

# SatGen GNSS Signal Simulation Software

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## BIOGRAPHY

Alison Brown is the President and Chief Executive Officer of NAVSYS Corporation, which she founded in 1986. NAVSYS Corporation specializes in developing next generation Global Positioning System (GPS) technology. Dr. Brown has a PhD in Mechanics, Aerospace, and Nuclear Engineering from UCLA, an MS in Aeronautics and Astronautics from MIT, and an MA and BA in Engineering from Cambridge University. She is a fellow of the Institute of Navigation and an Honorary Fellow of Sidney Sussex College, Cambridge.

Mark-Anthony Hutton is a Software Engineer with NAVSYS Corporation working on GNSS Signal Simulation Tools and the GPS Jammer Detection and Location System (JLOC). He holds a BS in Computer Science from the University of Colorado at Colorado Springs.

Marc Quigley is a Project Manager for NAVSYS Corporation working with Signal Simulation Tools and GPS/INS products. He holds a BS in Communications from San Francisco State University.

Mark Sampson is the LabSat Product Manager for Racelogic Ltd.

## ABSTRACT

Embedded GPS receivers have become commonplace with the proliferation of GPS navigation systems into all but the least expensive vehicle and cell phone lines. As more manufacturers embed low-cost GPS receivers in to their products, the need for low-cost GPS signal simulators have also grown. Controlled virtual testing is vital in ensuring the expected system performance. Many GPS signal generators are available that are designed specifically for high volume production test applications for devices that use commercial GPS/SBAS, GLONASS, and Galileo receivers. Often the cost of these high-end simulators is beyond the reach of small companies or universities. In response to this need, NAVSYS developed our low cost GNSS Signal Architect software that can be adapted for use with record and playback GNSS signal simulation devices, such as the LabSat

produced by Racelogic, to address a broad range of research, academic, industrial, and defense applications. GNSS Signal Architect is the core of Racelogic's SatGen software, which is available as a LabSat option. The system is designed to be flexible, scalable, and most importantly, inexpensive.

This paper provides a review of the Racelogic LabSat hardware with the SatGen software as a low cost GPS signal simulator and RF record and playback device. In addition, the hardware design and supported signals are described and test results are presented showing the LabSat hardware providing simulated signals to conventional GNSS user equipment.

## INTRODUCTION

The LabSat GNSS simulator (Figure 1) can be used to record live navigation satellite RF data streamed onto a hard drive. This can then be played back as an RF signal. When integrated with Racelogic's SatGen software, simulated digitized RF data can be generated and played back into the LabSat simulator in place of the recorded digitized GNSS RF signals.



Figure 1 LabSat GNSS Simulator

The core of Racelogic's SatGen software is NAVSYS' GNSS Signal Architect, which has been adapted to run on the LabSat platform to allow simulation of the multiple GPS signals and also of different GNSS satellite signals. In this paper we describe how SatGen can be used with Racelogic's new LabSat2 product to provide an

inexpensive GPS+GLONASS signal simulation capability.

### LABSAT2 HARDWARE DESIGN

The LabSat2 hardware design that enables the record and playback of GPS and GLONASS synchronized RF data streams is shown in Figure 2. When recording the GPS or GLONASS signals, the RF L1 channels (1575.42 MHz for GPS and 1602.0 MHz For GLONASS) are downconverted to a 0 Hz Intermediate Frequency (IF). The signals are sampled (2 bit I and Q) at 16.368 MHz to capture the full GLONASS set of frequency channels. The GPS and GLONASS data is then interleaved into a 4 bit data stream and recorded in an internal buffer as a binary file. A high-speed USB link then transmits the data to a PC prior to streaming onto the PC hard disk. For playback, the PC streams the stored binary data to the LabSat via the USB link. The recorded digital GPS+GLONASS signals are upconverted onto the GPS+GLONASS RF channels and played back into the receiver under test. A digital attenuator on the output can adjust the RF output level.

