



**mmVu™ 3.0**  
**Server**

**Precision Position Monitoring**

---



Knowledge Park, Suite 130  
40 Crowther Lane  
Fredericton, NB, Canada  
E3C 0J1

[www.gemini-navsoft.com](http://www.gemini-navsoft.com)

## Contents

1. Foreword .....	5
2. Description .....	6
2.1 Overview .....	6
2.2 System Configuration.....	7
2.3 System Field Setup .....	8
3. mmVu™ Server Layout .....	9
3.1 mmVu™ Server Window .....	9
3.2 Server Status Window.....	10
3.3 Station Status Window.....	11
3.4 Baseline Status Window.....	12
4. mmVu™ Server Menus.....	14
4.1 Project Menu.....	14
4.1.1 Project   New .....	14
4.1.2 Project   Open.....	14
4.1.3 Project   Close.....	15
4.1.4 Project   Exit .....	15
4.2 Security Menu .....	15
4.3 Special Features .....	16
4.3.1 Special Features   Integrity Monitoring Services.....	16
4.4 About Menu .....	21
4.5 Authorization .....	22
5. mmVu™ Server Buttons .....	24
5.1 Settings   Stations.....	24
5.1.1 Settings   Stations   Identifier .....	25
5.1.2 Settings   Stations   Station Data .....	26
5.1.3 Settings   Stations   Coordinates.....	27
5.1.4 Settings   Stations   Hardware .....	29
5.2 Settings   Baselines.....	30
5.3 Settings   Engine .....	31

---

5.4 Settings   Auto .....	35
5.5 Monitoring .....	35
6. Input and Output Files .....	38
6.1 Directory System .....	38
6.2 Project Files .....	39
6.3 Raw Data Files .....	39
6.4 Baseline Processing Files .....	40
6.4.1 Solution File .....	41
6.4.2 Residual File .....	42
6.4.3 Outlier File .....	42
6.4.4 Observation Information File .....	42
6.5 Event Log Files .....	43
6.6 Project File Description .....	43
6.7 Effect of Q Value .....	46
6.8 Effect of TC Value .....	46

## 1. Foreword

Congratulations on purchasing a Gemini Navsoft Technologies' (GNT) product. Gemini technology is built upon years of research and developments that have allowed us to deliver the highest level of GNSS positioning performance. This manual describes the operation of mmVu™ 3.0 Server software so that you can configure and deploy your own monitoring system.

No software can account for a prerequisite understanding of GNSS and the conditions that optimize GNSS performance. Gemini provides supporting manuals, documentation and training services to help you to gain this understanding. This combination of mmVu™ 3.0 processing technology and system deployment knowledge will help you to maximize the return on your purchase.

## 2. Description

### 2.1 Overview

mmVu™ 3.0 Server is a unique processor of GPS carrier phase observations that allows for mm level, relative position determination. It has been specifically designed for both short- and long-term deformation monitoring applications where monitored stations are moving several mm per day or less. mmVu™ 3.0 Server uses the Global Positioning System (GPS) to continuously monitor the stability of stations of interest. The user has the ability to configure stations in mmVu™ 3.0 Server so that data is captured and processed using the mmVu™ 3.0 processor. The unique processing technology allows for high precision position updates so that the user is continuously informed of the status of the monitored stations.

mmVu™ 3.0 Server utilizes parallel processing techniques to optimize positioning performance in your environment. One processor utilizes GNT's proprietary Time-Delayed Doppler (TDD) filter. A second engine utilizes GNT's sophisticated filter using Double-Differenced Carrier (DDC) observations. These results are utilized to achieve mm level and sub-mm trend analysis. This unique technology delivers robust quality control and performance assurance to help you achieve your positioning needs in the most challenging GNSS environments.

The TDD filter is characterized as a band pass filter that can mitigate the error sources and noise of GPS observations having low- and high-frequency components in their error spectrum. Due to the nature of the TDD observations, sufficient time must be given to allow the filter to converge on the true position before being able to reliably track movements. The GPS environment (satellite visibility and geometry) will dictate how long this convergence period will take. In areas of good satellite visibility and geometry, convergence on the true position with cm level precision typically occurs within 1-2 hours and with mm level precision in less than 12 hours. In areas of poor satellite visibility and poor satellite geometry, 24 hours may be required for the filter to converge to mm level. The TDD approach does not require the integer ambiguity of the number of wavelengths to be resolved, providing certain processing advantages.

The DDC filter is a regularized low pass filter that factors the quality of DDC observations and a time constant in a smoothing process. A regularization process is implemented to make the DDC filter quickly extract displacement trends with mm level precision in less than a few hours. The DDC filter is characterized as a finite impulse response (FIR) filter. Due to the nature of the DDC observations, cm level accuracy positioning solutions can be obtained instantaneously by resolving their ambiguities. Rigorous quality control is employed to verify ambiguity resolution so that the highest positioning performance can be provided.

## 2.2 System Configuration

mmVu™ 3.0 software system is comprised of three sub-systems, including mmVu™ Server, mmVu™ Engine and mmVu™ Client. As illustrated in Figure 1, each mmVu™ sub-system is connected through Ethernet TCP/IP and UDP communications.

As each mmVu™ sub-system runs independently, mmVu™ 3.0 can be configured on either a single hardware platform or multiple server computers. According to users' requirements, the system configuration of mmVu™ 3.0 can be optimized.

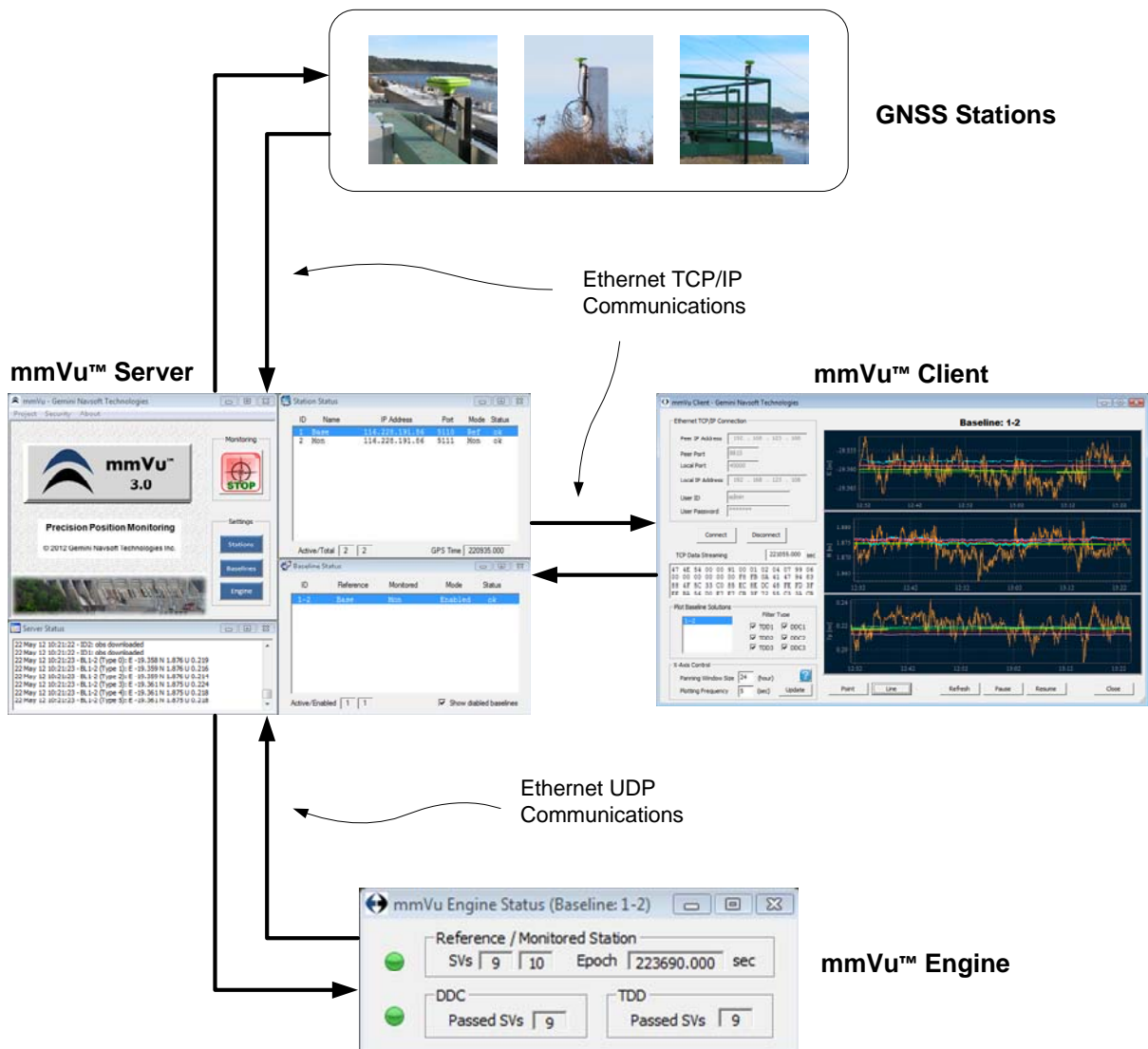


Figure 1: mmVu™ 3.0 system configuration

### 2.3 System Field Setup

A typical field setup of mmVu™ 3.0 is illustrated in Figure 2.

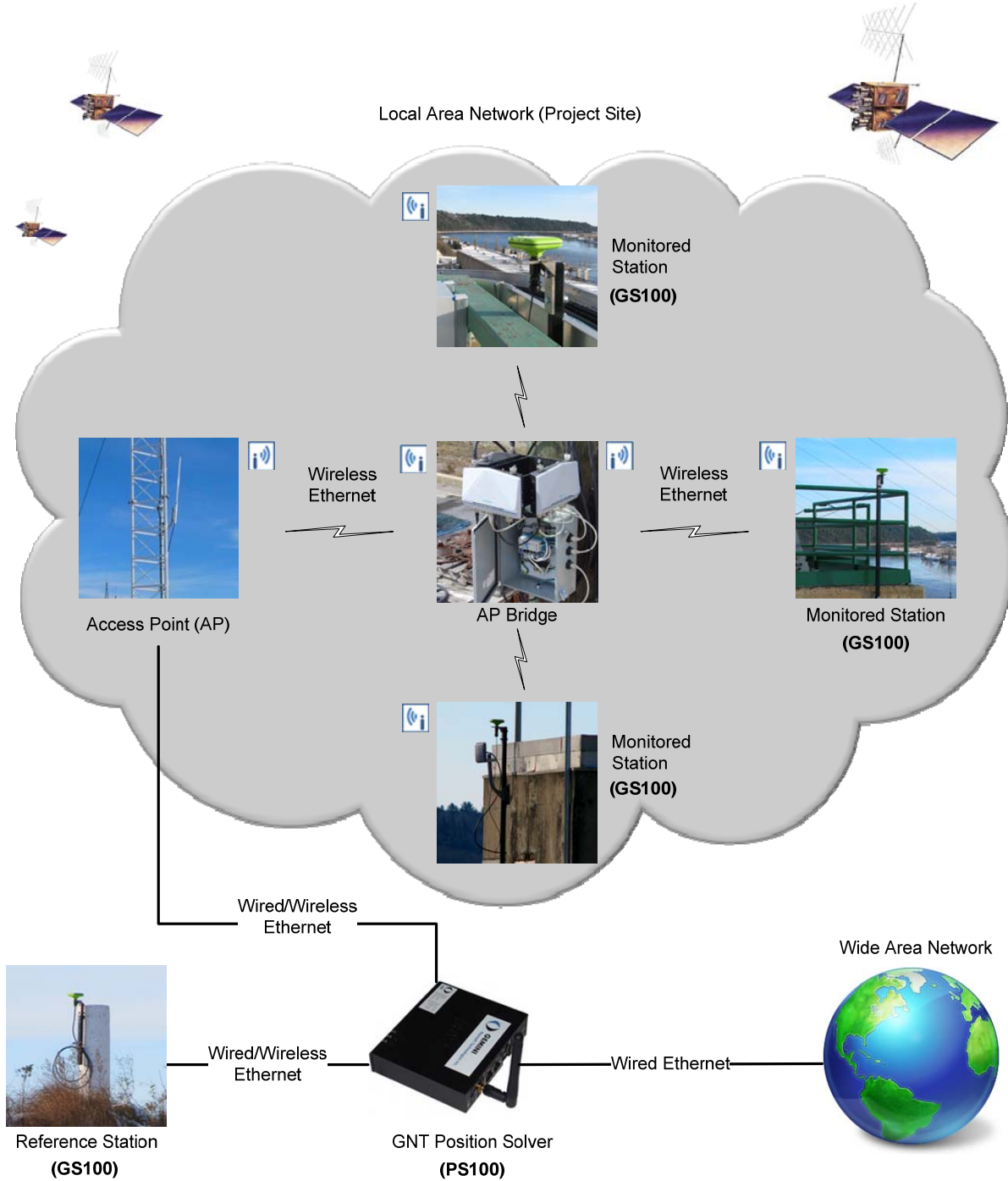


Figure 2: mmVu™ 3.0 field setup



## 3. mmVu™ Server Layout

The mmVu™ Server sub-system comprises four sub-windows as illustrated in Figure 3, including mmVu™ Server, Server Status, Station Status and Baseline Status.

