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(54) HOST BASED SATELLITE POSITIONING SYSTEMS

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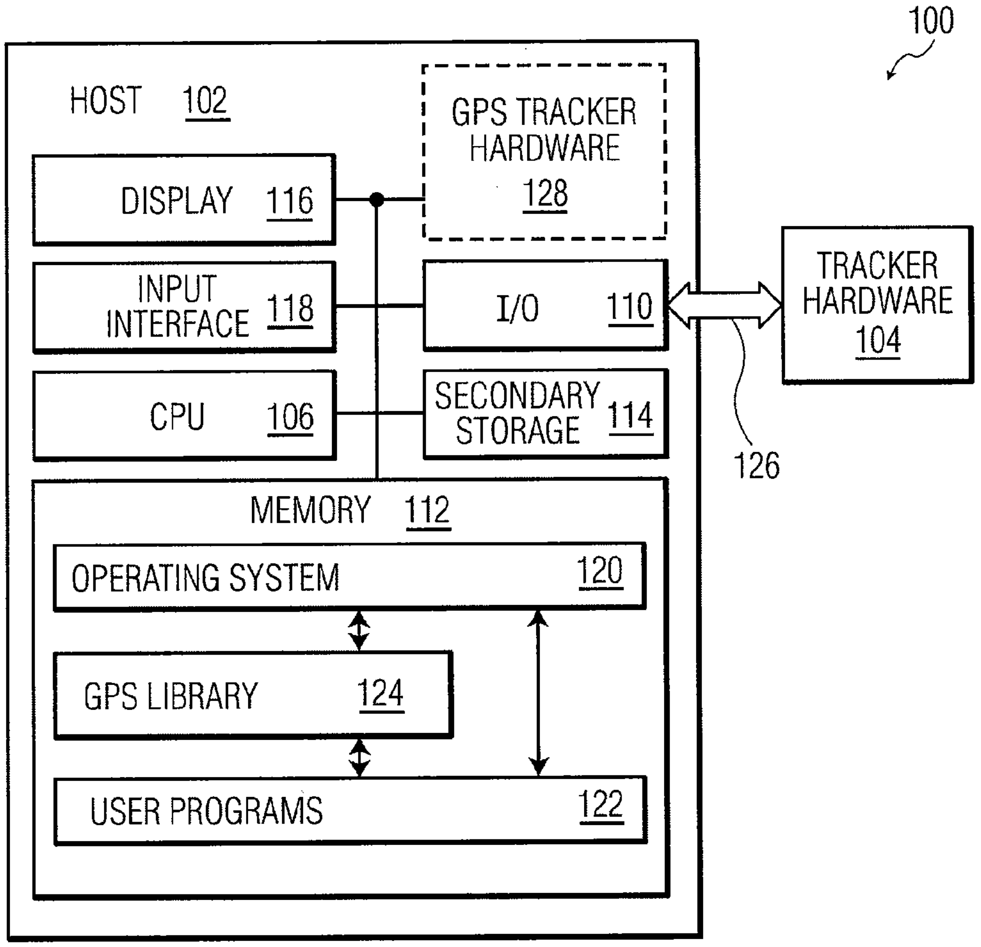
(57) **ABSTRACT**

Methods and systems consistent with the present invention provide a host based positioning system. The host based positioning system includes a tracker hardware interface that connects to a dedicated hardware space vehicle tracker. The tracker hardware interface receives positioning information from the space vehicle tracker. The host based positioning system also includes a memory that includes a GPS library having a user interface, a tracker interface, and an operating system interface. A processor runs functions provided by the interfaces.



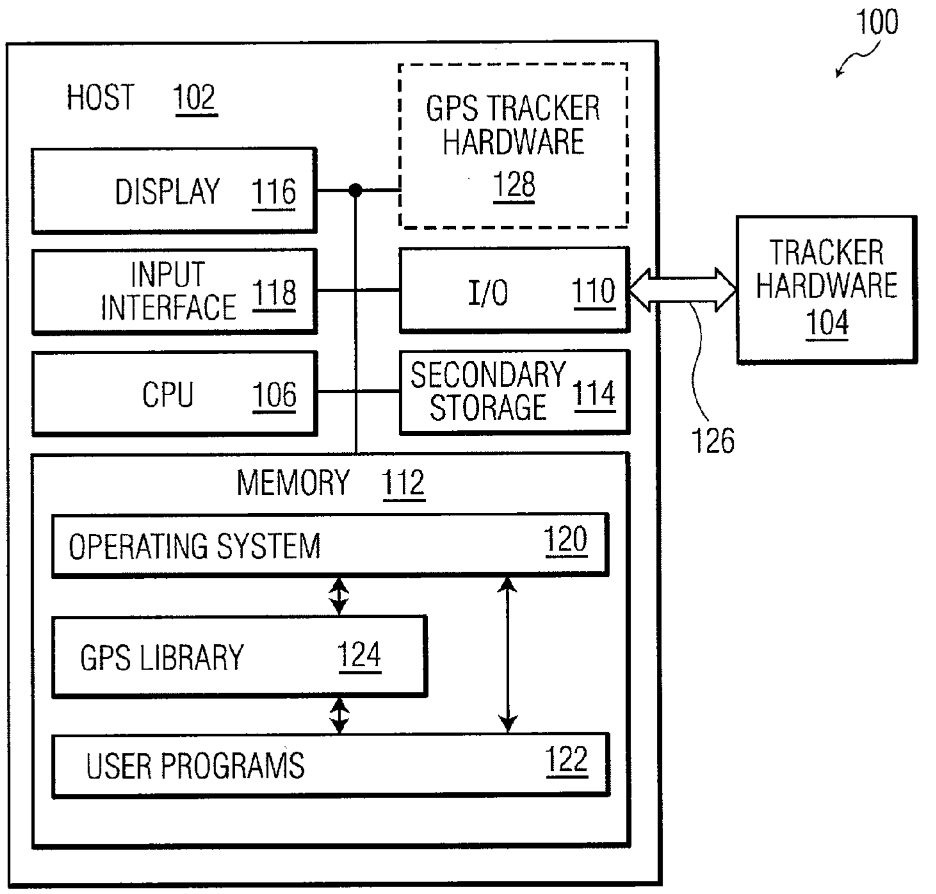

100
HOST 102
GPS TRACKER HARDWARE 128
DISPLAY 116
INPUT INTERFACE 118
I/O 110
TRACKER HARDWARE 104
CPU 106
SECONDARY STORAGE 114
126
MEMORY 112
OPERATING SYSTEM 120
GPS LIBRARY 124
USER PROGRAMS 122

FIG. 1

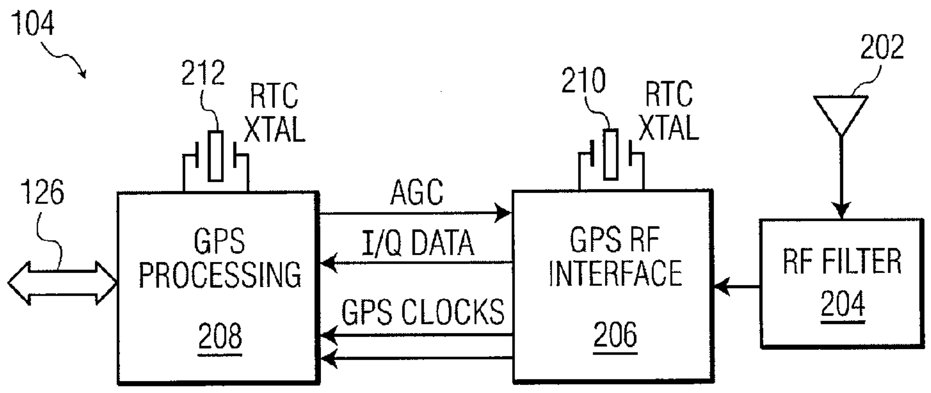

104
212
RTC XTAL
210
RTC XTAL
202
126
GPS PROCESSING 208
AGC
I/Q DATA
GPS CLOCKS
GPS RF INTERFACE 206
RF FILTER 204

FIG. 2

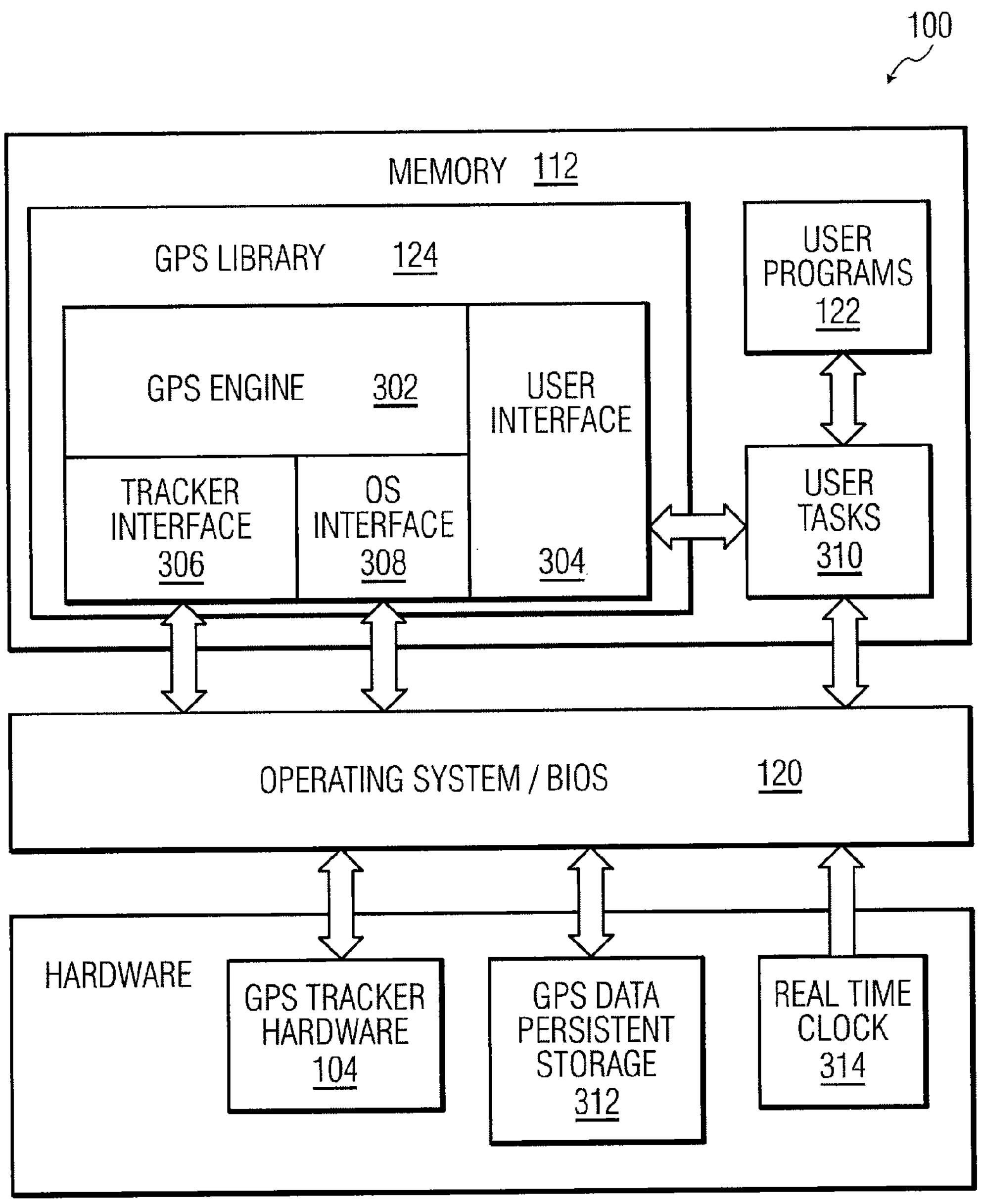

100
MEMORY 112
GPS LIBRARY 124
GPS ENGINE 302
USER INTERFACE 304
TRACKER INTERFACE 306
OS INTERFACE 308
USER PROGRAMS 122
USER TASKS 310
OPERATING SYSTEM / BIOS 120
HARDWARE
GPS TRACKER HARDWARE 104
GPS DATA PERSISTENT STORAGE 312
REAL TIME CLOCK 314

