

GPS M-code Signal Simulation using an Open Source Radio Platform

Joint Navigation Conference
Session B2: Modeling and Simulation 2
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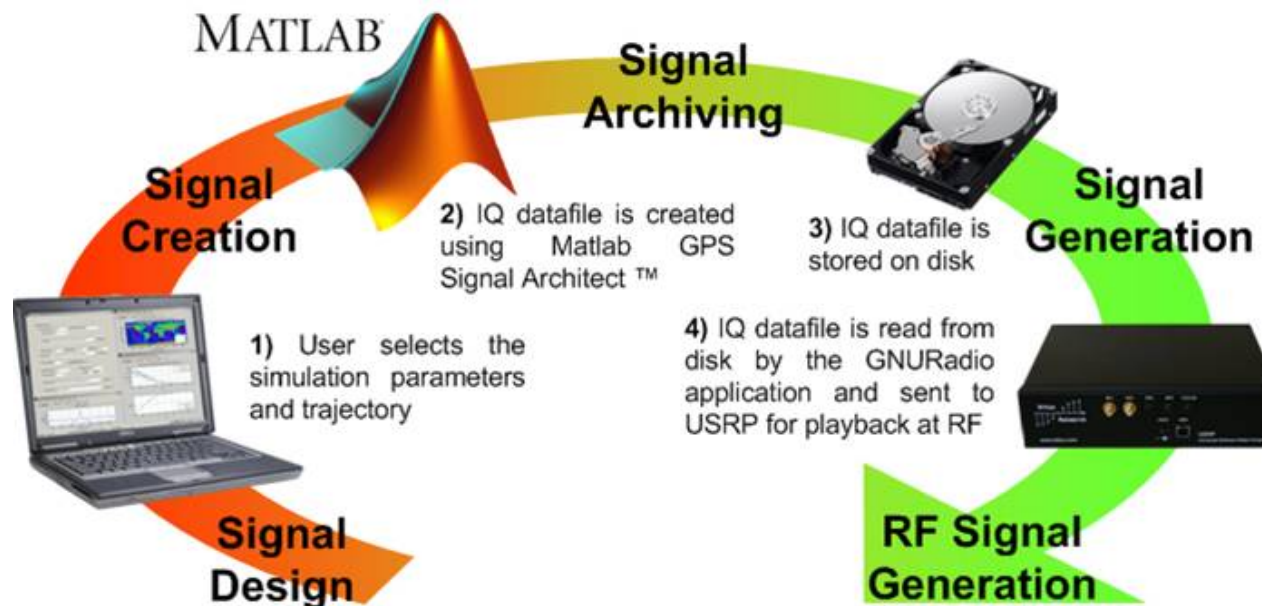
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Operational Need

- Current generation military simulators are expensive, increasing costs for GPS test and evaluation to
- Inexpensive commercial GPS simulators are available that use signal simulation, record and playback techniques to test receivers under representative environments
- Commercial record and playback GPS simulators do not have the bandwidth needed to collect military GPS signals
- NAVSYS military version of the Signal Architect GNSS Signal generator software enables full bandwidth GPS signal record, generation and playback providing an inexpensive test and evaluation tool for YMCA receivers