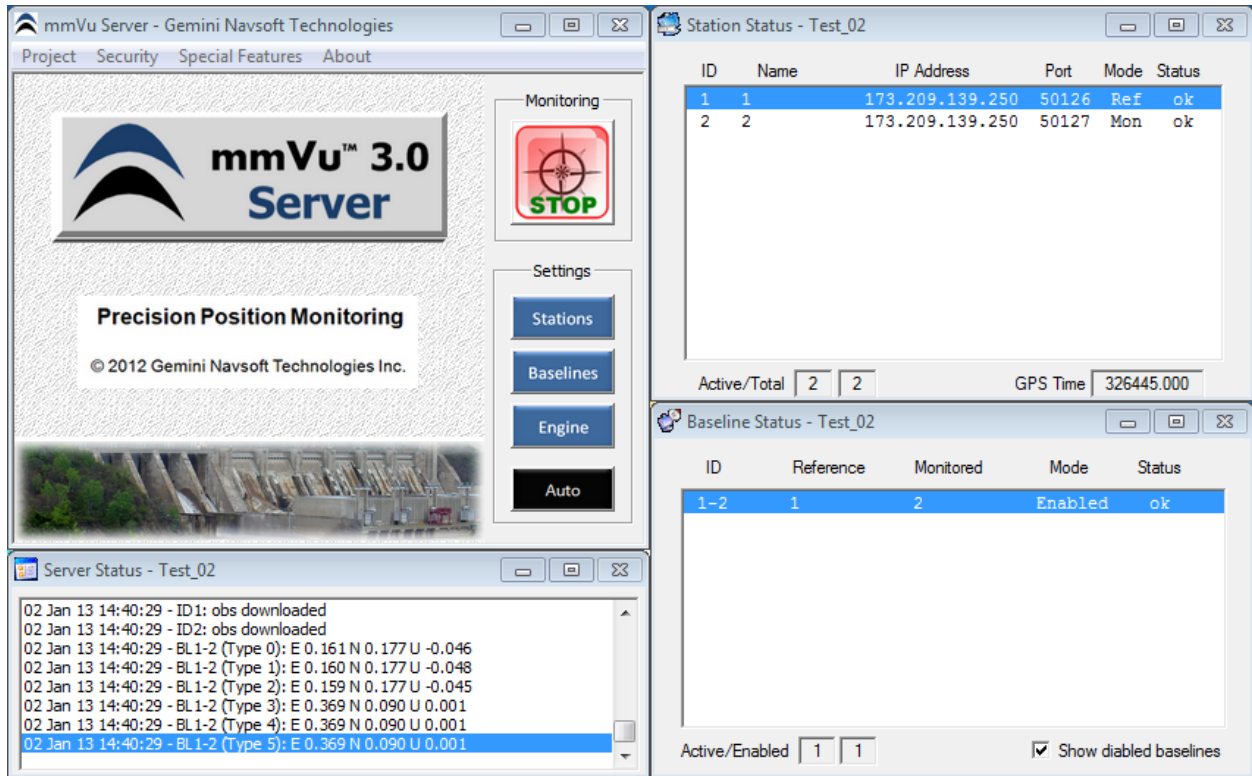


Figure 3: mmVu™ Server layout

### 3.1 mmVu™ Server Window

As shown in Figure 4, the mmVu™ Server window is the main window of mmVu™ 3.0. The menu system is used to access the utilities for project registration, user authorization, and license information (see Section 4. *mmVu™ Server Menus*). The utilities associated with user actions are activated through the button system (see Section 5. *mmVu™ Server Buttons*).



Figure 4: mmVu™ Server window

### 3.2 Server Status Window

The Server Status window displays main activities on the Server computer (PS100) such as Internet connection information of the Server and Stations, and user actions on the Server as shown in Figure 5. This information is logged in the Server database.

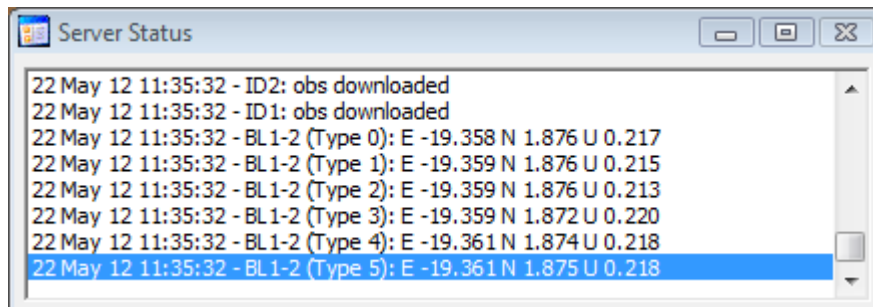


Figure 5: Server Status window

### 3.3 Station Status Window

The Station represents a GPS receiver/antenna that is used for recording GPS data at a geographical location of interest. Figure 6 illustrates status information of Stations.

The screenshot shows a window titled "Station Status" with a table of station data and summary statistics at the bottom.

ID	Name	IP Address	Port	Mode	Status
1	gnt1	173.209.139.250	50126	Ref	ok
2	gnt2	173.209.139.250	50126	Ref	ok
3	gnt3	173.209.139.250	50126	Ref	ok
4	gnt4	173.209.139.250	50126	Ref	--
5	shed1	173.209.139.250	50127	Mon	ok
6	shed2	173.209.139.250	50127	Mon	ok
7	shed3	173.209.139.250	50127	Mon	ok
8	shed4	173.209.139.250	50127	Mon	--

Summary statistics at the bottom of the window:

- Active/Total: 6 / 8
- GPS Time: 245580.000

Figure 6: Base Station Status

- **ID:** Unique Station identifier.
- **Name:** Station name.
- **IP Address:** Unique Station Ethernet IP address.
- **Port:** Station Ethernet port number.
- **Mode:** Type of Station (reference or monitored station).
- **Status:** Indicates the status of the Station receiver using the symbols outlined in Table 1.

Table 1: Symbol for status indication

Symbol	Indication
ok	Healthy
??	Unknown
--	Unhealthy

- **Active:** Number of active Stations.
- **Total:** Number of Stations registered.
- **GPS Time:** GPS Time in seconds at a given epoch.

### 3.4 Baseline Status Window

Figure 7 shows the status of Baseline. When the mmVu™ Server runs a project, it calls a series of the mmVu™ Engine and assigns the copied Engines to the corresponding Baselines.

ID	Reference	Monitored	Mode	Status
2-5	gnt2	shed1	Enabled	ok
2-6	gnt2	shed2	Enabled	ok
2-7	gnt2	shed3	Enabled	ok
2-8	gnt2	shed4	Enabled	--
3-5	gnt3	shed1	Enabled	ok
3-6	gnt3	shed2	Enabled	ok
3-7	gnt3	shed3	Enabled	ok
3-8	gnt3	shed4	Enabled	--
4-5	gnt4	shed1	Disabled	--
4-6	gnt4	shed2	Disabled	--
4-7	gnt4	shed3	Disabled	--

Active/Enabled    Show disabled baselines

Figure 7: Rover Status

- **ID:** Unique baseline identifier.
- **Reference:** Reference Station name.
- **Monitored:** Monitored Station name.
- **Mode:** Type of Baseline activation, “Enabled” or “Disabled”.
- **Status:** Indicates the status of Baseline using the symbols outlined in Table 2.

Table 2: Symbol for status indication

Symbol	Indication
ok	Baseline solution available
--	Not available

- **Active:** Number of active Baselines.
- **Enabled:** Number of Baselines enabled.
- **Show disabled baselines:** Check to display the disabled Baselines.

## 4. mmVu™ Server Menus

### 4.1 Project Menu

Project file utilities are located in the Project menu as illustrated in Figure 8. When a new project is created, a project folder is created within the “Projects” folder of the install directory. Separate folders are created for each Station and for each Baseline for archiving data and results.

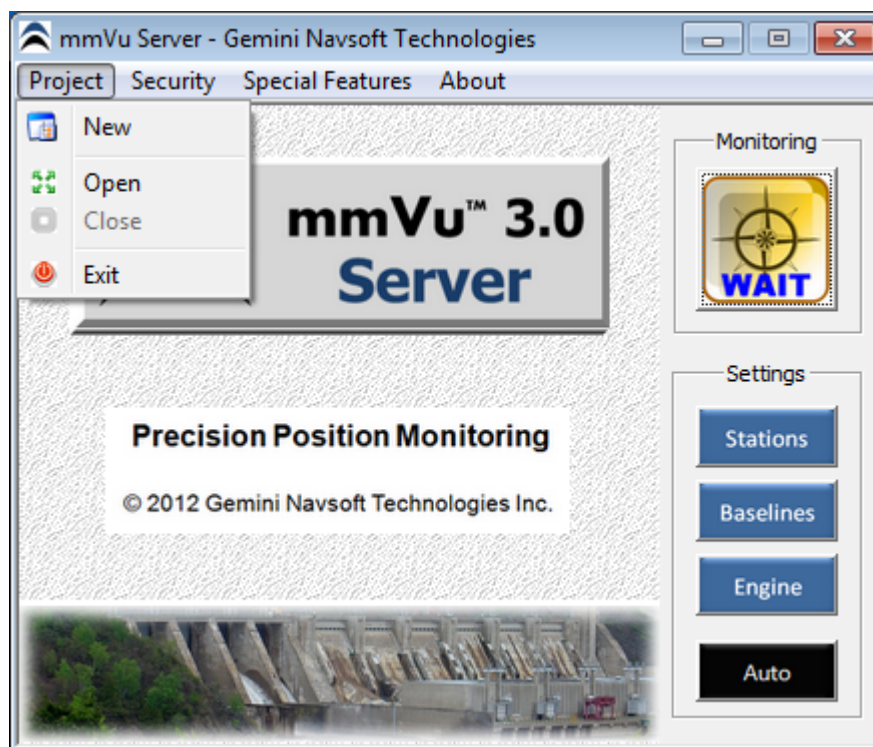


Figure 8: Project menu

#### 4.1.1 Project | New

This menu allows users to create a new Project.

#### 4.1.2 Project | Open


This menu allows users to access an existing Project.

### 4.1.3 Project | Close

This menu allows users to close an opened Project.

### 4.1.4 Project | Exit

This menu allows users to shutdown the mmVu™ Server.

 If the Exit menu is selected before the opened Project is properly closed, the mmVu™ Server will require Administrator's Authorization (see 4.4 Authorization).

## 4.2 Security Menu

The mmVu™ Server has multiple security layers to protect high-precision monitoring system from unauthorized or accidental activities. Security utility is located in the Security menu as illustrated in Figure 9.