FIG. 3

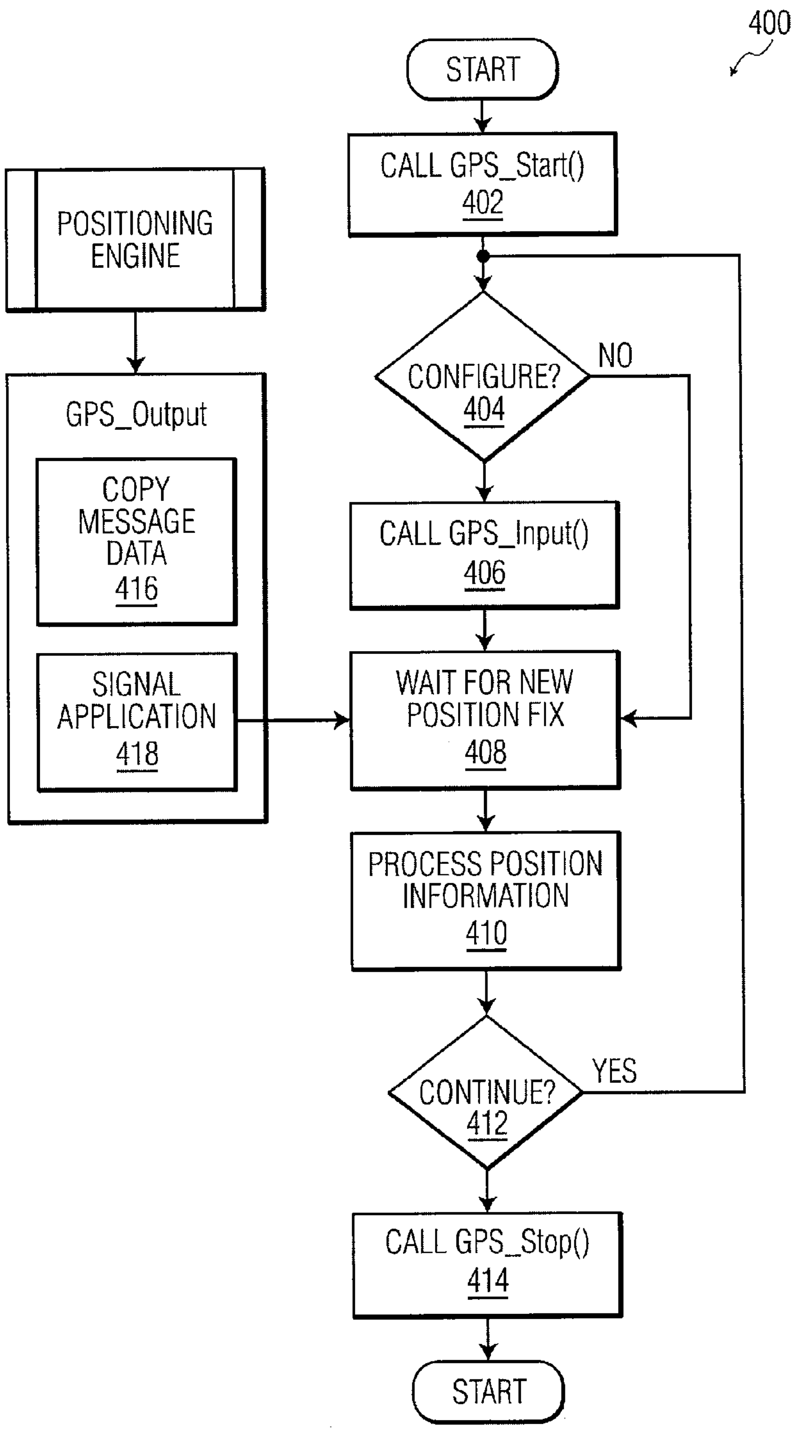

400
START
CALL GPS_Start() 402
CONFIGURE? 404
NO
CALL GPS_Input() 406
WAIT FOR NEW POSITION FIX 408
PROCESS POSITION INFORMATION 410
CONTINUE? 412
YES
CALL GPS_Stop() 414
START
POSITIONING ENGINE
GPS_Output
COPY MESSAGE DATA 416
SIGNAL APPLICATION 418

FIG. 4

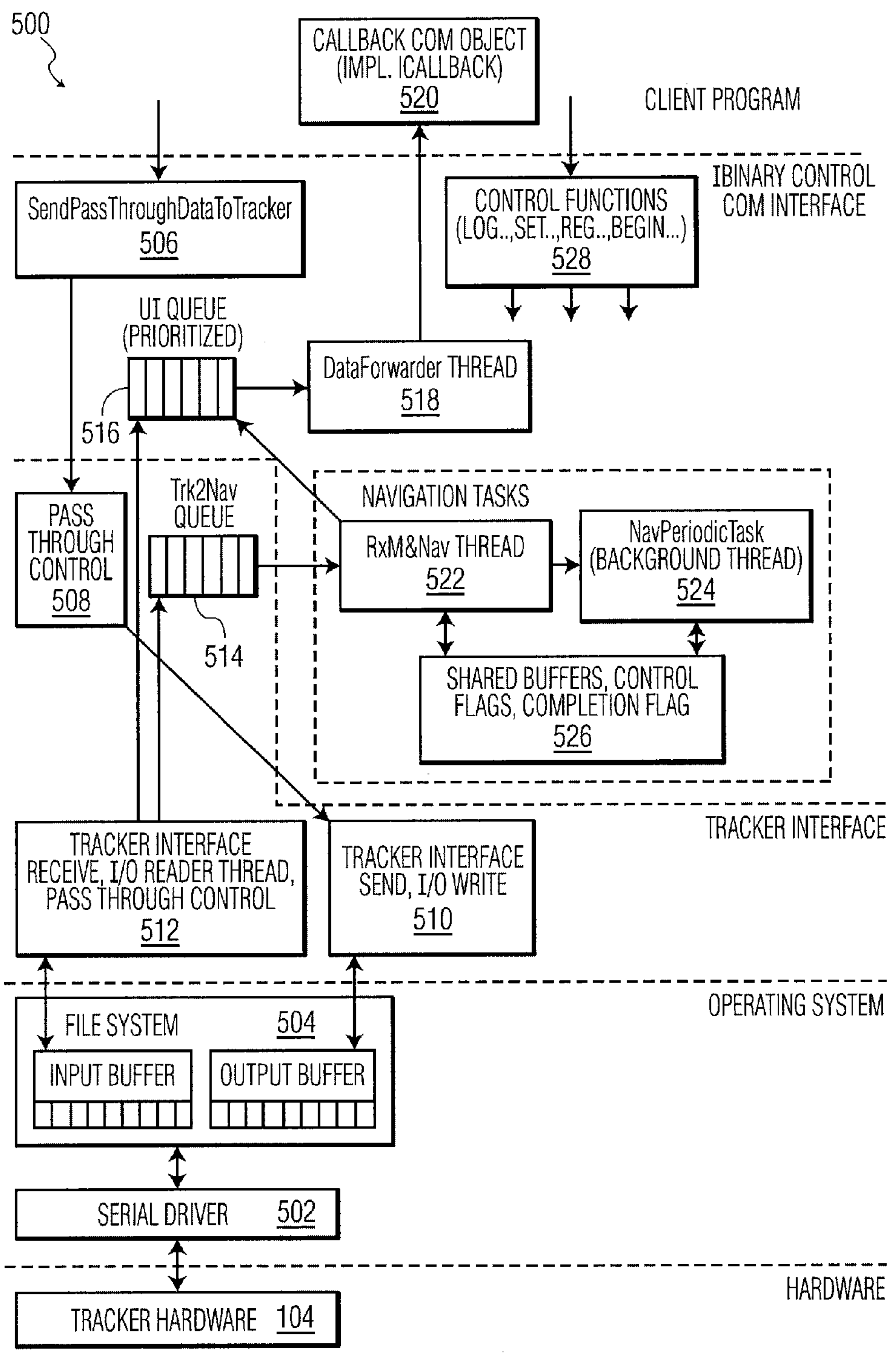

500
CALLBACK COM OBJECT (IMPL. ICALLBACK) 520
CLIENT PROGRAM
IBINARY CONTROL COM INTERFACE
SendPassThroughDataToTracker 506
CONTROL FUNCTIONS (LOG..,SET..,REG..,BEGIN...) 528
UI QUEUE (PRIORITIZED)
516
DataForwarder THREAD 518
PASS THROUGH CONTROL 508
Trk2Nav QUEUE
514
NAVIGATION TASKS
RxM&Nav THREAD 522
NavPeriodicTask (BACKGROUND THREAD) 524
SHARED BUFFERS, CONTROL FLAGS, COMPLETION FLAG 526
TRACKER INTERFACE
TRACKER INTERFACE RECEIVE, I/O READER THREAD, PASS THROUGH CONTROL 512
TRACKER INTERFACE SEND, I/O WRITE 510
OPERATING SYSTEM
FILE SYSTEM 504
INPUT BUFFER
OUTPUT BUFFER
SERIAL DRIVER 502
HARDWARE
TRACKER HARDWARE 104

FIG. 5

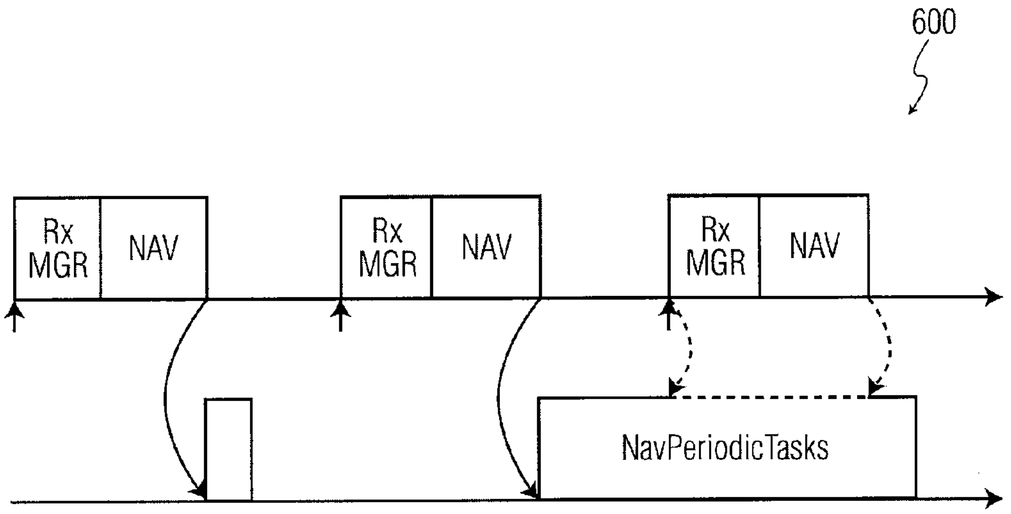


FIG. 6

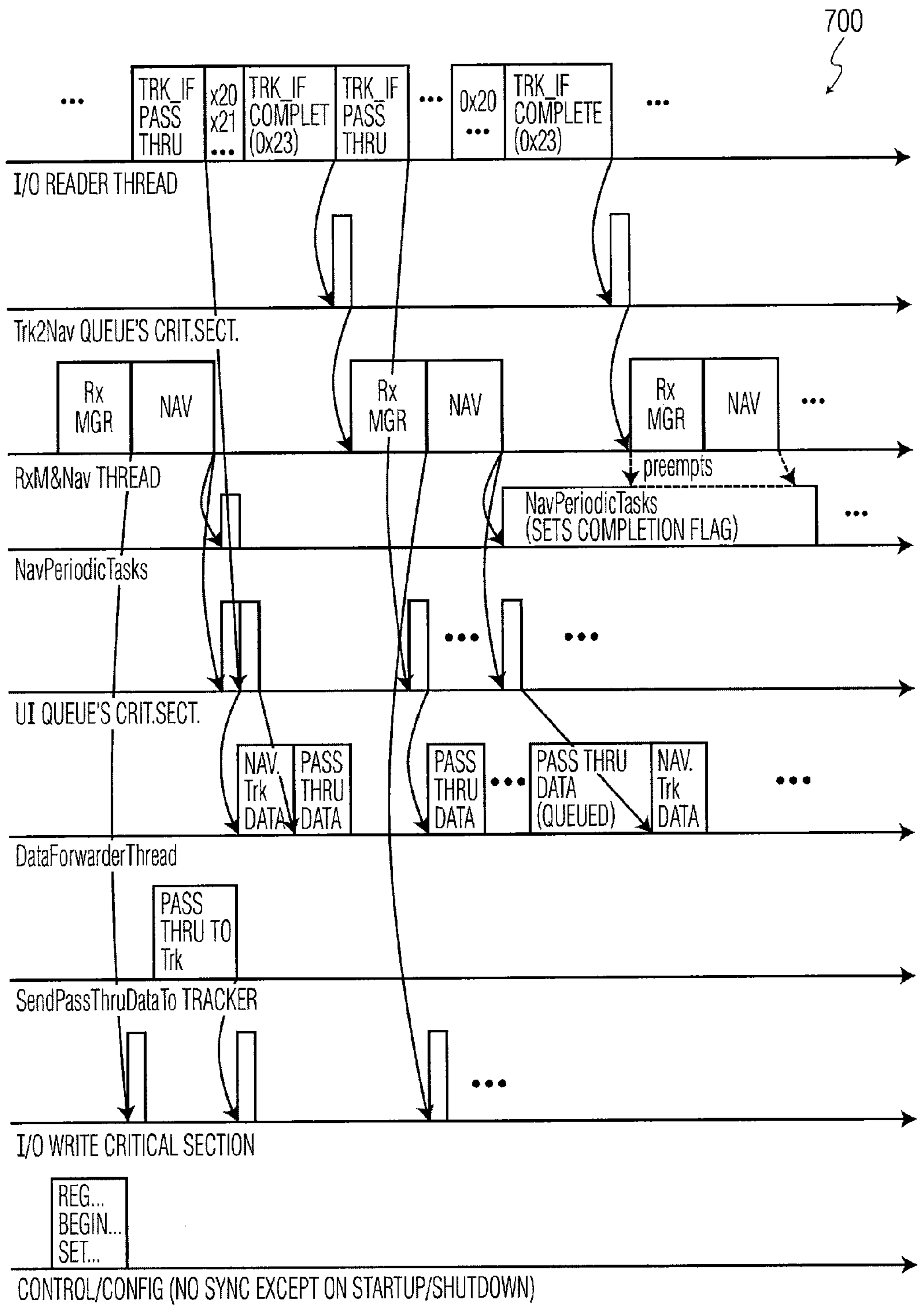

700
TRK_IF PASS THRU
x20 x21 ...
TRK_IF COMPLET (0x23)
TRK_IF PASS THRU
0x20 ...
TRK_IF COMPLETE (0x23)
I/O READER THREAD
Trk2Nav QUEUE'S CRIT.SECT.
Rx MGR
NAV
RxM&Nav THREAD
preempts
NavPeriodicTasks (SETS COMPLETION FLAG)
NavPeriodicTasks
UI QUEUE'S CRIT.SECT.
NAV. Trk DATA
PASS THRU DATA
PASS THRU DATA (QUEUED)
DataForwarderThread
PASS THRU TO Trk
SendPassThruDataTo TRACKER
I/O WRITE CRITICAL SECTION
REG... BEGIN... SET...
CONTROL/CONFIG (NO SYNC EXCEPT ON STARTUP/SHUTDOWN)

