Plextek Limited, London Road, Great Chesterford, Essex, CB10 1NY, UK
Telephone: +44 (0)1799 533200 Fax: +44 (0)1799 533201
Website: http://www.plextek.co.uk Email: post@plextek.co.uk

Communications Technology Consultants

Plextek

Gizmondo Terminal GPS Software Design Specification

25 May 2004

Alan Levy

Document Name EDT020

Version 01

Distribution:

Plextek	AL, KIO
Intrinsyc	Graeme Wintle

Registered Address
London Road
Great Chesterford
Essex, CB10 1NY, UK

Company Registration
No. 2305889
VAT Registration
No. GB 532 2188 67

Executive Summary

Design specification for the Gizmondo Terminal GPS software.

Revision History

Version	Date	Description	Author	Approved by
1	25/5/2004	First Issue	AL	AL

Version 01	Approved by	AL

Contents

1 Introduction

The Gizmondo terminal is an advanced gaming platform, which also incorporates wireless WAN data communications using GSM/GPRS and position dependent functions – using GPS to derive the position of the terminal.

The target market for this product is 10-35 year olds. It incorporates features that are designed to appeal to that market; of particular relevance in the context of this document are the following features:

- 3D gaming including peer to peer gaming using Bluetooth and position based gaming using GPS
- Remote tracking and Geofencing of the Gizmondo by parents using GSM and GPS (this feature is targeted at the bottom end of the age range and at their parents)
- Map download of current position using GPRS and GPS

The chosen Operating System platform is Microsoft Windows CE.NET (version 4.2). This selection encompasses the operating system kernel and some of the platform infrastructure (e.g. TCP/IP protocol stack). The user interface and most applications will be either custom developed for the Gizmondo terminal or ports of third party software.

Most of the functionality of the Gizmondo software resides on the terminal itself, however the terminal exists within the context of a network infrastructure and certain features interact heavily with that infrastructure. An overview of this is shown in Figure 1.

Unless otherwise stated, it is assumed that Plextek is responsible for implementation of all software functionality described in this document.

Text shown in italics is incomplete and requires further investigation/consideration/discussion. It is intended to invite comment.

1.1 Glossary

APM	Advanced Power Management. A power saving scheme built into the SiRF XTrac software
Flight Mode	A mode of operation where the GSM/GPRS, GPS and Bluetooth radios are turned off. This is required at certain places/times such as hospitals or in aircraft during takeoff.
Geofence	A defined geographical area. The terminal is expected to remain within that area while the Geofence is active and an alarm is generated if it leaves unexpectedly.
GNS	Gizmondo Network Services. A set of infrastructure services that interact with the terminal over GPRS/SMS.
Over The Air (OTA) configuration	A mechanism used by network operators to configure settings such as GPRS stack parameters by means of special SMS messages.
SiRF XTrac	The high sensitivity version of SiRF's GPS receiver firmware.

1.2 References

[1] Gizmondo Terminal Software Specification – EDR003

[2] Equipment (DTE – DCE) interface for Short Message Service (SMS) and Cell Broadcast Service (CBS) (GSM 07.05) – ETSI TS 100 585

[3] AT Command set for GSM Mobile Equipment (ME) (GSM 07.07) – ETSI TS 100 916

[4] Terminal Equipment to Mobile Station (TE-MS) multiplexer protocol (GSM 07.10) – ETSI TS 101 369

[5] SiRF Binary Protocol Reference Manual – 1050-0041, Revision 1.1, February 2004

[6] SiRFstarIIe/LP Evaluation Kit User's Guide – 1055-1028, Revision 1.3, February 2004

[7] SiRF XTrac Developers Reference Manual – 1050-0050, Revision 1.0, May 2004.

[8] Gizmondo terminal hardware schematic – EDP1S

[9] Gizmondo terminal power management - high level description – EDT024

2 Overview of the terminal

The Gizmondo terminal contains a host processor (Samsung S3C2440 multimedia CPU) and a GPS subsystem based on the SiRFStar II GPS2e/LP chipset. The GPS subsystem includes a high sensitivity receiver which can track satellite signals down to around –150dBm and is capable of operating indoors, thus allowing the terminal to be aware of its position under most normal usage conditions. Because of this capability, the terminal is able to support a number of position related functions, such as tracking and mapping that are normally only usable outdoors.

To perform the position related functions, the terminal software interacts with a number of Gizmondo Network Services (GNS) running on one or more network servers. A simplified configuration is shown in Figure 1.

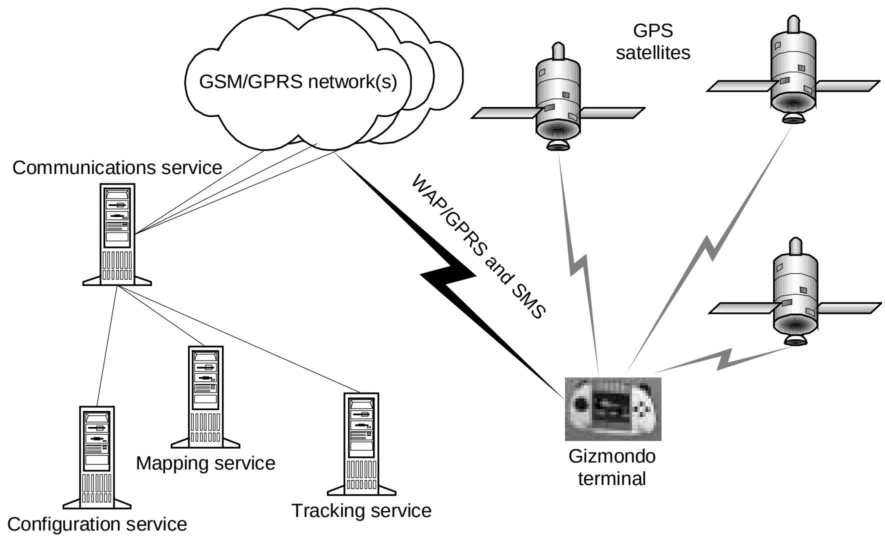


Figure 1 - Network context

3 GPS software overview

The Gizmondo GPS software consists of two components :–

- The GPS driver. This is a WinCE.NET built-in stream driver.
- The Gizmondo GPS firmware. This is a modified version of the standard SiRF XTrac 2.0 firmware.

