
VECTORNAV
Embedded Navigation Solutions

Experimental example – External GPS aiding on VN-200 running FW 0.1.11.3

This custom release note provides an overview of the requirements for interfacing an external position and velocity measurements to the VN-200. An example test setup using multiple VN-200 units and data from in-house testing performed by VectorNav are also provided. This document serves as a guide for three scenarios:

1. Measurements from an external GPS module are streamed to a real-time processor, which subsequently reformats NMEA (or other proprietary format) GPS messages into data packets that the VN-200 accepts;
2. Measurements from a VN-200 unit are asynchronously streamed into a second VN-200 via a direct connection between the two units. This scenario provides the capability for a VN-200 to be mounted on a gimbaled platform where an antenna cannot be mounted or where access to GPS RF signals is severely limited;
3. Measurements from an analogous positioning system are streamed or written by command into the VN-200.

External Position/Velocity Measurement – Top-Level Requirements

- External data must be provided at a minimum at 5Hz (note: faster data rates will be down sampled);
- A hardware pulse-per-second (PPS) line must be connected to the Sync_In pin on the VN-200;
- Measurements must be valid at the top of the GPS second and every 200 milliseconds thereafter;
- The transfer delay from the time of validity of the data to reception of the data onboard the VN-200, **must** be less than 200 milliseconds (VectorNav recommends <100 ms). This can be difficult to achieve without a near real-time / low jitter data processing system. If this requirement is violated, the external position/velocity message will be rejected;
- Position data must be in double precision.

External Position/Velocity Message Formats

External position/velocity measurements can either be written individually to the appropriate VN-200 register or alternatively streamed asynchronously.

Write Register Command Formats:

1. Position/Velocity in Earth-Centered Earth-Fixed Frame (ECEF):

   $VNWRG,59,TOW,Week,GpsFix,NumSats,PosX,PosY,PosZ,VelX,VelY,VelZ,PosAcX,PosAccY,PosAccZ,SpeedAcc,TimeAcc*XX<CR><LF>

a. Position and Velocity data are expected in the ECEF coordinate frame
b. Position uncertainty (1-sigma level confidence) is expected in the local North East Down (NED) coordinate frame (note: only the first two components of position uncertainty (North & East values) are used internally, the third component (Down value) is automatically scaled on-board.
c. The velocity uncertainty is expected as a scalar magnitude (1-sigma confidence level)
d. All uncertainty values must be positive, greater than zero

2. Position in Latitude, Longitude, Altitude (LLA), velocity in NED coordinate frame

   $VNWRG,58,TOW,Week,GpsFix,NumSats,Lat,Long,Alt,VelN,VelE,VelD,PosAcX,PosAccY,PosAccZ,SpeedAcc,TimeAcc*XX<CR><LF>

   a. Position data is expected as LLA in WGS84 coordinates
   b. Velocity is expected in the local NED frame.
   c. Position uncertainty (1-sigma level confidence) is expected in the local NED coordinate frame (note: only the first two components of position uncertainty (North & East values) are used internally, the third component (Down value) is automatically scaled on-board.
   d. The velocity uncertainty is expected as a scalar magnitude (1-sigma confidence level)
   e. All uncertainty values must be positive, greater than zero

Asynchronous Stream (5Hz) Formats:

1. Position/Velocity in Earth-Centered Earth-Fixed Frame (ECEF):

   $VNGPE,TOW,Week,GpsFix,NumSats,PosX,PosY,PosZ,VelX,VelY,VelZ,PosAcX,PosAccY,PosAccZ,SpeedAcc,TimeAcc*XX<CR><LF>

   a. Position and Velocity data are expected in the ECEF coordinate frame
   b. Position uncertainty (1-sigma level confidence) is expected in the local North East Down (NED) coordinate frame (note: only the first two components of position uncertainty (North & East values) are used internally, the third component (Down value) is automatically scaled on-board.
   c. The velocity uncertainty is expected as a scalar magnitude (1-sigma confidence level)
   d. All uncertainty values must be positive, greater than zero