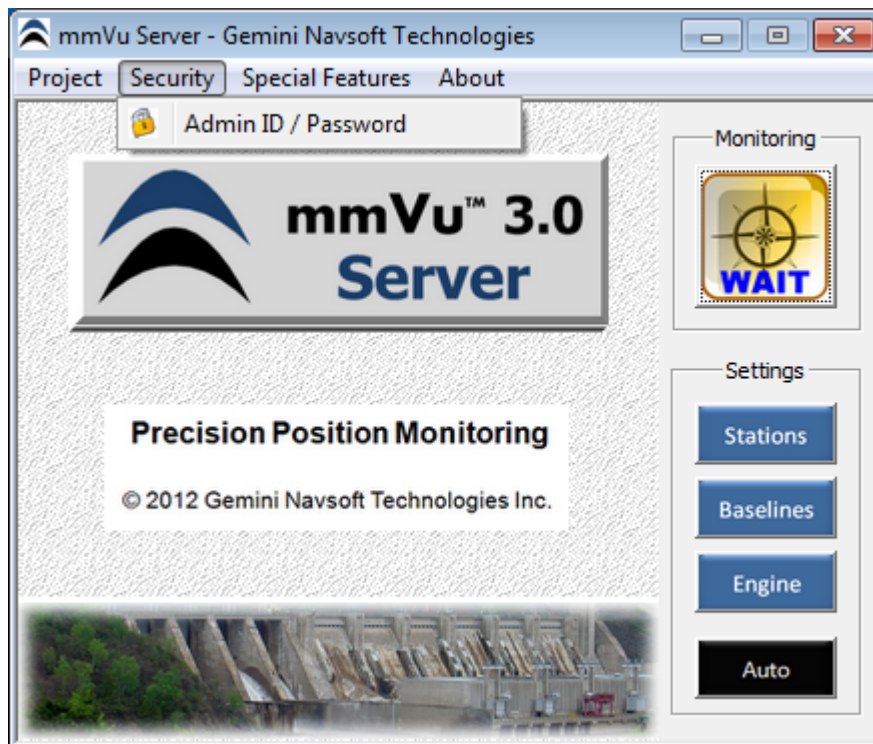


Figure 9: Security menu utility

Users can change Administrator’s ID and Password any time as illustrated in Figure 10. To access this utility, authorization is required through Old Security Code Validation. Once authorized, users can register a new ID and Password.



The screenshot shows a dialog box titled "Admin ID / Password Generation". It is divided into two main sections. The first section, "Old Security Code Validation", contains two text input fields labeled "Admin ID" and "Admin Password". The second section, "New Security Code Registration", also contains two text input fields labeled "Admin ID" and "Admin Password". At the bottom of the dialog are two buttons: "OK" and "Cancel".

Figure 10: Administrator’s ID and Password form

### 4.3 Special Features

The mmVu™ Server contains some special features. The first special feature is called Integrity Monitoring Services.

#### 4.3.1 Special Features | Integrity Monitoring Services

The mmVu™ Server Integrity Monitoring Services monitor the status of the mmVu™ Server. They can be set to notify the administrator of the deformation monitoring system in case of data stream interruption, high amount of packet errors and/or in case that no positioning solution is available. Integrity Monitoring Services utility is located in the Special Features menu as illustrated in Figure 11.



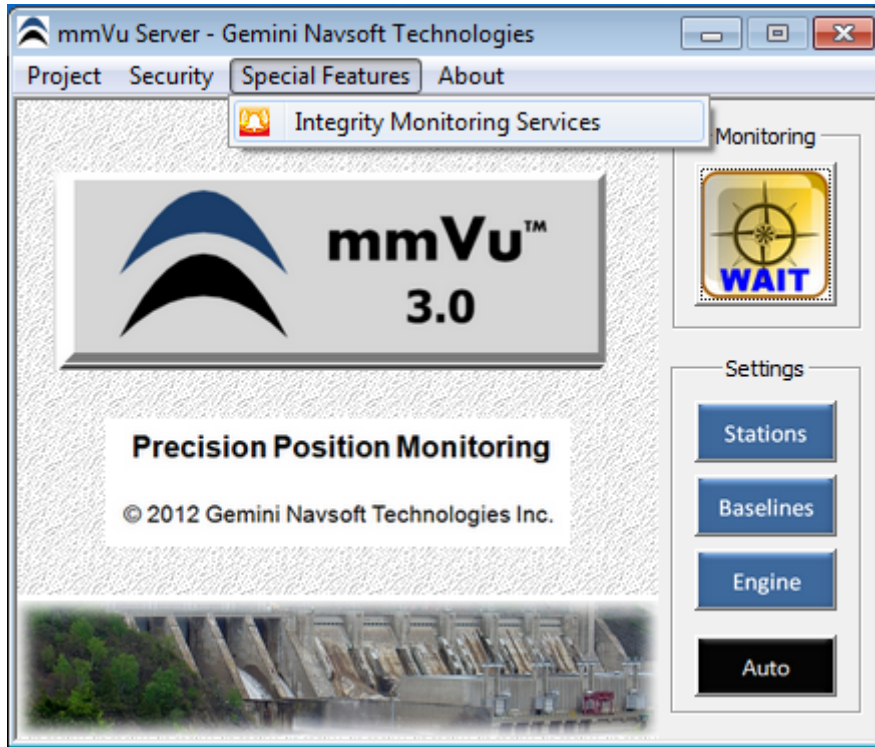


Figure 11: Special Features – Integrity Monitoring Services

Note: The access of the Integrity Monitoring Services requires authorization with User-ID and Password.

The Auto Email Service and Short Message Service will appear as displayed on Figure 12.

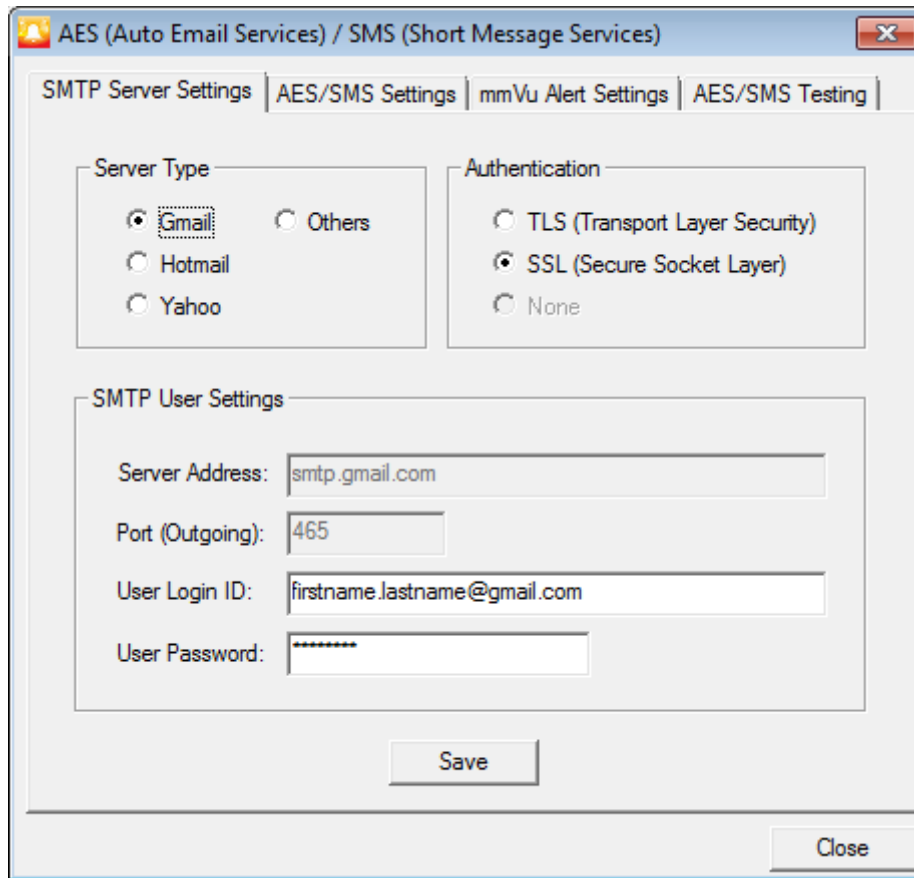


Figure 12: SMTP Server Settings

The SMTP Server Settings tab contains the Server Type section with 3 pre-defined e-mail server types one Others server type for all other e-mail servers. The Authentication section includes two types of authentication: Transport Layer Security (TSL) and Secure Socket Layer (SSL). The SMTP User Settings section has the following windows:

- **Server Address:** Enter the SMTP server address.
- **Port (Outgoing):** Enter the SMTP outgoing port.
- **User Login ID:** Enter your own user login ID.
- **User Password:** Enter your password.

The AES/SMS Settings tab will appear as displayed on Figure 13.

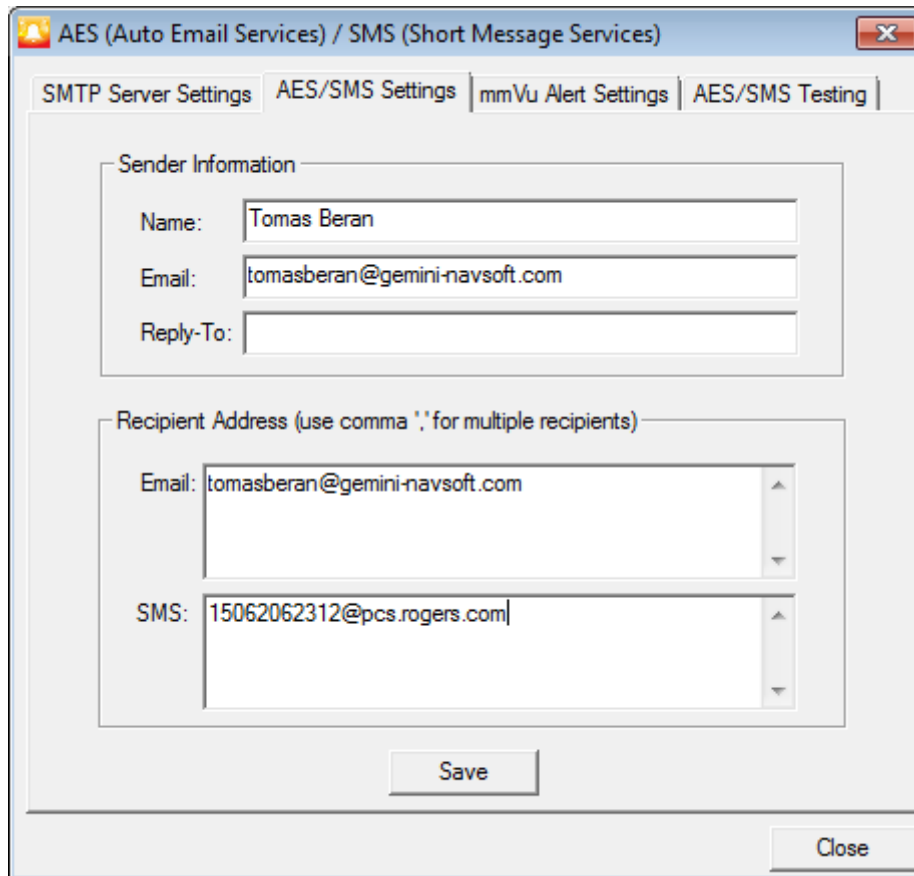


Figure 13: AES/SMS Settings

The AES/SMS Settings tab contains the Sender Information Section with 3 windows:

- **Name:** Enter the sender's name.
- **Email:** Enter the sender's e-mail.
- **Reply-To:** Enter the Reply-To e-mail.

The Recipient Address section has 2 windows:

- **Email:** Enter recipient's e-mail or multiple recipients' e-mails separated by commas.
- **SMS:** Enter the recipient's phone e-mail address or multiple recipients' phone e-mails separated by commas.

The mmVu Alert Settings tab will appear as displayed on Figure 14.

