least substantially reduce the $\pm 4\text{kHz}$ search extension for Doppler.

The time to first fix (TTFF) is thus reduced considerably, since the receiver is searching only for visible satellites, and the search windows need no longer
5 accommodate the large uncertainties associated with Doppler and oscillator frequency.

When tracking, the GNSS receiver may phase lock to the carrier of the signal of opportunity, and use the radio or television station clock to stabilize the receiver oscillator. The GNSS receiver can then use a narrower band during tracking, which
10 allows the receiver to track weaker GNSS signals.

The GNSS receiver may be included in a system that utilizes a base GNSS receiver which has a known position and sufficiently clear view of the sky over at least a substantial portion of a local area. The base GNSS receiver may provide navigation message data and data symbol boundary information to the remote
15 receiver. The remote receiver utilizes the data and boundary information to perform data "wiping," which allows use of longer integration periods during acquisition, and thus, acquisition of weaker satellite signals. In addition, the base GNSS receiver may provide the city or local area information to the remote GNSS receiver as assistance information, and the GNSS receiver can then determine which signals of opportunity
20 are in the area, and/or use the information along with the stored time and date to enter the Almanac. The base receiver may also provide more precise broadcast frequencies of the local signals of opportunity and/or locations of the transmitters to the remote receivers for improved performance.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention description below refers to the accompanying drawings, of which:

Fig. 1 is a functional block diagram of a GNSS receiver constructed in accordance with the invention; and

Fig. 2 is a functional block diagram of a system constructed in accordance with the invention.

DETAILED DESCRIPTION OF AN ILLUSTRATIVE EMBODIMENT

Referring to Fig. 1, a remote GNSS receiver 22 is illustrated connected to a communication network 24, such as, for example, the internet or a private network, through a connection 26, which may be wired (indicated by dotted line) or wireless. The remote receiver includes one or more processors 20, an oscillator 25 and an oscillator driven time of day clock 21 that perform GNSS signal acquisition and tracking and provide position solutions in a known manner. In addition, the remote receiver includes a battery-backed real time clock (RTC) 27 that maintains the current time and date during power down cycles and a memory 23 that contains an Almanac of GNSS satellite information. The real time clock, which operates in a known manner utilizing a low power oscillator and low power timing keeping logic, maintains the current time and date during power down cycles utilizing relatively little battery power. The Almanac, which is good for approximately 1 year without updating, and the current time and date are utilized to reduce the time to first fix, as discussed in more detail below.

The remote receiver 22 includes a radio frequency (RF) front end 28 that receives signals from GNSS satellites, represented collectively by reference numeral

10 in the drawing, and also receives signals broadcast from multiple high power radiators such as local radio and television station transmitters, Beacon or Loran transmitters, and so forth, which are represented collectively by reference numeral 30 in the drawing. The broadcast signals, which are selected due to their quality of
5 signal, known transmission locations, and continuous broadcast, are "signals of opportunity," that is, signals that are broadcast at various frequencies and for purposes such as the transmission of random conversation or dialog. This is in contrast to GNSS signals, for example, which are broadcast at the same frequencies by the GNSS satellites and carry particular codes. Further, in contrast to known systems, the
10 current system utilizes properties of the signals of opportunity and does not utilize the data or content of information modulated onto the broadcast signals. The current system does not, for example, utilize transmitted time of day information contained in the broadcast signals. The high-power radiators 30 are referred to hereinafter as the "SOP transmitters."

15 The remote receiver 22 may utilize the signals of opportunity directly to determine in which city or area the receiver is located. The remote receiver thus scans for the signals of opportunity and then checks which city or local area has, for example, radio and television transmitters that are transmitting using the same set of frequencies.

