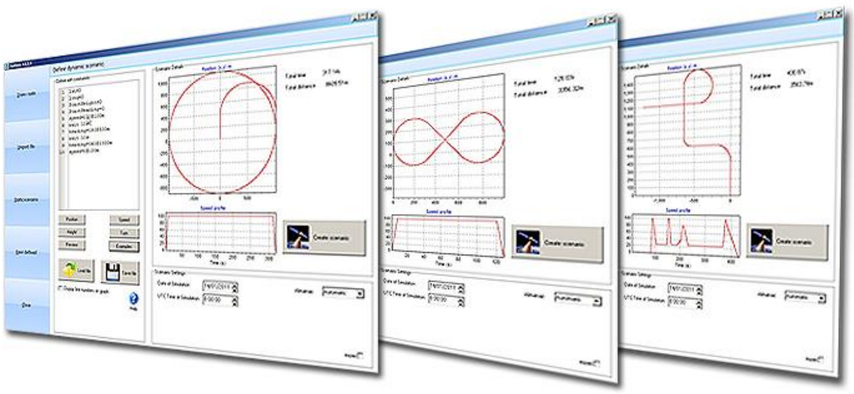
SatGen v3 Simulation Software



Instruction Manual

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Introduction

The use of multi-channel signal simulators to verify and evaluate Global Navigation Satellite Systems (GNSS) performance is at the core of any test approach. SatGen software provides an easy-to-use but powerful solution to users wishing to replay GNSS test scenarios. SatGen v3 allows users to specify a complete set of simulation parameters to create an IQ data file at baseband. The user can specify the simulation parameters including receiver dynamics, GPS satellite profile, and the GPS receiver signal and hardware profile. SatGen v3 provides accurate and repeatable RF signals and is up to 3 times faster than previous versions.
SatGen is ideal for applications requiring:

- High degree of flexibility not found in other hardware-based signal generators.
- The ability to make custom modifications to the simulator to support unique testing requirements.
- Highly repetitive testing where consistency between test runs is critical.

SatGen PC requirements

Minimum recommended specification for the desktop or laptop PC to be used with SatGen v3 software. Intel® i5™ 4GB RAM, 250GB Hard Drive. Operating System: Microsoft Windows 7 64 bit, Windows 8 64 bit, USB 2.0 port

Process overview

SatGen v3 software will run in two modes

- **Demonstration Mode:** to allow for short demonstrations SatGen software will run for 120 seconds without the Security dongle installed to allow for software feature demonstration.
- **Operational Mode:** SatGen v3 will operate as a single, dual or triple constellation version depending upon which security dongle is inserted. It is essential that users do NOT lose their dongle as the dongle cannot be replaced. A dongle replacement will require a full re-purchase of the SatGen v3 software.

SatGen software comes with the following configuration:

- **SatGen v3 Single Constellation** – This version allows for easy conversion of data into LabSat scenario files for replay with LabSat, LabSat 2 or LabSat 3 simulator systems. The software will create a single constellation file for GPS L1 or GLONASS L1 or BeiDou B1.
- **SatGen v3 Dual Constellation** - This version allows for easy conversion of data into LabSat scenario files for replay with all hardware versions of LabSat simulator systems. The software will create single or dual constellation files for GPS L1, GLONASS L1 or BeiDou B1 in any two or single constellation combination.
- **SatGen v3 Three Constellation** – This version allows for easy conversion of data into LabSat scenario files for replay with all hardware versions of LabSat simulator systems. The software will create three, two or single constellation files for GPS L1, GLONASS L1 or BeiDou B1 in any constellation combination.

There are four ways of generating the desired trajectory data with SatGen v3:

1. **Static Scenario Generation** – Use the inbuilt Google mapping to search for a location or enter the coordinate's ditectly.
2. **Draw Route -** Use the inbuilt Google map to draw a dynamic route.
3. **Import File** – Import trajectory files in the following formats:
    a. Google earth KML file.
    b. NMEA file in $GGA format.
    c. VBOX file in VBO format.
4. **User Defined** – create a trajectory using either the predefined examples or by entering user generated commands to control the position, velocity and dynamics of the output file.

System operation

The SatGen v3 GUI is shown below. The GUI will load default values upon start-up. There are two main stages of scenario production using SatGen. The first stage is to define the trajectory of the test, and the second is to convert this trajectory into a scenario file which can be replayed on LabSat. The software is designed to be as simple to use as possible and will need the PC that the software is installed on to be connected to the internet. This will allow for the Google maps and almanac details to be downloaded automatically.

The SatGen v3 main screen is divided into three sections. The left hand side has the main trajectory selection type control buttons. The middle section has the trajectory input section and the third right hand section has the Scenario Details and Scenario Settings sections.