FIG. 7

HOST BASED SATELLITE POSITIONING SYSTEMS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. patent application Ser. No. 11/149,438, entitled HOST BASED SATELLITE POSITIONING SYSTEMS, filed Jun. 6, 2005 which is a continuation of U.S. patent application Ser. No. 10/269,914, entitled HOST BASED SATELLITE POSITIONING SYSTEMS, filed on Oct. 10, 2002, that issued as U.S. Pat. No. 7,043,363 on May 9, 2006, which was related to U.S. patent application Ser. No. 10/269,105, titled, "LAYERED HOST BASED SATELLITE POSITIONING SOLUTIONS", filed on Oct. 10, 2002, and U.S. patent application Ser. No. 10/269,104, titled, "NAVIGATION PROCESSING IN HOST BASED SATELLITE POSITIONING SOLUTIONS", filed Oct. 10, 2002, both of which were incorporated by reference in their entirety and which are also incorporated by reference herein.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] This invention relates to satellite positioning systems. In particular, this invention relates to satellite positioning systems implemented utilizing the processing power of a host in communication with a hardware tracker.

[0004] 2. Related Art

[0005] The worldwide utilization of wireless devices such as two-way radios, pagers, portable televisions, personal communication system ("PCS"), personal digital assistants ("PDAs") cellular telephones (also known a "mobile phones"), Bluetooth, satellite radio receivers and Satellite Positioning Systems ("SPS") such as Global Positioning Systems ("GPS"), also known as NAVSTAR, is growing at a rapid pace. Current trends are calling for the incorporation of SPS services into a broad range of electronic devices and systems, including Personal Digital Assistants (PDAs), cellular telephones, portable computers, automobiles, and the like. At the same time, manufacturers constantly strive to reduce costs and produce the most cost-attractive product possible for consumers.

[0006] In the past, providing a SPS solution often involved expensive dedicated SPS signal reception and processing hardware, as well as dedicated post processing hardware for resolving location measurements, displaying location coordinates, updating map displays, and the like. However, given the rapid growth in speed, sophistication, and'processing power of the host microprocessors present in the host device (e.g., in a cellular telephone or automobile), the possibility exists for allowing the host microprocessor to bear the burden not only of running its regular applications, but also to operate as part of the SPS solution. Such an approach is presented in U.S. Pat. No. 6,430,503, titled "Distributed GPS Navigation System," issued to Paul W. McBurney et al., the entirety of which is incorporated herein by reference.

[0007] As noted above, however, there is a strong push toward incorporating SPS solutions in many electronic devices designed by numerous manufacturers. Of course, each device varies considerably in architecture, operating system, hardware interfaces, and the like. Prior SPS solutions did not provide the flexibility that allowed the solutions to be adapted to a wide range of electronic devices. Instead, expensive customized solutions were needed for each device, thereby undesirably increasing costs and delaying the introduction of SPS services into a wide range of devices.

[0008] Therefore, a need exists for implementations of SPS solutions that overcome the problems noted above and others previously experienced.

SUMMARY

[0009] Methods and systems consistent with an invention of a host based SPS solution are disclosed. The SPS solution is implemented in a convenient library form that is flexible and extensible, and that may adapt to meet he needs of many different hardware platforms. As a result, a wide variety of electronic devices may incorporate SPS functionality with less expense utilizing less development time.

[0010] In one example implementation, a host based SPS system may include a host processing system that connects through a tracker hardware interface to a dedicated hardware space vehicle tracker. The host processing system may also include a memory that includes a SPS library having a user interface, positioning engine, a tracker interface and an operating system interface. A processor in the host processing system runs the positioning engine and the functions provided by the interfaces.

[0011] The tracker hardware interface receives positioning information from the space vehicle tracker. Through functions in the tracker interface, the positioning information is communicated to the positioning engine. In turn, the positioning engine may determine a position and communicate the position to a user application through functions provided in the user interface.

[0012] Other apparatus, systems, methods, features and advantages of the present invention will be or will become apparent to one with skill in the art upon examination of the following figures and detailed description. It is intended that all such additional systems, methods, features and advantages be included within this description, be within the scope of the present invention, and be protected by the accompanying claims.

BRIEF DESCRIPTION OF THE FIGURES

[0013] The components in the figures are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention. In the figures, like reference numerals designate corresponding parts throughout the different views.

[0014] FIG. **1** illustrates a detailed block diagram of one example of a positioning systems implemented as a host based SPS solution.

[0015] FIG. **2** illustrates a hardware tracker that communicates with the positioning system shown in FIG. **1**.

[0016] FIG. **3** depicts a hardware and software diagram of a positioning system that includes a GPS library with a user interface, a tracker interface, and an operating system interface.

[0017] FIG. **4** illustrates a flow diagram of a user program running in the positioning system.

[0018] FIG. **5** illustrates a block diagram of the cooperation between threads, tasks and hardware in one implementation of a host based SPS solution.

[0019] FIG. **6** illustrates an execution schedule for a receive manager thread and a periodic navigation task.

[0020] FIG. **7** illustrates a synchronization diagram for the timing and interaction between the threads and tasks shown in FIG. **5**.

DETAILED DESCRIPTION

[0021] Reference will now be made in detail to an implementation in accordance with methods, systems, and products consistent with the present invention as illustrated in the accompanying drawings. The same reference numbers may be used throughout the drawings and the following description to refer to the same or like parts.

[0022] A typical satellite positioning system ("SPS") system has approximately 12 satellites that may be visible at any one time to a wireless device. SPS means any system utilizing satellites and/or land-based communications devices for providing or enabling the determination of a location of the wireless device on the earth, for example but not limited to: the global positioning system ("GPS") known as NAVSTAR, GLONASS, LORAN, Shoran, Decca, or TACAN. Although many of the interface functions below make reference to GPS, those functions are not limited to use with GPS, but, generally, are equally applicable in other SPS environments.

[0023] FIG. **1** depicts a block diagram of a positioning system **100** suitable for practicing methods and implementing systems consistent with the present invention. The positioning system **100** includes a host **102** and tracker hardware **104**. The host **102** includes a central processing unit ("CPU") **106**, a hardware tracker interface **110**, and a memory **112**. The host **102** also includes a secondary storage device **114** (e.g., generally non-volatile memory such as a magnetic disk, flash memory, optical storage, and the like), and a display **116**, and an input interface **118** (e.g., a mouse, keyboard, and the like).

[0024] An operating system **120** (e.g., Windows CE, QNX, Palm OS, UNIX, Linux, Windows 2000, NT, XP, or the like) runs in the memory **112**. As will be explained in more detail below, a user program **122** communicates with a SPS library **124** and the operating system **120**. The user program **122** thereby receives position information from the GPS library, and may also communicate commands to the SPS library. The user program **122** may be any program that utilizes positioning information, including, as examples, a mapping program, course charter, location aid, and the like.

[0025] The host **102** connects through the hardware tracker interface **110** and the interface connection **126** to the tracker hardware **104**. The hardware tracker interface **110** may be virtually any type of data transfer interface (as examples, a serial, parallel, compact flash, PC Card, or network interface). The interface connection **126** may then be, as examples, a serial cable, parallel cable, or network cable, and may optionally be wireless. In one implementation, the hardware tracker interface **110** is an RS232 port running at 38,400 bps, N-8-1 that communicates up to 2 KB of data per second between the host **102** and the tracker hardware **104**.

[0026] In other implementations, the tracker hardware (as illustrated by the reference numeral **128**) is more closely incorporated into the host **102**. Thus, rather than connecting to the host **102** through the interface connection **126**, for example, the tracker hardware **128** may be directly coupled to the host **102** address, data, and control buses. As will be explained in more detail below, the host **102** receives and processes navigation information from the hardware tracker **104**, **128** in order to provide the user programs **122** with position information.

[0027] Although aspects of the present invention are depicted as being stored in memory **112**, one skilled in the art will appreciate that all or part of systems and methods consistent with the present invention may be stored on or read from other machine-readable media, for example, secondary storage devices such as hard disks, floppy disks, and CD-ROMs; a signal received from a network; or other forms of ROM or RAM either currently known or later developed. Further, although specific components of positioning system **100** are described, one skilled in the art will appreciate that a positioning system suitable for use with methods, systems, and articles of manufacture consistent with the present invention may contain additional or different components. For example, the CPU **106** may be a microprocessor, microcontroller, application specific integrated circuit ("ASIC"), discrete or a combination of other types of circuits acting as a central processing unit. The memory **112** may be RAM, DRAM, SDRAM, or any other type of read/writeable memory.

[0028] Turning next to FIG. **2**, that figure shows one example of an implementation of the tracker hardware **104**. The tracker hardware **104** acquires and tracks SPS satellites and sends raw measurement data to the host **102** for position calculation. To that end, the tracker hardware **104** includes an antenna **202** for receiving SPS satellite signals and a radio frequency ("RF") filter **204** for passing the signals to the RF interface circuit **206**. The RF interface circuit **206** processes the signals, produces 2-bit Inphase and Quadrature ("I/Q") signals and recovers SPS clocks. The RF interface circuit **206** provides the I/Q signals and SPS clocks to the location processing circuit **208** for digital processing. A reference frequency source **210** (e.g., a crystal oscillator) provides a reference clock for the RF interface circuit **206**, while the optional real time clock ("RTC") source **212** provides a reference clock for the location processing circuit **208**.

[0029] The tracker hardware **104** may be implemented with components available from SiRF Technology, Inc. of San Jose Calif. For example, the RF interface circuit **206** may be implemented as a GRF2i/LP integrated circuit. The location processing circuit may be implemented, as examples, as a GSP2t integrated circuit or GSP2e integrated circuit. The tracker hardware **104** minimizes the overhead on the host **102** and operating system **120** by keeping low the maximum transmission rate of raw measurements to the host **102** (e.g., one measurement per second).

[0030] With regard next to FIG. **3**, that figure shows a detailed block diagram of a hardware and software diagram **300** for the positioning system **100**. The memory **112** in the host **102** includes a SPS library **124**, user programs **122** (e.g., map displaying, map matching, dead reckoning and route calculation programs), and the operating system **120** (which may be a multi-threaded operating system). The SPS library **124** includes a positioning engine **302**, a user interface **304**, a tracker interface **306**, and an operating system interface **308**. The user tasks **310** implement device drivers or link directly to the user programs **122**, as examples.

[0031] In addition to the hardware tracker **104**, persistent storage **312** and a real time clock **314** may optionally be provided. The persistent storage **312** may be, as examples, 2 KB of Flash memory, battery backed up RAM or a disk drive. The SPS library **124** may use the RTC in the host **102**, the RTC **314**, or may operate without an RTC.

[0032] The user interface **304** is called by the user programs **122** to start and configure the positioning system. The positioning engine **302** calls a function provide by the user program **122** (e.g., GPS_Output) to deliver positioning messages (e.g., position updates and other synchronous and asynchronous data) to the user program **122**. The tracker interface **306'** provides for communication between the tracker hardware **104** and the host **102** and, to that end, may load and call the operating system **120** serial communication drivers. The operating system interface **308** calls operating system functions for task scheduling and synchronization, RTC access, and storage access.

