RFView™ User Manual

Version 2.0

April 2017

Introduction

RFView™ is an advanced, cloud-based, site-specific, radio frequency simulation and analysis environment. The simulation environment is built on ISL's industry-leading Splatter, Clutter, and Target Signal (SCATS) RF phenomenology engine. SCATS has successfully supported numerous R&D projects for a wide range of Government and industry customers since 1989. Radar data simulated using ISL's models have been used by numerous researchers around the world to develop and evaluate signal processing algorithms and the data sets have been cited in thousands of journal articles.

It was one of the earliest site-specific radio frequency (RF) phenomenology analysis tools to provide an accurate characterization of complex RF environments. Uses of the model include system analysis, test planning, high-fidelity synthetic data generation, and signal processing algorithm development. The model provides characterization of target returns, direct path signal, ground scattered signal (clutter for radar), direct path signals from interferers, and ground scattered interference signals (hot clutter, splatter, or terrain-scattered interference).

RFView™ allows users to enter the simulation parameters in a web interface and then submit a job which is run remotely on a high performance computer cluster to ensure timely simulation results. Thus, no special computing software and hardware is required. When the simulation is completed, the user receives an email notification and can view the data on the RFView™ website. The data is also available for download in both Matlab binary format as well as KML format for easy display and analysis using Google Earth.

Version 2.0 of RFView™ now provides the user with the capability to easily set up a simulation with multiple CPIs along a flight path as well as provides a capability to simulate a bistatic scenario.

This user manual will guide a user through the process of setting up, running, and examining the results of a simulation. All that is required is a RFView™ user account and web access. The RFView™ login page can be found at https://rfview.islinc.com.

Defining the Simulation Scenario

When the user logs into their RFView™ account, the first page that comes up is the RFView™ Dashboard shown in Figure 1. This gives the options to start a new simulation, access previous simulations, update billing information or update user information. All of these options are also available on the left of the page.

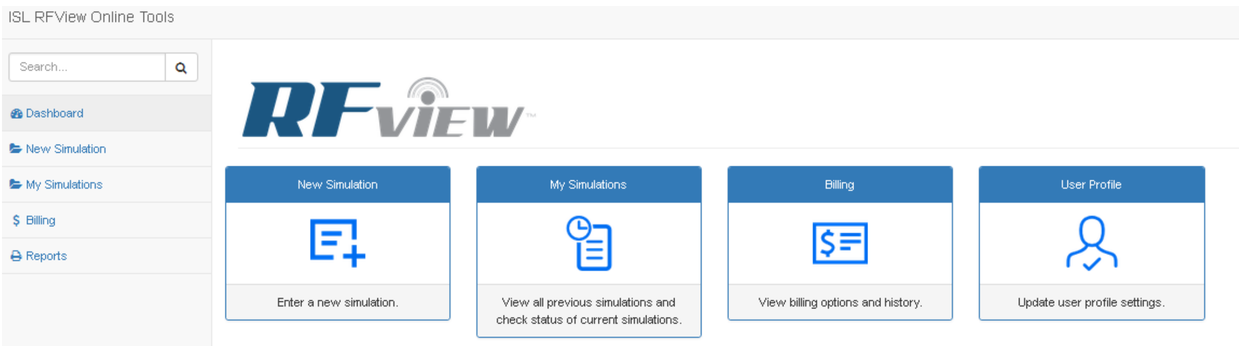

Figure 1: RFView™ Dashboard

For this guide the first step will be to set up a new simulation, which is done by selecting the new simulation option. The screen should appear as shown in Figure 2. The radar parameters for a default scenario will be loaded into the appropriate fields. A Google Maps interface is provided that allows a user to select the location of the radar, antenna aimpoint, and targets. The positions are defined on the map by selecting the proper button and then dragging the marker to the desired location. The coordinates may also be entered manually in the menu to the right. Similarly targets may be added to the simulation. Selecting the add target button places the target on the map and the icon may be dragged to the desired location. By selecting the target tab, the user can manually enter the target heading, speed, and radar cross section.

Figure 3 and Figure 4 show the input menus. Parameters may be entered in each of the fields as appropriate. Definitions for each of the fields are given in Table 1.