The GPS software communicates with other applications running both locally on the terminal and remotely on servers. It performs several tasks:

- Driving the hardware.
- Synchronising system time (on the host) with GPS time.
- Maintaining position data, and supplying it to applications running on the terminal.
- Geofencing

The relationship between these two software components and the context in which they operate is shown in Figure 2. For clarity, only the most significant system components and interfaces are identified; system services (e.g. WinCE Registry access) are available for use as necessary by all components. Components written/modified by Plextek are shown with a bold outline.

In normal use, the GPS device driver is loaded after the serial port driver as Windows CE is started. During factory test, this driver is not loaded and the FTS interfaces directly to the serial port.

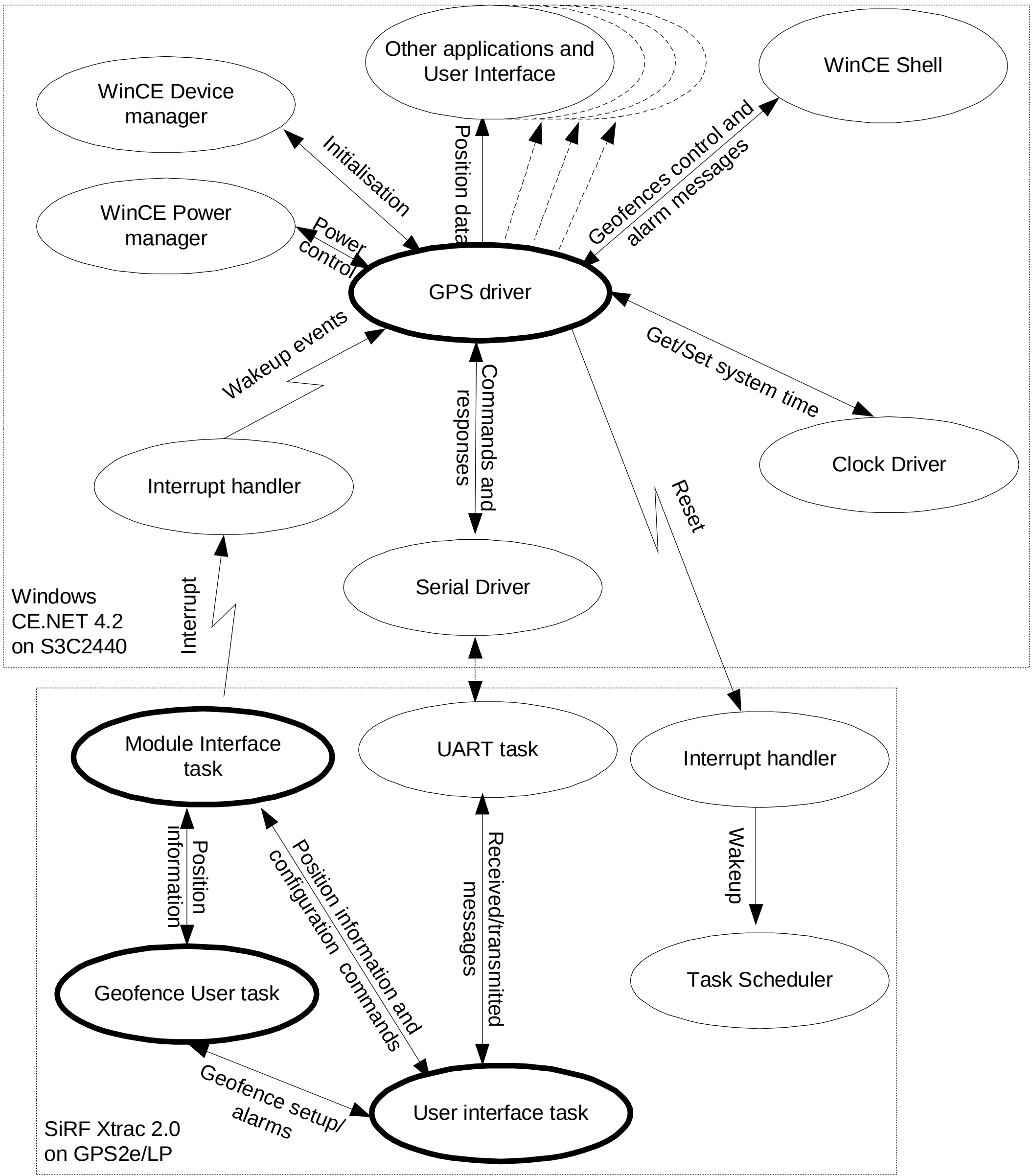


Figure 2 – GPS software context

4 WinCE Driver

The GPS driver is a built-in WinCE 4.2 power managed stream driver which appears as device GPS1:. This driver is responsible for interfacing the host to the GPS subsystem and for maintaining the host's idea of position and time.

A single instance of this driver runs continuously; it does not directly interact with the user.

The driver performs the following functionality:

- Hardware and software configuration and resource management
- Retrieving position and satellite constellation information from the GPS subsystem.
- Maintaining reliable communications with the GPS subsystem:
    - The power manager in the XTrac software (APM) periodically turns the GPS subsystem off. It sends messages to the host processor to advise it when it is about to turn off and when it turns back on. The host can wake up the GPS subsystem at any time by means of the reset line, but it must wait to be notified that the GPS subsystem has woken up before trying to talk to it, because the UART in the GPS subsystem does not function while it is turned off.
    - When a Geofence is active, the WinCE Power manager may put the host processor to sleep while the GPS subsystem is active and this disables the host UART. The GPS subsystem can wake up the host using a GPIO line to generate an interrupt. The interrupt will result in an event being sent to the GPS driver to indicate that the GPS subsystem wishes to talk to it. The driver must generate OK/Not OK to Send messages in a similar fashion to the XTrac software.
    - When a new Geofence is created, the driver must pass the Geofence parameters to the GPS subsystem. The driver must also retain Geofence parameters in non-volatile memory and – if necessary – pass the Geofence parameters to the GPS subsystem again after it has been power cycled.
    - When a Geofence is cancelled, the driver must delete its own record of the Geofence and instruct the GPS subsystem to cancel it.
    - After a Geofence times out, the driver must delete its own record of the Geofence.
- Adjusting the WinCE real time clock date/time to match the date/time reported by GPS. Note that a balance is struck between the frequency of updating the RTC and the maximum allowable discrepancy between the two clocks (and hence the step size of the adjustment). The factors that influence this are:
    - Latency in retrieving the time from the GPS chipset (sets a lower limit on the step size).
    - Resolutions of the two clocks (sets a lower limit on the step size)
    - The impact of the sudden time step on WinCE and its applications (can they cope with them).
    - Inconsistencies between position timestamps and current time as seen by WinCE (timestamps that appear to be from the future are undesirable).
- Processing incoming Geofence requests and reporting all Geofence creation, cancellation and alarm events to the GNS.