GNSS SDR Signal Generator

- Ettus URSP hardware and MATLAB software based low-cost GNSS signal simulator



Commercial Signal Architect Enabled Products



Agilent N5106A PXB Baseband Generator and Channel Emulator

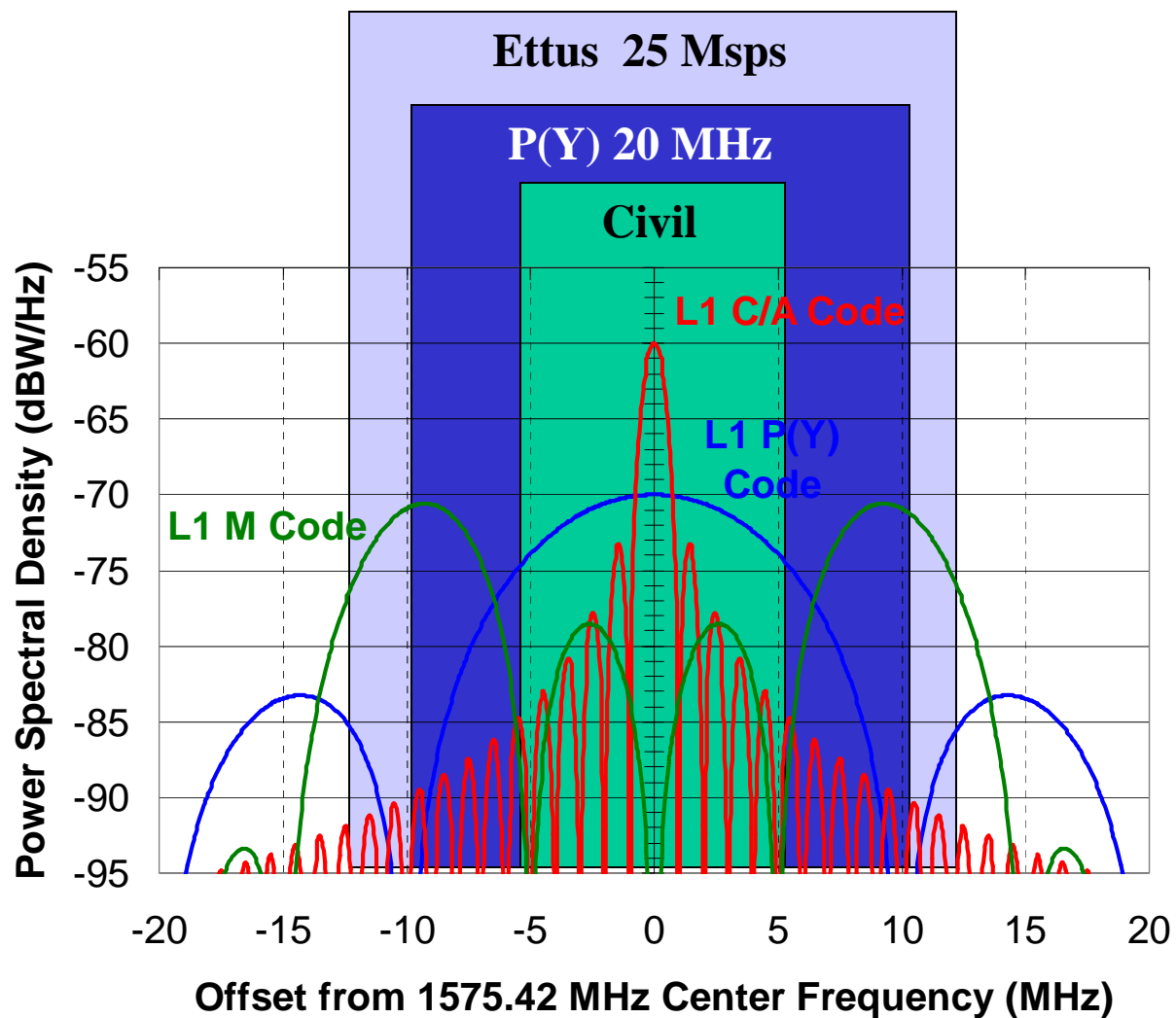
- C/A+Glonass
- Civil RF Signal Simulation
- Vector Generation



RaceLogic LabSat GNSS Simulator

- GPS + Glonass
- Civil RF Signal Recording
- Playback of recorded and simulated signal files