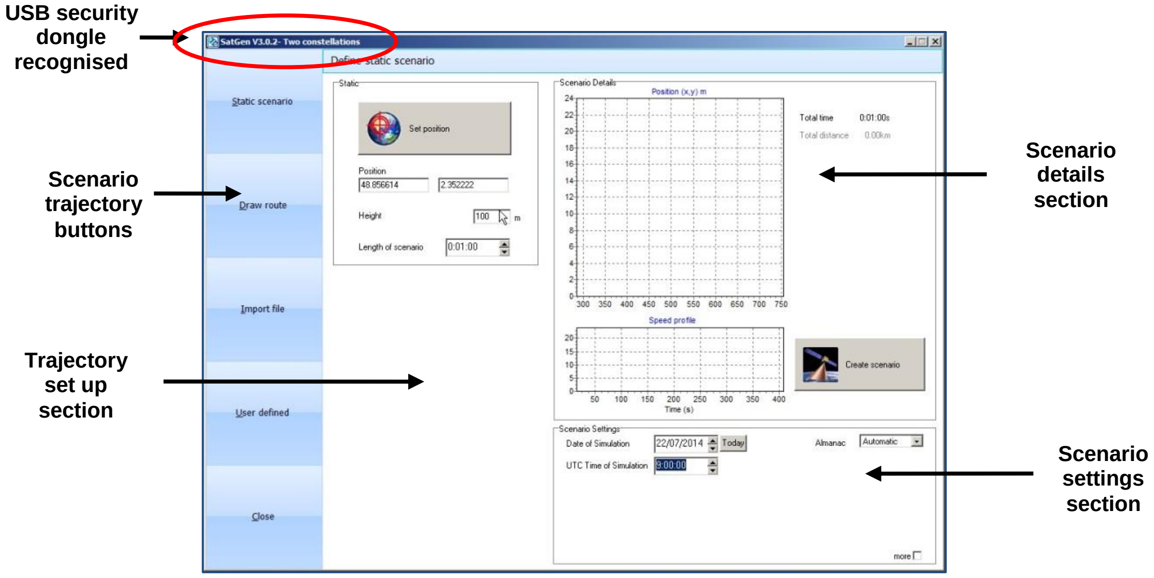

Figure 1: SatGen main screen

Security dongle

SatGen v3 software is available as a demonstration or operational product. The SatGen v3 demonstration version is readily available and will work as normal for demonstration and familiarisation purposes. The demonstration software is exactly the same as the operational software but without the security dongle inserted. The software will function as normal with the exception that it will only create a LabSat scenario of only 120 seconds duration. This is to allow for a demonstration scenario to be created but not of sufficient duration to be of any use as a device testing file. Operational software will create LabSat scenarios of any duration required.

The dongle is available in three different output variants:

Description	Racelogic Number	Output Capability	Constellation Available
SatGen v3 single constellation	RLLSSGSW03-1	Any single constellation scenario file of the three constellation's available	• GPS L1 • GLONASS L1 • Beidou B1
SatGen v3 dual constellation	RLLSSGSW03-2	Any single or dual constellation scenario file of the three available constellation's	• GPS L1 • GLONASS L1 • Beidou B1
SatGen v3 three constellation	RLLSSGSW03-3	Any single, dual or triple constellation scenario file of the three constellation's available	• GPS L1 • GLONASS L1 • Beidou B1

The software will recognise the USB dongle and display the following status:

- SatGen (Version Number) - No dongle detected – Demo version limited to 120 seconds
- SatGen (Version Number) – Single, Dual or Three channel enabled

The software dongle once inserted into the USB port will install automatically and will indicate that that it is installed correctly by displaying a red light.
For normal operation please ensure that the Security Dongle is installed prior to launching the SatGen software and is recognised by the PC. Please ensure your PC is connected to the internet when installing the dongle for the first time. This will allow for the automatic download of the relevant drivers for your security dongle.

Figure 2: SatGen software dongle installed in a USB port

Static Scenario Creation

If you are creating a simple stationary or static scenario, you just use the static scenario button located on the left of the screen.

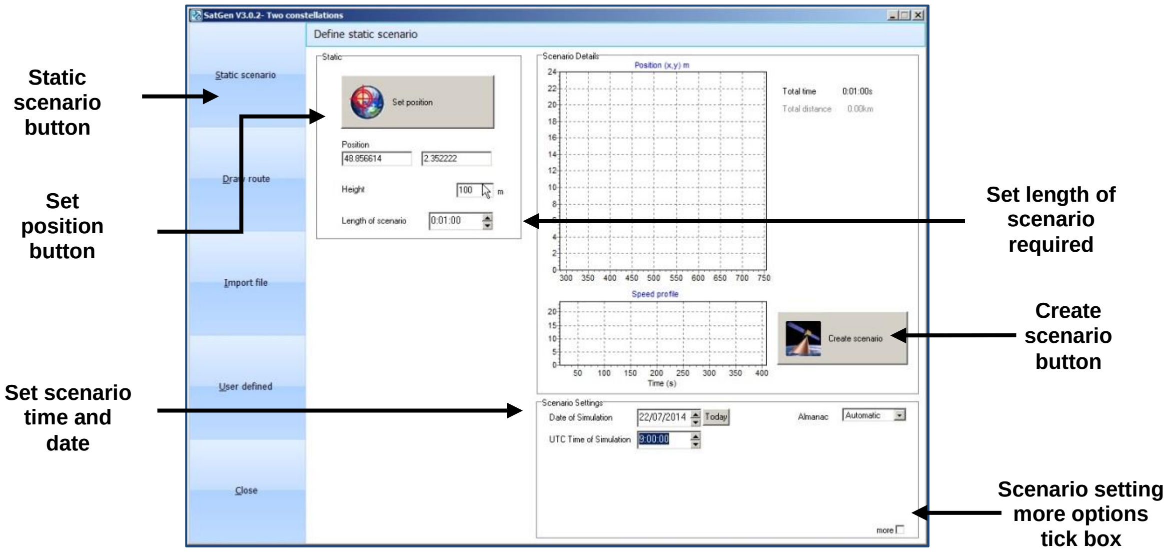

Figure 3: Static scenario creation

By clicking the Set position button you can easily select the location for your static scenario. If the static position is known then insert the position details in the latitude, longitude and height sections. By clicking the Set position button a Google map interface will appear. In the search box type the name of your required location. For example type London, UK and press the search button. The map will instantly move to London UK and automatically insert the Latitude and Longitude coordinates for the position located on the map. You can pan and zoom using the standard Google controls and use the standard map or a satellite photo map if required. By clicking on the required scenario location the position is automatically set into the software. Click the OK button to load the position. Then set the length of static scenario required in hours, minutes and seconds.

