NEO-M9N chipset characterization for GNSS-GAGAN performance

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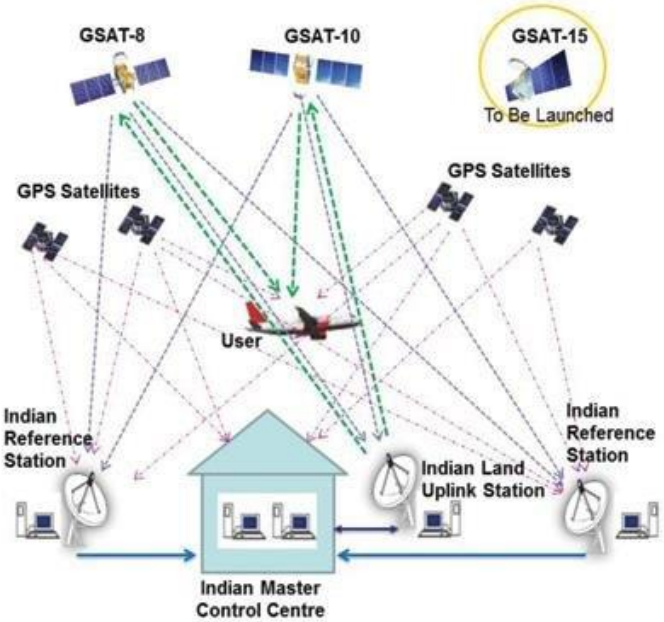
Abstract: GPS Aided GEO Augmented Navigation (GAGAN) is a Satellite Based Augmentation System (SBAS). In aviation industry, figure of merits of parameters associated with navigation is very stringent and dealing with such precision is not possible by GPS (Global Positioning System)alone and requires another sub-ordinate constellation of regional satellites (GAGAN) to correct the errors associated with latitude, longitude, height and UTC time value derived out of GPS. In this paper, we will discuss the errors associated with GPS only, and the improvements / minimizing the errors when SBAS-GAGAN is used alongside with GPS. Further to illustrate the case, we will thoroughly test and characterize the GNSS (Global Navigation Satellite System) chipset from U-blox with an inference at the end of each test,

Introduction

GPS-Aided Geo Augmented Navigation (GAGAN) system will offer seamless navigation to the aviation industry, was recently launched by the Civil Aviation Minister. The GAGAN system is designed to help pilots to navigate successfully under all-weather conditions by the accuracy of up to three meters, this capability would enable aircraft landing even on tough terrain and extreme weather. It will allow an aircraft to reduce fuel burn by flying on a specific path on straight routes and between two three-dimensional defined points. The primary objective of GAGAN is to establish, deploy and certify satellite-based augmentation system for safety-of-life civil aviation applications for the Indian air space.

It plays an important role in safety of life applications in transport, sensitive commercial applications and liability-critical applications needing legal course.GAGAN offers free enhanced satellite navigation signals by correcting deviancies in GPS signals by deploying ground based navigational infrastructure. The system is inter-operable with other international SBAS systems like US-WAAS, European EGNOS, and Japanese MSAS etc.GAGAN will provide augmentation service for the GPS over the country, the Bay of Bengal, Southeast Asia and Middle East and up to Africa. The aircraft now being used by Indian operators are not compatible with GAGAN. Only those aircraft that are fitted with SBAS will be able to use the new technology. Cost of refurbishing aircraft with new equipment and downtime for electronic restructuring are expenses that the financially stressed Indian airline industry does not seem comfortable having to bear.

GAGAN consists of set of ground reference stations positioned across various locations in India called Indian Reference Station (INRES), which gathers GPS satellite data. A master station, Indian Master Control Centre (INMCC) collects data from reference stations and creates GPS correction messages. The corrected differential messages are uplinkeded via Indian Uplink Station (INLUS) and then broadcasted on a signal from three geostationary satellites (GSAT-8, GSAT-10 and GSAT-15). The information on this signal is compatible with basic GPS signal structure, which means any SBAS enabled GPS receiver can read this signal. GAGAN systems architecture has two segments, one is ground segment, and the other is space segment. At present the ground segment consists of 15 reference stations spread all over India and three master control centers (two are in operation and one in shadow mode). These 15 reference stations are stationed at various fixed positions which receive GPS signals. The locations of reference stations are precisely chosen by the survey so that any errors in the received GPS signals can be detected.