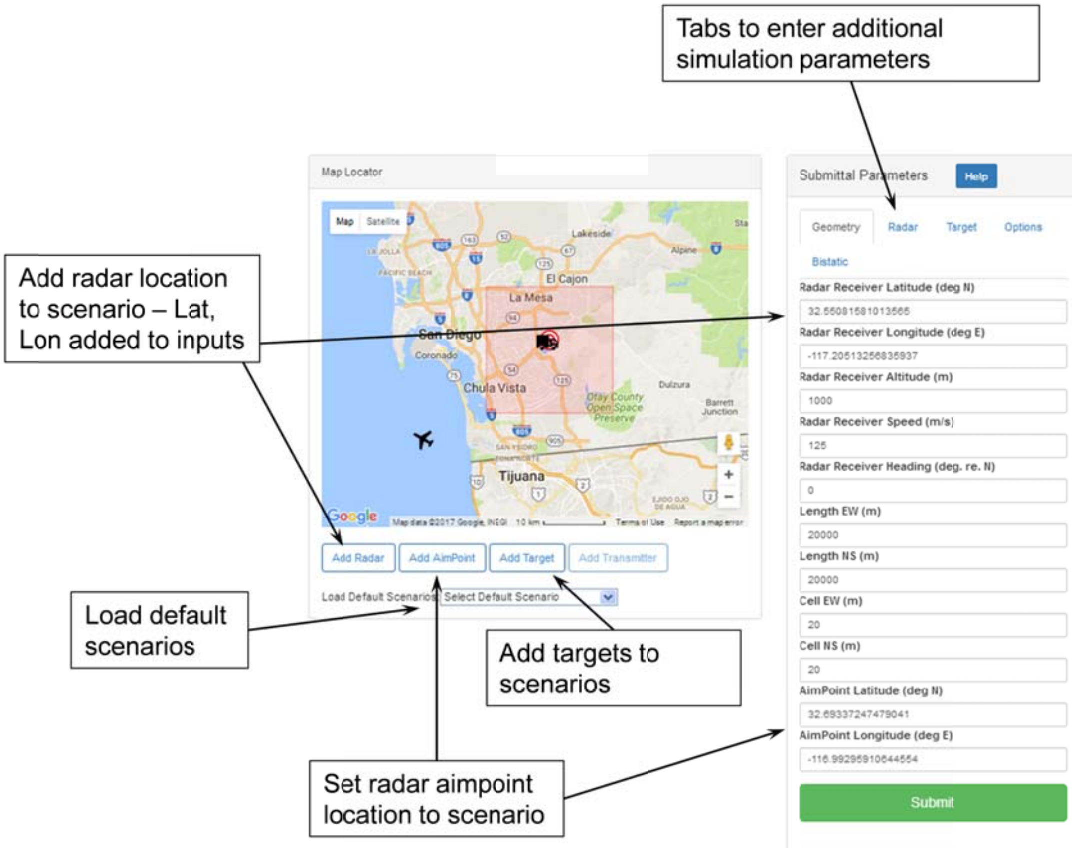

Figure 2: RFView™ Simulation Input Screen

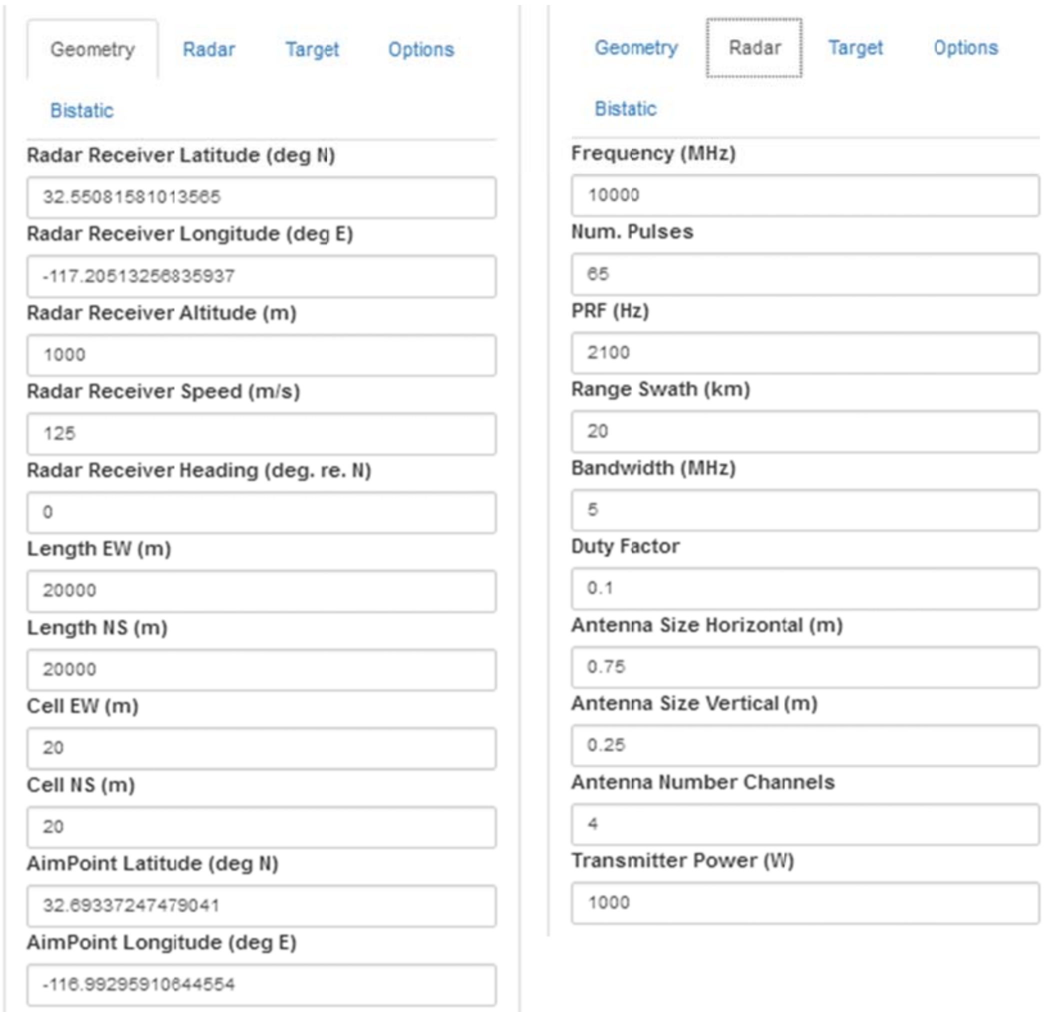

Figure 3: RFView™ Input Menus for scene and radar parameters.

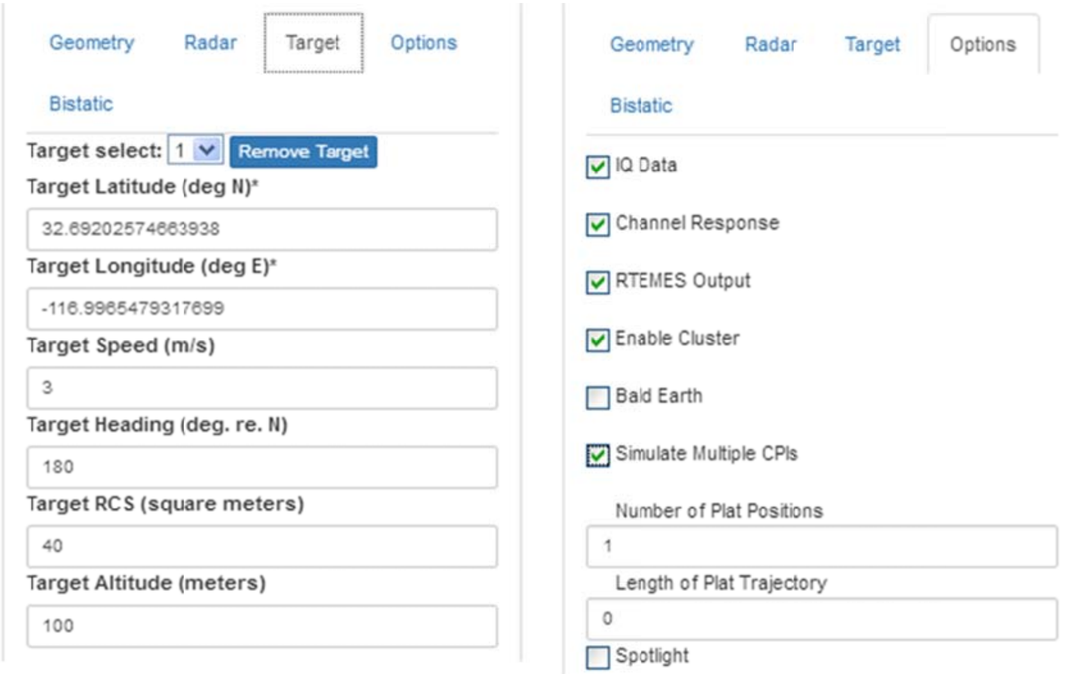

Figure 4: RFView™ Input Menus for options and targets.

