µ-blox GPS receiver performance Application Note

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Abstract

This application note describes the performance characteristics of µ-blox GPS receivers, that are based on the SiRFstar I Architecture[1]. First, an overview of commonly used GPS performance measures is given, followed by the measurement results.

Position Accuracy

GPS receiver accuracy is a function of GPS receiver performance, satellite constellation and Selective Availability[2] (S/A).

Definitions

GPS accuracy is not properly defined. Every manufacturer has his own means of defining, measuring and calculating position accuracy. We define commonly used measures and give the values for all of them, to simplify comparisons among receivers of different brands.

rms_v [3] The square root of the average of squared errors in the vertical dimension. (One-dimensional measure)

rms_h The square root of the average of squared errors in the local tangential plane (= LTP[4])

$2drms$ Twice the rms_h measure.

CEP Circular Error Probability. The radius of a circle, centered at the antenna's true position, containing 50 % of the fixes. (LTP)

$R95$ The radius of a circle, centered at the antenna's true position, containing 95 % of the fixes. (LTP)

SEP Spherical Error Probability. The radius of a sphere, centered at the antenna's true position, containing 50 % of the fixes. (Three Dimensional)

rms_{3D} The square root of the average of squared errors of the 3D position. (3D)

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[1] SiRF Technology, Inc. 3970 Freedom Circle, Santa Clara, CA 95054, USA

[2] Selective Availability: An intentional inaccuracy of the GPS L1 system, control by the U.S. government. It is the main contributor to degraded GPS performance

[3] rms: Root Mean Square

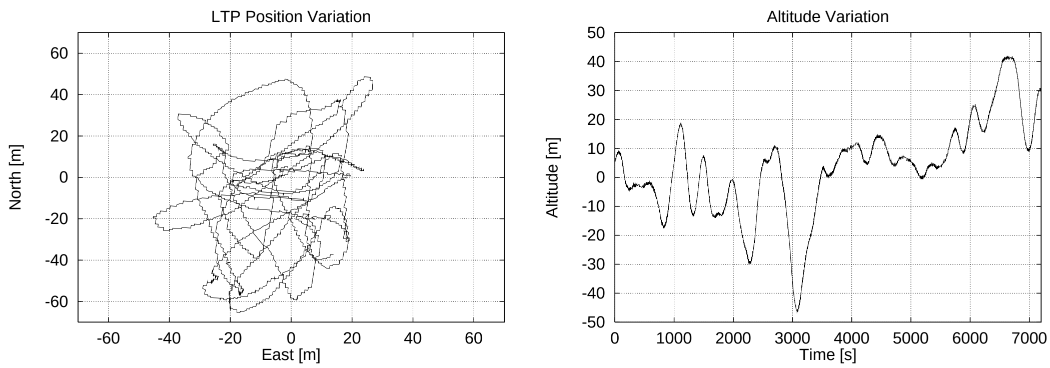
[4] LTP: Local tangential plane

Standard L1 Position Accuracy[5]

Figure 1.1 shows the wandering of the position fix due to Selective Availability for two hours. Figure 1.2 shows the same for the altitude reading.
Figure 2.1 shows a histogram[6] of the position errors in the local tangential plane. Figure 2.3 gives the 3D position errors, and figure 2.2 shows altitude errors.

Measure		Refers to
rms_v	33.7m	Altitude
rms_h	22.7m	LTP
$2drms$	45.4m	LTP
CEP	20.8m	LTP
$R95$	46.9m	LTP
rms_{3D}	44.5m	3D
SEP	37.7m	3D

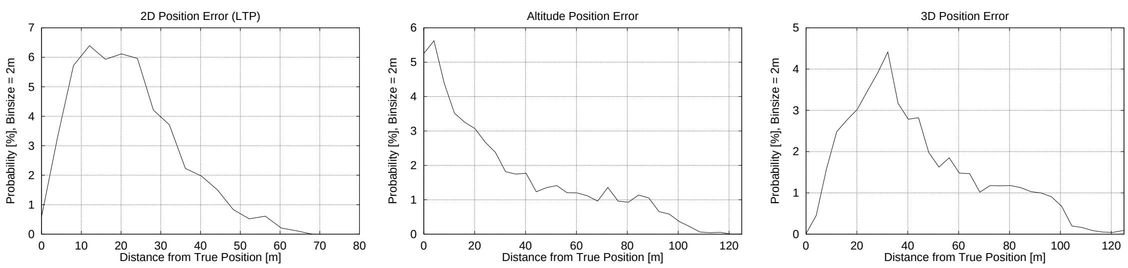
Position Accuracy (with S/A on)



1.1: 2D Position Variation

1.2: Altitude Variation

Figure 1: S/A On: Position Variation over time



2.1: LTP Errors

2.2: Altitude Errors

2.3: 3D Errors

Figure 2: S/A On: Histogram of Position Errors

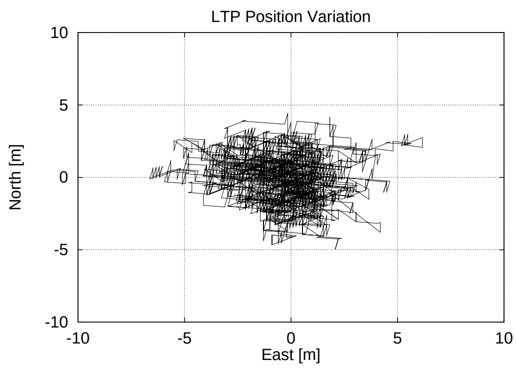
[5] Selective Availability On
[6] The Bin Size value gives the width of the interval for which the probability is shown