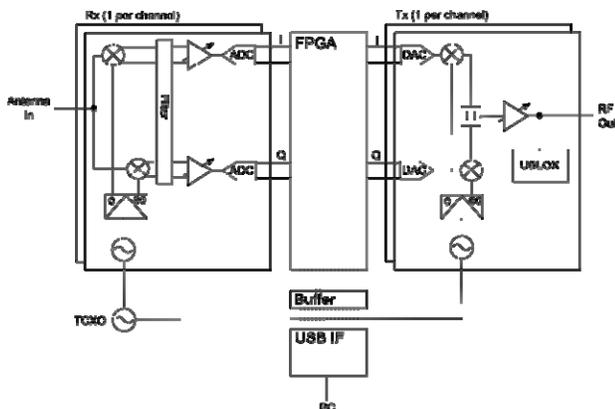


Figure 2 LabSat2 Hardware Design

Using the LabSat record and playback mode, all of the real world effects on the GNSS signal are recorded including multipath effects, drop-outs, atmospheric effects allowing repeatable tests to be performed on GNSS receivers under a variety of real world conditions, such as urban canyons. This is ideal for debugging fault conditions on GNSS equipment and software. For more extensive simulations in different environments, the LabSat SatGen software can be used to generate simulated scenarios at any time, place or dynamic environment.

### SATGEN SCENARIO SIMULATION

SatGen is a software package which allows users to create user defined trajectories for use in generating simulated data files for playback into LabSat. As shown in Figure 3, a user-defined trajectory file can be used to create a

LabSat simulated scenario for a route anywhere in the world. Routes can be generated directly from NMEA files imported directly into SatGen from a GPS data-logger such as Racelogic’s VBOX or from user defined routes generated using Google Earth.

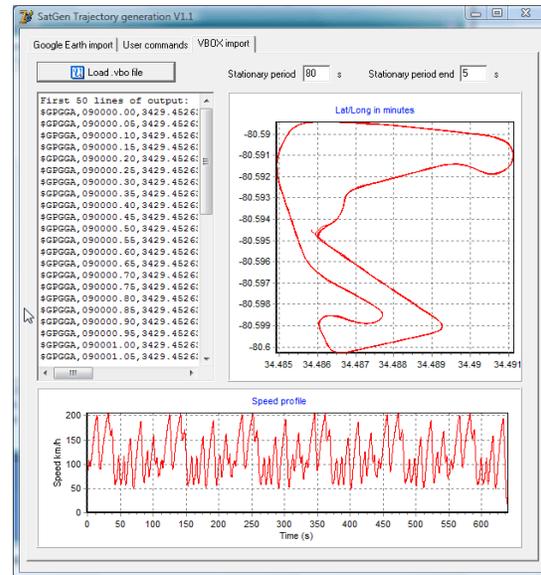


Figure 3 SatGen Trajectory Generation

As shown in Figure 4, SatGen users can use Google Earth to define a route by creating a path using the “Add Path” tool in Google Earth. The user can use as many or as few waypoints as they want and can edit routes by moving, adding, or removing waypoints. The path is saved as a standard Google Earth KML file which is imported into SatGen, which then fills in and smoothes the trajectory between the waypoints. The user can also define velocity profiles, or SatGen can provide these automatically. SatGen creates an NMEA file that is used to generate binary I/Q simulated signal file for replay on the LabSat hardware.

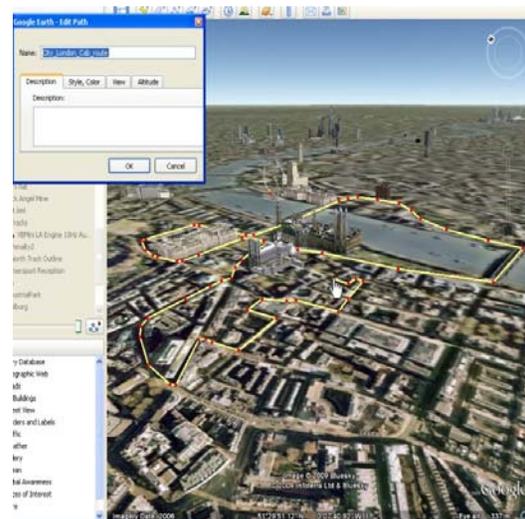


Figure 4 Google Earth Defined Routes

## SIGNAL ARCHITECT SIMULATION

The core of Racelogic’s SatGen software is NAVSYS’ GNSS Signal Architect, which provides the capability to simulate multiple GPS signals and also different GNSS satellite signals. The GNSS Signal Architect software was developed by NAVSYS based on our MATLAB Signal Simulation Toolbox<sup>[1, 2, 3]</sup>.