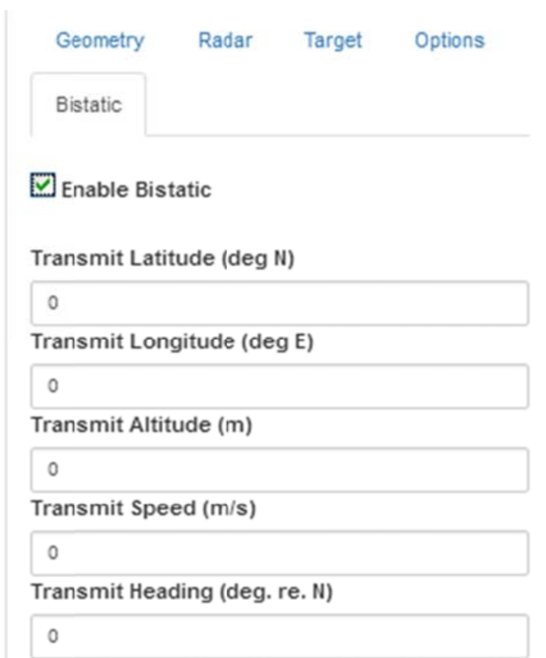

Figure 5: RFView™ Input Menu for Bistatic Option

Table 1: RFView™ Input Parameters

Name	Definition	Units	Default Value
Geometry			
Radar Receiver Latitude	Latitude of radar receiver platform; also transmitter for monostatic case.	Degrees North	32.5508
Radar Receiver Longitude	Longitude of radar receiver platform (negative for degrees west); also transmitter for monostatic case.	Degrees East	-117.2051
Radar Receiver Altitude	Radar receiver altitude above MSL; also transmitter for monostatic case.	Meters	1000
Radar Receiver Speed	Radar receiver platform speed; also transmitter for monostatic case.	m/s	125
Radar Receiver Heading	Radar receiver platform heading (0° is due north); also transmitter for monostatic case.	Degrees North	0
Length EW	Scene size in east-west dimension	Meters	20000
Length NS	Scene size in north-south dimension	Meters	20000
Cell EW	Size of simulation cell in east-west dimension	Meters	20
Cell NS	Size of simulation cell in north-south dimension	Meters	20
AimPoint Latitude	Location on earth surface where radar is pointed – this defines the antenna boresite. Also is center of scene defined by Length	Degrees North	32.6934
AimPoint Longitude	Location on earth surface where radar is pointed – this defines the antenna boresite. Also is center of scene defined by Length	Degrees East	-116.9929
Radar Parameters			
Frequency	Radar frequency	MHz	10,000
Num Pulses	Number of pulses to be simulated	Integer	65
PRF	Pulse repetition frequency	Hz	2100
Range Swath	Range dimension of simulated radar data – range swath is centered on aimpoint	Km	20
Bandwidth	Radar bandwidth – defines radar resolution	MHz	5
Duty factor	Radar duty factor – fraction of time in pulse repetition interval that is occupied by transmitted waveform	Fraction e.g. 0.1 is 10% of PRI	0.1
Antenna Size Horizontal	Size of antenna in horizontal dimension	Meters	0.75
Antenna Size Vertical	Size of antenna in vertical dimension	Meters	0.25
Antenna Number of Channels	Number of channels in horizontal dimension which are equally spaced. Assumes on channel in vertical dimension	Integer	4

Transmitter Power	Power of transmitter	Watts	1000
Options			
IQ Data	Simulate and save complex (I&Q) radar data	Check box	Checked
Channel Response	Simulate and save channel response	Check box	Checked
RTEMES Output	Simulate and save data file for input into ISL RTEMES radar emulation system	Check box	Not selected
Enable Cluster	Enable cluster processing – runs simulation in parallel on multiple cluster nodes. Can speed up larger simulations	Check box	Not selected
Bald Earth	Bald earth terrain model – all terrain is set to zero elevation	Check box	Not selected
Simulate Multiple CPIs	Enables multiple CPIs to be simulated in one run	Check box	Not selected
Number of Plat Positions	Number of platform positions along the trajectory to simulate	Number	1
Length of trajectory	Length of trajectory to simulate; positions are equally spaced along the trajectory	Meters	0
Spotlight	Spotlight mode keeps antenna pointed at defined aimpoint; otherwise aimpoint moves along with aircraft at a fixed antenna pointing angle.	Check box	Not selected
Target Menu			
Target select	Drop down menu to select target ID – multiple targets can be added to the simulation		1
Target Latitude	Latitude of target	Degrees North	32.9874
Target Longitude	Longitude of target	Degrees East	-83.7739
Target Speed	Speed of target	m/s	3
Target Heading	Direction of travel of target relative to North (0° is due north)	Degrees North	180
Target RCS	Target radar cross section	Square meters	40
Target Altitude	Height of target above local terrain	Meters	
Bistatic Menu			
Enable bistatic	Check box to select bistatic simulation; enables transmitter inputs below; also provides marker option on map.	Check box	Not selected
Radar Transmitter Latitude	Latitude of radar transmitter platform	Degrees North	0
Radar Transmitter Longitude	Longitude of radar transmitter platform (negative for degrees west)	Degrees East	0

Radar Transmitter Altitude	Radar transmitter altitude above MSL	Meters	0
Radar Transmitter Speed	Radar transmitter platform speed	m/s	0
Radar Transmitter Heading	Radar transmitter platform heading (0° is due north)	Degrees North	0

Table 1: RFView™ Input Parameters

RFView™ is a site specific simulation which takes the local environment into consideration. This local environment includes the height of the terrain as well as the land cover of the local terrain. The local terrain height impacts the propagation (e.g. line-of-sight blockage) as well as the scattering due to the local tilt of the terrain. RFView™ hosts a data base that contains digital elevation models (DEM) derived from the Shuttle Radar Topographic Mission (SRTM, see http://www2.jpl.nasa.gov/srtm/ for details). This data is available from the USGS Earth Explorer site (https://earthexplorer.usgs.gov/). Figure 6 shows the coverage of the DEM data available in RFView™ at the current time. Coverage areas are continually being updated with new areas of interest being added. Please make a data request if DEM data is desired in an area not currently covered. If the DEM data for the simulation scene is not available, the local terrain height is set to zero.

