USER'S MANUAL

Datalogging Option V2.0
for µ-blox GPS Receiver Modules

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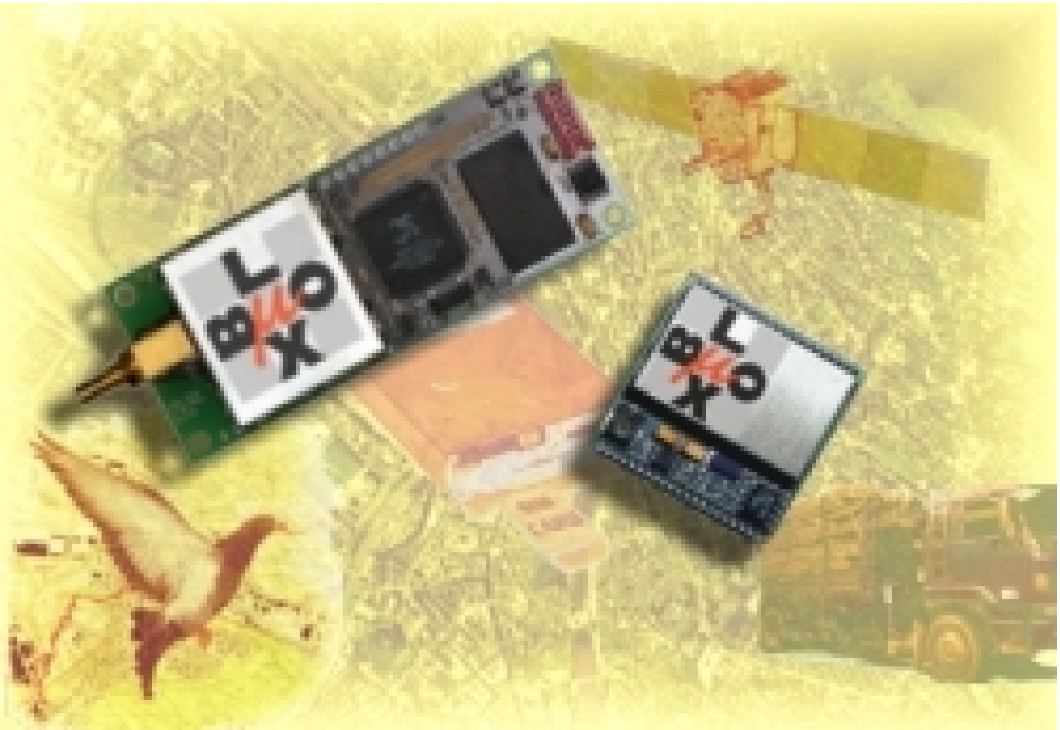

GPS Receiver with integrated Datalogger

CONTENTS

1 FEATURES

- SW Enhancement for the μ-blox GPS-MS1E and GPS-PS1E
  - Integrated Datalogger
  - Fully compatible to standard receivers
  - Configuration through the serial interface
  - no additional external circuitry required

- Data compression
  - GPS-MS1E-DL stores up to 100'000 positions
  - GPS-PS1E-DL stores up to 20'000 positions

- Intelligent Logging algorithm triggered by GPS events.

- Various configurable filter parameters
  - Time
  - Distance
  - Velocity

- General purpose Input / Output (GPIO) Logging.
  - 12 independent pins
  - Pins are configurable as Inputs or Outputs
  - The logger observes Inputs and Outputs
  - Outputs may be configured high or low

- External requirements:
  - Power supply for GPS
  - Backup battery for real time clock and SRAM
  - Serial interface for NMEA or SiRF binary data
  - Passive or active Antenna

2 INTRODUCTION

μ-blox offers Software Enhancements to standard GPS receivers. An integrated datalogger enables the receiver to store position, time and events in the onboard flash memory. A datalogging enabled GPS receiver fulfils the specification of a standard receiver. For a description of the hardware please refer to the datasheet of the respective receiver. This document is intended to explain the concept of the logging implementation, the protocol to configure the receiver and a real world example.

The datalogger opens up a wide range of applications.

- Vehicle tracking
- Road pricing systems
- Automatic project accounting for field personnel
- Behavioural studies of animals
- Time table analysis for public transport systems
- …

μ-blox offers a PC utility, that enables you to easily configure the datalogger and read out stored data. This PC utility named **'u-Logger.exe'** is described in a separate chapter.

The Datalogging FW is available for the GPS-MS1E as well as for the GPS-PS1E. In order to get a Datalogging enabled GPS receiver the modules has to be ordered in the Datalogging version. The ordering numbers are GPS-MS1E-DL and GPS-PS1E-DL for the GPS-MS1E and GPS-PS1E with integrated datalogger, resp. It is possible to up-grade a Datalogging enabled receiver to the latest version of the datalogger using the update utility available on our homepage (http://www.u-blox.com). See the *Update Manual* for details on the up-date procedure.

Due to the different HW setups of the two GPS receivers, there are some differences in the specification of the datalogger:

Feature	GPS-MS1E-DL	GPS-PS1E-DL
FLASH Memory available	5 Mbit	1 Mbit
Max.Number of Logs	100'000	20'000
GPIO	Yes, 12 Pins	no

Table 1: HW specifics

3 INSTALLATION GUIDE

The Logging Option is a special firmware. Firmware '134l283.s3' contains the data logger. This firmware can be used on GPS-MS1–DL, GPS-MS1E–DL, GPS-PS1–DL or GPS-PS1E–DL modules only. It will not work in combination with any other module. The firmware may be updated with the standard 'gpsxs-dl.exe' update utility.

The additional program 'u-logger.exe' is a standalone application for the PC. It requires Windows 95/98 or Microsoft Windows NT 4.

4 SYSTEM OVERVIEW

The Software is optimized for maximum stored data and maximum flexibility. A differential storage technology is used to store data in the flash memory. There are two main logging functionalities: position fix and GPIO logging. Both can be configured separately and are totally independent from each other. In addition to the traditional position fix logging, it can also be configured to store changes on the GPIO Pins. For example, a temperature sensor or an event, e.g. ignition on/off, could be logged. The information stored includes:

- GPS Timestamp (WNO, TOW), not UTC corrected, resolution 1 [s]
- Position (ECEF), resolution 1 [m]
- Velocity, range 0…1023 [km/h], resolution 1 [km/h]
- Number of satellites used for navigation
- DGPS used
- GPIO signal levels, GPIO pins 0 to 11

Figure 1 describes the software structure of the datalogger. There are the two main logging functionalities: position fix and GPIO logging.

In case of position fix logging the GPS receivers stores data in the onboard flash memory in addition to the transmission over the serial port. Basically every position fix may be stored in the FLASH. But in most applications filters are used. These prevent the datalogger from storing all the positions into the Flash memory and lengthen total logging time.

Chapter 5.2 describes these filters. The user may configure the filter parameters to suit his application.

In case of GPIO logging the GPS receiver stores data on the basis of an event which recurs every second. In addition to logging it is possible to control the GPIO's. A GPIO may be used as input or output. It is also possible to set the output level to High (VCC) or Low (Gnd). Controlling the GPIOs is independent on the logging functionality.

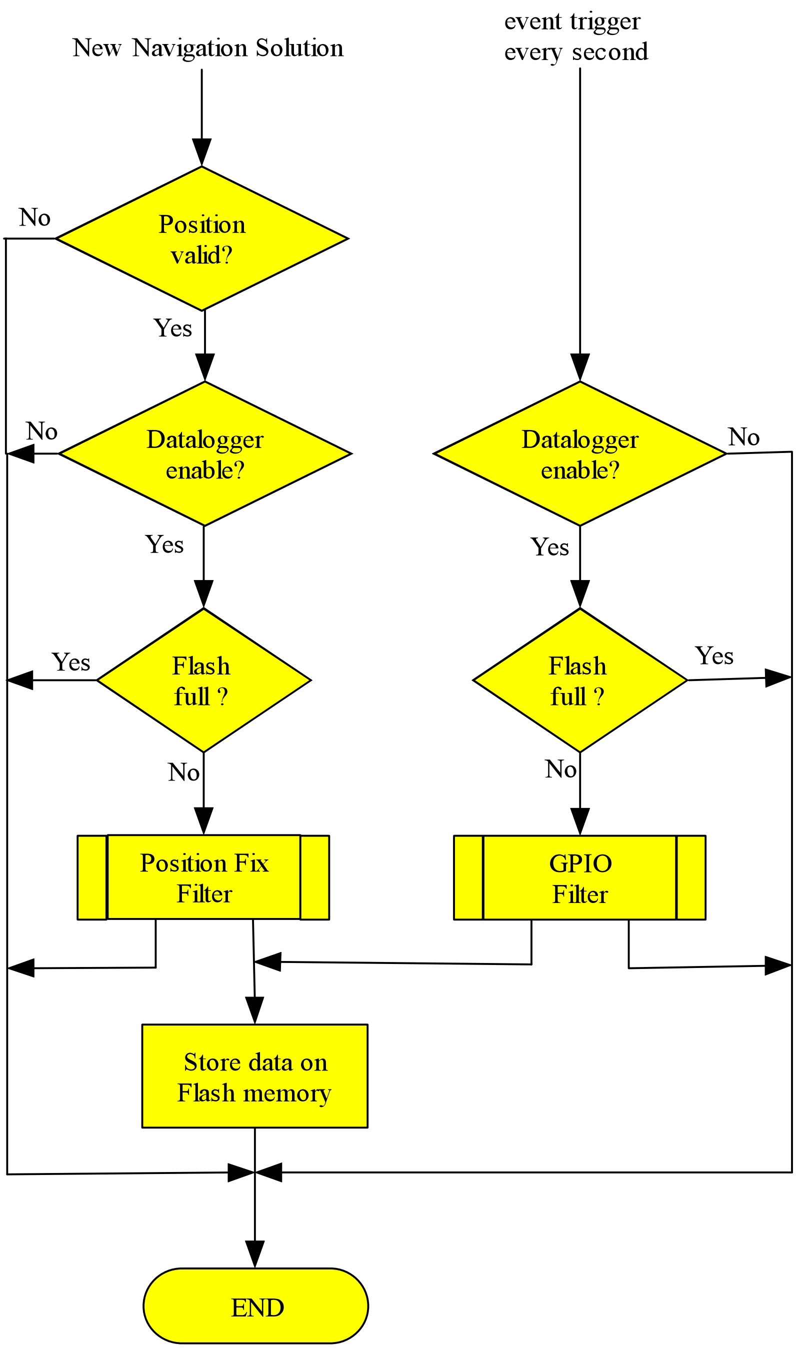

Figure 1: Functionality of Datalogger

5 USING THE LOGGER

5.1 Communication with the Logger

The controlling of the Logger takes place using SiRF binary Protocol via serial port (UART). Additional SiRF binary commands (proprietary) allow to adjust logger options and to download stored data.