20 The locations of the SOP transmitters 30 are usually known or can be readily determined from the information provided by a registration authority, such as, for example, the U.S. Federal Communications Commission or FCC. The information may be available, for example, over the internet or the private network 24 or retained in memory 23 as part of stored area maps. The network 24 may also provide the
25 remote receiver with a list of usable local signals of opportunity, or the receiver may

select particular signals of opportunity, for example, based on the field strengths of the signals at the receiver, and/or the stability of the carrier frequencies, and so forth. Alternatively, the list of usable local signals of opportunity may be supplied to the receiver by a user over a user interface (not shown), such as, for example, a keyboard
5 or screen. Similarly, the user may supply the locations of the signal of opportunity transmitters to the receiver over the user interface. In addition or in the alternative, the user may provide the receiver with the city or local area of operation.

Notably, the broadcast signals are of sufficiently low frequency and higher signal power to have excellent building penetration. Thus, the remote receiver need
10 not have a particularly good view of the sky, but instead must have relatively good reception of the selected broadcast signals of opportunity. Further, the use of such low frequency signals allows the receivers to scan with configurable front end filters, such as charged capacitor filters or digital FIR filters, to find the best signal of opportunity candidates.

15 Once the remote receiver 22 has determined a city or local area, and thus, an approximate location to within at least 100 kilometers, the remote receiver may use the stored almanac and the stored time and date information to determine which satellites are then in view and also estimate satellite Doppler frequency offsets. This eliminates or substantially reduces the associated $\pm 4\text{kHz}$ uncertainty in searching for
20 the GNSS satellite signals.

The remote receiver may also utilize the signals of opportunity to reduce the $\pm 12\text{kHz}$ uncertainty associated with oscillator frequency offset. The receiver thus determines the difference between the frequency to which it tunes to receive a strong signal of opportunity and the nominal, or published, frequency of the signal of
25 opportunity. One of the signals of opportunity may, for example, be a radio station

that nominally transmits at 1030 kHz, and the receiver may tune to a frequency that differs slightly to receive the signal. The receiver then uses the difference between the received and nominal frequencies as an estimated receiver oscillator frequency error or offset. The receiver may also do the same for other local strong signals of opportunity and, based on the average difference between the respective frequencies at the receiver and the nominal frequencies, estimate its oscillator frequency offset. The estimated offset can then be used to essentially eliminate the associated ± 12 kHz search window extension typically associated with unknown oscillator offsets, though a time of day clock phase uncertainty still exists.

10 The remote receiver can thus significantly reduce its time to first fix (TTFF) using the stored Almanac and time and date information, and the oscillator frequency offset of the estimates that are based on local signals of opportunity.

The remote receiver 22 can also phase lock to the carrier of a local radio or television signal of opportunity, and use the radio or television station clock to stabilize the receiver oscillator 25. For example, the remote receiver may use the zero crossings or timing pulses of the television signals to stabilize the receiver oscillator. The receiver can then use a narrower band tracking loop to track weaker GNSS signals, since the signal-to-noise ratio increases with the use of the narrower band. Further, the receiver may utilize an inexpensive oscillator and still achieve improved tracking, by remaining phase locked to the local signal of opportunity.

Referring now to Fig. 2, a system for use with the remote receiver 22 includes a base GNSS receiver 32 that has a clear view of the sky over at least a portion of the area covered by the system and can readily acquire and track GNSS satellite signals. The base receiver has a known position, determined either from the GNSS satellite signals in view or, alternatively, during installation by, for example, a hand-held GPS

unit, a survey and/or through use of topological maps. The base receiver acquires and tracks the signals from the GNSS satellites in view and may provide GNSS time and/or frequency information to the remote receiver, to assist the remote receiver in reducing TTFF. The base GNSS receiver is shown in the drawing connected to the communications network 24. Alternatively, the base receiver 32 may be configured to transmit signals directly to and/or receive signals directly from the receiver 22.

Alternatively or in addition, the base GNSS receiver 32, with its oscillator synchronized to GNSS frequency, may measure the exact broadcast frequencies of the signals of opportunity and transmit the carrier frequencies to the remote GPS receiver 22 either directly or over the communications network 24. Using the frequency information, the remote receiver can more precisely control the frequency of its oscillator by phase locking to the exact broadcast frequency of a strong signal of opportunity.