The conventional model of GPS is a serial input stream consisting of NMEA messages generated autonomously by the GPS receiver at a fixed rate (generally once per second). The SiRF GPS subsystem is capable of operating in this mode, however this is not done for several reasons:

- The NMEA protocol has no error checking capability.
- NMEA messages have to be encoded/parsed.
- When used indoors, the GPS receiver intermittently loses its position fix. NMEA messages faithfully report this, which is undesirable given that the receiver is unlikely to have moved significantly from its last reported position.
- The Gizmondo GPS implementation includes proprietary extensions that do not fit within the framework of NMEA messages.

The model that has been adopted is that the GPS driver hides the details of communications between the host and the GPS subsystem. Instead of a stream of NMEA messages, it provides a well-defined set of APIs that applications can use to retrieve positioning data. These APIs are designed around the standard WinCE stream driver model.

4.1 GPS driver APIs

The driver supports the following standard stream device I/O functions:

- CreateFile
- ReadFile
- WriteFile
- CloseHandle
- DeviceIoControl
- Initialisation

In addition, it supports two non-standard capabilities (which are not visible to applications other than the WinCE shell and power manager):

- Geofence notifications
- Device wakeup

In the data definitions that follow, certain conventions have been adopted:

1. Where decimal fractions are required, integers are used to represent the numbers to a stated number of decimal places and the decimal point is implied. For example, given an integer variable representing a number to 3 decimal places, the value 12345 is interpreted as 12.345.
2. All horizontal and vertical error figures are calculated to a certainty of 1 Sigma (i.e. 67% of all readings will be within this distance of the stated position).
3. UTCTIME is a 32-bit unsigned count of time in seconds since 00:00h on 1/1/1972. This format is optimised for efficient transmission in SMS messages and for use in time difference calculations. To convert it into an absolute date and time, first convert it to a FILETIME (not forgetting to adjust for the different epoch and resolution), then use FileTimeToSystemTime to convert it to a SYSTEMTIME structure.

4.1.1 CreateFile

Multiple threads can open the device for reading, however only one can open it for writing.

4.1.2 ReadFile

A call to read file with a correctly sized buffer returns the last known position information structure (LATEST_GPS_DATA) defined as follows:

```
Typedef UINT32 UTCTIME;

typedef struct
{
        UINT8   SatVehicleID;
        UINT16  Azimuth;
        UINT8   Elevation;
        UINT16  State;
        UINT8   C_NO;
        BOOL    InFix;
} GPS_VISIBLE_SATS, *PGPS_VISIBLE_SATS;

typedef struct
{
      UINT8              DriverVersion;
      BOOL               FixSincePowerUp;
      UINT16             GpsExtendedWeek;
      UINT32             GpsTimeOfWeek;
      UTCTIME            Timestamp;
      BOOL               FixValidated;
      UINT16             FixType;
      INT32              Latitude;
      INT32              Longitude;
      INT32              AltitudeMSL;
      UINT16             EstSpeed;
      UINT16             EstCourse;
      UINT32             EstHorizError;
      UINT32             EstVertError;
      UINT8              SatsUsed;
      UINT8              HorizDilution;
      UINT8              NumSatsVisible;
      GPS_VISIBLE_SATS VisibleSats[12];
} LATEST_GPS_DATA, *PLATEST_GPS_DATA;
```

The semantics of the data fields are as follows:

Field	**Comments**
SatVehicleID	Satellite vehicle ID code (1-32). 0 means unused entry
Azimuth	Satellite Azimuth in degrees from true North (0-360)
Elevation	Satellite Elevation in degrees above the horizon (0-90)
State	Diagnostic info about the satellite – for debug
C_NO	Current carrier/noise level (0-50) dBHz.
InFix	This Satellite is being used when calculating the current position fix

Table 1 - Semantics of GPS_VISIBLE_SATS

Field	**Comments**
DriverVersion	Version number of the GPS driver
FixSincePowerUp	Indicates that a fix has been made since the GPS receiver was last powered up
GpsExtendedWeek	GPS week number (doesn't wrap at 1024)
GpsTimeOfWeek	Seconds since 0:00 on Sunday morning
Timestamp	UTC timestamp for last known position fix. A zero timestamp means that the GPS receiver data has not seen any satellites since it was last reset and the data in this structure should not be used.
FixValidated	Flag indicating whether the fix has been made using least 4 satellites simultaneously (referred to as (“validation”).
FixType	Diagnostic data about how fix was derived – for debug purposes

Field	Comments
Latitude	Latitude in decimal degrees (7 dec places)
Longitude	Longitude in decimal degrees (7 dec places)
AltitudeMSL	Altitude above mean sea level in meters (2 dec places)
EstSpeed	Estimated speed in meters/second (2 dec places)
EstCourse	Estimated heading in degrees from true North (2 dec places)
EstHorizError	Estimated horizontal position error (2 dec places).
EstVertError	Estimated horizontal position error (2 dec places).
SatsUsed	Number of satellites used in latest valid fix (0-12)
HorizDilution	Horizontal dilution of precision (0-50) – a figure of merit
NumSatsVisible	Number of satellites currently above the horizon (includes ones from which no signal is available)
VisibleSats[12]	Array of GPS_VISIBLE_SATS structures – see Table 1 for the semantics of this structure