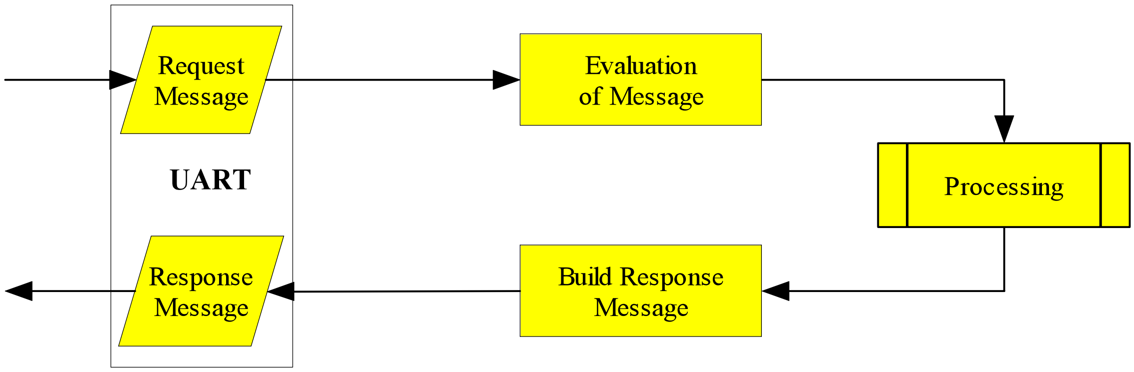

Figure 2: Model of Data Stream

Figure 2 shows the communication process with the data logger. The process is initiated by an incoming message. The content of the message is evaluated and processed. After processing a response is created and transmitted via UART.

The Logging Option defines a new set of SiRF binary protocol messages. The messages can be used for configuring the filter parameters. This enables user-defined position, time and velocity logging in the onboard memory. Download and erasing of the flash is also supported by this protocol extension. Although the logging option is designed as an extension to the SiRF binary protocol, data is also stored while in NMEA mode. However, to configure the logger and download data, SiRF binary protocol is needed.

5.2 Filter Settings

In addition to the data compression performed during the storage of a data record, the datalogger offers the possibility to further reduce the number of stored data records by configuring special filters. These filters prevent the logger from storing unnecessary data, e.g. if a vehicle is not moving. However these filters have to be set according to the requirement of the final application. The configuration is done using the additional SiRF binary commands.

Basically one can distinguish two different types of filters: Minimum filters prevent a data record from being stored, maximum filters in contrary bypass the minimum filters, if exceed. Therefore maximum filters can be used to make sure that data is stored, e.g. after maximum 10h.

This chapter describes the possible filter settings. An easy way to set these filters is by connecting the GPS receivers to a PC and to use the 'u-Logger.exe' for the configuration. In an embedded environment the configuration could be set by a controller, which sends the according SiRF binary message to the GPS receiver.

5.2.1 GPIO Filter

The GPIO logger is invoked every second. During storage, all Pin states will be saved. See chapter 5.5.3 for the definition of the storage format.

The GPIO logging algorithm stores the following information:

- Timestamp of stored position, Resolution 1 [s].
- Values of all GPIO pins 0 to 11.

The filter sets a time and event mask which control the storage.

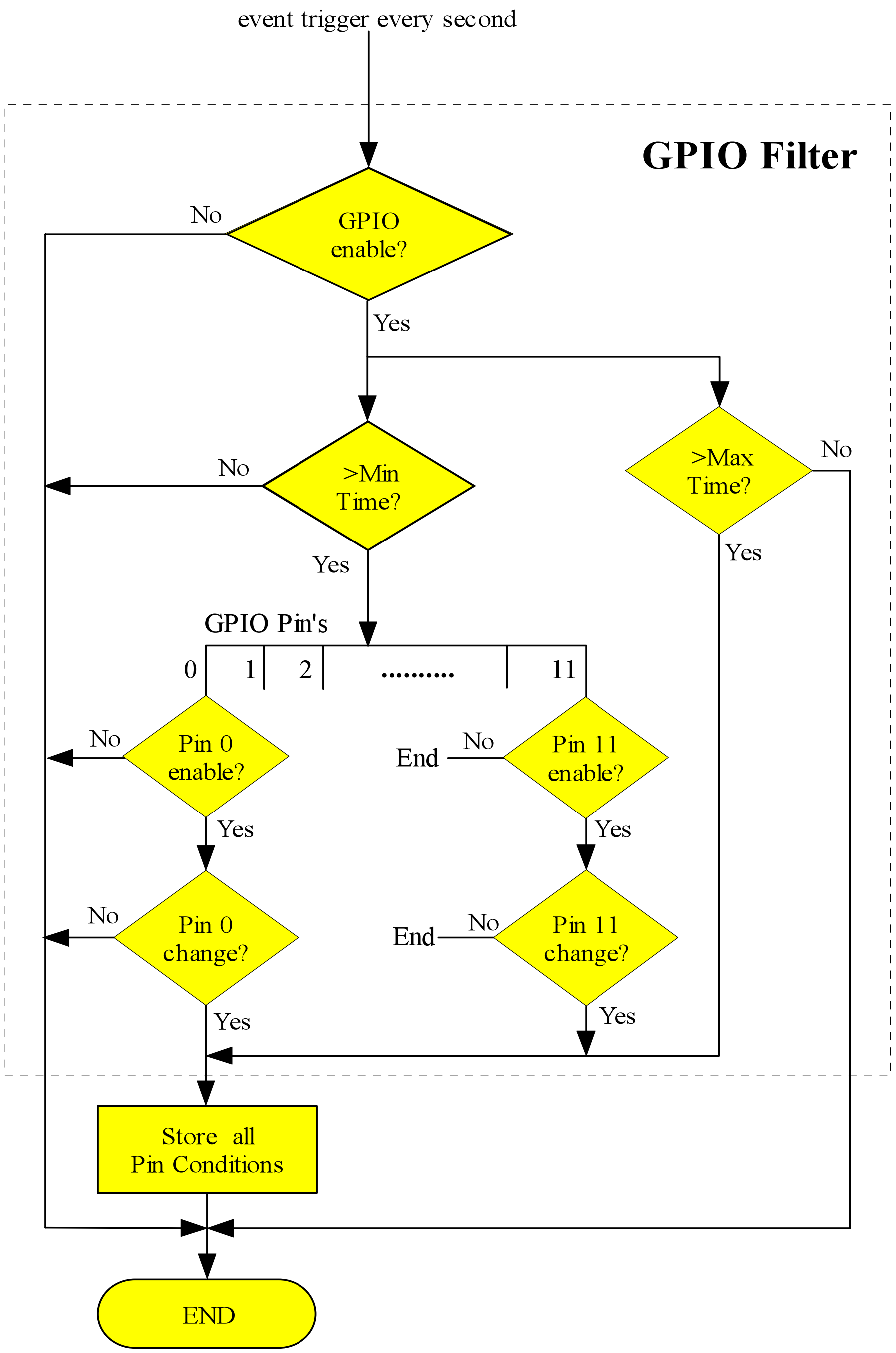

Figure 3: GPIO filter

5.2.1.1 GPIO Filter Algorithm in Pseudocode

The algorithm stores according to the following pseudo code, which is called once every second:

```
-- Calculate the difference between now and the last storage time.
T_Diff = Current.Time - Last.GPIOTime

-- Only store if the filter checks are ok.
-- The lower bounds are anded the higher bounds are ored.
IF (((Current.GPIOValue & Mask) <> (Last.GPIOValue & Mask)) AND
    (T_Diff > T_Min)) OR (T_Diff > T_Max)) THEN

  IF (T_Diff > 65535) THEN
    --Store a GPIO_FULL record to the flash.
  ELSE
  --Store a GPIO_INC record to the flash.
  END IF

  --Backup the storage time and GPIO values.
  Last.GPIOTime = Current.Time
  Last.GPIOValue = Current.GPIOValue

END IF
```

5.2.2 Position Fix Filter

This filter is active only if a new and valid position fix has been calculated.