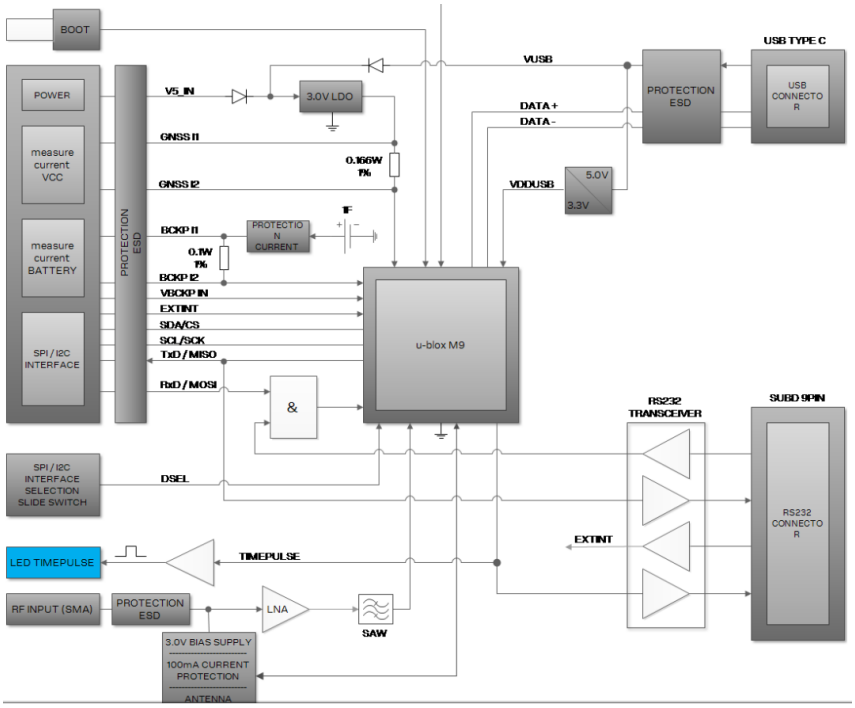
Description of Tests

Biasing, Test Setup

The tests will be conducted in normal lab environment, which is 22-27°C. Evaluation board of NEOM9N chipset is used to characterize the GNSS receiver; here the evaluation board is interfaced with PC through USB interface. The PCis installed with u-center software utility, this utility is accessory supplied by U-Blox used to characterize the receiver chipset.

- Download and install the u-center GNSS evaluation software from www.u-blox.com/u-center
- Connect the unit to a PC. Options:
  - Connect via USB port. The USB driver installs automatically when the device is connected to the PC; internet connection is required.
  - Connect via RS232 port (UART interface). Set the interface switch (2) to I2C.
  - SPI / I2C: Set switch to either SPI or I2C and connect the appropriate pins (1).
- The device must always have power, either via USB on the back or the V5 IN pin (3) on the front.
- Connect the provided GNSS antenna to the evaluation unit and place the antenna so that it has an unobstructed view to the sky. Alternatively, connect a GNSS simulator signal directly to the EVK-M91 RF input.
- Start the u-center GNSS evaluation software and select the corresponding COM port and baud rate.

The below block diagram represents the evaluation board of NEO-M9N; EVK-M91 evaluation unit contains the GNSS receiver, external TCXO, SAW and an LNA. The EVK-M91 supports all three communication interfaces: UART, I2C and SPI. For connecting the EVK to a PC, use a standard SUBD-9 cable or the included USB Type-C cable depending on the interface in use. The USB Type-C connector on the evaluation board can be used for both power supply and communication. The easiest way to evaluate theEVK-M91operationis to connect the EVK to a PC by the USB-C 2.0 cable and then to use the u-center to configure and monitor the GNSS functions. The USB connector has a direct connection to the u-blox M9 receiver, which enables the USB interface to be used as a communication interface as well.