GPS Record & Playback



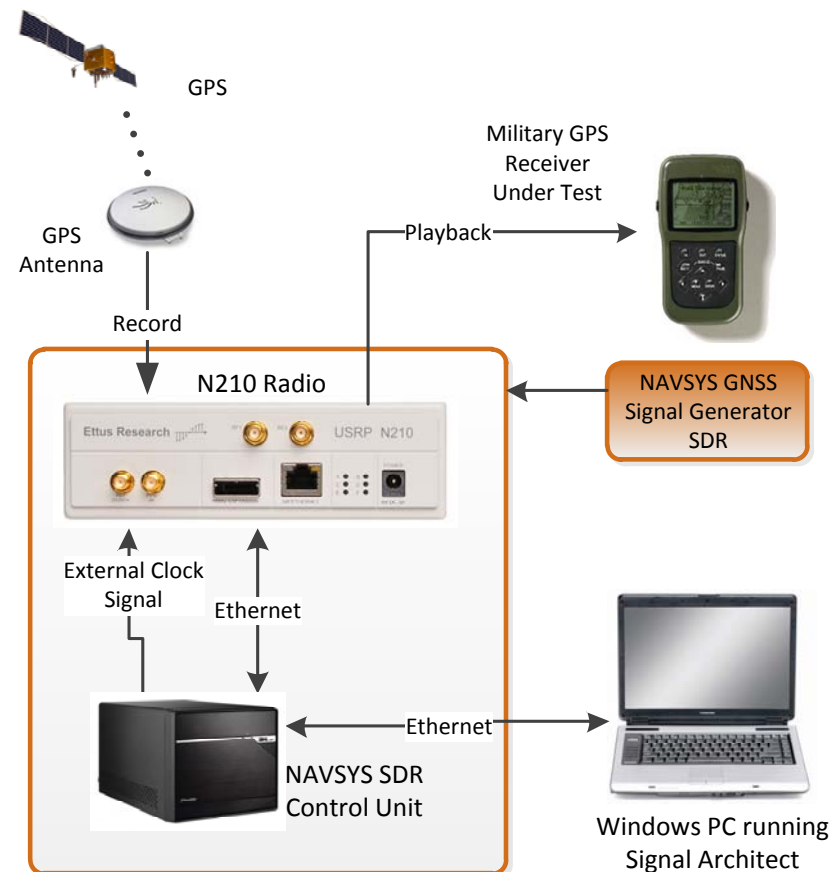
GPS Signal Generator SDR

NAVSYS Signal Architect

- Trajectory generation from Google Earth (KML) or NMEA file
- Almanac file used to define SVs
- User defines mask angle & CN0
- Generates simulated digital storage files (DSF)

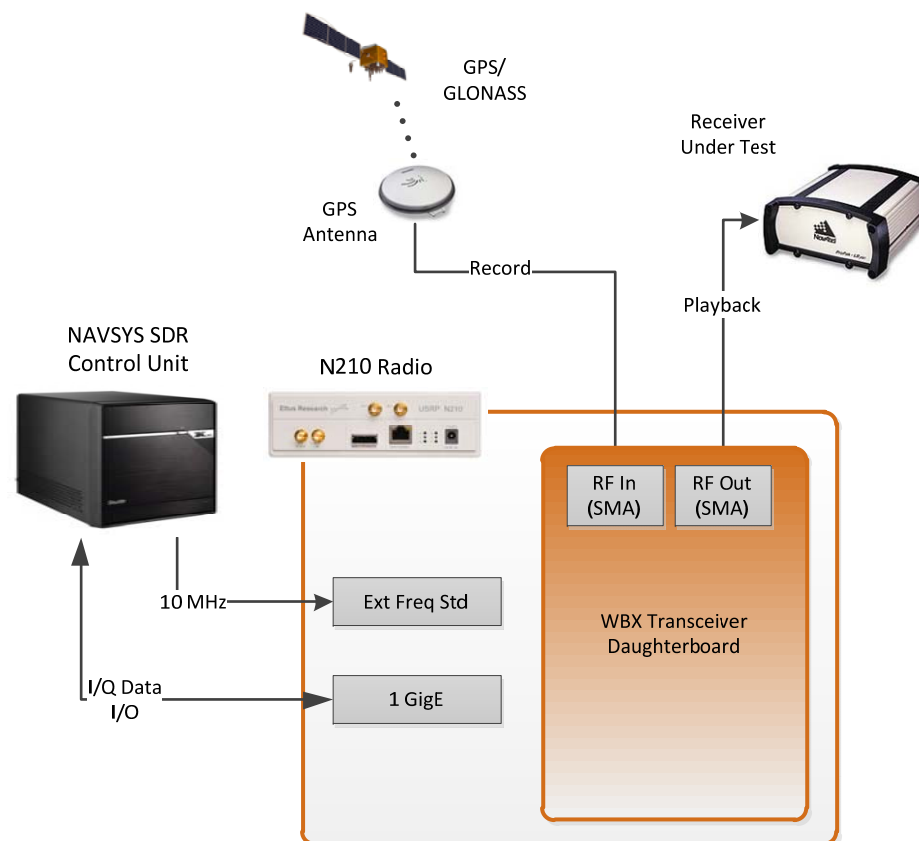
GPS Signal Generator

- Signal Architect transfers DSF files to SDR Control Unit (SCU)
- SCU controls USRP
- SCU records and plays back DSF files to generate RF signal



Ettus Universal Software Radio Peripheral (USRP)

