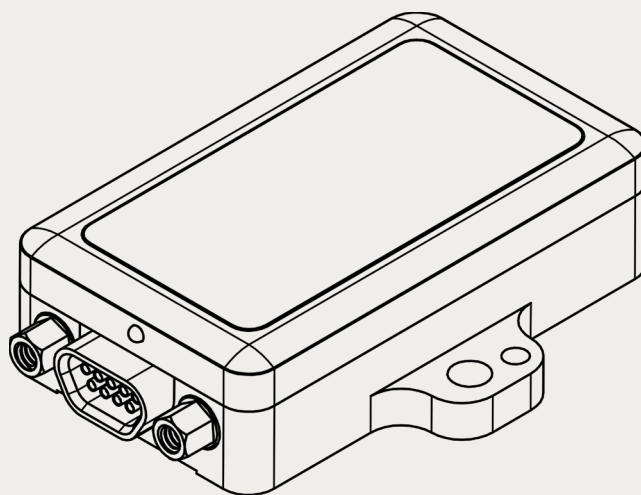


Inertial Sensor Utils Software 2.0

Inertial Sensor Data Processing and Analysis Tools





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What's new in Release 2.0?

- "Device List" Tab: Use for recording binary log files (same as MIP Monitor) and also for sending any ("copy-paste" or custom) command from LORD DCP and getting a response back. Details in Section 6 of this User Manual.
- A new drop-down for Yaw/Heading type columns, with options: Unbounded, 360 deg Bounded, Orig in Deg, and Orig Log (described in Section 5.4.9)
- An improved user-interface
- A more detailed User Manual, with several new figures and examples explaining each feature of the utility.

1. Overview

1.1 Objectives of Inertial Sensor Utils Software

1. Parse binary log files from either LORD Sensing MIP inertial sensors or Novatel devices into csv files and/or upload to the LORD Sensing SensorCloud™ software platform.
2. Load such csv files or other csv files* that have GPS Week/Time-of-Week (TOW) columns, or download sensor data from SensorCloud™, and create:
 - Overlay plot of column(s) of data as a function of TOW/Relative Time/UNIX Timestamp** from a single csv file or sensor, or
 - Overlay plot of a column of data as a function of TOW/Relative Time/UNIX Timestamp** from two or more csv files or sensors
 - A “diff plot” of differences between a specific column in 2 csv files or sensors, or
 - A list of LORD EKF flags from (0x82, 0x10) message that turned on at least once during the run (this applies only when csv files are loaded)
 - Overlay plot of LORD EKF flags from (0x82, 0x10) message on a specific column of data (this is available only when csv files are loaded)
 - Lat-lon plots:
 - either stand-alone from a single csv file/sensor, or
 - overlay plot of lat-lon from 2 or more csv files or sensors, or
 - “diff plot” between lat-lon (in meters) as a function of TOW/Relative Time/UNIX Timestamp**
3. Upload csv files (obtained by parsing earlier, or “other csv files”*) to SensorCloud™
4. Compare 2 sensors even if one of them does not have a GPS Timestamp but contains only time from start of log as “TOW” (such as: 3DM-GX5-25 with no GPS)
5. Perform following actions on SensorCloud™:
 - Add new sensor with channel data, or
 - Add new channel data to an existing sensor, or
 - Append to existing channel data of existing sensor or
 - Delete existing sensor(s) on SensorCloud™
6. Upload up to 5 binary and/or csv files as a batch to SensorCloud™
7. Export plots to Word or PowerPoint
8. Display a list of MIP inertial sensors connected to a PC and record binary log files
9. Send “copy-paste” or custom commands using the LORD Data Communications Protocol (DCP) to inertial sensors and get a response back.

1.2 Notes

The utility automatically converts LORD Sensing device values to appropriate units when plotting. For example, all radian values are converted to degrees. For this, it uses the LORD Sensing MIP™ Data Communications Protocol to determine which columns are in radians. Similarly, values in ‘g’ are converted to m/s².

* Rules for "other csv files":

Must have a column with text "tow" or "time" (case-insensitive) which will be considered as "GPS Time of Week (TOW)". This requirement is automatically met if the csv file is obtained by parsing the binary log file from this utility. This column can contain GPS TOW or just time from start of recording. If uploading to SensorCloud™ or doing overlay/diff plot with Relative Time unchecked, must also have a column with text "week" (case-insensitive), which will be considered as "GPS Week".

1. Each row in the csv must have a value in these 2 columns. Other columns can have empty cells.
2. The csv files can have any number of comment lines in the beginning, but must have a line that has the text "DATA_START" (all by itself on that row) immediately preceding the line that has the column headers.
3. The column headers must all appear in a single row in the csv and cannot spread over 2 or more lines.
4. The values of columns in these "other csv files" will not be converted automatically because they can contain any text in the column headers. The user is responsible for supplying data in the converted units that the LORD Sensing device data would be (such as degrees for Pitch/Roll/Yaw).
5. If the device does not have GPS, the GPS Week column could be 0 and GPS TOW could contain time from start of logging. The user cannot upload such csv files to SensorCloud™, but can still load those csv files and create overlay and diff plots. The plotting feature of the utility can be used for any time-based csv file, not necessarily an inertial sensor.

** UNIX Timestamp

This option is available only when downloading sensor data from SensorCloud™ and not when loading plain csv files.

This User Manual assumes familiarity with LORD Sensing inertial sensors, the DCP (Data Communication Protocols) that go with them and use of MIP™ Monitor software to collect binary log files.

No Warranty

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2. Installation

1. Save the InertialSensorUtils_GUI_exe.zip into a folder of your choice.
2. Extract all files from the zip file.
3. Double-click the QInertialSensorUtils_GUI.exe to launch the program.
4. Proceed to the User Manual for step-by-step instructions.

2.1 Settings File

MIP™ Monitor software allows the user to export the inertial sensor's settings into a Settings File with a .ini extension. This file captures the configuration of a LORD Sensing inertial sensor that was used when collecting a specific log file. It is therefore required by LORD Sensing support to perform analysis of data set(s) sent by the customer.

2.2 Help/User Manual

The User Manual can either be accessed using the User Manual link inside the device spec on the web-site, or via the '?' Icon in the Main tab of this utility.

2.3 Use of data-loggers instead of MIP™ Monitor

The Inertial Sensor Utils Software can parse binary log files recorded from LORD Sensing inertial sensors using either MIP™ Monitor software or a third-party data-logger. The binary file format is simply the serial stream from the device written directly into a .bin file.

2.4 CSV logging in MIP™ Monitor vs Parsing Binary log in Inertial Sensor Utils

Currently one can record output of LORD Sensing inertial sensors in either binary or csv format using MIP™ Monitor. The csv files obtained from MIP™ Monitor have some issues that still need to be resolved. At this time, it is recommended that the user get the binary log file from MIP™ Monitor and parse into csv using Inertial Sensor Utils.

2.5 System Requirements

The software requires a 64-bit Windows machine (may or may not have Python or PyQt already installed).

Note that no new modules are "installed" nor are any existing software modules touched or modified when the user unzips the distribution zip file. Python 2.7.6 is included as part of that zip, but isn't really "installed" on the user's PC in a technical sense. Same thing with PyQt4. Whatever files are required by the software are included in sub-folders that go with the zip. Because of that, the target PC may or may not have Python or PyQt4 installed on it, or may have a later or older version of Python/PyQt4 installed, and the software would still use the required files from sub-folders included in the zip.

2.6 Supported Devices

This software supports all LORD Inertial devices that use the MIP Protocol with the exception of GX3, DH3, and GX910. The utility also supports Novatel SPAN and FlexPak6 devices. Note that the LORD MV5 is not supported since it does not use the MIP protocol. The CSV file loading and plotting feature supports any csv file that meets the rules for "other csv files" described in Sec. 1.2.

3. Logging In (with SensorCloud option unchecked - default)

When the user double-clicks on QInertialSensorUtils_GUI.exe, it opens a window:

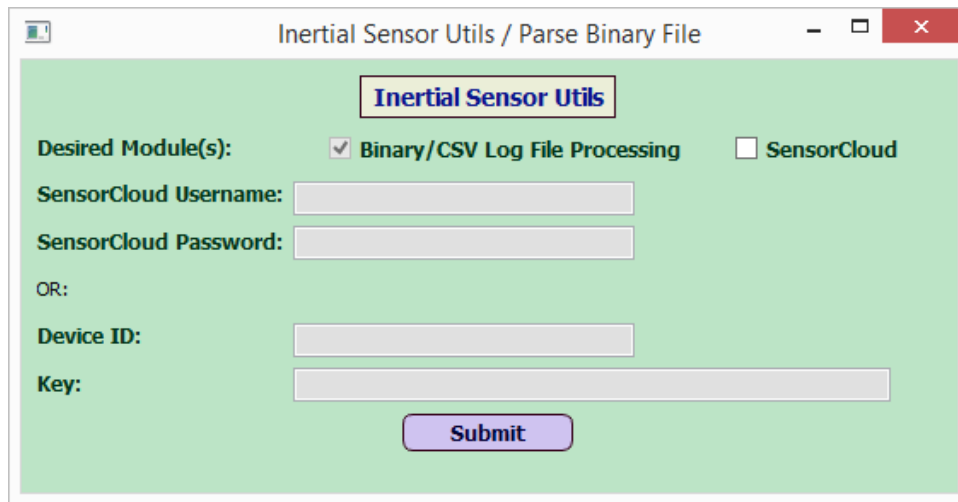


Figure 1 - Log In Window Without SensorCloud™

By default, the 'SensorCloud' box is unchecked. The Binary/CSV Log File Processing check-box is always checked. If the 'SensorCloud' box is unchecked and the user clicks the Submit button, it would open a window that looks like this:

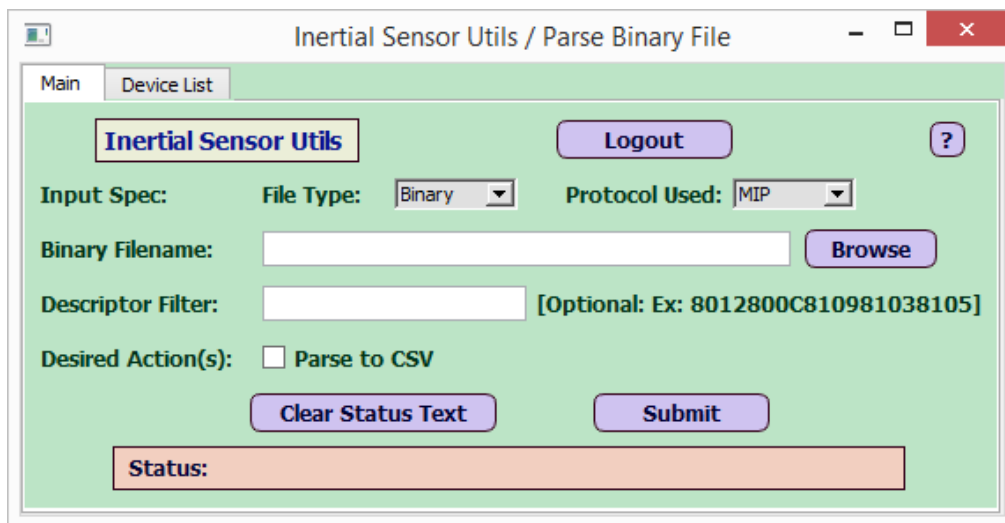


Figure 2 - View After Selecting Submit

Note that this shows exactly two tabs: one labeled 'Main' and the other 'Device List'.

- The 'File Type' drop-down shows two options: Binary and CSV. With 'File Type' of Binary, the Desired Action(s) field shows a single option that says 'Parse to CSV'.
- The 'Protocol Used' drop-down has two options: MIP™ (default for all LORD Sensing devices), or Novatel.
- The Descriptor Filter field is optional; the user can enter a string of field descriptors (example: '810981038105' to select a subset of fields to parse from the binary file.

4. Parsing Binary Log Files

If File Type is Binary, the user can select 'Parse to CSV'. The Protocol Used can be MIP™ (for LORD Sensing devices) or Novatel. This would parse the binary log file based on the appropriate DCP (MIP™ or Novatel) and place the parsed csv files in the same folder as the binary file.

4.1 Parsing MIP Binary Files

For MIP™ binary files, it creates three csv files from one binary:

- IMU
- GPS
- EKF

The 3 csv files here represent the 3 tabs (or categories) in MIP Monitor shown below:

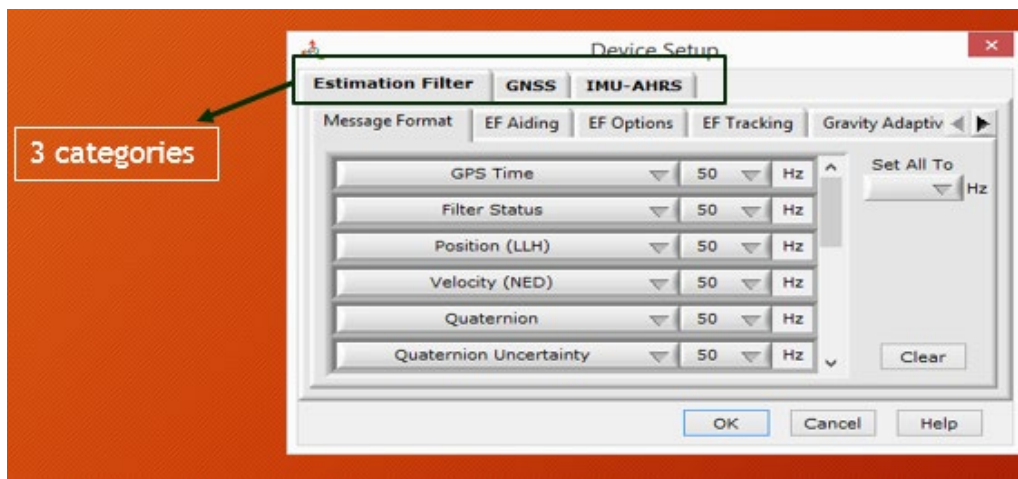


Figure 3 - Three Categories of Messages in MIP Monitor

Notes:

- The csv files would have the same name as the binary file name, with the file extension replaced with .csv, and extra text: “_IMU_Log”, “_GPS_Log” and “_EKF_Log” at the end of the filename for the three categories IMU-AHRS, GNSS, and EF respectively.
- When parsing MIP™ binary files, the “GPS Timestamp” message is required in any category (EF, GNSS and IMU-AHRS) that has messages selected by the user, in order for the binary log file to be parsed. If a category has messages selected but no “GPS Timestamp”, the error displays: “GPS Timestamp required in each message format”.
- If parsing encounters any other error, the Status bar displays the error: “ERROR. Please check Log file processing log file”. “Log file processing log file” refers to a file named “InertialSensorUtils_LogFileProcessing.log” which resides in the root directory that contains “QInertialSensorUtils_GUI.exe”. When this error is displayed, open the log file in any text editor and look at the bottom, which should display details of the exact (Python) error that was encountered. The user can send that log file to LORD sensing support if further clarification or tracing of the error is required.
- If the EF packet payload exceeds 255 char, the device automatically creates “split packets”, with only one of them containing the timestamp. The other split packet would not contain the timestamp but this specific situation is ok with the parser, which looks for contiguous EF split packets (if any) and connects them together as a single output row in the csv file. Split packets are described in more detail in section 4.5.

- The output frequency of the GPS Timestamp message must be the highest in that category. In other words, the other messages in each category can have same or less output frequency as the GPS Timestamp message but not more.
- Messages within each category can have different output rates (Hz). In that case, the parsed csv file would have empty cells for columns that don't have a value for a given timestamp.
- If a LORD Sensing device does not have GPS (such as: 3DM®-GX5-15, 3DM®-GX5-25), the GPS Week will be zero inside the GPS Timestamp message; that is acceptable and will be parsed as such. However even for such devices, the user must still select the GPS Timestamp message in each category of the MIP™ Monitor Message Format.

4.2 Parsing Novatel Binary Files

For Novatel, it creates five csv files from one binary:

- INS
- RAWIMU
- EKF
- GPS
- Veh2BodyRotation

The messages included (currently supported by this tool) in each of these five categories are listed below. Novatel can include either a 'Short Header' or a 'Long Header' for each message, with different message id for the Short Header vs the Long Header version.

Category	Message	Long/Short Header Message ID
INS	INSATT	263/319
	INSPOS	265/321
	INSSPD	266/323
	INSVEL	267/324
	INSPVA	507/508
RAWIMU	RAWIMU	268/325
EKF	BESTPOS	42
	BESTVEL	99
	BESTXYZ	241
GPS	TIME	101
Veh2BodyRotation	VEHICLEBODYROTATION	642

4.3 Descriptor Filter String

One can specify a "descriptor filter string" (such as: "810981038105") when parsing MIP™ binary files. By doing so, only the fields specified in that string would be retrieved into the csv. This is useful when the user wants to focus on a subset of columns instead of getting every column from the binary file. The field is optional; if left empty, all columns from the binary are retrieved.

4.4 Different Output Rates for Individual Messages

The parsing feature can also handle the situation where individual messages are logged at different Hz within each category (for either MIP™ or Novatel). For messages that are output slower, the csv would contain empty cells when no message is available for a given timestamp, as shown below:

Example of different Hz used in EF Message Format:

EKF Week	EKF TOW	Lat [x8201]	Lon [x8201]	Ht Abv Ellips [x8201]	Flags [x8201]	Vel N [x8202]	Vel E [x8202]	Vel D [x8202]	Flags [x8202]	X Acc Bias [x8207]	Y Acc Bias [x8207]	Z Acc Bias [x8207]	Flags [x8207]
1916	226118.036	44.43753355	-73.10613565	132.185101	1	0.0255772	0.01386291	0.18307298	1				
1916	226118.056	44.43753356	-73.10613565	132.1814347	1								1
1916	226118.076	44.43753356	-73.10613565	132.1777608	1	0.02559953	0.01367807	0.18391918	1				
1916	226118.096	44.43753351	-73.10613573	132.2005483	1								
1916	226118.116	44.43753351	-73.10613573	132.1969653	1	0.02490844	0.01154777	0.17918588	1				
1916	226118.136	44.43753352	-73.10613573	132.193379	1					-0.00004594	0.00002832	0.00003869	1
1916	226118.156	44.43753352	-73.10613572	132.1897871	1	0.0247643	0.01160305	0.17980917	1				
1916	226118.176	44.43753352	-73.10613572	132.1861878	1								
1916	226118.196	44.43753353	-73.10613572	132.1825832	1	0.02477476	0.01166952	0.18031368	1				
1916	226118.216	44.43753353	-73.10613571	132.1789745	1								
1916	226118.236	44.43753354	-73.10613571	132.1753592	1	0.02489745	0.01145912	0.18092525	1	-0.00004594	0.0000281	0.00004327	1
1916	226118.256	44.43753354	-73.10613571	132.1717355	1								
1916	226118.276	44.43753355	-73.10613571	132.1681046	1	0.02481489	0.01166561	0.18172224	1				
1916	226118.296	44.43753355	-73.1061357	132.1644676	1								
1916	226118.316	44.43753356	-73.1061357	132.1608271	1	0.02504625	0.01188218	0.18207203	1				
1916	226118.336	44.43753353	-73.10613567	132.1836195	1					-0.00004638	0.00002819	0.0000478	1
1916	226118.356	44.43753354	-73.10613567	132.1800697	1	0.02530281	0.01266507	0.1775348	1				
1916	226118.376	44.43753354	-73.10613567	132.1765171	1								
1916	226118.396	44.43753354	-73.10613566	132.1729592	1	0.02551677	0.01272592	0.17805503	1				
1916	226118.416	44.43753355	-73.10613566	132.1693956	1								
1916	226118.436	44.43753355	-73.10613566	132.1658278	1	0.02562726	0.01268288	0.17846127	1	-0.00004638	0.00002819	0.0000478	1

50 Hz: 0x8201 25 Hz: 0x8202 10 Hz: 0x8207

Figure 4 - Empty Cells in csv File for Slower Messages

4.5 Split Packets

Each MIP™ packet has a payload that consists of one or more field descriptor(s) along with field data. When the payload size exceeds 255 bytes, the device splits the packet into 2 or more separate “split” packets. Each split packet can handle up to 255 bytes of payload size. Note that at the current time, only the EKF category can exceed 255 bytes in size, so split packets can occur only within the EKF category. The maximum payload size for each of the 3 categories (EF, GNSS and IMU-AHRS) is shown in the figures below:

(A) IMU-AHRS Category:

Message	Message Description	Length	Message	Message Description	Length
0x8004	Scaled Accel Vector	14	0x800A	CF Quaternion	18
0x8005	Scaled Gyro Vector	14	0x800C	CF Euler Angles	14
0x8006	Scaled Mag Vector	14	0x8010	CF Stabilized North Vector	14
0x8017	Ambient Pressure	6	0x8011	CF Stabilized Up Vector	14
0x8007	Delta Theta	14	0x8012	GPS Corr. Timestamp	14
0x8008	Delta Velocity	14		TOTAL	188
0x8009	CF Orientation Matrix	38			

→ Less than 255

Figure 5 - Max Total Payload Size of IMU-AHRS Packet

(B) GNSS Category:

Message	Message Description	Length	Message	Message Description	Length
0x8103	LLH Position	44	0x810A	Clock Info	28
0x8104	ECEF Position	32	0x810B	GNSS Fix Info	8
0x8105	NED Velocity	36	0x810C	SV Info	14 x n
0x8106	ECEF Velocity	20	0x810D	H/W Status	7
0x8107	DOP Data	32	0x810E	DGNSS Info	14
0x8108	UTC Time	15	0x810F [TBD]	DGNSS Channel Status	17 x n [TBD]
0x8109	GPS Time	14		TOTAL	250 + 14n + 17n

where: n = Number of visible SV's

Annotations:

- 0x810C and 0x810F [TBD] are highlighted in blue.
- Arrows point from 0x810C and 0x810F [TBD] to a box: "Come off in separate MIP packet(s) with no timestamp".
- An arrow points from the TOTAL row to a box: "Less than 255 if n <= 18".
- Another arrow points from the TOTAL row to a box: "Less than 255".

Figure 6 - Max Total Payload Size of GNSS Packet

(C) EF (EKF) Category:			Message	Message Description	Length	Message	Message Description	Len
0x8210	Filter Status	8	0x8204	Orientation Matrix	40	0x8217	Accel Scale Factor	16
0x8211	GPS Time	14	0x820E	Compensated Ang Rate	16	0x8219	Accel Scale Factor UC	16
0x8201	LLH Position	28	0x8206	Gyro Bias	16	0x8221	Pressure Altitude	8
0x8208	LLH Position UC	16	0x820B	Gyro Bias UC	16	0x8220	Std Atm Model	24
0x8202	NED Velocity	16	0x8216	Gyro Scale Factor	16	0x8213	Gravity Vector	16
0x8209	NED Velocity UC	16	0x8218	Gyro Scale Factor UC	16	0x820F	WGS84 Local Gravity Mag	8
0x8203	Quaternion	20	0x821C	Compensated Accel	16	0x8214	Heading Update Source	14
0x8212	Quaternion UC	20	0x820D	Linear Acceleration	16	0x8215	Magnetic Model Solution	24
0x8205	Euler Angles	16	0x8207	Accel Bias	16	0x8225	Mag Auto Hard Iron Offset	16
0x820A	Euler Angles UC	16	0x820C	Accel Bias UC	16		(Cont'd)	

(C) EF (EKF) Category (Cont'd):

Message	Message Description	Length
0x8228	Mag Auto Hard Iron Offset UC	16
0x8226	Mag Auto Soft Iron Matrix	40
0x8229	Mag Auto Soft Iron Matrix UC	40
0x8230	GNSS Antenna Offset Correction	24
0x8231	GNSS Antenna Offset Correction UC	16
	TOTAL	624

Annotation:

- An arrow points from the TOTAL row to a box: "More than 255; Up to 3 split EKF packets".

Figure 7 - Max Total Payload Size of EF (EKF) Packet

When the user combines this feature with the 'different output rates' feature in EKF category (section 4.4), one could alternate between split and non-split packets, or alternate between 2 split packets and 3 split packets, during the run. This would happen if the user selects different data rates within the EF category such that the number of slower output messages is much more than the number of faster output messages. In that scenario, the packets are not initially split but are split further down when the slower messages start appearing. The binary file parser in this utility able to concatenate the split packets together even if they alternate like this, to show up as a single row in the csv.