For a basic scenario set the date and start time of the scenario and if the PC is connected to the internet the automatic almanac download will activate, then just click the Create scenario button. (For further details on the Scenario settings section go to the dynamic scenario creation section below) Set the LabSat details to LabSat version required and if you need to change the name of the file, click the change button in the output file box. Fill in the new name in the file name box, click Save, then OK and the software will create the file. The SatGen progress box will appear giving an indication of the progress and time until file completion. See figures 4 & 5 below.

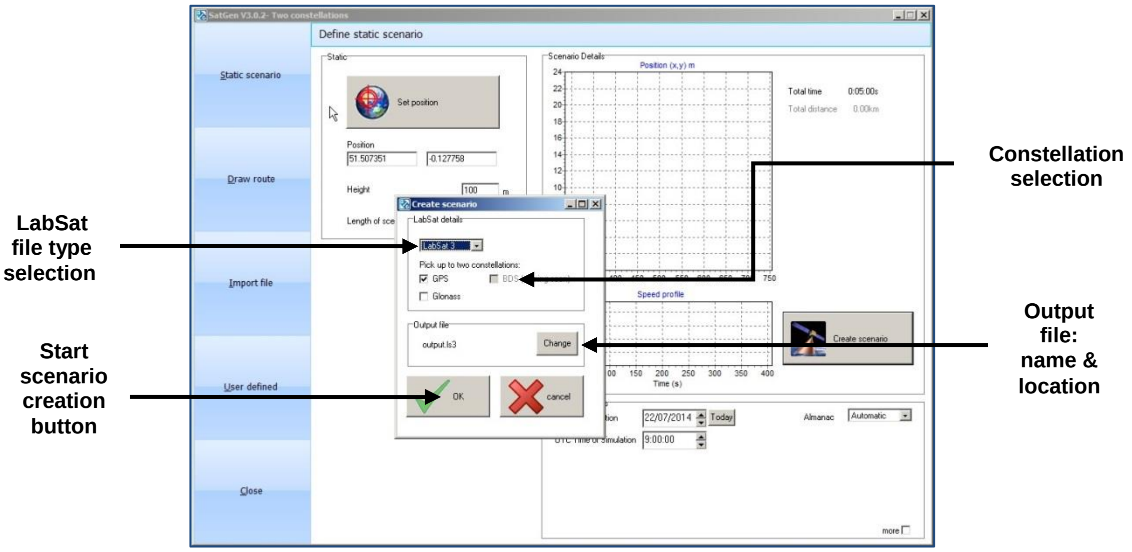

Figure 4: Create scenario screen

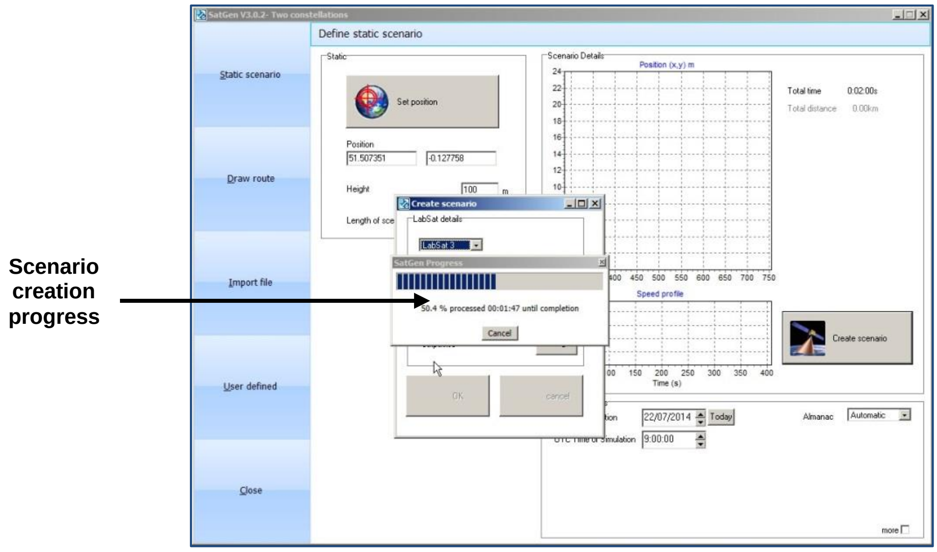

Figure 5: Scenario progress screen

Dynamic Scenario Creation

Draw route

To create a dynamic route click the draw route command. The new window allows you to draw a route on the map quickly and accurately. By inserting a location description in the search box, any location can be found in Google maps. You can then easily insert a route by clicking on the map in sequence. The map can be zoomed in or out for additional accuracy by using the normal Google map commands. Digital maps, terrain maps or satellite photo maps can be selected and the route edited or cleared by clicking the relevant command.