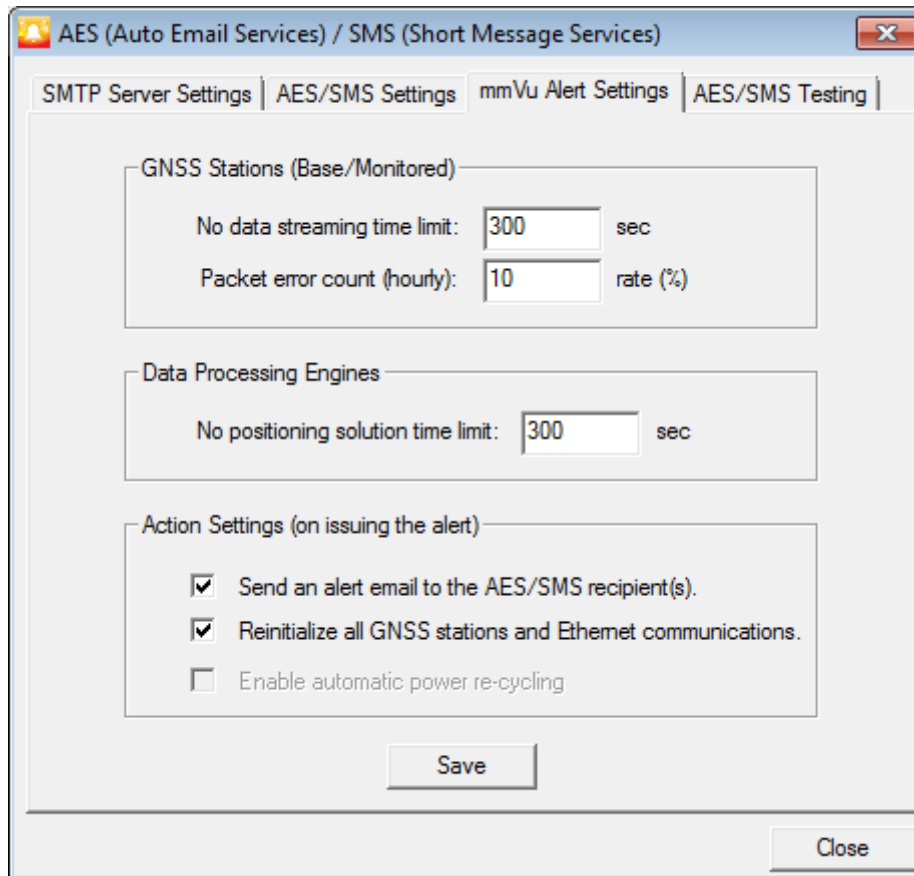


Figure 14: mmVu™ Alert Settings

The mmVu Alert Settings tab has 3 sections. GNSS Stations (Base/Monitored) with 2 windows:

- **No data streaming time limit:** Enter time limit between 60 and 86400 seconds when you wish to be notified when there is no data streaming. Default value is 300 seconds or 5 minutes.
- **Packet error count (hourly):** Enter percentage of the hourly error packet count. This option indicates how many error packets can occur within one hour.

Data Processing Engines with 1 window:

- **No processing solution time limit:** Enter the maximum amount of time for which the engine does not produce a solution. The time limit is between 60 and 86400 seconds.

Action Settings (on issuing the alert) has 2 checkboxes:

- **Send an alert e-mail to the AES/SMS recipient(s).** Checking this option will generate an alert e-mail every time when the conditions describe above occur.
- **Reinitialize all GNSS stations end Ethernet communications.** Checking this option will cause reinitialization of all communication every time when the conditions describe above occur.

The AES/SMS Testing tab will appear as displayed on Figure 15.

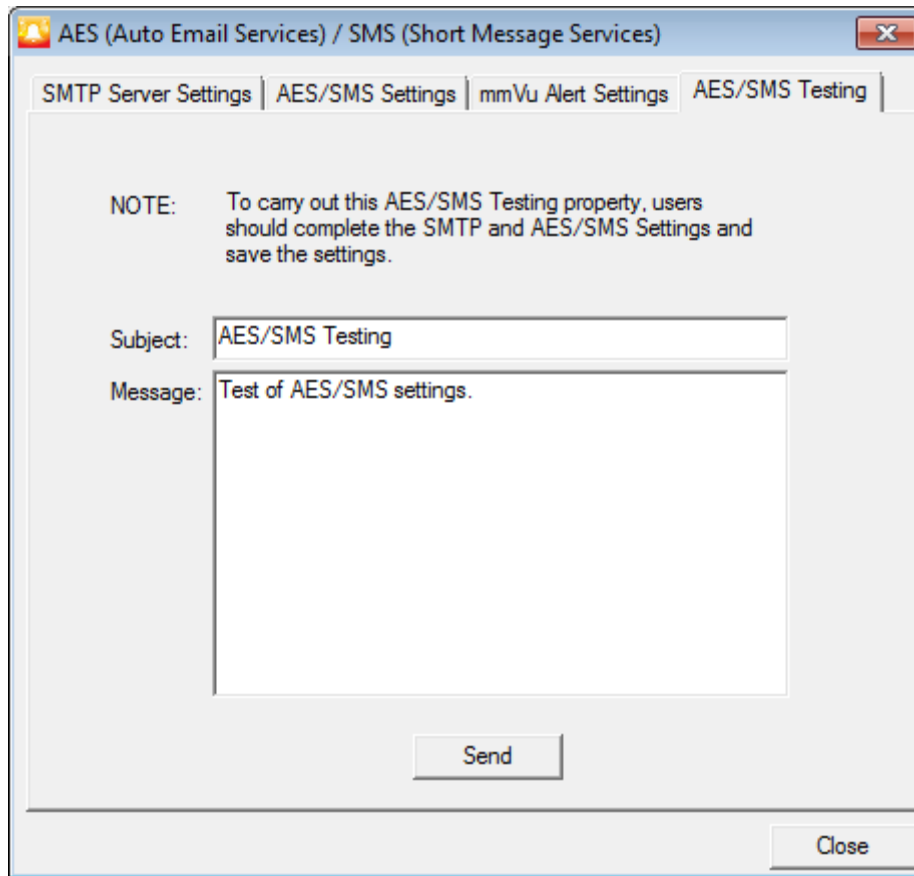


Figure 15: AES/SMS Testing

The note on the top indicates that in order to complete the AES/SMS testing users should complete the SMTP Server Settings and the AES/SMS Settings as shown on Figure 12 and Figure 13.

The AES/SMS Testing tab has two windows. First window for the Subject and the second window for the body of the AES/SMS Test. Hit the Send button once everything is ready for the test.

#### 4.4 About Menu

mmVu™ 3.0 License information is located in the About menu as illustrated in Figure 16.

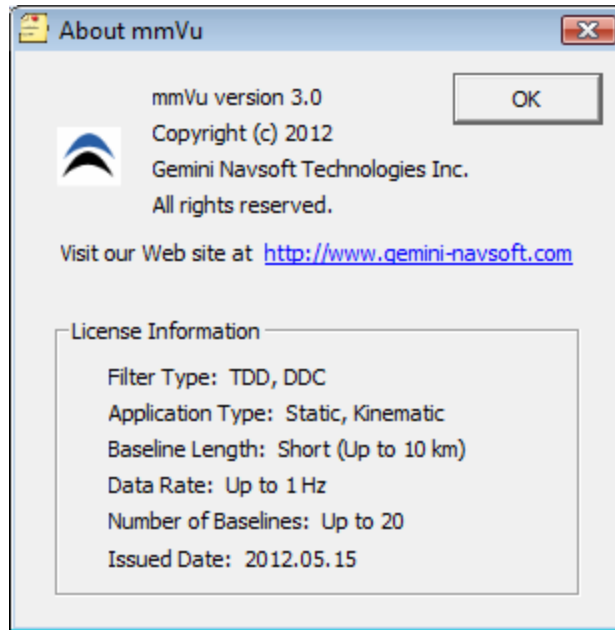


Figure 16: mmVu™ 3.0 License information

#### 4.5 Authorization

When users try to shutdown the mmVu™ Server, Administrator's Authorization will be required as illustrated in Figure 17.

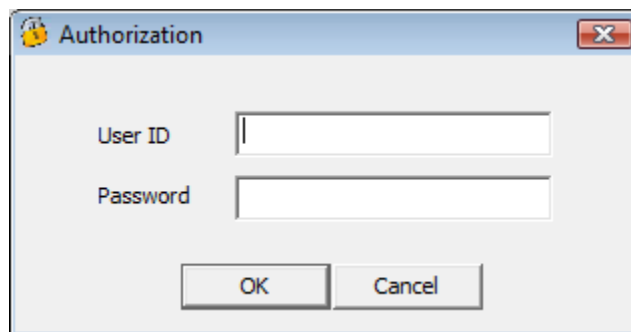


Figure 17: Authorization window

The default user inputs for Authorization are outlined in Table 3.

Table 3: Default user inputs for Authorization

Type	User Input
User ID	admin
Password	default

If users are not authorized, a warning message will be issued as seen in Figure 18.

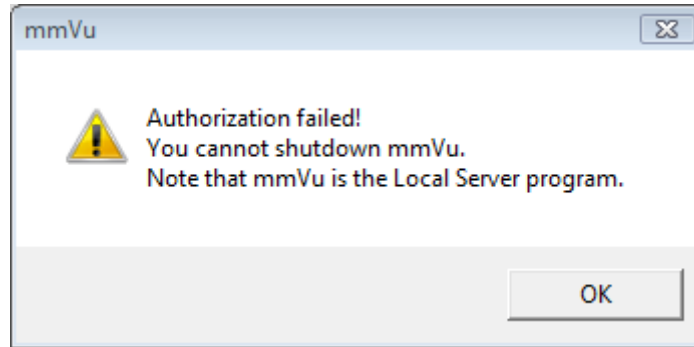


Figure 18: Authorization failure warning message

## 5. mmVu™ Server Buttons

As illustrated in Figure 19, Monitoring and Settings utilities are accessed through the Buttons on the mmVu™ Server window.



Figure 19: Buttons for user inputs and actions



The Buttons are enabled only if a new Project is created or an existing Project is opened.

### 5.1 Settings | Stations

Station Settings allows users to select one of the registered Stations from the Station Database. It also allows users to Add or Delete Stations as illustrated in Figure 20.



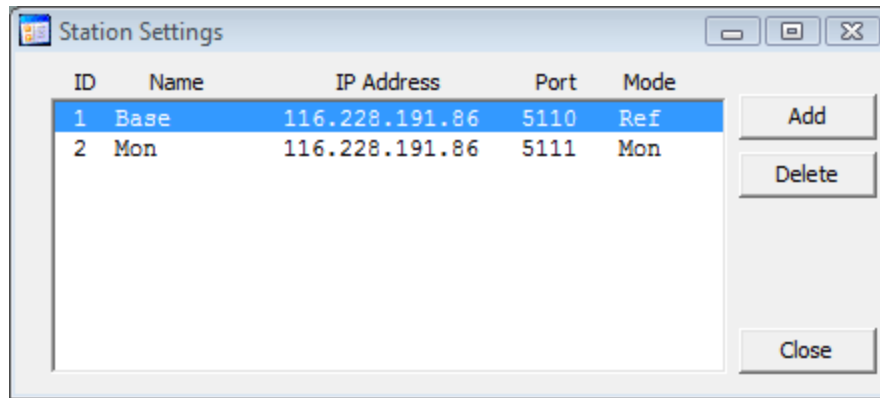


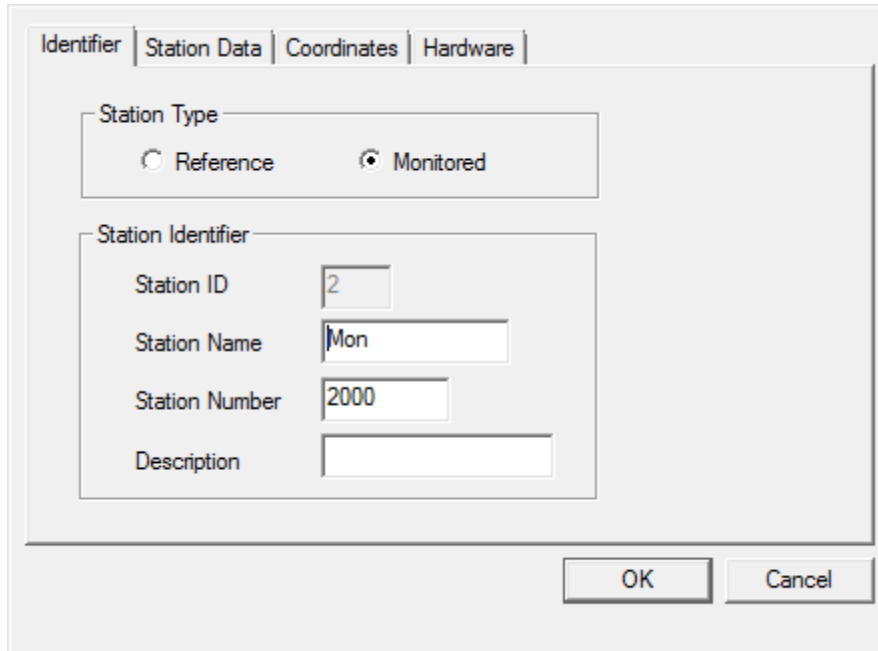
Figure 20: Station Settings window

Every station to be monitored must be equipped with the necessary hardware to stream GPS data for processing (for more information on hardware setup, see the GNT Hardware Configuration Guide). Station information is entered by selecting a Station from the list box. When a Station is selected, it will be highlighted in blue as illustrated in Figure 20. The station must be properly configured using the tabs of the Station Properties as illustrated in Figure 21, Figure 22, Figure 23 and Figure 25 so that data can be received.