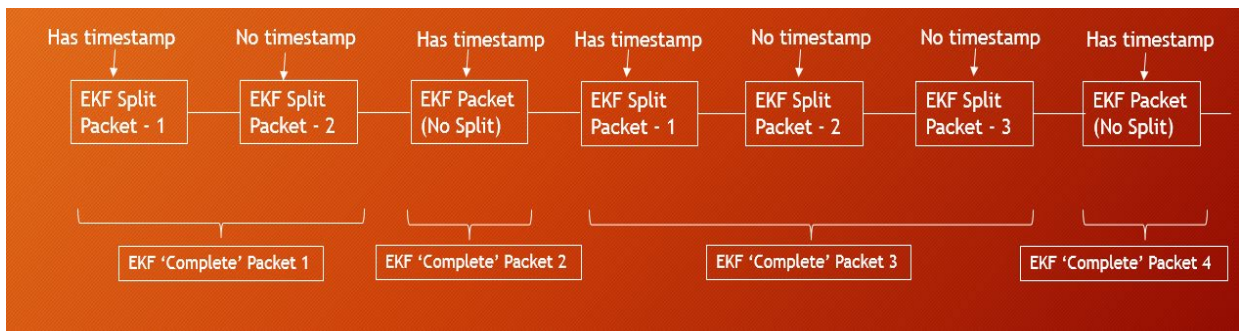


Figure 8 - Split EKF Packets With Mix of Fast/Slow Messages

4.6 The 'SV Info' [x810C] MIP Message

The MIP™ GPS 'SV Info' [x810C] message is somewhat special and behaves a little differently than other MIP™ messages. x810C comes as a separate MIP packet with no timestamp, and can be either one or two x810C packets, depending on the number of visible SV's™. If that number is 18 or less, we have a single x810C packet, otherwise we have two contiguous x810C packets that can either follow the 'main' GNSS packet or precede it (depending on the order of selecting messages in MIP™ Monitor).

Since the visible SV's can change during the run, it is possible to have one x810C for certain time periods, followed by two x810C packets at other times, or even alternating between one and two x810C packets. If the GNSS signal is lost, the x810C packets stop coming, and later reappear when the GNSS signal is restored. The parsing feature can handle all of these cases, and would combine data from the main GNSS packet and the one or two x810C packets, into a single row in the csv. The following figures show how the x810C packet(s) can precede or succeed the main GNSS packet and how they can alternate between 0, 1 or 2 x810C packets depending on number of visible SV's.

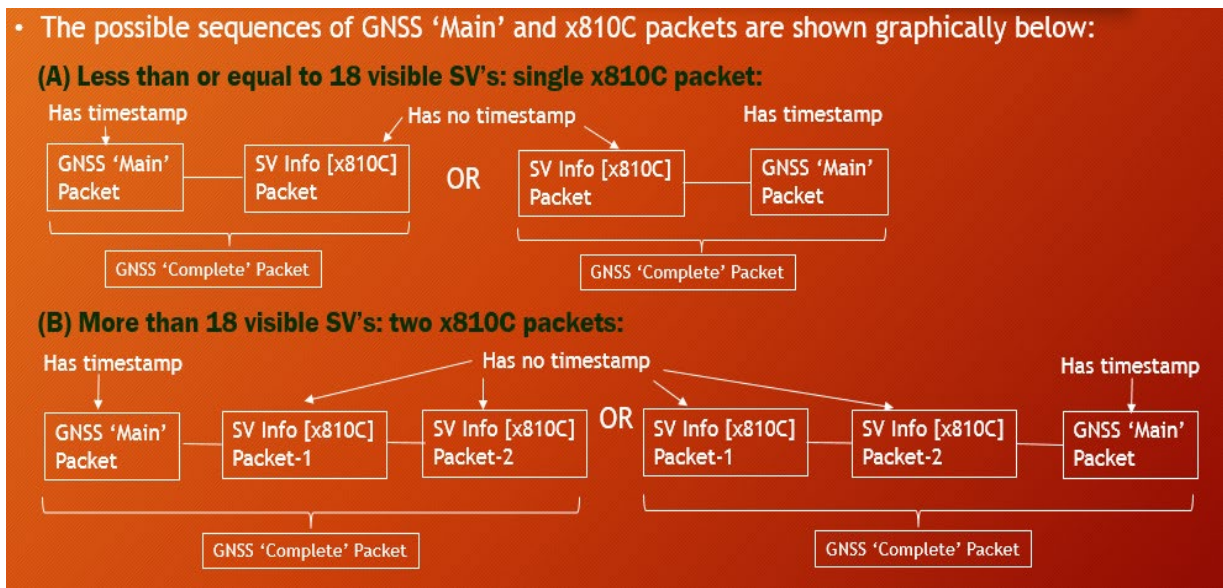


Figure 9 - How SV Info [x810C] Packet Relates to GNSS Packet

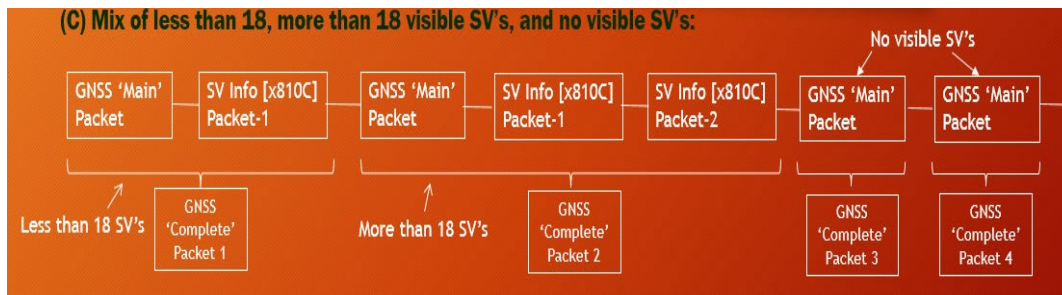


Figure 10 - SV Info Packets When Number of Visible SV's Changes

If binary file size is 30 MB or less, the csv file contains SV Info column headers for the 'Master List' of SV's visible during the entire run, with values filled in for SV's, visible at any point in time.

Each SV would have 7 columns in x810C: Channel #, SV ID, C/N Ratio, Az, El, SV Flags and Valid Flags.

Example: (Binary file size \leq 30 MB, Master List of visible SV's: [2, 5, 7, 10]):

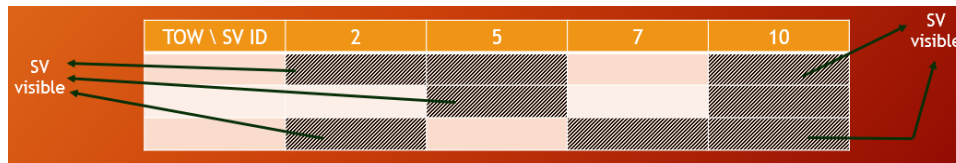


Figure 11 - SV Info Packets in csv File When Binary Log File \leq 30 MB

(Binary file size $>$ 30 MB, Master List of visible SV's: [2, 5, 7, 10]):

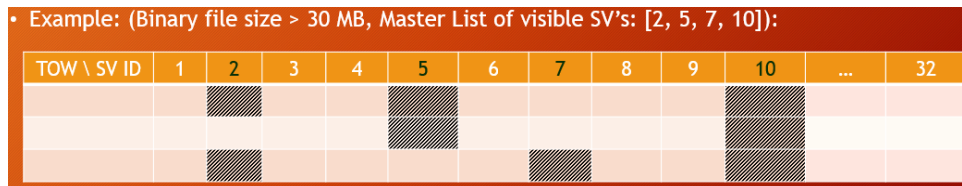


Figure 12 - SV Info Packets in csv File When Binary Log File $>$ 30 MB

The following figure shows a sample plot of the 'Azimuth' field in the SV Info message:

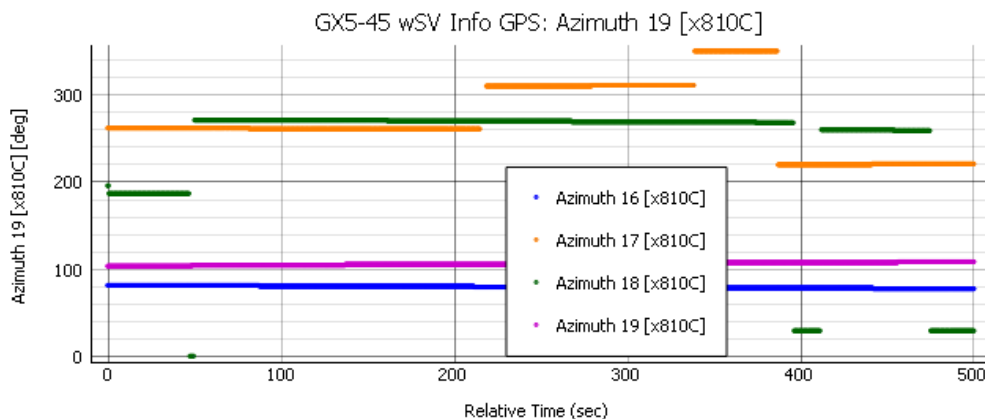


Figure 13 – Plot of Azimuth of 4 visible SV's in SV Info [x810C] message

4.7 EKF Filter Status [x8210] MIP Message

If the binary file being parsed contains the EKF Filter Status [x8210] message, the tool determines 15 different flags from the 16-bit 'Status Flags' field on that message using the DCP. The mapping between individual bits of this field and the flags is shown in the figure below:

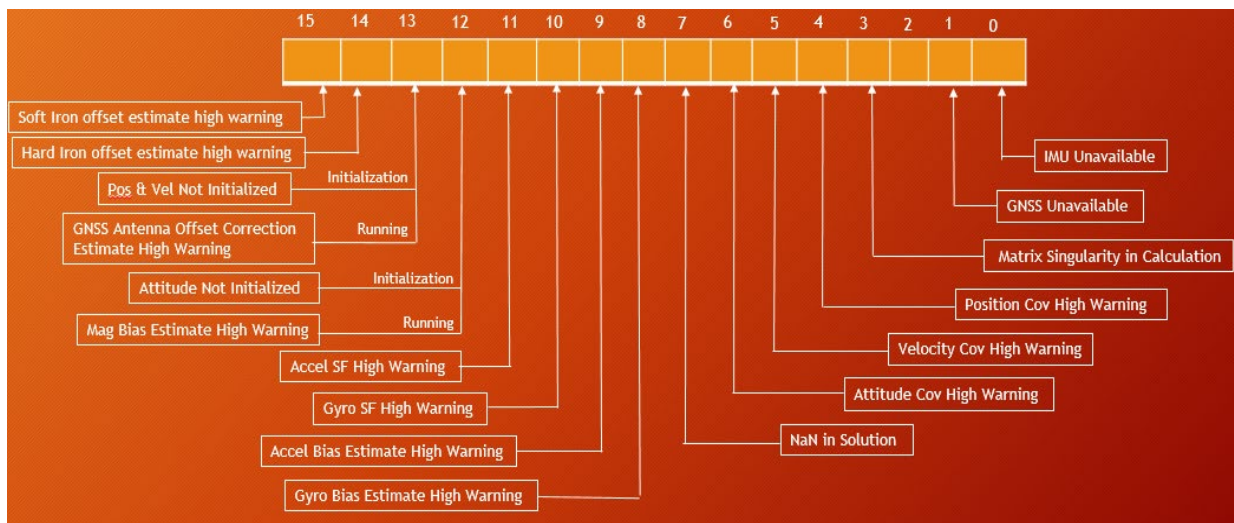


Figure 14 - Flags Obtained From 'Status Flags' field of Filter Status [x8210] Message

Bits 12 and 13 can have a different meaning based on whether the filter is in Initialization or Run state. In the parsed csv file generated by parsing the binary log, the 15 flags become 17 separate columns, considering two possible meanings for bits 12 and 13. These 15 flags and the corresponding headers in the csv file are listed below.

Bit Position	Hex Value	DCP Flag Description	Parsed CSV Column Header/'CSV Data' tab Flag Display
0	0x0001	IMU unavailable	Flag_IMU_Unavailable [x8210]
1	0x0002	GNSS unavailable	Flag_GPS_Unavailable [x8210]
3	0x0008	Matrix singularity in calculation	Flag_Matrix_Singularity [x8210]
4	0x0010	Position covariance high warning	Flag_Pos_Cov_High [x8210]
5	0x0020	Velocity covariance high warning	Flag_Vel_Cov_High [x8210]
6	0x0040	Attitude covariance high warning	Flag_Att_Cov_High [x8210]
7	0x0080	NAN in solution	Flag_NaN_in_Soln [x8210]
8	0x0100	Gyro bias estimate high warning	Flag_Gyro_Bias_Est_High [x8210]
9	0x0200	Accel bias estimate high warning	Flag_Accel_Bias_Est_High [x8210]
10	0x0400	Gyro scale factor estimate high warning	Flag_Gyro_SF_Est_High [x8210]
11	0x0800	Accel scale factor estimate high warning	Flag_Accel_SF_Est_High [x8210]
12	0x1000 [Filter State: Initialization]	Attitude not initialized	Flag_Att_Uninitialized [x8210]
13	0x2000 [Filter State: Initialization]	Position & Velocity not initialized	Flag_Pos_Vel_Uninitialized [x8210]
12	0x1000 [Filter State: Running]	Mag bias estimate high warning	Flag_Mag_Bias_Est_High [x8210]
13	0x2000 [Filter State: Running]	GNSS antenna offset correction estimate high warning	Flag_GPS_Ant_Off_Corr_Est_High [x8210]
14	0x4000	Hard Iron offset estimate high warning	Flag_Mag_Hard_Iron_Est_High [x8210]
15	0x8000	Soft iron correction estimate high warning	Flag_Mag_Soft_Iron_Est_High [x8210]

5. Loading and Plotting CSV Files

5.1 CSV Object Name

When the 'File Type' drop-down changes to 'csv', the descriptor filter string label automatically changes to 'CSV Object Name'. This name is used to identify an "object" that shows up in the 'CSV Data' tab when a csv file is loaded. One "CSV Object Name" represents one .csv file that is loaded. The field is optional; if it is left blank, the csv file name is used to identify the content when plotting.

With 'File Type' of 'csv', the Desired Action(s) field shows the following check-boxes as options:

- a. Load CSV
- b. Create KML/GPX
- c. IMR

The interface is as shown in the figure below:

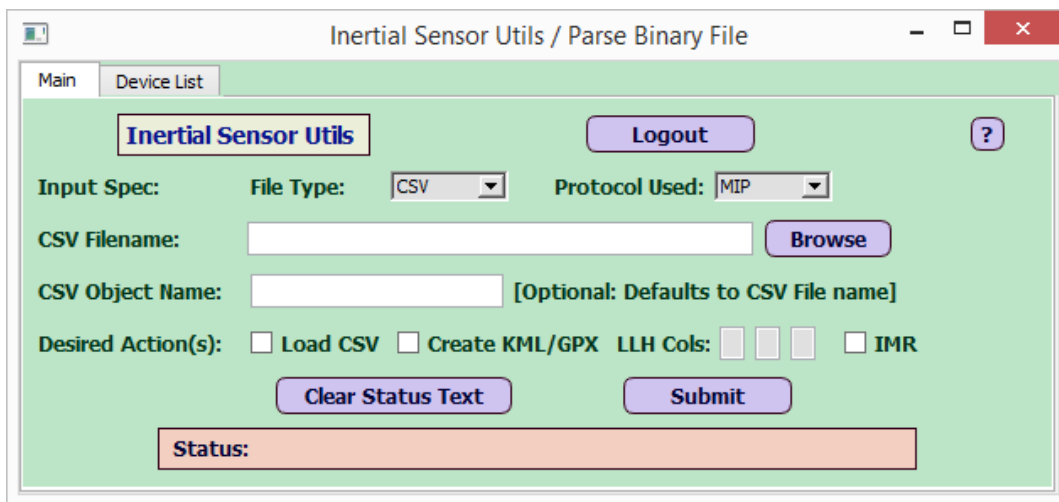


Figure 15 - CSV File Options

5.2 "KML/GPX" File Generating Feature

If File Type is csv, select 'Create KML/GPX' to enable 3 more fields for specifying the LLH columns in the csv file (default to 4,5,6 respectively). The user can change the numbers in those 3 fields, to specify the exact column numbers for Lat, Lon and Height that apply for the csv file being loaded. Checking this box would create a ".kml" and a ".gpx" file in the same folder as the input csv file, with a file name same as the csv file name (with the .csv extension replaced with .kml and .gpx for the 2 new files generated per csv).

5.3 'IMR' Check-box

The 'IMR' check-box creates a .imr file from a MIP™ IMU csv file that has deltaTheta, deltaV columns, for use in Novatel's Inertial Explorer post-processing software. Note that the deltaTheta/ deltaV values in the .imr are in LORD IMU frame in units of arcsec and micrometer/s respectively. Use this file in Inertial Explorer's File -> Convert -> Raw IMU Data to Waypoint Generic (IMR) menu option, and create a new IMU Profile to specify the Gyro/Accel Scale Factors [360000 arcsec/deg and 1000000 micrometer/m respectively] and exact orientation of LORD IMU frame axes [X-Forward, Y-Right, Z-Down]. Then use the converted Waypoint IMR file as IMU input to the Inertial Explorer project. The user would also require a new LORD INS profile with LORD IMU error model created using its Settings -> Manage Profiles menu option. Specify the Novatel Vehicle (Body) Frame to LORD IMU Rotation in the Process TC Menu option to get a blended solution.

5.4 Plotting

The user can plot from either the 'CSV Data' tab or the 'Sensors on Cloud' tab.

5.4.1 'CSV Data' Tab

When the user loads a csv file, a new tab labeled 'CSV Data' is created that displays the CSV object name with an arrow icon and a check box on its left. If the user clicks on the arrow icon, it expands the csv object to show individual columns for that object, with check-boxes on the left of each column. When the user loads a second csv file, it adds another CSV object in the 'CSV Data' tab. The user can repeat this process to keep adding several CSV objects in that tab.

Once the desired CSV objects are created, the user can generate various types of plots as follows:

A. '1 plot (tab) per column' button

This plots one column of a given CSV object vs TOW. User must select a TOW column; otherwise shows an error. Lat-lon plots are an exception to the rule: here, the user selects only Lat and Lon columns (no need for TOW or Week), then clicks the '1 plot (tab) per column' button to get a plot of lat vs lon. If multiple dependent columns are selected and the user clicks on this button, it creates 1 tab per plot (column), in other words, as many new tabs as the columns selected.

B. 'Multi-CSV Files on 1 plot' button

The user can overlay the same column from up to 5 different CSV objects using this button.

C. 'Diff plot' button

The diff plot would display a specific column's difference between 2 sensors or CSV objects. The user must select exactly 2 sensors/CSV objects in this case, otherwise it displays an error.

Also the user cannot select more than 1 column in this case. For a diff plot, the user must select the TOW and Week columns along with the column being plotted (except when the user checks the Relative Time check-box and also selects the "Self" radio-button, described in Sec). This applies to lat-lon diff plots as well; the user must select TOW and Week, along with lat-lon, for each CSV object.

Note that the sensors / CSV object names are sorted alphabetically (case-sensitive), so the selected sensor or CSV object that appears at the top of the list would be considered the "first" sensor (or CSV object) ["Sensor 1"]; the one below it would be the "second" sensor (or CSV object) ["Sensor 2"], and so on.

The "diff" in a diff plot is defined as:

$$\text{diff} = (\text{Sensor 2 Column} - \text{Sensor 1 Column})$$

where: Sensor 2 values are interpolated at Sensor 1 TOW and the "diff" is plotted as a function of Sensor 1 TOW.

The following screen shows two sensors being diff'ed. An extra character "A" was added in front of the "Novatel INS" sensor, to name it as "A Novatel INS", to force it to become Sensor 1, since it is alphabetically ahead of the other sensor named "GX5-45 59120 EKF" which now becomes Sensor 2:

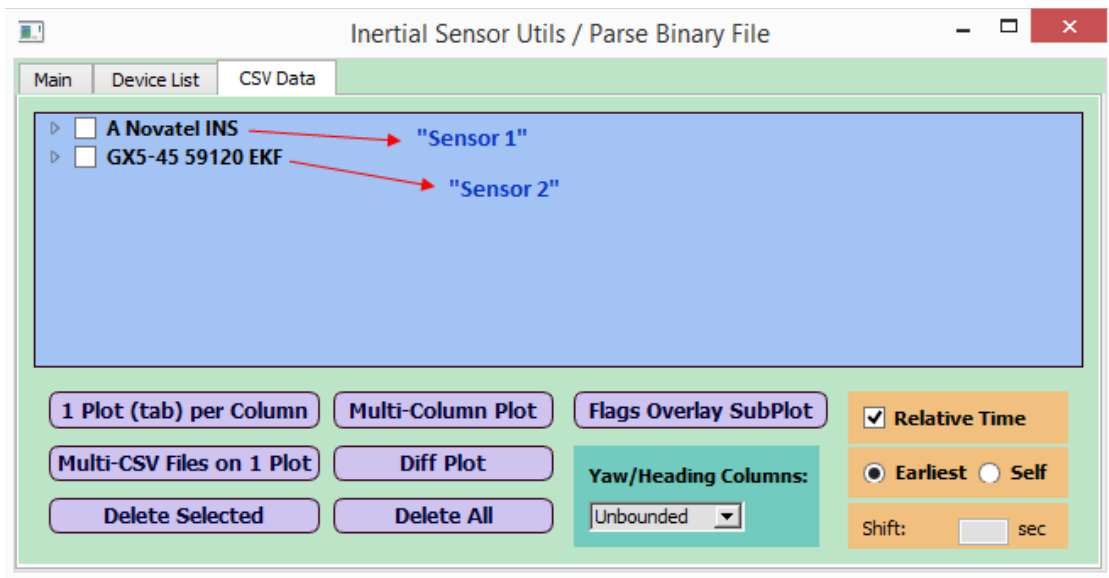


Figure 16 -Sensor Sequence for Diff Plot

The following screen shows a diff plot between these two sensors for the “Pitch” column.

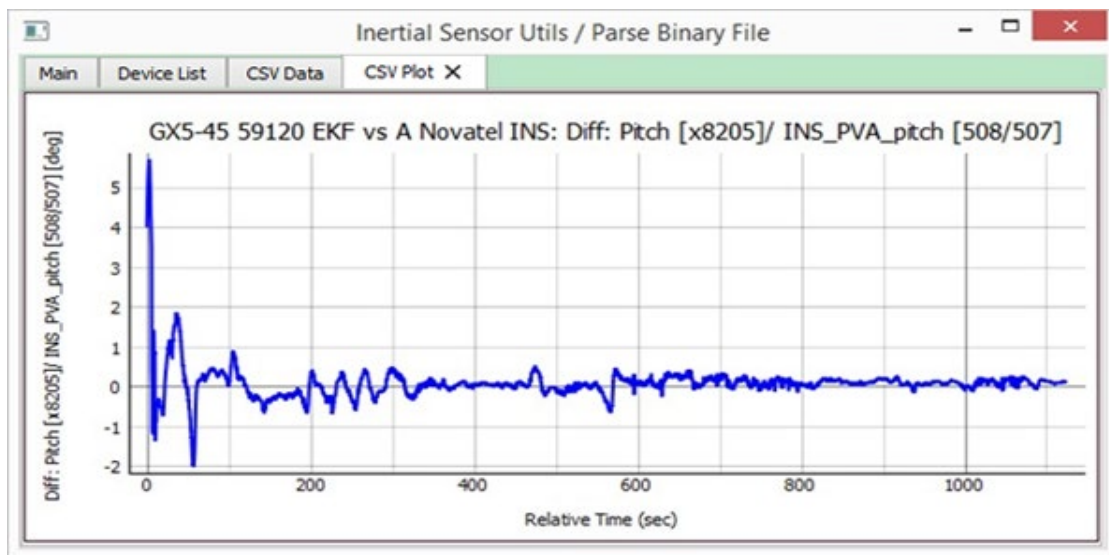


Figure 17 -Diff Plot Graph for Pitch

If the initial TOW of Sensor 2 is after the initial TOW of Sensor 1, and/or if the last TOW of Sensor 2 is before the last TOW of Sensor 1, then the tool takes only the portion of exact overlapping TOW between the 2 sensors when doing the diff plot. This is shown in the following figure:

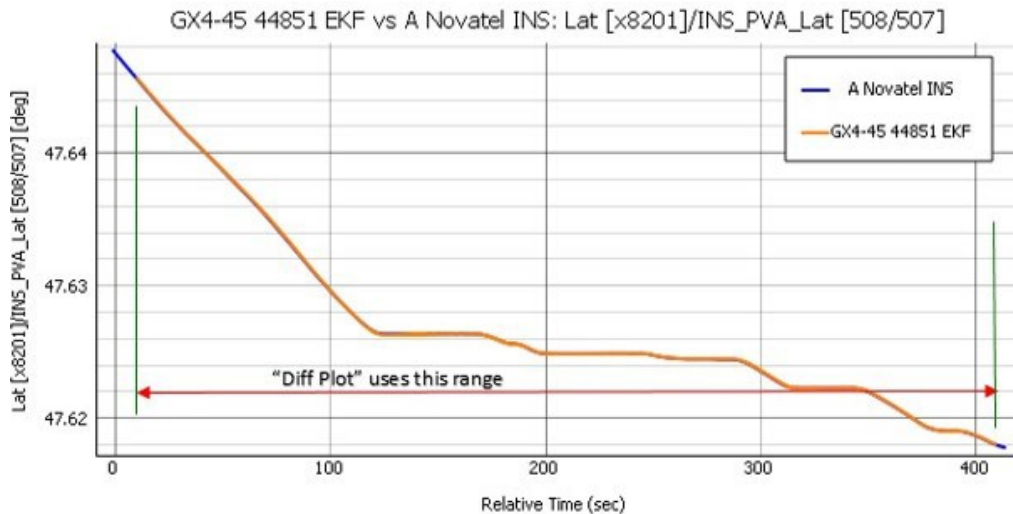


Figure 18 - Overlapping TOW Range Used in Diff Plot

If the 'Relative Time' check-box is selected, the relative time is computed from the first point on the overlapped TOW region.