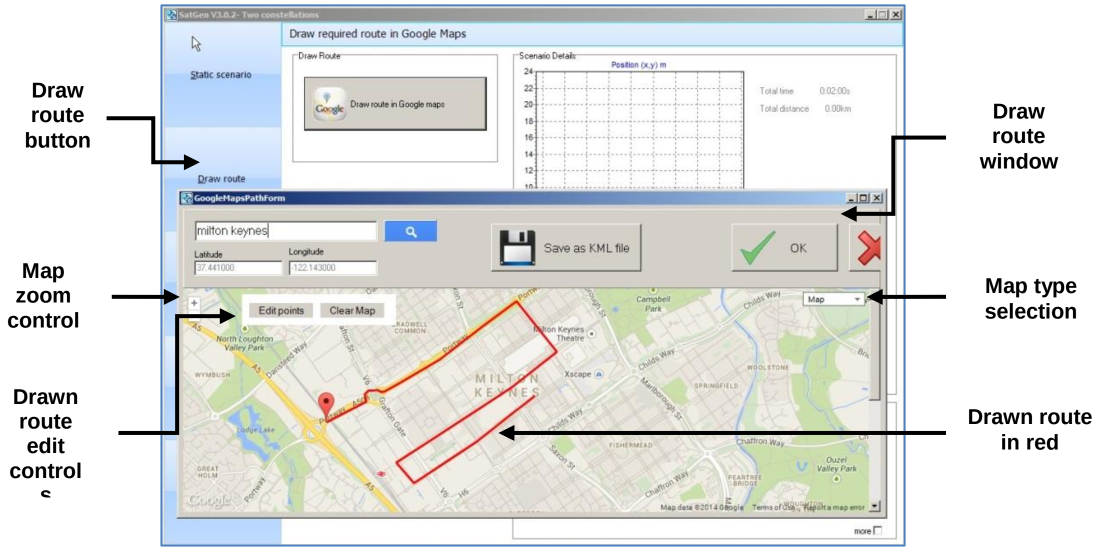

Figure 6: Draw route in Google maps screen

Draw the required route by clicking in sequence to draw the route on the Google map the route can then be saved as a KML file. By clicking on the OK button the drawn route is automatically inserted into the software and is ready for processing into a scenario.

The software then shows the drawn route in the Scenario details screen with a display of the position (x,y) in meters and the speed profile in kilometres per hour against time.

Scenario settings

In the Scenario settings section the more tick box should be ticked to reveal further settings. Date and time (UTC) can easily be defined. The dynamics selected will be reflected in the Scenario Details screen. By selecting High Dynamics the maximum speed will be 300 kph, Medium Dynamics for a maximum of 100 kph and Low Dynamics for a maximum of 60 kph. The software will automatically smooth the dynamic data to reflect turns at slower speeds. The update rate for the route can be defined from 1 Hz to 100 Hz. This will defined the granularity of the route created in the software. The elevation mask can be set to replicate the antenna environment when using a GPS receiver. This feature is normally used to improve GPS signal quality when nearby obstacles like trees and building are reflecting or temporarily obscuring the signal from satellites at low elevation. Raising the mask will cause a GPS engine to ignore satellites below the mask angle, so must be used carefully as it also reduces the total number of received satellites. So the higher the elevation mask the fewer satellite in the scenario file created. The elevation mask should normally be set to 5 degrees.

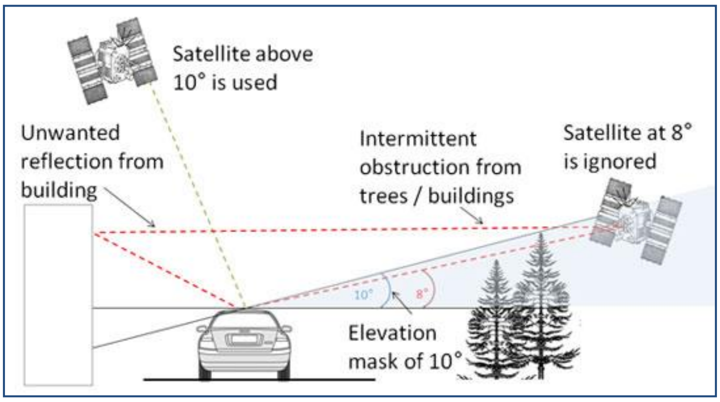

Figure 7: Elevation mask example

Select the almanac update to automatic or manual. For automatic almanac download the software needs to be connected via the PC to the internet to download the relevant almanac required.

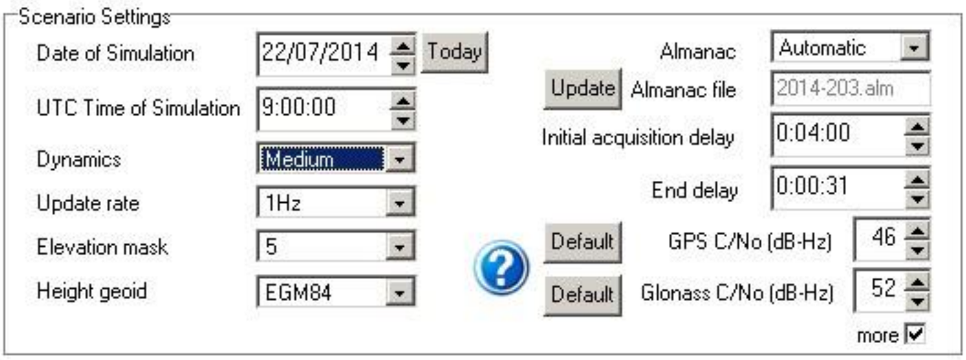

Figure 8: Scenario settings section

These almanacs are stored in the older Almanacs located in My Documents\SatGen\Almanacs. The initial acquisition delay should be set to reflect the static time allowed for the device under test (DUT) to acquire the signals and to start to navigate. As a standard Racelogic recommend 4 minutes to allow for DUT set up and signal acquisition. End delay should be set to allow for the receiver to stop and any files saved of the DUT performance. Normally set to 30 seconds.