Test Summary

EVAL-M91 FW support SBAS – Verification

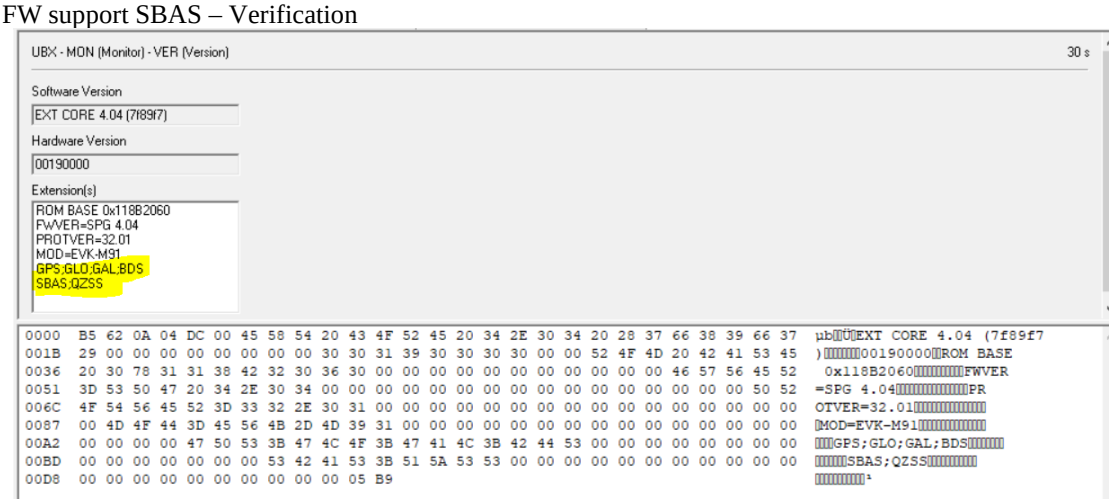


Figure 3 Observation- SBAS support

Test Result: Test Passed

Purpose of this test is to check if the firmware loaded in flash has SBAS. Is it observed from the u-center utility that the NEO-M9N receiver is SBAS enabled GNSS receiver, the SBAS that NEO-M9N supports include GAGAN.

Type of Datum – Verification

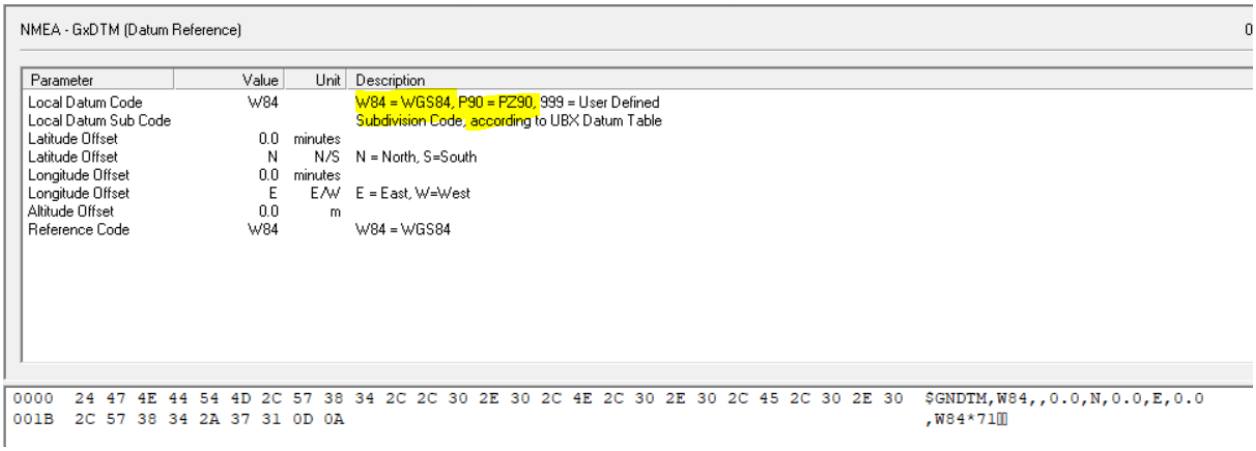


Figure 4 NMEA Datum Code

Test Result: Test Passed

The Datum of GNSS when used together with SBAS gives model of earth that is used in mapping. It is observed that NEO-M9N received data is based on W84 – Worldwide reference ellipsoid WGS-84. The WGS-84 coordinate system is a three dimensional, right-handed, Cartesian coordinate system with its original coordinate point at the center of mass of an ellipsoid, which approximates the total mass of the Earth.