Table 2 - Semantics of LATEST_GPS_DATA

4.1.3 WriteFile

A call to WriteFile with a valid data structure sets or cancels a Geofence. The data structure is defined as follows:

```
typedef Struct
{
        INT32           CentreLatitude;     // Latitude in decimal degrees (7 dec places)
        INT32           CentreLongitude;    // Longitude in decimal degrees (7 dec places)
        INT32           Radius;             // Geofence radius in meters
        UTCTIME         StartTimeUTC;       // Start time of Geofence.
        UTCTIME         StopTimeUTC;        // Stop time of Geofence.
} GEOFENCE_PARAMETERS, *PGEOFENCE_PARAMETERS;
```

The semantics of the data fields are as follows:

Field	Comments
CentreLatitude	Latitude in decimal degrees (7 dec places). 0 = Cancel Geofence.
CentreLongitude	Longitude in decimal degrees (7 dec places). 0 = Cancel Geofence
Radius	Geofence radius in meters (minimum TBD). 0 = Cancel Geofence
StartTimeUTC	Start time of Geofence. Supplying a start time that is earlier than the current time means activate/cancel the Geofence immediately (it is recommended to set StartTime = 0 in this case).
StopTimeUTC	Stop time of Geofence. Supplying a stop time of 0 means run until explicitly cancelled. Otherwise, the stop time must be later than the StartTime and also later than the current time.

Table 3 - Semantics of GEOFENCE_PARAMETERS

To set a Geofence, supply valid data in all fields.

A Geofence status message is generated to indicate the status of the Geofence after the request has been processed.

4.1.4 DeviceIoControl

The following standard WinCE IOCTL operations are supported:

- IOCTL_POWER_CAPABILITIES
- IOCTL_POWER_QUERY
- IOCTL_POWER_SET
- IOCTL_POWER_GET
- IOCTL_PSL_NOTIFY (may not be required – TBC)

Details of the relationship between GPS device power states and system power states are given in Appendix A.1.

The following Gizmondo SiRF GPS specific IOCTL operations are supported:

- IOCTL_GPS_CONFIGURE. Allows the WinCE shell to configure settings such as APM parameters. This operation should not be used by applications other than the WinCE shell. Before using it, please consult the authors of this document, since it can significantly alter the behaviour of the device.

The following data structure is supplied:

```
typedef struct
{
	UINT8			ConfigType;
	union
	{
		APM_PARAMETERS		ApmParameters[4];
	} ConfigParameters;
} GPS_CONFIG_PARAMETERS, *PGPS_CONFIG_PARAMETERS;
```

The semantics of the data fields are as follows:

Field	Comments
ConfigType	0 = APM settings, other values are reserved
ApmParameters	An array of four APM parameters settings corresponding to the settings for power levels D0-D4 in that order.

Table 4 - Semantics of GPS_CONFIG_PARAMETERS

The ApmParameters structure is defined as follows:

```
typedef struct
{
	BOOL			ApmEnabled;
	UINT8			TimeBetweenFixes;
	UINT8			PowerDutyCycle;
	BOOL			PowerSavePriority;
} APM_PARAMETERS, *PAPM_PARAMETERS
```

The semantics of the data fields are as follows:

Field	Comments
ApmEnabled	True = power saving enabled, False = always on
TimeBetweenFixes	Time in seconds between attempts to get a position fix (10-180)
PowerDutyCycle	Percentage of time that GPS is on (5%-95% in increments of 5%)
PowerSavePriority	Power save has priority over maintaining time between fixes

Table 5 - Semantics of APM_PARAMETERS

The following extract from SiRF’s documentation explains how APM works:

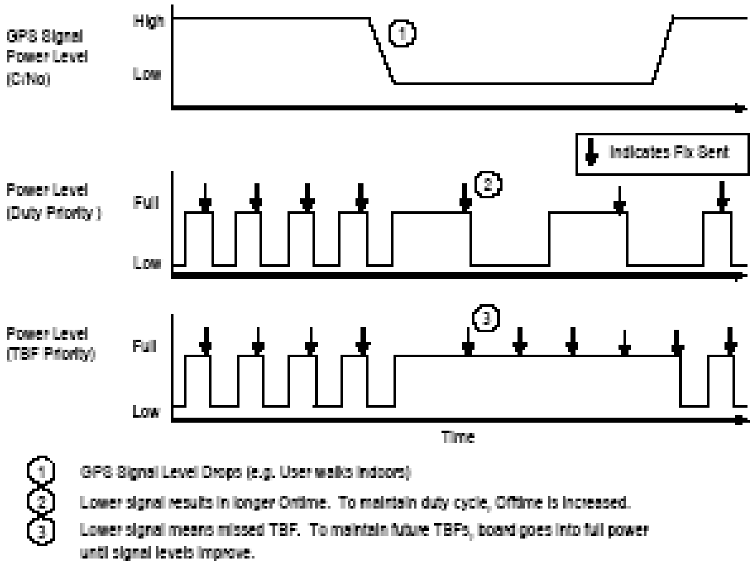
The actual operation of APM and power saving is very dependant on two things - the available satellite signal strength and whether power consumption has priority over the expected time between fixes.

Available signal strength will affect the behaviour of APM as APM will keep the receiver operating in full power until a position fix is possible before shutting down to conserve power. The lower the signals available, the longer the receiver must remain on to obtain a position fix.

If power consumption (or duty cycle) is priority, the receiver will monitor the on-time and then set subsequent off-times to maintain the designated duty cycle. In changing signal environments, variable time between fixes can be expected.

If time between fixes is of priority, the receiver will maintain the expected time between fixes without maintaining duty cycle. In low signal environments, this may result in the receiver staying in full power to maintain time between fixes.

The figure[1] below demonstrates the difference in operation between duty cycle and time between fixes priority operation in changing signal strength environments.



Details of the default values for APM settings are given in Appendix A.2.