[0033] FIG. **4** shows a flow diagram of a user program **122**. The user program **122** calls GPS_Start to start the positioning engine **302** (step **402**). The user program **122** determines whether to configure the positioning engine **302** (step **404**).

The program **122** configures the positioning engine **302** by sending a message to the positioning engine **302** using the GPS_Input function, for example (step **406**). Next, the program **122** waits for a new position fix (or other information) from the positioning engine **302** (step **408**).

[0034] When information is received, the user program **122** processes the information, for example, to display or update a map (step **410**). If the program **122** continues to run (step **412**), processing returns to step **404**. Otherwise, the program **122** stops the positioning engine (step **414**) and terminates. The positioning engine runs separately and, when new positioning information is available, creates a message for the program **122** (step **416**) and sends the message to the program **122** (step **418**). Tables 1-5 below show exemplary function calls.

TABLE 1

GPS__Start( )

```
/* Starts GPS Engine tasks, initial acquisition begins: */
tGPS__UINT32                    result;
result = GPS__Start (
                GPS__CTRL__MODE__AUTO,      /* default - hot start */
                0,                          /* use default clock
                                            offset */
                1,                          /* use port 1 */
                38400                       /* baud rate */
            );
```

TABLE 2

User Callback GPS__Output( )

```
    /* User callback function. Receives all communication from GPS. */
    #include "GPS__interface.h"
    void GPS__Output(
        tGPS__UINT32 message__id,
        void *        message__structure,
        VtGPS__UINT32     length )
    {
        tGPS__NAV__MEASURED__NAVIGATION nav__data;
        switch ( message__id )
       {
            case GPS__NAV__MEASURED__NAVIGATION:
                memcpy( &nav__data, message__structure,
    sizeof(tGPS__NAV__MEASURED__NAVIGATION) );
            if ( nav__data.nav__mode & GPS__MODE__MASK )
                {
                printf("x=%ld, y=%ld, z=%ld \n",
                        nav__data.ecef__x, nav__data.ecef__y,
                        nav__data.ecef__z);
                else
                    printf("no fix \n");
                break;
            case GPS__NAV__MEASURED__TRACKER:
                /*...*/
                break;
            default:
                /*...*/
                break;
        } // switch
    } // GPS__Output( )
```

TABLE 3

Configure using GPS__Input( )

```
    /* Configures GPS Engine to turn off SBAS correction: */
        tGPS__NAV__SET__DGPS__SOURCE       DGPSSrc;
        tGPS__UINT32                    result;
```

TABLE 3-continued

Configure using GPS__Input( )

```
        DGPSSrc.bit__rate = 0;
        DGPSSrc.freq = 0;
        DGPSSrc.src = GPS__DGPS__SRC__NONE;
        result = GPS__Input( GPS__NAV__SET__DGPS__SOURCE,
    (void*)&DGPSSrc, sizeof(DGPSSrc) );
```

TABLE 4

Configure using GPS__Input( )

```
  /* Forces cold start of GPS receiver: */
  tGPS__NAV__INITIALIZE                  InitMsg;
  tGPS__UINT32                        result;
  memset(&InitMsg, 0, sizeof(InitMsg));
InitMsg.restart__flags = GPS__RESTART__COLD;
  result = GPS__Input (      GPS__NAV__INITIALIZE, (void*)&InitMsg,
  sizeof(InitMsg) );
```

TABLE 5

GPS__Stop( )

```
            /* Stops GPS Engine and all SiRFNav tasks: */
            tGPS__UINT32                    result;
            result = GPS__Stop( );
```

[0035] Below, one exemplary implementation of the user interface **304**, tracker interface **306**, and an operating system interface **308** is set forth. Table 6 shows which functions and messages are associated with each interface, while Tables 7-10 set forth files and data types used or referred to in the follow description.

TABLE 6

Interface Functions and Messages

User Interface:
GPS__Start( )
GPS__Stop( )
GPS__Output( )
GPS__Input( )
GPS__NAV__MEASURED__NAVIGATION output message
GPS__NAV__MEASURED__TRACKER output message
GPS__NAV__SW__VERSION output message
GPS__NAV__CLOCK__STATUS output message
GPS__NAV__ERROR output message
GPS__ADC__ODOMETER__DATA output message
GPS__NAV__COMPLETE output message
GPS__NAV__TEXT output message
GPS__NAV__INITIALIZE input message
GPS__NAV__POLL__SW__VERSION input message
GPS__NAV__SET__DGPS__SOURCE input message
GPS__NAV__POLL__CLOCK__STATUS input message
GPS__NAV__SET__SBAS__PRN input message
Operating system interface:
OS__Thread__Create( )
OS__Thread__Delete( )
OS__Thread__Sleep( )
OS__Mutex__Create( )
OS__Mutex__Delete( )
OS__Mutex__Enter( )
OS__Mutex__Exit( )
OS__Semaphore__Create( )

TABLE 6-continued

Interface Functions and Messages
OS__Semaphore__Delete( )
OS__Semaphore__Wait( )
OS__Semaphore__Release( )
OS__Storage__Open( )
OS__Storage__Close( )
OS__Storage__Write( )
OS__Storage__WriteAll( )
OS__Storage__Read( )
OS__RTC__Read( )
Tracker interface:
GPS__COMM__TRK__Create( )
GPS__COMM__TRK__Delete( )
GPS__COMM__TRK__Open( )
GPS__COMM__TRK__Reopen( )
GPS__COMM__TRK__Close( )
GPS__COMM__TRK__Wait( )
GPS__COMM__TRK__Read( )
GPS__COMM__TRK__Write( )

TABLE 7

Include file	Description
gps__types.h	Type definitions used in GPS library interfaces
gps__rtos.h	Definitions and prototypes of the GPS operating system interface
gps__ctrl.h	Definitions and prototypes of the GPS control interface
gps__interface.h	Definitions and prototypes of the GPS communication interface
gps__messages.h	Definitions and structure defines of messages used by the communication interface
gps__comm__trk.h	Definitions and prototypes of the tracker communication interface
gps__proto__sirfbinary.h	Definitions and prototypes of the binary serial protocol
gps__debug.h	Definitions for development and debugging

TABLE 8

Source file	Description
gps__rtos.c	Contains implementation of the GPS operating system interface
gps__comm__trk.c	Contains implementation of the tracker communication interface

TABLE 9

Library file	Description
SiRFNavServer.lib	GPS receiver library

TABLE 10

Data Types		
Type name	Data range	Defined as
tGPS__SINT8	−128 . . . 127	signed char
tGPS__UINT8	0 . . . 255	unsigned char
tGPS__SINT16	−32768 . . . 32767	signed short
tGPS__UINT16	0 . . . 65535	unsigned short
tGPS__SINT32	−2147483648 . . . 2147483647	signed long
tGPS__UINT32	0 . . . 4294967295	unsigned long
tGPS__HANDLE	32 bit pointer	void *

[0036] The user or GPS interface includes a GPS control interface and a GPS communication interface. The GPS control Interface functions allow a user program to start and stop the GPS engine using the functions shown in Table 11.

TABLE 11

Function	Description	Provided in
GPS__Start( )	Starts GPS engine	GPS library
GPS__Stop( )	Stops GPS engine	GPS library

[0037] The GPS communication interface functions allow a user program to send and receive messages to and from the GPS engine using the functions shown in Table 12.

TABLE 12

Function	Description	Provided in
GPS__Output( )	Receives a data from the GPS engine	user code
GPS__Input( )	Send commands to the GPS engine	GPS library

[0038] GPS_Start( ) initializes and starts positioning engine threads and communication interface. This function should be called by user programs to start GPS activity.

TABLE 13

```
Include file
    gps__ctrl.h
Syntax
    tGPS__RESULT GPS__Start(tGPS__UINT32 start__mode,
            tGPS__UINT32 clock__offset,
            tGPS__UINT32 port__num,
            tGPS__UINT32 baud__rate )
```

Parameter	Data range	Units	Description
start__mode			Start configuration flags. See Table 14below for details.
clock__offset	0, 25000 . . . 146000	Hz	Default GPS clock offset. This value is used by the factory start or when a saved value is not available. This value should reflect a tracker's hardware peculiarity. If zero is provided here a default value of 96250 Hz is used.
port__num	1 . . . 64		Specifies a communication port where tracker is connected to. 1 = serial port 1, 2 = serial port 2, . . .
baud__rate	4800, 38400, 57600, 115200	bps	Specifies a baud rate at which tracker is connected to. Default 2t tracker baud rate is 38400 bps.

TABLE 14

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Reserved. Write 0 only.															
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Text enable	ADC mode. See below.		Reserved. Write 0 only.									Start type. See below for allowed values.			

TABLE 15

Text Enable		
Value	Macro	Description
0		Development text messages are disabled after start. Can be enabled later by GPS input message.
1	GPS__CTRL__MODE__TEXT__ENABLE	Enables development text messages right after start (via GPS__Output( ) function)

TABLE 16

ADC Mode		
Value	Macro	Description
0		ADC messages from tracker are disabled.
1	GPS__CTRL__MODE__ADC__ENABLE__1HZ	Enables ADC message from tracker at 1 Hz rate
2	GPS__CTRL__MODE__ADC__ENABLE__10HZ	Enables ADC message from tracker at 10 Hz rate
3		Reserved

TABLE 17

Start Type		
Value	Macro	Description
0	GPS__CTRL__MODE__AUTO	GPS will automatically choose a start mode accordingly to availability of time, position and ephemeris information. This start mode should be used for normal operation.
1	GPS__CTRL__MODE__HOT	For testing purposes only. GPS will make a hot start.
2	GPS__CTRL__MODE__WARM	For testing purposes only. GPS will make a warm start.
3	GPS__CTRL__MODE__COLD	For testing purposes only. GPS will make a cold start.
4	GPS__CTRL__MODE__FACTORY	For testing purposes only. GPS will make a factory cold start. All saved information will be deleted.
5	GPS__CTRL__MODE__TEST	For SiRF internal testing purposes only.
Other value		Reserved

TABLE 18

Return Values	
Return value	Description
GPS__SUCCESS	GPS engine has started successfully
GPS__CTRL__ALREADY__STARTED	Error: GPS engine is already running
GPS__CTRL__INVALID__MODE	Error: invalid start mode
GPS__CTRL__CLOCK__OFFSET__OUT__OF__RANGE	Error: clock offset is out of range
GPS__CTRL__ERROR__OPENING__PORT	Error: could not open serial port
GPS__CTRL__RTOS__ERROR	Error creating OS objects (threads, semaphores, mutexes)

TABLE 19

Example

```
#include “gps__types.h”
#include “gps__ctrl.h”
if ( GPS__Start(GPS__CTRL__MODE__AUTO |
GPS__CTRL__MODE__TEXT__ENABLE, 96250, 1, 38400)
!= GPS__SUCCESS )
{
      // error handler
}
// GPS engine has started successfully
...
```

[0039] The GPS_Stop function stops the positioning engine threads and communication interface. This function should be called by the user program to stop GPS activity.

```
Include file
gps__ctrl.h
Syntax
tGPS__RESULT GPS__Stop( void )
```

-continued

Return value	Description
GPS__SUCCESS	GPS engine has stopped successfully
GPS__CTRL__ALREADY__STOPPED	Error: GPS engine is already stopped

TABLE 21

Example

```
#include “gps__types.h”
#include “gps__ctrl.h”
if ( GPS__Stop( ) != GPS__SUCCESS )
{
      // error handler
}
// GPS engine has stopped successfully
...
```

[0040] The GPS_Output function retrieves a message from positioning engine. There are no return values. The function is called by the positioning engine whenever any message is sent out. This function is implemented by the user program and statically linked with the GPS library.

TABLE 22

```
Syntax
void GPS__Output( tGPS__UINT32 message__id, void *message__structure,
tGPS__UINT32 length )
```

Parameter	Data range	Units	Description
message__id	GPS__NAV__MEASURED__NAVIGATION GPS__NAV__MEASURED__TRACKER GPS__NAV__RAW__TRACKER GPS__NAV__SW__VERSION GPS__NAV__CLOCK__STATUS GPS__NAV__50BPS__DATA GPS__NAV__ERROR GPS__NAV__ACK GPS__NAV__NAK GPS__NAV__VISIBLITY__LIST GPS__NAV__NL__MEAS__DATA GPS__NAV__NL__DGPS__DATA GPS__NAV__NL__SV__STATE__DATA GPS__NAV__NL__INIT__DATA GPS__ADC__ODOMETER__DATA GPS__NAV__COMPLETE GPS__NAV__TEXT		Message identifier. See chapter 7 for message details.