User dynamics input

The dynamics setting allows for four dynamic settings; Low, Medium, High, settings and a user controlled input screen.

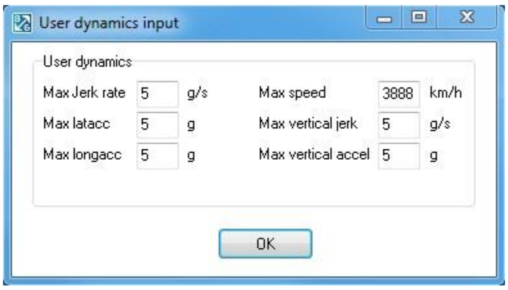

Figure 9: User dynamics input screen

- **Max jerk rate:** This controls the maximum rate of change of acceleration in a 2D horizontal plane, a low setting would allow for slowly increasing acceleration and a high setting giving a rapid change.
- **Max lat acc:** The maximum lateral acceleration controls the maximum acceleration perpendicular to the direction of travel.
- **Max long acc:** The maximum longitudinal acceleration controls the maximum acceleration/deceleration in the direction of travel.
- **Max speed:** The maximum speed controls the maximum speed the scenario can achieve.
- **Max vertical jerk:** The Maximum vertical jerk rate controls the rate of change of acceleration in the vertical direction.
- **Max vertical accel:** The maximum acceleration controls the acceleration in the vertical direction.

SatGen v3 height

When establishing a position solution, a GPS receiver generally works in Earth Centred Earth Fixed (ECEF) coordinates. It then translates these using a given datum into geodetic coordinates - latitude, longitude, altitude. The datum specifies an oblate spheroid model for the earth that best approximates the surface of the planet, ignoring all topographical irregularities; different datum's can be chosen to best approximate the region of interest to the end user. SatGen v3 uses the de facto standard World Geodetic System (WGS 84) which is applicable globally.

The initial altitude determined by translating the ECEF X,Y,Z to geodetic latitude, longitude altitude with the WGS 84 datum is an altitude above (or below) the theoretical oblate spheroid and not the surface of the planet in reality. To derive a more accurate representation of the true altitude, a GPS receiver will then use a model of the earth's gravitational field to reference the altitude to mean sea level (MSL). Various models exist for these estimates of MSL around the world, using increasing numbers of coefficients to derive more accurate estimates. The most common are EGM 84, EGM 96 and EGM 2008. Any altitude you enter into SatGen will be taken as height above MSL and in the process of simulation, this height will be added to the geoid separation for the current latitude and longitude, as estimated by the EGM84 geoid model. When generating a simulation from a provided NMEA file containing $GGA sentences, SatGen does not perform any geoid modelling, but instead uses the geoid separation in addition to the altitude above MSL provided in the NMEA 0183 GGA sentence

Carrier to noise ratio

SatGen v3 allows for the desired Carrier to Noise ratio (C/No) to be set for GPS and Glonass signals. The maximum setting which give the strongest signal for GPS is 51 dB-Hz and for Glonass the maximum setting is 57 dB-Hz. Some GPS engines require a few dB's of noise in order to get lock. The default setting for GPS is 46 dB-Hz and Glonass 52 dB-Hz. i.e. 5 dB-Hz of added noise.

Start the scenario creation by clicking the Create Scenario button, selecting the LabSat file format as described in the previous section.

Import File

SatGen v3 allows for the import of three file format:

- **Load Google Earth KML File -**. Google Earth files in KML format can be loaded into the software. The Position (x,y) and Speed profile is immediately displayed. Date, Time, Dynamics, update rate and mask angle can bet set to users requirements.
- **Load NMEA File -** NMEA Files in the $GGA format can be loaded into the software. The Position (x,y) and Speed profile is immediately displayed. Date, Time, (not dynamics), update rate and mask angle can bet set to users requirements.
- **Load VBOX File** - The VBOX product range a number of high specification GNSS data loggers from Racelogic ranging from 5Hz to 100 Hz VBOX files in the *.vbo format can be loaded into the software. The Position (x,y) and Speed profile is immediately displayed. Date, Time, (not dynamics), update rate and mask angle can bet set to users requirements.
- For test scenario files go to the examples sections at the rear of the manual