2. Position in Latitude, Longitude, Altitude (LLA), velocity in NED coordinate frame

   $VNGPS,TOW,Week,GpsFix,NumSats,Lat,Long,Alt,VelX,VelN,VelE,VelD,PosAccY,PosAccZ,SpeedAcc,TimeAcc*XX<CR><LF>

a. Position data is expected as LLA in WGS84 coordinates
b. Velocity is expected in the local NED frame.
c. Position uncertainty (1-sigma level confidence) is expected in the local NED coordinate frame (note: only the first two components of position uncertainty (North & East values) are used internally, the third component (Down value) is automatically scaled on-board.
d. The velocity uncertainty is expected as a scalar magnitude (1-sigma confidence level)
e. All uncertainty values must be positive, greater than zero

Field Descriptions:

TOW = Time of Week (GPS seconds)

Week = GPS week number

GpsFix = 3 if data packet contains a valid 3D GPS fix. Set to 0 if the data is not valid.

NumSats = Number of visible satellites used in the GPS solution. If unavailable or not applicable set to 0.

PosXYZ = ECEF position in units of meters

VelXYZ = ECEF velocity in units of meters/second

PosAccXYZ = 1-Sigma position uncertainty in NED frame (3 components), units of meters

SpeedAcc = Velocity uncertainty (1-sigma scalar magnitude), units of meters/second

TimeAcc = Uncertainty on timestamp in seconds. (Typically in the nanosecond range for GPS). If unavailable set to 0.

PosLLA = Latitude, Longitude and Altitude in units of degrees, degrees and meters respectively

VelNED = North, East and Down velocity components in units of meters/second

Example package:

$VNGPE,414167.400007,1745,3,13,-0611931.210,-5327005.350,+3442499.850,+004.470,-017.160,-026.000,+001.920,+001.711,+001.671,+000.096,1.00E-09*XXXX<CR><LF>

Note that the 16 Bit CRC was utilized here.

Example Test Setup

The following test setup and configuration was utilized to demonstrate the VN-200 external position/velocity measurement feature and is provided as reference:

1 VN-200T Rugged (Unit A) – Used as GPS source in this test.

1 VN-200T Rugged (Unit B) – Used as the VN-200 running on external GPS measurements.

Hardware Configuration:

GPS antenna: ANTCOM 4G15A connected to ➔ Unit A MMCX input jack

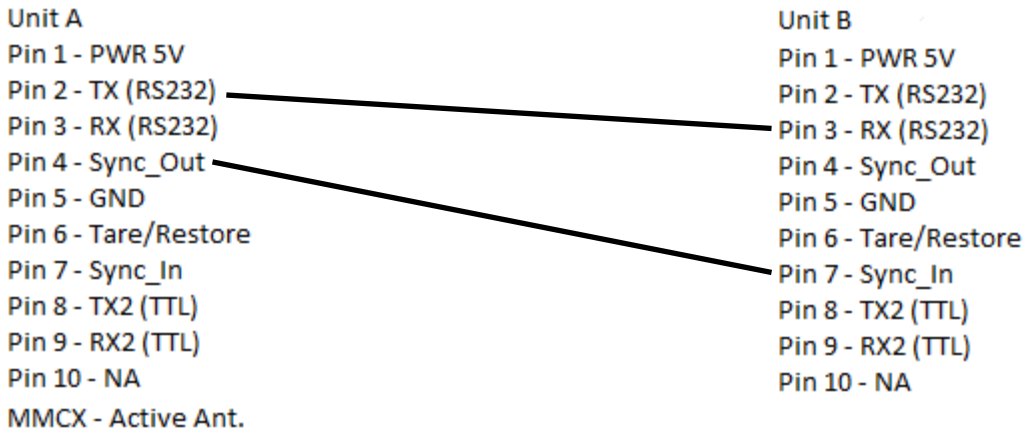
Unit A UART1 TX (Pin 2) ➔ Unit B UART1 RX (Pin 3) (RS-232 logic levels)

Unit A Sync_Out (Pin 4) ➔ Unit B Sync_In (Pin 7)

External 5 V from single board computer ➔ Unit A (Pin 1) and Unit B (Pin 1)

External GND from single board computer ➔ Unit A (Pin 5) and Unit B (Pin 5)

(Note: UART 2 on Unit B was connected to a data logger for this test and 50 Hz INS data was logged for comparison to reference units)



Unit A and unit B pin-out for this example

Software configuration of Unit A & Unit B:

Unit A

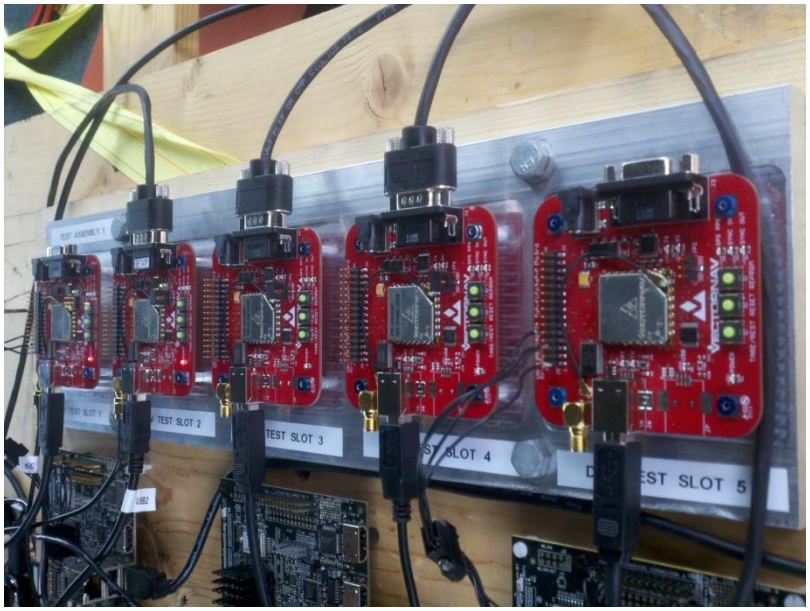
1. Restore Factory Default Settings: $VNRFS*5F<LF> (unit will not respond for approximately 1 second)
2. Disable Default Asynchronous Output on UART1: $VNWRG,06,0,1*XX<LF>
3. Disable Default Asynchronous Output on UART2: $VNWRG,06,0,2*XX<LF>
4. Set GPS PPS to Sync_Out Pin: $VNWRG,32,6,0,0,0,6,1,0,100000000,0*XX<LF>
5. Enable Asynchronous GPS Data at 5 Hz on UART1: $VNWRG,6,21,1*XX<LF>
6. Set 16 Bit CRC: $VNWRG,30,0,0,0,0,2,0,0*XX<LF>
7. Save Settings to Non-Volatile Memory: $VNWNV*XXXX<LF> (Note, unit now uses 16 Bit CRC)

Note that the Unit will Echo all commands it accepts. If it does not accept a command it will respond with and error.

Unit B

1. Restore Factory Default Settings: $VNRFS*5F<LF> (unit will not respond for approximately 1 second)
2. Disable Default Asynchronous Output on UART1: $VNWRG,06,0,1*XX<LF>
3. Disable Default Asynchronous Output on UART2: $VNWRG,06,0,2*XX<LF>
4. Enable External GPS Input: $VNWRG,55,2,2,5,0,0*XX<LF>
5. Enable INS Output on UART2: $VNWRG,6,22,2*XX<LF>
6. Set INS Output to 50 Hz on UART2: $VNWRG,7,50,2*XX<LF>
7. Save Settings to Non-Volatile Memory: $VNWNV*XX<LF>

Test Rig (VN-200 Rugged units not shown)



To demonstrate the feature a drive test was performed. Several VN-200 modules utilizing internal GPS modules were used as reference units to evaluate the performance of the External GPS aiding feature.

Hardware present in the test:

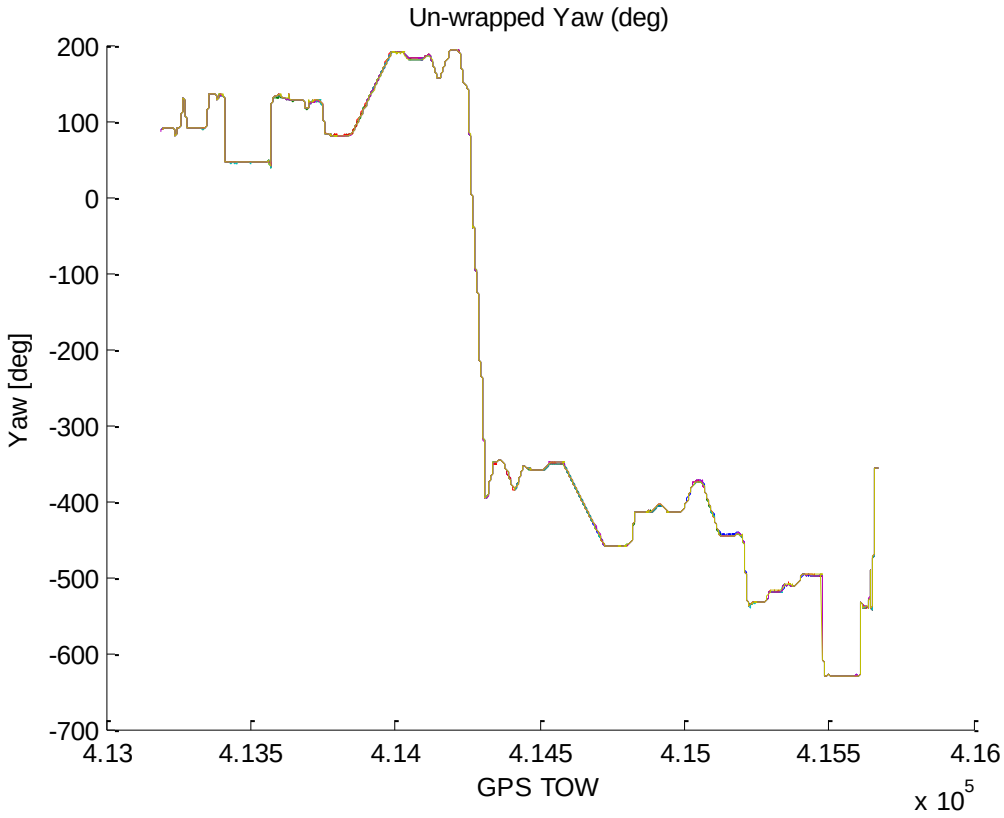
VN-200 Dev boards 1-3: HW v1, Thermal, FW v0.1.11.0

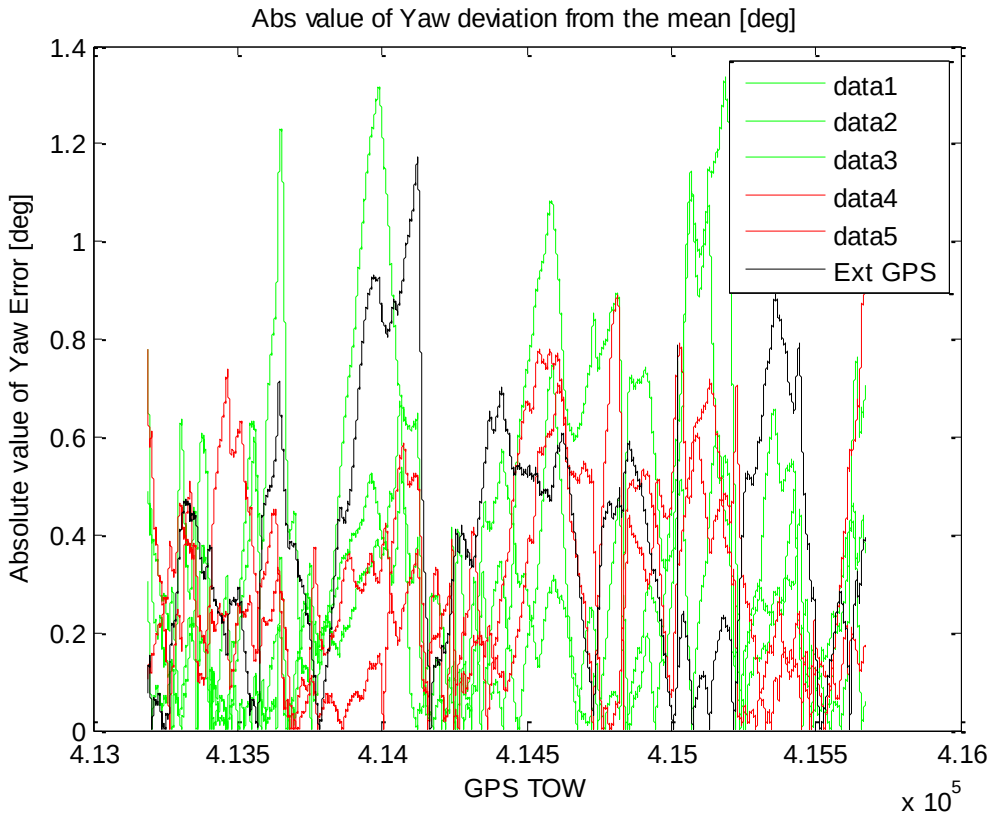
VN-200 Dev boards 4: HW v2, Thermal, FW v0.1.11.3