Further, the use of the precise frequencies eliminates an associated Doppler frequency uncertainty. Typically the AM/FM stations broadcast signals of opportunity at frequencies that are within a 1 or 2 parts per million offset of their nominal broadcast allotted frequency. A 2 parts per million broadcast frequency error will result in a $\pm 3\text{kHz}$ Doppler frequency uncertainty for acquiring GNSS signals, and the use of the precise frequencies as determined by the GNSS base station eliminates this uncertainty.

In addition, the base GPS receiver 32 may supply the Almanac to the remote receiver 22, such that the remote receiver need not maintain the Almanac during power down cycles. Also, the base GNSS receiver may provide to the remote receiver navigation messages and the data symbol boundaries for the respective GNSS satellites in view. The data symbol boundaries are the times at which the data

symbols in the navigation message are transmitted by the GNSS satellites. Using the data symbols and the symbol boundary information, the remote receiver can "wipe" the data off of the received satellite signals, that is, the receiver can compensate for the corresponding phase changes during correlation operations. The wiping allows the remote receiver to integrate correlation measurements over longer periods, that is, integrate beyond the data symbol boundary times. The receiver can thus acquire weaker GNSS signals, such as signals that are weakened by multipath or are partially blocked by buildings or foliage.

Also, the navigation messages may be made available to the remote receiver at an earlier time than the receiver can obtain the messages from the GNSS satellite signals, and this allows the remote receiver to more accurately determine the locations of the GNSS satellites that are required to compute the position solution during the TTFF. Using the navigational messages, the remote receiver can generally compute more accurate satellite locations than the receiver can compute using the information from the Almanac.

The remote receiver 22 may also, or instead, utilize assistance information provided by the base receiver 32 in the form of satellites in view, ephemeris information, Doppler offsets, and so forth, to quickly determine position to within 150 meters based on received GNSS signals and/or one or more signals of opportunity. Using the assistance information, the remote receiver need not then take the time to use the Almanac. The remote receiver may also determine time of day to within at least several microseconds based on the RTC time and date information and using the properties of the signals of opportunity. Accordingly, the remote receiver may, in addition to determining its oscillator clock frequency offset as described, determine its phase offset of its clock 21 and preposition its PRN code search based upon

the known times of code chip transmissions from the GNSS satellites. The code search prepositioning reduces the code search from, for example, 1000 code chips to 10 code chips, thereby reducing the time it takes to perform the search. The code search prepositioning is particularly useful for longer PRN codes.

5 The GNSS receiver and system described herein have the advantage of reducing TITF by utilizing RTC time and, date, and as appropriate Almanac information, along with the properties of broadcast signals of opportunity and the known locations of the SOP transmitters. The known locations of the SOP transmitters may be trajectories rather than fixed locations. For example, an SOP
10 transmitter may transmit from a moving platform such as an automobile, aircraft, ship or satellite, provided that the location and the velocity vector of the transmitter can be determined by the system. For a satellite transmitter, for example, the orbital ephemeris parameters must be readily available. The remote receivers may be mobile or fixed-position receivers.

15 The receiver's one or more processors may be configured as a single processor, the operations of determining position solutions and oscillator frequency offsets may be performed in hardware, software or firmware, and the remote and base receivers include the known hardware, software or firmware utilized to perform the acquisition and tracking operations, including the hardware, software or firmware to
20 make correlation measurements, produce local codes and so forth. The processors may be programmed to perform the operations and/or operate hardware, and so forth, with the programs provided as computer executable instructions on computer readable media. The RTC may be replaced by other known mechanisms that maintain time and date during power down cycles. The RTC or mechanism may alternatively

or in addition be powered by alternative energy sources, such as, for example, a large capacitor.