4.1.5 Geofence notifications

A named window is created by the shell ("GMShell" class "GMSHELLCLASS"). The Device driver sends Geofence notifications to this window via a WM_COPYDATA message. There are two Geofence notification messages – Geofence Alarm and Geofence Status. These share a single data structure as follows:

```
typedef struct
{
	UINT8		NotificationType;
	INT32		CentreLatitude;
	INT32		CentreLongitude;
	INT32		Radius;
	UTCTIME		StartTimeUTC;
	UTCTIME		StopTimeUTC;
	INT32		CurrentLatitude;
	INT32		CurrentLongitude;
	UINT16		SpeedOverGround;
	INT16		CourseOverGround;
	UINT32		EstHorizError;
} GEOFENCE_NOTIFICATION, *PGEOFENCE_NOTIFICATION;
```

The semantics of the data fields are as follows:

Field	Comments
NotificationType	0 = Geofence Alarm, 1 = Geofence Status, other values reserved.
CentreLatitude	Geofence centre latitude in decimal degrees (7 dec places)
CentreLongitude	Geofence centre longitude in decimal degrees (7 dec places)
Radius	Geofence radius in meters

[1] Apologies for the poor image quality.

Field	Comments
StartTimeUTC	Geofence start time
StopTimeUTC	Geofence stop time
CurrentLatitude	Current latitude in decimal degrees (7 dec places). Geofence status message only.
CurrentLongitude	Current longitude in decimal degrees (7 dec places). Geofence status message only.
SpeedOverGround	Estimated speed in meters/second (2 dec places). Geofence status message only.
CourseOverGround	Estimated heading in degrees from true North (2 dec places). Geofence status message only.
EstHorizError	Estimated horizontal position error (2 dec places). Geofence status message only.

Table 6 - Semantics of GEOFENCE_NOTIFICATION

The notification type field allows the shell to easily distinguish between the two messages and also makes provision for other notifications in the future. Geofence Alarm messages use all of the fields in the message. Geofence Status messages only fill in the first six fields and set the fields concerned with current position and velocity to 0.

Geofence Alarm notifications are sent to the GNS when the GPS subsystem reports that an active Geofence has been breached.

Geofence status notifications are sent to the GNS to report the result of a Geofence Set or Geofence Cancel request. Status notifications are not sent to the GMS to report activation of Geofences, or cancellation of a Geofence at the stop time.

4.1.6 Device wakeup

A named event (“GPSPowerEvent”) is set when the GPS device wakes up the host. This event causes the driver to notify the GPS subsystem that it is ready for input.

4.1.7 Initialisation and De-initialisation

On system startup, the initialisation (GPS_Init) function is invoked to set up any necessary resources, threads etc.

If the device driver is ever unloaded, the de-initialisation (GPS_Deinit) function is invoked to release resources and terminate threads set up by the GPS_Init function.

5 SiRF XTrac firmware

The XTrac firmware is modified[2] as follows:

- Adding a mechanism to ensure that the host is ready to receive before sending any messages to it. This allows the GPS subsystem to talk to the host without loss of messages.
- Each time that the GPS receiver performs a new fix, remember and timestamp it if the fix is successful. This information (the last known position) is then reported in Position Data messages. The purpose of this is to avoid “no fix” reports in low signal conditions, where the ability to achieve a good fix may be intermittent (e.g. indoors). Typically under these conditions, the previous fix is good enough, since the terminal will not have moved very far. The use of a timestamp allows any application that retrieves position information to determine how old the fix is and thus how much reliance to place on it.
- Remember the last known position data across a power-off cycle[3]. This allows the terminal to

[2] see [7] for details of how to modify the SiRF firmware

[3] This may have to be moved to the host if there is insufficient non-volatile storage in the GPS subsystem

report its last known position immediately after power up, even before a new fix can be obtained (which can take a long time under weak signal conditions).

- Adding a Geofence mechanism. This can save power while the Geofence is active, since the host does not need to remain awake merely in order to monitor the Geofence.
- Default operating state configured as defined in Appendix D. There are two key differences from the normal XTrac defaults. Firstly periodic reporting is turned off by default for all messages, so that they are only generated when explicitly requested. This allows the host to sleep for long periods without being woken up unnecessarily by the GPS subsystem. Secondly, degraded and altitude hold modes are set to maintain a fix for as long as possible under low signal conditions.
- A number of new SiRF Binary messages are added (see Appendix A) to support the functionality outlined above.

5.1 SiRF XTrac user interface task

This is the standard XTrac user interface task (see [7]), extended to support additional proprietary messages (see Appendix A). The user interface task must honour Set Message Rate commands for all messages including Gizmondo specific messages.

The user interface task must also implement OK/Not OK to report messages as follows:

- If the host has notified it that it is not OK to send, discard non Geofence messages.
- If the host has notified it that it is not OK to send and it has a Geofence message to send, wake up the host, wait for an OK to send message, then send the Geofence message.

5.2 SiRF XTrac Geofence task

This is a custom user task that runs on the SiRF GPS2e baseband processor and is responsible for implementing Geofences. A single instance of this task runs continuously.

Only one Geofence can be defined at any time. It has the following attributes:

- Centre Position (Latitude/Longitude)
- Radius (meters)
- Start time/date (UTC). If this is not set, or if it is earlier than or equal to the current time the Geofence is activated immediately.
- Stop time/date (UTC). If this is not set the Geofence remains active until it is explicitly cancelled. If this is earlier than or equal to the current time, the Geofence is deactivated and the state is set to undefined.
- Geofence state (indicates whether the Geofence is currently undefined, defined or active)

While a Geofence is active, the Geofence task monitors the last known position and calculates the linear distance from the Geofence centre position. The calculation must adjust the distance to take into account any uncertainty in the last known position as reported by the GPS receiver. If the adjusted distance is greater than the Geofence radius, plus an adjustment factor (TBD), a Geofence alarm message is sent to the host. Following a Geofence alarm, the Geofence task continues to monitor the position, but does not generate any further alarms while it remains outside the Geofence. If the position moves back inside the Geofence, subsequent behaviour is TBD.

When a Geofence is activated (at the Geofence start time), the GPS subsystem should notify the host by sending a Geofence status message with the status set to “active”.

When a Geofence times out (at the Geofence stop time), the GPS subsystem should notify the host by sending a Geofence status message with the status set to “undefined”.

The GPS subsystem does not need to retain Geofence settings in non-volatile storage; it is the responsibility of the GPS driver on the host to set up any Geofence (if necessary) whenever it turns the GPS subsystem on.

Appendix A Hardware interface to the GPS subsystem

The hardware signals listed in Table 7 provide the interface between the host and the GPS subsystem; refer to the Gizmondo terminal schematic [8] for further details.