- USRP Software
 - Open source GNU Radio
 - GNU Radio Companion
- N210 Radio
 - Spartan-3A 3400 DSP
 - Transceiver Daughterboards
- USRP WBX Transceiver Daughterboard
 - Full-Duplex
 - 50 MHz to 2.2 GHz
 - 14 bits A/D

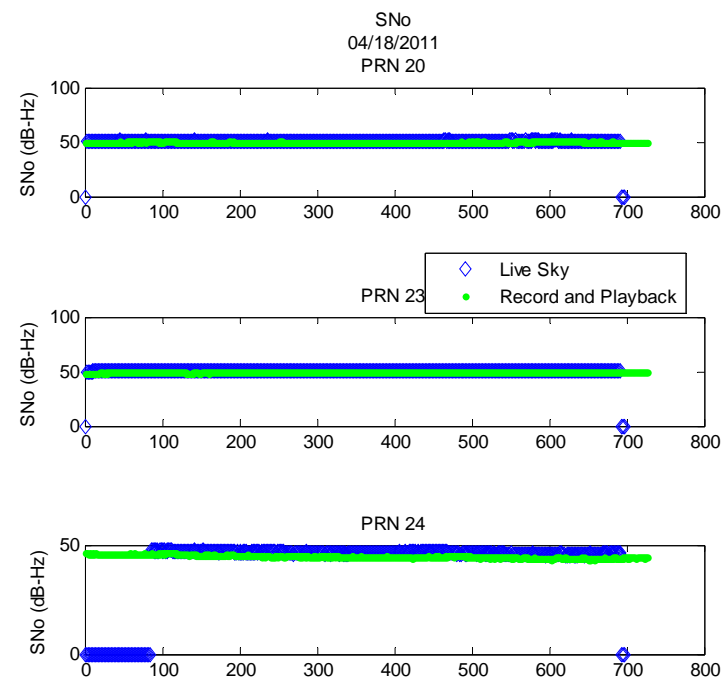
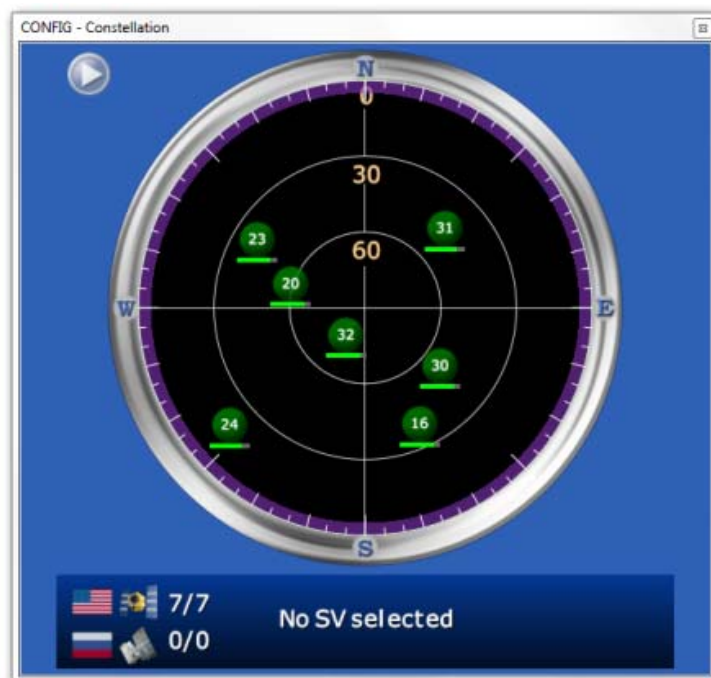


GPS Signal Generator Features

- L-Band Signal Recording
 - L1: 1575.42 MHz I&Q (Fs=20 Msps, IF Freq=0)
 - Length dictated by SCU flash drive storage
- GPS Signal Generation
 - User inputs simulated profile and GPS satellite almanac
 - Specifies codes and power levels for the satellite signals
 - C/A & P-code + M'
 - (L1c, L2 and GLONASS in development)
 - Digital Storage File generated
- L-Band Signal Playback
 - L1: I&Q from either prior recorded or simulated file

Record/Playback Example

- GNSS Signal Architect used to generate a IQ data simulation file
 - C/N0 was 1-2 dB lower in playback mode (Green) when compared to data collected in real-time from GPS antenna (Blue)



Signal Architect

Signal Architect

Receiver Dynamics

Static Scenario
Latitude (deg) - Longitude(deg) - Altitude (m) -
GPS Week - GPS Start Time (s) - Duration (s) -