What is claimed is:

CLAIMS

- 1 1. A GNSS receiver including:
2 a radio frequency front end for receiving GNSS satellite signals and signals of
3 opportunity;
4 an oscillator used for acquiring and tracking the GNSS satellite signals; and
5 one or more processors for
6 processing the signals of opportunity and estimating a frequency offset for
7 the oscillator based on a difference between the frequencies of one or more of the
8 signals of opportunity as determined by the front end and nominal broadcast
9 frequencies of the one or more signals of opportunity, and
10 using the estimated oscillator frequency offset to reduce a search window for
11 acquiring the GNSS satellite signals.
- 1 2. The GNSS receiver of claim 1 wherein the one or more processors further determine
2 an estimated location of the receiver based on the broadcast frequencies of multiple
3 signals and signal of opportunity transmitter location information.
- 1 3. The GNSS receiver of claim 1 further including
2 a means for maintaining current time and date,
3 a memory for storing an Almanac, and
4 the one or more processors determine satellites in view and estimate Doppler
5 offsets associated with signals from the satellites in view based on an estimated location

6 of the receiver, the stored Almanac and the current time and date and utilize the estimated
7 Doppler offsets to further reduce the search window.

1 4. The GNSS receiver of claim 3 wherein the one or more processors determine the
2 estimated location of the receiver based on the broadcast frequencies of multiple signals
3 of opportunity and signal of opportunity transmitter location information.

1 5. The GNSS receiver of claim 1 further including one or more configurable front end
2 filters that scan the broadcast signals to tune to the signals of opportunity.

1 6. The GNSS receiver of claim 4 further including a connection to a communications
2 network, the network providing the signal of opportunity transmitter location information
3 to the receiver over the connection.

1 7. The GNSS receiver of claim 6 wherein the receiver selects the signals of opportunity
2 from a list of usable signals of opportunity.

1 8. The GNSS receiver of claim 6 wherein the network connection provides access to the
2 internet.

1 9. The GNSS receiver of claim 1 wherein the one or more processors phase lock an
2 oscillator used for signal acquisition and tracking to one of the signals of opportunity to
3 provide narrow band tracking of the GNSS signals.

1 10. The GNSS receiver of claim 1 further including
2 a means for maintaining current time and date; and
3 the one or more processors determine time to within several microseconds of
4 GNSS time based on the maintained current time and a timing property of the signals of
5 opportunity, and preposition code searching based on known times of code chip
6 transmissions from GNSS satellites.

1 11. A GNSS receiver including:
2 a radio frequency front end for receiving GNSS satellite signals and signals of
3 opportunity;
4 an oscillator for use in acquiring and tracking the GNSS satellite signals, and
5 one or more processors for
6 processing the signals of opportunity and phase locking the oscillator to
7 one of the signals of opportunity, and
8 using a narrow band to track the GNSS satellite signals.

1 12. A system for reducing the time to first fix position, the system including:
2 a base GNSS receiver for acquiring and tracking GNSS satellite signals and
3 providing assistance information;
4 a remote GNSS receiver with

5 a radio frequency front end for receiving GNSS satellite signals and signals of
6 opportunity;
7 a means for receiving assistance information from the base GNSS receiver;
8 an oscillator for use in acquiring and tracking the GNSS signals; and
9 one or more processors for
10 processing the signals of opportunity and estimating a frequency offset for
11 the oscillator based on a difference between the frequencies of one or more of the
12 signals of opportunity as determined by the front end and broadcast frequencies of
13 the one or more signals of opportunity, and
14 using the estimated oscillator frequency offset to reduce a search window
15 for acquiring the GNSS satellite signals.

1 13. The system of claim 12 wherein the assistance information is the broadcast
2 frequencies of the signals of opportunity.

1 14. The system of claim 13 wherein broadcast frequencies are determined by the base
2 GNSS receiver when the base GNSS receiver is phase locked to a GNSS frequency.

1 15. The system of claim 13 wherein the broadcast frequencies are the nominal broadcast
2 frequencies of the signals of opportunity.

1 16. The system of claim 12 wherein
2 the assistance information is the location of signal of opportunity transmitters, and
3 the one or more processors determine the estimated location of the receiver based
4 on the broadcast frequencies of multiple signals of opportunity and signal of opportunity

5 transmitter location information.