In some cases the user may wish to not use the terrain elevation data in the simulation. In this case, the bald earth option may be selected. If this option is selected, all the terrain heights in the simulation are set to zero.

The simulation area is defined by the Length EW and Length NS variables which define the scene size in meters in the east-west and north-south dimension. The simulation resolution in this area is set by the Cell EW and Cell NS variables, also in meters. A smaller resolution cell results in a higher resolution simulation, to a point, and also a longer run time. Two other factors determine the limiting resolution of the simulation. The waveform bandwidth defines the achievable resolution of the radar system in the range dimension. Also the resolution of the underlying terrain and land use/land cover databases also impacts the achievable simulation resolution. Currently the input databases are one arc-second resolution, approximately 30m post spacing. Cell spacing below half this value (15 m) will not result in a more accurate simulation, but smaller cell sizes on the order of the radar resolution can be used.

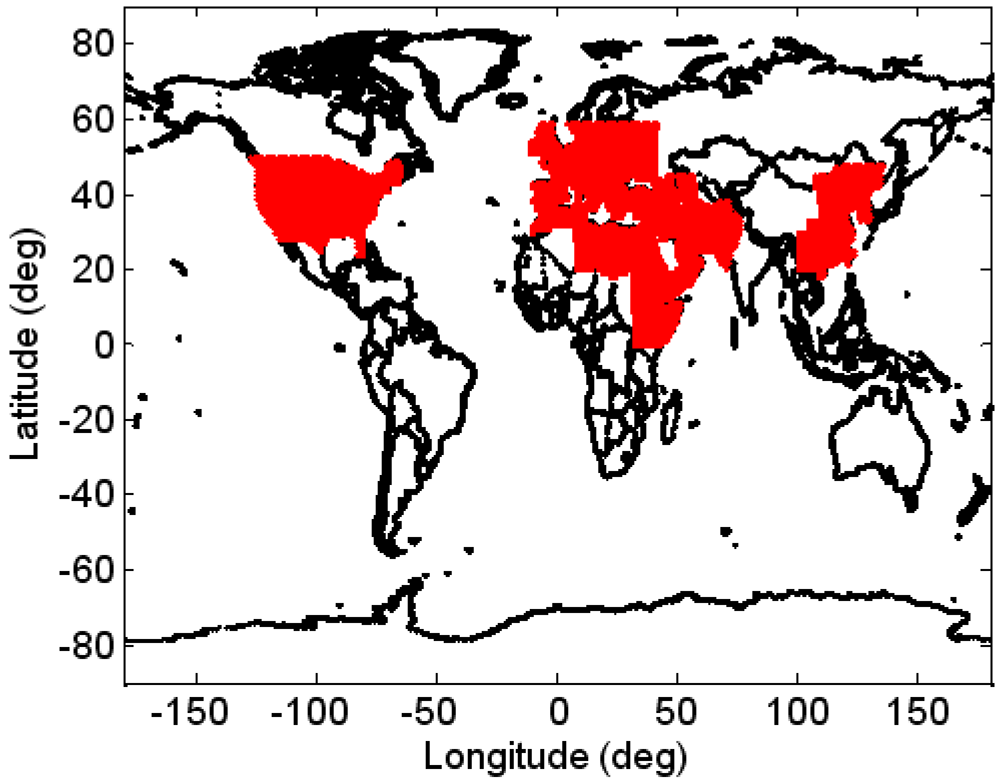

Figure 6: Current areas of available terrain height in RFView™.

Two new capabilities have been added in RFView™ Version 2. These are the capability to simulate multiple coherent processing intervals (CPIs) along a trajectory and a capability to simulate a bistatic system.

By selecting the Simulate Multiple CPIs option (see Figure 4) the option to define the number of CPIs and the length of the trajectory is available for input. The processing code will automatically generate a simulation for each CPI, equally spaced along the trajectory. The trajectory is defined as a straight and level flight at the defined heading and speed. Each simulation is available for download with the filename suffix *_n#, where # is the CPI number along the trajectory.

Below the trajectory parameters, is the option for spotlight mode. When the spotlight mode is selected, the aimpoint is fixed at its initial location. At each new CPI position, the antenna pointing direction is updated to point at the same aimpoint. If it is not selected (i.e. stripmap mode), the antenna pointing angle is fixed and the aimpoint and scene are moved along with the aircraft. The new aimpoint is the same heading and range from the radar at the new CPI position as was the original aimpoint. Figure 7 shows a diagram of the two options.

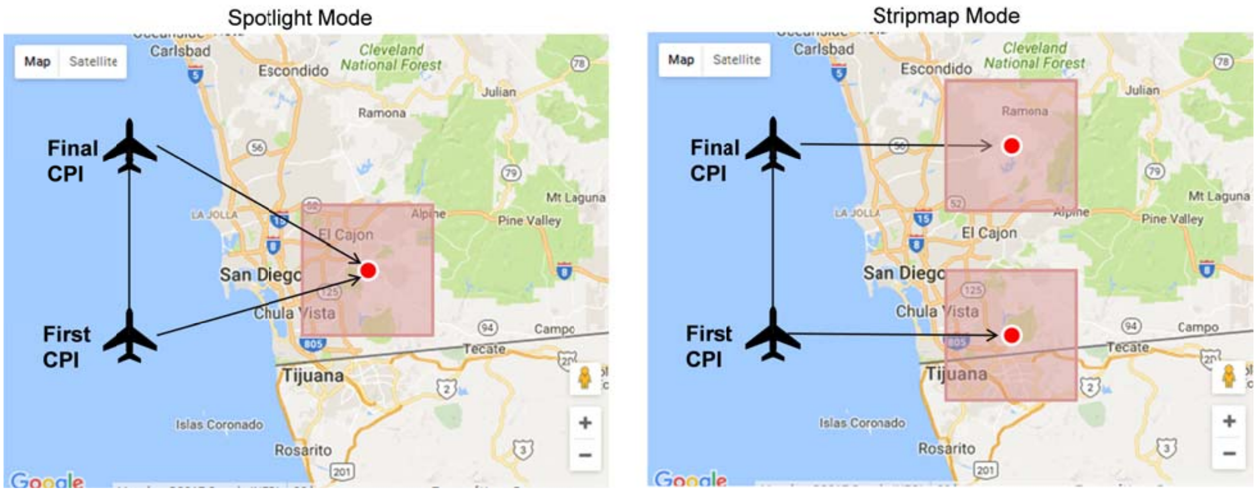

Figure 7: Diagram showing spotlight and stripmap modes.