VN-200 Dev boards 5: HW v2, Standard, FW v0.1.11.3

VN-200 Rugged 6: HW v2, Thermal, FW v0.1.11.3 (Unit with external GPS)

Results YAW:

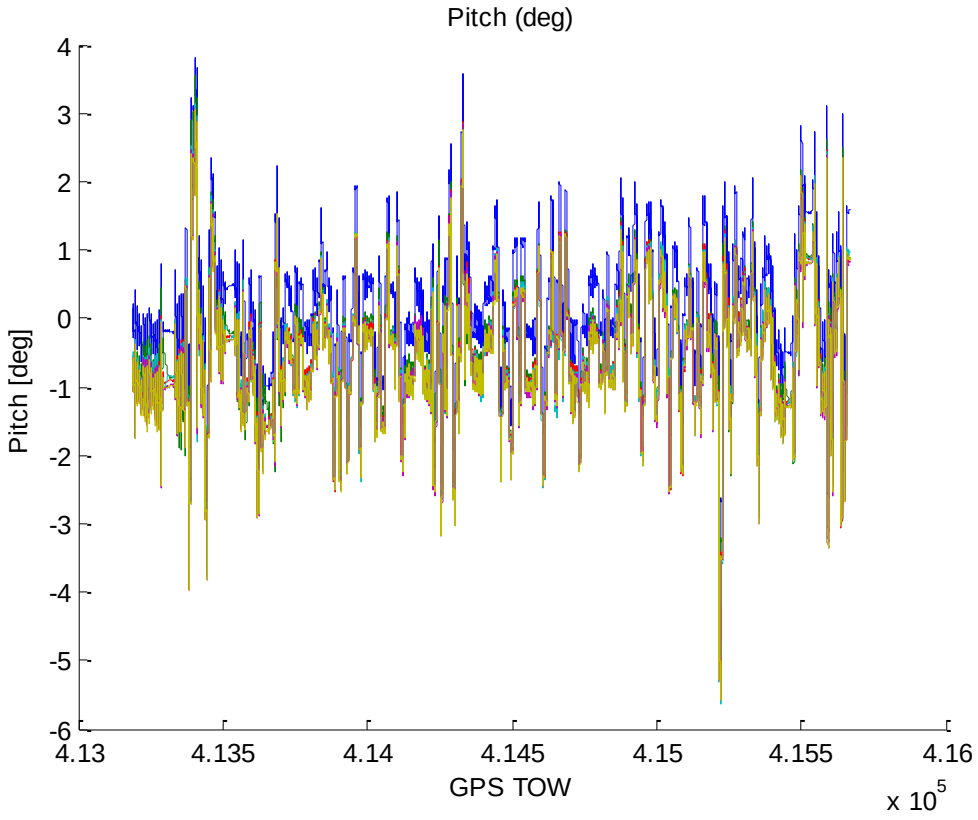

Un-wrapped Yaw (deg)
Yaw [deg]
200
100
0
-100
-200
-300
-400
-500
-600
-700
4.13
4.135
4.14
4.145
4.15
4.155
4.16
GPS TOW
x 10^5