Dynamic Scenario
Input NMEA File -
Simulation At Day Month - Year -

GPS Satellites Profile
Almanac File (Yuma) -
Mask (deg)

Receiver Signal and Hardware Profile

Sample Rate (KHz) - IF Freq (Hz) - **Output Format**
 I Only
 I & Q
Noise Figure (dB) - # Sample Bits -

Simulation Output
IF IQ Data (DSF) -
NMEA File -

Simulation Status and Progress

Error Models

Iono
 Iono On Load Default Parameters

<input type="text" value="0"/>	Alpha[0]
<input type="text" value="0"/>	Alpha[1]
<input type="text" value="0"/>	Alpha[2]
<input type="text" value="0"/>	Alpha[3]
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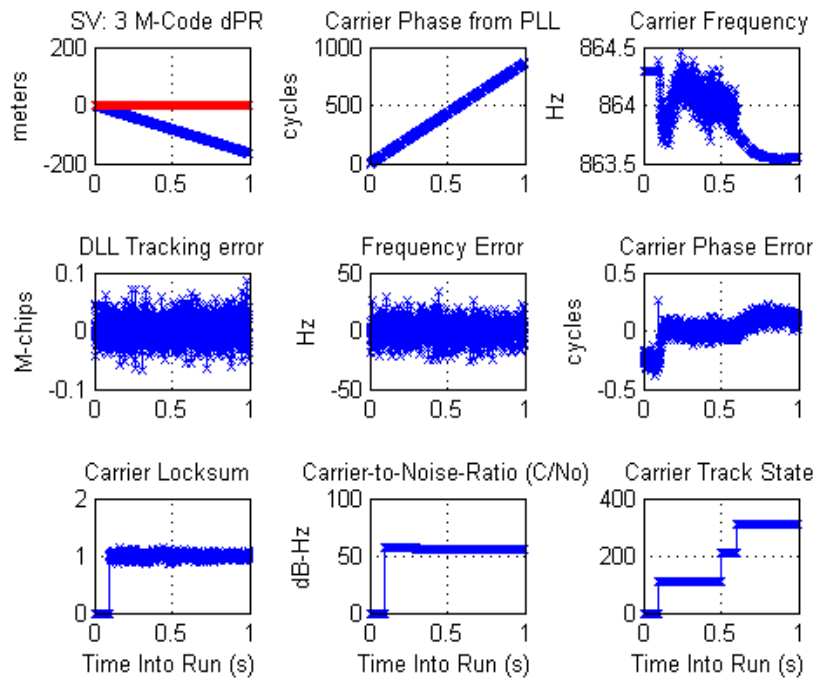
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SVN 49 SVN 49 On

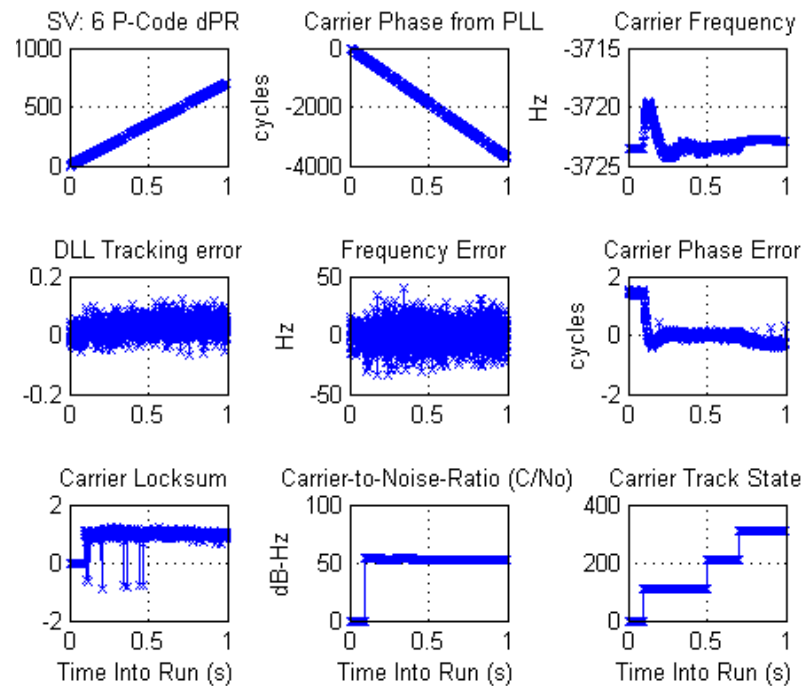
Signal Architect, Version 2.1, Copyright 2009