S3C2440 Pin	Input or Output	GPS signals	Purpose
TXD2 RXD2	Output Input	RXA TXA pins on GPS baseband	Serial Tx/Rx lines driven by UART2 on S3C2440 and UART A on the GPS baseband. Provides communications between the host and the GPS subsystem; handshaking is not supported, so messages larger than the UART FIFOs on the GPS baseband (16 bytes) can be lost due to overruns.
GPA18	Output	SRESET_N JTRST_N pins on GPS baseband	Used to initiate communication with the GPS subsystem when the GPS baseband is sleeping. Pulse this output before talking to it over the serial port.
GPA17	Output.	GPS_BOOT_SEL (ED0) pin on GPS baseband.	Controls whether the GPS baseband boots from its own Flash memory, or downloads its program over the serial interface. In normal operation this pin is driven low or tri-stated (internal pulldown) to select Flash boot. During factory programming only, this pin is driven high to select serial boot.
GPB5	Input.	TIMERSYNC (GPIO15) pin on GPS baseband.	This provides a high precision 1Hz strobe for applications requiring accurate timing synchronisation. This signal is not currently used by the GPS interface software and is potentially available to be read by other software if required.
GPD15	Output	GPS_EN signal	Enables (high) or disables (low) power to the GPS subsystem.
GPF3	Input.	APM_INTR_N (GPIO10) pin on GPS baseband.	This input allows the GPS subsystem to interrupt the host. It is only used by the SiRFLoc Lite version of the client software. The corresponding host interrupt is disabled by default.
GPG10	Input	GPS_INTR_N (GPIO13) pin on GPS baseband.	This input allows the GPS subsystem to interrupt the host. It is used by the Gizmondo firmware to wake up the host if it needs to send a message (such as a Geofence alert) while the host is sleeping.

Table 7 - GPS interface signals

Appendix B GPS device power control settings

In general, the GPS driver does not attempt to modify its own power state, but relies on the power manager to instruct it what state to select. If the driver does want to modify its power state, it should call DevicePowerNotify and wait for the Power Manager to instruct it to change state.

A.1 WinCE device power states

The relationship between the system power states and the device power control states for the GPS (defined in [9]) are as follows.

Power management state	**UI state**	**WinCE power state**
Off	UI Off	D4
Suspend	UI Off	D4
Charging	UI Off	D4
Standby	UI Standby	D3 (Geofence active) D2 (Geofence inactive)
Standby Charging	UI Standby	D3 (Geofence active) D2 (Geofence inactive)
Flight mode	UI On	D4
On	UI On	D0 (GPS in use[4]) D1 (GPS not in use)

Figure 3 – System states versus device power control states

The device power states are used as follows:

DO - GPS is fully powered on and optimised to maximise the accuracy and minimise the latency of position fixes. This state should be selected by the power manager when at least one application (other than the Shell) wants to open the device for reading. When all applications have finished with the device, the power manager should switch the driver back to state D1.

D1 - GPS is powered on but performance and latency are slightly reduced to reduce power consumption. This is the default device power setting for the “UI On” state.

D2 - GPS is powered on and performance is optimised to save power at the expense of potentially less accurate and frequent position fixes. This is the default setting for the “UI Standby” state.

D3 - GPS is powered on and the device is monitoring a Geofence. The power settings are adjusted to ensure that breaches of the Geofence can be detected within a short period. This setting is used when a Geofence is active in the “UI Standby” state. From this state, the device is able to wake up the host CPU in the event that it goes to sleep.

D4 - GPS is powered off. This is the default setting in the “UI Off” State and when in Flight mode.

[4] GPS in use means that one or more GPS aware applications are active

A.2 SiRF APM settings

The SiRF APM settings (see [5]) corresponding to the WinCE device power states are as follows[5]:

APM Settings	Device Power Control States				
	D0	**D1**	**D2**	**D3**	**D4**
Device powered	Yes	Yes	Yes	Yes	No
APM enabled	No	Yes	Yes	Yes	N/A
Number fixes	N/A	0	0	0	N/A
Time between fixes	N/A	10 seconds	*TBC*	20 seconds	N/A
Horiz pos error max	N/A	Unlimited	Unlimited	Unlimited	N/A
Vertical pos error max	N/A	Unlimited	Unlimited	Unlimited	N/A
Response time max	N/A	0	0	0	N/A
Time acc priority	N/A	No priority	No priority	No priority	N/A
Power duty cycle	N/A	50%	*TBC*	50%	N/A
Time/Power priority	N/A	Time	Power	Time	N/A

Table 8 - SiRF APM power settings versus device power control states

An IOCTL function is available to allow the WinCE Shell to modify some of these settings (see section 4.1.4).

[5] These values are a starting point and will be adjusted once actual performance and power consumption have been measured.

Appendix C SiRF Binary Messages

The GPS subsystem is configured to communicate with the host using the SiRF binary protocol (see [5] for further details). This is preferred to NMEA for several reasons:

1. It supports an ACK/NAK response.
2. No message parser is required.
3. It is the default protocol across the serial link to the host processor.
4. It is easy to extend.

The format of SiRF binary messages is as follows:

Field	Length (bytes)	Contents
Start Sequence	2	0xA0, 0xA2 (used for data stream synchronisation)
Payload Length	2	length of the payload field in bytes (MSB first)
Payload	< 1023	Payload contents[6]
Checksum	2	Sum of bytes in payload. The top bit of the checksum is cleared.
End Sequence	2	0xB0, 0xB3 (used for data stream synchronisation)

Table 9 - Format of SiRF Binary messages

The following standard SiRF Binary commands (output messages) are used:

Message	Msg Id	Purpose and contents
Advanced Power Management	53	Enable/disable/configure the operation of APM.
Set Message Rate	166	Poll for a response message

Table 10 – Output messages

The following standard SiRF Binary responses (input messages) are used:

Message	Msg Id	Purpose and contents
Error ID Data	10	Error messages – used or ignored as appropriate
Command Acknowledge	11	Response to a successful command. Additional responses may be received after this.
Command NAcknowledge	12	Response to an unsuccessful command.
OK To Send	18	Reports when the GPS baseband sleeps/wakes up.