1 17. The system of claim 12 wherein

2 the assistance information is navigation messages and message bit timing, and
3 the one or more processors wipe the navigation messages from received GNSS
4 satellite signals and use correlation intervals that span multiple message bits to acquire
5 the GNSS satellite signals.

1 18. The system of claim 12 wherein

2 the assistance information includes one or more of a list of GNSS satellites in
3 view, associated Doppler offsets, ephemeris information, and

4 the remote receiver uses the assistance information to reduce the search to
5 satellites in view and further reduce the search window based on the Doppler offsets.

1 19. The system of claim 12 wherein the remote receiver further includes

2 a means for maintaining current time and date; and

3 the one or more processors determine time to within several microseconds of
4 GNSS time based on the maintained current time and a timing property of the signals of
5 opportunity, and preposition code searching based upon known times of code chip
6 transmissions from GNSS satellites.

1 20. The system of claim 12 wherein

2 the assistance information includes current time and date, estimated city or area
3 location information and an Almanac, and

4 the one or more processors determine satellites in view and associated estimated
5 Doppler offsets using the assistance information and utilize the estimated offsets to
6 reduce further reduce the search window.

1 21. The system of claim 17 wherein the one or more processors
2 phase lock an oscillator used in acquiring and tracking the GNSS signals to one of
3 the signals of opportunity, and
4 narrow the band used to track the GNSS satellite signals.