Results from Tracking a Simulated DSF File

M'-Code Tracking Results



P-Code Tracking Results

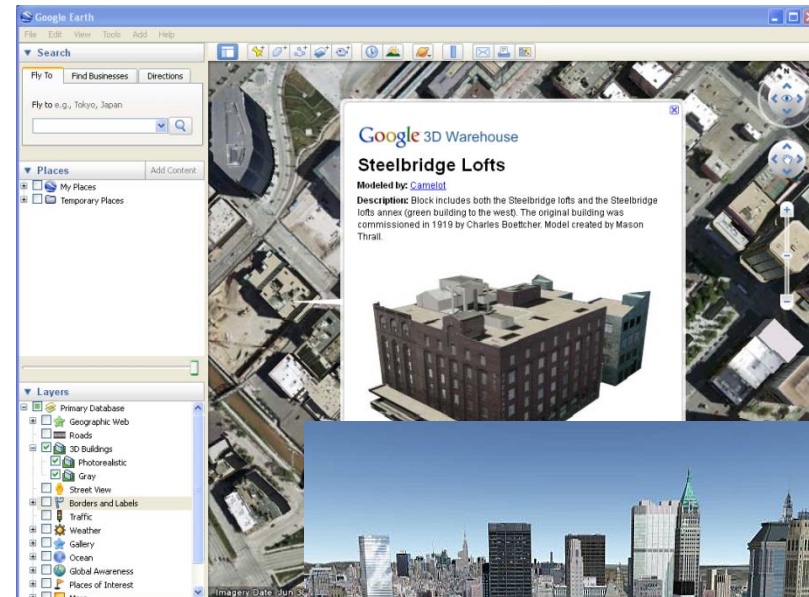


NAVSYS GPS Matlab Toolbox

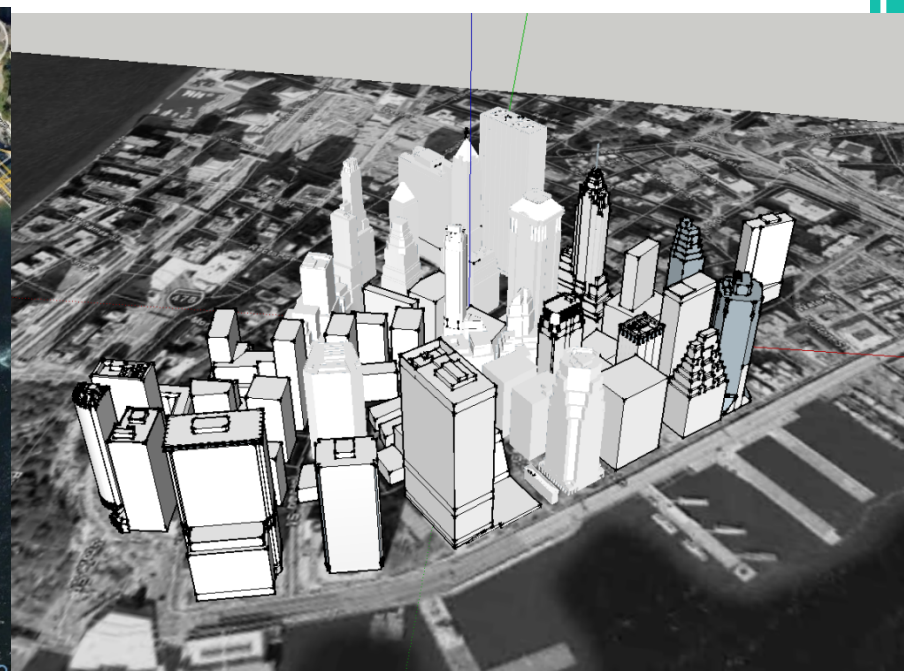
- GPS Signal Architect GUI calls compiled GPS Toolbox
- Purchasing GPS Matlab Toolbox enables users to generate advanced GPS signal simulations including:
 - Antenna patterns (transmit and receive)
 - Atmospheric effects (group delay and attenuation)
 - Jamming, spoofing or interference
 - Signal fading and multipath in challenged environments
 - Satellite anomalies – e.g. group delay
- Matlab Toolbox also includes Software GPS Receiver
 - Tools for reading DSF files and acquiring and tracking GPS satellite signals