NMEA GPGBS_GNSS satellite fault detection – Verification

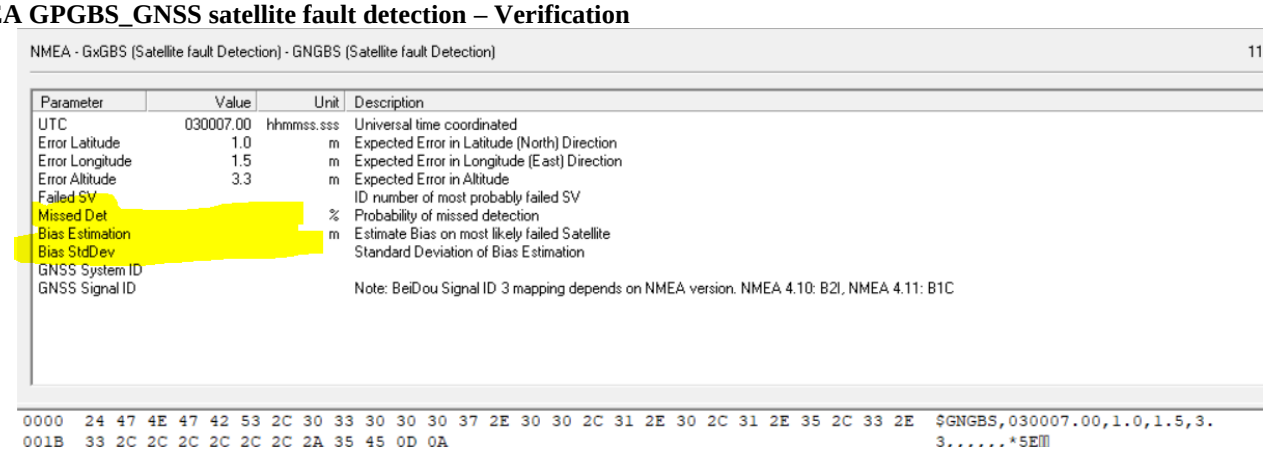


Figure 5 Observation-GNSS RAIM

This test read the output of Receiver Autonomous Integrity Monitoring Algorithm (RAIM).

NMEA GPGGA_GNSS Global positioning system fix data – Verification

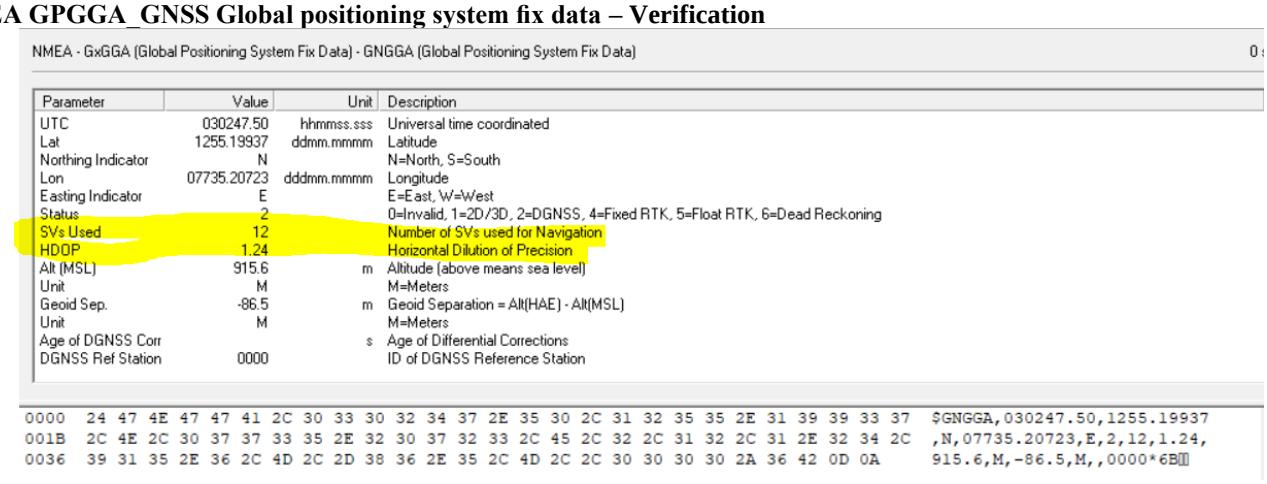


Figure 6 Observation- NMEA GPGGA (GPS data)

Test Result: Test Pass

This test read the number of GPS satellites in use and time, position data. In observation it is seen that NEO-M9N receiver is receiving time signals from 12 satellites simultaneously and Horizontal Dilution of Precision is 1.24.

Data format: $--GGA,hhmmss.ss,llll.lll,a,yyyyy.yyy,a,x,uu,v.v,w.w,M,x.x,M,,zzzz*hh

NMEA GPGLL_Geographical Position – Latitude and Longitude – Verification

This test read the Latitude and longitude, with time of position fix and status. From the observation of u-center utility, while testing this case, co-ordinates are shown in terms of latitude and longitude as Lat'1255.19884-N and Long'07735.20653-E, when we put these lat and long info in Google map is showed my home location.