TABLE 22-continued

message__structure	32 bit pointer		Pointer to the message structure with data
Length	Varies depending on the message	bytes	Length of the message structure

TABLE 23

Example

```
#include “gps__types.h”
#include “gps__interface.h”
#include “gps__messages.h”
void GPS__Output( tGPS__UINT32 message__id,
void *message__structure, tGPS__UINT32 length )
{
    tGPS__NAV__MEASURED__NAVIGATION nav__data;
    switch ( message__id )
    {
        case GPS__NAV__MEASURED__NAVIGATION:
            memcpy( &nav__data, message__structure,
sizeof(tGPS__NAV__MEASURED__NAVIGATION) );
            if ( nav__data.nav__mode & GPS__MODE__MASK )
                printf(“x=%ld, y=%ld, z=%ld \n”,
                nav__data.ecef__x, nav__data.ecef__y,
```

TABLE 23-continued

Example

```
                nav__data.ecef__z);
            else
                printf(“no fix \n”);
            break;
        case GPS__NAV__MEASURED__TRACKER:
            // use tracker information here
            break;
    default:
            break;
    } // switch
} // GPS__Output( )
```

[0041] The GPS_Input function sends a command to the GPS engine. The function may be called by the client program to send a command to the GPS receiver.

TABLE 24

Include file
gps__interface.h
Syntax
tGPS__UINT32 GPS__Input(tGPS__UINT32 message__id, void *message__structure,
tGPS__UINT32 length)

Parameter	Data range	Units	Description
message__id	GPS__NAV__INITIALIZE GPS__NAV__POLL__SW__VERSION GPS__NAV__SET__DGPS__SOURCE GPS__NAV__SET__NAV__MODE GPS__NAV__SET__DOP__MODE GPS__NAV__SET__DGPS__MODE GPS__NAV__SET__ELEV__MASK GPS__NAV__SET__POWER__MASK GPS__NAV__SET__STAT__NAV GPS__NAV__POLL__CLOCK__STATUS GPS__NAV__POLL__RX__MGR__PARAMS GPS__NAV__SET__MSG__RATE GPS__NAV__SET__SBAS__PRN		Message identifier. See chapter 7 for message details.
message__structure	32 bit pointer		Pointer to the message structure with data to send
length	Varies depending on the message	bytes	Length of the message structure

TABLE 25

Return values	
Return value	Description
GPS_SUCCESS	Message was sent successfully
GPS_ERROR	Error: Message was not acknowledged
GPS_ERROR_NOT_STARTED	Error: GPS engine is not running

TABLE 26

Example

```
#include "gps_types.h"
#include "gps_interface.h"
```

TABLE 26-continued

Example

```
#include "gps_messages.h"
/* Forces cold start of GPS receiver: */
tGPS_NAV_INITIALIZE          InitMsg;
tGPS_UINT32                  result;
memset( &InitMsg, 0, sizeof(tGPS_NAV_INITIALIZE) );
InitMsg.restart_flags = GPS_RESTART_COLD;
result = GPS_Input( GPS_NAV_INITIALIZE, (void*)&InitMsg,
sizeof(tGPS_NAV_INITIALIZE) );
```

[0042] The GPS communication interface messages are exchanged between the GPS client (e.g., a user program) and positioning or GPS engine via the user interface input and output functions.

TABLE 27

Primary GPS output messages		
Message id value	Message id macro	Description
2 (0x02)	GPS_NAV_MEASURED_NAVIGATION	Provides ECEF position, velocity, GPS time, position status
4 (0x04)	GPS_NAV_MEASURED_TRACKER	Provides satellite status, azimuth, elevation and C/No information
6 (0x06)	GPS_NAV_SW_VERSION	Provides GPS engine software version
7 (0x07)	GPS_NAV_CLOCK_STATUS	Provides current GPS clock status
10 (0x0A)	GPS_NAV_ERROR	Provides error information
45 (0x2D)	GPS_ADC_ODOMETER_DATA	Provides ADC, odometer and GPIO values from tracker
47 (0x2F)	GPS_NAV_COMPLETE	This message is sent as a last one in the navigation cycle. Informs that navigation cycle is complete.
255 (0xFF)	GPS_NAV_TEXT	Provides development text information

TABLE 28

Primary GPS input messages		
Message id value	Message id macro	Description
128 (0x80)	GPS_NAV_INITIALIZE	Performs re-initialization of the GPS receiver: factory, cold, warm or hot restarts.
132 (0x84)	GPS_NAV_POLL_SW_VERSION	Asks for the GPS engine software version
133 (0x85)	GPS_NAV_SET_DGPS_SOURCE	Sets differential correction source
144 (0x90)	GPS_NAV_POLL_CLOCK_STATUS	Asks for the current GPS clock status
170 (0xAA)	GPS_NAV_SET_SBAS_PRN	Sets SBAS (WAAS/EGNOS) PRN number

TABLE 29

Additional GPS output messages for development and debug process

Message id value	Message id macro	Description
8 (0x08)	GPS_NAV_50BPS_DATA	Provides 50 bps subframe data
11 (0x0B)	GPS_NAV_ACK	Command acknowledgment
12 (0x0C)	GPS_NAV_NAK	Command not acknowledgment
13 (0x0D)	GPS_NAV_VISIBLITY_LIST	Provides current visibilty list
28 (0x1C)	GPS_NAV_NL_MEAS_DATA	Provides navigation library measurement data
29 (0x1D)	GPS_NAV_NL_DGPS_DATA	Provides navigation library differential data
30 (0x1E)	GPS_NAV_NL_SV_STATE_DATA	Provides navigation library satellite state data
31 (0x1F)	GPS_NAV_NL_INIT_DATA	Provides navigation library initialization data

TABLE 30

Additional GPS input messages for development and debug process

Message id value	Message id macro	Description
136 (0x88)	GPS_NAV_SET_NAV_MODE	Sets navigation mode
137 (0x89)	GPS_NAV_SET_DOP_MODE	Sets DOP mask control mode
138 (0x8A)	GPS_NAV_SET_DGPS_MODE	Sets differential mode of operation
139 (0x8B)	GPS_NAV_SET_ELEV_MASK	Sets elevation mask
140 (0x8C)	GPS_NAV_SET_POWER_MASK	Sets power mask
143 (0x8F)	GPS_NAV_SET_STAT_NAV	Configures static navigation mode
152 (0x98)	GPS_NAV_POLL_RX_MGR_PARAMS	Asks for current navigation parameters
166 (0xA6)	GPS_NAV_SET_MSG_RATE	Sets message output rate

[0043] The GPS_NAV_MEASURED_NAVIGATION output message provides ECEF position, velocity, GPS time and position status information. The message is outputted periodically at 1 Hz rate:

TABLE 31

Include file gps_messages.h
Message id:

Value	Macro
2 (0x02)	GPS_NAV_MEASURED_NAVIGATION

TABLE 32

Message structure tGPS_NAV_MEASURED_NAVIGATION

Structure member	Data type	Data range (after de-scaling)	Scale factor	Units	Description
ecef_x	SINT32		1	meters	Computed ECEF position.
ecef_y	SINT32		1	meters	
ecef_z	SINT32		1	meters	
ecef_vel_x	SINT16		0.125	m/sec	Computed ECEF velocity
ecef_vel_y	SINT16		0.125	m/sec	
ecef_vel_z	SINT16		0.125	m/sec	
nav_mode	UINT8		n/a	n/a	Navigation status flags. See below for details.

TABLE 32-continued

Message structure
tGPS_NAV_MEASURED_NAVIGATION

Structure member	Data type	Data range (after de-scaling)	Scale factor	Units	Description
hdop	UINT8	0 . . . 50.0	0.2	n/a	Horizontal Dilution Of Precision
nav_mode2	UINT8		n/a	n/a	Navigation status flags. See below for details.
gps_week	UINT16	>0	1	n/a	Computed full GPS week number.
gps_tow	UINT32	0 . . . 604799.99	0.01	sec.	Computed GPS time of the week.
sv_used_cnt	UINT8	0 . . . 12	1	n/a	Number of satellites used in solution.
sv_used	UINT8[12]	1 . . . 32	1	n/a	Array of PRN numbers of satellites used in solution

Note:
To get a real value of the parameter a value from the structure should be multiplied by the scale factor.

TABLE 33

nav_mode bit fields

7	6	5	4	3	2	1	0
DGPS status	DOP mask status	Altitude status		reserved 0	Position status		

TABLE 34

Position status

Value	Macro	Description
0		No navigation solution
1		1 satellite degraded solution
2		2 satellites degraded solution
3		3 satellites solution (2D)
4		More than 3 satellites solution (3D)
5		3 satellites least square solution (2D)
6		More than 3 satellites least square solution (3D)
7		Dead reckoning

TABLE 35

Altitude status

Value	Macro	Description
0		No altitude hold
1		Altitude used from filter
2		Altitude used from user
3		Forced altitude (from user)

TABLE 36

DOP mask status:

Value	Macro	Description
0		DOP mask not exceeded
1	GPS_MODE_DOP_MASK_EXCEED	DOP mask exceeded

TABLE 37

DGPS status:

Value	Macro	Description
0		Differential corrections are not used in solution
1	GPS_MODE_DGPS_USED	Differential corrections are used in solution

TABLE 38

nav_mode2 bit fields:

7	6	5	4	3	2	1	0
reserved	reserved	reserved	reserved	reserved	DR timed out	Solution validation status	reserved

TABLE 39

Solution validation status:		
Value	Macro	Description
0		Solution is not validated
1	GPS__MODE2__SOLUTION__VALIDATED	Solution is validated

TABLE 40

DR timed out status:		
Value	Macro	Description
0		Dead reckoning not timed out
1	GPS__MODE2__DR__TIMED__OUT	Dead reckoning has timed out

[0044] The GPS_NAV_MEASURED_TRACKER output message provides satellite status, azimuth, elevation and C/No information. The message is outputted periodically at 1 Hz rate.

TABLE 41

Include file gps__messages.h Message id:	
Value	Macro
4 (0x04)	GPS__NAV__MEASURED__TRACKER

TABLE 42

Message Structure					
Message structure tGPS_NAV_MEASURED_TRACKER					
Structure member	Data type	Data range (after de-scaling)	Scale factor	Units	Description
gps_week	UINT16	1 . . .	1		Computed full GPS week number.
gps_tow	UINT32	0 . . . 604799.99	0.01	sec.	Computed GPS time of the week.
chnl_cnt	UINT8	12	1		Number of receiver's channels
chnl	tGPS_SV_INFO[12]				Array of structures containing satellite information for each receiver channel. See below.

TABLE 43

tGPS__SV__INFO sub-structure:					
Structure member	Data type	Data range (after de-scaling)	Scale factor	Units	Description
svid	UINT8	1 . . . 32	1		Satellite PRN number
azimuth	UINT8	0 . . . 359.5	1.5	deg.	Satellite azimuth angle.
elevation	UINT8	0 . . . 90.0	0.5	deg	Satellite elevation angle
state	UINT16		n/a		Satellite tracking status. See below.
cno	UINT8[10]	0 . . . 60	1	dB-Hz	Array of satellite signal to noise ratios for the past second. Measurements are made every 100 ms. Value at index zero is the oldest.

Note:
To get a real value of the parameter a value from the structure should be multiplied by the scale factor.

TABLE 44

state bit fields:							
15	14	13	12	11	10	9	8
reserved 0	reserved 0	reserved 0	reserved 0	reserved 0	reserved 0	reserved 0	Initial acquisition in progress

TABLE 45

state bit fields:							
7	6	5	4	3	2	1	0
Ephemeris data available	Acquisition failed	Code locked	Carrier Pulling done	Sub Frame sync done	Bit sync done	Delta Phase valid	Acquisition success

[0045] The GPS_NAV_SW_VERSION output message provides a positioning engine software version string. Message is sent as a reply to the GPS_NAV_POLL_SW_VERSION input message.

TABLE 46

Include file gps__messages.h
Message id:

Value	Macro
6 (0x06)	GPS__NAV__SW__VERSION

TABLE 47

Message structure
tGPS__NAV__SW__VERSION

Structure member	Data type	Data range (after de-scaling)	Scale factor	Units	Description
sw__version[100]	UINT8	ASCII characters			GPS engine software version. Version string is NULL terminated.
					Message length is variable but does not exceed 100 bytes.

[0046] The GPS_NAV_CLOCK_STATUS output message provides current GPS clock status information. Message is outputted periodically at 1 Hz rate or on demand as a reply to GPS_NAV_POLL_CLOCK_STATUS input message.

TABLE 48

Include file gps__messages.h
Message id:

Value	Macro
7 (0x07)	GPS__NAV__CLOCK__STATUS

TABLE 49

Message structure
tGPS__NAV__CLOCK__STATUS

Structure member	Data type	Data range (after de-scaling)	Scale factor	Units	Description
gps__week	UINT16	1 . . .	1		Computed full GPS week number.
gps__tow	UINT32	0 . . . 604799.99	0.01	sec	Computed GPS time of the week.
sv__used__cnt	UINT8	0 . . . 12	1		Number of satellites used in solution.