Matlab 3D Model Import

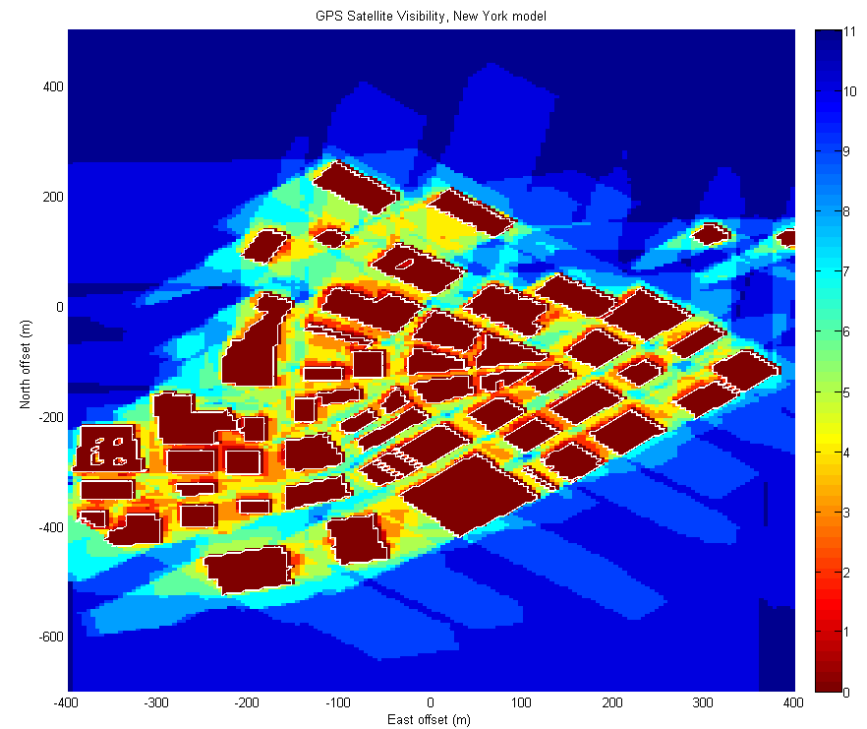
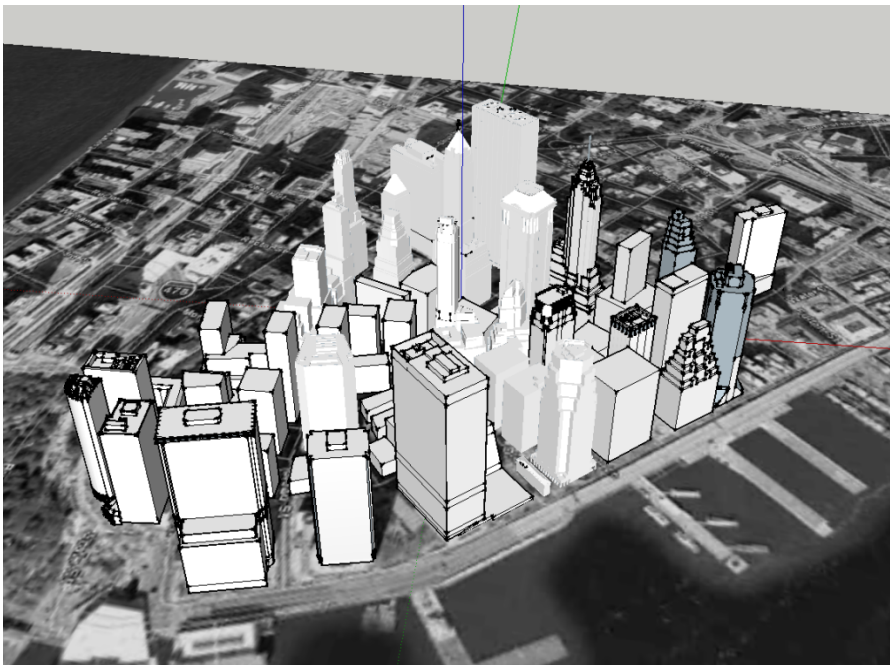
- Matlab Toolbox 3D Models
 - Simulates SV reception in an urban environment
- Google Earth 3D Model:
 - 3D Warehouse includes downloadable city models
 - Sketch-Up exports into 3D model file
 - Matlab reads as shape file for simulation
 - User paths entered in using Google Earth as KML file