Data format: $--GLL,llll.lll,a,yyyyy.yyy,b,hhmmss.sss,A,a*hh

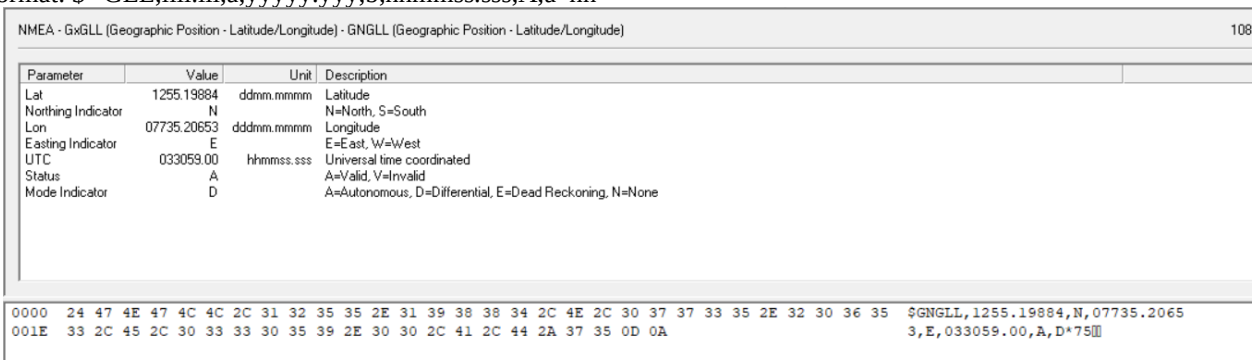


Figure 7 Observation- NMEA GPGLL (Position data)

Test Result: Test Passed.

NMEA GPGNS_GNSS fix data – Verification

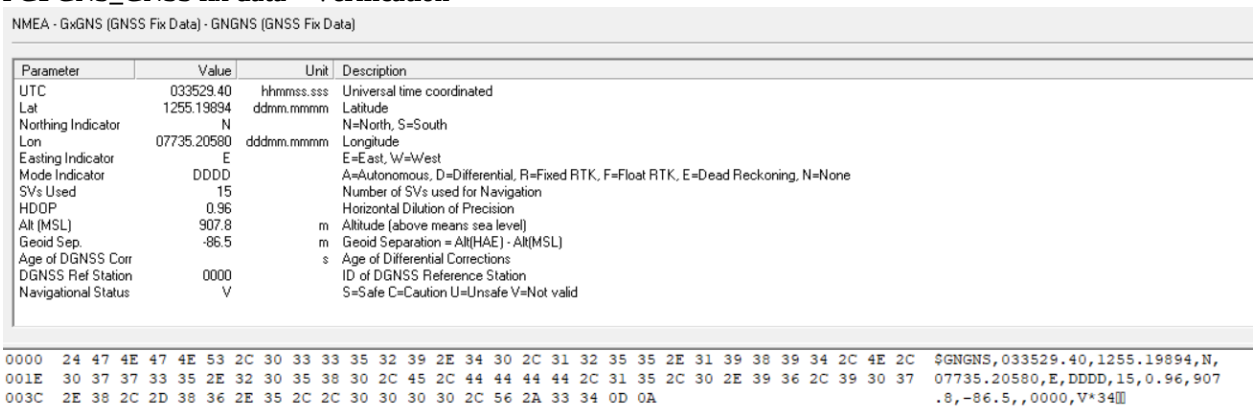


Figure 8 Observations- NMEA GPGNSS

This test read the Time and position, together with GNSS fixing-related data.

NMEA GPGSA_GNSS DOP and active satellite – Verification

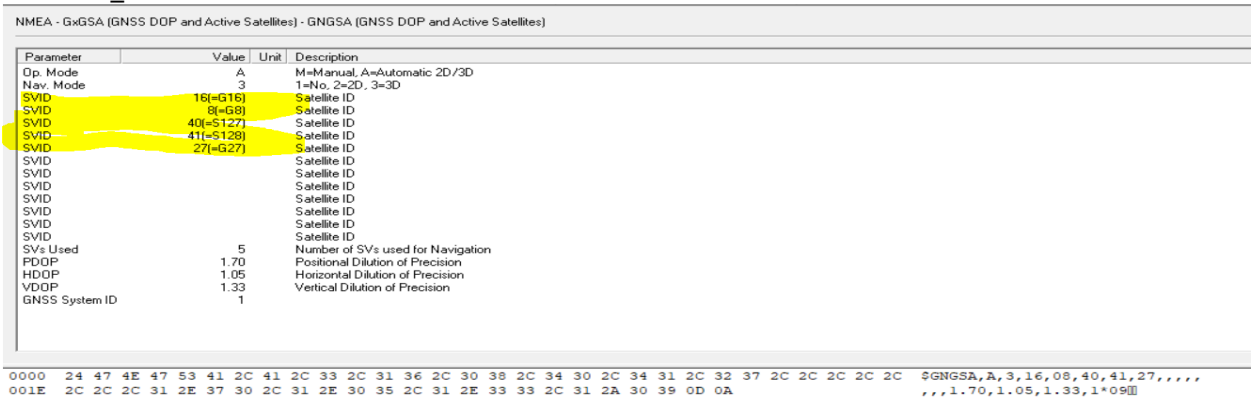


Figure 9 Observation- NMEA GPGSA (SBAS Information)

This test read the GNSS receiver operating mode, satellites used for navigation, and DOP values.