The option for a bistatic simulation is also available. By selecting the bistatic option, as in Figure 8, the menu provides the opportunity to input the transmitter location, speed, heading, and altitude. It also enables the add transmitter button below the map region. This provides a transmitter icon that can be dragged to the desired location, just as with the monostatic option.

For the bistatic scenarios, the antenna pointing angles are steered toward the aimpoint. If the multiple CPI option is selected, the spotlight option is selected by default and the aimpoint is fixed and each antenna is steered to the aimpoint as the platforms move along the trajectory.

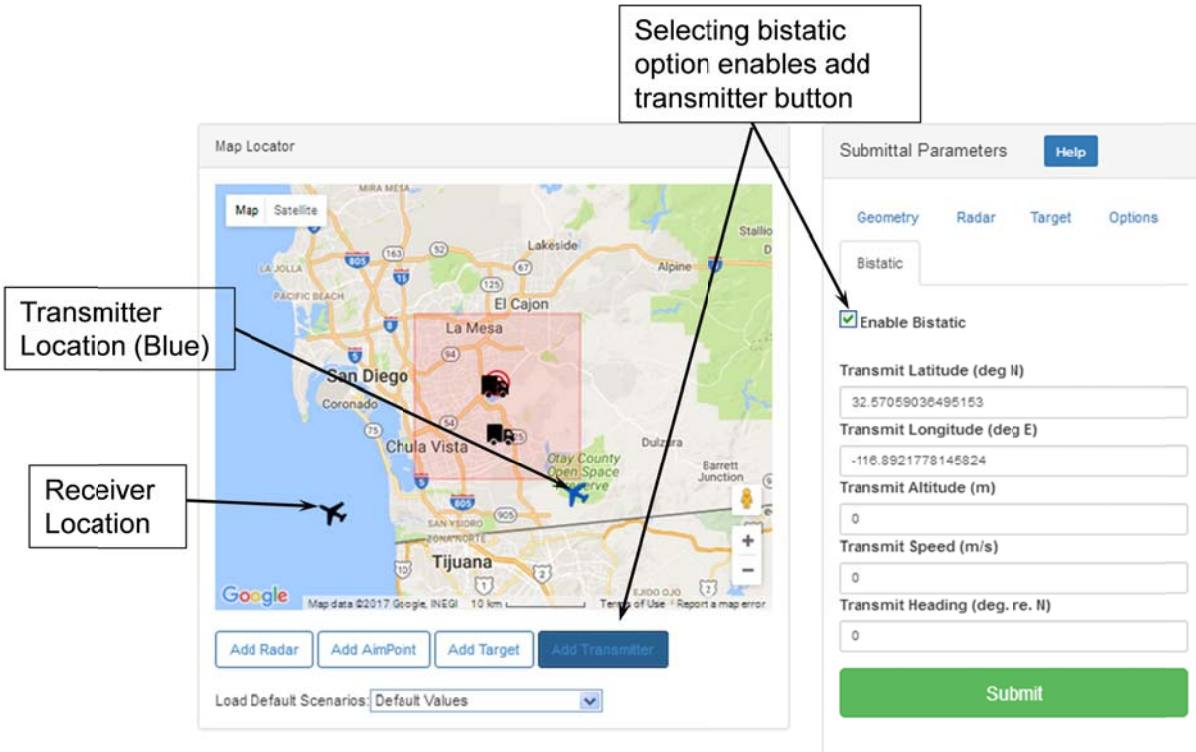

Figure 8: Enabling the bistatic option allows the input of the transmitter platform parameters.

Submitting the Simulation

Once the input of the simulation parameters is complete, selecting the submit button on the bottom right of the input screen submits the simulation for processing. A dialog box will be displayed (Figure 9) confirming the simulation has been submitted.

By selecting the "My Simulations" tab on the left, the user will be brought to the simulation history page. This page lists all the simulations submitted by the user as well as the simulation ID number, status, and options to edit the scenario (useful to make changes to a previous scenario and resubmit) and to view the results of a completed scenario. Figure 10 shows an example. When the scenario has completed simulation the user will receive an email with a link to RFView™ to examine the results.

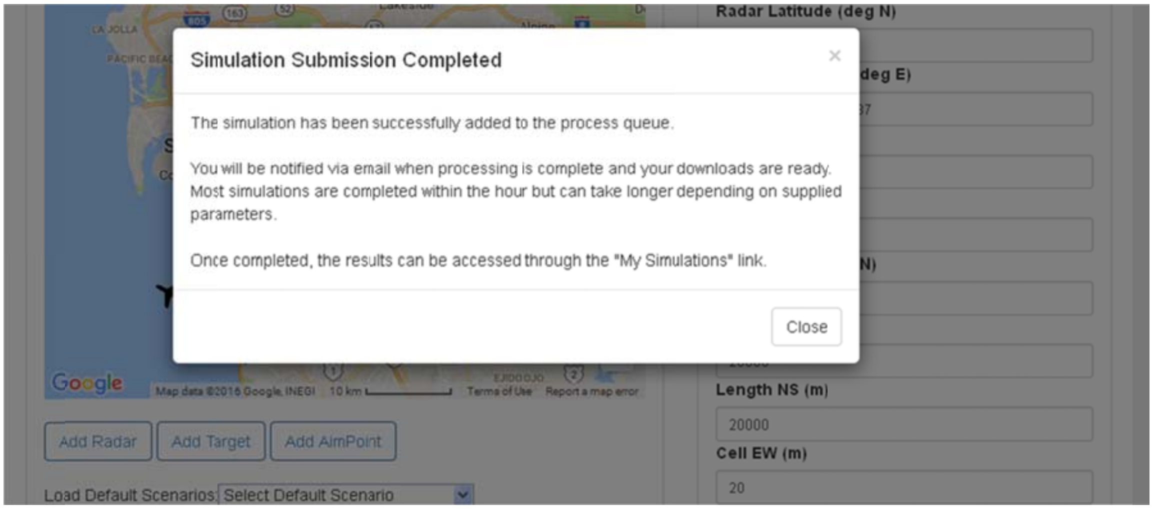

Figure 9: Simulation submission confirmation.