D. 'Multi-column plot' button

Up to 5 columns from a given CSV file can be overlaid in the same plot using this button.

E. 'Flags overlay subplot' button

Use this button to overlay up to 3 flags from the EKF x8210 "Filter Status" message, onto 1 dependent column. This includes a total of 17 flags from that field (IMU Unavailable, GPS Unavailable, Accel Bias Est High, etc.) based on the Filter Status (0x82, 0x10) field described in the DCP for the device.

The 3 flags show up as 3 sub-plots, each flag using a different color. If 2 flags are selected, it shows 2 sub-plots, and if only 1 flag is selected, it shows a single plot.

For CSV files that get loaded, the tool displays only flag(s) that turned on at least once during the run, and are red. So, the set of flags that show up may be different from one sensor to the other. Select up to 3 flag(s) to overlay on the main column being plotted. Note that the sensors loaded from SensorCloud™ show all 17 flags, and no red color, because the data is loaded from cloud only when the user selects the flag column to plot. A sample screen with these flags showing in red color is shown below:

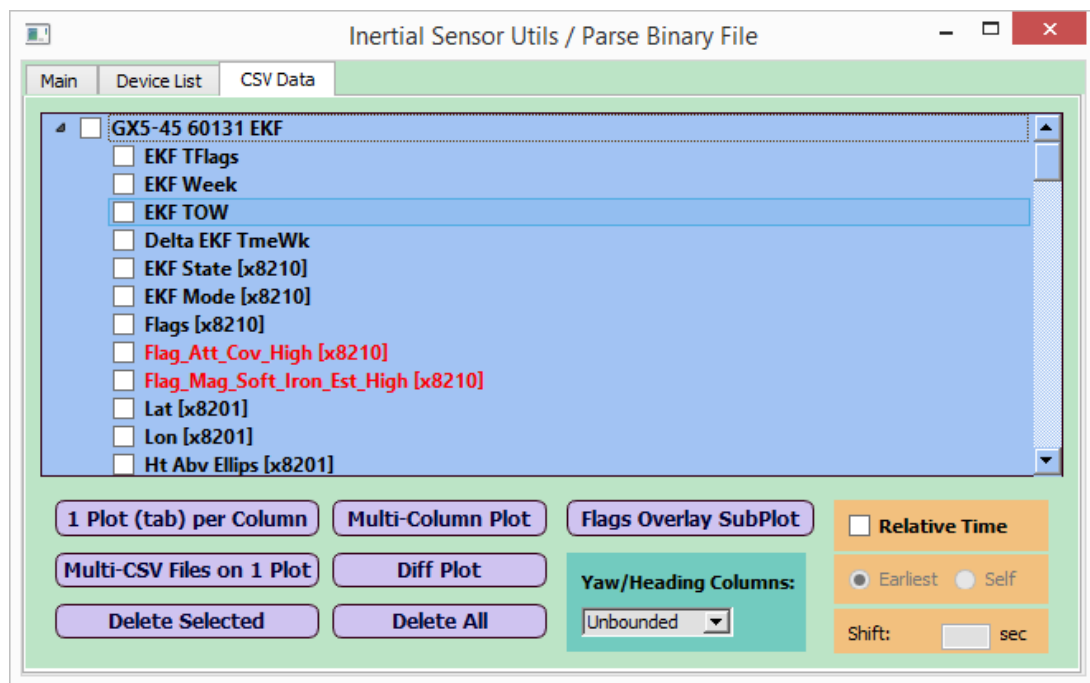


Figure 19 - EKF Status Flags that Turned ON Show in Red

A sample 'Flag overlay subplot' from this may look like this:

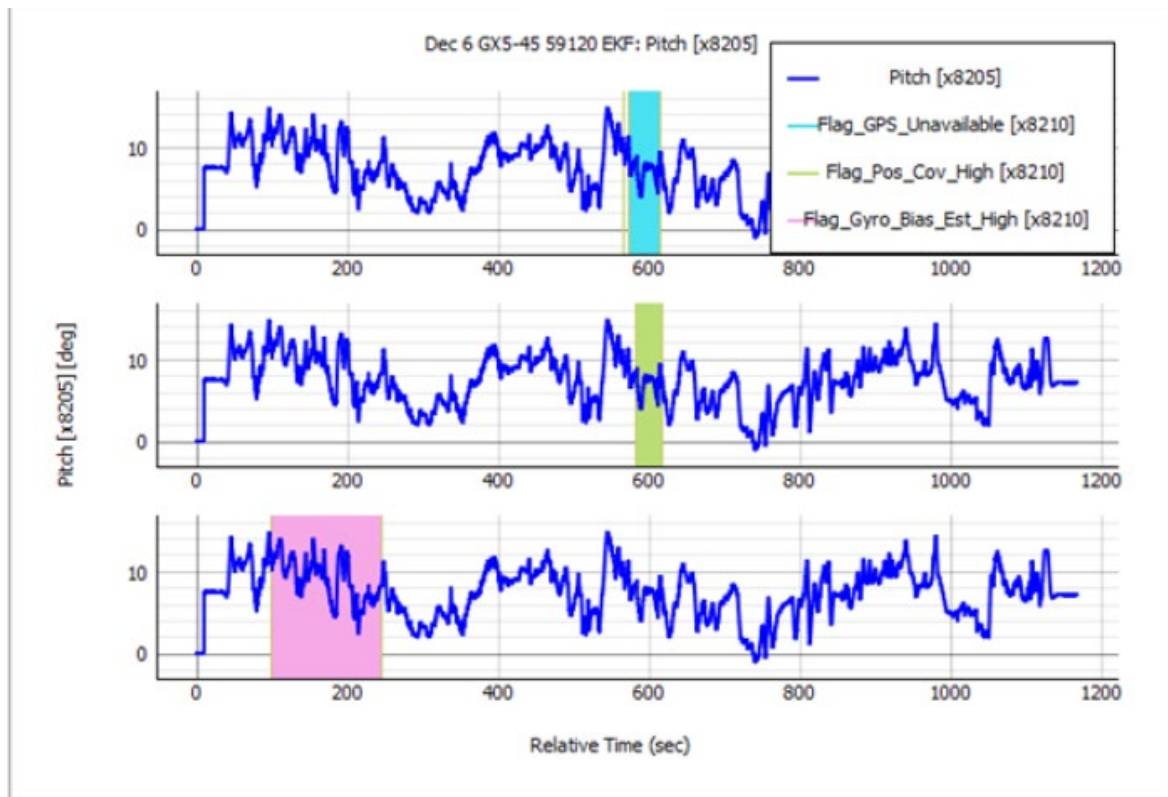


Figure 20 - Flag Overlay Subplot

5.4.2 Relative Time Check-box

Selecting the “Relative Time” check-box would plot in relative time from time $t = 0$ sec, by deducting the initial GPS Time of Week from all GPS TOW values on the X-axis. In this case, the user can use an extra set of radio buttons with labels: “Earliest” (default) or “Self”. When the “Relative Time” check-box is checked, the radio button defaults to “Earliest”. The following snap-shot shows a window with two sensor objects loaded using csv files, with the Relative Time check-box checked:

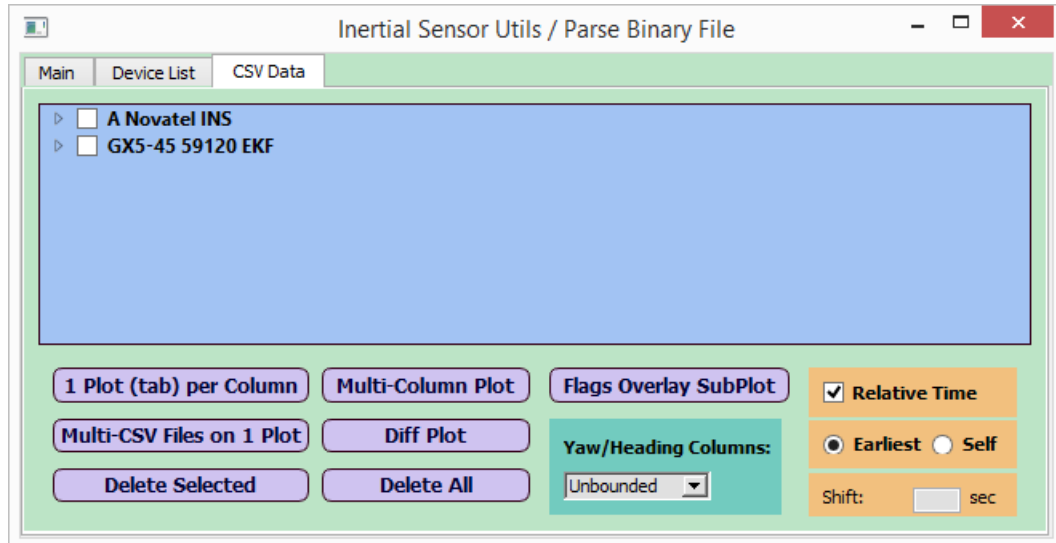


Figure 21 - Using Relative Time Option

The “Earliest” option would use the earlier of all sensors as time = 0, so the sensors other than the one with the earliest start time would have their relative start time as a non-zero value. When two or more sensors (or CSV objects) are being overlaid or differenced, the earliest start TOW of the sensors (or CSV objects) is deducted from the TOW of all sensors (or CSV objects). In other words, after such deduction, the relative time of the sensor with the earliest start TOW would start from time = 0 sec, but all other sensors would have a relative start time greater than or equal to zero. This is shown in the following figure:

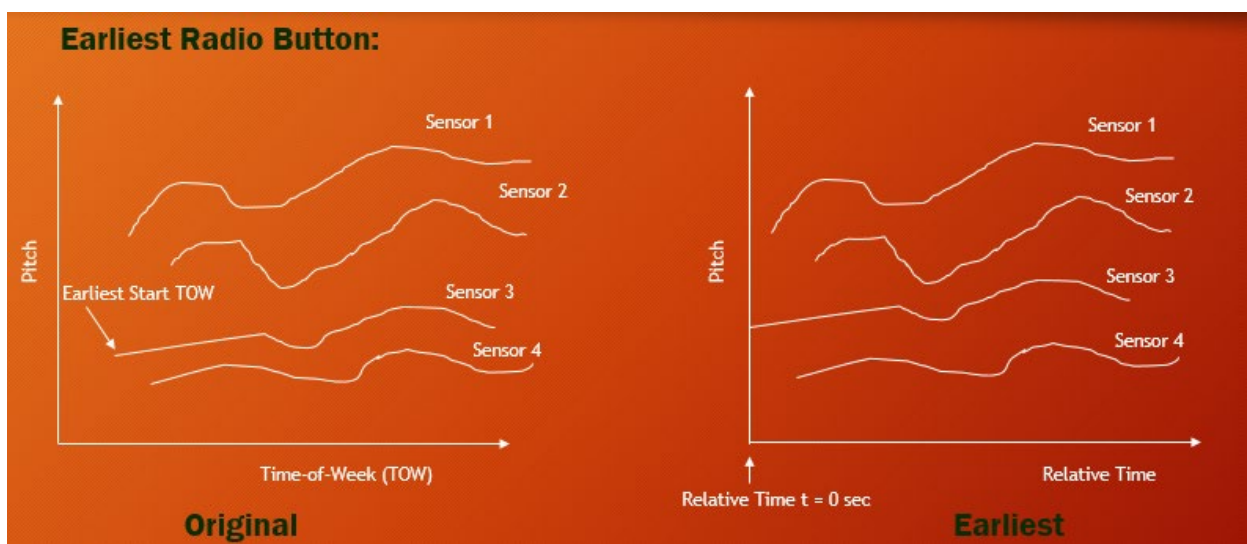


Figure 22 - Using the Earliest Radio Button

The “Self” option would deduct each sensor’s initial TOW from all TOW of that sensor. Each sensor’s data would start at time = 0 sec. As the user selects the “Self” radio button, it enables one more field called “Shift”, where the user can specify the number of seconds to shift the second (and subsequent) plot data, with respect to the first. The default value of “shift” is 0.0 sec. This case is shown in the figure below:

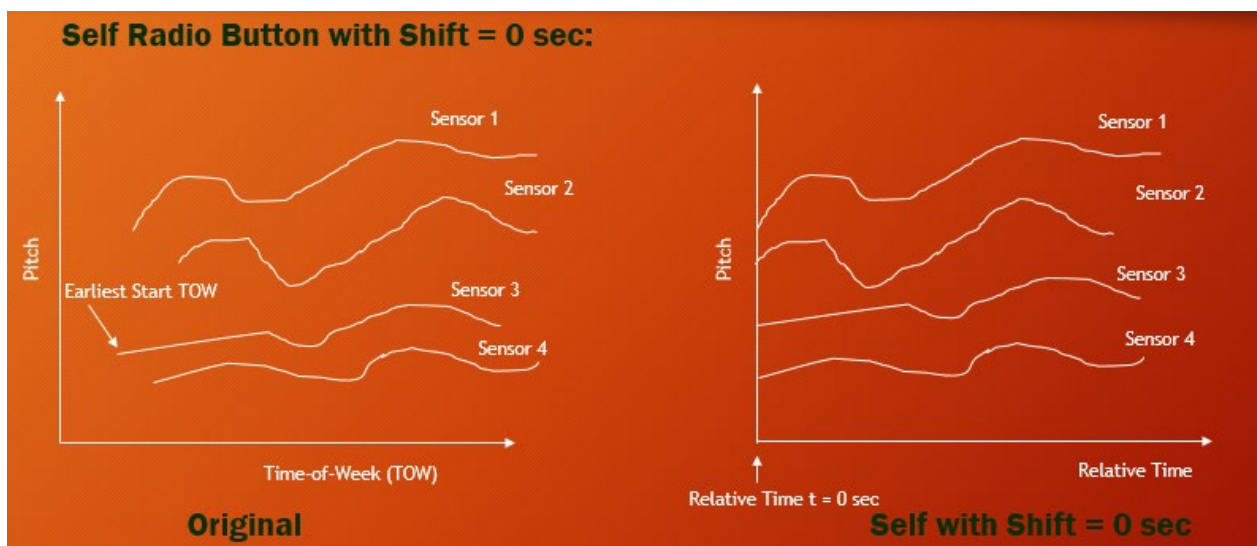


Figure 23 - Using the Self Radio Button with Shift = 0.0 sec

With a non-zero shift, the first sensor deducts its own initial TOW value from all of its TOW. All other sensors deduct that value from their TOW and also shift to the right (with positive shift value) or left (with negative shift value) compared to the first sensor. A sample shift of +3 sec is shown in the figure below:

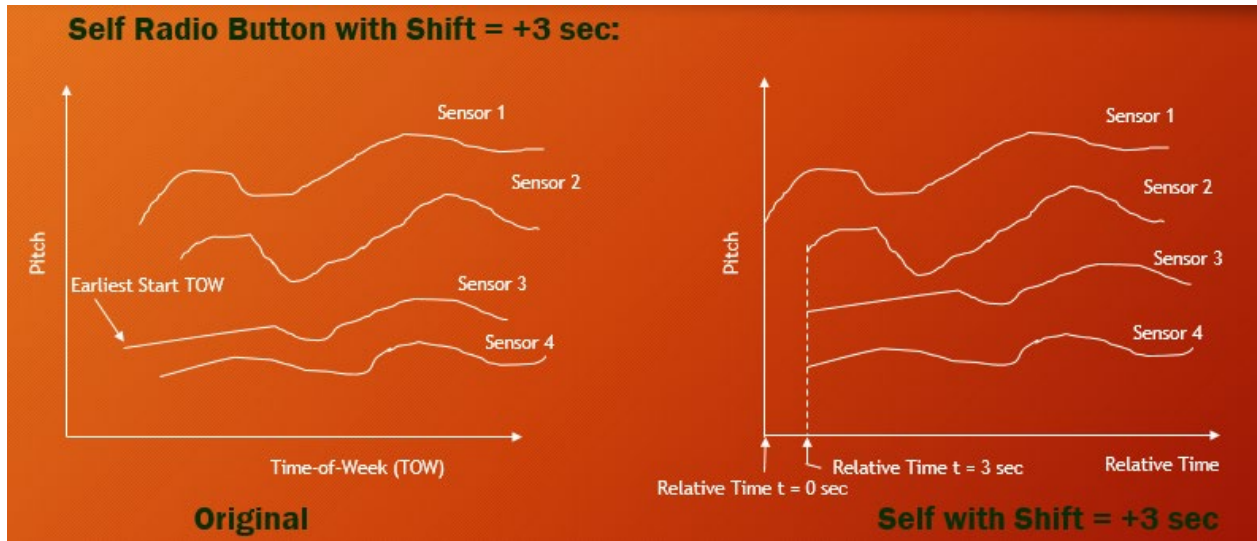


Figure 24 - Using the Self Radio Button with Shift = +3.0 sec

Note that when the 'Relative Time' check-box is checked, and the "Self" radio-button is selected, the 'GPS Week' column automatically becomes optional.

When the user specifies the shift value and clicks the "Multi-Sensor" (or "Multi-CSV Files in 1 Plot") or "Diff Plot" button, it moves all values of the second and other sensors by that amount, either to the right or left, for positive and negative shift respectively. In addition, the plot now shows a new label which displays the shift value specified for that plot, so there is no ambiguity when looking at plots with different shift values.

The shift value defaults to 0.0 sec. The user can specify a positive or negative shift value with up to 2 decimal places. Note that a "Self" radio-button selection with shift of 0.0 sec is not the same as the "Earliest" option. In the former, all sensors would begin at a relative time of 0 sec, whereas in the latter, sensors other than the "Earliest" would begin at a non-zero relative time.

The "Self" radio button and the shift value combination would typically be used in situations where one or more sensors being compared uses its own clock that may be out of sync with the other sensor's clock(s), or the other sensor(s) may be using the GPS timestamp. LORD inertial devices that do not use GNSS timestamp are: GX5-10, GX5-15, GX5-25, CV5-10, CV5-15, CV5-25, CX5-10, CX5-15, CX5-25 among others.

The Relative Time check-box and the Earliest and Self radio buttons also work for a diff plot with some differences. The diff plot takes exactly 2 sensors to diff, so it cannot take more than 2 sensors.

The following paragraphs describe an example of the "Self" radio button usage, when comparing GX5-25 device and a Novatel sensor. Here, the GX5-25 does not have GPS and so its TOW (Time of week) column only represents relative time from start of recording, whereas the Novatel does have real GPS TOW. The GX5-25 is made the "first sensor" and the Novatel is the "second sensor". The user first uses a Shift of 0.0 sec, and determines an approximate shift of the second sensor with respect to the first, by zooming in on the plot and looking at similar pattern in the two sensors' output variable (which is the pitch angle in this example). The shift value is then used to re-plot the two sensors to get a better overlay and match.

Select the TOW and Pitch columns from the first sensor (GX5-25):

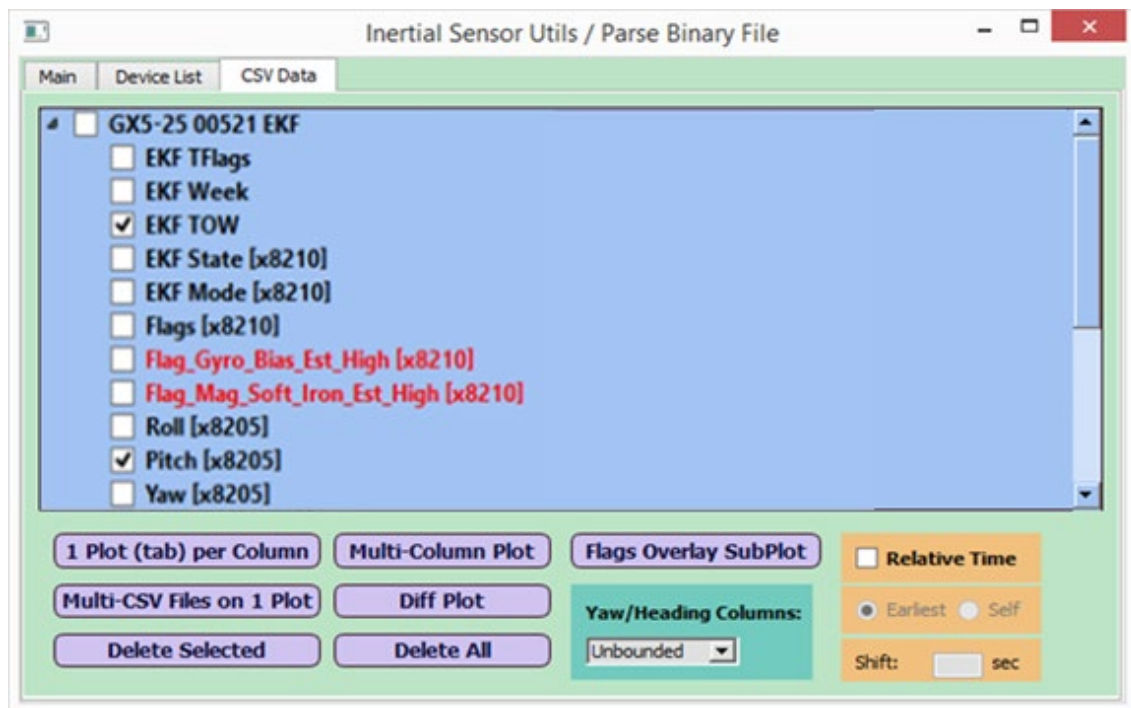


Figure 25 - Check EKF TOW and Pitch - Sensor 1

Next, select the TOW and Pitch from the second sensor (Novatel):