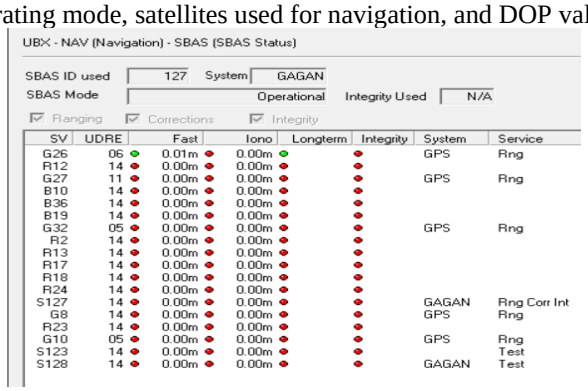


Figure 10 Observation- UBX NAV SBAS Status

Test Result: Test PASS

GPS receiver operating mode, satellites used in the navigation solution reported by the GGA or GNS sentence and DOP values. From the observation using u-center utility, NEO-M9N GNSS receiver relates to GPS satellite with satellite ID- G16, G8, G27, and also connected with GAGAN-SBAS constellation of satellite with ID- S127, S128. This NMEA message gives dilution of precision value along with satellite IDs. Data Format: $--GSA,a,x,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,u.u,v.v,z.z*hh

NMEA GPGST_GNSS pseudo range error statistics – Verification

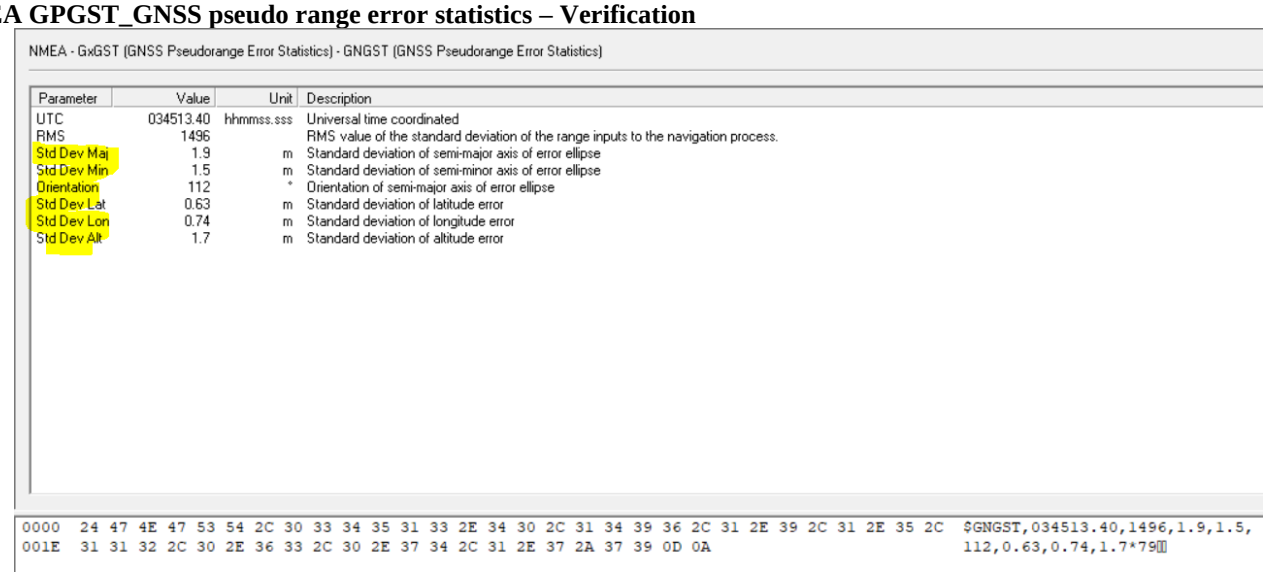


Figure 11 Observation- NMEA GNGST

This test read message reports statistical information on the quality of the position solution.