### 5.1.1 Settings | Stations | Identifier

The following identifiers can be entered for each station (Figure 21):

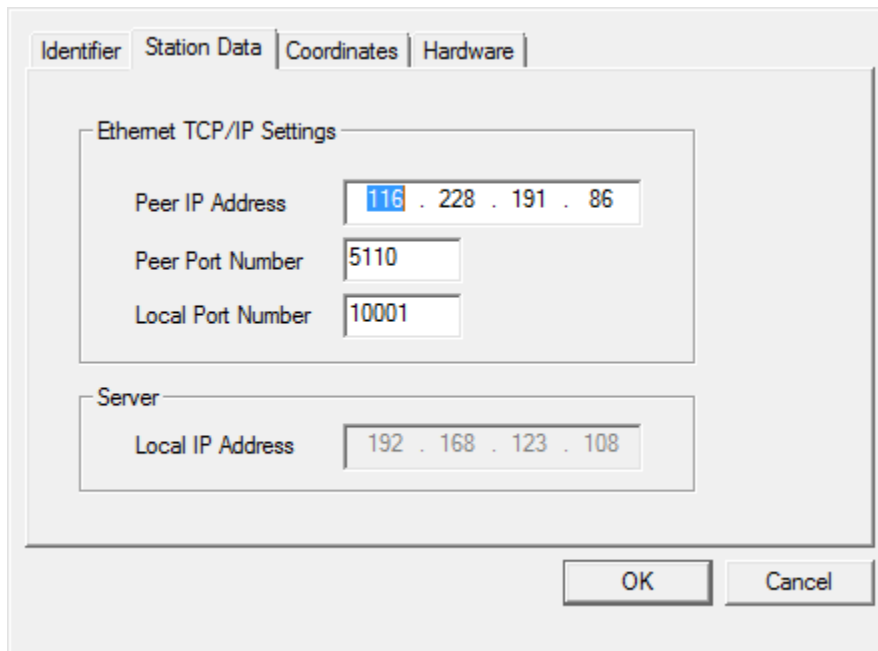
- **Station Type:** Select **Reference** if this station is to be a stable reference point from which the positions of other stations will be determined. Select **Monitored** if this station is to be monitored. Reference stations appear with “Ref” in the Station Status window, monitored stations appear with “Mon”.
- **Station ID:** Unique software generated station identifier.
- **Station Name:** Unique station name.
- **Station Number:** Unique station identifier.
- **Description:** Description of station particulars.



The dialog box has four tabs: Identifier, Station Data, Coordinates, and Hardware. The Identifier tab is active. It contains two sections: 'Station Type' with radio buttons for 'Reference' and 'Monitored' (selected), and 'Station Identifier' with text boxes for 'Station ID' (value: 2), 'Station Name' (value: Mon), 'Station Number' (value: 2000), and 'Description' (empty). 'OK' and 'Cancel' buttons are at the bottom right.

Figure 21: Station Properties – Identifier

### 5.1.2 Settings | Stations | Station Data



The dialog box has four tabs: Identifier, Station Data, Coordinates, and Hardware. The Station Data tab is active. It contains two sections: 'Ethernet TCP/IP Settings' with text boxes for 'Peer IP Address' (value: 116 . 228 . 191 . 86), 'Peer Port Number' (value: 5110), and 'Local Port Number' (value: 10001); and 'Server' with a text box for 'Local IP Address' (value: 192 . 168 . 123 . 108). 'OK' and 'Cancel' buttons are at the bottom right.

Figure 22: Station Properties – Station Data

mmVu™ 3.0 communicates with the GPS receiver using an Ethernet Connection. The user must specify the IP address and port number of the source of the GPS data (Figure 22). Additionally, the user must also specify the local port number on the PC dedicated to listening to the receiver. Only TCP (connection orientated) option is available for users. mmVu™ 3.0 utilizes UDP (connectionless) for multicasting the received data internally.

- **Peer IP Address:** Unique Ethernet IP address of the GPS receiver.
- **Peer Port Number:** Port number of the GPS receiver for TCP connection (Valid range: 0-65535).
- **Local Port Number:** Port number of the Local Server (PS100) for TCP connection (Valid range: 0-65535).
- **Local IP Address:** Unique Ethernet IP address of the Local Server (PS100). It will be automatically detected by the mmVu™ Server.

### 5.1.3 Settings | Stations | Coordinates

The screenshot shows the 'Coordinates' tab of the 'Station Properties' dialog. It contains the following fields and options:

- Coordinates Type (Reference):**
  - Use Single Point Position Coordinates
  - Coordinates Known
- Coordinates:**
  - X:  (m)
  - Y:  (m)
  - Z:  (m)
- Transformation:**
  - Local Coordinate System (Rotation - Azimuth)
  - (deg)

Buttons: OK, Cancel

Figure 23: Station Properties – Coordinates

mmVu™ 3.0 requires known Coordinates for ‘Reference’ stations (Figure 21). Select ‘Coordinates Known’ (Figure 23) if the coordinates for the station are already known from a previous survey (WGS84 values). Select ‘Use Single Point Position (SPP) Coordinates’ if initial estimates are unavailable. The accuracy of the SPP solution is at best meter level. This will be sufficient for relative positioning. However, if the output coordinate values from this software are to be used in combination with other software for analysis, it is important that reference station coordinates correspond with other coordinate values in the network. If a station is selected as a ‘Reference’ station, its coordinates will be treated as fixed. For “Monitored” stations, Coordinates input will be disabled by the mmVu™ Server.

- **Use Single Point Position Coordinates:** WGS84 coordinates are not known for this station, so generate a Single Point Position estimate.
- **Coordinates Known:** WGS84 coordinates are known for this stations antenna location, so use them. If the WGS84 coordinates are known and you select “Use Single Point Position Coordinates” a confirmation stating “Changing the Coordinates Known status of a Station will result in a loss of any stored results for Baselines using this Station” will appear (see Figure 24)

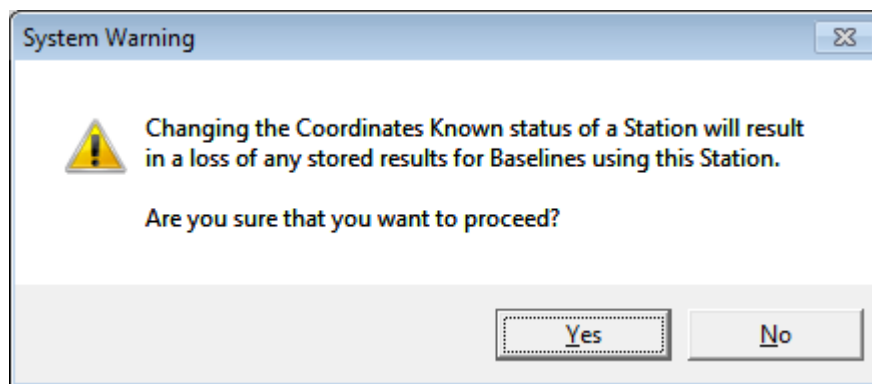


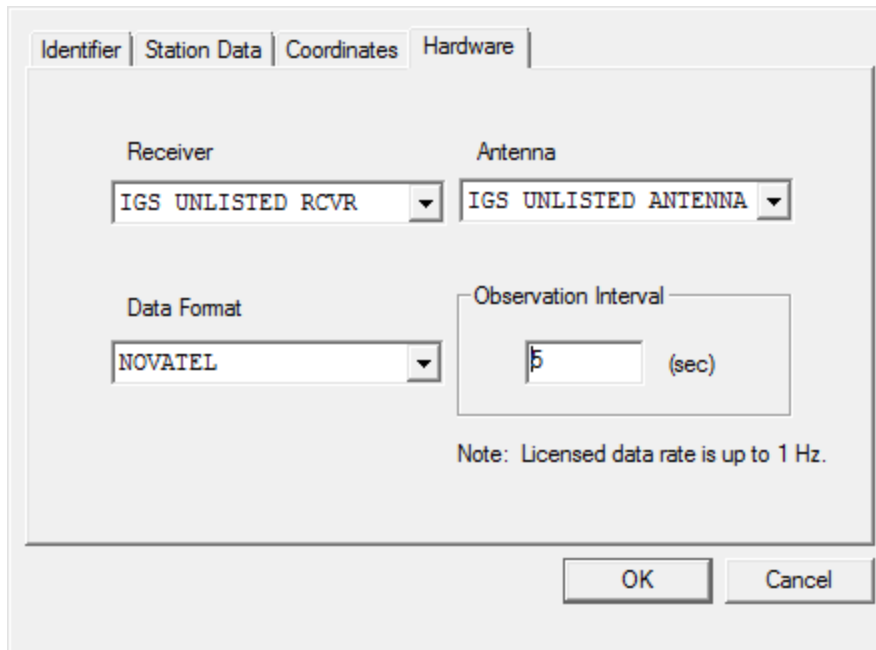
Figure 24: Use a Single Point Position Coordinates confirmation

- **X, Y, Z:** WGS84 coordinates.
- **Transformations:** Allows users to align mmVu™ local coordinate system output with an existing coordinate system. The rotation angle between Geodetic North and the north (or + Y) axis of the user’s coordinate system can be input. All local coordinate output for this station will be rotated (when plotted) by this rotation angle. To avoid potential discontinuities in results, the solution output will not be rotated in the solution output file.

### 5.1.4 Settings | Stations | Hardware

mmVu™ uses the manufacturer and model information for the GPS antenna and receiver to optimize the results. Specify the hardware being used at the station (Figure 25).

- **Receiver:** Select the GPS receiver from the IGS receiver database. If no receiver is matched with the one to be used, select “IGS UNLISTED RCVR”.
- **Antenna:** Select the GPS antenna from the IGS antenna database. If no antenna is matched with the one to be used, select “IGS UNLISTED ANTENNA”.
- **Data Format:** Format of the GPS data output by the receiver. Currently Javad JPS and NovAtel OEM4, 5 and 6 data logs are supported.
- **Observation Interval:** Sample rate of the GPS observations in seconds. mmVu™ 3.0 will trigger a receiver command to change the receiver setting automatically.
- **Note:** The mmVu™ Server informs users of the licensed data rate.



The screenshot shows a dialog box titled "Station Properties - Hardware". It has four tabs: "Identifier", "Station Data", "Coordinates", and "Hardware". The "Hardware" tab is selected. Inside the dialog, there are four main sections: "Receiver" with a dropdown menu showing "IGS UNLISTED RCVR", "Antenna" with a dropdown menu showing "IGS UNLISTED ANTENNA", "Data Format" with a dropdown menu showing "NOVATEL", and "Observation Interval" with a text input field containing "5" and "(sec)" next to it. Below these fields is a note: "Note: Licensed data rate is up to 1 Hz." At the bottom right of the dialog are two buttons: "OK" and "Cancel".

Figure 25: Station Properties – Hardware



Users should be aware of that all user inputs in the Station Properties will not be updated and will be ignored if “OK” is not clicked or “Cancel” is clicked.

## 5.2 Settings | Baselines

Baseline Settings allows users to enable or disable specific Baselines. Baseline information is accessed by selecting a Baseline from the list box. When a Baseline is selected, it will be highlighted in blue as illustrated in Figure 26.