Example of a New York Model

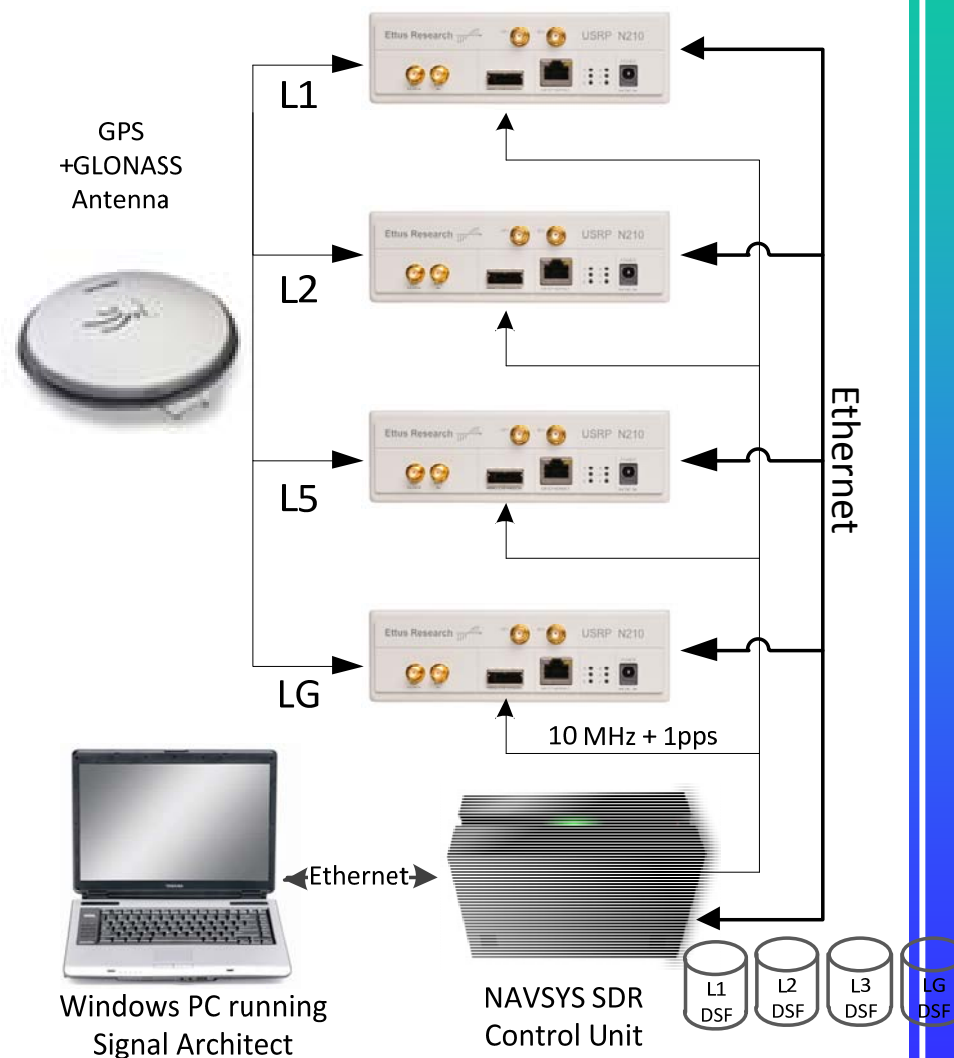


New York SV Visibility Simulation



Multi-Frequency Signal Generator in Development

- Multiple USRPs
 - Synced using common clock/1-pps
- Multi-GNSS SCU
 - Tunes USRPs
 - Records/Playbacks DSF files
- GNSS Signal Architect
 - L1/L2/L5 GPS
 - LG GLONASS



Signal Generator Benefits

- RF Broadband Signal Recording
 - Allows representative scenarios to be recorded for repeat testing with all military signals captured
- RF Broadband Signal Playback
 - Allows direct comparison between different UE under test
- Signal Architect DSF Generation
 - Allows for high fidelity signal simulation and performance analysis
- USRP + GNU Radio
 - Provides inexpensive test platform with flexibility to upgrade to handle different frequencies and A/D bits (up to 14)
 - Core software is Open Source

Backup