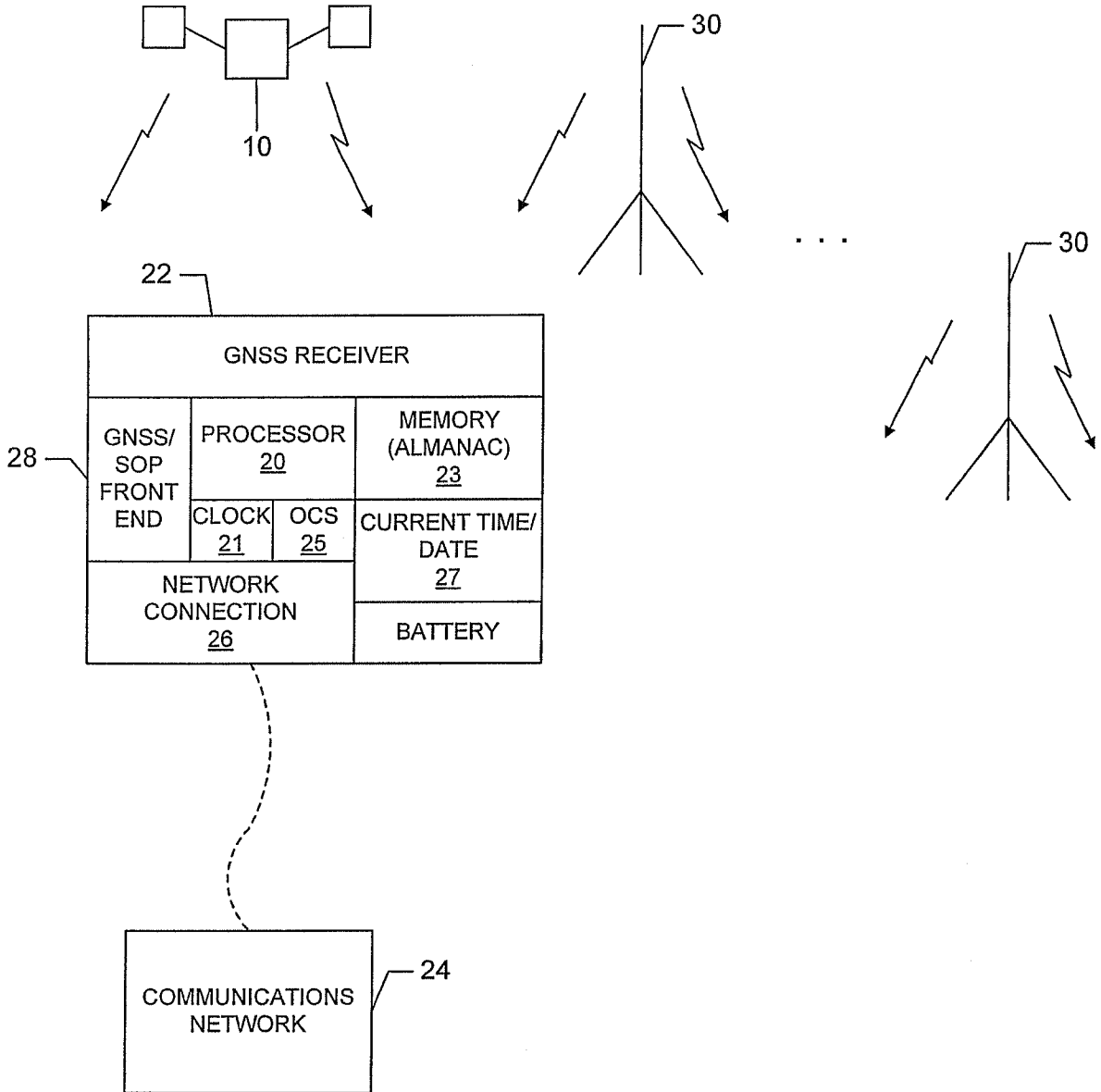


FIG. 1

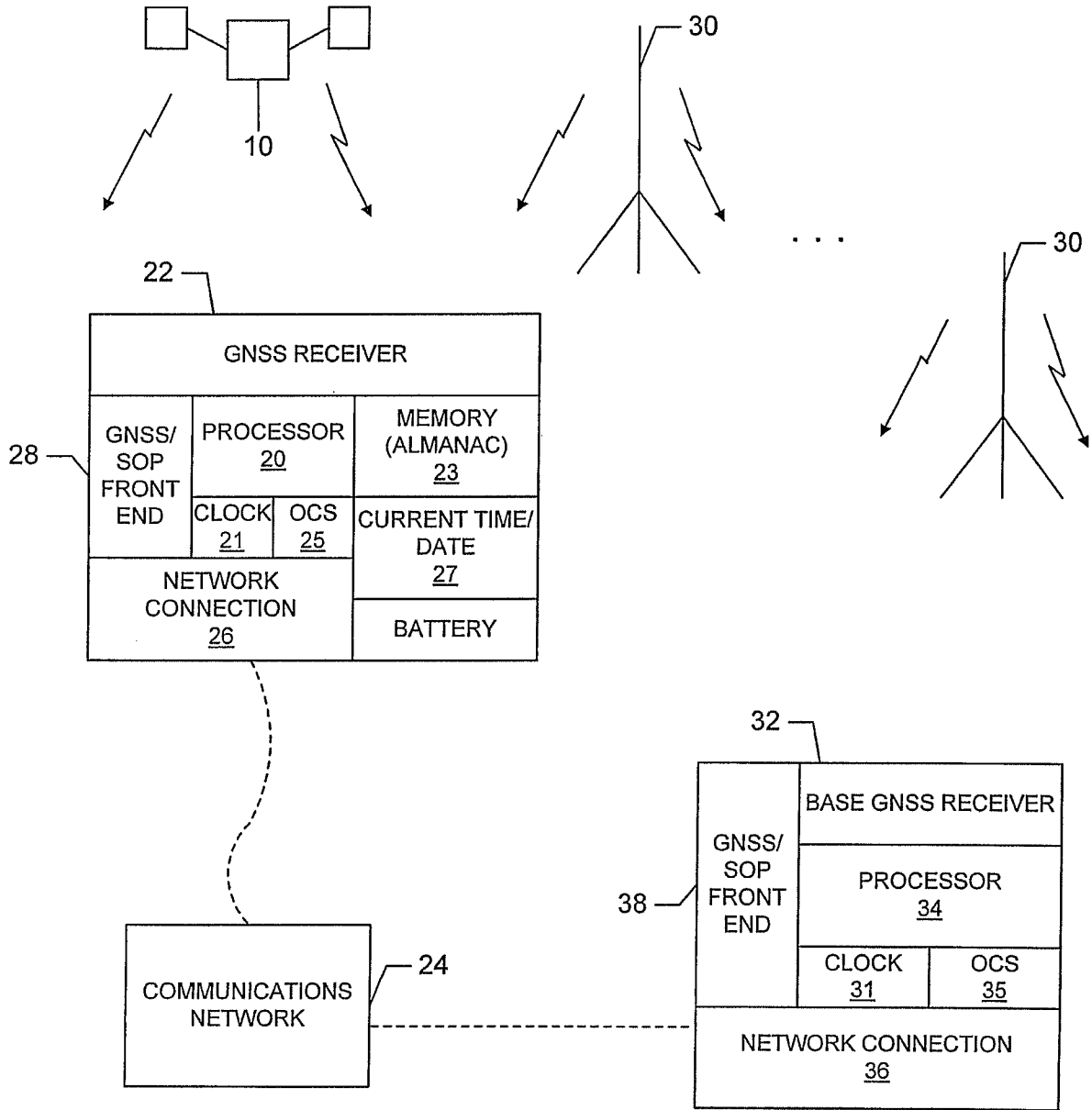


FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2009/000702

<p>A. CLASSIFICATION OF SUBJECT MATTER IPC: G01S 5/14 (2006.01) According to International Patent Classification (IPC) or to both national classification and IPC</p>														
<p>B. FIELDS SEARCHED</p> <p>Minimum documentation searched (classification system followed by classification symbols) IPC: G01S</p> <p>Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched</p> <p>Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used) Databases Searched: Canadian Patent Database, US West Patent Database, Delphion, IEEE Xplore Keywords Searched: GNSS, GPS, signals of opportunity, frequency offset, oscillator, time, date, Almanac</p>														
<p>C. DOCUMENTS CONSIDERED TO BE RELEVANT</p> <table border="1" style="width:100%; border-collapse: collapse;"> <thead> <tr> <th style="width:10%;">Category*</th> <th style="width:60%;">Citation of document, with indication, where appropriate, of the relevant passages</th> <th style="width:30%;">Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td align="center">A</td> <td>US 5,663,735 (ESHENBACH) 2 September 1997 (02-09-1997) see entire document</td> <td align="center">1-21</td> </tr> <tr> <td align="center">A</td> <td>US 2007/0216575 A1 (DIESPOSTI) 20 September 2007 (20-09-2007) see entire document</td> <td align="center">1-21</td> </tr> <tr> <td align="center">A</td> <td>US 2007/0050824 A1 (LEE et al.) 1 March 2007 (01-03-2007) see entire document</td> <td align="center">1-21</td> </tr> </tbody> </table>			Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	A	US 5,663,735 (ESHENBACH) 2 September 1997 (02-09-1997) see entire document	1-21	A	US 2007/0216575 A1 (DIESPOSTI) 20 September 2007 (20-09-2007) see entire document	1-21	A	US 2007/0050824 A1 (LEE et al.) 1 March 2007 (01-03-2007) see entire document	1-21
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A	US 2007/0050824 A1 (LEE et al.) 1 March 2007 (01-03-2007) see entire document	1-21												
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“E”	earlier application or patent but published on or after the international filing date	“X”												
“L”	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone												
“O”	document referring to an oral disclosure, use, exhibition or other means	“Y”												
“P”	document published prior to the international filing date but later than the priority date claimed	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art												
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		document member of the same patent family												
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Information on patent family members

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PCT/CA2009/000702

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
US 5663735A	02-09-1997	None	
US 2007216575A1	20-09-2007	EP 2049915A2 US 2009171583A1 WO 2008021121A2 WO 2008021121A3 WO 2008021121B1	22-04-2009 02-07-2009 21-02-2008 10-04-2008 12-06-2008
US 2007050824A1	01-03-2007	JP 2009027696A	05-02-2009