

Technical Manual

SATGEN II SATELLITE DATA GENERATION PROGRAM

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1. General Information

1.1. Overview of the SATGEN II Satellite Data Generation Program

SATGEN II is a graphical user interface (GUI)-based program used to generate data files necessary for the Dynamic Mode of dBm's Satellite Link Emulator (SLE). The program calculates Doppler, delay, and path loss for up to eight entities per channel, and up to four channels. Entities include a fixed location earth transponder, a moving land vehicle or ship, aircraft, and specified satellite orbits.

Pre-defined entities include:

- nine predefined satellite orbits, and
- ground station coordinates for over forty cities world-wide

You can monitor the progress of the satellite orbit through an animation of the ground trace for satellites and other entities over a projection map of the Earth.

2. System Requirements and Installation

2.1. System Requirements

This is a PC based application, and requires the following minimum configuration:

Windows 2000, XP or Windows 7 operating system

512 MB RAM

20 MB hard disk space

Two button mouse

2.2. Registration

To save and output data files, you must enter the product's license number supplied by dBm. All functions, other than data file generation, will operate without a license number. You may enter the license number from the Help menu. The licensing validation is required only the first time SATGEN II is run.



Figure 3-1 The SATGEN II Registration Window

3. Operation

3.1. Getting Started

The SATGEN II user interface is based on a projection map of the earth. Below is an example of the interface with numerous transponders (called entities) shown on the map. When two entities are within line of sight, a rubber banding line is drawn between them. Four colors of rubber bands are used to designate which channel the entities are associated with: red is channel 1, yellow is channel 2, turquoise is channel 3, and violet is channel 4.

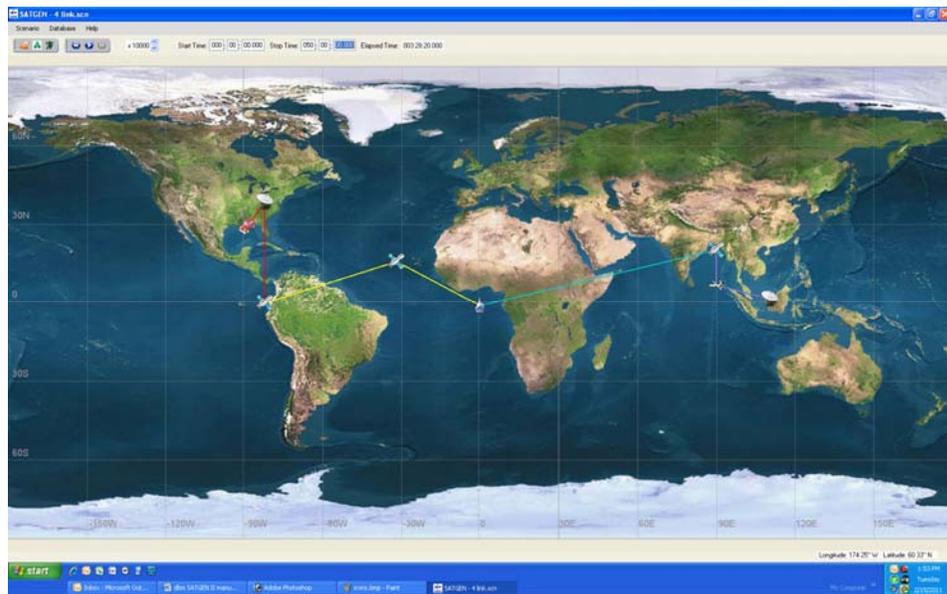


Figure 3-2 SATGEN II User's interface. The rubber banding color indicates the channel number.

Following is a general overview of the steps required to create parameter data files for the SLE.

3.1.1. Add Entities

Entities are communications transponders. Non-satellite entities are added to the projection map, either by placing them at the mouse coordinates, or by entering the desired latitude and longitude. Non-stationary entities, which include land vehicles, ships, and aircraft, require start position and

start velocity, stop position and stop velocity, and antenna height. Aircraft additionally require start and stop altitude.

Fixed location earth terminals require location and altitude only.

Satellites are added by entering their orbital parameters, or by selecting from a list of numerous predefined satellite orbits.