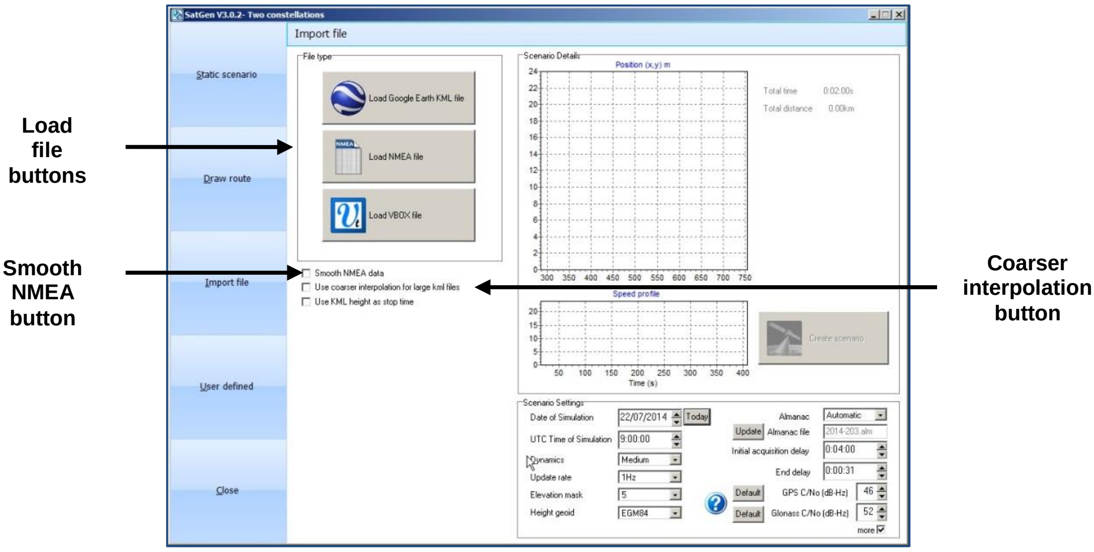

Figure 10: Import file screen

- **Smooth NMEA data -** This must be ticked before the NMEA file is loaded, this will then apply smoothing to the data to give a more accurate representation when noise is encountered in the original data. See figure 13: The original data in red and the smoothed data in blue. This is displayed in the scenario details section once the file is loaded.
- **Coarse interpolation for large KML files -** Very large KML files will exceed the software's memory limits and cannot be loaded. If this occurs tick this radio button and the software will use a coarser interpolation method reducing the size of the memory allocation required.

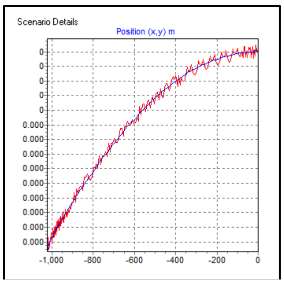

Figure 11: Smooth NMEA data

User defined

The user defined trajectory input feature is the most versatile of all scenario input methods. By building a simple list of commands a trajectory can easily be created. By clicking the Preview Button the Scenario details Section will display the output of the preloaded instructions. By clicking the Help button a full description of the command definitions and update commands types is displayed. A quick and easy way to get going is to load one of the predefined examples loaded in the software by clicking the Examples button. This list of predefined user instructions covers a selection of popular tests to be completed with the SatGen v3 and LabSat combination to test GNSS devices.

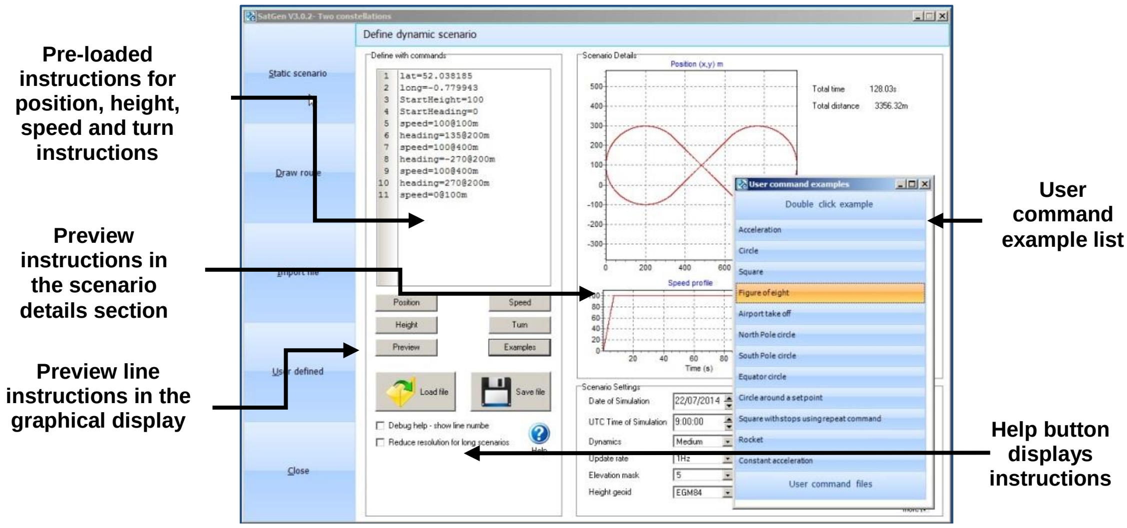

Figure 12: User defined examples screen

Commands available

Recognised user commands details are available in the Help button together with user tips and details of the debug mode. :

Commands to define initial conditions	Commands to update trajectory
Time=xxxxx.xx {time in seconds from midnight} Lat=+xxxx.xx {latitude of starting point in degrees} Long=+xxxx.xx {longitude of starting point in degrees} StartHeight=+xxxx.xx {height of starting point in metres} StartHeading=xxx.xx {initial heading in degrees} Wait xxs {Wait stationary for xx seconds}	speed=xxx@yyym {change velocity to xxx in yyy metres} speed=xxx@yyys {change velocity to xxx in yyy seconds} Heading=+xxx@yyym {change heading by +(or-)xxx degrees, using radius of yyy metres} Heading=+xxx@yyys {change heading by +(or-)xxx degrees in yyy seconds} Height=xxx@yyys{change height to xxx metres in yyy seconds} Height=xxx@yyym {change height to xxx metres in yyy metres} wait xxs {continue at same speed and heading for xxs}

Figure 13: User commands

Should you encounter any memory capacity issues when loading very large files please tick the Reduce resolution for long scenario tick box.