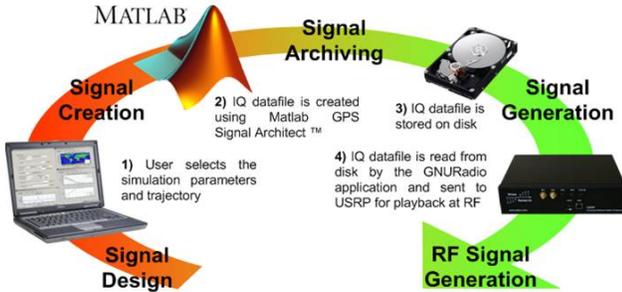


Figure 5 NAVSYS Signal Architect Software

Signal Architect imports the NMEA trajectory either from a prerecorded file or generated using SatGen and uses this file to generate a GNSS simulated scenario. As shown in Figure 6, the user specifies the input GPS satellite constellation through a Yuma format almanac file<sup>[4]</sup> and the GLONASS constellation through a Glonass.agl or Rinex almanac file<sup>[5]</sup>. These files are then used to generate the simulated pseudorange, Doppler and carrier-phase for the GPS and GLONASS satellites in view of the simulated GNSS receivers above a specified mask angle. This simulated range data is then used to generate the digitized I&Q signals for the GPS and GLONASS signals. Users who purchase the GNSS Signal Simulation Toolbox from NAVSYS will have the added ability to modify the GNSS signal strength and add additional high resolution error models to the simulated signals including multipath or GNSS signal error characteristics. The resulting I/Q simulated data file for the GPS+GLONASS constellation is then recorded in a data file which can be loaded into the LabSat hardware for playback into a receiver under test.

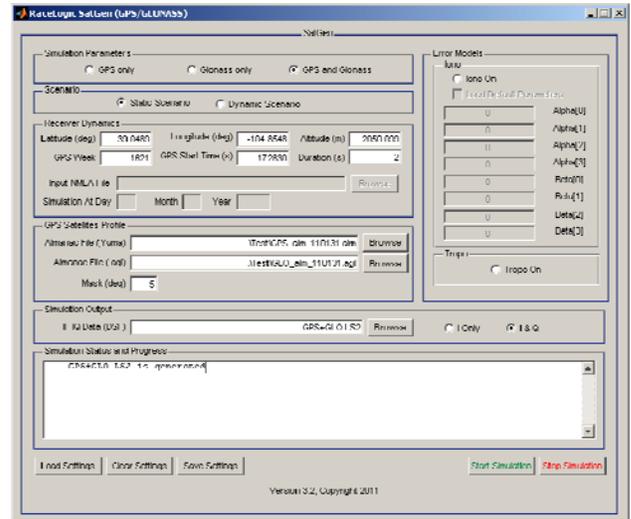


Figure 6 SatGen GUI

## TEST RESULTS

To demonstrate the GPS, GLONASS and GPS+GLONASS simulation results, the test data was played back into a JAVAD receiver under test. In Figure 7, the GPS navigation results are shown from playing back the GPS only signals. In Figure 8, the same results are shown from playing back the GLONASS only signals. In Figure 9, the results from using both GPS+GLONASS signals in the receiver are shown. From these plots it can be seen that a highly accurate navigation solution can be obtained from any of these playback modes using the combination of Racelogic’s LabSat hardware with the SatGen software.



Figure 7 GPS Only Simulation Results



**Figure 8 GLONASS Only Simulation Results**



**Figure 9 GPS+GLONASS Simulation Results**

## CONCLUSION

The LabSat2 product, purchased with the optional SatGen software, manufactured by Racelogic allows their users to leverage the capabilities of the NAVSYS GNSS Signal Architect software to obtain a GPS/GLONASS signal generation capability in addition to the LabSat record and playback capability. This allows GNSS signal simulations to be performed at a much lower cost than using dedicated GNSS signal simulators currently available on the market. Further GNSS signals are planned to be added in the near future enabling users to also simulate signals from systems such as SBAS GPS augmentation systems or other L1 GNSS systems such as QZSS or Galileo.

## REFERENCES

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