3.1.2. Configure Links

A channel correlates to one hardware channel in the SLE. SATGEN II can generate data for up to four channels simultaneously. Each channel can include up to eight entities. The Link Configuration window is used to configure the order of communication between entities, and the nominal carrier frequency for each link.

3.1.3. Setup Parameter Files

The parameter data files must be configured for each channel. The Parameter File Setup window is used to:

- Define which files are to be generated
- Define file names that conform to the SLE file naming conventions.
- Set data generation triggering to occur during line of sight only, or continuously.
- Set the total time duration of the data files
- Define the atmospheric losses
- Set the resolution for each parameter type
- Set the time period between data points (i.e. update rate)
- Set the folder location to store the resulting parameter files.

3.1.4. Save the Scenario

All settings can be saved as a Scenario. The Scenario has a unique name, and a general description can be attached when creating or editing the scenario. All settings for links, entities, and parameter files are saved with the Scenario.

3.1.5. Verify Settings with the Animation Player

Prior to generating data files, the scenario can be animated to verify that its settings appear as desired. The map animation will show the motion of each entity, and create a rubber band between entities that are configured to communicate to each other. When line of sight is lost, the rubber band

disappears. Use the Animation Player controls to set the start and stop time of the animation. The time scale multiplier causes the animation to run faster than real time. Use Run, Reset, and Fast Forward buttons to control the animation.

3.1.6. Generate Data

Once all settings are as desired, generate the data files.

3.2. Creating and Editing Entities

Entities include land vehicles, ships, aircraft, fixed earth terminals, and satellites. Entities can be re-used within a channel, and can also be used in multiple channels.

Up to eight entities can be configured in each channel.

An entity can be saved to the SATGEN II database. Existing entities in the database can be overwritten.

3.2.1. Entity Icons

There are five icons to represent different types of entities. These icons are used to depict the position of entities on the projection map. They are depicted below from left to right: a) satellite b) earth station c) aircraft d) ship and e) ground vehicle.



Figure 3-3 The five entity icons

3.2.2. Create an Entity

With the SATGEN II application loaded, right click on the map and move the mouse to Add Entity.

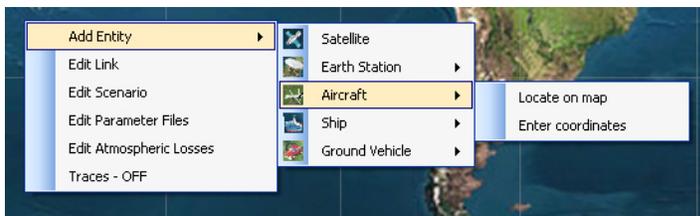


Figure 3-4 Quick Functions available using the right mouse button

Next slide the mouse to the desired entity type. In this example, we have selected Aircraft. Finally, to manually enter the start Latitude and Longitude, slide the mouse to Enter Coordinates. The Aircraft editing window will appear.