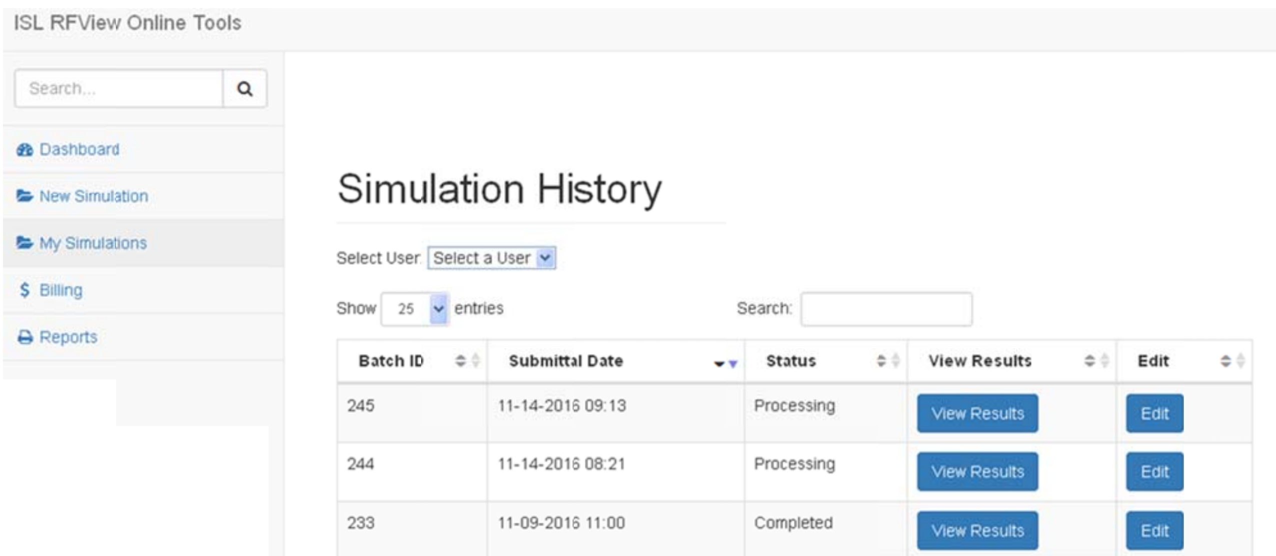

Figure 10: Simulation history screen.

Viewing Simulation Results

By selecting the view results screen, the user is directed to the results screen as shown in Figure 11. Numerous simulation results are available for viewing and download. The radar clutter map, Doppler, line of sight (LoS), terrain, and range information are available for display on the map screen. At the bottom of the screen is displayed the range Doppler map and the channel response[1]. All the results are available for download by selecting the output files tab as shown in Figure 12. A zip file with all the results is available, or the individual files are available for

[1] The channel response is the impulse response of the channel, also known as the Green's function. A user can thus obtain the response to any transmit waveform by convolving it with the channel response. This is ideal for Fully Adaptive Radar (FAR) simulations.

download. These include kml files for display in Google Earth and a *.mat file with the simulation results in Matlab format. The inputs tab allows the user to view the simulation input values (Figure 12).

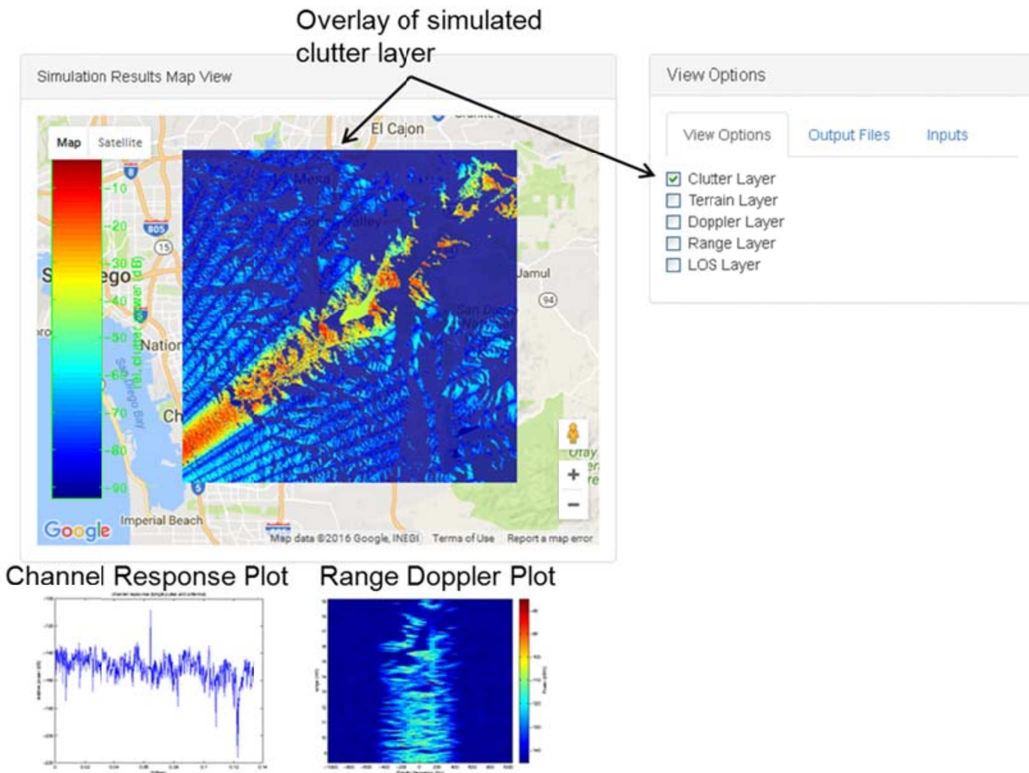

Figure 11: RFView™ simulation results screen.