User command examples

A selection of predefined command instructions is available as a set of common user applications. Any of the examples listed can easily be modified to suit user requirements and saved for later use

User command example files	Description
Acceleration	Example of a simple acceleration and deceleration profile.
Circle	Simple circle profile.
Square	Simple square profile.
Figure of Eight	A figure of eight profile.
Airport take off	Take from from a runway.
North Pole Circle	Circle around the north pole to test latitude and longitude output.
South Pole Circle	Circle around the south pole to test latitude and longitude output.
Equator Circle	Circle around the equator to test latitude and longitude output.
Circle around a set point	Change the Latitude and longitude settings to move the circle.
Square with stops using repeat command	Circuits around a square
Rocket	Basic rocket trajectory
Constant acceleration	Standard acceleration command

Figure 14: User command examples

Example data files

Example 1 – Google KML dynamic scenario

This example uses a pre-recorded KML file to define a dynamic path:

1. Click the import file button on the SatGen v3 main screen.
2. Click the Load Google Earth KML File button.
3. Select the KML file City_London_Cab_route located in My Documents\SatGen\Examples
4. Click Open in the file selection window and the file will automatically load into the software
5. Select the date required for the simulation and enter the UTC time
6. Check that the correct almanac is present
7. Click the Create scenario button, select LabSat system file name.
8. Click OK to create your scenario.

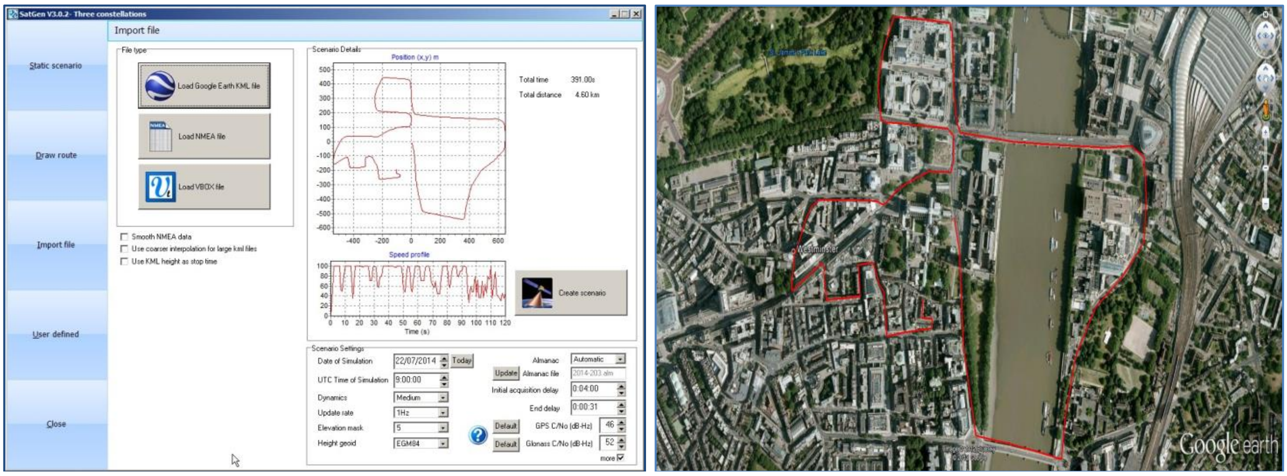

Figure 15: KML example file loaded

Example 2 – NMEA dynamic scenario

This example uses a pre-recorded NMEA file to define a dynamic path:

1. Click the import file button on the SatGen v3 main screen.
2. Click the Load NMEA File button.
3. Select the NMEA File Vesuvius_rim_NMEA located in My Documents\SatGen\Examples
4. Click Open in the file selection window and the file will automatically load into the software
5. Select the date required for the simulation and enter the UTC time
6. Check that the correct almanac is present
7. Click the Create scenario button, select LabSat system file name.
8. Click OK to create your scenario.