TABLE 49-continued

Message structure
tGPS_NAV_CLOCK_STATUS

Structure member	Data type	Data range (after de-scaling)	Scale factor	Units	Description
clk_offset	UINT32	25000 . . . 146000	1	Hz	Computed clock offset
clk_bias	UINT32	0 . . . 0.1	1e−9	sec	Computed clock bias
est_gps_time	UINT32	0 . . . 604799.999	0.001	sec	Estimated GPS time

Note:
To get a real value of the parameter a value from the structure should be multiplied by the scale factor.

[0047] The GPS_NAV_ERROR output message outputs notification, warning, and alert messages.

TABLE 50

Include file
gps_messages.h
Message id:

Value	Macro
10 (0x0A)	GPS_NAV_ERROR

TABLE 51

Message structure
tGPS_NAV_ERROR

Structure member	Data type	Data range (after de-scaling)	Scale factor	Description
err_id	UINT16	0 . . . 0x0FFF	n/a	Notification code
		0x1000 . . . 0x1FFF	n/a	Warning code
		0x2000 . . . 0x2FFF	n/a	Alert code
param_cnt	UINT16	0 . . . 5	1	Number of 32-bit parameters in param[ ]

TABLE 51-continued

Message structure
tGPS_NAV_ERROR

Structure member	Data type	Data range (after de-scaling)	Scale factor	Description
param[5]	UINT32	UINT32 range	n/a	Array of information parameters. Meaning depends on error code

[0048] The GPS_ADC_ODOMETER_DATA output message provides ADC, odometer and GPIO lines state from tracker. Message is outputted periodically at 1 or 10 Hz rate depending on setting used in GPS_Start( ) function.

TABLE 52

Include file
gps_messages.h
Message id:

Value	Macro
45 (0x2D)	GPS_ADC_ODOMETER_DATA

TABLE 53

Message structure
tGPS_ADC_ODOMETER_DATA

Structure member	Data type	Data range (after de-scaling)	Scale factor	Units	Description
current_time	UINT32	>=0	1	ms	Tracker Time, millisecond counts from tracker reset
adc2_avg	INT16	−8192 . . . 8191	1	n/a	Averaged measurement from ADC[2] input. See below for voltage formula.
adc3_avg	INT16	−8192 . . . 8191	1	n/a	Averaged measurement from ADC[3] input. See below for voltage formula.
odo_count	UINT16	0 . . . 0xFFFF	1	n/a	Odometer counter measurement at the most recent 100 ms tracker input
gpio_stat	UINT8	0 . . . 0xFF	n/a	n/a	GPIO input states at the most recent 100 ms tracker input. Bit field, see below.

TABLE 54

gpio__stat bit field:							
7	6	5	4	3	2	1	0
GPIO12 input state	GPIO8 input state	GPIO7 input state	GPIO5 input state	GPIO4 input state	GPIO3 input state	GPIO2 input state	GPIO0 input state

TABLE 55

GPIOxx state:

Value	Macro	Description
0		Input pin xx is in low state
1		Input pin xx is in high state

[0049] In one implementation, the Voltage formula is Uin [V]=Vref*((adcX_avg+8192)/16384), where: Vref=2.55V, and adcX_avg is a measurement value from message above. The analog to digital converter may, for example, take measurements at 50 Hz rate and the reported value adcX_avg may be an average of the last 5 samples.

[0050] The GPS_NAV_COMPLETE output message is sent at the end of the navigation cycle to confirm that the GPS engine has finished a position computation cycle (with or without success). In one implementation, this message is outputted at 1 Hz rate.

TABLE 56

Include file
gps__messages.h
Message id:

Value	Macro
47 (0x2F)	GPS__NAV__COMPLETE

TABLE 57

Message structure
tGPS__NAV__COMPLETE

Structure member	Data type	Data range (after de-scaling)	Scale factor	Units	Description
control	UINT8	0			Not in use.

[0051] The GPS_NAV_TEXT output message outputs debug and development messages in text format.

TABLE 58

Include file
gps__messages.h
Message id:

Value	Macro
255 (0xFF)	GPS__NAV__TEXT

TABLE 59

Message structure
tGPS__NAV__TEXT

Structure member	Data type	Data range (after de-scaling)	Scale factor	Units	Description
msg__text[256]	UINT8	ASCII characters			Text of the message

[0052] The GPS_NAV_INITIALIZE input message performs GPS engine re-initialization. Message should be used to perform factory, cold, warm or hot restart.

TABLE 60

Include file
gps__messages.h
Message id:

Value	Macro
128 (0x80)	GPS__NAV__INITIALIZE

TABLE 61

Message structure
tGPS__NAV__INITIALIZE

Structure member	Data type	Data range (before scaling)	Scale factor	Units	Description
ecef__x	SINT32		1	meters	Approximate ECEF
ecef__y	SINT32		1	meters	position. Those values
ecef__z	SINT32		1	meters	are used by warm start with initialization only.
clk__offset	SINT32	0, 25000 . . . 146000	1	Hz	Default GPS clock offset. This value is used by the factory re-

TABLE 61-continued

Message structure
tGPS__NAV__INITIALIZE

Structure member	Data type	Data range (before scaling)	Scale factor	Units	Description
					start only. If zero is provided here a default value of 96250 Hz is used.
gps__tow	UINT32	0 . . . 604799	1	sec.	Approximate GPS time of the week. This value is used by warm start with initialization only
gps__week	UINT16	0 . . .	1		Approximate full GPS week number. This value is used by warm start with initialization only.
chnl__cnt	UINT8	12	1		Number of channels to use.
restart__flags	UINT8				Restart configuration flags. See below for details.

TABLE 62

restart__flags bit fields:

7	6	5	4	3	2	1	0
reserved 0	reserved 0	Enable text output	reserved 0	Restart mode. See below for allowed values.			

TABLE 63

Restart mode

Value	Macro	Description
0	GPS__RESTART__HOT	Hot restart
2	GPS__RESTART__WARM__NOINIT	Warm restart with no initialization
3	GPS__RESTART__WARM__INIT	Warm restart with initialization (fields ecef__x, ecef__y, ecef__z, gps__tow, gps__week are used)
6	GPS__RESTART__COLD	Cold restart
8	GPS__RESTART__FACTORY	Factory restart
Other value		Reserved

TABLE 64

Enable text output:

Value	Macro	Description
0		Development text output (messages GPS__NAV__TEXT) is disabled
1	GPS__RESTART__TEXTOUT	Development text output (messages GPS__NAV__TEXT) is enabled

[0053] In one implementation, the navigation engine will initiate restart within one second and a default clock offset value is 96250 Hz. When the actual clock offset is unknown a value of 96250 Hz should be used. However, if the real clock offset is far from a specified value a longer TTFF will be observed.

TABLE 65

Example

```
#include “gps__types.h”
#include “gps__interface.h”
/* Forces cold start of GPS receiver: */
tGPS__NAV__INITIALIZE    InitMsg;
tGPS__UINT32             result;
memset( &InitMsg, 0, sizeof(tGPS__NAV__INITIALIZE) );
gps__init.chnl__cnt = 12;
gps__init.restart__flags = GPS__RESTART__HOT |
GPS__RESTART__TEXTOUT;
result = GPS__Input( GPS__NAV__INITIALIZE, (void*)&InitMsg,
sizeof(tGPS__NAV__INITIALIZE) );
```

[0054] The GPS_NAV_POLL_SW_VERSION input message asks for the software version of the position/GPS library.

TABLE 66

Include file
gps__messages.h
Message id:

Value	Macro
132 (0x84)	GPS__NAV__POLL__SW__VERSION

TABLE 67

Message structure
tGPS__NAV__POLL__SW__VERSION

Structure member	Data type	Data range (before scaling)	Scale factor	Units	Description
control	UINT8	0			Not in use.

[0055] The software version string may be returned, for example, in a GPS_NAV_SW_VERSION output message via GPS_Output( ) function.

[0056] The GPS_NAV_SET_DGPS_SOURCE input message selects a data source for differential (DGPS) corrections.

TABLE 68

Include file
gps__messages.h
Message id:

Value	Macro
133 (0x85)	GPS__NAV__SET__DGPS__SOURCE

TABLE 69

Message structure
tGPS__NAV__SET__DGPS__SOURCE

Structure member	Data type	Data range (before scaling)	Scale factor	Units	Description
src	UINT8	see below	n/a	n/a	Selects differential correction data source. Default is NONE after factory reset.
freq	UINT32	0			Internal beacon frequency. Not used, set to 0.
bit__rate	UINT8	0			Internal beacon bit rate. Not used, set to 0.

TABLE 70

Differential correction source:

Value	Macro	Description
0	GPS__DGPS__SRC__NONE	Differential corrections are not used for navigation
1	GPS__DGPS__SRC__SBAS	Selects SBAS as a data source
Other value		Reserved

[0057] These settings may be saved in nonvolatile data storage.

[0058] The GPS_NAV_POLL_CLOCK_STATUS input message asks for the current GPS clock status of the GPS library.

TABLE 71

Include file
gps__messages.h
Message id:

Value	Macro
144 (0x90)	GPS__NAV__POLL__CLOCK__STATUS

TABLE 72

Message structure
tGPS__NAV__POLL__CLOCK__STATUS

Structure member	Data type	Data range (before scaling)	Scale factor	Units	Description
control	UINT8	0			Not in use.

[0059] The clock status data may be returned in GPS_NAV_CLOCK_STATUS output message via GPS_Output( ) function.

[0060] The GPS_NAV_SET_SBAS_PRN input message manually forces PRN for use in SBAS corrections.

TABLE 73

Include file
gps__messages.h
Message id:

Value	Macro
170 (0xAA)	GPS__NAV__SET__SBAS__PRN

TABLE 74

Message structure
tGPS__NAV__SET__DGPS__MODE

Structure member	Data type	Data range (before scaling)	Scale factor	Units	Description
prn	UINT8	0, 120 . . . 138	1		PRN number, 0 = Automatic search
reserved__0	UINT32				Reserved
reserved__1	UINT32				Reserved

[0061] These settings may be saved in permanent data storage.

[0062] The Operating System Interface functions are operating system dependent and are implemented in the open source format available from SiRF Technology, Inc. The functions include Thread, mutex and semaphore functions. Permanent storage and RTC functions may be available depending on hardware availability.

TABLE 75

Thread control functions

Function name	Description	Provided in
OS_Thread_Create( )	Function creates a thread	gps_rtos.c
OS_Thread_Delete( )	Function deletes a thread	gps_rtos.c
OS_Thread_Sleep( )	Function suspends a thread for a given time	gps_rtos.c

TABLE 76

Mutex control functions

Function name	Description	Provided in
OS_Mutex_Create( )	Function creates a mutex object - a software critical section	gps_rtos.c
OS_Mutex_Delete( )	Function deletes a mutex object	gps_rtos.c
OS_Mutex_Enter( )	Function obtains a mutex object	gps_rtos.c
OS_Mutex_Exit( )	Function releases a mutex object	gps_rtos.c

TABLE 77

Semaphore control functions

Function name	Description	Implemented in
OS_Semaphore_Create( )	Function creates a semaphore object	gps_rtos.c
OS_Semaphore_Delete( )	Function deletes a semaphore object	gps_rtos.c
OS_Semaphore_Wait( )	Function waits for a semaphore	gps_rtos.c
OS_Semaphore_Release( )	Functions releases a semaphore object	gps_rtos.c

TABLE 78

Permanent storage control functions

Function name	Description	Implemented in
OS_Storage_Open( )	Functions opens a storage system	gps_rtos.c
OS_Storage_Close( )	Functions closes a storage system	gps_rtos.c
OS_Storage_Write( )	Function writes given words to the non-volatile storage area (battery backed RAM, file, registry, etc.)	gps_rtos.c
OS_Storage_WriteAll( )	Function writes all storage data to the non-volatile storage area (battery backed RAM, file, registry, etc.)	gps_rtos.c
OS_Storage_Read( )	Function retrieves a data from the non-volatile storage area	gps_rtos.c

TABLE 79

Real Time Clock control function

Function name	Description	Implemented in
OS_RTC_Read( )	Function returns a current time from on-board's real time clock.	gps_rtos.c

[0063] The OS_Thread_Create( ) function uses an appropriate operating system service to create a thread. The function is called by the GPS engine at the startup to create all desired threads.

TABLE 80

```
File
gps_rtos.c
Syntax
tGPS_UINT32 OS_Thread_Create( tGPS_UINT32 thread_id,
                              tGPS_HANDLE function_ptr,
                              tGPS_THREAD *thread_handle )
```

Parameter	Data range	Units	Description
thread_id	Thread macros defined in gps_rtos.h		Identifier of the thread to be created
function_ptr			Thread function
thread_handle			Handle of the created thread

TABLE 81

Return values

Return value	Description
GPS_SUCCESS	Thread was created successfully
GPS_RTOS_ERROR	An error occurred

[0064] A maximum number of desired threads may be specified by a GPS_RTOS_THREAD_MAX define.