Table 11 – Input messages

[6] Numeric fields within the payload are Big-endian (MSB first) and 1-byte aligned

A number of additional input and output messages are implemented by the Gizmondo firmware. These messages extend the standard SiRF Binary protocol:

Message	**Msg Id**	**Purpose and contents**
Set Geofence	180	Sets up a new Geofence
Cancel Geofence	181	Cancels any existing Geofence
OK/Not OK to report	182	Tells the GPS subsystem whether it can talk to the host

Table 12 - Gizmondo GPS Input messages

Message	**Msg Id**	**Purpose and contents**
Geofence alarm	97	Reports a breach of an active Geofence
Geofence status	98	Report the status of the Geofence
Position data	99	Report the latest known position and satellite constellation data

Table 13 - Gizmondo GPS Output messages

All other input messages will be either disabled or discarded by the host processor.

A.3 Set Geofence message

This command sets a Geofence. Any existing Geofence is overridden/cancelled as necessary.

		Binary(Hex)			
Name	**Bytes**	**Scale**	**Example**	**Units**	**Description**
Message ID	1		B4		Decimal 192
Centre Latitude	4	10^7	1F081DCE	Deg	Latitude in decimal degrees (7 dec places)
Centre Longitude	4	10^7	1D1B19	Deg	Longitude in decimal degrees (7 dec places)
Radius	2	1	7B	Metres	Radius of the Geofence in meters
Start Time Year	2	1	7D4	Years	Start time, year part
Start Time Month	1	1	5	Mths	Start time, month part (1-12)
Start Time Day	1	1	14	Days	Start time, day part
Start Time Hour	1	1	0F	Hours	Start time, hour part
Start Time Minute	1	1	34	Mins	Start time, minute part
Start Time Second	1	1	1E	Secs	Start time, seconds part
Stop Time Year	2	1	7D4	Years	Stop time, year part
Stop Time Month	1	1	5	Mths	Stop time, month part (1-12)
Stop Time Day	1	1	14	Days	Stop time, day part
Stop Time Hour	1	1	0F	Hours	Stop time, hour part
Stop Time Minute	1	1	34	Mins	Stop time, minute part

Name	Bytes	Binary(Hex) Scale	Example	Units	Description
Stop Time Second	1	1	1E	Secs	Stop time, seconds part

Payload Length: 25 bytes

Table 14 - Set Geofence Message

A.4 Cancel Geofence message

This command cancels a Geofence with immediate effect.

Name	Bytes	Binary(Hex) Scale	Example	Units	Description
Message ID	1		B5		Decimal 193

Payload Length: 1 bytes

Table 15 - Cancel Geofence Message

A.5 OK/Not OK to report message

This command tells the GPS subsystem whether it is OK to send messages to the host. The GPS subsystem must not send anything to the host unless it has been told that it is OK to do so. When the GPS subsystem powers up, it can assume that sending is OK. Only a single message can be queued up to be sent while the host is still sleeping. In the event that multiple messages are generated, Geofence alarm messages take priority over other messages and newer messages over older ones.

Name	Bytes	Binary(Hex) Scale	Example	Units	Description
Message ID	1		B6		Decimal 194
Reporting Status	1		0		0 = Not OK to report 1 = OK to report

Payload Length: 2 bytes

Table 16 – OK/Not OK to Report Message

A.6 Geofence alarm message

This message is automatically sent when the terminal breaches an active Geofence.

Name	Bytes	Binary(Hex) Scale	Example	Units	Description
Message ID	1		61		Decimal 64
Geofence centre latitude	4	10^7	1F081DCE	Deg	Latitude in decimal degrees (7 dec places)
Geofence centre longitude	4	10^7	1D1B19	Deg	Longitude in decimal degrees (7 dec places)
Geofence radius	2	1	7B	Metres	Radius of the Geofence in meters
Geofence Start Time Year	2	1	7D4	Years	Start time, year part
Geofence Start Time Month	1	1	5	Mths	Start time, month part (1-12)

Name	Bytes	Binary(Hex) Scale	Example	Units	Description
Geofence Start Time Day	1	1	14	Days	Start time, day part
Geofence Start Time Hour	1	1	0F	Hours	Start time, hour part
Geofence Start Time Minute	1	1	34	Mins	Start time, minute part
Geofence Start Time Second	1	1	1E	Secs	Start time, seconds part
Geofence Stop Time Year	2	1	7D4	Years	Stop time, year part
Geofence Stop Time Month	1	1	5	Mths	Stop time, month part (1-12)
Geofence Stop Time Day	1	1	14	Days	Stop time, day part
Geofence Stop Time Hour	1	1	0F	Hours	Stop time, hour part
Geofence Stop Time Minute	1	1	34	Mins	Stop time, minute part
Geofence Stop Time Second	1	1	1E	Secs	Stop time, seconds part
Current latitude	4	10^7	1F082338	Deg	Latitude in decimal degrees (7 dec places)
Current longitude	4	10^7	1D1B8F	Deg	Longitude in decimal degrees (7 dec places)
Speed over ground	2	100	3039	M/sec	Estimated speed in meters/second (2 dec places)
Course over ground	2	100	AFFA	Deg	Estimated heading in degrees from True North (2 dec places)
Horizontal Position Error	4	100	3E8	Meters	Estimated maximum error of current horizontal position (2 Dec places). Confidence figure is 1 Sigma.

Payload Length: 41 bytes

Table 17 - Geofence Alarm Message

A.7 Geofence status message

This message reports current Geofence status. It is sent in response to the corresponding Set Message Rate command with the Send Now flag set.