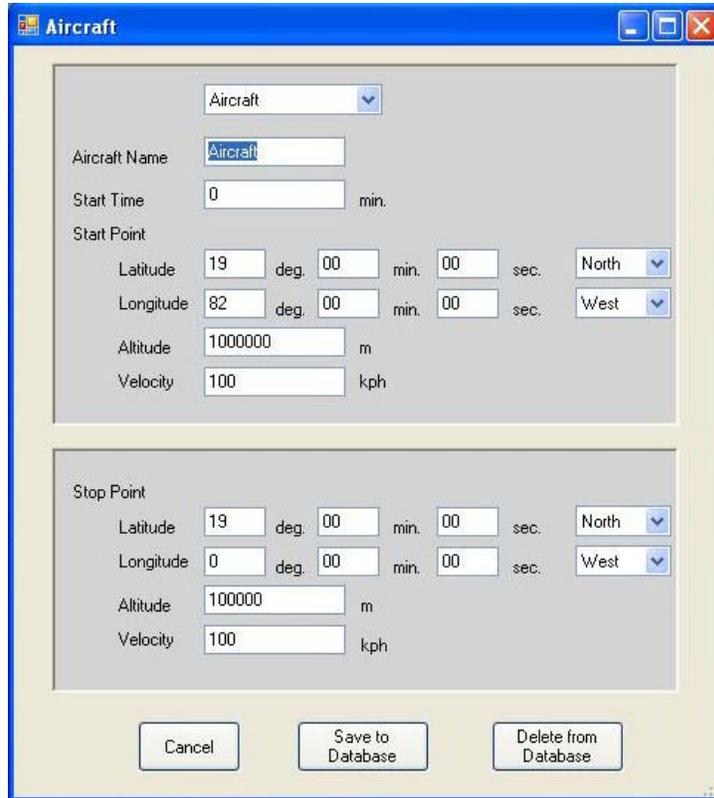


Figure 3-5 The Aircraft entity editor window

Create a new Aircraft Name. Leaving the name unchanged will over-write the existing aircraft parameters which may affect other saved scenarios that used the same entity. Enter the location, altitude and velocity of the aircraft at its start point, and again for its stop point. Enter the start time, which defines the time at which the aircraft begins its motion toward the Stop Point. Note that Start Time is relative to the start time of the Scenario, and also should not be confused with the animation start time. Press Save to Database to save the aircraft, and to place it on the map at its Start Position.

Alternative to entering the Latitude and Longitude values for an entity, you may also select the start and stop positions using the mouse. The mouse coordinates are displayed at the lower right of the map. This method is not recommended if precise locations are required. In lieu of selecting Enter Coordinates, select Locate on map. Now the first left click

of the mouse will define the start position, and the second left click of the mouse will define the stop position.



Figure 3-6 Creating Start and Stop Positions using the mouse

A prompt for Undo or Accept will appear. Each time Undo is chosen a step backwards is taken, allowing re-entry of the positions. Selecting Accept will invoke the Aircraft editing window, with the coordinates selected with the mouse now pre-loaded. Non-positional data still needs to be entered to complete the entity.

Land vehicles, and ships are created identically, but in lieu of altitude, they require an entry for antenna height. Note that the antenna height for objects near the earth has a large effect on line of sight distances to other low elevation entities.

Earth stations are immobile, and so do not require stop positions or velocity.

3.2.3. Edit an Entity

A previously created entity can be modified in the database, or deleted from the current scenario. Note that an entity must be removed from all Links before it can be removed from the map. Deleting an entity from the map does not delete it from the SATGEN II database.

To edit an existing entity, right click on its icon on the map. In this example, an Earth station has been selected for editing. Pressing Delete removes it from the map. Pressing Edit, invokes the Entity Edit window to allow changes.

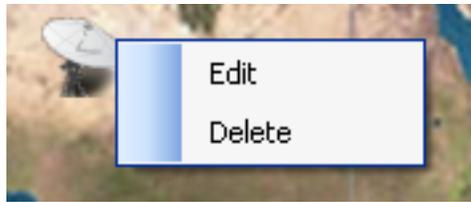


Figure 3-7 Existing entities can be modified using the right mouse button

3.2.4. Link Configuration

Once all entities have been defined, they need to be placed in a link according to the desired communication path.

Right click anywhere on the map and select Edit Link. The Link Configuration window will appear.