[0065] The OS_Thread_Delete( ) function uses appropriate OS service to stop a thread and/or to wait for thread to gracefully stop. Function is called by the GPS engine from GPS_Stop( ) to stop all SiRFNav threads.

TABLE 82

```
File
gps_rtos.c
Syntax
    tGPS_UINT32 OS_Thread_Delete(tGPS_THREAD
    thread_handle, tGPS_UINT32 timeout )
```

Parameter	Data range	Units	Description
thread_handle			Thread handle
Timeout		ms	Grace period allowed before terminating the thread

TABLE 83

Return values

Return value	Description
GPS_SUCCESS	Thread was deleted successfully
GPS_RTOS_ERROR	An error occurred

[0066] Thread identifiers and functions may be specified, for example, in the gps_rtos.h header file.

[0067] The OS_Thread_Sleep( ) function uses appropriate OS service to suspend a thread for a given number of milliseconds. Function is called by the GPS engine to suspend current thread temporarily.

TABLE 84

File
gps_rtos.c
Syntax
tGPS_UINT32 OS_Thread_Sleep (tGPS_UINT32 milliseconds)

Parameter	Data range	Units	Description
Miliseconds		ms	Time for what thread will be suspended

TABLE 85

Return values	
Return value	Description
GPS_SUCCESS	Thread sleep has finished successfully

[0068] The OS_Mutex_Create( ) function uses an operating system service to create a Mutex (mutually exclusive) object, or OS-specific equivalent such as a software critical section. This function is called by the GPS engine at the startup to create all desired mutexes.

TABLE 86

File
gps_rtos.c
Syntax
tGPS_UINT32 OS_Mutex_Create(tGPS_MUTEX *mx_handle)

Parameter	Data range	Units	Description
mx_handle			Handle of the created mutex object

TABLE 87

Return values	
Return value	Description
GPS_SUCCESS	Mutex was successfully created
GPS_RTOS_ERROR	An error occurred

[0069] The maximum number of desired mutexes may be specified by a GPS_RTOS_MUTEX_MAX define.

[0070] The OS_Mutex_Delete( ) function uses an operating system service to delete a Mutex object. The function is called by the GPS engine at the stopping procedure to delete all used mutexes.

TABLE 88

File
gps_rtos.c
Syntax
tGPS_UINT32 OS_Mutex_Delete(tGPS_MUTEX mx_handle)

Parameter	Data range	Units	Description
mx_handle			Mutex object handle

TABLE 89

Return values	
Return value	Description
GPS_SUCCESS	Mutex was successfully deleted
GPS_RTOS_ERROR	An error occurred

[0071] The OS_Mutex_Enter( ) function uses an operating system service to obtain a Mutex object. This function is called by the GPS engine just before entering into a critical section.

TABLE 90

File
gps_rtos.c
Syntax
tGPS_UINT32 OS_Mutex_Enter(tGPS_MUTEX mx_handle)

Parameter	Data range	Units	Description
mx_handle			Mutex object handle

TABLE 91

Return values	
Return value	Description
GPS_SUCCESS	Mutex was successfully obtained
GPS_RTOS_ERROR	An error occurred

[0072] The OS_Mutex_Exit( ) function uses appropriate OS service to release a Mutex object. Function is called by the GPS engine just after leaving from a critical section.

TABLE 92

File
gps_rtos.c
Syntax
tGPS_UINT32 OS_Mutex_Exit(tGPS_MUTEX mx_handle)

Parameter	Data range	Units	Description
mx_handle			Mutex object handle

TABLE 93

Return values	
Return value	Description
GPS_SUCCESS	Mutex was successfully released
GPS_RTOS_ERROR	An error occurred

[0073] The OS_Semaphore_Create( ) function uses an operating system service to create a Semaphore object. The function is called by the GPS engine at the startup to create all desired semaphores.

TABLE 94

File gps__rtos.c Syntax tGPS__UINT32 OS__Semaphore__Create(tGPS__SEMAPHORE *sem__handle, tGPS__UINT32 init__value)			
Parameter	Data range	Units	Description
sem__handle			Handle of the created semaphore object
init__value	any UINT32		Semaphore initialization value

TABLE 95

Return values	
Return value	Description
GPS__SUCCESS	Semaphore was successfully created
GPS__RTOS__ERROR	An error occurred

[0074] The maximum number of desired semaphores may specified by a GPS_RTOS_SEM_MAX define.

[0075] The OS_Semaphore_Delete( ) function uses an operating system service to delete a Semaphore object. The function is called by the GPS engine at the stopping procedure to delete all used semaphores.

TABLE 96

File gps__rtos.c Syntax tGPS__UINT32 OS__Semaphore__Delete(tGPS__SEMAPHORE sem__handle)			
Parameter	Data range	Units	Description
sem__handle			Semaphore object handle

TABLE 97

Return values	
Return value	Description
GPS__SUCCESS	Semaphore was successfully deleted
GPS__RTOS__ERROR	An error occurred

[0076] The OS_Semaphore_Wait( ) function uses an operating system service to wait for Semaphore object. Function is called by the GPS threads to wait for events.

TABLE 98

File gps__rtos.c Syntax tGPS__UINT32 OS__Semaphore__Wait(tGPS__SEMAPHORE sem__handle, tGPS__UINT32 timeout)			
Parameter	Data range	Units	Description
sem__handle			Semaphore object handle
Timeout	0-4000000000 or GPS__INFINITE	ms	Maximum time allowed to wait for semaphore

TABLE 99

Return values	
Return value	Description
GPS__SUCCESS	Semaphore was successfully obtained
GPS__RTOS__ERROR	An error occurred
GPS__RTOS__SEM__WAIT__TIMEOUT	Waiting for the semaphore has timed out, semaphore was not obtained.

[0077] The OS_Semaphore_Release( ) function uses appropriate OS service to release a Semaphore object. The function is called by the GPS engine to schedule other thread.

TABLE 100

File gps__rtos.c Syntax tGPS__UINT32 OS__Semaphore__Release(tGPS__SEMAPHORE sem__handle)			
Parameter	Data range	Units	Description
sem__handle			Semaphore object handle

TABLE 101

Return values	
Return value	Description
GPS__SUCCESS	Semaphore was successfully released
GPS__RTOS__ERROR	An error occurred

[0078] The OS_Storage_Open( ) function uses an operating system or BIOS service to open a non volatile storage system. The function is called by the GPS engine at the startup to open a storage.

TABLE 102

File gps__rtos.c Syntax tGPS__RESULT OS__Storage__Open(void)			
Parameter	Data range	Units	Description
none			

TABLE 103

Return values	
Return value	Description
GPS__SUCCESS	Storage has been opened successfully
GPS__RTOS__ERROR	An error occurred

[0079] When the nonvolatile storage is not available then function may return GPS_RTOS_ERROR.

[0080] The OS_Storage_Close( ) function uses appropriate OS or BIOS service to close a non volatile storage system. The function is called by the GPS engine at the shut down procedure to close a storage.

TABLE 104

File
gps__rtos.c
Syntax
tGPS__RESULT OS__Storage__Close(void)

Parameter	Data range	Units	Description
none			

TABLE 105

Return values	
Return value	Description
GPS__SUCCESS	Storage has been closed successfully
GPS__RTOS__ERROR	An error occurred

[0081] When the nonvolatile storage is not available then function may return GPS_RTOS_ERROR.

[0082] The OS_Storage_Write( ) function uses appropriate OS or BIOS service to write given words to a non volatile storage system (battery backed RAM, file system, etc.). The function is called by the GPS engine periodically, for example every 30 seconds, to save time, position and ephemeris information. That information is used later to speed up the GPS start procedure (e.g., for hot or warm starts).

TABLE 106

File
gps__rtos.c
Syntax
tGPS__RESULT OS__Storage__Write(tGPS__UINT32 offset,
tGPS__UINT16 *data,
tGPS__UINT16 words)

Parameter	Data range	Units	Description
offset		bytes	Offset from the beginning of the storage structure where new data should be written
data			Pointer to the data to write
words		16 bit words	Number of 16 bit words to write

TABLE 107

Return values	
Return value	Description
GPS__SUCCESS	Write done successfully
GPS__RTOS__ERROR	An error occurred

[0083] The OS_Storage_WriteAll( ) function uses an operating system or BIOS service to write a GPS data structure to a nonvolatile storage system. The function is called by the GPS engine periodically, for example every 30 seconds, to save time, position and ephemeris information. That information is used later to speed up the GPS start procedure (hot or warm starts)

TABLE 108

File
gps__rtos.c
Syntax
tGPS__RESULT OS__Storage__WriteAll(tGPS__UINT8 *data,
tGPS__UINT16 length)

Parameter	Data range	Units	Description
data			Pointer to the data to write
length		bytes	Length of the data

TABLE 109

Return values	
Return value	Description
GPS__SUCCESS	Write done successfully
GPS__RTOS__ERROR	An error occurred

[0084] The OS_Storage_Read( ) function uses an operating system or BIOS service to read GPS data structure from a nonvolatile storage system. The function is called by the GPS engine at the startup to retrieve time, position and ephemeris information. This information is used to speed up the GPS start procedure (e.g., for hot or warm starts).

TABLE 110

File
gps__rtos.c
Syntax
tGPS__RESULT OS__Storage__Read(tGPS__UINT8 *data,
tGPS__UINT16 words)

Parameter	Data range	Units	Description
data			Pointer to the data to read
words		16 bit words	Length of the data

TABLE 111

Return values	
Return value	Description
GPS__SUCCESS	Read done successfully
GPS__RTOS__ERROR	An error occurred

[0085] The OS_RTC_Read( ) function uses an operating system or BIOS service to read a real time clock information from the host's RTC. The function is called periodically by the GPS engine.

TABLE 112

File
gps__rtos.c
Syntax
tGPS__UINT32 OS__RTC__Read(tGPS__UINT16 *weekno, tGPS__UINT32 *timeOfWeek)

Parameter	Data range	Units	Description
weekno	1 ..		GPS full week number
timeOfWeek	0 .. 604799999	ms	GPS time of the week

TABLE 113

Return values

Return value	Description
GPS__SUCCESS	Read done successfully
GPS__RTOS__ERROR	An error occurred

[0086] The tracker communication interface functions allow messages to be sent and received between the tracker hardware and the user programs and position library.

TABLE 114

tracker communication interface functions

Function	Description	Implemented in
GPS__COMM__TRK__Create( )	Creates tracker interface port handle	gps__comm__trk.c
GPS__COMM__TRK__Delete( )	Deletes tracker interface port handle	gps__comm__trk.c
GPS__COMM__TRK__Open( )	Opens and configures tracker port	gps__comm__trk.c
GPS__COMM__TRK__Reopen( )	Reopens and/or reconfigures tracker port	gps__comm__trk.c
GPS__COMM__TRK__Close( )	Closes tracker port	gps__comm__trk.c
GPS__COMM__TRK__Wait( )	Waits for data from the tracker	gps__comm__trk.c
GPS__COMM__TRK__Read( )	Reads data from the tracker	gps__comm__trk.c
GPS__COMM__TRK__Write( )	Send commands to the tracker	gps__comm__trk.c

[0087] The GPS_COMM_TRK_Create( ) function uses an OS or BIOS service to create a tracker communication handle. The function is called by the GPS engine at the startup to create a communication handle.

TABLE 115

File
gps__comm__trk.c
Syntax
tGPS__UINT32 GPS__COMM__TRK__Create(tGPS__COMM *port__handle)

Parameter	Data range	Units	Description
port__handle			Pointer to the communication port handle

TABLE 116

Return values

Return value	Description
GPS__SUCCESS	Port handle was successfully created
GPS__COMM__ERROR	Error creating port handle

[0088] The GPS_COMM_TRK_Delete( ) function uses an OS or BIOS service to delete a tracker communication handle. The function is called by the GPS engine at the stopping procedure to delete a communication handler.

TABLE 117

File
gps__comm__trk.c
Syntax
tGPS__UINT32 GPS__COMM__TRK__Delete(tGPS__COMM port__handle)

Parameter	Data range	Units	Description
port__handle			Pointer to the communication port handle

TABLE 118

Return values

Return value	Description
GPS__SUCCESS	Port handle was successfully deleted
GPS__COMM__ERROR	An error occurred while deleting port handle

[0089] The GPS_COMM_TRK_Open( ) function uses an OS or BIOS service to open and configure a tracker communication port. The function is called by the GPS engine at the startup.

TABLE 119

File
gps__comm__trk.c
Syntax
tGPS__UINT32 GPS__COMM__TRK__Open(tGPS__COMM port__handle, tGPS__UINT32 port__num, tGPS__UINT32 baud__rate)

Parameter	Data range	Units	Description
port__handle			Pointer to the communication port handle
port__num			Specifies a communication port where tracker is connected to. 1 = serial port 1, 2 = serial port 2, . . .
baud__rate	4800, 38400, 57600, 115200	bps	Specifies a baud rate at which tracker is connected to. Default 2t tracker baud rate is 38400 bps.