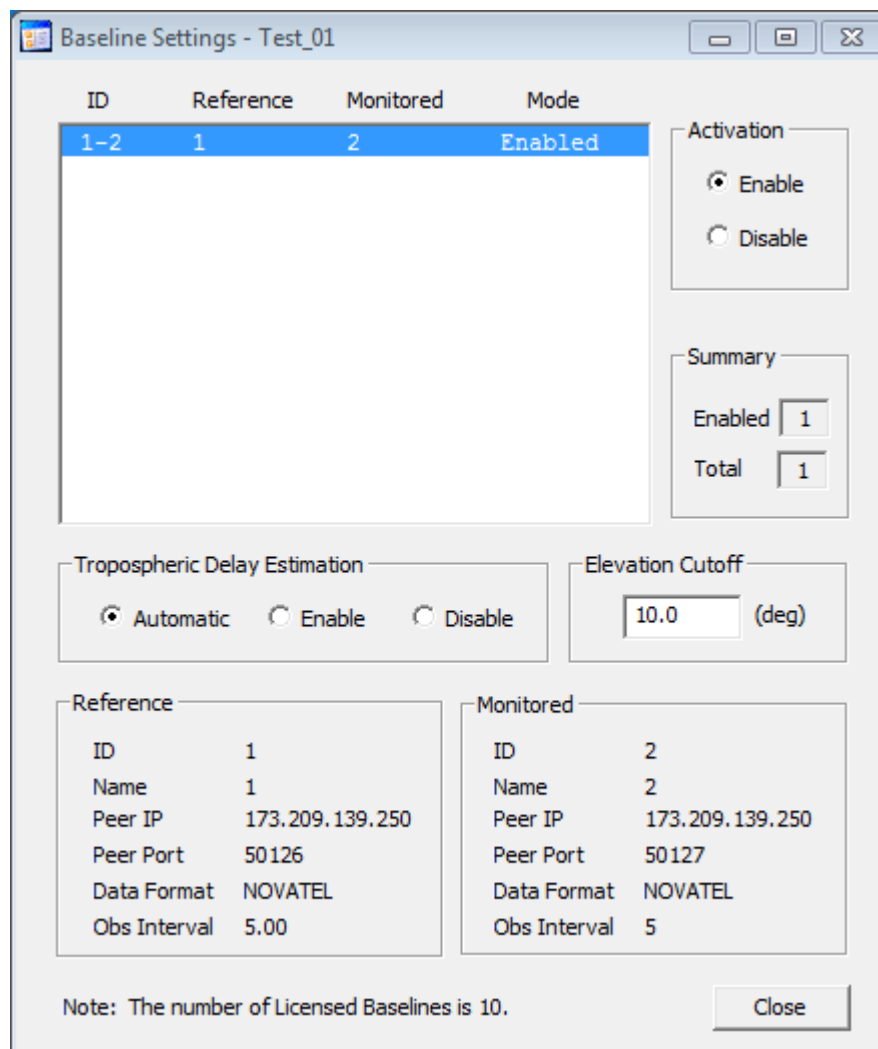


Figure 26: Baseline Settings window

- **Activation:** Select “Enable” to activate the Baseline highlighted, “Disable” to deactivate.
- **Summary:** Number of “Enabled” Baselines and total number of Baselines registered in a Project.
- **Tropospheric Delay Estimation:** Select “Automatic” to make the software decide whether to use the Tropospheric Delay Estimation. The software enables the Tropospheric Delay Estimation for baselines longer than 10 km or if the height difference between the reference and the monitored station is larger than 50 m. Select “Enable” to always enable the Tropospheric Delay Estimation. Select “Disable” to always disable the Tropospheric Delay Estimation.
- **Elevation Cutoff:** The default elevation cutoff angle is 10 degrees. Select a number between 0 degrees (no cutoff) and 90 degrees (complete cutoff).
- **Reference:** “Reference” Station user input information.
- **Monitored:** “Monitored” Station user input information.
- **Note:** The mmVu™ Server informs users of the licensed number of Baselines.

### 5.3 Settings | Engine

To optimize positioning performance, mmVu™ 3.0 utilizes parallel processing techniques, including the Time-Delayed Doppler (TDD) filter and the Double-Differenced Carrier (DDC) filter (Figure 27). This unique technology is utilized to achieve mm level and sub-mm trend analysis.

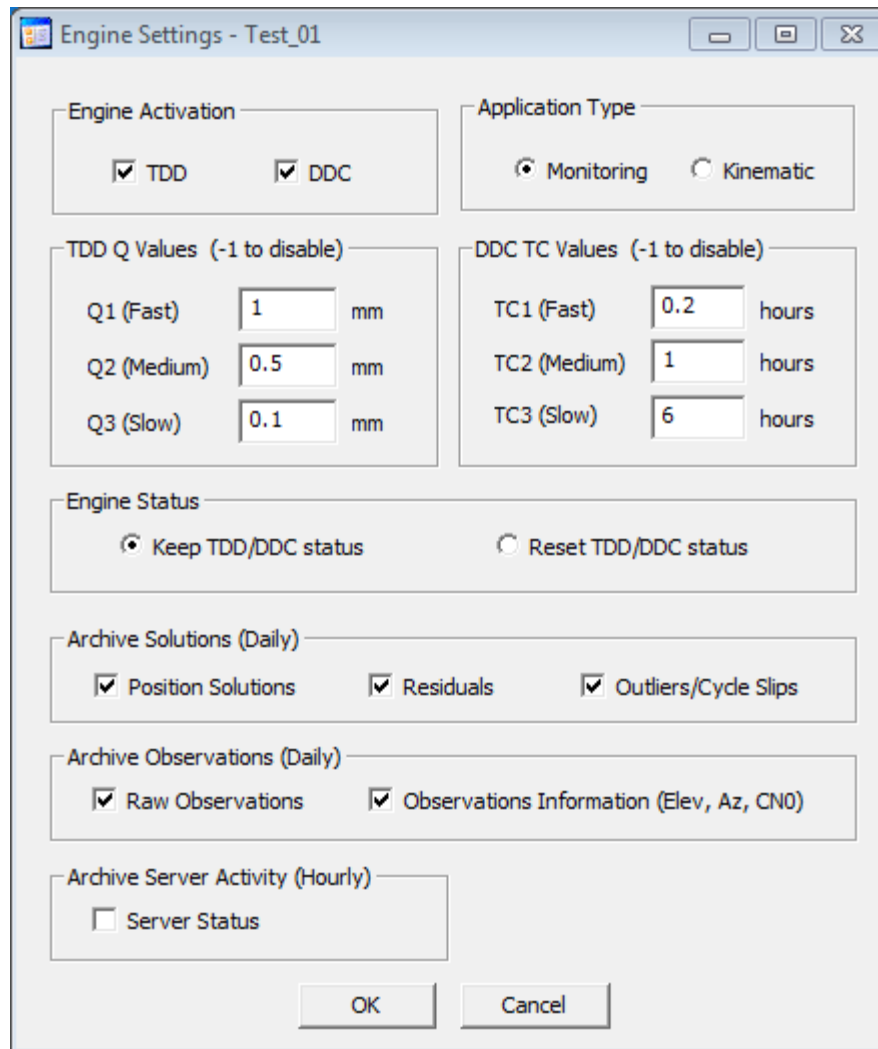


Figure 27: Engine Settings window

- **Engine Activation:** Select which type of processing engine to use.

**TDD:** Time-Delayed Doppler filters

**DDC:** Double-Differenced Carrier-phase filters

- **Application Type:** Select which type of application to use.

**Monitoring:** Static, monitoring applications

**Kinematic:** RTK (real-time kinematic) applications.

Depending on the License of mmVu™ 3.0 being used, specific type of Engine and Application will be automatically disabled unless a full license has been issued.



– **TDD Q Value:**

The Q value specifies the amount of uncertainty to add to the covariance matrix of the unknowns at each epoch of observations. The Q value should be based upon the anticipated rate of displacement of the monitored stations. Larger Q values allow the filter to respond more quickly to displacements, but results in greater uncertainty in the unknowns. See the Appendices for an illustration of the impact of Q values.

To maximize the amount of information that can be obtained from the GPS data, mmVu™ 3.0 can calculate three, simultaneous, TDD filter solutions. This provides the user with different resolution vs. time options. The default Q values are:

Table 4: Default TDD Q values

	Static	Kinematic*	Remarks
Q1	1 mm	10 mm	for fast but less precise displacement detection
Q2	0.5 mm	-1	for moderate speed and precision
Q3	0.1 mm	-1	for slow but most precise displacement detection

\*This option (i.e., a TDD kinematic filter) is not available for the current version (v1.0) of mmVu™ 3.0.

The number of filters used will dictate the amount of output data that is generated and the amount of time required for processing. For large scale applications, it may be necessary to be selective in which Q values are employed. To disable any particular Q value, enter a value of -1.

– **DDC TC Values:**

The TC value used with DDC solutions specifies the period of time over which DDC solutions should be used in calculating filtered DDC solutions. Large TC values result in higher precision but slower filter response time and vice versa. See the Appendices for an illustration of the impact of TC values.

To maximize the amount of information that can be obtained from the GPS data, mmVu™ 3.0 can calculate 3, simultaneous, DD low-pass filter solutions. This provides the user with different resolution vs time options. The default TC values are:

Table 5: Default DDC TC values

	Static	Kinematic	Remarks
TC1	0.2 hr	0 hr*	for fast but less precise displacement detection
TC2	2 hrs	-1	for moderate speed and precision
TC3	6 hrs	-1	for slow but most precise displacement detection

\*This option is available for the users who have an RTK license.

The number of filters used will dictate the amount of output data that is generated and the amount of time required for processing. For large scale applications, it may be necessary to be selective in which TC values are employed. To disable any particular TC value, enter a value of -1.

If one or more TDD Q values or DDC TC values gets assigned a new value, a particular filter or more filters get reinitialized.

- **Engine Status:** Select “Keep TDD/DDC status” to keep the filter status. Select “Reset the TDD/DDC status” to reset the filter status. If you select “Reset the TDD/DDC status” the confirmation stating “Resetting TDD/DDC will result in a loss of any stored results for all Baselines registered in the project” will appear (Figure 28).

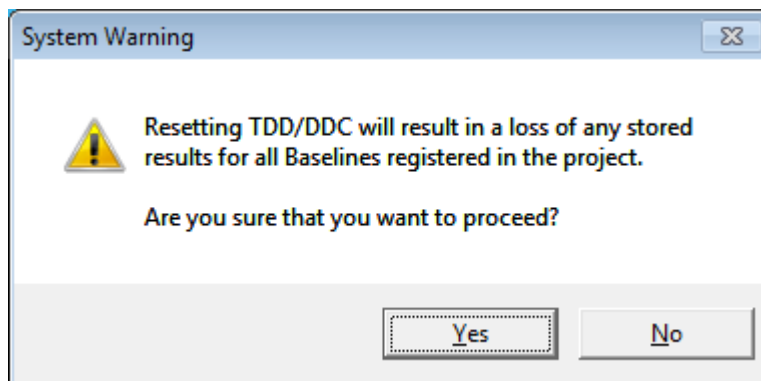


Figure 28: Reset the TDD/DDC status confirmation

- **Archive Solutions (Daily):** Select which type of processing results to be saved.
- **Archive Observations (Daily):** Select which type of data to be saved.
- **Archive Server Activity (Hourly):** Select if Server status needs to be saved.

## 5.4 Settings | Auto

Automatic Run Settings allows users to run the mmVu™ Server in an Automatic Mode (Figure 29). This feature is very useful when the Local Server (PS100) should be rebooted for some reasons and that users want to run a pre-registered project automatically.

- **Enable Auto Run:** Select this button to run a pre-registered project automatically.
- **Disable Auto Run:** This button disables the Auto Run mode.
- **Project Name:** Pre-registered project name.
- **Project Folder:** Folder and project file name.

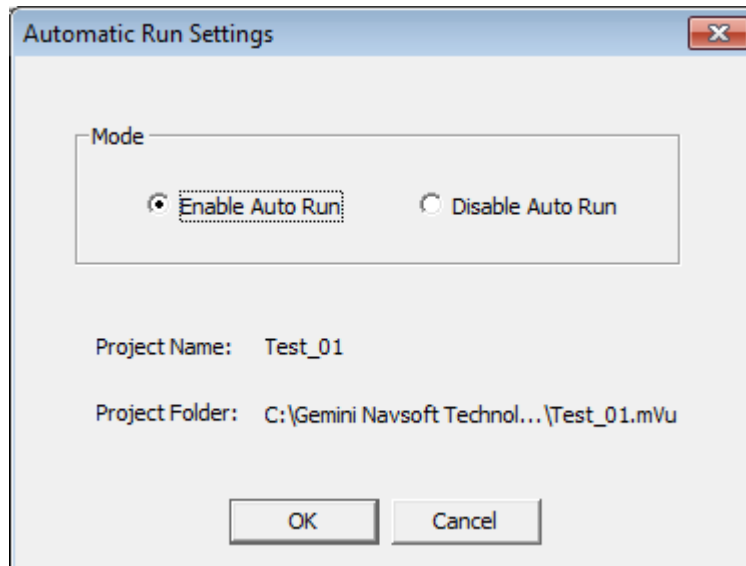





Figure 29: Automatic Run Settings window

## 5.5 Monitoring

Once all stations have been added, Monitoring can begin. The Monitoring button outlined in Table 6 gives access to these capabilities.