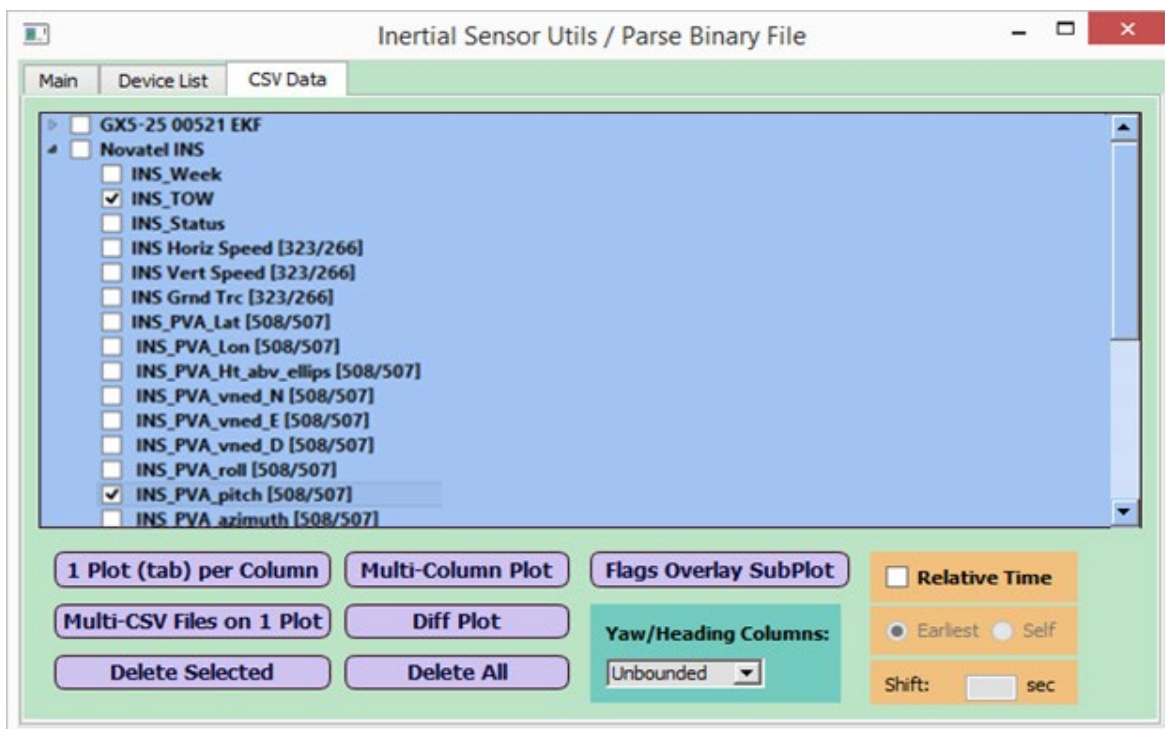


Figure 26 - Check EKF TOW and Pitch - Sensor 2

Finally, select the “Relative Time” check- box, the “Self” radio button with shift of 0.0 sec, and then click on “Multi-CSV Files on 1 Plot” button:

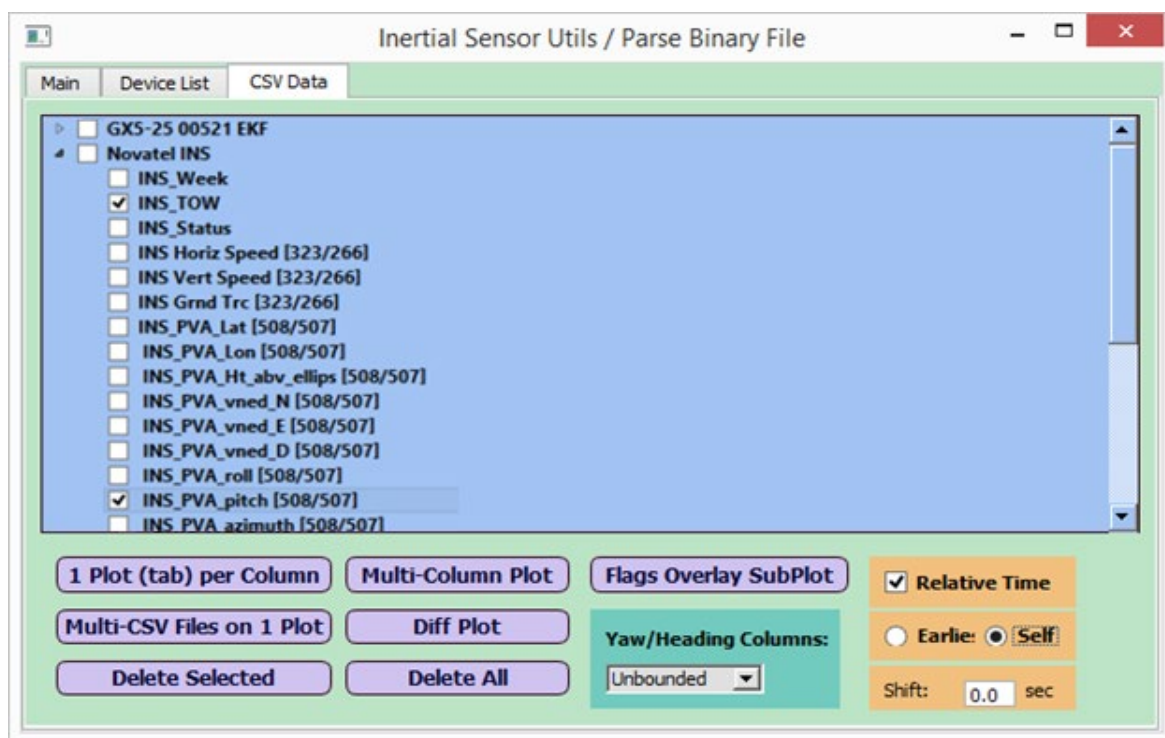


Figure 27 - Submit Self Radio Option with 0.0 Sec Shift

The plot looks like this:

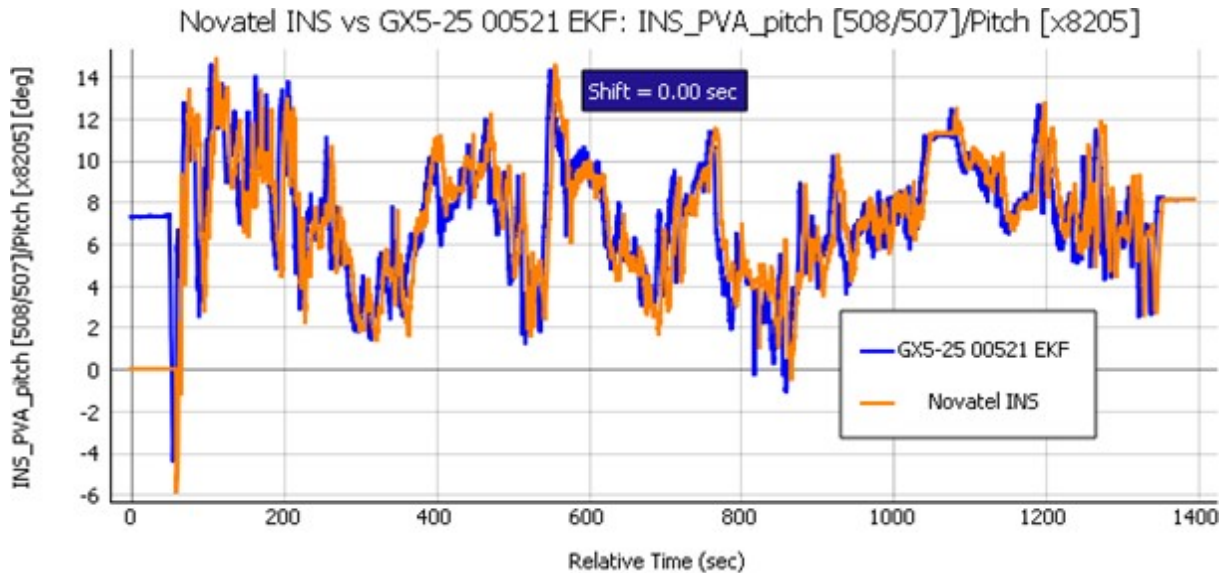


Figure 28 - Overlay Plot with 'Self' Radio and 0.0 Sec. Shift

The user zooms in on this plot to estimate the time shift to be about 6.6 sec; in other words, Sensor 2, “Novatel INS” is ahead of Sensor 1, “GX5-25 00521 EKF” by 6.6 sec. He/she then goes back to CSV Data tab, re-selects the columns in the 2 sensors, and specifies a shift of -6.6 sec. Here, a negative sign indicates that the sensor 2 needs to move to the left with respect to sensor 1 by 6.6 sec:

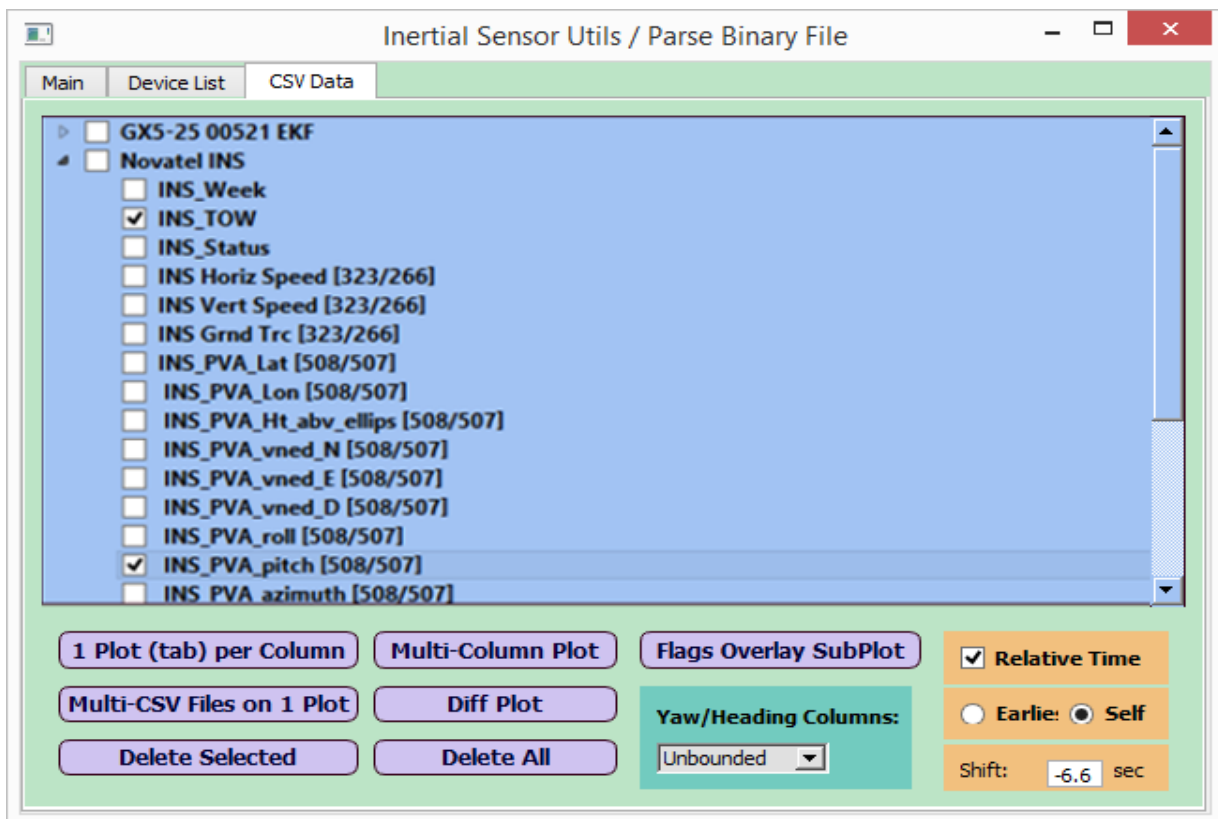


Figure 29 - Submit Self Radio Option with -6.6 Sec Shift

The plot now looks like this (note that the match is much better than before):

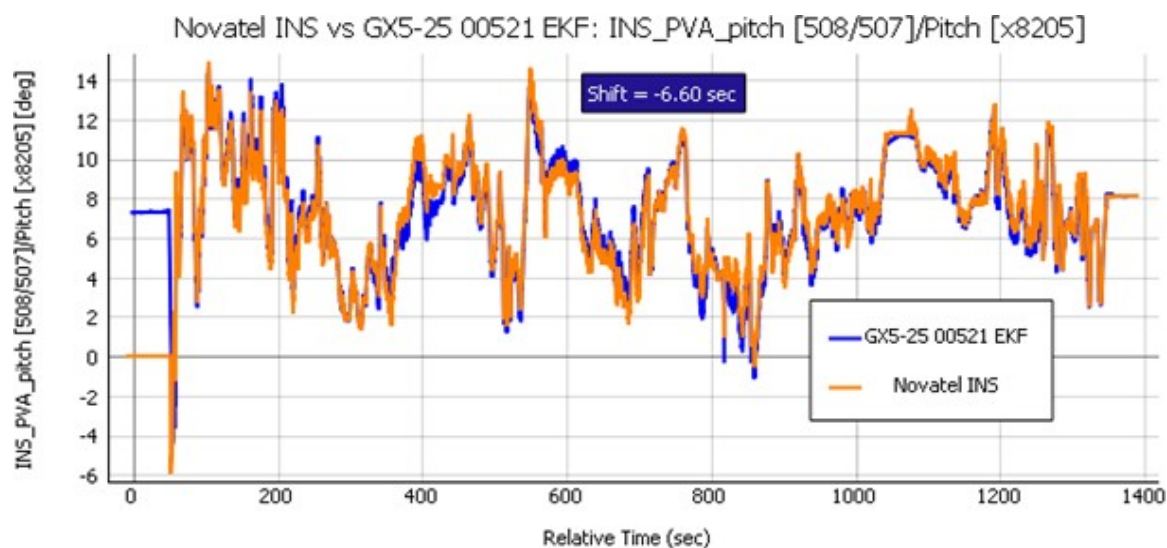


Figure 30 - Overlay Plot with 'Self' Radio and -6.6 Sec. Shift

The user is expected to zoom in on the first overlay plot to determine the approximate shift value to use for best match between the two sensors (or CSV objects) in this case.

Note that the "Earliest" and "Self" radio buttons and the shift field value would be ignored if the user chooses a plot other than a multi-sensor or a diff plot.

5.4.3 Zooming In/Out On Plots

The tool has an option to switch between a 3-button mouse zoom (the default) or a 1-button mouse zoom. With a 3-button mouse mode, the mouse scroll wheel is used to zoom in or out of a plot. With a 1-button mouse mode, a rectangular area of the plot is zoomed in by dragging the left mouse button. To change from 3-button to 1-button mouse mode, right-click on the plot area, choose Mouse Mode > 1 button.

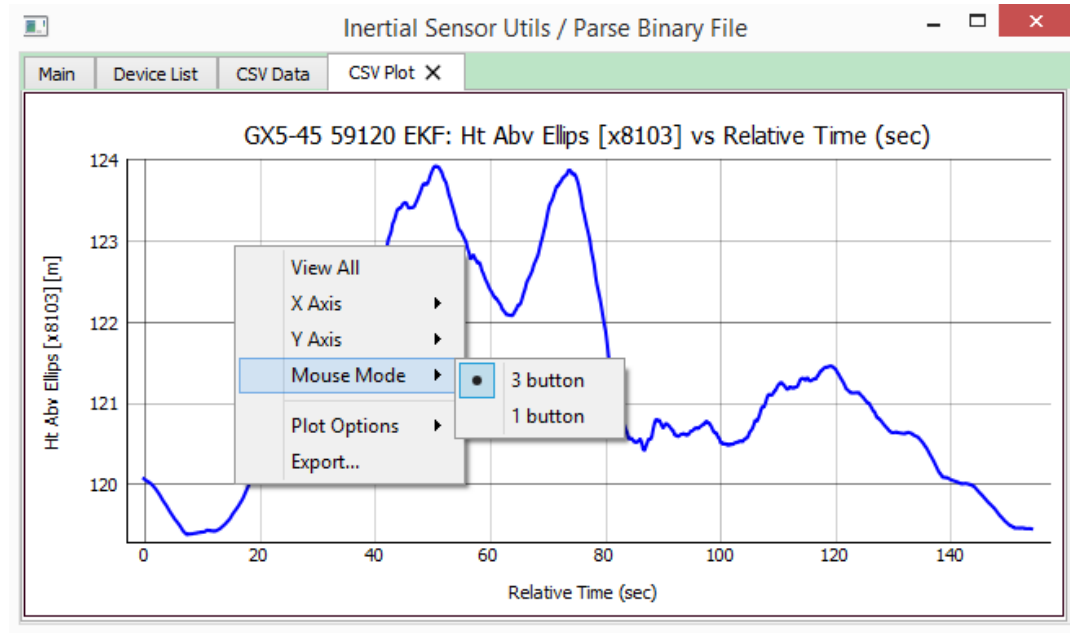


Figure 31 - Mouse Mode Options

A 1-button mouse mode zooming action is shown below:

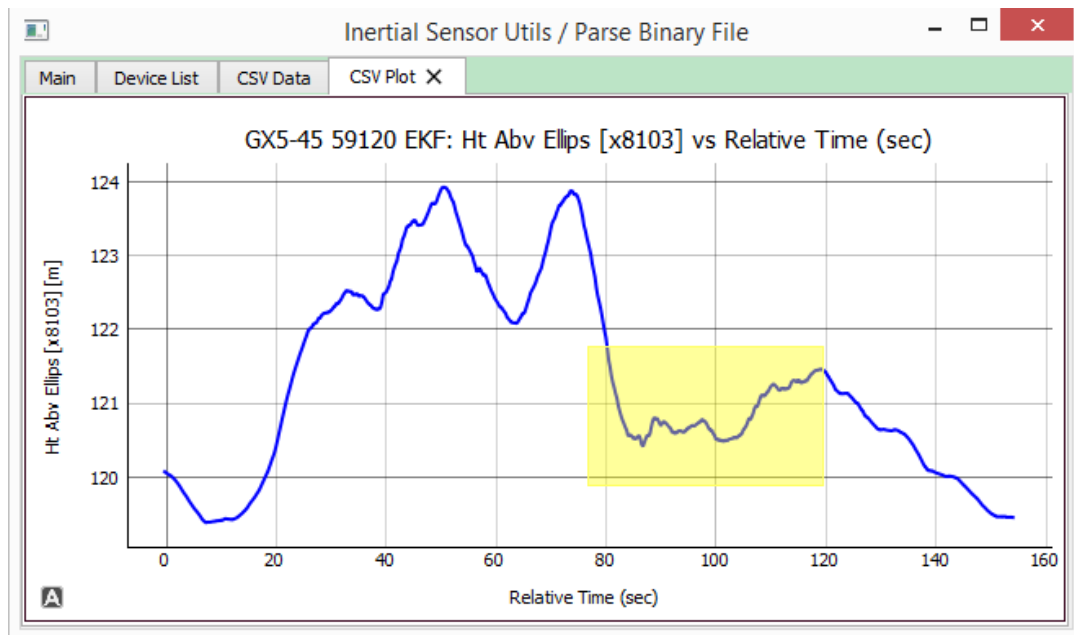


Figure 32 - 1-Button Mouse Zoom

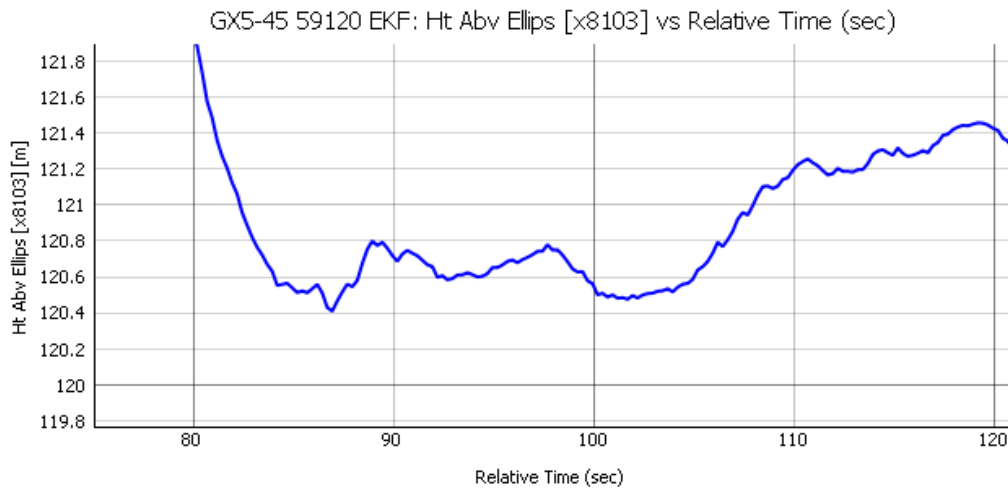


Figure 33 - Zoomed-In Plot View

Selecting 'View All' from the right-click brings back the entire plot in view.

5.4.4 Exporting Plots As Image To Word, Powerpoint, or .CSV

To export a plot as an image, right-click on the plot area, choose 'Export', then 'Entire Scene', and click on the 'Copy' button at the bottom. The pop-up for making these selections looks like this:

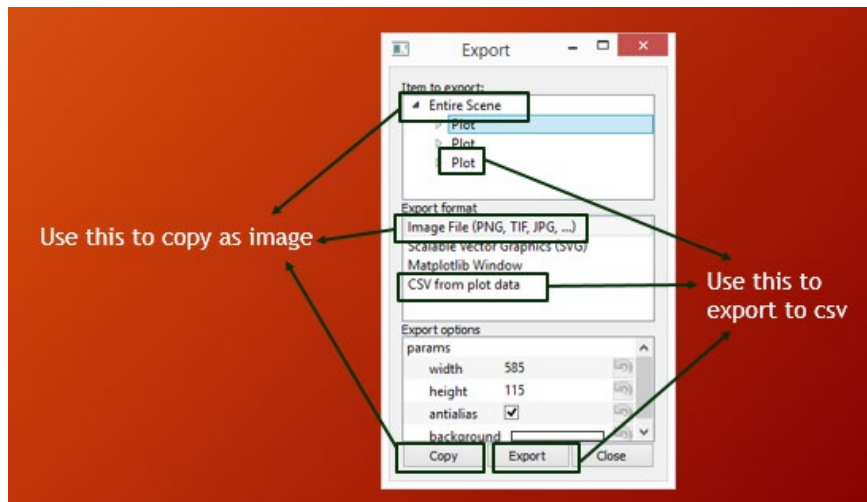


Figure 34 - Export Plots Menu

The 'Export Format' is 'Image File'. If the user wants to export the plot data as a csv file instead, he/she needs to select a plot in the top pane, and 'CSV from plot data' under 'Export format' section of the pop-up, then click on 'Export' button at the bottom.

5.4.5 Plot Units

- For LORD MIP-based csv files, the utility automatically converts all "radians" type columns to "degrees", "g" type columns to "m/s²", then plots (regular or diff plot).
- For each column being plotted, it displays the exact units at the end of the Y axis label in square brackets.

5.4.6 Lat-Lon Plots

It can plot lat vs lon, in different formats: regular 1 plot per tab, 2 sensors on 1 plot, or diff plot. As with other diff plots and 2 sensor plots, the lat-lon diff plots and 2 sensor plots can use TOW, Unix Timestamp or Relative Time.

“Lat-lon plot” for a single sensor or CSV Object does not require the TOW or Week to be selected. It would plot Lat vs Lon, both in degrees, as shown below.

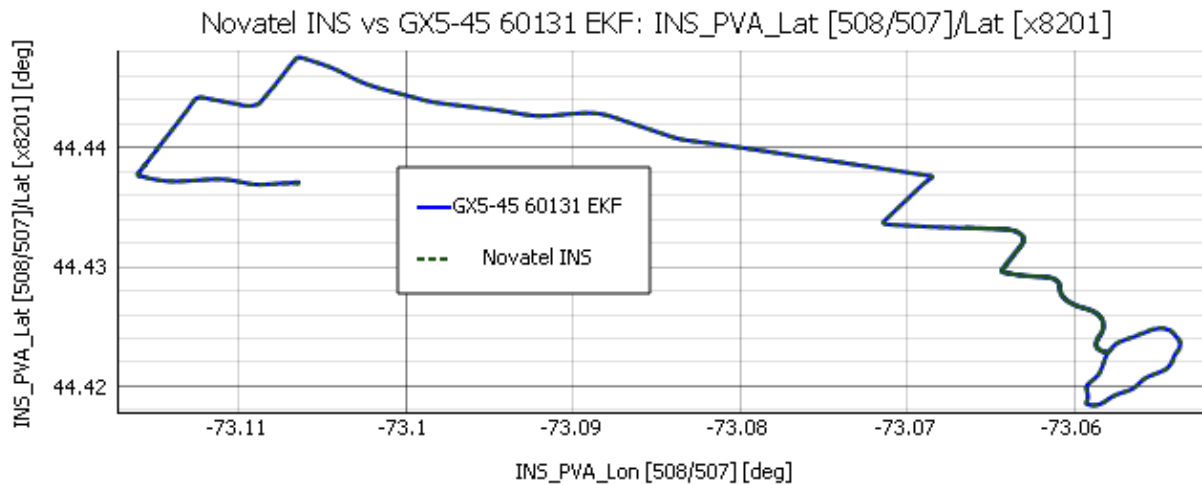


Figure 35 - Lat-Lon Plot

(A) The “lat diff plot” shows the difference in meters instead of degrees (uses earth mean radius = 6371 km for the conversion). Same with lon diff plot. That way it’s easier to visualize the exact difference over the ground in meters. Note that lat, lon and lat-lon plots always show in degrees; it’s only their ‘diff plots’ that convert to meters.