The position fix logging algorithm stores the following information:

- Timestamp of stored position, Resolution 1 [s].
- Velocity. Range 0 ...1023 [km=h] , Resolution 1 [km=h].
- Position. Full ECEF Position. Resolution 1 [m].
- Number of SVs (<3, 3, 4 or >4 SVs).
- DGPS used.

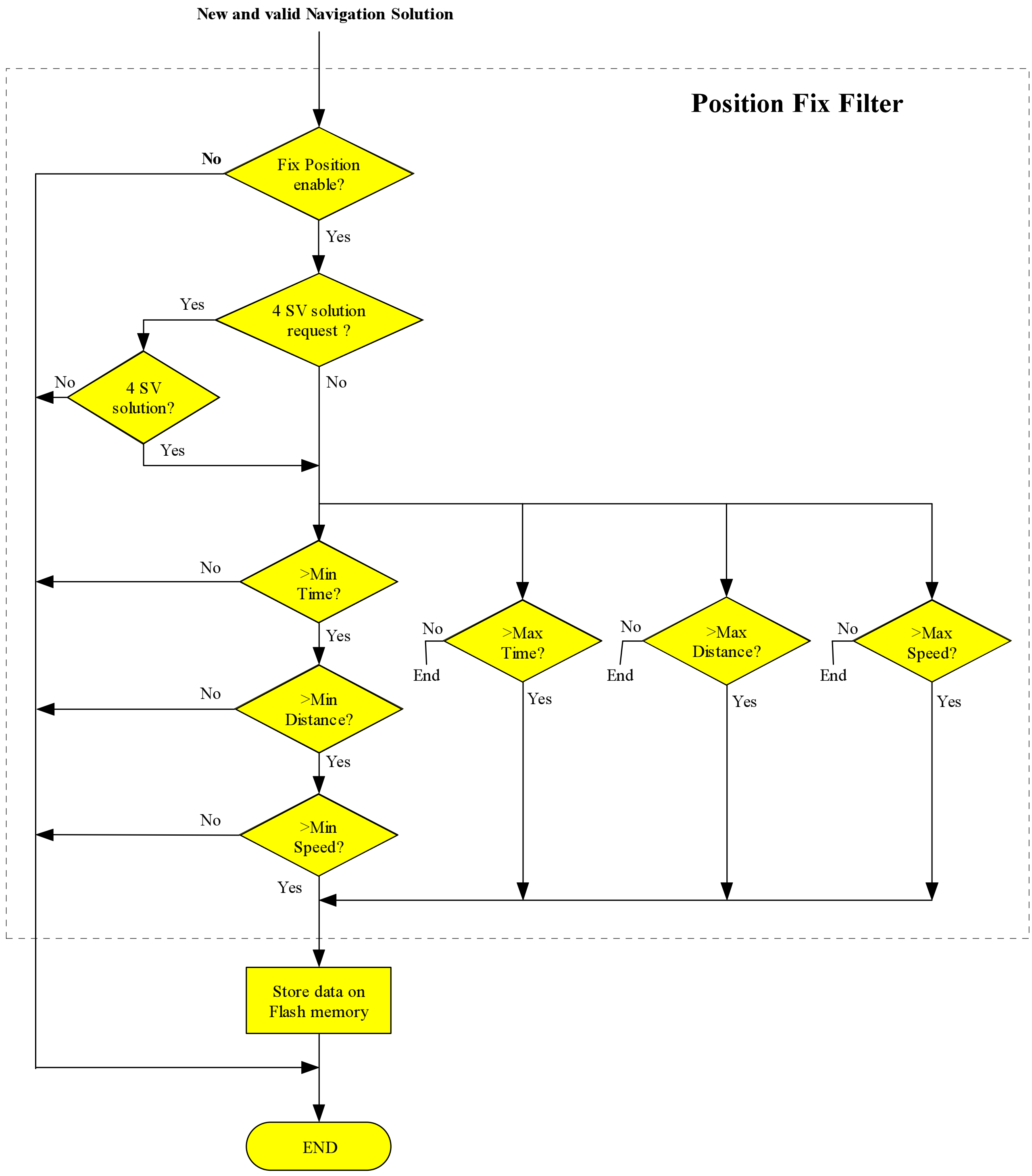

Figure 4: Position fix filter

5.2.2.1 Position Fix filter Algorithm in pseudo code

The algorithm stores according to the following pseudo code, which is called whenever a position fix is done:

```
--Calculate the difference between now and the last storage time.
T_Diff = Current.Time - Last.FixTime

--Calculate the difference between here and the last stored position.
D_Diff = ABS(Current.Position - Last.Position)

--Get the current speed.
V = Current.Speed
```

```
--Only store if the filter checks are ok.
--The lower bounds are anded the higher bounds are ored.
IF (((T_Diff > T_Min) AND (D_Diff > D_Min) AND (V > V_Min)) OR
    (T_Diff > T_Max) OR (D_Diff > D_Max) OR (V > V_Max)) THEN

  IF ((D_Diff > 32767) OR (T_Diff > 65535)) THEN
    --Store a FIX_FULL record to the flash.
  ELSE IF (D_Diff > 511) THEN
    --Store a FIX_INCL record to the flash.
  ELSE IF (D_Diff > 15) THEN
    --Store a FIX_INCM record to the flash.
  ELSE
    --Store a FIX_INCS record to the flash.
  END IF

  --Backup storage time and position.
  Last.FixTime = Current.Time
  Last.Position = Current.Position

END IF
```

5.3 Default settings of the datalogger

The logging firmware has the following default settings:

Validity	Parameter	Value	Protocol
Logger	Flags	Enabled	MID 0xBC
Position Fix Filter	Flags	Enabled	MID 0xBE
	Min Time	5 s	
	Max Time	3600 s	
	Min Distance	150 m	
	Max Distance	0 m (Disabled)	
	Min Speed	0 m/s (Disabled)	
	Max Speed	0 m/s (Disabled)	
GPIO Filter	Flags	Disabled	MID 0xCA
	Min Time	5 s	
	Max Time	0 s (Disabled)	
	Mask (Configuration mask)	0x000 (None)	
	Check (Logging mask)	0x000 (Not Set)	
GPIO Settings	Input / Output mask	0x000 (Not Set)	
GPIO Settings	Value mask	0x000 (Not Set)	

Table 2: Datalogger Default settings

Table 2 describes the default settings of the Logger. The column 'Protocol' refers to these messages, which can change the settings. These messages are used to control the datalogger, e.g. switch it on/off, change the settings.

The logger starts automatically during the first system start. Only the Filters with above described settings will be active.

5.4 Protocol Extension

The logging protocol extension can be used with SiRF Binary protocol only. Please refer to the μ-blox protocol documentation for a specification of the transport and verification layer. This document describes the payload portion of the extended SiRF binary protocol, only. The following Input[1] and Output messages are supported:

5.4.1 Input Messages

MID	Message	Description
0xB6	LogSectorErase (responses with LogSectorEraseEnd)	Erases all sectors or a specified sector in the Flash memory
0xB8	LogRead (responses with LogData)	Initiates data download from a specified address
0xBA	LogPollSectorInfo (responses with LogSectorInfo)	Requests flash sector information
0xBB	LogPollInfo (responses with LogInfo)	Requests information about flash memory and logging space
0xBC	LogSetConfig	Sets general logging configuration
0xBD	LogPollConfig (responses with LogConfig)	Requests general logging configuration
0xBE	LogFixSetConfig	Sets the position fix logging configuration
0xBF	LogFixPollConfig (responses with LogFixConfig)	Requests the position fix logging configuration
0xC0	LogGPIOSetConfig	Sets the GPIO logging configuration
0xC1	LogGPIOPollConfig (responses with LogGPIOConfig)	Requests the GPIO logging configuration

Table 3: Input Messages

5.4.1.1 LogSectorErase

This message causes the receiver to erase a specific flash sector. The receiver disables flash writing. After erasing the receiver returns a message of type LogSectorEraseEnd (0x7B). After erasing sectors you must reset the receiver. Send the Navigation Initialization Message (MID = 0x80). There are two special sector numbers that erase all sectors in a row. If you send the message with 0xFF as Sector Number, the module will erase all used sectors, then it replies with the LogSectorEraseEnd Message and performs a reset. If you send the message with 0xFE as Sector Number, the module will erase all sectors regardless of the usage, then it replies with the LogSectorEraseEnd Message and performs a reset. Keep in mind that the erase command may take several seconds to complete. During this time no communication is possible.

Field	Type	Description
MID	U8	`0xB6`
Sector	U8	Sector Number
		Payload: 2 Byte

Table 4: LogSectorErase Message

5.4.1.2 LogRead

This message requests 512 bytes of stored and compressed log data. The module returns a message of type LogData (0x79)

Field	Type	Description
MID	U8	`0xB8`
Address	U32	Address from which data should be returned
		Payload: 5 Byte

Table 5: LogRead Message

[1] Input as seen from the receiver, i.e. from the Host PC to the μ-blox receiver.

5.4.1.3 LogPollSectorInfo

This message requests information on a specific sector of the flash memory. The receiver returns a message of type LogSectorInfo (0x7A).

Field	Type	Description
MID	U8	`0xBA`
Sector	U8	Sector number
		Payload: 2 Byte

Table 6: LogPollSectorInfo Message

5.4.1.4 LogPollInfo

This message requests information on flash memory and logging space. The receiver returns a message of type LogInfo (0x7C).

Field	Type	Description
MID	U8	`0xBB`
		Payload: 1 Byte

Table 7: LogPollInfo Message

5.4.1.5 LogSetConfig

This message sets the general logging configuration.