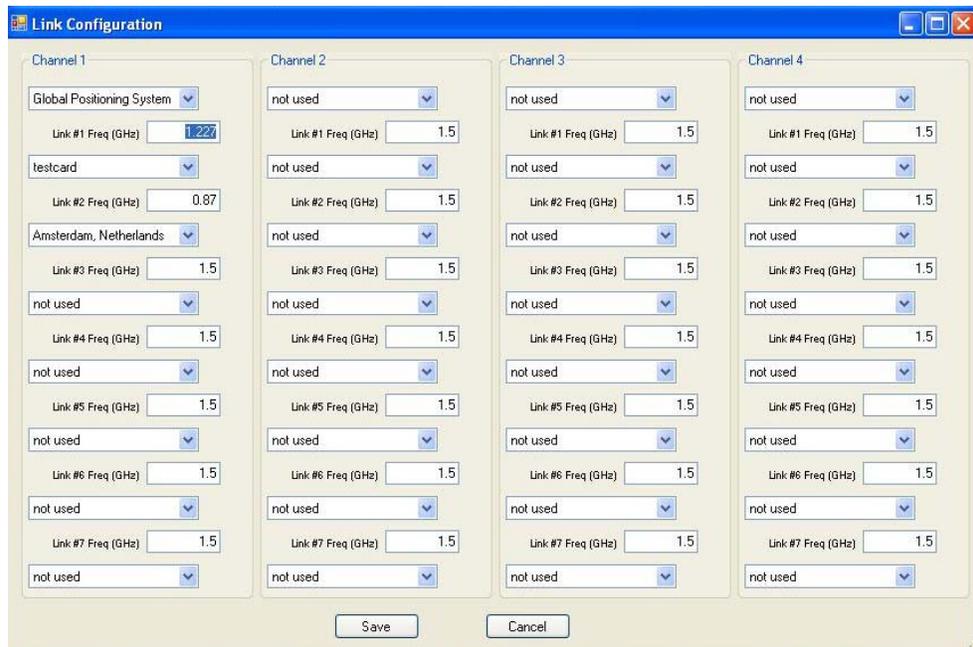


Figure 3-8 Link Configuration Window

Entities that have been placed on the map will be available at each drop down menu. The order of communication within each channel is from top to bottom in this window. Entities must appear as consecutive locations, so there cannot be a “not used” slot placed between entities.

Entities can be reused within a channel, and also used in multiple channels.

Enter the nominal carrier frequency for each link. This value is used to compute Doppler offsets and atmospheric losses.

Communication within a channel will only occur when every entity is within line of sight of entities it is linked to.

3.3. Parameter File Setup

With the SATGEN II application loaded, right click on the map and move the mouse to Edit Parameter Files. The Parameter File Setup window will appear.

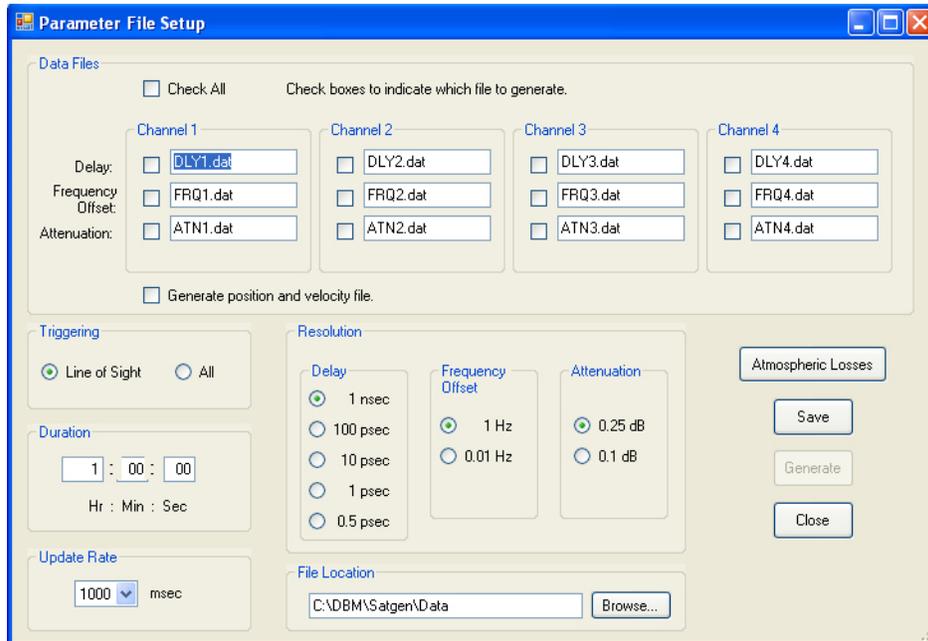


Figure 3-9 Parameter File Setup Window

Begin by placing a check mark next to each file types for which data is required. Next, give each file a unique name. Note that file naming conventions for the SLE require that:

- Delay file names begin with DLY
- Frequency Offset file names begin with FRQ
- Attenuation file names begin with ATN
- File names are limited to 10 characters, excluding the .dat extension.

If satellite position and velocity data is required, check this box.

Select the desired Triggering. Data can be generated continuously for the entire time duration by selecting ALL, or it can be limited to only when line of sight is present within a channel by selecting Line of Sight.