The “lat-lon diff plot” shows the RMS difference of lat-lon (in meters) as a function of TOW, Unix Time or Relative Time. A sample “lat-lon diff plot” is shown below.

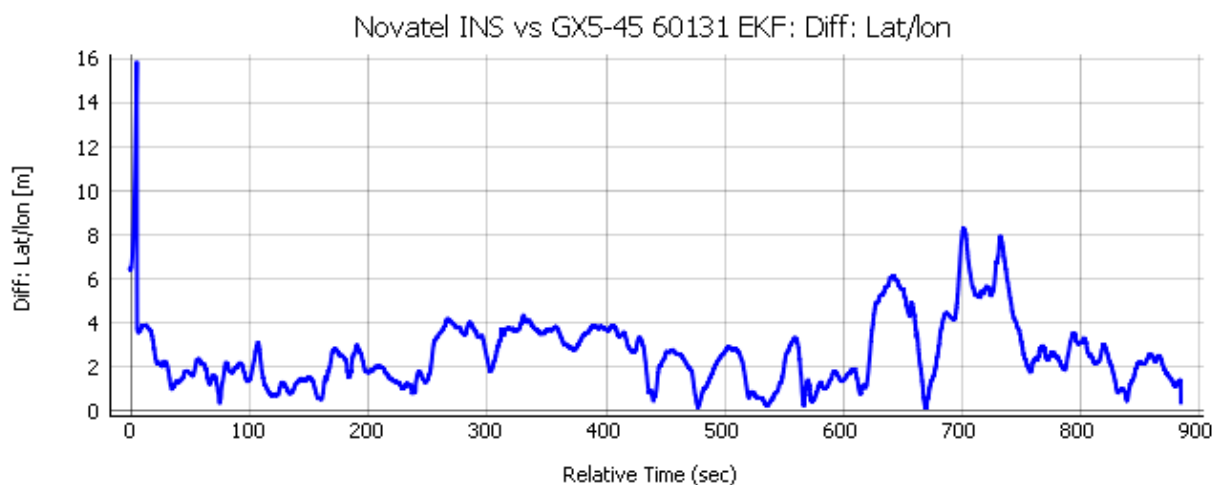


Figure 36 - Lat-Lon Diff Plot

5.4.7 Processing CSV Data For Plotting

When loading a MIP IMU or Novatel RAWIMU csv file that has DeltaTheta and DeltaV, the tool does the following to facilitate overlay and diff plots for deltaTheta and deltaV:

- (a) For Novatel RAWIMU file, it converts DeltaTheta_Y and DeltaTheta_Z to degrees, and then to the MIP Y and Z axes by multiplying by -1 (to be comparable with MIP device values). Note that these are in deg units, because it applies the Gyro Scale Factor to raw values and converts to deg.
- (b) For Novatel RAWIMU file, it converts DeltaV_Y and DeltaV_Z to MIP Y and Z axes by multiplying by -1 (to be comparable with MIP device values). Note that these are in m/s units, because it applies the Accel Scale Factor to raw values.
- (c) For MIP IMU file, it converts DeltaV values to m/s by multiplying the raw values by g, and deltaTheta values to deg.

Note that changes (a), (b) and (c) above are only when plotting; the original parsed csv file remains same as before, which will have units and orientation as in the LORD DCP or Novatel's Firmware Ref Manual (except Novatel's VNED_D column, which will point down and not up).

5.4.8 'Grnd Trace' Derived Column

A computed column 'Grnd Trace [x8202]' and 'Grnd Trace [x8105]' is included when loading an EKF and GPS csv file respectively, provided such a csv file has NED velocity columns. The derived Grnd Trace gets inserted as a new column after the VNED_D column in the csv tree widget for plotting. These derived columns are also considered as "Yaw/Heading" type columns, so the drop-down for Yaw/Heading type (described in Sec 5.4.9) can be used. This does not affect the parsed csv which remains unchanged. The following figure shows the definition of the Ground Trace angle from the North and East components of the NED velocity.

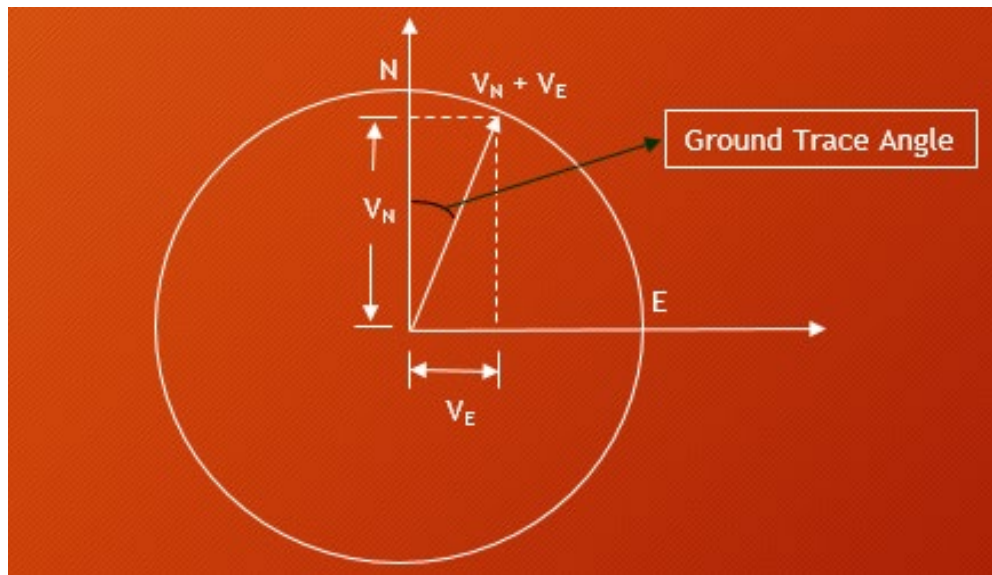


Figure 37 - Ground Trace Angle

5.4.9 Unbounded/360 deg Bounded Yaw, Heading and Ground Trace

Euler Yaw, Azimuth and Heading often use different ranges, such as ± 180 deg and 0 – 360 deg. For easier comparison between such parameters, the utility now gives the following 4 options when plotting such “yaw-type” columns. Note that the utility considers any column that has the word “Yaw”, “Azimuth”, “Heading” or “Grnd Trace” (case-insensitive) but does **not** include the text “UC” (for uncertainty) or “acc” (for accuracy) to be “Yaw/Heading type column”.

(a) Unbounded (default):

If the original value is in ± 180 range, the tool first converts it to 0 - 360 deg range, and then converts the result to an unbounded value (\pm infinity). LORD Euler Yaw [x8205] has a default range of ± 180 deg. In contrast, the Novatel Azimuth is 0 - 360 deg. Even if one converts the LORD Euler Yaw to 0-360 deg range, there can be huge spikes at certain points on a diff plot comparing it with Novatel Azimuth. This is because at the North cross-over, a value slightly on the left and another slightly on its right would be considered to have a huge difference. The unbounded option resolves this problem and also facilitates computing a proper RMS of the differences. Note that this does not affect the parsed csv which still has the ± 180 deg range for EKF Euler Yaw (per the DCP).

(b) 360 deg bounded:

Original value from log file converted to 0 – 360 deg range, if currently in ± 180 deg. If original is already in 0-360 deg range, it remains untouched.

(c) Original Log value [converted to degrees]

Original value from log file converted to degrees (if in radians). If original is in degrees, it remains intact.

(d) Original Log value [raw, could be in radians or degrees per the DCP]

Original “raw” value from log file is plotted, with no conversion to radians or degrees.

Note that selection in this drop-down has no effect on plot of a non-Yaw/Heading type column.

The following screen-shot shows the Yaw/Heading drop-down in the CSV Data tab:

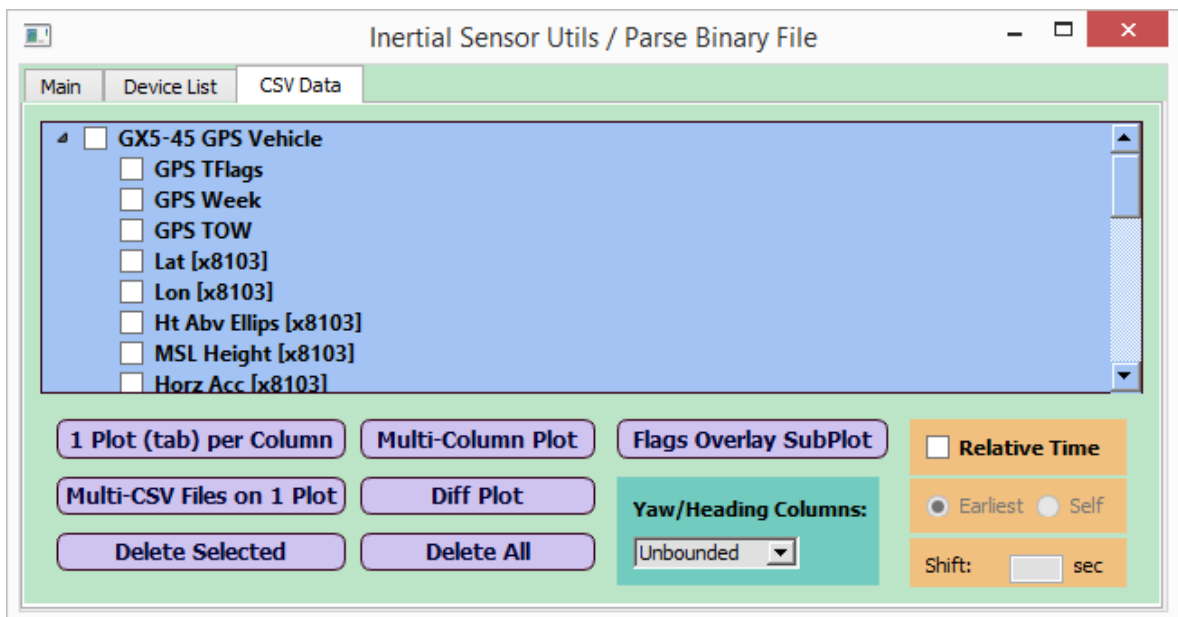


Figure 38 - Yaw/Heading Column Drop-down

As an example, the following plots show all 4 cases for EKF Euler Yaw on GX5-45:

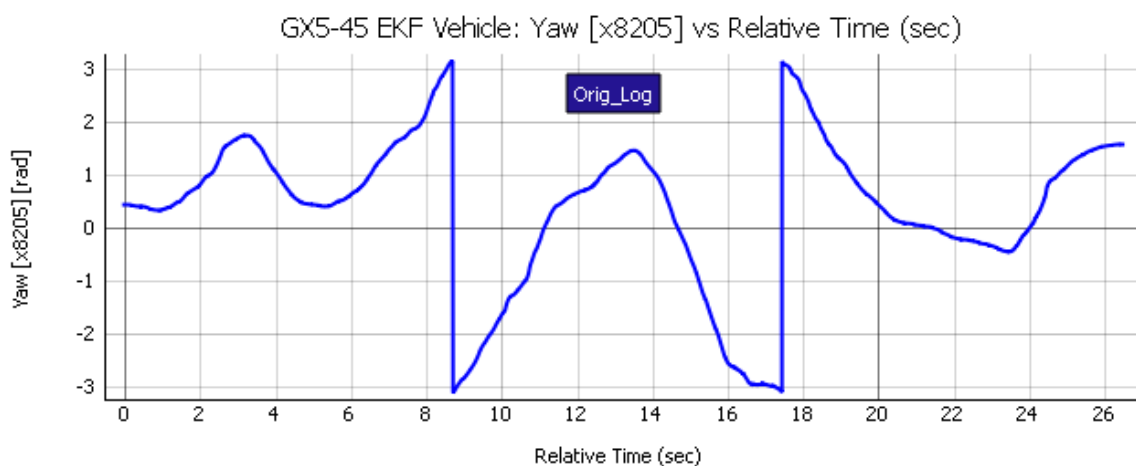


Figure 39 – “Orig_Log” option in Yaw/Heading Drop-down

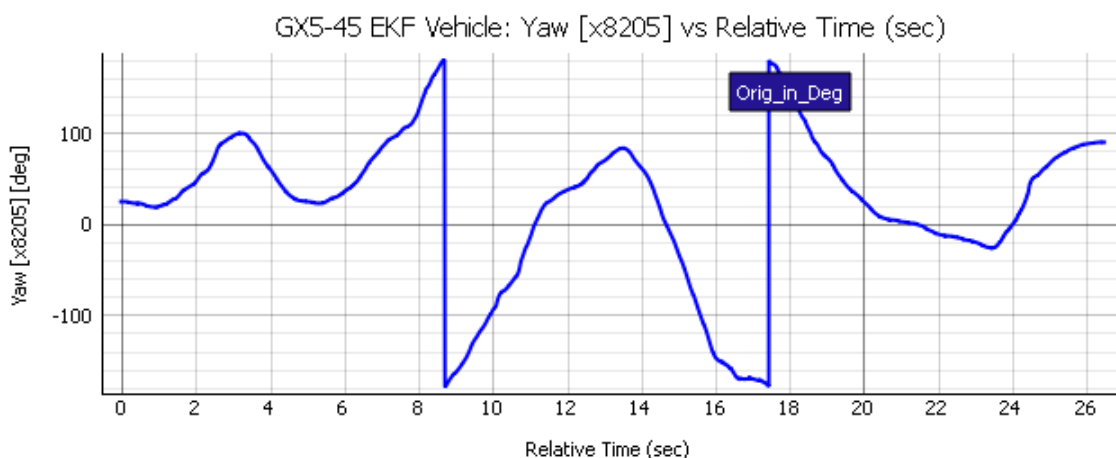


Figure 40 – “Orig_in_Deg” option in Yaw/Heading Drop-down

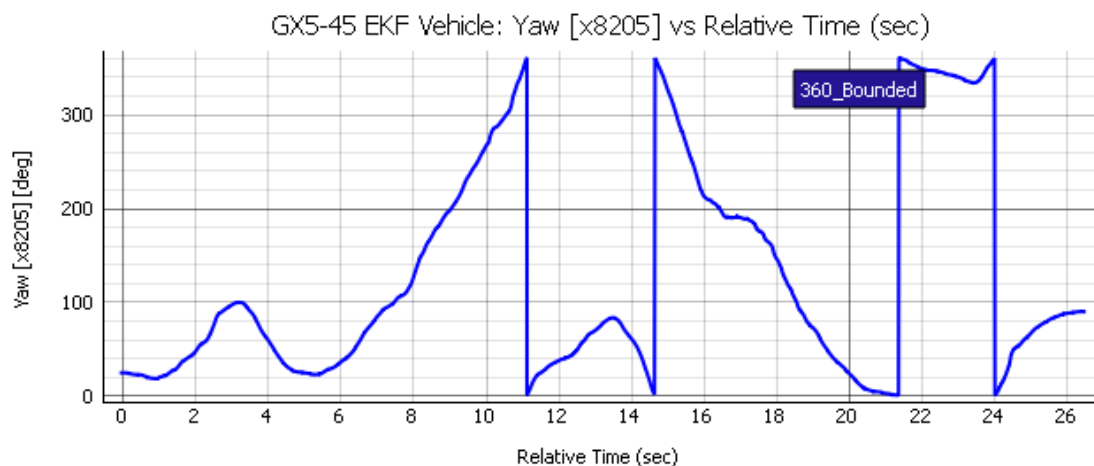


Figure 41 – “360_Bounded” option in Yaw/Heading Drop-down

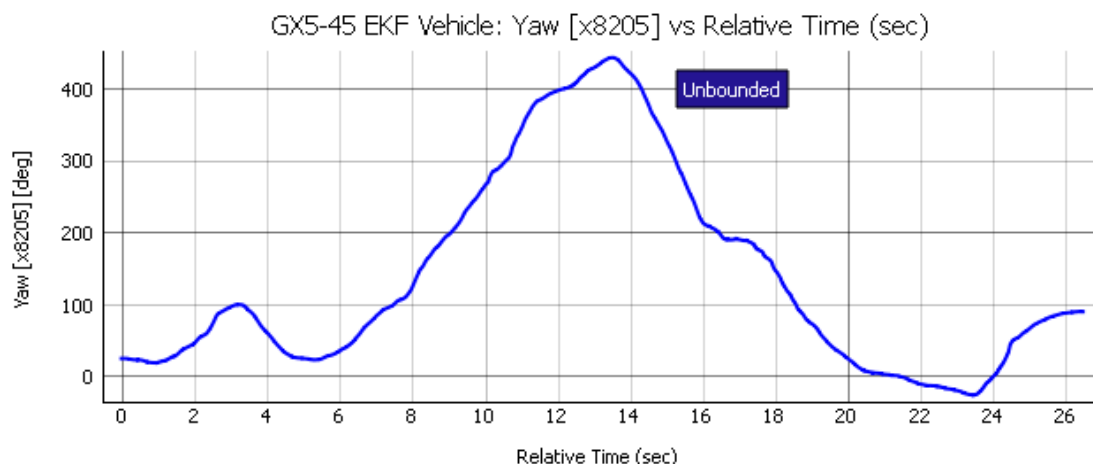


Figure 42 – “Unbounded” option in Yaw/Heading Drop-dow

The relation between unbounded and 360-deg bounded yaw is shown in the figures below. Two distinct cases are considered here:

Case (A): The vehicle nose crosses the North direction in clockwise direction (negative change in Yaw)

Case (B): The vehicle nose crosses the North direction in anti-clockwise direction (positive change in Yaw)

For the sake of simplicity, the cases here assume that the vehicle keeps crossing the North direction multiple times but in the same direction (clockwise or anti-clockwise depending on the case being considered). In a real-life scenario, one can extend this concept to have a mixture of such clockwise and anti-clockwise cross-overs based on the description of these two fundamental cases.

Case (A): Negative Change in Yaw (crossing North in clockwise direction):

The cross-over is shown in the following figure:

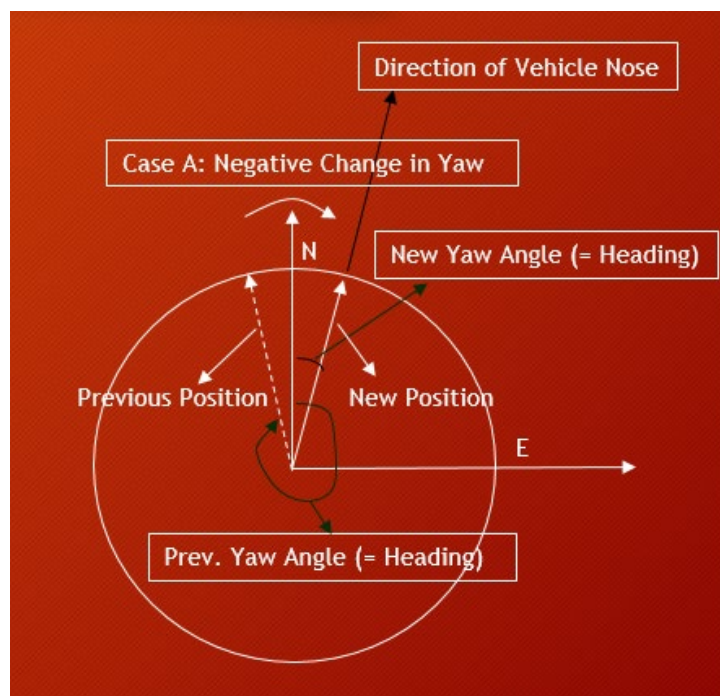


Figure 43 - Case A: Negative Change in Yaw Angle

When the vehicle repeats clockwise crossovers multiple times, a pattern is shown below. For every crossover, an extra “adder” value of 360 deg adds on to the original reading to get an “unbounded” value.

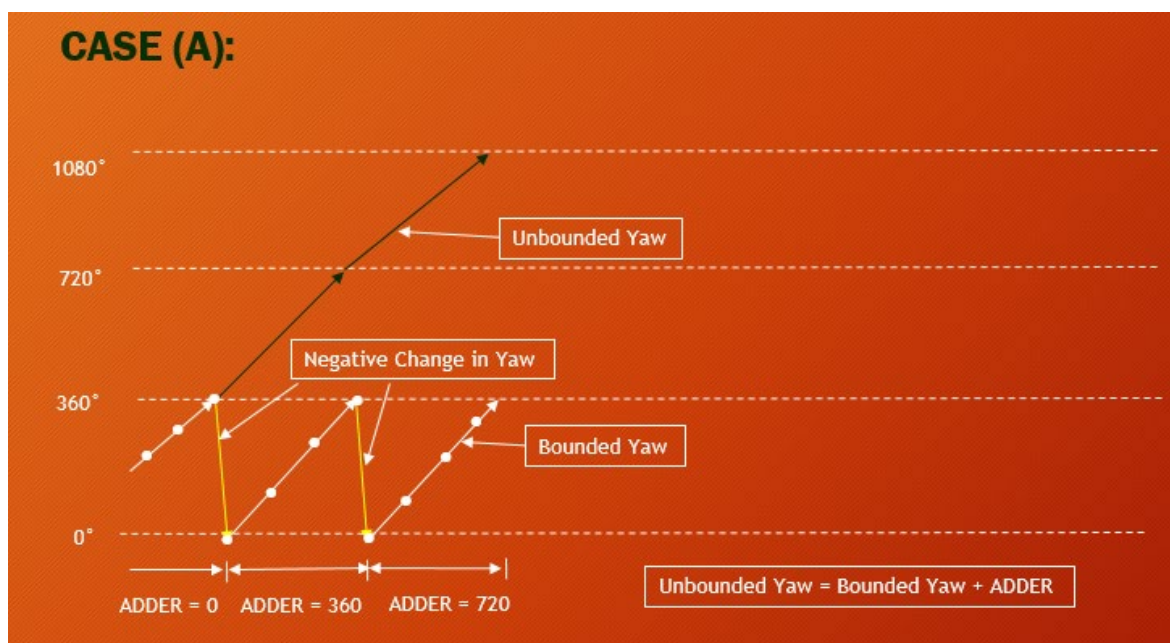


Figure 44 - Case A: Unbounded Yaw with Negative Change

Case (B): Positive Change in Yaw (crossing North in anti-clockwise direction):

The cross-over is shown in the figure below:

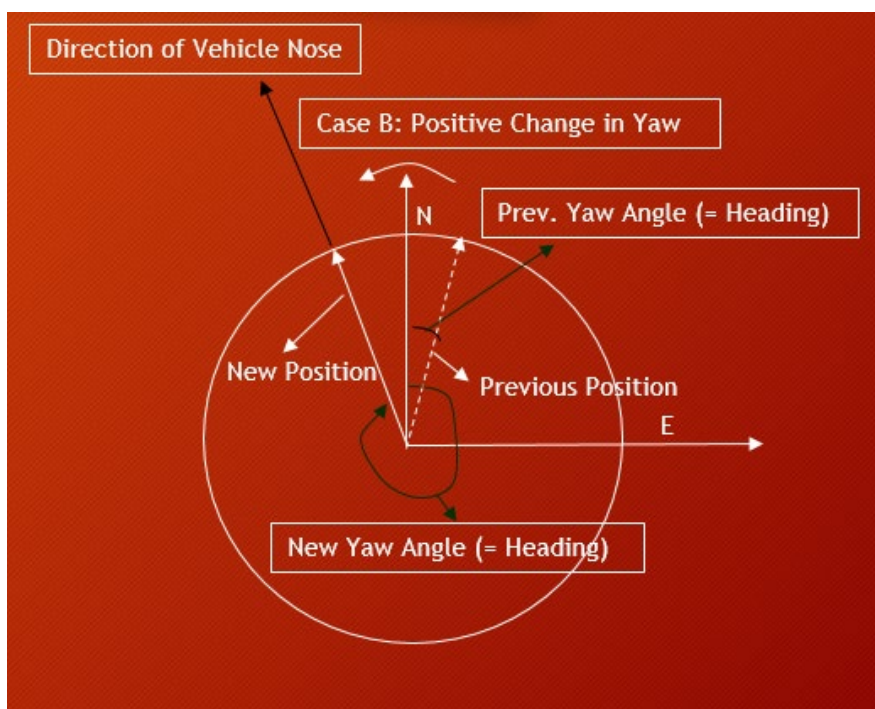


Figure 45 - Case B: Positive Change in Yaw Angle

When the vehicle repeats such anti-clockwise crossovers multiple times, a pattern is shown below. For

every cross-over an extra “adder” value of -360 deg adds to the original reading for an “unbounded” value.