Field	Type	Description
MID	U8	`0xBC`
Flags	U16	Logging Flags. See Table 9 for meaning
		Payload: 3 Bytes

Table 8: LogSetConfig Message

Bit #	Meaning	Parameters
Bit 0	Logging Control	0=Disabled 1=Enabled
Bit 1	Logging Debug Messages	0=Disabled 1=Enabled
Bit 2	Logging Diagnostics Strings	0=Disabled 1=Enabled
Bit 7	Flash 1PPS LED when logging	0=Disabled 1=Enabled

Table 9: LogSetConfig.Flags Bitmap

5.4.1.6 LogPollConfig

This message requests the general logging configuration. The receiver returns a message of type LogConfig (0x7D).

Field	Type	Description
MID	U8	`0xBD`
		Payload: 1 Byte

Table 10: LogPollConfig Message

5.4.1.7 LogFixSetConfig

This message sets the position fix logging configuration. The lower bounds (min) of the filter parameters are AND-ed, the higher bounds are OR-ed.

Field	Type	Description
MID	U8	0xBE
Flags	U16	*Fix Logging Flags*. See Table 12 for meaning
T_min [s]	U16	*Time difference filter*. This Field sets the minimum time difference with which a record maybe stored. 0=disabled
T_max [s]	U16	*Time difference filter*. This Field sets the maximum time difference with which a record is stored regardless from the other parameters. 0=disabled
D_min [m]	U16	*Distance filter*. This Field sets the minimum distance with which a record may be stored. 0=disabled
D_max [m]	U16	*Distance filter*. This Field sets the maximum distance with which a record is stored regardless from the other parameters. 0=disabled
V_min [m/s]	U16	*Velocity filter*. This Field sets the minimum speed with which a record may be stored. 0=disabled
V_max [m/s]	U16	*Velocity filter*. This Field sets the maximum speed with which a record is stored regardless from the other parameters. 0=disabled
		Payload: 15 Byte

Table 11: LogFixSetConfig Message

Bit #	Meaning	Parameters
Bit 0	Position Fix Logging Control	0=Disabled 1=Enabled
Bit 2	Output Measured Navigation on Serial Port (SiRF Binary Message 2) while Logging	0=Output 1=Don't Output
Bit 3	Log Filter for 4SV Solution	1=Log only if 4 or more SV used 0=Log if valid navigation solution
Bit 6	Speed Format	0=3D Speed 1=2D Speed, Speed over ground
Bit 7	Store FULL records only	0=Compressed 1=Uncompressed

Table 12: LogFixSetConfig.Flags Bitmap

5.4.1.8 LogFixPollConfig

This message requests the position fix logging configuration. The receiver returns a message of type LogFixConfig (0x7E).

Field	Type	Description
MID	U8	0xBF
		Payload: 1 Byte

Table 13: LogFixPollConfig Message

5.4.1.9 LogGPIOSetConfig

This message sets the GPIO logging configuration. The lower bound (min) of the time filter is AND-ed with the gpio filter, the higher bound is OR-ed.

Field	Type	Description
MID	U8	`0xC0`
Flags	U16	*GPIO Logging Flags*. See Table 15 for meaning
T_min [s]	U16	*Time difference filter*. This Field sets the minimum time difference with which a record maybe stored. 0=disabled
T_max [s]	U16	*Time difference filter*. This Field sets the maximum time difference with which a record is stored regardless from the gpio filter parameters. 0=disabled
Mask	U16[2]	*Pin Mask*, Any modification applies to the here masked pins only. (1 = Change, 0 = Leave)
Direction	U16[2]	*Direction Bitmask* (1=Input, 0=Output)
Value	U16[2]	*Value Bitmask* (1 = High, 0 = Low)
Check	U16[2]	*Check Bitmask* (1=Log if Pin changes)
		Payload: 15 Bytes

Table 14: LogGPIOSetConfig Message

Bit #	Meaning	Parameters
Bit 0	GPIO Logging Control	0=Disabled 1=Enabled
Bit 7	Store FULL records only,	0=Compressed 1=Uncompressed

Table 15: LogGPIOSetConfig.Flags Bitmap

5.4.1.10 LogGPIOPollConfig

This message requests the GPIO logging configuration. The receiver returns a message of type LogGPIOConfig (0x7F).

Field	Type	Description
MID	U8	`0xC1`
		Payload: 1 Byte

Table 16: LogGPIOPollConfig Message

5.4.2 Output Messages

MID	Message	Description
0x79	LogData (response to LogRead)	Logged data
0x7A	LogSectorInfo (response to LogPollSectorInfo)	Sector information
0x7B	LogSectorEraseEnd (response to LogSectorErase)	Indicates the end of a sector erase
0x7C	LogInfo (response to LogPollInfo)	Contains information about flash architecture and logging space
0x7D	LogConfig (response to LogPollConfig)	Contains the general logging configuration
0x7E	LogFixConfig (response to LogFixPollConfig)	Contains the position fix logging configuration
0x7F	LogGPIOConfig (response to LogGPIOPollConfig)	Contains the GPIO logging configuration

Table 17: Output messages

[2] Bitmask: the bit X represents GPIO X, bits 12 to 15 are not used

5.4.2.1 LogData

This message is sent as a response to a LogRead message.

Field	Type	Description
MID	U8	`0x79`
Start	U32	Start address of this 512 Byte Block.
Data[256]	256 x U16	Compressed Data See chapter 'Storage Format' for a description of the compressed data structures
		Payload: 517 Bytes

Table 18: LogData Message

5.4.2.2 LogSectorInfo

This message is sent as a response to a LogPollSectorInfo message.

Field	Type	Description
MID	U8	`0x7A`
Sector	U8	sector number
Flags	U16	(reserved)
Size	U32	Size of this sector in bytes.
Base	U32	Start address of this sector. To be used with LogRead.
Free	U32	Number of bytes available in this sector.
		Payload: 16 Bytes

Table 19: LogSectorInfo Message

5.4.2.3 LogSectorEraseEnd

This message is sent as a response to a LogSectorErase message.

Field	Type	Description
MID	U8	`0x7B`
Sector	U8	Sector number
		Payload: 2 Bytes

Table 20: LogSectorEraseEnd Message

5.4.2.4 LogInfo

This message is sent as a response to a LogPollInfo message.

Field	Type	Description
MID	U8	`0x7C`
S_First	U8	Index of first sector of the available logging space (zerobased)
S_Last	U8	Index of last sector of the available logging space (zerobased)
A_First	U32	First address in the logging space.
A_Last	U32	Last address in the logging space.
A_Start	U32	Start address of the used logging space.
Size	U32	Size of the used logging space.
		Payload: 19 Bytes

Table 21: LogInfo Message

5.4.2.5 LogConfig

This message is sent as a response to a LogPollConfig message.

Field	Type	Description
MID	U8	`0x7D`
Flags	U16	See LogSetConfig message.
		Payload: 3 Bytes

Table 22: LogConfig Message

5.4.2.6 LogFixConfig

This message is sent as a response to a LogFixPollConfig message.

Field	Type	Description
MID	U8	`0x7E`
Flags	U16	See LogFixSetConfig message.
T_min [s]	U16	See LogFixSetConfig message.
T_max [s]	U16	See LogFixSetConfig message.
D_min [m]	U16	See LogFixSetConfig message.
D_max [m]	U16	See LogFixSetConfig message.
V_min [m/s]	U16	See LogFixSetConfig message.
V_max [m/s]	U16	See LogFixSetConfig message.
		Payload: 15 Bytes

Table 23: LogFixConfig Message

5.4.2.7 LogGPIOConfig

This message is sent as a response to a LogGPIOPollConfig message.

Field	Type	Description
MID	U8	`0x7F`
Flags	U16	See LogGPIOSetConfig message.
T_min [s]	U16	See LogGPIOSetConfig message.
T_max [s]	U16	See LogGPIOSetConfig message.
Mask	U16	See LogGPIOSetConfig message.
Direction	U16	See LogGPIOSetConfig message.
Value	U16	See LogGPIOSetConfig message.
Check	U16	See LogGPIOSetConfig message.
		Payload: 15 Bytes

Table 24: LogGPIOConfig Message

5.4.3 Transferring logged data using the extended protocol

```
-- get information on the flash structure.
-- send the message LogPollInfo and receive the message LogInfo.

-- allocate the required memory to store the data.
Data = MEMALLOC(Size)

-- now download all the data.
Address = A_Start

WHILE (Address < A_Start + Size)

  -- now download the block from address Address.
  -- send the message LogRead and receive the message LogData.
  -- copy the received block to its position in Data.

  -- calculate the starting address of the next block to download.
  Address = Address + 512

END WHILE

-- decompress Data.
-- use the algorithm given in charter 'Decompressing a downloaded memory block'.
```

5.5 Storage Format

The logged data is stored in the flash memory in different storage records. The logging algorithms automatically choose the type of the storage record. The data compression may be switched off by setting the 'store FULL records only' flag. Separate chapters describe the logging algorithms and the decompressing.

The three most significant bits (bits 15 to 13) determine the type of the storage record. In addition to the basic types, a flexible storage record, the so-called escape type storage record, is defined for future logging applications.