NMEA GPGSV_GNSS satellites in view – Verification

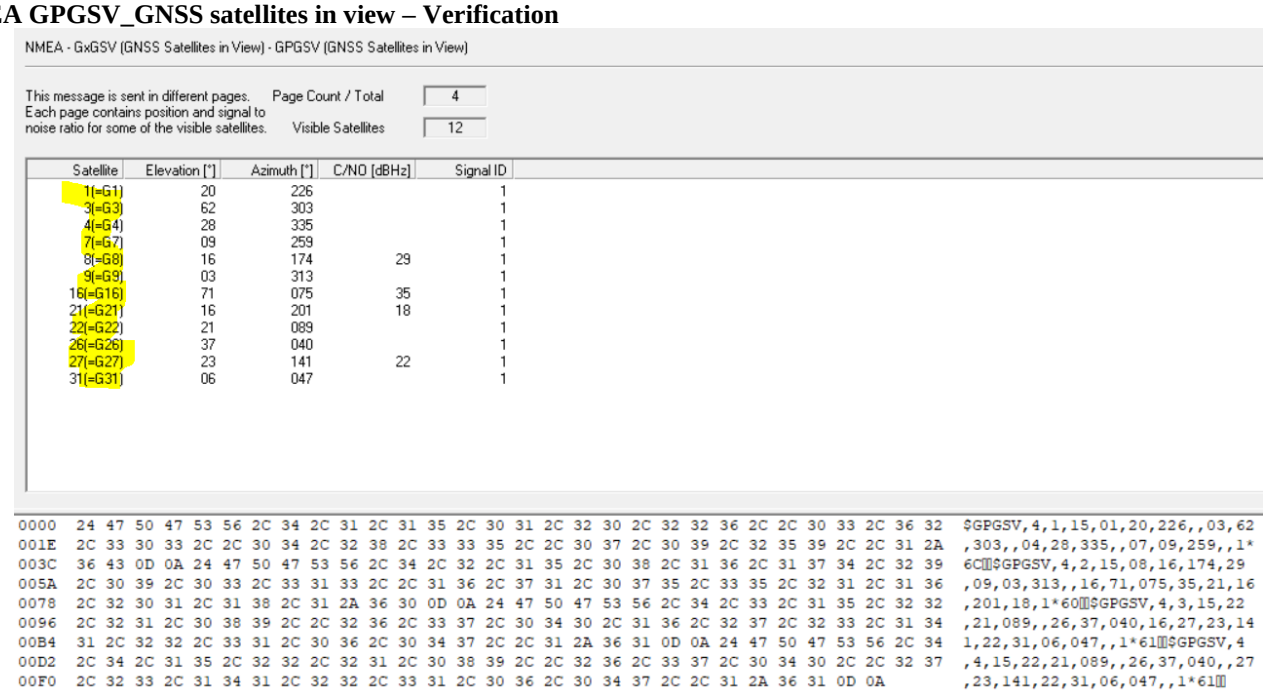


Figure 12 Observation- NMEA GPGSV Satellites in View

Test Result: Test Pass

This test checks number of satellites in view, together with each SV ID, elevation azimuth, and signal strength. From the u-center utility, it is observed that around 15 satellites are in view of NEO-M9N GNSS receiver with corresponding elevation and azimuth information.

Data Format: $--GSV,x,u,xx,uu,vv,zzz,ss,uu,vv,zzz,ss,…,uu,vv,zzz,ss*hh

NMEA GPRMC _ Recommended Minimum Specific GNSS Data

NMEA - GxRMC (Recommended Minimum Specific GNSS Data)

Parameter	Value	Unit	Description
UTC	051522.70	hhmmss.sss	Universal time coordinated
Status	A		A=Valid, V=Invalid
Lat	1255.19937	ddmm.mmmm	Latitude
Northing Indicator	N		N=North, S=South
Lon	07735.20750	dddmm.mmmm	Longitude
Easting Indicator	E		E=East, W=West
SOG	0.071	knots	Speed Over Ground
COG (true)		°	Course Over Ground (true)
Date	110222	ddmmyy	Universal time coordinated
Magnetic Variation		°	Magnetic Variation
Magnetic Variation			E=East,W=West
Mode Indicator	D		A=Autonomous, D=Differential, R=Fixed RTK, F=Float RTK, E=Dead Reckoning, N=None
Navigational Status	V		S=Safe C=Caution U=Unsafe V=Not valid

```
0000  24 47 4E 52 4D 43 2C 30 35 31 35 32 32 2E 37 30 2C 41 2C 31 32 35 35 2E 31 39 39 33 37 2C  $GNRMC,051522.70,A,1255.19937,
001E  4E 2C 30 37 37 33 35 2E 32 30 37 35 30 2C 45 2C 30 2E 30 37 31 2C 2C 31 31 30 32 32 32 2C  N,07735.20750,E,0.071,,110222,
003C  2C 2C 44 2C 56 2A 31 33 0D 0A                                                              ,,D,V*13
```

Figure 13 Observation- NMEA GPRMC

Test Result- Test Pass

This test read the output recommended minimum sentence defined by NMEA for GNSS system data. The observation is recorded as UTC time to be 051522.70, Lat to be 1255.19937, lon to be 07735.20750.