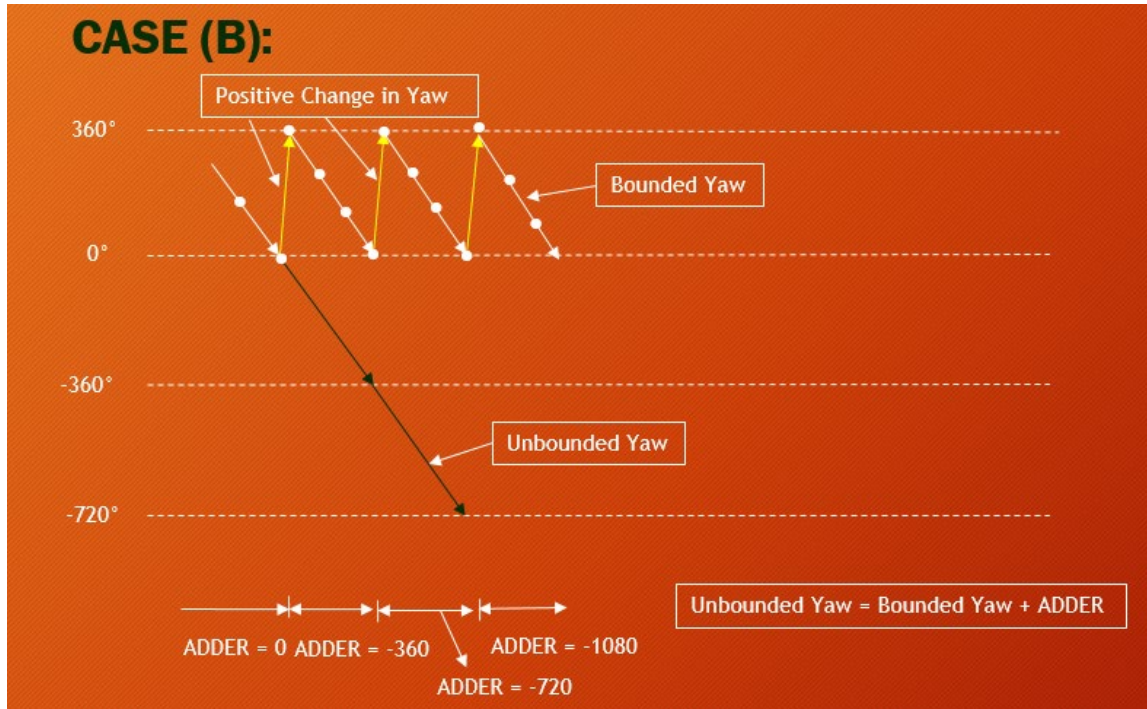


Figure 46 - Case B: Unbounded Yaw with Positive Change

An unbounded yaw value becomes clear when looking at a diff plot between a 360 deg bounded yaw and another diff plot between the unbounded yaw, as shown below. A diff plot between the 360 bounded values creates spikes at certain points, which are eliminated with a diff plot between the unbounded values instead.

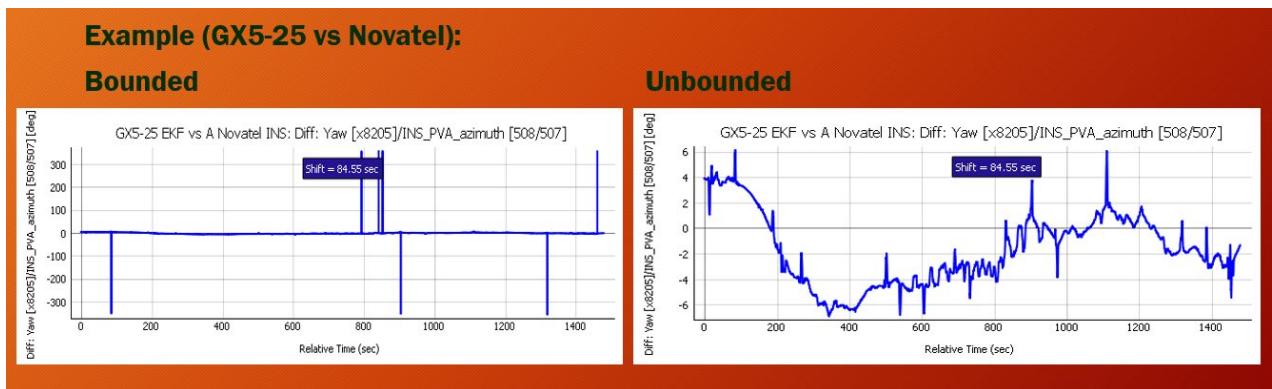


Figure 47 – Diff Plot Using Unbounded and Bounded Yaw

5.4.10 Novatel 'Up' vs 'Down' Velocity

The Novatel parsed csv file had a couple of headers: “Vel D [324/267]” and “INS_PVA_vned_D [508/507]”. The actual velocity parsed is “up” velocity and not “down” velocity, so the tool multiplies the parsed value by -1 to make it a “down” velocity. That way it matches with the headers of those 2 columns, which can be used to compare with the VNED_D velocity of LORD devices.

- The “vertical speed” fields in messages 99 and 323 remain unchanged, and reflect the speed going up as positive. The down velocity in “Vel D [324/267]” and “INS_PVA_vned_D [508/507]” columns are negative of the ones in the “EKF Vert Speed [99]” and “INS Vert Speed [323/266]”

columns.

5.4.11 Miscellaneous Notes

If a column contains one or more empty cells in the csv, the utility picks only the rows with non-empty cells in that column and its matching TOW in the plot.

6. Device List Tab

A new tab called “Device List” is now available in Release 2.0. The tab looks like this:

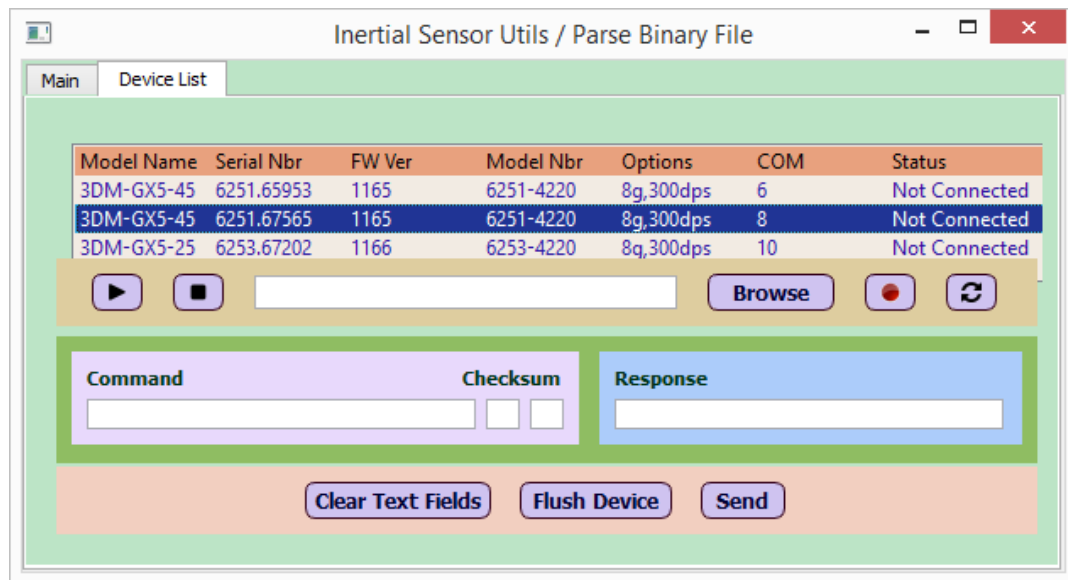


Figure 48 - Device List Tab

6.1 List of devices

The top pane shows a list of LORD devices connected to the host PC:

Model Name	Serial Nbr	FW Ver	Model Nbr	Options	COM	Status
3DM-GX5-45	6251.65953	1165	6251-4220	8g,300dps	6	Not Connected
3DM-GX5-45	6251.67565	1165	6251-4220	8g,300dps	8	Not Connected
3DM-GX5-25	6253.67202	1166	6253-4220	8g,300dps	10	Not Connected

Figure 49 – Top Pane Showing List of LORD Devices

For each device, it shows the following fields (or columns):

Field (Column)	Sample value
Model Name	3DM-GX5-45
Serial Nbr	6251-67565
FW Ver	1165
Model Nbr	6251-4220
Options	8g,300dps
COM	8
Status*	Possible Values:* Not Connected Streaming Data Recording Data Waiting to Record

* Status of a device can be one of the following:

Status	Notes
Not connected	Same as “Idle”. The device is not streaming or recording any data, although it may be physically connected to the port on the PC.
Streaming Data	The device is streaming data but not currently recording.
Waiting to Record	<p>The device has the log filename for next recording and is waiting for user to click on Stream button. This can happen in two situations: the user clicked on:</p> <p>(a) Record button when the device was not streaming data, or</p> <p>(b) Stop Streaming button when it was recording.</p> <p>The device has the filename of the next recording [case (a)] or filename to append (resume) next recording [case (b)] and is waiting for user to click Stream button to start or resume recording. The first click on the Stream button while “Waiting to Record” would start recording on the file. The device status would change to “Recording Data” and the Record button icon would change to “Stop Record” from the default “Record”.</p>
Recording Data	<p>The device is actively recording data to a file (and is also streaming data at the same time).</p> <p>To start recording on a new file, the user can either:</p> <p>(a) click on the Browse button to specify the new file name / location, and then click the Record button, or</p> <p>(b) click on the Record button while it is still displaying the previously recorded file name. In this case, it pops another message asking if the user wants to over-write the existing log file:</p> <ul style="list-style-type: none"> ➤ If the user responds with a Yes, then it wipes out the contents of that log file and starts recording on it right away (if Streaming is on), or goes into “Waiting to record” mode and records next time the user clicks on Stream button. ➤ If the user responds with a No, it displays a new file name with current timestamp, and either records right away (if Streaming is on), or goes into “Waiting to record” mode and records next time the user clicks on Stream button. <p>To stop recording, the user has two options:</p> <p>(A) Click on the Stop Streaming button: This would stop recording on that file and switch the Record button back to “Waiting to Record” mode (with a green border). When the user clicks the Stream button one more time, it resumes (appends) recording on the same file. The user can repeat this process of Stop and Start Streaming to capture pieces of device output that have time gaps onto a single log file.</p> <p>(B) Click on the Record button one more time, so it changes its icon from a “Stop Record” to a “Start Record”. That would pop a message asking if the user wants to close the file and not record anymore on that file. The user would choose this option if he/she wants to record on a different file instead of recording different pieces of output on the same log file.</p>

6.2 Streaming and Recording from a Device

Below this pane is a set of buttons to start/stop streaming, browse for specifying a log file, a button to record data, and a refresh button:



Figure 50 – Stream, Stop Streaming, Record and Refresh Buttons

The purpose of each of these buttons is listed below:

Button (default icon)	Purpose	Other modes	
		Icon	State (or mode)
	Stream Data		"Streaming Data"
	Stop Streaming (and Recording if applicable)	N/A	N/A
	Browse		
	Record data		"Waiting to Record"
			"Recording Data" / "Stop Record"
	Refresh device list	N/A	N/A

A sample interaction by the user is shown below:

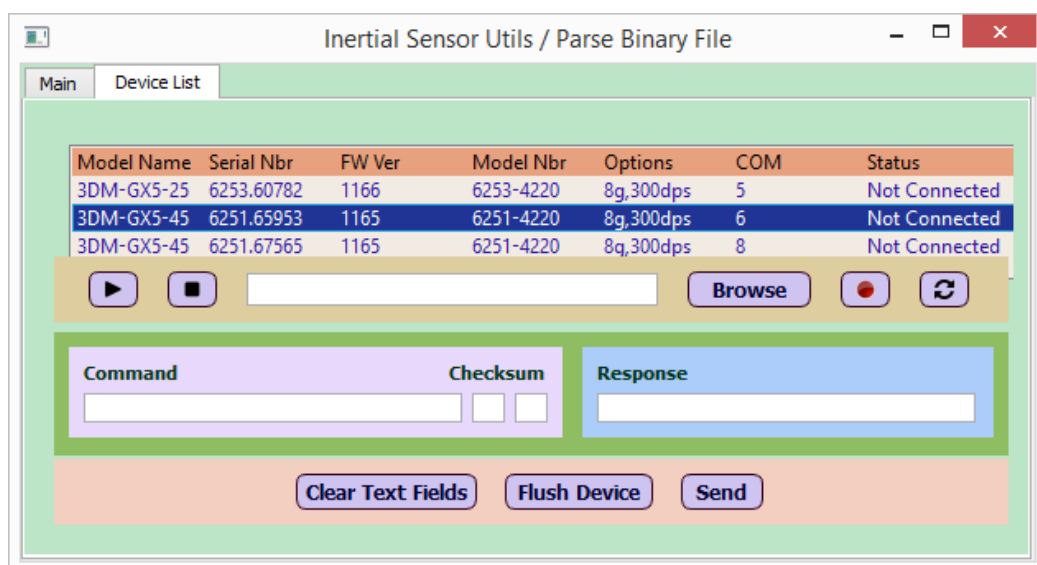


Figure 51 - Selecting a Device in the Device List

(A) The user clicks on a device in the device list pane, then on Stream button to start streaming. The Stream button changes to a red border, and the Status of the device changes to “Streaming Data” as shown below:

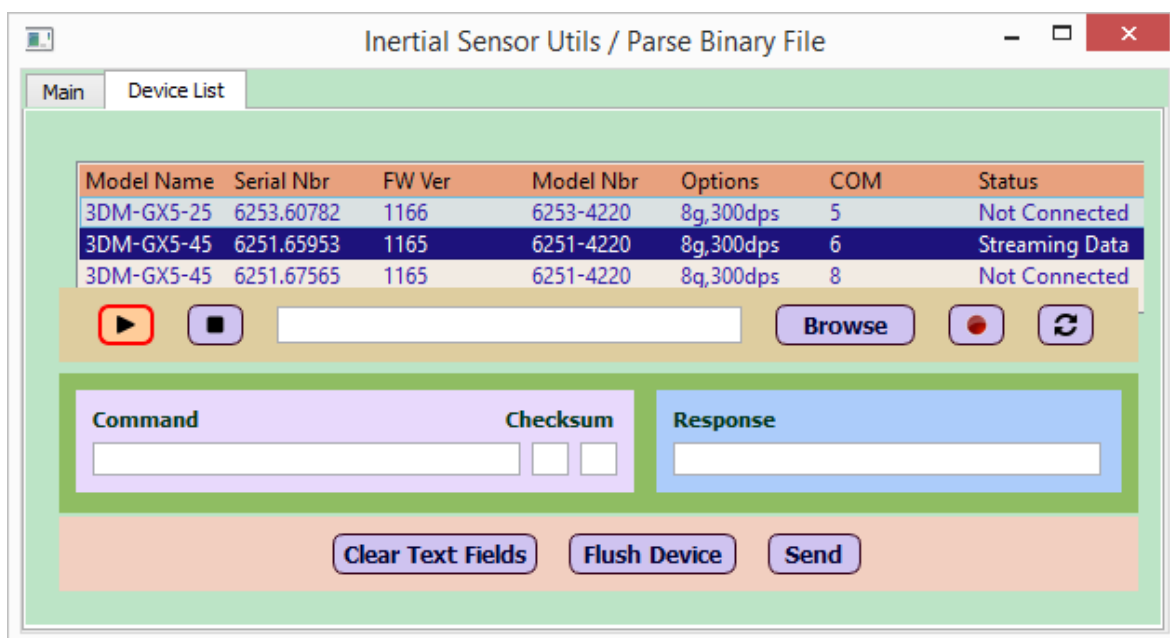


Figure 52 - Clicking on Stream Button

(B) The user clicks on Browse button and accepts the filename and location suggested by the utility:

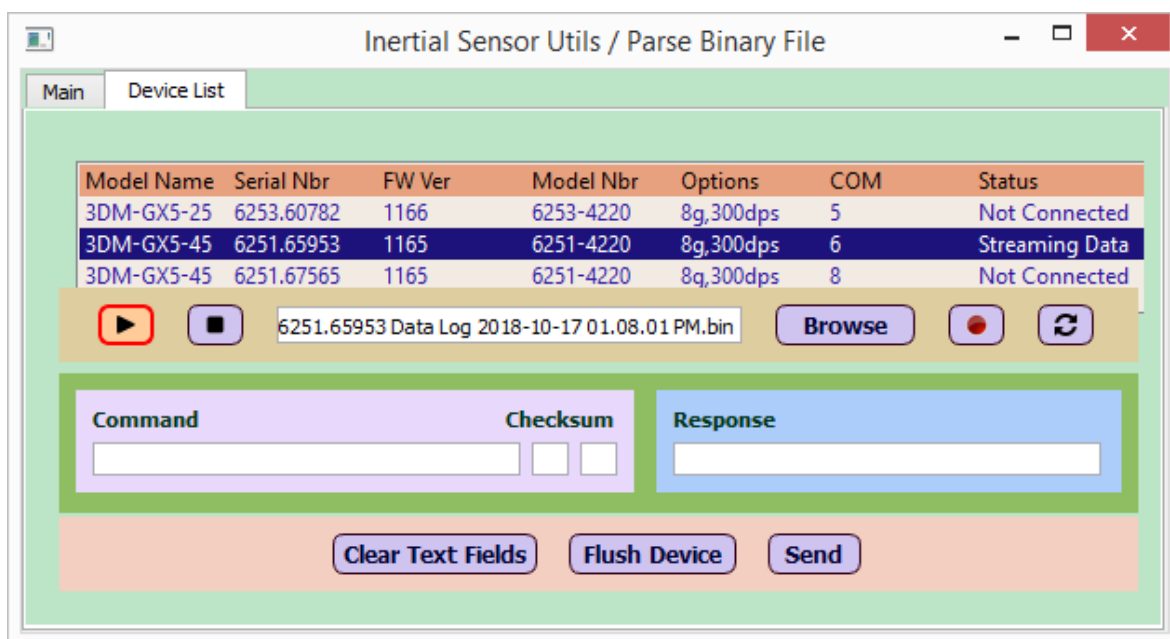


Figure 53 - Specifying Log File Name Using Browse Button

(C) The user clicks on the Record button, which changes to a “Stop Record” icon with a red border. The Status of the device changes to “Recording Data” as shown below:

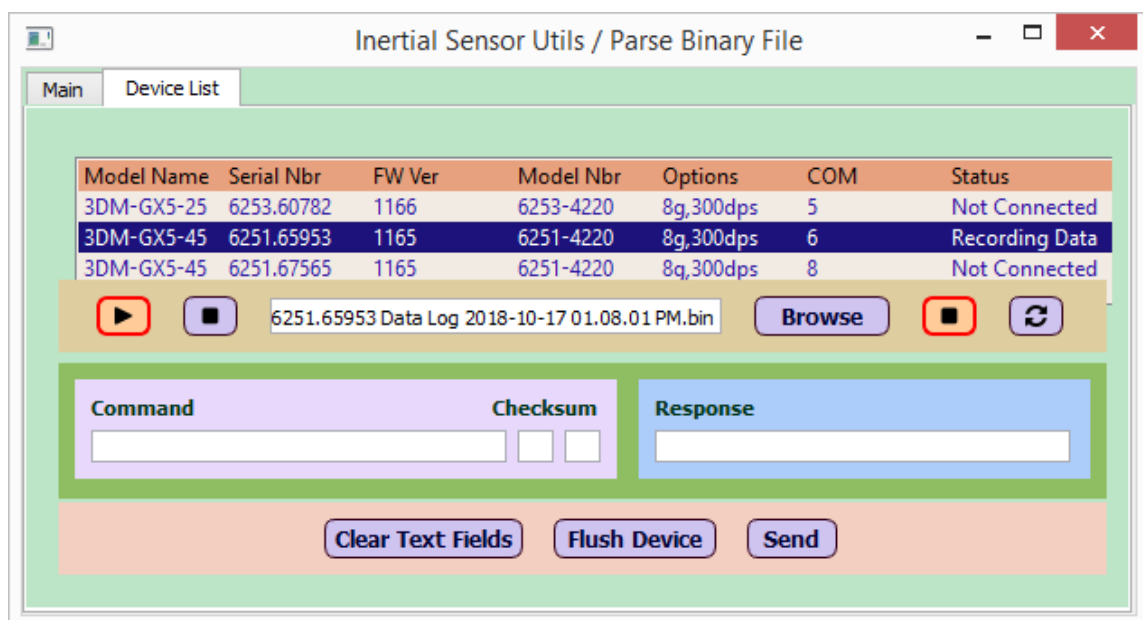


Figure 54 - Clicking on Record Button While Streaming

(D) The user clicks on the Record button again to stop recording, and it pops a message asking if the user wants to close the file as shown below:

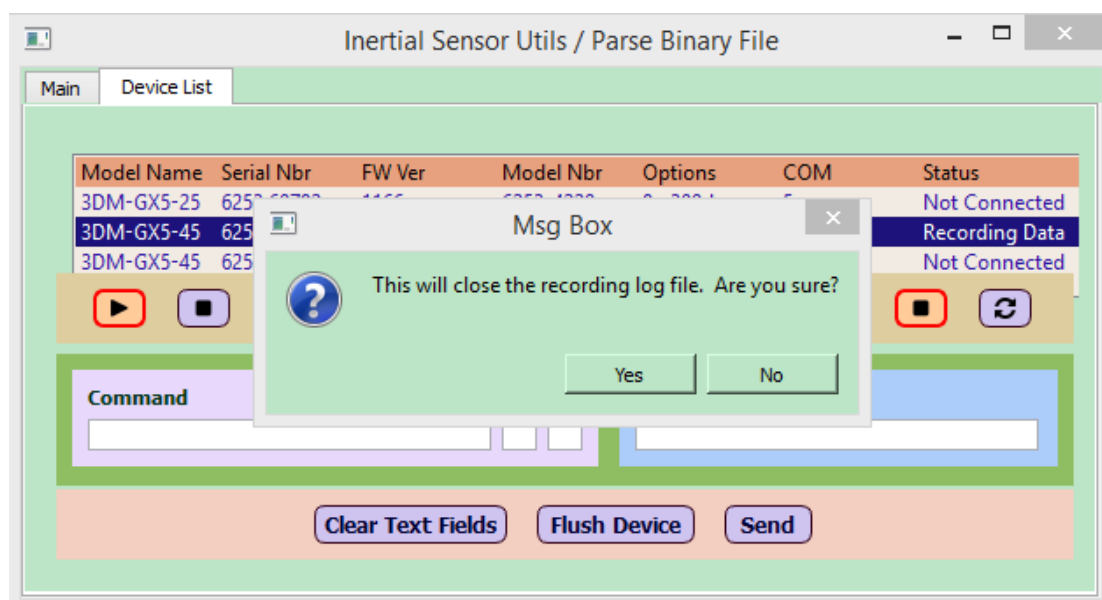


Figure 55 - Clicking on Record Button Again to Stop Recording

(E) The user clicks Yes in response. The utility closes the log file. The Status of the device changes back to “Streaming Data” as shown below:

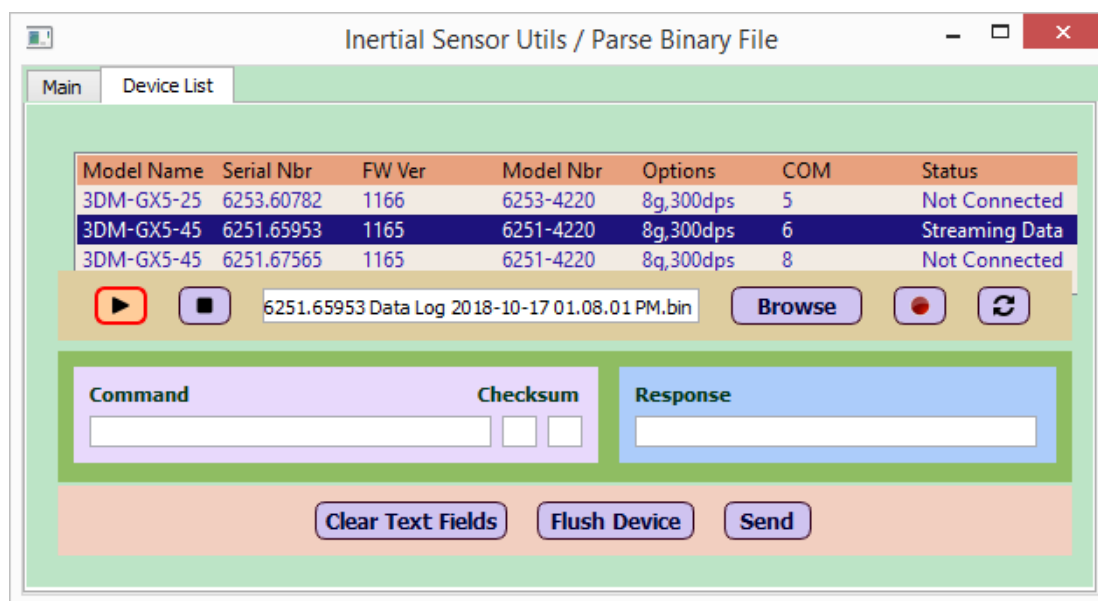


Figure 56 - Recording Over, Back to Streaming State

(F) In Step (D), the user could click on the “Stop Streaming” button instead of the Record button, to stop the recording. That would stop the streaming in addition to recording. The Record button would change its icon and appearance to a “Waiting to Record” with a green border, and the device status would change to “Waiting to Record” as shown below:

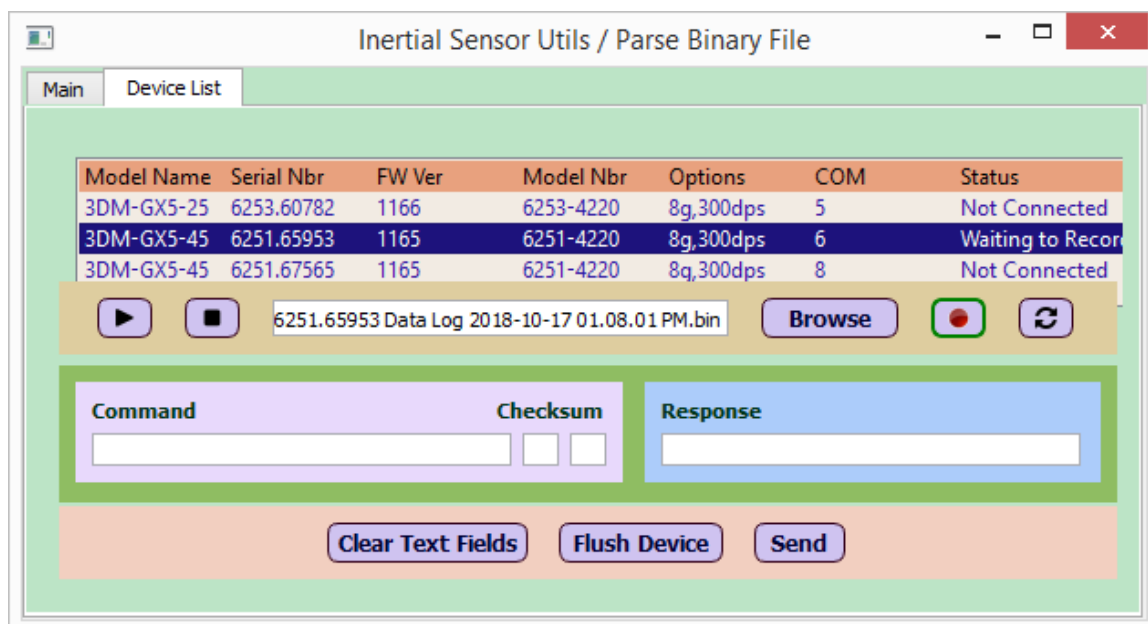


Figure 57 - Clicking on Stop Streaming Button Instead of Record Button to Stop Recording

(G) If the user decides to not record anymore on that file, click the Record button while it is in the “Waiting to Record” mode. A pop up message asks if the user wants to close the log file, as shown below:

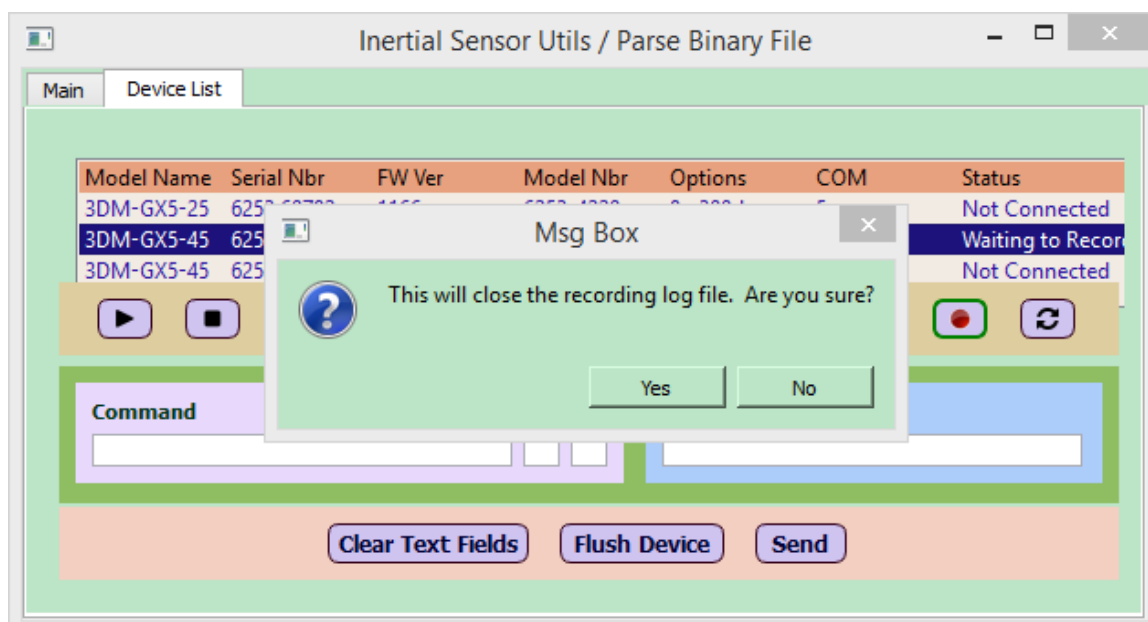


Figure 58 - Clicking on Record Button While in Waiting To Record Mode

(H) Alternatively, after step (F), the user can record more output onto the same log file by clicking on the Stream button while the Record button is in the “Waiting to Record” mode. That would change the Record button to the “Stop Record” icon and mode, and the device status to “Recording Data” as shown below:

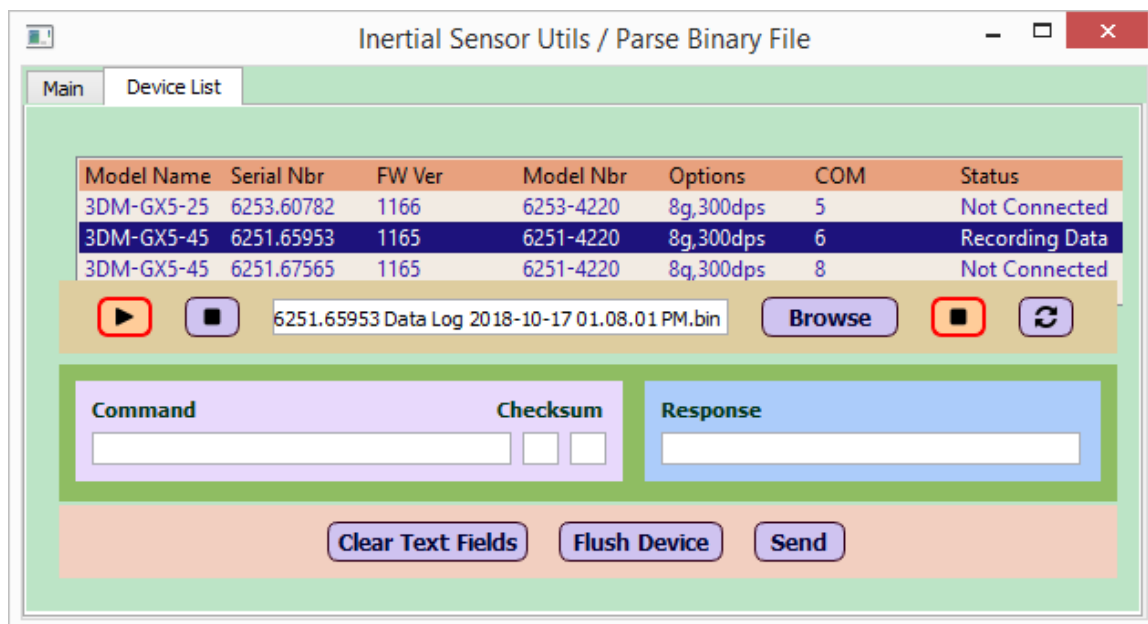


Figure 59 - Recording Multiple Log Sessions on Same File Using Stream/Stop Stream Buttons

(I) To stop recording there are two options: click on the Stop Streaming button (if he/she intends to record on the same log file in future), or click on the Record button (if he/she is done recording on that file).

The user can repeat this process any number of times to record data on same or different log file.

(J) After step (E), the user may click the Record button while the previously recorded filename is displaying. In this case, it pops a message asking if the user wants to overwrite the previous log file as shown below:

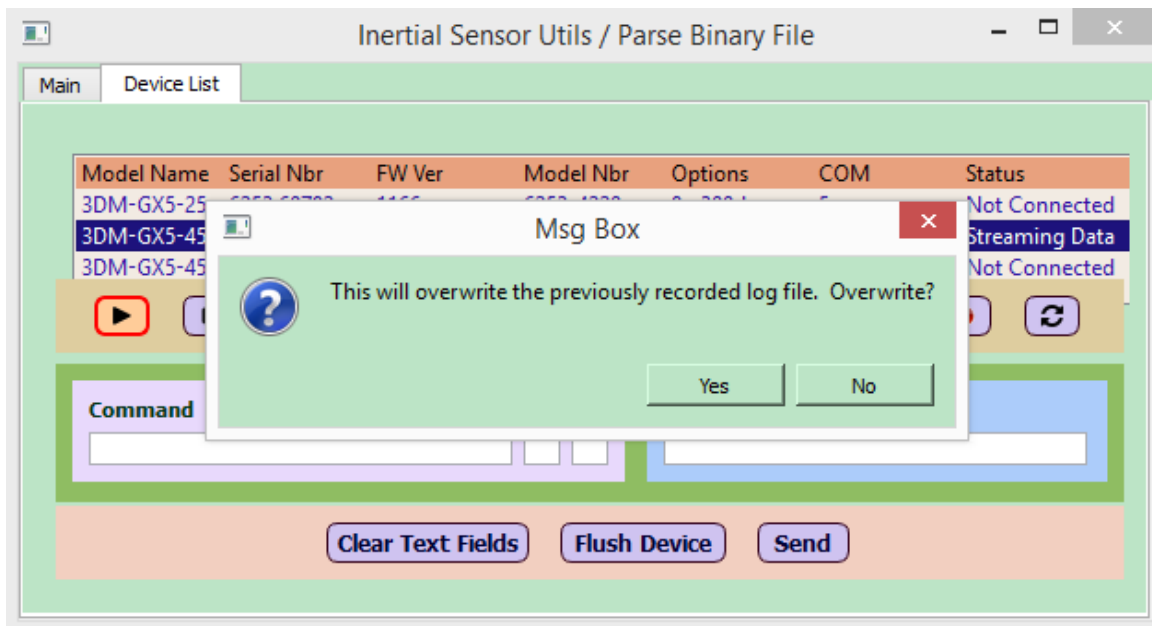


Figure 60 - Overwriting Existing Log File Using Record Button

(K) The user clicks Yes in response; that wipes out the content of the previous log file, change the Status of the device back to "Recording Data", and start new recording on that file as shown below:

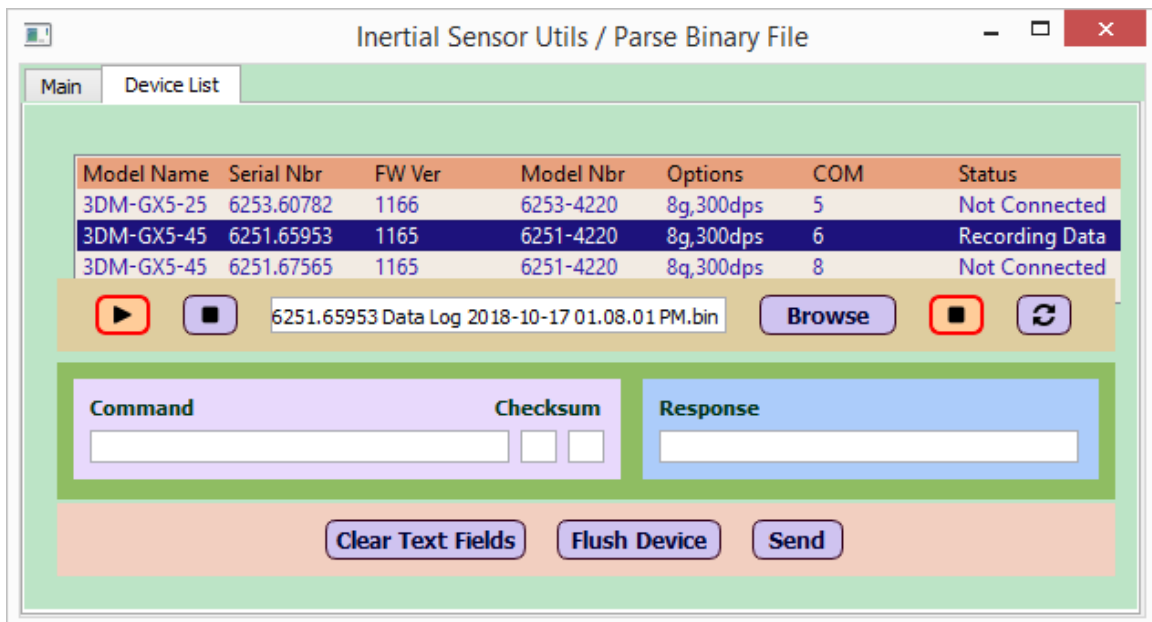


Figure 61 - Overwriting Existing Log File

(L) The user can repeat this process for several devices, so one device could be streaming data, the next one could be recording and a third one could be Waiting to Record. The utility remembers the device status and the current state of the buttons that apply to the selected device in the device list pane. For example:

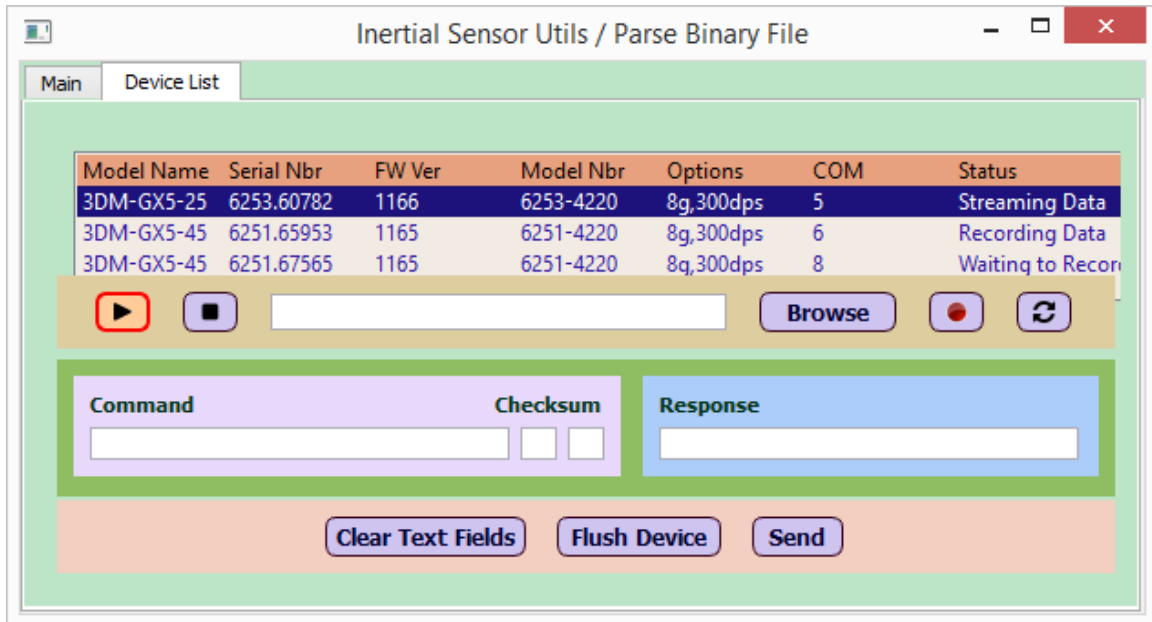


Figure 62 - Devices in Different States at the Same Time

6.3 Command-Response capability

This is a new feature in Release 2.0 that allows the user to send a complete command to any LORD inertial device and get a response back. The bottom pane of the Device List tab consists of Command-Response fields and a set of buttons to clear the text fields, flush device bytes, and to send a command to the device:

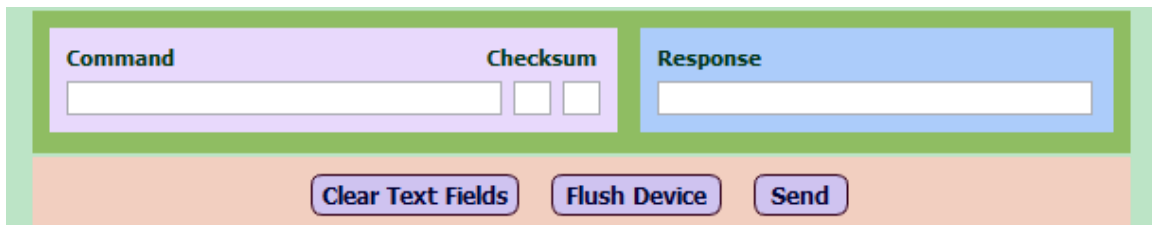


Figure 63 – Command, Check-sum and Response Text Fields in Device List Tab

The user can “copy-paste” any command from the device’s Data Communications Protocol (DCP) available on LORD Sensing web-site, or enter custom commands created using the DCP. While doing so, the check-sum bytes must be excluded. The utility computes the check-sum using the command bytes supplied and displays it in two read-only fields on the right of the Command field.

When the user clicks the Send button, the command bytes with the check-sum are sent to the selected device, and the response bytes are displayed in the Response field. The user is expected to refer to the DCP to decipher the content of the Response field and determine if it was an ACK or NACK.

As an example, the user may want to read back the Gyro Noise Standard Deviation on a particular device. The command to be used for this is [0x0D, 0x1B] (excluding check-sum bytes):

75 65 0D 03 03 1B 02

The user enters these bytes as the command and hits the Send button. The utility displays the response bytes as follows:

75 65 0D 12 04 F1 1B 00 0E 8A 39 06 37 BD 39 06 37 BD 39 06 37 BD 3A 37

Here, “39 06 37 BD” = 1.28e-4, so the Gyro Noise Std Deviation is 1.28e-4 in all 3 body axes (X, Y and Z).

The utility also displays the check-sum bytes [0A 1F] used in the sent packet.

The screen-shot would look like this:

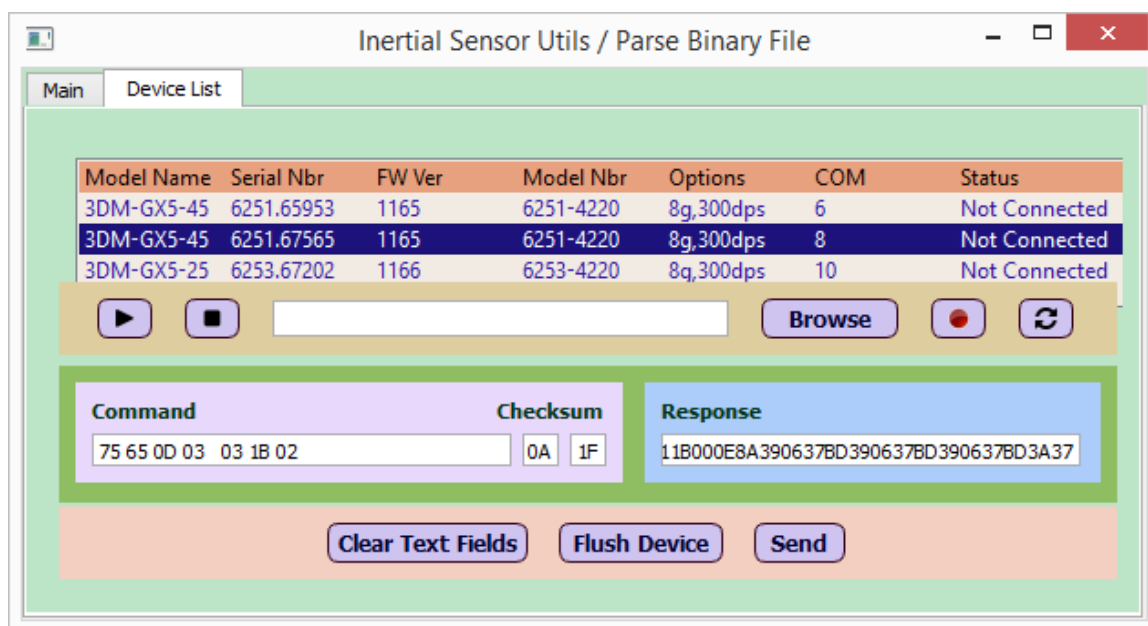


Figure 64 - Sending Command to Get Gyro Noise Std Deviation

6.4 Commonly used commands for reading back (or using new) device parameters

Commonly used commands to read back values are shown below, with sample responses:

[Note: Commands represent “read back settings” unless otherwise specified]

Descriptor Set / Field Descriptor Bytes	Description	Command [check-sum]	Response [check-sum]
0x01/0x04	Get Desc Set	75 65 01 02 02 04 [E3 C9]	75 65 01 2C 04 F1 07 00 28 86 0D28 0D2B 0D2C 0D4B 0D27 0D43 8225 8226 8228 8229 8251 8252 8253 8254 8255 825C 822A 822C 822D [E7 20]
0x01/0x07	Get Extended Desc Set	75 65 01 02 02 07 [E6 CC]	75 65 01 26 04 F1 07 00 22 86 0C21 0C22 0C23 0C24 0D28 0D29 0D2B 0D2C 0D47 0D4B 0D27 0D43 8225 8226 8228 8229 0F 86