3 Bits[15:13]	Type	Size [WORDS]	Description
111	NONE	1	No or unwritten data
100	FIX_FULL	9	Position Fix data, Full storage format
010	FIX_INCL	5	Position fix data, Large incremental Storage format
000	FIX_INCM	4	Position fix data, Medium incremental Storage format
110	FIX_INCS	3	Position fix data, small incremental storage format
101	GPIO_FULL	3	GPIO data, Full storage format
011	GPIO_INC	2	GPIO data,Incremental storage format
001	ESCAPE	var	Used for Future logging Applications

Table 25: Storage Types

5.5.1 Empty Storage Record

If the first three bits are all '1', then the word is considered as unwritten data and is skipped therefore. The following table lists the layout of an empty storage record in memory.

	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Word 0	1	1	1	x[3]	x	x	x	x	x	x	x	X	x	x	x	x

Table 26: Storage Type None

5.5.2 Position Fix Storage Records

The logging option has different kinds of position fix storage records. The following parameters are stored:

Field name	Size	Description	Unit
WNO	10 Bit	Week Number (in GPS notation)	Week
TOW	20 Bit	Time of Week (in GPS notation)	Seconds
DTOW	16 Bit	Difference between last and current TOW	Seconds
ECEF_X/Y/Z	32 Bit[4]	Position in ECEF X/Y/Z Coordinate	Meters
DECEF_X/Y/Z	5/10/16[5] Bit[6]	Difference between last and current ECEF X/Y/Z Coordinate	Meters
V	10 Bit	Velocity[7]	kmh
SV	2 Bit	Number of satellites. See table 4 for meaning.	
DGPS	1 Bit	Differential GPS (1 = used, 0 = not used).	

Table 27: Position Fix Logging Parameters

[3] Reserved

[4] Signed Integer

[5] size depends on storage format

[6] Signed Integer

[7] absolute speed or speed over ground, depending on the flags in the configuration.

SV[1:0]	Symbol	Description
0 0	1D	less than 3 satellites used or Dead Reckoning
0 1	2D	3 satellites used
1 0	3D	4 or more satellites used
1 1	3D+	5 or more satellites used and fix is validated

Table 28: SV bits description

The following tables list the layout of the position fix storage records in memory.

	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Word 0	1	0	0	SV[1:0]		DGPS	V[9:0]									
Word 1	WNO[9:0]										x[8]		TOW[19:16]			
Word 2	TOW[15:0]															
Word 3	ECEF_X[31:16]															
Word 4	ECEF_X[15:0]															
Word 5	ECEF_Y[31:16]															
Word 6	ECEF_Y[15:0]															
Word 7	ECEF_Z[31:16]															
Word 8	ECEF_Z[15:0]															

Table 29: Storage Type FIX_FULL

	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Word 0	0	1	0	SV[1:0]		DGPS	V[9:0]									
Word 1	DTOW[15:0]															
Word 2	DECEF_X[15:0]															
Word 3	DECEF_Y[15:0]															
Word 4	DECEF_Z[15:0]															

Table 30: Storage Type FIX_INCL

	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Word 0	0	0	0	SV[1:0]		DGPS	V[9:0]									
Word 1	DTOW[15:0]															
Word 2	DECEF_Z[5:0]						DECEF_X[9:0]									
Word 3	X[9]		DECEF_Z[9:6]				DECEF_Y[9:0]									

Table 31: Storage Type FIX_INCM

	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Word 0	1	1	0	SV[1:0]		DGPS	V[9:0]									
Word 1	DTOW[15:0]															
Word 2	x[10]	DECEF_Z[4:0]					DECEF_Y[4:0]					DECEF_X[4:0]				

Table 32: Storage Type FIX_INCS

[8] reserved

[9] reserved

[10] reserved

5.5.3 GPIO Storage Records

The logging option has different kinds of GPIO storage records. The following parameters are stored:

Field name	Size	Description	Unit
WNO	10 Bit	Week Number (in GPS notation)	Week
TOW	20 Bit	Time of Week (in GPS notation)	Seconds
DTOW	16 Bit	Difference between last and current TOW	Seconds
GPIO	12 Bit	Values of the GPIO Pins 11 to 0	

Table 33: GPIO logging parameters

The following tables list the layout of the GPIO storage recods in memory.

	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Word 0	1	0	1	x	GPIO[11:0]											
Word 1	WNO[9:0]										x[11]		TOW[19:16]			
Word 2	TOW[15:0]															

Table 34: Storage Type GPIO_FULL

	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Word 0	0	1	1	X	GPIO[11:0]											
Word 1	DTOW[15:0]															

Table 35: Storage Type GPIO_INC

5.5.4 ESCAPE Type Storage Records

ESCAPE type storage records are defined for future use of the logging firmware. They have a flexible format. Its size can be determined by the second byte (SIZE field).

For example diagnostics strings may be written to the flash memory as ESCAPE_TYPE 0x1F with a string as the payload.

The following table lists the layout of the escape storage records in the memory.

	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Word 0	0	0	1	ESCAPE_TYPE					SIZE (n Words)							
Word 1	Payload															
Word ..	Payload															
Word ..	Payload															
Word n	Payload															

Table 36: Storage Type ESCAPE

5.6 Decompressing a downloaded memory block

The algorithm decompresses a previously downloaded memory block.

```
-- Download the data from the GPS receiver flash.
-- Use the logging protocol extension.

-- Get the first storage record into Data.

-- Decompress all storage records while we have Data.

WHILE (Data)
```

[11] reserved

```
  -- Now decode the storage record
  -- Get the Type bits of the storage record.

  IF (Type = EMPTY) THEN
    -- No data , just skip this word.
  ELSE IF (Type = FIX_FULL) THEN
    -- Save WNO and DTOW fields as the position fix logging time stamp
    -- Save the position , speed and the other mode flags
  ELSE IF ((Type = FIX_INCL) OR (Type = FIX_INCM) OR (Type = FIX_INCS)) THEN
    -- Add the DTOW field to the last position fix logging time stamp.
    -- Add the DECEF to the last position.
    -- Save the speed and the other mode flags.
  ELSE IF (Type = GPIO_FULL) THEN
    -- Save WNO and DTOW fields as the GPIO logging time stamp.
    -- Save the GPIO values.
  ELSE IF (Type = GPIO_INC) THEN
    -- Add the DTOW field to the last GPIO logging time stamp.
    -- Save the gpio values.
  ELSE IF (Type = ESCAPE) THEN
    -- Handle the additional ESCAPE type storage records.
  END IF

  -- The size of each storage record can be determined from the type
  -- and if it is an escape  type from the additional size field.

  -- Get the next storage record into Data.

END WHILE
```

6 TRANSFERRING LOGGED DATA USING U-LOGGER.EXE

The μ-logger is a simple program to demonstrate and evaluate the logging capabilities of the μ-blox GPS logging firmware and the protocol extension. It allows to configure the module and to download or erase the logged data. The logged data may be stored in various formats that can be post processed by using third party programs.

The program runs on IBM compatible PCs running Microsoft Windows 95/98 or Microsoft Windows NT 4. It needs an unused serial port where the μ-blox GPS receiver is connected. The status bar shows the actual connection and its current status. It also indicates the step and progress of the current operation. The user may abort any operation by pressing the Cancel button.

! **Note** All programs settings are stored in the File u-blox.ini under the section μ-logger in your windows directory.

6.1 Setup the communication

For changing settings and downloading logged data, a communication between the GPS receiver and host PC with μ-logger has to be created. The window 'Connection' is used to set up a connection.

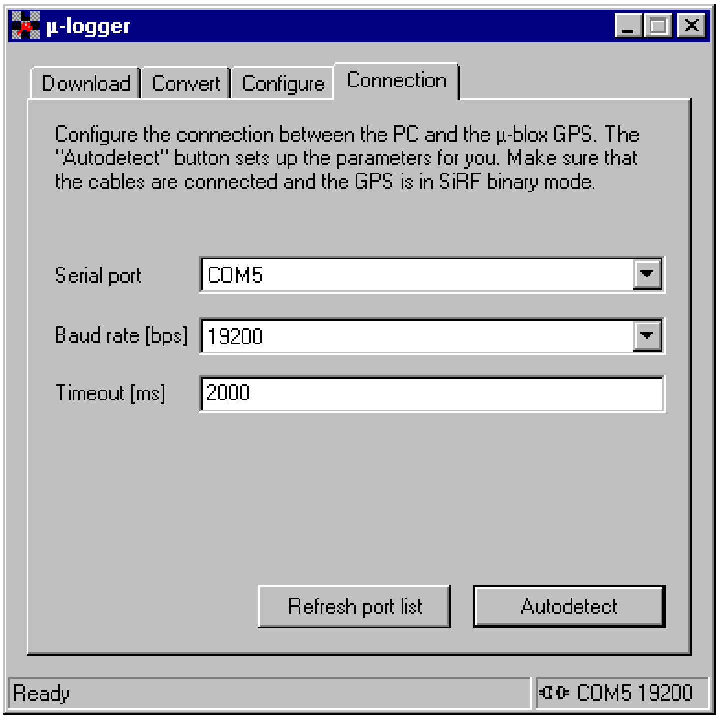

Figure 5: Setup Communication Window

Figure 5 shows the possibilities of settings for the serial interface. The communications port can be selected from the 'Serial Port' pulldown menu. If a port is not in the port list, another program is still connected with your GPS. Close the connection and then press the 'Refresh port list' button. The port should now appear in the port list.

The appropriate baud rate may be selected by the 'Baud rate [bps]' pull down menu. The default baud rate is 19200.

The μ-logger expects a response from the GPS receiver within the timeout value. The default is 2000 ms, it should be suitable for most applications.

! **Note** The Auto detect button checks all serial ports and baud rates for a connected GPS. If this does not detect the GPS, make sure that it uses the SiRF binary mode protocol and, that the cables are properly connected.