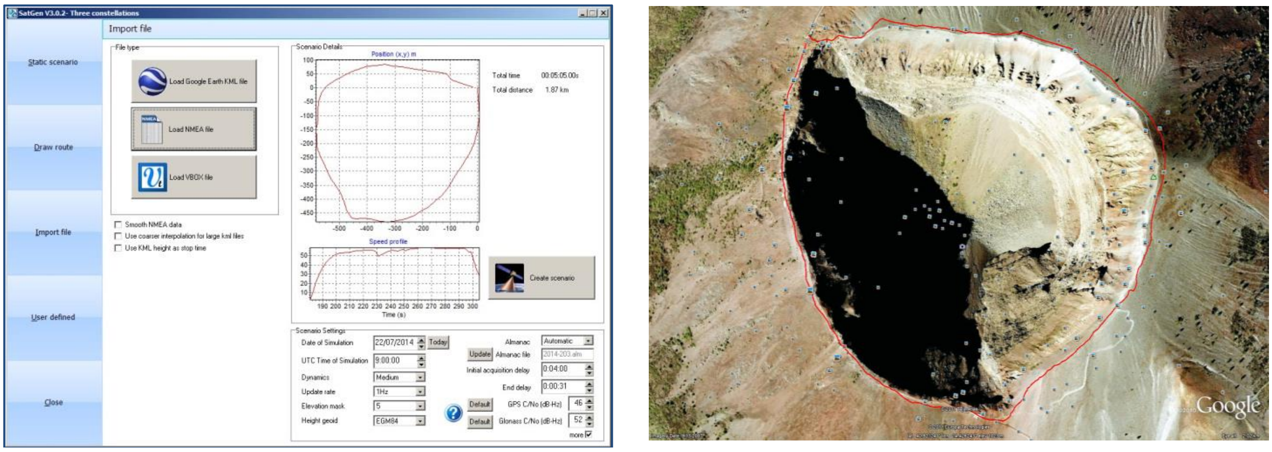

Figure 16: NMEA example file loaded

Example 3 – VBOX VBO dynamic scenario

This example uses a pre-recorded VBOX VBO file to define a dynamic path

1. Click the import file button on the SatGen v3 main screen.
2. Click the Load VBOX File button.
3. Select the VBO file F430-Carolina.vbo located in My Documents\SatGen\Examples
4. Click Open in the file selection window and the file will automatically load into the software
5. Select the date required for the simulation and enter the UTC time
6. Check that the correct almanac is present
7. Click the Create scenario button, select LabSat system file name.
8. Click OK to create your scenario

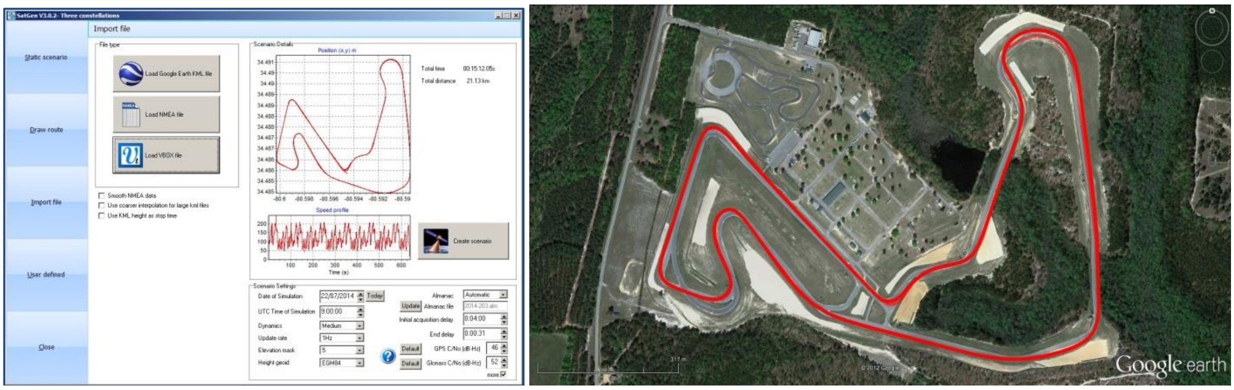

Figure 17: VBOX example file loaded

Appendix:

GGA NMEA format

Define the dynamic profile using a GGA NMEA formatted text message. The GGA format is shown below. SatGen will properly handle the UTC midnight rollover if it exists in the NMEA input file.

GGA NMEA Format Definition
$--GGA,hhmmss.ss,llll.ll,a,yyyyy.yy,a,x,xx,x.x,x.x,M,x.x,xxx*hh<CR><LF>
hhmmss.ss – UTC of position
lll.ll,a – Latitude –N/S
yyyyy.yy,a – Longitude – E/W
x – GPS Quality indicator – Shall not be a null field

0 – Fix not available or invalid
1 – GPS SPS Mode, fix valid
2 – Differential GPS, SPS Mode, fix valid
3 – GPS PPS Mode, fix valid
4 – Real Time Kinematic. Satellite system used in RTK mode, fixed integers
5 – Float RTK. Satellite system used in RTK mode, floating integers
6 – Estimated (dead reckoning) Mode
7 – Manual Input Mode
8 – Simulator Mode

xx – Number of satellites in use (00-12) may be different from number in view
x.x – HDOP
x.x, M- Altitude, Mean-sea-level (geoid), meters
x.x,M – Geoidal separation, meters

Geoidal Separation: the difference between the WGS-84 earth ellipsoid surface and mean-sea-level (geoid) surface, “-“ = mean-sea-level surface below WGS-84 ellipsoid surface

x.x – Age of Differential GPS data

Time in seconds since last SC104 Type 1 or 9 update, null field when DGPS is not used

xxxx – Differential reference station ID, 0000-1023

Example GGA Data File

$GPGGA,212331.00,3902.9511,N,10451.2682,W,8,00,0.0,2057.8,M,-15.5,M,,*68
$GPGGA,212332.00,3902.9531,N,10451.2694,W,8,00,0.0,2058.6,M,-15.5,M,,*6F
$GPGGA,212333.00,3902.9548,N,10451.2718,W,8,00,0.0,2059.0,M,-15.5,M,,*62
$GPGGA,212334.00,3902.9559,N,10451.2750,W,8,00,0.0,2059.0,M,-15.5,M,,*69
$GPGGA,212335.00,3902.9565,N,10451.2786,W,8,00,0.0,2059.0,M,-15.5,M,,*6C

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3.0	First Release - MS	23/07/2014