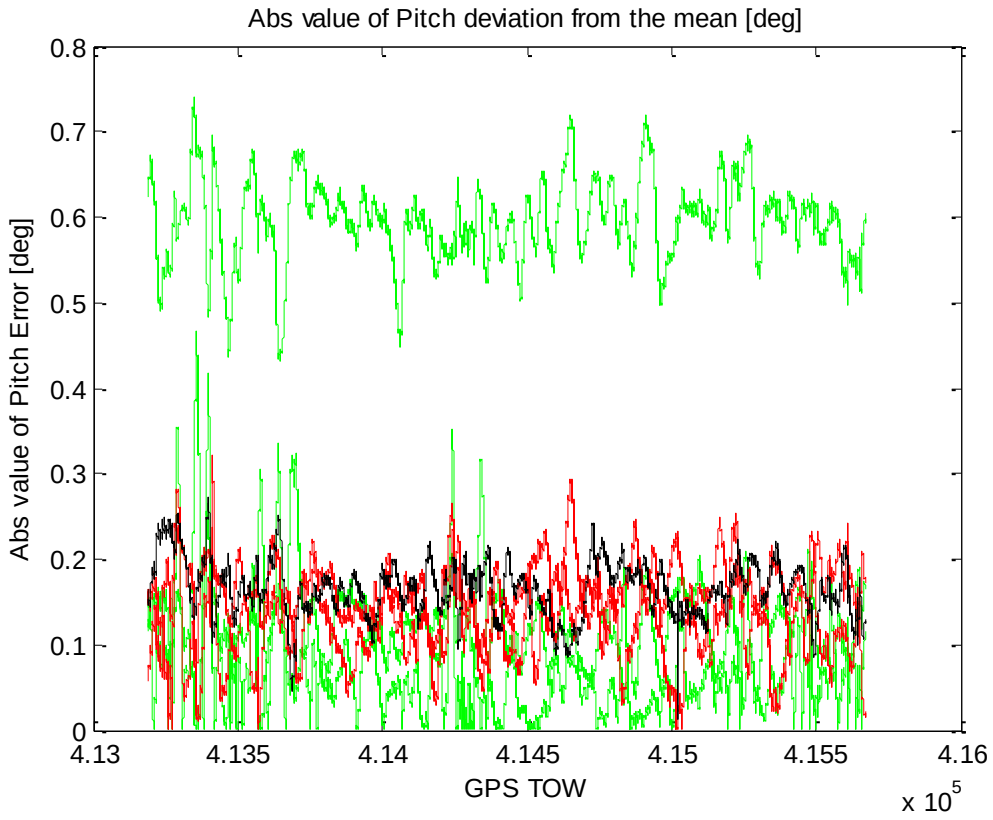


RMS Yaw [deg]:	**0.40**	**0.51**	**0.40**	**0.36**	**0.37**	**0.47**
Sigma Yaw [deg]:	**0.40**	**0.43**	**0.39**	**0.27**	**0.28**	**0.44**

(Note: RMS errors include mounting misalignments, VN-200 Using External GPS in black)

Results PITCH:

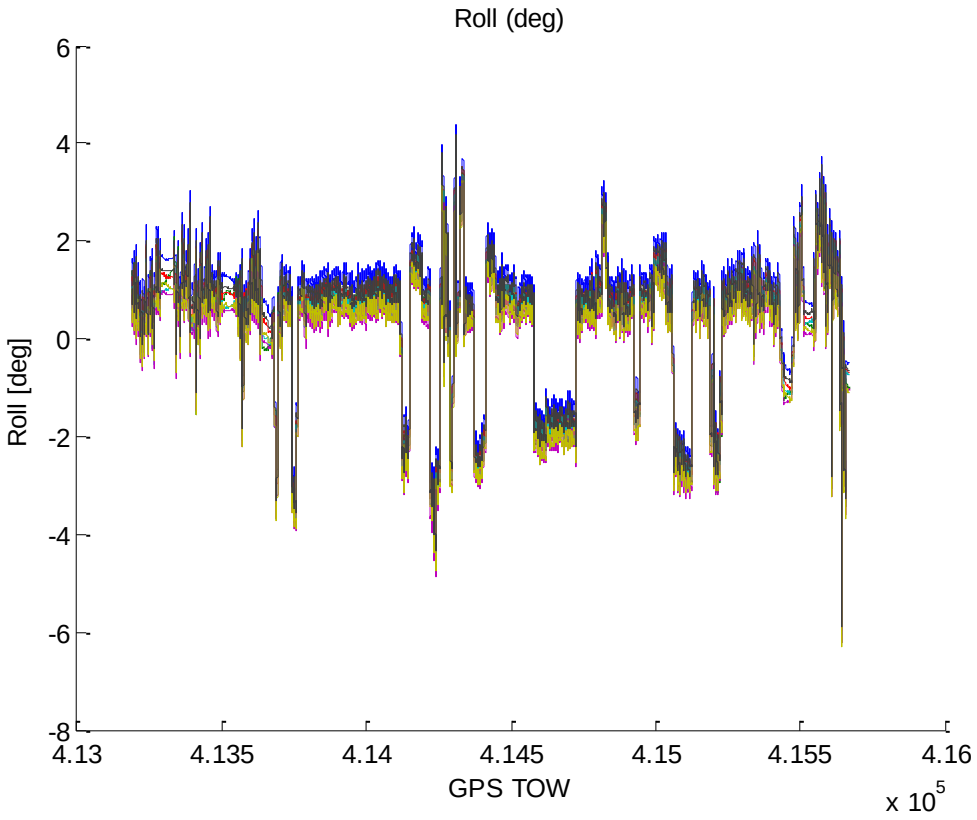


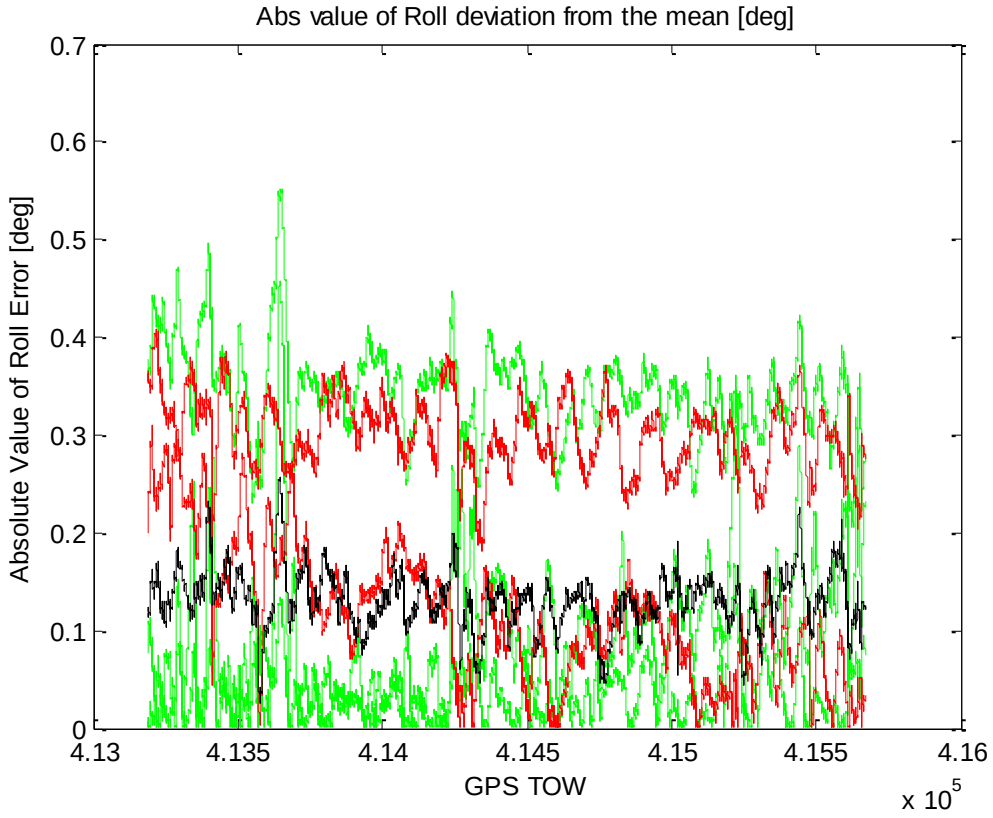


RMS Pitch [deg]:	**0.60**	**0.11**	**0.12**	**0.13**	**0.17**	**0.17**
Sigma Pitch [deg]:	**0.05**	**0.10**	**0.04**	**0.05**	**0.03**	**0.03**

(Note: RMS errors include mounting misalignments, VN-200 Using External GPS in black)

Results ROLL:





RMS Roll [deg]:	**0.35**	**0.12**	**0.04**	**0.13**	**0.30**	**0.13**
Sigma Roll [deg]:	**0.05**	**0.09**	**0.04**	**0.07**	**0.04**	**0.03**

(Note: RMS errors include mounting misalignments, VN-200 Using External GPS in black)

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