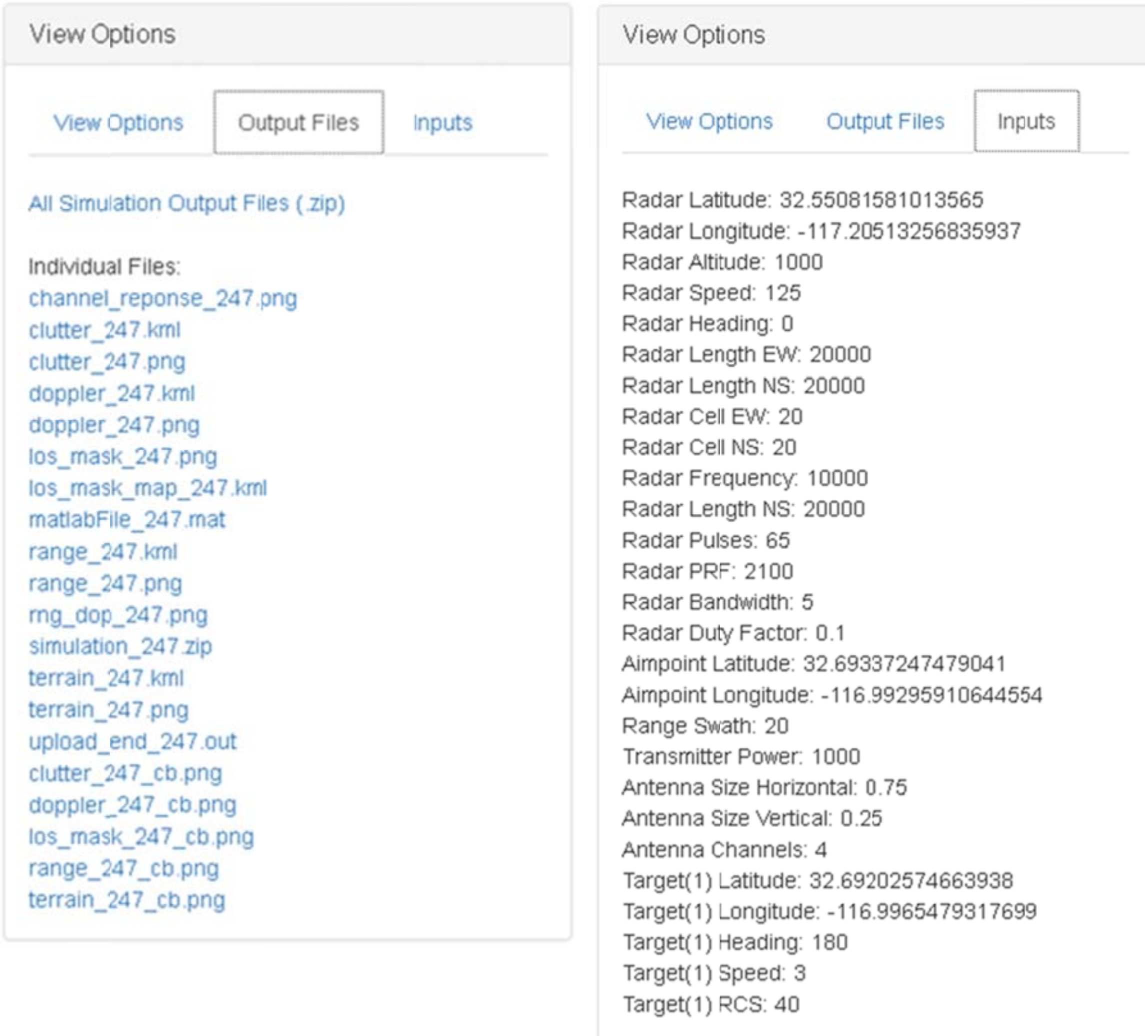

Figure 12: RFView™ simulation output files (left) and input parameters (right).

Example RFView™ Data Processing

At the completion of the simulation, a Matlab formatted data file is available for download containing the simulation results. This provides the user with the capability to use the simulated data for their specific purposes. The contents of the Matlab data file are defined in Appendix 1 of this document.

Also available for download on the RFView™ website is a sample Matlab processing code, range_Doppler_process_rfview_example.m. This processing code produces the range-Doppler plot shown on the RFView™ results page from the IQ data in the Matlab data file. The IQ Data box in the Options Tab must be selected to generate the IQ data.

The algorithm performs these steps:

1. Re-orders the IQ data for processing
2. Beamforms the multi-channel data by applying the array steering vector.
3. Applies a motion compensation correction
4. Pulse compress the data in the range dimension
5. Scale and plot the results

Figure 13 shows the Range-Doppler plot generated using the example code for the default simulation scenario.