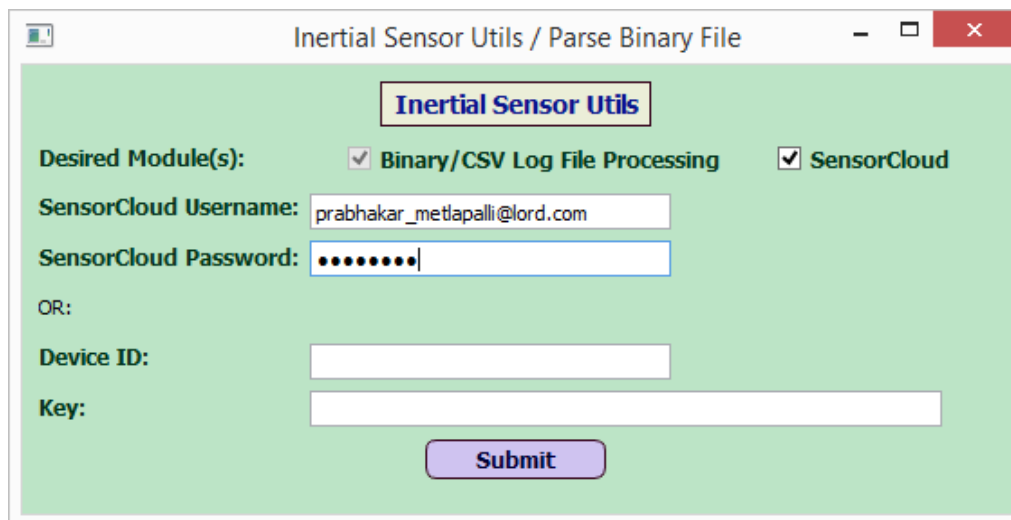
0x0C/0x3A	Mag Hard Iron Offset	75 65 0C 03 03 3A 02 [28 58]	75 65 0C 12 04 F1 3A 00 0E 9C 00 00 00 00 00 00 00 00 00 00 00 [D1 36]
0x0C/0x3B	Mag Soft Iron Offset	75 65 0C 03 03 3B 02 [29 5A]	75 65 0C 2A 04 F1 3B 00 26 9D 3F 80 00 00 00 00 00 00 00 00 00 00 00 00 3F 80 00 00 00 00 00 00 00 00 00 00 00 00 3F 80 00 00 [40 F7]
0x0C/0x0A	Estimation Filter Message Format [Use new settings]	75 65 0C 34 34 0A 01 10 11 0001 10 0001 01 0001 02 0001 08 0001 09 0001 05 0001 0A 0001 03 0001 12 0001 13 0001 14 0001 25 0001 26 0001 28 0001 29 0001 [95 05]	75 65 0C 04 04 F1 0A 00 [E9 BE]
0x0C/0x0A	Estimation Filter Message Format [Read back settings]	75 65 0C 04 04 0A 02 00 [FA F9]	75 65 0C 37 04 F1 0A 00 33 82 10 11 0001 10 0001 01 0001 02 0001 08 0001 09 0001 05 0001 0A 0001 03 0001 12 0001 13 0001 14 0001 25 0001 26 0001 28 0001 29 0001 [0D 8C]
0x0C/0x0A	Estimation Filter Message Format [Save current settings as startup]	75 65 0C 04 04 0A 03 00 [FB FB]	75 65 0C 04 04 F1 0A 00 [E9 BE]
0x0D/0x26	LLH Reference (on GX5-25)	75 65 0D 03 03 26 02 [15 35]	75 65 0D 1F 04 F1 26 00 1B 90 01 40 46 37 ED 11 0F F2 BC C0 52 46 CD 26 23 80 38 40 5E 69 CA C0 83 12 6F [00 58]
0x0D/0x1B	Gyro Noise Std Deviation	75 65 0D 03 03 1B 02 [0A 1F]	75 65 0D 12 04 F1 1B 00 0E 8A 39 06 37 BD 39 06 37 BD 39 06 37 BD [3A 37]
0x0D/0x1A	Accel Noise Std Deviation	75 65 0D 03 03 1A 02 [09 1D]	75 65 0D 12 04 F1 1A 00 0E 89 3D CC CC CD 3D CC CC CD 3D CC CC CD [85 22]
0x0D/0x1D	Gyro Bias Model Parameters	75 65 0D 03 03 1D 02 [0C 23]	75 65 0D 1E 04 F1 1D 00 1A 8C 00 00 00 00 00 00 00 00 00 00 00 37 27 C5 AC 37 27 C5 AC 37 27 C5 AC [2A 5B]

0x0D/0x2B	Hard Iron Offset Process Noise	75 65 0D 03 03 2B 02 [1A 3F]	75 65 0D 12 04 F1 2B 00 0E 96 38 D1 B7 17 38 D1 B7 17 38 D1 B7 17 [42 A8]
0x0D/0x2C	Soft Iron Offset Process Noise	75 65 0D 03 03 2C 02 [1B 41]	75 65 0D 2A 04 F1 2C 00 26 97 38 D1 B7 17 38 D1 B7 17 38 D1 B7 17 38 D1 B7 17 38 D1 B7 17 38 D1 B7 17 38 D1 B7 17 38 D1 B7 17 38 D1 B7 17 [7E 31]
0x0D/0x42	Mag Noise Std Deviation	75 65 0D 03 03 42 02 [31 6D]	75 65 0D 12 04 F1 42 00 0E B1 3D CC CC CD 3D CC CC CD 3D CC CC CD [D5 AA]
0x0D/0x28	Grav Noise Std Deviation	75 65 0D 03 03 28 02 [17 39]	75 65 0D 12 04 F1 28 00 0E 93 3D CC CC CD 3D CC CC CD 3D CC CC CD [9D 84]
0x0D/0x20	Zero Angular Rate Update Control	75 65 0D 03 03 20 02 [0F 29]	75 65 0D 0B 04 F1 20 00 07 8E 00 3C 56 A1 62 [31 5F]
0x0D/0x44	Gravity Mag Error Adaptive Measurement	75 65 0D 03 03 44 02 [33 71]	75 65 0D 1F 04 F1 44 00 1B B3 02 42 C8 00 00 BF 00 00 00 3F 00 00 00 40 00 00 00 40 00 00 00 3F 80 00 00 [56 1D]
0x0D/0x45	Mag Magnitude Error Adaptive Measurement	75 65 0D 03 03 45 02 [34 73]	75 65 0D 1F 04 F1 45 00 1B B4 02 42 C8 00 00 BD CC CC CD 3D CC CC CD 3D CC CC CD 3D CC CC CD 3D 4C CC CD [45 7D]
0x0D/0x19	Auto-Initialization Control	75 65 0D 03 03 19 02 [08 1B]	75 65 0D 07 04 F1 19 00 03 88 01 [88 FF]
0x0D/0x18	Heading Aid Control	75 65 0D 03 03 18 02 [07 19]	75 65 0D 07 04 F1 18 00 03 87 01 [86 F8]
0x0D/0x4B	Pitch/Roll Aid Control	75 65 0D 03 03 4B 02 [3A 7F]	75 65 0D 07 04 F1 4B 00 03 BB 01 [ED 5F]
0x0D/0x14	Estimation Control Flags	75 65 0D 03 03 14 02 [03 11]	75 65 0D 08 04 F1 14 00 04 84 FF 80 [FF E6]

7. Logging In With SensorCloud Option Selected

The 'SensorCloud' box must be checked to view sensor data already uploaded to SensorCloud™ (<http://www.sensorcloud.com/>), and/or uploading new sensor data to it. When the 'SensorCloud' box is checked, it enables the SensorCloud™ Username/Password and Device ID/Key fields on that window. The user can either enter the SensorCloud™ Username/Password OR the Device ID and Key.

When the user enters the Username/Password combination before hitting Submit, it looks like this:

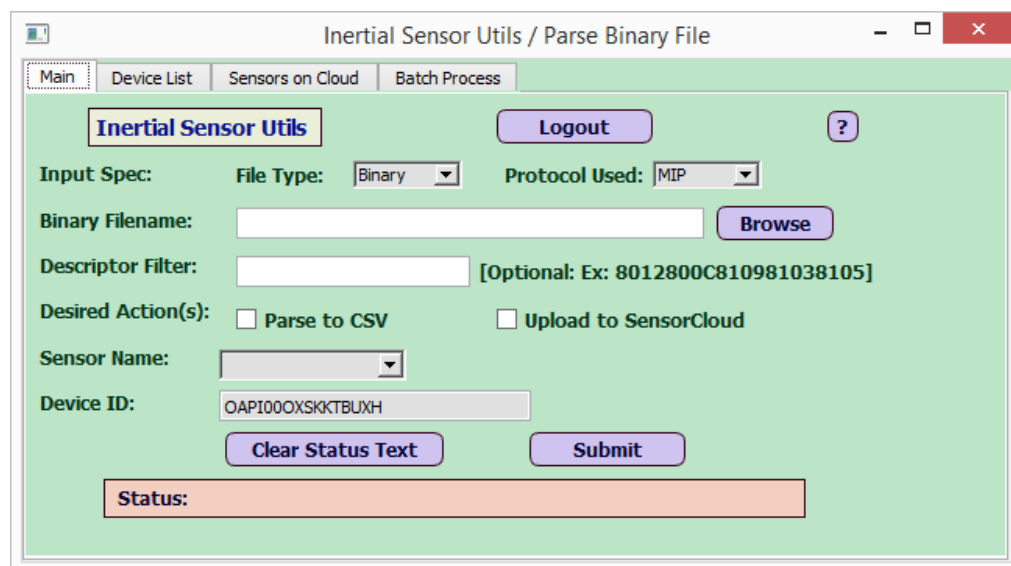


The screenshot shows a window titled "Inertial Sensor Utils / Parse Binary File". Inside, there's a section titled "Inertial Sensor Utils". Under "Desired Module(s)", both "Binary/CSV Log File Processing" and "SensorCloud" are checked. The "SensorCloud Username" field contains "prabhakar_metlapalli@lord.com". The "SensorCloud Password" field is masked with dots. Below these, there's an "OR:" label, followed by "Device ID:" and "Key:" fields. A "Submit" button is at the bottom.

Figure 65 - Log In Window With SensorCloud™

Once the user hits Submit, it figures out the Device ID assigned to that user on SensorCloud™. Each user on SensorCloud™ gets a single Device ID. Multiple sensors can be added under that single Device ID. Note that the term “device” in SensorCloud™ is not the same as a physical “device” used in the Device List tab, where the word “device” meant a single physical sensor such as GX5-45 or GX5-25. In SensorCloud™, a “device” is a collection of one or more physical sensor(s).

Select Submit on the log on window to open a new window with the Device ID field at the bottom:



The screenshot shows the same window after logging in. The "Main" tab is selected. The "Inertial Sensor Utils" section now includes a "Logout" button and a help icon (?). The "Input Spec:" field is empty. "File Type:" is set to "Binary" and "Protocol Used:" is set to "MIP". The "Binary Filename:" field is empty with a "Browse" button. The "Descriptor Filter:" field is empty with a note "[Optional: Ex: 8012800C810981038105]". Under "Desired Action(s)", both "Parse to CSV" and "Upload to SensorCloud" are unchecked. The "Sensor Name:" field is empty. The "Device ID:" field contains "OAPI000XSKKTBUXH". There are "Clear Status Text" and "Submit" buttons. At the bottom, there's a "Status:" field.

Figure 66 - View After Selecting Submit Using Username / Password

Instead of Username/Password, a user can also enter a Device ID directly on the log on window. However in that case, the app expects the user to enter a Key value as well. This is to prevent inadvertent use of the Device ID by users other than its owner. The Key is specific to a device and can be obtained by registering at <http://www.sensorcloud.com/>. The key expires after about 12 hours (max 24 hours) and the user needs to log in at <http://www.sensorcloud.com/> and generate a new key.

The following snap-shot shows the user entering the Device ID/Key combination before hitting Submit:

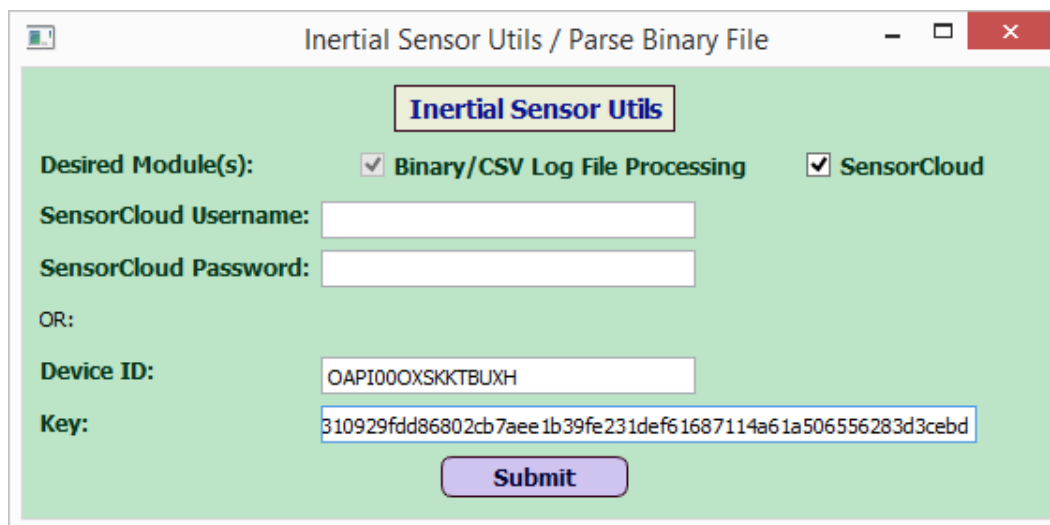


Figure 67 - Log In Using Device ID/Key

After the user hits Submit, the window opens as before, but this time there is a new Key field below the Device ID field as shown below:

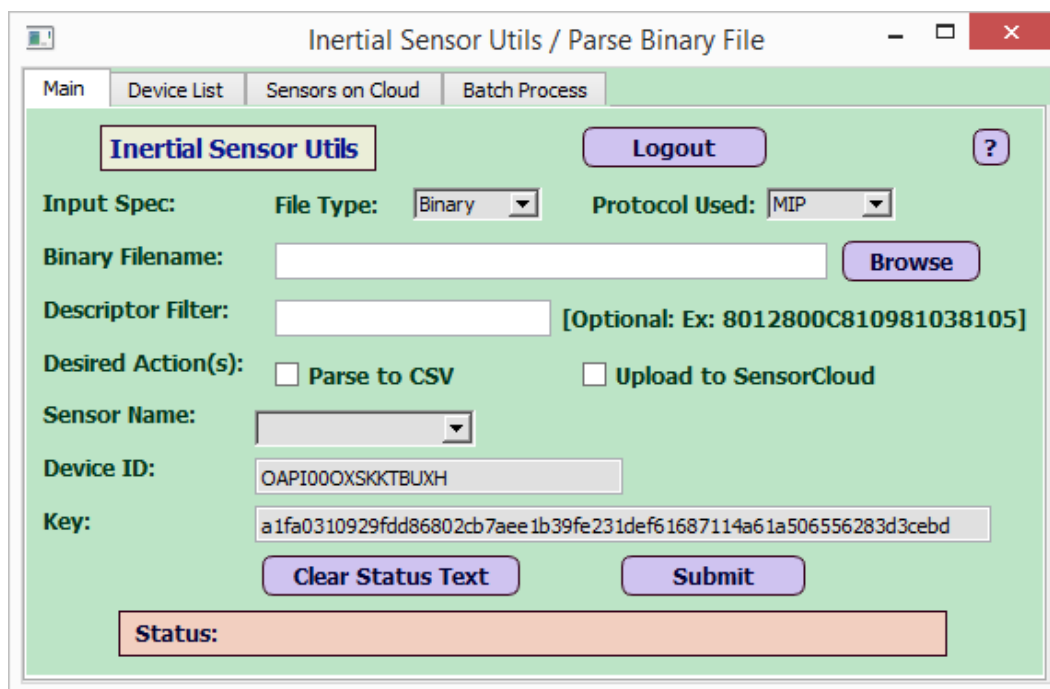


Figure 68 - View After Selecting Submit Using Device ID / Key

Note that with 'SensorCloud' checked, there are two extra tabs called 'Sensors on Cloud' and 'Batch Process' that show up after the 'Device List' tab. These tabs do not display when the 'SensorCloud' check-box is unchecked. With 'SensorCloud' checked, the screen displays an extra check-box labeled 'Upload to SensorCloud' as shown below. This check-box shows for both file types (binary and csv).

Figure 69 - Upload A CSV File To SensorCloud™

By checking that box, the user can upload a binary or csv file directly to SensorCloud™, provided the csv file (or csv equivalent of the binary) contains non-zero GPS Week and GPS Time-of-Week columns.

7.1 'Sensors on Cloud' Tab

When the user clicks on the 'Sensors on Cloud' tab, it loads and displays all sensors for the user's "device id" on SensorCloud™. Currently it assumes that each user has only one "device" on SensorCloud™, with one or more sensors associated to that device.

On the bottom of this tab, it shows the same 7 buttons for plotting data as on the CSV data tab described in section 5.4.1, which work in a similar way, with the following differences:

- Replace the 'CSV object name' with 'Sensor'
- The user can (optionally) select a TOW column as the X-axis. In this case, the plot would look the same as on the CSV Data tab. If the user does not select a TOW column on this tab, it uses the Unix Timestamp for that column as the X-axis. Note that the TOW column was required in the CSV Data tab, but is optional in the "Sensors on Cloud" tab because it has a default option of using the Unix Timestamp as the X-axis.

With SensorCloud™ enabled, if the channels have different data rates (Hz), then the slower message columns cannot be plotted vs TOW on the "Sensors on Cloud" tab. The user must select only the slower message column and unselect TOW, so that it plots the column as a function of Unix Timestamp (the default). This is because on SensorCloud™, only the Unix Timestamps are associated to each individual value of the column (or channel), but not the TOW. Different Unix timestamps are possible for each column on a given row of a csv. If the user chooses to plot such column vs TOW, it would show an error message stating that the TOW must have the same length as the column to plot.

A sample 'Sensors on Cloud' tab is shown below with 4 sensors associated with a device ID:

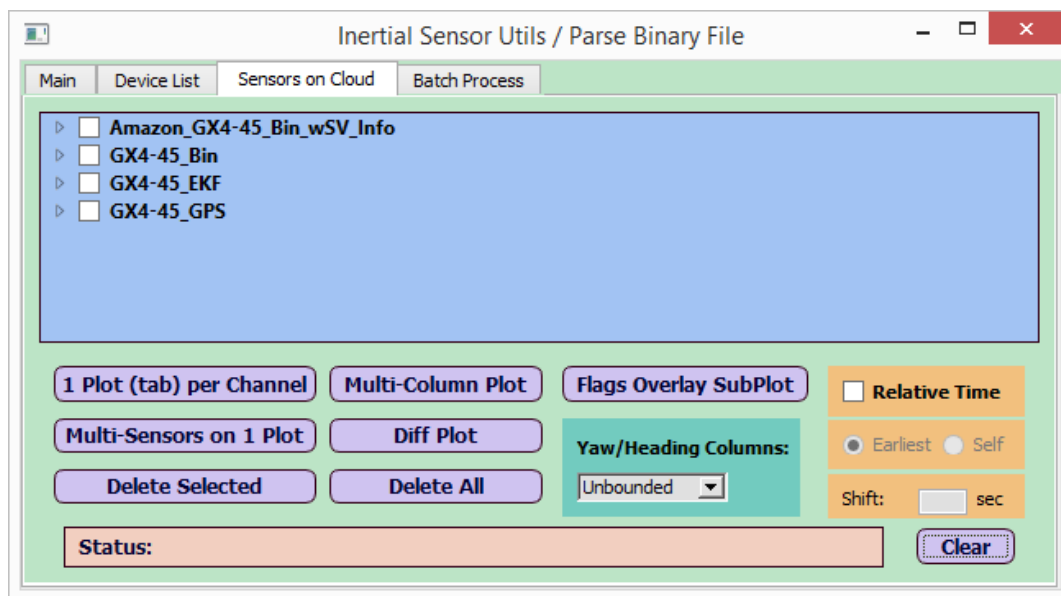


Figure 70 – Sensors on Cloud Tab

Each sensor has one or more channels. A channel is similar to a column in a csv file. The channel names for each sensor in the “Sensors on Cloud” tab are sorted into the same sequence as the columns in a csv file obtained by parsing a binary file in this utility.

When logging with 'SensorCloud' checked, the user can check 'Upload to SensorCloud' as one of the Desired Actions, as shown in Figure 71 below. This enables the Sensor Name drop-down field so the user can either enter a new sensor name or pick an existing sensor from the drop-down.

- If an existing sensor is selected, the upload would append new data to existing content on SensorCloud™ for that sensor.
- If a new sensor is entered, it would create a new sensor on SensorCloud™ and upload the data to that sensor.

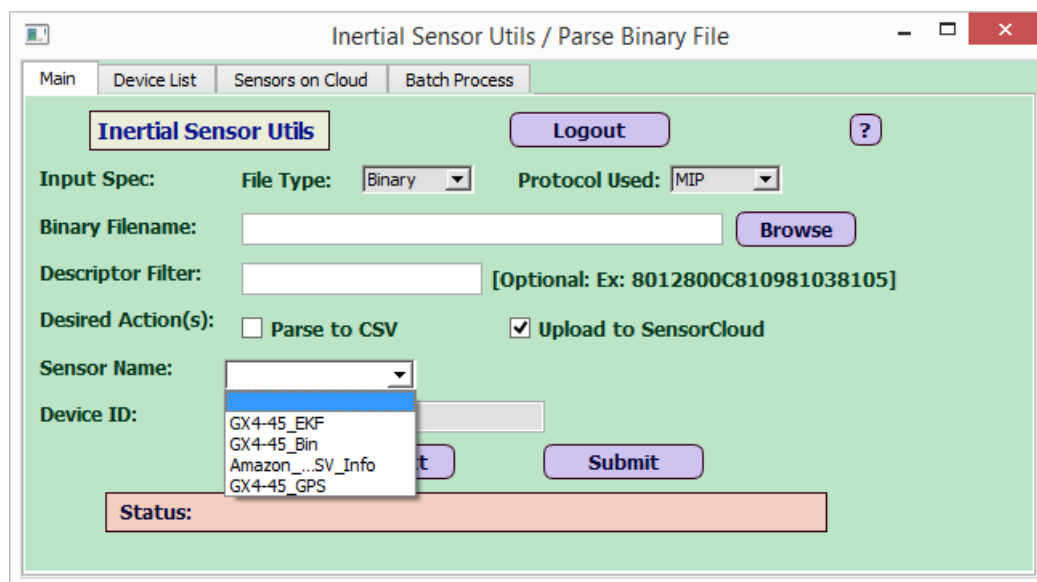


Figure 71 - Uploading A New Sensor To SensorCloud™

Notes:

- The file must have GPS Week and TOW in order to upload to SensorCloud. These are used to compute the UNIX Timestamp stored against each data value in SensorCloud.
- The user can also delete one or more sensors from SensorCloud (this can currently be done only via this utility; one cannot delete sensors using the actual SensorCloud web-site).

7.2 Batch Process Tab

When logging in with 'SensorCloud' checked, it shows an extra tab called 'Batch Process'. The user can upload up to 5 binary and/or csv files at a time to SensorCloud™ using this tab. The interface is shown below:

Inertial Sensor Utils / Parse Binary File

Main Device List Sensors on Cloud **Batch Process**

Batch Process for SensorCloud Upload

File Type	Protocol	Filename	Descriptor Filter	Sensor Name
Binary	MIP		Browse	
Binary	MIP		Browse	
Binary	MIP		Browse	
Binary	MIP		Browse	
Binary	MIP		Browse	

Clear Status Text Submit

Status:

Figure 72 - Batch Process Tab Menu

At the end of the job, it generates a Batch Process Report as a .csv file with the timestamp of the batch request included in the filename (example: "BatchProcess_Report_2017-01-11_15_48_51.csv", content shown below). The report would reside in the 'root' folder (location of QInertialSensorUtils_GUI.exe)

***** Batch Process Report for command issued at: 2017-01-11 15:48:51

File					
Row	Type	Protocol	Filename	Sensor Name	Status
1	CSV	MIP	GPS_Log.csv	GX4-45 GPS csv	ERROR: CSV File must have GPS TOW col
2	Binary	MIP	GX4-45 6-30-2016.bin	GX4-45 GPS	DONE Batch Process: Time taken: 60 sec
3	Binary	MIP	GX5-45 7-19-2016.bin		ERROR: Sensor name cannot be empty
4	Binary	MIP		ExampleSensor	ERROR: File name cannot be empty
5	CSV	MIP	EKF_Log.csv	GX4-45 EKF csv	DONE Batch Process: Time taken: 31 sec

7.3 GPS Leap Seconds

When uploading to SensorCloud™ or creating a .gpx file from .csv, it converts the GPS Timestamp to a Unix Timestamp. To convert from GPS to UTC time, it uses 18 leap seconds as a default (valid for Jan 2017 and later). If GPS Week is less than 1930 (the first week of 2017), it uses 17 leap seconds as difference between GPS and UTC, so that should cover log files obtained during the second half of 2016.

7.4 Parsing binary log and uploading to SensorCloud at the same time

- The 'Upload to SensorCloud' check-box shows for both Binary and CSV File Type. By checking that box, the user can upload a binary or csv file directly to SensorCloud, provided the file contains a non-zero GPS Week column and a GPS Time-of-Week (TOW) column as well.
- If file type is Binary, the user can check both boxes: 'Parse to CSV' and 'Upload to SensorCloud'. In that case, as the binary file is parsed to csv, data is also uploaded to SensorCloud at the same time.
- If the csv file (or binary file) has more than 1,00,000 rows, the tool uploads 1,00,000 rows at a time to SensorCloud.
- Currently Lat/Lon channels are uploaded as 'floats' instead of 'doubles' due to SensorCloud limitation, giving step-like pattern in lat-lon plots.