Table 6: Signal of Monitoring

Signal	Action
	Monitoring is not ready yet. This button is signalled when no Project is open or users are working on the Settings of a Project.
	Monitoring is ready for action. This button is activated when a Project is open. Users should make sure that all Settings are properly arranged for a Project. Click the button to start the Monitoring operation.
	Monitoring is in action. When users click the button to stop the Monitoring operation, the mmVu™ Server will require Administrator's Authorization (see 4.4 Authorization).

During the Monitoring operation, the mmVu™ Server will update the status of Stations and Baselines every update cycle (by default, a 1 minute update cycle) as illustrated in Figure 30. Users can easily identify which Stations and Baselines have problems.

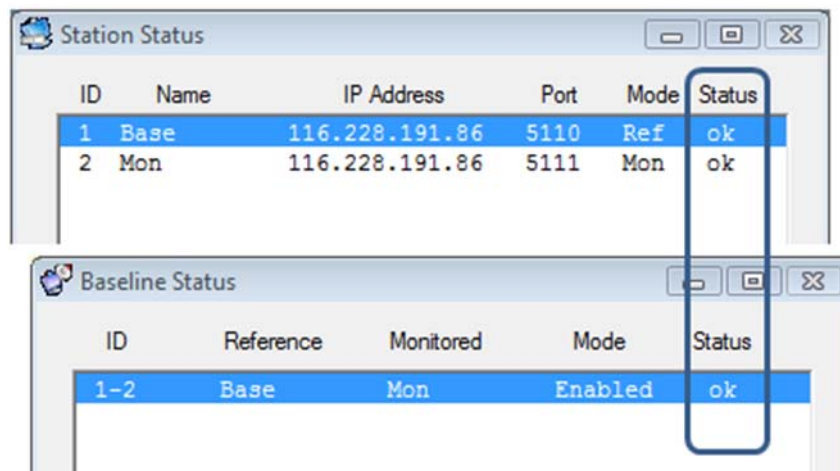


Figure 30: Status of Stations and Baselines in the Monitoring mode

During the Monitoring operation, the Server Status window also shows the solutions of Baselines processed by the mmVu™ Engine at the observation interval as illustrated in Figure 31.

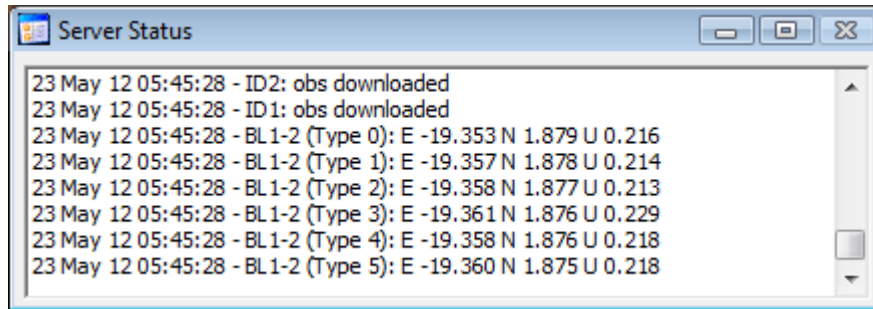


Figure 31: Baseline solutions posted in the Server Status window

When users click the Monitoring button, the mmVu™ Server calls the mmVu™ Engine as illustrated in Figure 32. By default, the mmVu™ Engine runs background and is invisible.

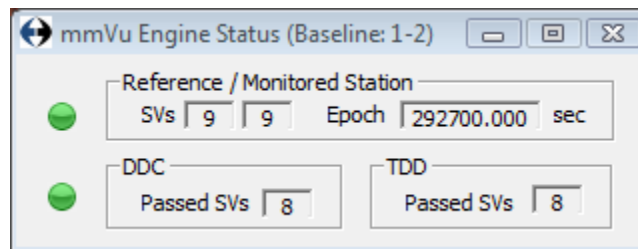


Figure 32: mmVu™ Engine Status window (invisible)

## 6. Input and Output Files

### 6.1 Directory System

The primary install directory for mmVu™ 3.0 is “C:\Gemini Navsoft Technologies\mmVu Server”. “Projects”, “System” and “System Log” directories reside in the Gemini folder. All projects folders and project files exist in the “Projects” folder. mmVu™ 3.0 events can be stored in a log file (not project specific) in the System Log folder.

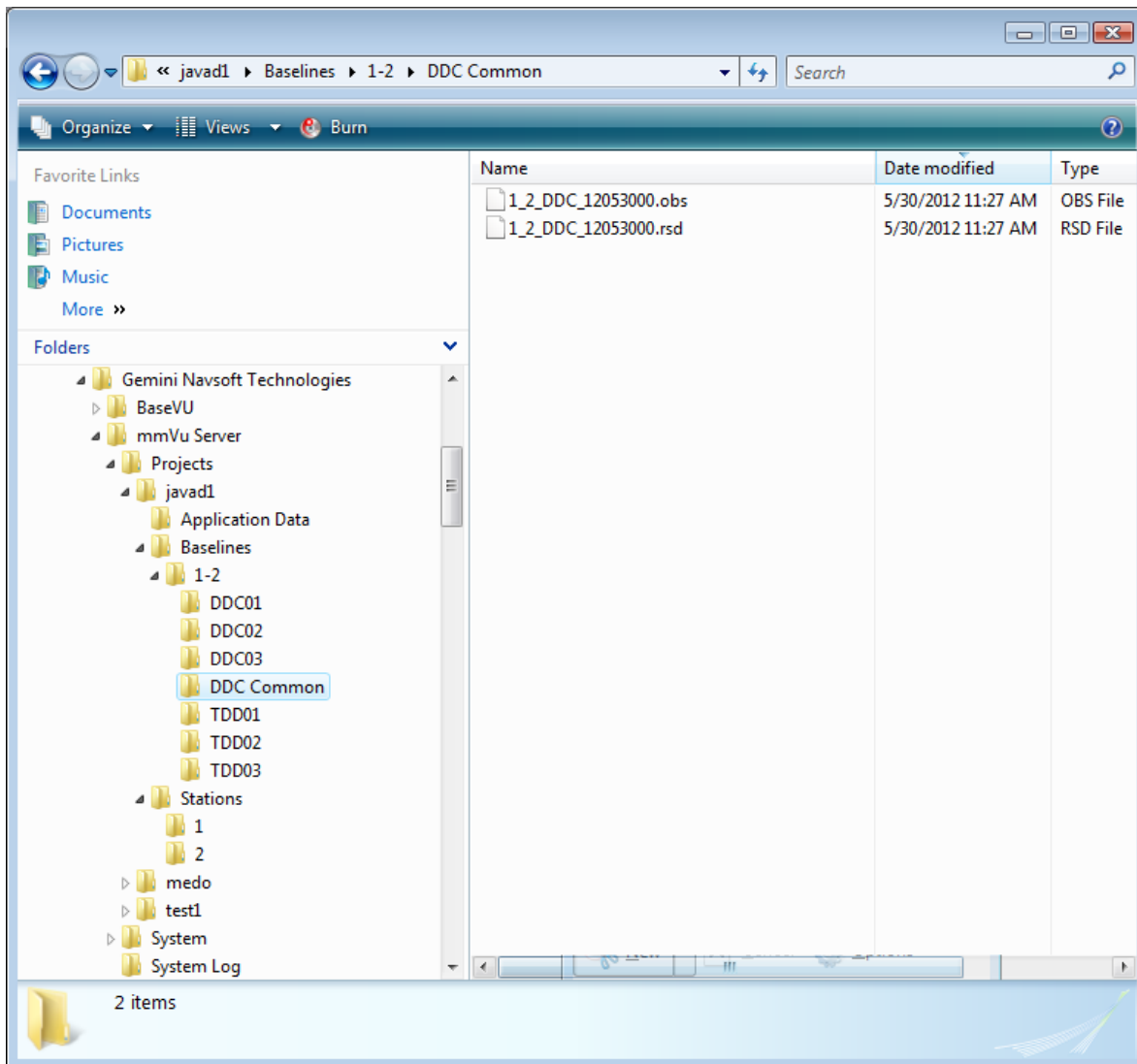


Figure 33: mmVu™ 3.0 directory structure

“Application Data”, “Baselines” and “Stations” folders reside in the “Projects” folder. Each Station has its own folder that is named by its Station ID. “Application Data” folders contain system files that the mmVu™ Engine looks up and maintains. Any corruption with the system files will cause fatal errors and poor performance. All raw data are stored in the “Stations” folders.

All processing results for each baseline are stored in the “Baselines” folders. Each Baseline has its own folder that is named by the Station ID of the reference station + “\_” + Station ID of the monitored station. The “Baselines” folder has subdirectories for the various solution output types (“TDD01”, “TDD02”, “TDD03”, “DDC01”, “DDC02”, “DDC03”, “DDC Common”). The DDC Common folder contains output files common to all DDC solution types.

Figure 33 illustrates the directory structure.

## 6.2 Project Files

mmVu™ 3.0 projects files reside in “Application Data” folders. The contents of mmVu™ 3.0 projects files with sample entries are described in 6.6 *Project File Description*.

## 6.3 Raw Data Files

Raw data files from each GPS receiver are stored in their respective Station folder. Raw data file formats are receiver dependent. The following naming convention is used:

$$\text{Identifier} + \text{"_"} + \text{YY} + \text{MM} + \text{DD} + \text{HH} + \text{.extension}$$

Table 7 describes the file name components.

Table 7: Raw Data File Name Components

Parameter	Entries
Identifier	Station ID
YY MM DD HH	UTC Year Month Day Hour of file when created.
Extension	.nov for NovAtel .jps for Javad .ncd for Navcom .rtc for RTCM 3.0 .bnx for BINEX

## 6.4 Baseline Processing Files

mmVu™ 3.0 processing results can be archived as readable ASCII text files. The types of data archived are user selectable. The file types include:

- Solution coordinates values
- Detected outliers/cycle slips
- Residuals of each solution
- Baseline observation information

Baseline processing files are stored in their respective “Baseline” folders named using the following naming convention:

*Identifier + “\_” + Solution Type + Solution Number + YY + MM + DD + HH + .File Type Extension*

Examples:

```
100_2_DDC01_11013100.sol
100_2_TDD01_11013100.obs
101_3_TDD02_11010100.out
101_4_TDD03_12010300.res
```

The file name components for baseline processing files are summarized in Table 8.

Table 8: Baseline Processing File Name Components

Parameter	Entries
Identifier	- Reference Station ID + “_” + Monitored Station ID
Solution Type and Q/TC Value	- “DD” or “TD” + “XX”  Where: DD = Double-Differenced, Carrier Phase Solution TD = Time Delayed, Doppler Solution XX = the Q value or TC value index (01, 02, 03)
YY MM DD HH	UTC Year Month Day Hour of file when created
Extension	- “obs” for observation information - “out” for outliers - “res” for residuals



- "sol" for epoch coordinates solutions

Each output file has a header, which is described in Table 9.

Table 9: Baseline Output File Headers

File Type	Headers	Present in Version #s
Obs. Info Files (.obs)	[Version #] [Desc.] [Format 1] [Format 2]	> 3.0
Outlier Files (.out)	[Version #] [Desc.] [Units] [N Significance] [F Significance] [Format]	> 3.0
Residual Files (.res)	[Version #] [Desc.] [Units] [Obs. Type] [Format]	> 3.0
Solution Files (.sol)	[Version #] [Desc.] [Q Value] or [TC Value] [Units] [Obs. Type] [Format]	> 3.0

The format of each Baseline Processing output file is subsequently described.