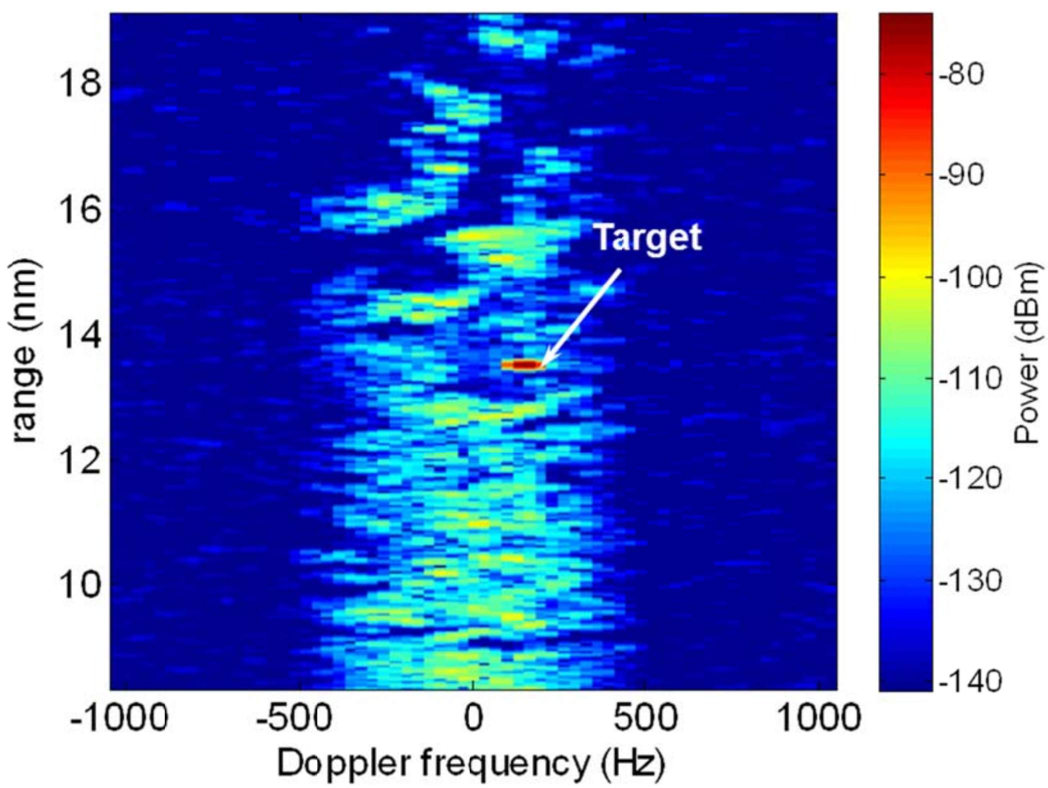

Figure 13: Example range-Doppler plot generated for default RFView™ scenario.

Appendix 1

Matlab File Definition

The table below describes the elements in the RFView™ Matlab file that is available for download after the simulation is completed. Not all the elements may be present in the file depending on what options are selected in the simulation.

Definition of the contents of the RFView™ Matlab File

Variable	Size	Complex/Real	Description
Chan	nchan X num pulses X range	complex	Complex channel response - clutter+targets+noise
Chan_clut	nchan X num pulses X range	complex	Complex channel response - clutter only
Chan_targ	nchan X num pulses X range	complex	Complex channel response - target only
DEM	Structure		Terrain Data
DEM.TerrainHeight	Ncells Ns x Ncells EW	real	Terrain height at each cell - meters
DEM.SouthmostLatitude	1	real	Latitude of south most cell - degrees North
DEM.WestmostLongitude	1	real	Longitude of west most cell - degrees East
DEM.dLat	1	real	Latitude dimension of each cell - degrees
DEM.dLon	1	real	Longitude dimension of each cell - degrees
IQ	nchan X num pulses X range	complex	Complex IQ data - clutter+targets+noise
IQ_clut	nchan X num pulses X range	complex	Complex IQ data- clutter only
IQ_targ	nchan X num pulses X range	complex	Complex IQ data - target only
PRF	1	real	Pulse repetition frequency (Hz)
PathPower	Ncells Ns x Ncells EW	real	Scattered power from each cell
PathRange	Ncells Ns x Ncells EW	real	Range to each cell from radar - meters
RxArray	Structure		Description of receiver array

RxArray.dh	1	real	horizontal spacing of the elements
RxArray.dv	1	real	vertical spacing of the elements
RxArray.Nh	1	real	Total number of elements in horizontal dimension
RxArray.Nv	1	real	Total Number of elements in vertical dimension
RxArray.NumChannels	1	real	Number of channels
RxArray.Hplane	numchannels X 1	real	Number of elements/channel in horizontal dimension
RxArray.Vplane	numchannels X 1	real	Number of elements/channel in vertical dimension
RxArray.boresight_az	numchannels X 1	real	Boresite (mechanical)azimuth of each receive channel - degrees N
RxArray.boresight_el	numchannels X 1	real	Boresite (mechanical) elevation of each receive channel - degrees from horizontal
RxArray.pre_steer_az	numchannels X 1	real	Electronic steering azimuth angle of each receive channel - degrees N
RxArray.pre_steer_el	numchannels X 1	real	Electronic steering elevation angle of each receive channel - degrees from horizontal
RxArray.sepos	numchannels x 3	real	Relative positions of channels in topocentric coordinates
RxArray.Pattern	1	real	Receive antenna pattern (uniform, hamming)
RxArray.fb_ratio	1	real	Receiver front/back ratio (dB)
RxArray.spvect	numchannels x numchannels	complex	Receiver spatial steering vector

RxArray.tt_delay	numchannels x numchannels	real	True time delay
TxArray	Structure		Transmit array, Same fields as RxArray
RxAztoCell	Ncells Ns x Ncells EW	real	Azimuth angle from radar to each cell - degrees North
RxEltoCell	Ncells Ns x Ncells EW	real	Elevation angle from radar to each cell - degrees from horizontal (negative is down)
TxFrequency	1		Radar transmit frequency - Hz
WGS84_SPHEROID	Structure		Structure with WGS84 Spheroid information
array_steering_v	nchannels	complex	Complex spatial steering vector for each channel along receiver steering direction; Same as RxArray.spvect
bandwidth	1		Radar waveform bandwidth - Hz
lambda	1		Radar wavelength - meters
num_pulses	1		Number of pulses simulated
platrx	Structure		Receiver platform information at each pulse; also transmitter platform for monostatic scenario.
platrx.lat	number of pulses	real	Latitude of platform at each pulse - Degrees North
platrx.lon	number of pulses	real	Longitude of platform at each pulse - Degrees East
platrx.hgt	number of pulses	real	Height of platform at each pulse - meters above MSL
platrx.az	number of pulses	real	Azimuth/heading of platform at each pulse - Degrees North

platrx.el	number of pulses	real	Elevation angle of platform heading at each pulse - degrees from horizontal (negative is down)
platrx.speed	number of pulses	real	Speed of platform at each pulse - m/s
plattx	structure	real	Transmitter platform information for bistatic scenario; same fields as platrx structure
radar_aim	Structure		Location on earth radar antenna is point toward
radar_aim.lat	1	real	Latitude of radar aimpoint
radar_aim.lon	1	real	Longitude of radar aimpoint
radar_aim.hgt	1	real	Height of aimpoint - meters above ground level
range_bins	number range bins	real	Range bins of simulated data - meters
targets	Structure		
targets.lat	number of targets	real	Latitude of each target - Degrees North
targets.lon	number of targets	real	Longitude of each target - Degrees East
targets.hgt	number of targets	real	Height of each target - meters above MSL
targets.az	number of targets	real	Azimuth/heading of each target - Degrees North
targets.el	number of targets	real	Elevation angle of each target heading - degrees from horizontal (negative is down)
targets.speed	number of targets	real	Speed of each target - m/s
targets.rcs	number of targets	real	Radar cross section of each target - square meters

waveform	length waveform	complex	Time samples of waveform
wf_duty_factor	1	real	Waveform duty factor - fraction