6.2 Configure the GPS logging parameters

For an optimised storage, several different parameters may be adjusted. Therefore the window with the different sub pages serves for this purpose. For additional information please consult the "System Overview" chapter.

! **Note:** You must set or get the configuration for each sub tab separately.

The *Set configuration* button stores the parameters selected in the dialog box to the module. The *Get configuration* button reads out the configuration parameters from the module and fills them into the dialog box.

6.3 General logging configuration

The Datalogger contains two main logging functionalities: position fix and GPIO logging. The general logging configurations affects both functionalities.

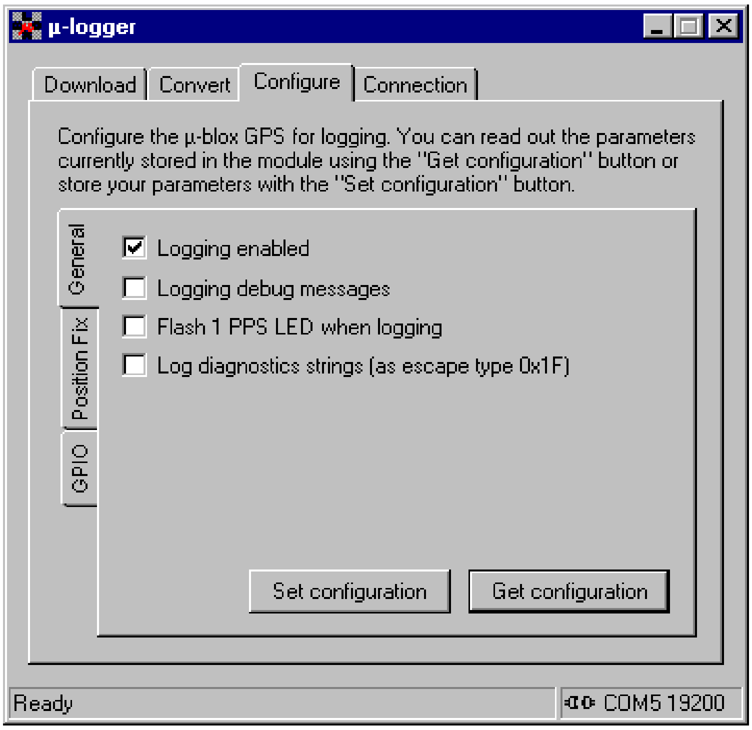

Figure 6: General Logging Configure

The 'Logging enabled checkbox allows an On/Off switch of the whole Datalogger. By default the Datalogger is enabled.

If the 'Logging debug messages' flag is set, the GPS receiver transmits the logging debug messages within the SiRF binary Protocols. That means: additional messages are output. By default it is disabled.

If the 'Flash 1 PPS LED when logging' flag is set, the LED indicates a logging cycle. By default it is disabled and the LED flashes at the measurement cycle.

'Log diagnostic strings' is useful to store important events like *Reset* into the flash. By default it is disabled.

! **Note:** If the Logging isn't enabled, the GPS receiver will not store any records, regardless of other flags.

6.3.1 Position fix logging configuration

The 'Position fix logging' window contains the Position Fix Filter settings. The chapter "Position Fix Filter" explains this in depth.

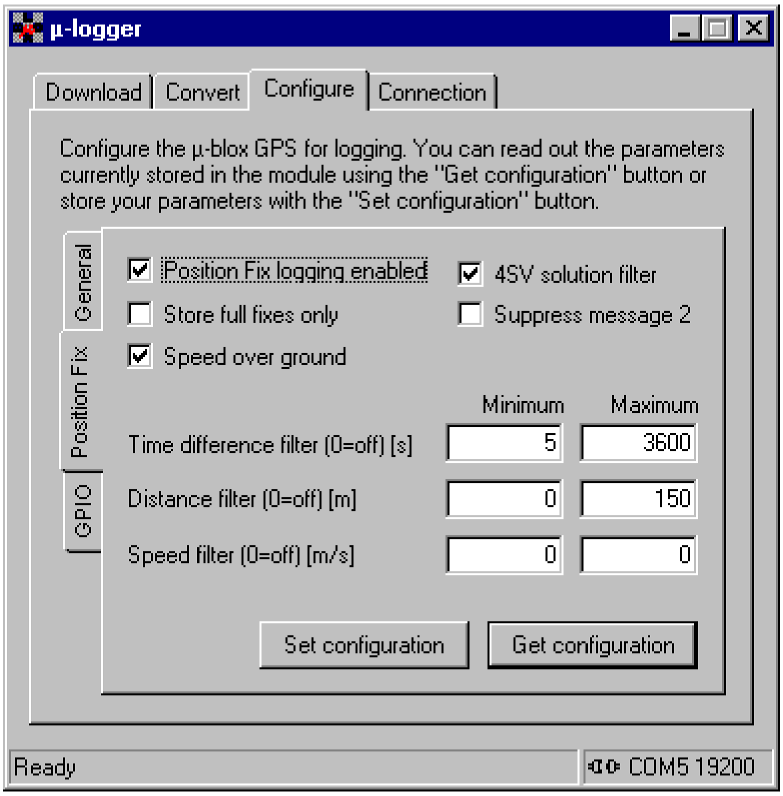

Figure 7: Position Fix Logging Configuration Window

The 'Position Fix logging enable' checkbox allows an On/Off switch of the Position Fix Logger. By default it is enabled.

The Datalogger allows different storage formats. The 'Store full fixes only' checkbox disables the incremental storage technology. It is not useful for small storage resources. By default the flag 'Store full fixes only' is disabled.

If you only want to log the speed over ground as velocity instead of the absolute speed of all three dimensions, the flag 'Speed over ground' has to be enabled. By default this flag is disabled.

The message 2 (Navigation Measurement Data Out) of the SiRF binary protocol can be suppressed by the checkbox. By default this message is sent.

If you only want to log when 3D position fixes are calculated, the 4SV solution filter has to be enabled. By default it is enabled.

The time, distance and speed filter values are described in chapters "Position Fix Filter" and "Default settings of the datalogger".

6.3.2 GPIO logging configuration

GPIO logging is more difficult to configure since it interacts with the hardware connected to the GPIO pins. The GPS has no knowledge of what components are connected, and therefore has no way to find out which signals are driven by external components and which can be driven by the GPS itself.

! **Note:** You have to make sure that the GPS module and its surrounding electronics don't drive signal lines at the same time. Improper use can lead to permanent damage to the system!

The GPS is configured by bit masks, which are represented by the checkboxes in the dialog box.

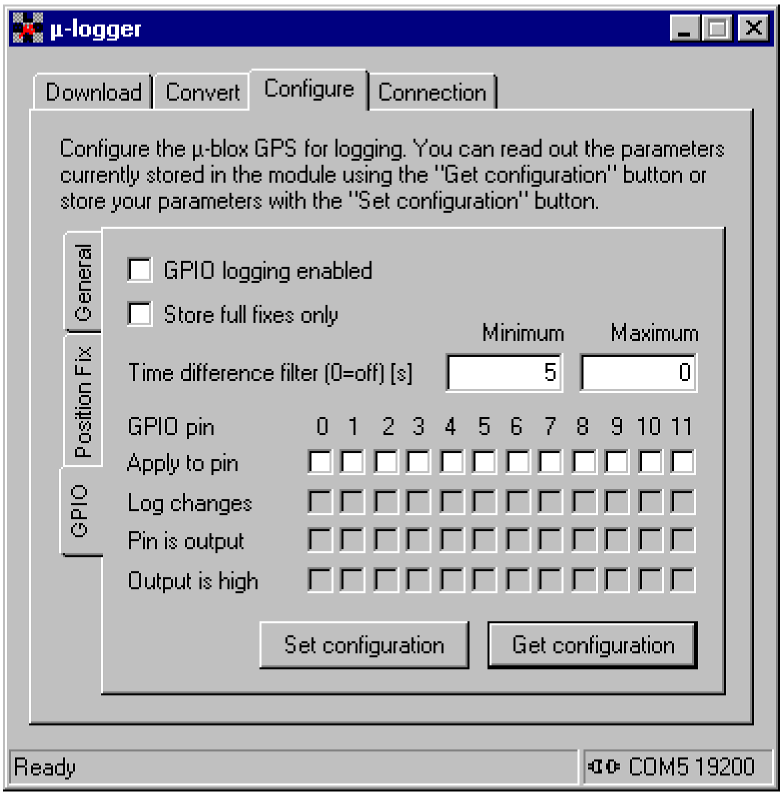

Figure 8: GPIO Logging Configuration Window

Figure 8 shows the GPIO Logging Configuration Window. This window contains general GPIO settings and GPIO logging settings.

The GPIO logging settings control the GPIO logging. The 'GPIO logging enable' checkbox allows an On/Off switch of the GPIO Logger. By default it is disabled. The 'Store full fixes only' checkbox disables the incremental storage technology. The chapters "GPIO Filter" and "Default settings of the datalogger" contain a detailed description of these settings.

The general GPIO settings allow the user to adjust the pin function according to the application requirements.