Cold Start – Time to First Fix (TTFF)

UBX - NAV (Navigation) - STATUS (Navigation Status)

Param	Value
Position Fix Type	3D Fix
Position within Limits (FixOK)	Yes
DGNSS Fix	No
Weeknumber Valid	Yes
Time of Week Valid	Yes
Diff Corrections Available	No
Map Matching	None
TTFF	85.980 s
Time since Powerup	389.084 s
PSM state	ACQUISITION
Spoofing detection state	OK
Carrier Range Status	N/A

Test Result - Test passed

This test will measure the time; it takes for the receiver to determine its first good location fix when the receiver is placed in Cold Start state. In this test, the receiver is placed into a cold start state by powering it OFF for more than a day. Using the option to read TTFF, provided in u-center under UBX protocol. TTFF information is available under STATUS drop down within NAV (Navigation) section of UBX protocol. The time it takes for the receiver to determine its first good location fix is recorded.

Warm Start – Time to First Fix (TTFF)

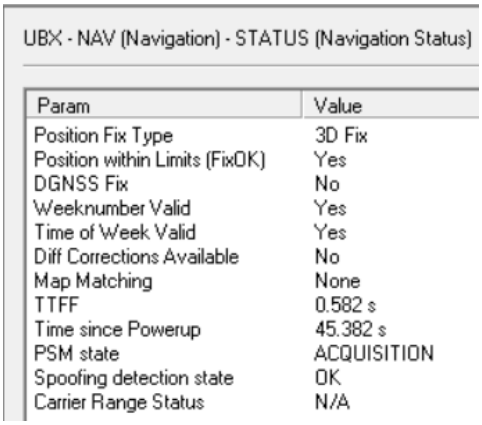
UBX - NAV (Navigation) - STATUS (Navigation Status)

Param	Value
Position Fix Type	3D Fix
Position within Limits (FixOK)	Yes
DGNSS Fix	No
Weeknumber Valid	Yes
Time of Week Valid	Yes
Diff Corrections Available	No
Map Matching	None
TTFF	8.984 s
Time since Powerup	13.484 s
PSM state	ACQUISITION
Spoofing detection state	OK
Carrier Range Status	N/A

Test Result - Test passed

This test will measure the time; it takes for the receiver to determine its first good location fix when the receiver is placed in Warm Start state. In this test, the receiver is placed into a warm start state. Using the option to read TTFF, provided in u-center under UBX protocol. TTFF information is available under STATUS drop down within NAV (Navigation) section of UBX protocol the time it takes for the receiver to determine its first good location fix is recorded.

Hot Start – Time to First Fix (TTFF)


UBX - NAV (Navigation) - STATUS (Navigation Status)

Param	Value
Position Fix Type	3D Fix
Position within Limits (FixOK)	Yes
DGNSS Fix	No
Weeknumber Valid	Yes
Time of Week Valid	Yes
Diff Corrections Available	No
Map Matching	None
TTFF	0.582 s
Time since Powerup	45.382 s
PSM state	ACQUISITION
Spoofing detection state	OK
Carrier Range Status	N/A

Test Result - Test passed

This test will measure the time; it takes for the receiver to determine its first good location fix when the receiver is placed in Hot Start state. In this test, the receiver is placed into a hot start state. Using the option to read TTFF, provided in u-center under UBX protocol. TTFF information is available under STATUS drop down within NAV (Navigation) section of UBX protocol the time it takes for the receiver to determine its first good location fix is recorded.

Conclusion

The performance parameters of NEO-M9N series GNSS receiver chipset from U-blox is characterized using EVALUATION BOARD and U-center software utility, the main parameters we touch based in this white paper include, cold start, worm start, hot start TIME TO FIRST FIX (TTFF) along with NMEA (Navy Marine Electronics Association) message that include following

$GPGGA – Time, position, and fix related data of the receiver
$GPGLL – Position, time and fix status
$GPGSA – Used to represent the IDs of satellites which are used for position fix
$GPGSV – Satellite information about elevation, azimuth and CNR
$GPRMC – Time, data, position, course and speed data
$GPVTG – Course and speed relative to the ground

Reference

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