Choose the desired Resolution for each data file type. The selected resolution controls the number of significant digits placed to the right of

the decimal place, which in turn controls the resolution of the SLE (see the SLE operating manual for further details).

Edit Atmospheric Losses to create the pathloss due to atmospheric gases and free space path loss.

Choose the time Duration over which the data will be generated.

Update Rate is the time interval between data points. It can be selected in a 1,2,5 sequence between 1 msec and 1000 msec. The data file size will be determined by the ratio of Duration/Update Rate (excluding any reduction that may be caused by Line of Sight triggering). For example, for a Duration of 1 minute, and an Update Rate of 1 msec, each data file will have 60,000 points.

Finally, select the desired location to store the parameter data files, and press the Save button.

Once a valid Scenario has been created, the Generate button will create and store the parameter data files.

3.4. Atmospheric and Free Space Losses

SATGEN II can create an attenuation file based on atmospheric gaseous losses and also free space path loss. Each of these components can be individually enabled or disabled.

The path loss model can be accessed by right clicking on the map, or from the Atmospheric Losses button in the Parameter Setup window.

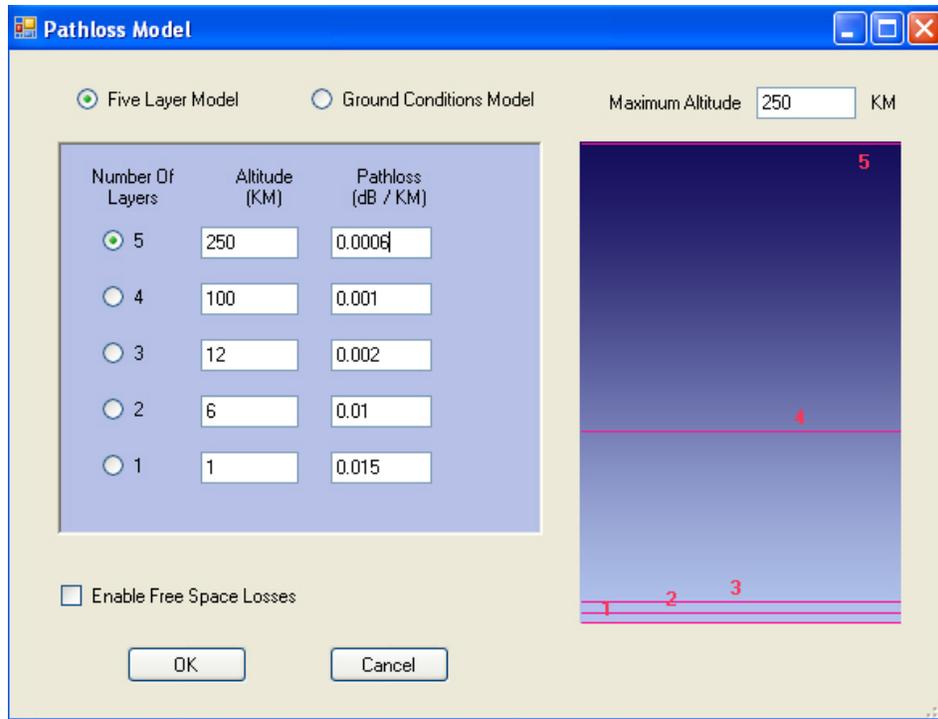


Figure 3-10 Five Layer Model for Atmospheric Losses

Free space path loss is the signal power lost due to the distance between two objects in a vacuum. This component may be enabled by selecting the “Enable Free Space Losses” check box. The value created by SATGEN II is a relative number, normalized to the shortest distance occurring between the two entities for the current scenario. For example, if an LEO satellite passes directly over an earth terminal, the shortest distance between them occurs when the satellite is directly overhead, and the free space path loss at this point is set to zero. As the satellite moves toward the horizon, the path length increases and the free space path loss increases accordingly.

The second component of path loss is the attenuation due to atmospheric gases. Gaseous losses in the atmosphere vary with pressure, temperature, water vapor content, and the signal frequency. There are two methods available in SATGEN II to model these losses. The first method is a Five Layer model, as shown in Figure 3-10. The user may manually enter from one to five layers. Each layer has a height (in km) and corresponding loss (in dB/km). The maximum total atmospheric altitude is limited to 500 km.