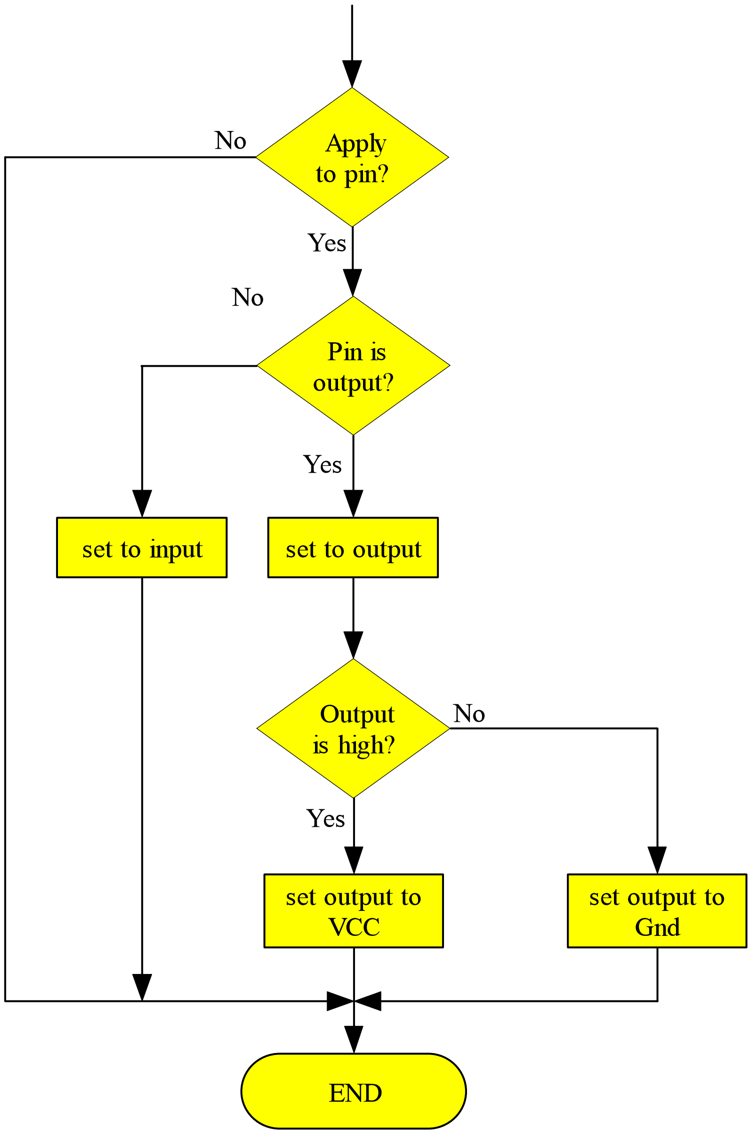

Figure 9: General GPIO settings

Figure 9 describes dependencies on the checkboxes for configuring a GPIO pin. This applies to all 12 GPIO pins.

! **Note:** The checkbox 'Apply to pin' has to be enabled for each GPIO in order to the change a pin's settings and enables its pin logging capability.

6.4 Download or erase the logged data

During GPS processing, data is stored in the flash memory of the GPS module. This Window allows you to download or erase the logged data. You can choose the file formats in which the data is stored on your PC.

The data logger works only if the flash memory has free space. Thus it has to be possible to erase the flash memory on the GPS module. Erasing takes place after download of logged data or separately.

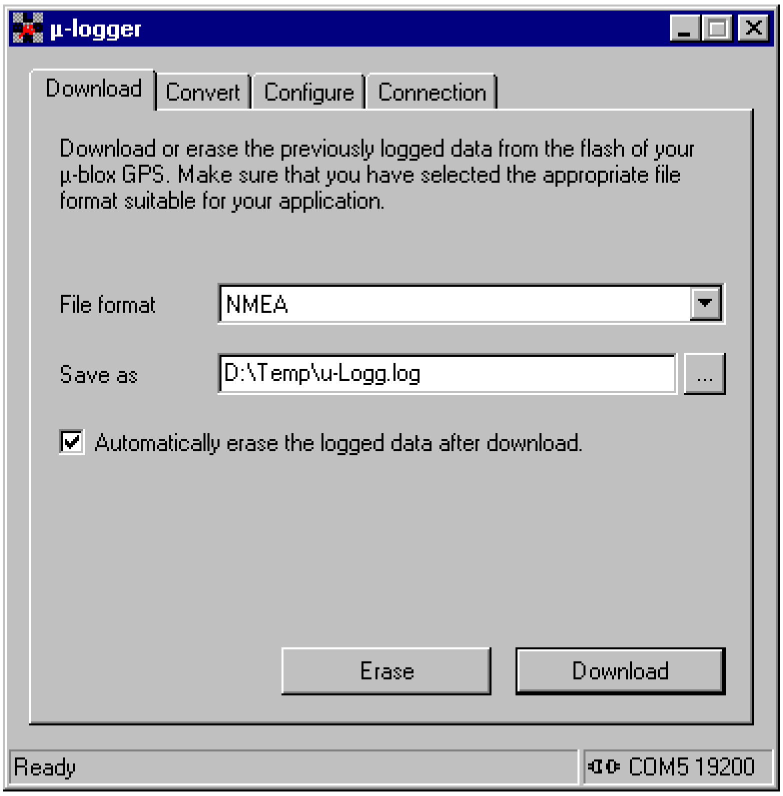

Figure 10: Download-Erase Data Window

Figure 10 shows the download and erase window. The following settings are possible:

- Selection of appropriate file format. Please note, that the NMEA formats contain only information of the Position Fix storage records.
- Selection of path and filename, where you want to store the File. You can press the button next to the edit box to select the path and filename.
- If you want to automatically erase the logged data after download tick the check box.
- Click the Download button to download and store the data on the disk.
- **Note:** The Erase button deletes the flash area reserved for data logging.

The following table describes the possible file formats in which the data can be stored on you PC.

Type	Description
Binary	Compressed data as in the flash, saved binary, bigendian byte order
NMEA	Decompressed data, saved as NMEA GLL, RMC, GGA and VTG messages
NMEA GLL	Decompressed data, saved as NMEA GLL messages
NMEA RMC	Decompressed data, saved as NMEA RMC messages
NMEA GGA	Decompressed data, saved as NMEA GGA messages
NMEA VTG	Decompressed data, saved as NMEA VTG messages
Text	Decompressed data, saved as ASCII text, All data
Text FIX	Decompressed data, saved as tabular ASCII text, Fix data only
Text GPIO	Decompressed data, saved as tabular ASCII text, GPIO data only

Table 37: Download file formats

6.5 Conversion of logged data

The logged data is transmitted within SiRF binary message only. The logged data is stored into a file on PC with the defined format. The μ-logger offers the possibility to convert binary download files into all other described download formats.

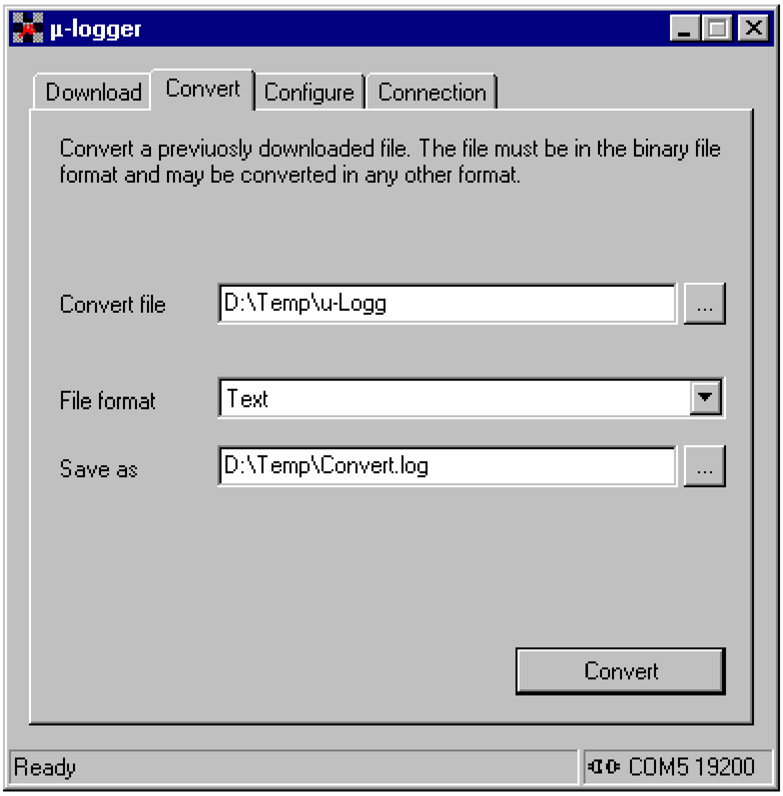

Figure 11: Convert Window

This picture shows the Convert Window. The file to be converted has to be filled into the field 'Convert File'. The 'File Format' describes the format of the resulting file. The field 'Save as' describes the destination file to hold the converted data.

! **Note:** This enables you to convert the downloaded data of a binary file into the different formats. The Data Logger does not need to be connected while converting.

6.6 Fix Logging Performance Example

Assume that the Fix logging parameters are

```
T_min = 5[s]
T_max = 3600[s]
D_Delta = 150[m]
```

The logging time depends on the memory available for logging and on how the receiver is moved. The μ-blox GPS receivers have 1`024 kBytes (8 MBits) of flash memory of which 640 kBytes[12] may be used for logging. The following equation calculates how long data can be logged.

$$\text{logging time} = \text{time between storage} \cdot \frac{\text{free flash memory}}{\text{size per storage record}}$$

The worst case is that we would have to store a logging record in FIX_FULL format every second. The logging time will be around 2 days (10 hours if the T_min filter is not active).

Let's assume that we are constantly traveling with 50 km/h (14 m/s). The time between storage will be 11 seconds. Since we moved about 150 meters the data is most probably stored in the FIX_INCM storage record format. The calculated logging time is more than 8 days.