#### 6.4.1 Solution File

[Format] (GPS Week) (GPS Second of Week) (Day) (Month) (Year) (Hour) (Minute) (Second)  
 (Local E) (Local N) (Local U) (STD DEV EE) (STD DEV NN) (STD DEV UU) (WGS84 X) (WGS84 Y)  
 (WGS84 Z) (STD DEV XX) (STD DEV YY) (STD DEV ZZ) (Outliers/Cycle Slips Present) (RHDOP)  
 (RVDOP)

Example:

```
651 311270.00 30 5 2012 14 27 50 -0.34109 -0.73679 -0.08248 0.001474 0.001412 0.003745
1763380.47364 -4079406.65735 4559595.45448 0.002172 0.002305 0.002857 False 0.92 1.42
```

### 6.4.2 Residual File

[Format] (GPS Week) (GPS Second of Week) (Day) (Month) (Year) (Hour) (Minute) (Second) (Ref Satellite) (#Satellites/Residuals) (List of Satellites) (List of Residuals)

Example:

```
651 311270.00 30 5 2012 14 27 50 G14 8 G01 G18 G27 G09 G12 G22 G25 G31 0.00347 -0.00573
-0.01076 -0.01029 0.00204 -0.00034 0.00101 0.00561
```

### 6.4.3 Outlier File

[Format] (GPS Week) (GPS Second of Week) (Day) (Month) (Year) (Hour) (Minute) (Second) (# Satellites/Outliers) (List of Satellites) (List of L1 Model Error Estimates) (List of L2 Model Error Estimates)

Example:

```
651 413280 23 2 2012 18 48 0 G18 1 G19 0.188 0.000
```

### 6.4.4 Observation Information File

[Format 1] (GPS Week) (GPS Second of Week) (Day) (Month) (Year) (Hour) (Minute) (Second) (#Satellites)

[Format 2] (PRN) (Ref. Elev) (Ref. Az) (Ref. S1) (Ref. S2) (Mon. Elev) (Mon. Az) (Mon. S1) (Mon. S2)

Example:

```
651 311270.00 30 5 2012 14 27 50 9
G1 11.85 319.97 42.75 24.50 11.85 319.97 42.00 30.00
G9 20.05 53.41 44.75 31.50 20.05 53.41 48.25 30.00
G12 41.92 78.20 50.75 42.50 41.92 78.20 50.50 39.50
G14 69.36 315.65 50.25 43.25 69.36 315.65 51.00 43.50
G18 29.41 157.87 47.50 35.75 29.41 157.87 47.00 33.00
G22 65.91 201.56 51.50 44.25 65.91 201.56 51.75 44.25
G25 41.20 139.28 55.00 42.50 41.20 139.28 54.00 43.25
```

G27 7.08 54.61 40.00 26.00 7.08 54.61 38.75 21.50  
 G31 29.46 232.72 48.75 39.75 29.46 232.72 49.50 40.75

## 6.5 Event Log Files

mmVu™ 3.0 reports software events to the Main Console. These events can be stored to a log file which can be useful for troubleshooting purposes. mmVu Event Log files are stored in the “System Log” folder and are named using the following naming convention:

*log + “\_”+YY + MM + DD + HH + .txt*

## 6.6 Project File Description

The contents of mmVu™ 3.0 project files are described in Table 10

Table 10: mmVu Project File Description

Project Entry	Description
[Version #] mmVu 3.0	mmVu Version Number
[Last Saved] 2012,5,30,11,25,5	UTC Year, Month, Day, Hour, Minute, Second of the last time the file was saved
[DD Solutions] False	Indicates whether or not DD solutions should be computed
[TDD Solutions] True	Indicates whether or not TDD solutions should be computed
[Store Residuals] True	Indicates if residuals will be archived to file
[Store Raw Obs] True	Indicates if raw observation data will be archived to file
[Store Outliers] True	Indicates if outliers will be archived to file
[Store Solutions] True	Indicates if solutions will be archived to file
[Archive Path] C:\Gemini Navsoft Technologies\mmVu Server\Projects\javad1\	Project folder to which data will be archived
[Processing Mode] 0	Indicates how data should be processed (0= real-time mode, 1 = post-processing)
[Application Mode] 1	Indicates application type (1= static, 2= kinematic, 3= dynamic)
[Q1 Status] True	Indicates if Q1 value has been changed (True=no change, False=changed)
[Q2 Status] True	Indicate if Q2 value has been changed (True=no

	change, False=changed)
[Q3 Status] True	Indicates if Q3 value has been changed (True=no change, False=changed)
[TC1 Status] True	Indicates if TC1 value has been changed (True=no change, False=changed)
[TC2 Status] True	Indicates if TC3 value has been changed (True=no change, False=changed)
[TC3 Status] True	Indicates if TC3 value has been changed (True=no change, False=changed)
[TC Correction] 0.000	TC correction value
[Q1 Value] 1.0E-006	Q1 value
[Q2 Value] 2.5E-007	Q2 value
[Q3 Value] 1.0E-008	Q3 value
[TC1 Value] 0.200	TC1 value
[TC2 Value] 1.000	TC2 value
[TC3 Value] 6.000	TC3 value
[# Stations] 6	Number of stations to follow
<b>For 1 to # Stations...</b>	
[Station ID] 1	Stations unique ID (mmVu assigned)
[Station #] 100	User assigned station number
[Station Name] Base	User assigned station name
[Station Desc.] Reference station	User assigned station description
[Reference Station] True	Indicates if this is a reference station
[Coords Known] True	Indicates if approximate coordinates for this station are known
[X] -2853952.21937	Approximate WGS84 X coordinate
[Y] 4656069.04876	Approximate WGS84 Y coordinate
[Z] 3284017.39144	Approximate WGS84 Z coordinate
[Interval] 5.00	Observation interval of GPS receiver
[Antenna Manufacturer] NOVATEL	Antenna manufacturer
[Antenna Model] IGS UNLISTED ANTENNA	Antenna model
[Receiver Manufacturer] NOVATEL	Receiver manufacturer
[Receiver Model] IGS UNLISTED RCVR	Receiver model
[ENU Rot. Az.] 0	Rotation Azimuth to apply to coordinate output (degrees)
<b>Next Station...</b>	
[# Baselines] 8	
<b>For 1 to # Baselines...</b>	
[Baseline ID] 1-2	Baseline ID

[Enabled] True	Baseline Enabled
[Tropo Estimation Mode] 2	Indicates how to deal with tropospheric delay estimation (1=Automatic, 2=Enabled, 3=Disabled)
[Elevation Cutoff] 10.0	Elevation cut-off angle
[Reference Station ID] 1	Station ID of reference
[Rover Station ID] 2	Station ID of rover
[TDD Q1 X Estimate] - 2853940.06416	Last WGS84 X coordinate from TDD engine
[TDD Q1 Y Estimate] 4656058.43948	Last WGS84 Y coordinate from TDD engine
[TDD Q1 Z Estimate] 3284009.48678	Last WGS84 Z coordinate from TDD engine
[TDD Q1 Var XX Estimate] 9.9723050792E-004	Last WGS84 X variance estimate from TDD engine
[TDD Q1 Var YY Estimate] 5.8531714279E-004	Last WGS84 Y variance estimate from TDD engine
[TDD Q1 Var ZZ Estimate] 4.2802703617E-004	Last WGS84 Z variance estimate from TDD engine
[TDD Q1 Var XY Estimate] 7.4307495016E-006	Last WGS84 XY co-variance estimate from TDD engine
[TDD Q1 Var XZ Estimate] - 8.7498573169E-007	Last WGS84 XZ co-variance estimate from TDD engine
[TDD Q1 Var YZ Estimate] 1.4641847224E-005	Last WGS84 YZ co-variance estimate from TDD engine
<b>TDD Q2...</b>	
<b>TDD Q3...</b>	
[DDC TC4 X Estimate] - 2853940.07085	Last WGS84 X coordinate from DD engine
[DDC TC4 Y Estimate] 4656058.45517	Last WGS84 Y coordinate from DD engine
[DDC TC4 Z Estimate] 3284009.48495	Last WGS84 Z coordinate from DD engine
[DDC TC4 Var XX Estimate] 4.7056187388E-006	Last WGS84 X variance estimate from DD engine
[DDC TC4 Var YY Estimate] 1.1070654472E-005	Last WGS84 Y variance estimate from DD engine
[DDC TC4 Var ZZ Estimate] 3.6550318644E-006	Last WGS84 Z variance estimate from DD engine
[DDC TC4 Var XY Estimate] - 5.5344394324E-006	Last WGS84 XY co-variance estimate from DD engine
[DDC TC4 Var XZ Estimate] - 1.3327610809E-006	Last WGS84 XZ co-variance estimate from DD engine
[DDC TC4 Var YZ Estimate]	Last WGS84 YZ co-variance estimate from DD

3.1794663448E-006	engine
DDC TC5...	
DDC TC6...	
Next Baseline...	

### 6.7 Effect of Q Value

Table 11 illustrates the impact of the Kalman filter Q value on detection time and solution component precision when a 25 mm displacement occurs over a period of 10 seconds. Note that a 25 mm level displacement in 10 seconds would be considered a very large displacement. This analysis applies to the TDD filtered solutions.

Table 11: Variation in Displacement Detection Time and Precision with Varying Q Values

Q value	Approximate Displacement Rate Accommodated [mm / 30 minutes]	Delay in Detecting Full Displacement [Hours]	$\sigma_E$ [±mm]	$\sigma_N$ [±mm]	$\sigma_U$ [±mm]
$(0.4 \text{ mm})^2$	5	0.5	10	7	9
$(0.2 \text{ mm})^2$	3	1	7	5	6
$(0.1 \text{ mm})^2$	1.5	4.5	5	3	4
$(0.05 \text{ mm})^2$	0.75	15	3	3	3
$(0.001 \text{ mm})^2$	0.015	35	< 2	< 2	< 2

### 6.8 Effect of TC Value

Figure 34 illustrates mmVu™ tracking (using the DDC Filter) of a GPS antenna that experiences a displacement. After approximately 15 hours of stationary data collection, the monitored station’s antenna was moved 5 mm in the east direction using a translation stage. The observations were collected at 1 Hz. Varying degrees of a regularized low pass filter are applied to the 1 Hz solutions to illustrate the displacement trend. It can be seen that larger TC values provide higher precision solutions but increase the time required for displacement detection. The 5 mm displacement is clearly illustrated by all filtered output types but the filter response time and precision vary according to the TC value.

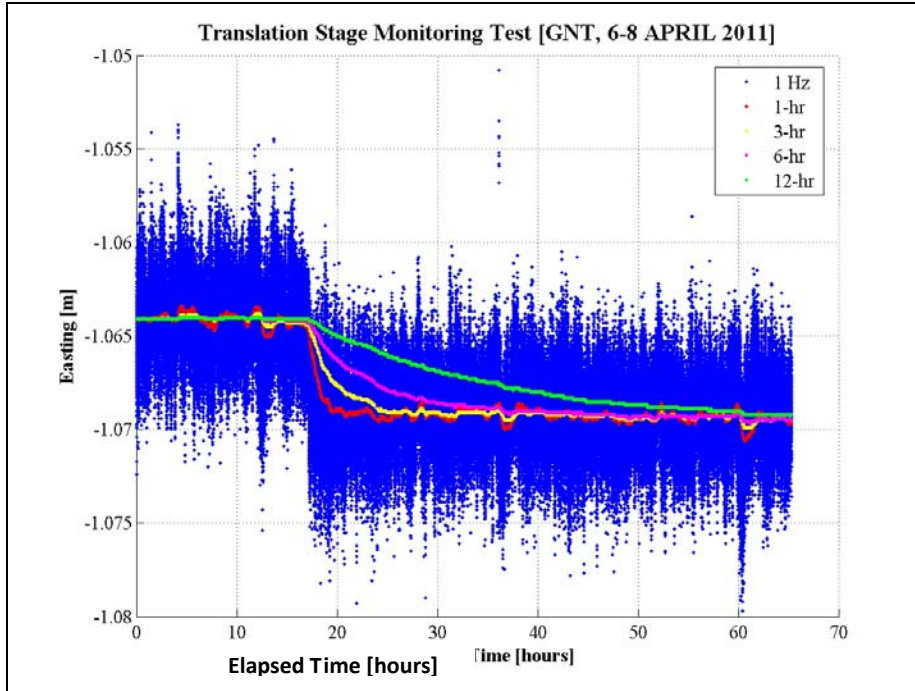


Figure 34: mmVu™ Software East Component Output

## Document Change Record

Issue	Date of Release	Reasons for Revision
v1.0	2012-08-14	Separating Sever and Client Manuals, Adding section describing the Integrity Monitoring Services
v2.0	2012-10-17	New version released
v2.1	2012-11-09	New project entries are added (see Table 10).