TABLE 120

Return values

Return value	Description
GPS__SUCCESS	Port was successfully opened
GPS__COMM__ERROR	An error occurred while opening or configuring the port

[0090] The GPS_COMM_TRK_Reopen( ) function uses an OS or BIOS service to re-open a tracker communication port. The function is called by the GPS engine after coming back from a power suspend mode. When power suspend mode is not required then the function may return GPS_SUCCESS only.

TABLE 121

File
gps__comm__trk.c
Syntax
tGPS__UINT32 GPS__COMM__TRK__Reopen(tGPS__COMM port__handle)

Parameter	Data range	Units	Description
port__handle			Pointer to the communication port handle

TABLE 122

Return values	
Return value	Description
GPS__SUCCESS	Port was successfully re-opened
GPS__COMM__ERROR	An error occurred

[0091] The GPS_COMM_TRK_Close( ) function uses an OS or BIOS service to close a tracker communication port. The function is called by the GPS engine at the stopping procedure to close the port.

TABLE 123

File
gps__comm__trk.c
Syntax
tGPS__UINT32 GPS__COMM__TRK__Close(tGPS__COMM port__handle)

Parameter	Data range	Units	Description
port__handle			Pointer to the communication port handle

TABLE 124

Return values	
Return value	Description
GPS__SUCCESS	Port was successfully closed
GPS__COMM__ERROR	An error occurred

[0092] The GPS_COMM_TRK_Wait( ) function uses an OS or BIOS services to wait for data from a tracker communication port. The function is called by the GPS engine to wait for the tracker data.

TABLE 125

File
gps__comm__trk.c
Syntax
tGPS__UINT32 GPS__COMM__TRK__Wait(tGPS__COMM port__handle, tGPS__UINT32 timeout)

Parameter	Data range	Units	Description
port__handle			Pointer to the communication port handle
timeout	0-4000000000 or GPS__INFINITE	ms	Timeout value

TABLE 126

Return values	
Return value	Description
GPS__SUCCESS	Data from tracker is available
GPS__COMM__DATA__NOT__AVAILABLE	Error: data from tracker was not available within given time

[0093] The GPS_COMM_TRK_Read( ) function uses appropriate OS or BIOS services to read data from a tracker communication port. The function is called by the GPS engine to read tracker data.

TABLE 127

```
    File
    gps__comm__trk.c
Syntax
    tGPS__UINT32 GPS__COMM__Trk__Read(tGPS__COMM
    port__handle,
                tGPS__UINT8 *data,
                tGPS__UINT32 length,
                tGPS__UINT32 *bytes__read )
```

Parameter	Data range	Units	Description
port__handle			Pointer to the communication port handle
data			Pointer to the read data
length	1 . . . 65535	bytes	Number of requested bytes
bytes__read	0 . . . length	bytes	Number of bytes read

TABLE 128

Return values	
Return value	Description
GPS__SUCCESS	Data read was successful
GPS__COMM__DATA__NOT__AVAILABLE	An error occurred

[0094] The GPS_COMM_TRK_Write( ) function uses appropriate OS or BIOS services to write data to the tracker communication port. The function is called by the GPS engine to send commands to the tracker hardware.

TABLE 129

File gps_comm_trk.c Syntax tGPS_UINT32 GPS_COMM_Trk_Write(tGPS_COMM port_handle, tGPS_UINT8 *data, tGPS_UINT32 length)			
Parameter	Data range	Units	Description
port_handle			Pointer to the communication port handle
data			Pointer to the data to send
length	1 . . . 65535	bytes	Number of bytes to send

TABLE 130

Return values	
Return value	Description
GPS_SUCCESS	Data write was successful
GPS_COMM_ERROR	An error occurred

[0095] Turning next to FIG. **5**, that figure shows a block diagram **500** of the Cooperation between threads, tasks and hardware in one implementation of a host based GPS solution. In particular, the tracker hardware **104** communicates through a serial driver **502** (for example, the Windows CE serial driver). The serial driver **502** communicates and cooperates with a file system **504** (for example, the Windows CE file system), which includes input buffers and output buffers for the communications that will occur.

[0096] FIG. **5** shows a pass through data flow path to the tracker hardware **104**. The path includes the SendPasahroughDataToTracker thread **506** that forwards data directly from a client program, through a pass through control function **508** to a tracker interface send function **510**. In the reception direction, the tracker interface receive function **512** forwards data from the tracker hardware **104** to the navigation/positioning engine queue **514** (if the message is destined for the positioning engine), or to the user interface queue **516** (if the message is destined directly for the user program). The DataForwarder thread **518** removes messages from the user interface queue **516** and sends them via the user callback function **520** to the user program. When the host **102** includes the Component Object Module interface (available from Microsoft), the user callback function **520** may be the ICallBack function.

[0097] The receive manager and navigation thread **522** removes messages destined for the GPS library from the positioning engine queue **514**, and also places messages destined for the user programs on the user interface queue **516**. The messages for the GPS library are processed by the tasks including the NavPeriodicTask **524**. A set of shared buffers, control flags, completion flags, and the like **526** are maintained by the GPS library. Finally, it is noted that the COM interface provides a set of control functions **528**.

[0098] Turning next to FIG. **6**, that figure illustrates one execution schedule **600** for the receive manager thread **522** and the NavPeriodicTask **524**. In the schedule **600**, the NavPeriodicTask **524** runs as a low-priority (background) thread, while the receiver manager and navigation thread **522** run in one normal-priority thread.

[0099] With regard to FIG. **7**, that figure shows a synchronization diagram **700**. The synchronization diagram **700** illustrates the timing and interaction between the threads and tasks shown in FIG. **5**.

[0100] With reference to FIG. **7**, receive manager (RxM) and navigation (Nav) run sequentially in one loop that waits for new data from Tracker Interface (TRK_IF) Receiver before each iteration. Either RxM or Nav may signals NavPeriodicTask **524** to proceed with one iteration of its loop (unless NavPeriodicTask **524** already performing its task, in which case it will finish the task and skip one loop).

[0101] The RxM and Nav thread **522** may wait on a Critical Section when writing data to the UI Queue **516**, or when sending data to Tracker **104**. There will typically be a thread running while RxM&Nav are waiting. In one implementation, NavPeriodicTasks **524** runs at smaller priority than the other tasks and it will not run as long as any other thread is running. In an alternative implementation, NavPeriodicTasks **524** runs at normal priority, but does not present a conflict as long as RxM&Nav have sufficient priority to consume data generated by NavPeriodicTasks **524**.

[0102] The RxM and Nav thread **522** runs the RxM control task that maintains a state machine for the Rx and manages the state machine transitions based on current state. The RxM communicates with the tracker hardware **104** through the tracker interface. It both sends data and commands to the tracker hardware **104** to pace it through initial acquisition and tracking of SPS satellites, and receives data and status messages from the receiver with raw SPS satellite tracking data. The primary purpose of the RxM task is to manage and control the operation of the tracker hardware **104**. It also preprocesses the raw tracker data and submits the processed data to the Navigation Processing Task. The RxM gets scheduled or called by the Nav Task once the tracker hardware **104** starts tracking.

[0103] The NavPeriodicTasks thread **524** is a pseudo task that performs miscellaneous support operations for the RxM and Nav tasks. Its functions include determining and performing updates to the satellite state tables, and generating new visible SPS satellite list when new ephemeris data is collected, or whenever it is requested.

[0104] The Nav Processor Thread performs position, velocity and time computations based on the RxM generated individual SPS satellite data. This makes use of the functionality offered through the navigation library in optimally computing the navigation position data. The computed navigation data is made available to the Data Forwarding thread. At the beginning of each iteration, the Nay Processor calls or schedules the RxM task to run, and then it performs navigation computations and generates the user position, velocity, and time data. Based on the computation results, if pre-selected error thresholds are exceeded, the Nay Processor may send commands to the receiver, either directly or through the RxM, to force the receiver to reset.

[0105] The I/O Reader thread and Tracker Interface Receiver **512** sends data to queues as shown in FIG. **5**. In addition, data length error checks may be performed with error counts logged in a global variable. Erroneous message bytes will be reported to the user program through debug messages.

[0106] Note that in some implementations, the I/O Writer thread **510** is not used. Instead, its role may been taken by TRK_IF, whose methods are invoked from the RxM+Nav thread **522** and SendPassThruDataToTracker **504**. TRK_IF writes directly to the serial port. (All I/O functions will be grouped into one class). In WinCE, buffering is performed on the File System level, which allows TRK_IF to return quickly upon sending data. On Nucleus, additional buffering may be provided.

[0107] The DataForwarderThread **518** reads from the UI Queue **516** and calls the user program's ICallBack interface for each binary message to be sent. If the UI queue's Semaphore is still signaled after Callback returns, the DataForwarderThread **518** may continue piping data until the UI queue **516** is empty. In one implementation, the UI Queue **516** is not locked while Callback is being executed, which allows other threads to run while waiting for Callback to return. Client Callback typically puts data in internal storage for another thread to use. Generally, one Callback is called at a time. The UI Queue **516** is prioritized and it will put pass-thru messages before all others in the queue.

[0108] The SendPassThruDataToTracker function **506** is an API call for sending pass-thru messages from the user program to the tracker hardware **104**. Note that the pass through control function **504** may be implemented as a filter to enable or disable pass-thru messages:

[0109] A Shutdown may be performed by purging all queues and I/O. For example, 300 ms (enough for RxM&Nav to complete) may then be given for threads to complete. Although some threads may not complete in that time, such as the DataForwarderThread **518** (that may be waiting for Callback to return), and NavPeriodicTask **524**, for which there may or may not be a provision to interrupt long-term calculations. Regardless, threads which do not complete on time are terminated.

[0110] The following synchronization objects may be used: a Semaphore and Critical Section in UI Queue **516** for triggering UI output, a Semaphore and Critical Section in Trk2Nav Queue **514** for triggering Nav update, a Positioning/Navigation Library sync flag (from NavPeriodTasks to RxM and Nav), and a shutdown semaphore and flag. Note that the Critical Section(s) in the Tracker Interface are for protecting access to the serial port.

[0111] Queues may have the following API and features: Constructor/destructor, void *GetBuffer(int priority, long size) to obtain a pre-allocated, buffer for Put( ) void Put( ) to queues the buffer with specified priority, void *BeginGet° to waits until data ready or shutdown, void EndGet( ), void Remove( ), void Purge( ) to cancel all BeginGet calls, an internal Semaphore for notifying BeginGet( ) when data is ready, and an internal Critical Section.

[0112] With regard to error checking, all queue overruns, I/O errors, timeouts and COM errors may optionally be reported to client, packaged in debug messages, UI queue **516** overruns will be reported as an error to user program, Tracker message time-outs may be handled by Nav, and Trk2Nav Queue **514** overruns may be signaled to RxM and Nay.

[0113] It is further noted that the Windows registry may provide a mechanism for configuring thread priorities (that may, for example, be set once at startup and remain unchanged during execution), I/O buffer sizes, and queue sizes. Note that the SetupComm( ) function may be used to increase the size of existing WinCE I/O buffers. Doing so prevents input data loss under stress conditions. This may also be configurable through registry, and default values may be chosen to accommodate several seconds of I/O (e.g., 4 kb for input and 1 kb for output).

[0114] The foregoing description of an implementation of the invention has been presented for purposes of illustration and description. It is not exhaustive and does not limit the invention to the precise form disclosed. Modifications and variations are possible in light of the above teachings or may be acquired from practicing of the invention. For example, the described implementation includes software but the present invention may be implemented as a combination of hardware and software or in hardware alone. Note also that the implementation may vary between systems. The invention may be implemented with both object-oriented and non-object-oriented programming systems. The claims and their equivalents define the scope of the invention.

What is claimed is:

1. A system for processing positioning signals, the system comprising:

a mobile phone including:

a tracker hardware interface for receiving positioning information from a tracker hardware internal or external to the mobile phone;

a memory including a GPS library having a user interface, a tracker interface, and an operating system interface, the tracker interface including at least one tracker interface function for communicating with the tracker hardware over the tracker hardware interface; and

a processor for running the tracker interface function,

wherein the processor, using the GPS library, computes a location of the mobile phone based on the positioning information obtained by the tracker interface function, and is configured to communicate the location of the mobile phone to a plurality of respectively different user programs running on the mobile phone in response to requests from the respective programs.

2. The system of claim **1**, wherein the tracker hardware interface comprises a serial interface.

3. The system of claim **1**, wherein the user interface comprises at least one positioning control function and at least one positioning engine communication function.

4. The system of claim **3**, wherein the positioning control function comprises a positioning engine start function.

5. The system of claim **3**, wherein the positioning control function comprises a positioning engine stop function.

6. The system of claim **3**, wherein the positioning engine communication function is a command delivery function.

7. The system of claim **1**, wherein the user programs includes at least one of: a mapping program displaying the location of the mobile phone, a course charter program displaying a path traveled by the mobile phone and a location aid program displaying location information of the mobile phone.

* * * * *