Name	Bytes	Binary(Hex) Scale	Example	Units	Description
Message ID	1		62		Decimal 65
Geofence status	1		0		0 = undefined or timed out 1 = defined but inactive 2 = active 3 = cancelled (only reported at stop time)
Geofence centre latitude	4	10^7	1F081DCE	Deg	Latitude in decimal degrees (7 dec places)
Geofence centre longitude	4	10^7	1D1B19	Deg	Longitude in decimal degrees (7 dec places)
Geofence radius	2		7B	Metres	Radius of the Geofence in meters
Geofence Start Time Year	2	1	7D4	Years	Start time, year part
Geofence Start Time Month	1	1	5	Mths	Start time, month part (1-12)
Geofence Start Time Day	1	1	14	Days	Start time, day part

Name	Bytes	Binary(Hex) Scale	Example	Units	Description
Geofence Start Time Hour	1	1	0F	Hours	Start time, hour part
Geofence Start Time Minute	1	1	34	Mins	Start time, minute part
Geofence Start Time Second	1	1	1E	Secs	Start time, seconds part
Geofence Stop Time Year	2	1	7D4	Years	Stop time, year part
Geofence Stop Time Month	1	1	5	Mths	Stop time, month part (1-12)
Geofence Stop Time Day	1	1	14	Days	Stop time, day part
Geofence Stop Time Hour	1	1	0F	Hours	Stop time, hour part
Geofence Stop Time Minute	1	1	34	Mins	Stop time, minute part
Geofence Stop Time Second	1	1	1E	Secs	Stop time, seconds part

Payload Length: 26 bytes

Table 18 - Geofence Status Message

A.8 Position data message

This message reports the latest known position data and satellite constellation. It is sent in response to the corresponding Set Message Rate command with the Send Now flag set.

Name	Bytes	Binary(Hex) Scale	Example	Units	Description
Message ID	1		63		Decimal 65
Data is current	1		1		0 = No fix since power up 1 = Fix made since power up
GPS extended week No	2		4F6	Weeks	Number of weeks since GPS week 0 (does not wrap at 1024)
GPS time of week	4	10^3	178C5ECD	Secs	Seconds since 0:00 on Sunday morning (3 dec places)
Current Time Year	2	1	7D4	Years	Current time, year part
Current Time Month	1	1	5	Mths	Current time, month part (1-12)
Current Time Day	1	1	14	Days	Current time, day part
Current Time Hour	1	1	0F	Hours	Current time, hour part
Current Time Minute	1	1	34	Mins	Current time, minute part
Current Time Second	1	1	1E	Secs	Current time, seconds part
Timestamp Year	2	1	7D4	Years	Last known position timestamp, year part
Timestamp Month	1	1	5	Mths	Last known position timestamp, month part (1-12)
Timestamp Day	1	1	14	Days	Last known position timestamp, day part
Timestamp Hour	1	1	0F	Hours	Last known position timestamp, hour part
Timestamp Minute	1	1	34	Mins	Last known position timestamp, minute part

Name	Bytes	Binary(Hex) Scale	Binary(Hex) Example	Units	Description
Timestamp Second	1	1	1E	Secs	Last known position timestamp, seconds part
Fix validated[7]	1		1		0 = fix not validated 1 = fix has been validated
Fix type[7]	2				Diagnostic info about how the fix was derived
Latitude[7]	4	10^7	1F081DCE	Deg	Latitude in decimal degrees (7 dec places)
Longitude[7]	4	10^7	1D1B19	Deg	Longitude in decimal degrees (7 dec places)
Altitude (MSL) [7]	4	100	5B68	Meters	Altitude above mean sea level (2 dec places)
Speed over ground[7]	2	100	3039	M/sec	Estimated speed in meters/second (2 dec places)
Course over ground[7]	2	100	AFFA	Deg	Estimated heading in degrees from True North (2 dec places)
Horizontal Position Error[7]	4	100	3E8	Meters	Estimated maximum error of current horizontal position (2 Dec places). Confidence figure is 1 Sigma.
Vertical Position Error[7]	4	100	7D0	Meters	Estimated maximum error of current vertical position (2 Dec places). Confidence figure is 1 Sigma.
Satellites Used[7]	1		5		Number of satellites used to calculate the position
HDOP[7]	1	5	A		A figure of merit used when calculating position error. A lower HDOP yields a more accurate fix. (1 sig fig, resolution of 0.2)
Number of visible satellites	1				The number of satellites that are currently above the horizon[8].
First SVID[9]	1		14		The ID of the first satellite. A value of 0 means that this slot is not valid.
Azimuth	1	2/3			Azimuth in degrees (1 sig fig, resolution of 1.5 degrees).
Elevation	1	2			Elevation in degrees (1 sig fig, resolution of 0.5 degrees).
State	2		BF		Bitmap indicating the current state of the signal from this satellite. See [5] entry for Message ID 4 for further details.
C_NO	1		32		Mean C/No over the last second from this satellite. A value above 28 is good.

[7] The Timestamp applies to the data in these fields. All other fields continue to be updated even when no fix is available

[8] The GPS receiver may not actually be receiving signals from all of these satellites.

[9] Satellite data is not sorted by SVID

Name	Bytes	Binary(Hex) Scale	Example	Units	Description
In Fix[7]	1		1		0 = This satellite was not used to calculate the latest position fix 1 = This satellite was used to calculate the latest position fix
SVID, Azimuth, Elevation, State, C_NO and InFix are repeated for each of the 12 available slots (some or all of which may be empty.					

Payload Length: 136 bytes

Table 19 – Position Data Message

Notes:

1) All timestamp fields are set to zero when the unit is first programmed, and following a cold start or a factory reset.
2) The visible satellites list omits channels for which the SVID = 0 or the State = 0xff.

Appendix D Configuration of the GPS subsystem

The GPS subsystem is configured as follows:

- UART settings:
    - 38400 baud
    - 8 data bits
    - 1 Stop bit
    - No Parity
- SiRF Binary protocol
- Message rate for all messages set to 0 (no periodic reporting).
- Mode settings:
    - Track Smoothing enabled
    - Altitude Hold mode – automatic
    - Last computed altitude – enabled
    - Degraded modes – Clock then direction hold
    - Degraded mode timeout – 120 seconds
    - Dead reckoning – On
    - Dead reckoning timeout – 5 sec
- Oscillator precision – 2.5ppm (TCXO)

Appendix E Programming conventions

All code to be written for the Gizmondo terminal adopts the following conventions:

- Numeric data is stored Little endian (LSB first)
- Structures are 1 byte aligned (#pragma pack(1))
- C naming conventions (extern "C")

On the Windows CE platform, variable naming follows the Microsoft convention of decorating the names with data types and using initial capitals for words within the name (e.g. hMyHandle for a variable of type HANDLE). This convention need not be followed for code running on the SiRF Xtrac platform.