DGPS L1 Position Accuracy[7]

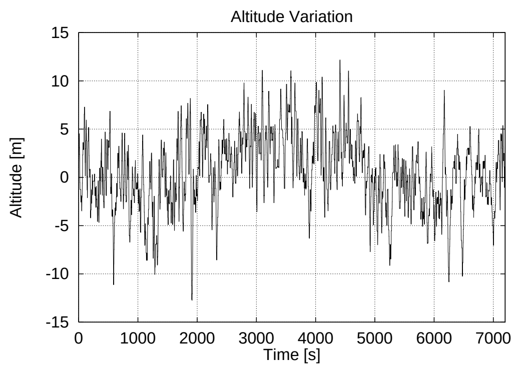
The LTP plot for a two hour run with DGPS aided operation is depicted in Figure 3.1. Figure 3.2 shows the Altitude variation for the same period of time.
Figure 4.1 shows a histogram of the position errors in the local tangential plane. Figure 4.3 gives the 3D position errors, and figure 4.2 shows altitude errors.

Measure		Refers to
rms_v	3.2m	Altitude
rms_h	2.2m	LTP
$2drms$	4.4m	LTP
CEP	2.0m	LTP
$R95$	4.4m	LTP
rms_{3D}	4.2m	3D
SEP	3.7m	3D

Position Accuracy (with DGPS)

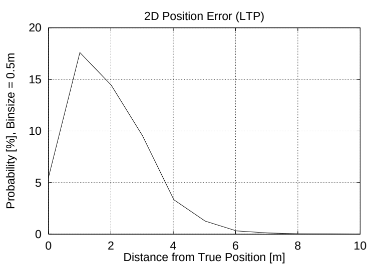


3.1: 2D Position Variation

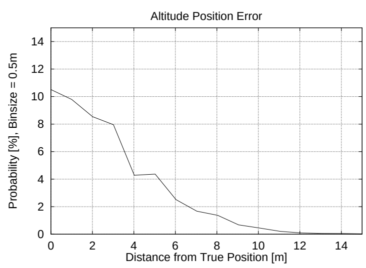


3.2: Altitude Variation

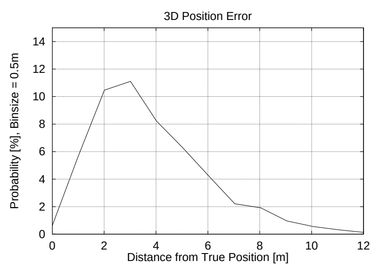
Figure 3: DGPS: Position Variation over time



4.1: LTP Errors



4.2: Altitude Errors



4.3: 3D Errors

Figure 4: DGPS: Histogram of Position Errors

[7]Corrected using RTCM messages 1,2 and 9

Startup Time

Just like GPS accuracy, startup times for GPS receivers are another field where every manufacturer has his own naming scheme, and therefore, comparison between receivers is complicated. The following are our definitions:

Cold Start In Cold Start Mode, the receiver has no knowledge on last position, approximate time or satellite constellation. The receiver starts to search for signals blindly. This is standard behaviour if no backup battery is connected. Cold Start time is the longest startup time for μ-blox GPS receivers.

Warm Start In Warm Start Mode, the receiver knows - due to a backup battery - his last position, approximate time and almanach[8]. Thanks to this, it can quickly acquire satellites and get a position fix faster than in cold start mode.

Hot Start In Hot Start Mode, the receiver was off for less than 2 hours. It uses its last ephemeris [9] data to calculate a position fix.

TTFF [10] This gives the time required for a GPS receiver from power up until a first position fix is done. For μ-blox GPS receivers, this is either the time required for hotstart, warm start or coldstart.

Reacquisition The reacquisition figure gives the time required to get lock on a satellite if the signal has been blocked for a short time (e.g. due to buildings). This is most important in urban areas. Reacquisition time is not related with TTFF.

Measure		
Cold Start	60s	typical
Warm Start	45s	
Hot Start	4s	
Reacquisition	0.1s	

Startup- and Reacq Time

The cold start time is depended on the antenna used. The above figure gives a typical value for an active antenna with 20 dB gain.

One Pulse Per Seconds

The μ-blox GPS receivers generate a pulse that is aligned with the GPS system time. The following table shows the accuracy of this signal.

	Accuracy	Sigma
S/A On	±180ns	60ns
DGPS corrected	±60ns	18ns

1PPS Accuracy

Related Documents

Related documents can be found at `http://www.u-blox.ch/restricted`.

[8] Almanac: A coarse set of orbit data, used to determine satellite visibility
[9] Ephemeris: A precise set of satellite orbits, used for navigation solutions
[10] Time to first fix

Revision History		
Date	**Revision**	**Changes**
Nov. 18, 1998	0.91	Minor typos corrected
Nov. 16, 1998	0.90	Initial Version