6.6.1 Real Example

This example shows a short ride with a car. Table 38 lists the configuration used in this example. No differential GPS was connected.

Parameter	Value
Flags	0x01
T_min	2 [s]
T_max	3600[s]
D_delta	50 [m]

Table 38: Module fix logging configuration

The following lines show an extract of a hexadecimal dump of the file saved in binary format.

```
000001a0: .... 1831 0003 73e3 03fe 1836 0003 7be1
000001b0: 03fc 1835 0003 83df 03ff 1836 0003 87e2
000001c0: 03fc 1833 0003 83e0 03fd 1838 0003 7be2
000001d0: 03fe 182e 0003 7fe4 0001 1828 0003 73e6
000001e0: 03fe 1819 0005 77e4 0003 182c 0004 73dd
000001f0: 03fd 1816 0004 53e1 0000 1824 0006 bc10
00000200: 3c22 1821 0003 b412 3c12 1813 0004 b80e
00000210: 3c17 1816 0006 c00c 3c21 181e 0005 c80c
00000220: 3c1f 1827 0003 c40c 3c1a 1827 0003 b80b
00000230: 3c1d 1824 0003 c00a 3c1d 1818 0004 c40b
00000240: 3c1d ....
```

The following lines show an extract of the data saved as a tabular text.

[12] GPS-PS1E 512 kBytes (4 MBits) of flash memory of which 128 kBytes are free.

FIX_Type	FIX	DGPS	WNO	TOW	DTOW	Time	Date	Decef_X	Decef_Y	Decef_Z	Ecef_X	Ecef_Y	Ecef_Z	Speed	Longitude	Latitude	Altitude
FIX_INCM	3D+	No	999	120495	3	09:28:15	03/01/1999	29	2	28	4278899	643178	4670897	49	8.548354	47.380770	418
FIX_INCM	3D+	No	999	120498	3	09:28:18	03/01/1999	31	4	30	4278868	643174	4670927	54	8.548363	47.381159	419
FIX_INCM	3D+	No	999	120501	3	09:28:21	03/01/1999	33	1	32	4278835	643173	4670959	53	8.548415	47.381571	420
FIX_INCM	3D+	No	999	120504	3	09:28:24	03/01/1999	30	4	33	4278805	643169	4670992	54	8.548421	47.381972	424
FIX_INCM	3D+	No	999	120507	3	09:28:27	03/01/1999	32	3	32	4278773	643166	4671024	51	8.548445	47.382380	426
FIX_INCM	3D+	No	999	120510	3	09:28:30	03/01/1999	30	2	30	4278743	643164	4671054	56	8.548478	47.382761	427
FIX_INCM	3D+	No	999	120513	3	09:28:33	03/01/1999	28	1	31	4278715	643165	4671085	46	8.548546	47.383132	432
FIX_INCM	3D+	No	999	120516	3	09:28:36	03/01/1999	26	2	28	4278689	643163	4671113	40	8.548571	47.383474	435
FIX_INCM	3D+	No	999	120521	5	09:28:41	03/01/1999	28	3	29	4278661	643166	4671142	25	8.548666	47.383831	437
FIX_INCM	3D+	No	999	120525	4	09:28:45	03/01/1999	35	3	28	4278626	643163	4671170	44	8.548695	47.384234	434
FIX_INCM	3D+	No	999	120529	4	09:28:49	03/01/1999	31	0	20	4278595	643163	4671190	22	8.548756	47.384558	428
FIX_INCM	3D+	No	999	120535	6	09:28:55	03/01/1999	16	34	17	4278611	643197	4671173	36	8.549170	47.384317	430
FIX_INCM	3D+	No	999	120538	3	09:28:58	03/01/1999	18	18	19	4278629	643215	4671154	33	8.549370	47.384065	430
FIX_INCM	3D+	No	999	120542	4	09:29:02	03/01/1999	14	23	18	4278643	643238	4671136	19	8.549644	47.383842	428
FIX_INCM	3D+	No	999	120548	6	09:29:08	03/01/1999	12	33	16	4278655	643271	4671120	22	8.550052	47.383633	428
FIX_INCM	3D+	No	999	120553	5	09:29:13	03/01/1999	12	31	14	4278667	643302	4671106	30	8.550435	47.383439	429
FIX_INCM	3D+	No	999	120556	3	09:29:16	03/01/1999	12	26	15	4278679	643328	4671091	39	8.550752	47.383243	428
FIX_INCM	3D+	No	999	120559	3	09:29:19	03/01/1999	11	29	18	4278690	643357	4671073	39	8.551110	47.383033	425
FIX_INCM	3D+	No	999	120562	3	09:29:22	03/01/1999	10	29	16	4278700	643386	4671057	36	8.551470	47.382842	423
FIX_INCM	3D+	No	999	120566	4	09:29:26	03/01/1999	11	29	15	4278711	643415	4671042	24	8.551828	47.382650	422

Third party software can be used to overlay decoded logging data onto a map. Figure 12 shows an example of such overlaying techniques.

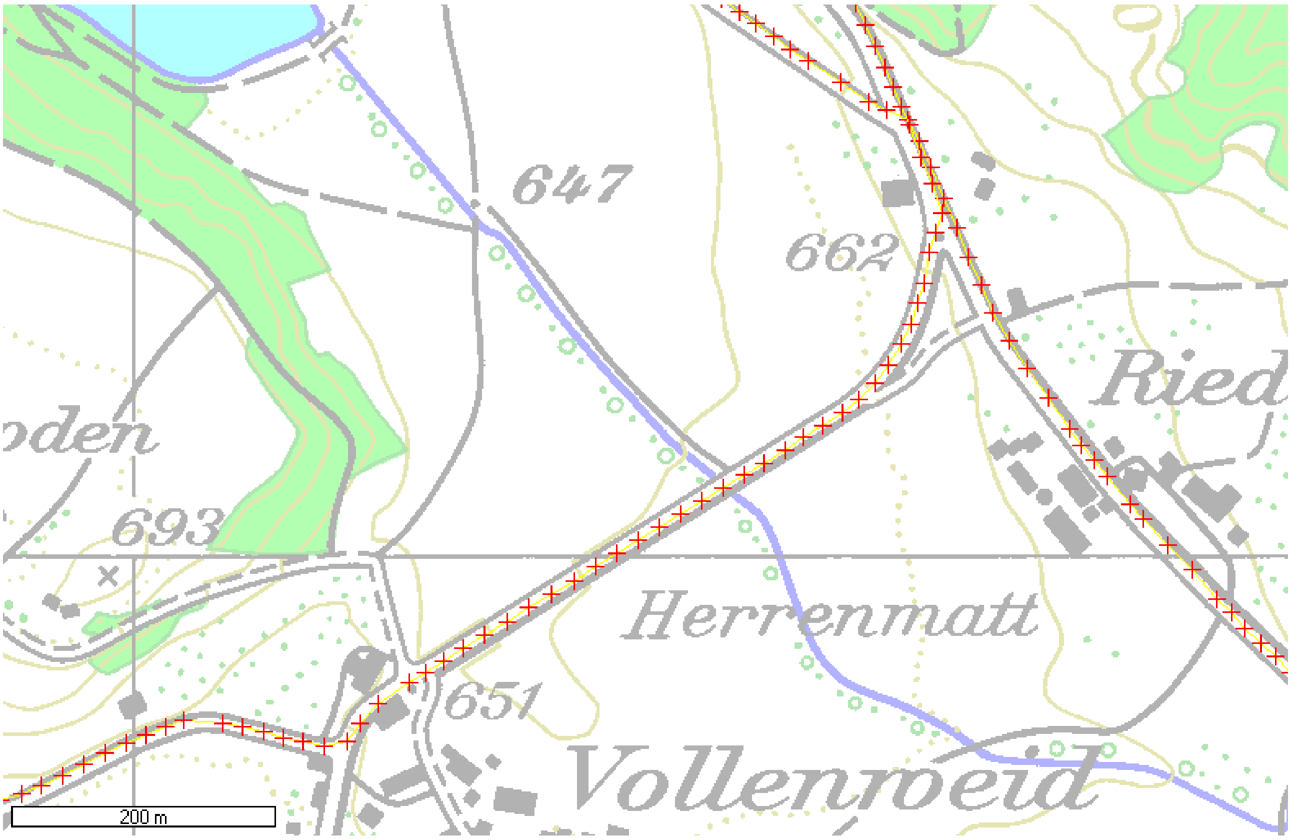

Figure 12: Short ride represented on a map

7 Related Documents

GPS.G1-MS1-00002	GPS-MS1E Datasheet
GPS.G1-PS1-00002	GPS-PS1E Datasheet
GPS.G1-X-00005	GPS-MS1E/GPS-PS1E Protocol Specification
GPS.G1-X-00002	Update Manual

All these documents are available on our homepage (http://www.u-blox.com).

A GLOSSARY

DGPS	Differential GPS
FLASH	No Volatile Memory Chip
GPIO	General Purpose Input / Output
GPS	Global Positioning System
NMEA	Special GPS Protocol Format
MID	Message Identifier (of a Protocol)
PC	Personal Computer
SV	Space Vehicle (Satellite)
TOW	Time of Week (GPS Time)
UART	Asynchronous Serial Interface

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REVISION HISTORY

Revision Index	Date	Name	Status / Comments
P1	18.10.00	PE	Initial Version
P2	30.10.00	JR	Release Candidate
	02.11.00	JR, MA	Public Release