A second method for computing the atmospheric losses utilizes a model for the total loss based on the ground conditions. Based on the ground level temperature and humidity, a single layer model for the entire atmosphere is created. Pressure, water vapor density, oxygen content, and atmospheric height are computed, and then using the link operating

frequency, the losses are computed for that link. This model is valid for frequencies less than 57 GHz.

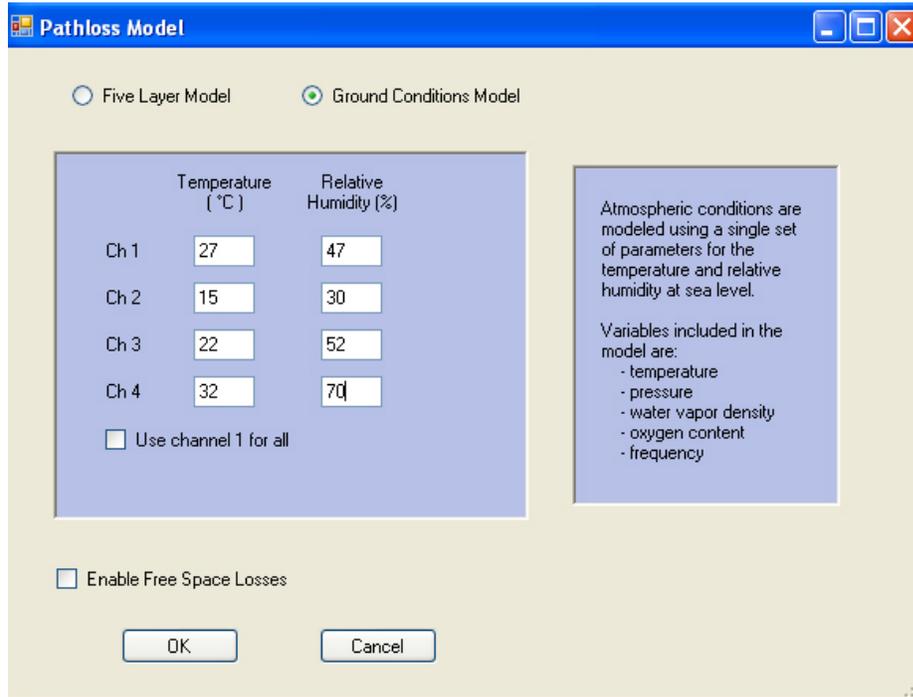


Figure 3-11 Single Layer Atmospheric Loss Model

3.5. Save and Edit Scenarios

A Scenario consists of all entities, Link Settings, and Parameter File Settings, and can be saved under a unique name and description. With the SATGEN II application loaded, right click on the map and move the mouse to Edit Scenario.

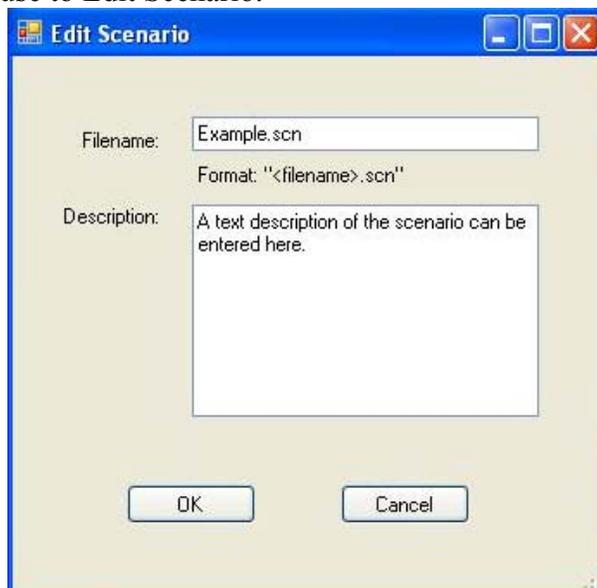


Figure 3-12 Scenario Editor Window

Enter a name and description, then press OK to save the Scenario. Right clicking with an existing Scenario loaded will invoke this window, and allow changes to be made to it.

3.6. Navigating with Menus and Icons

In addition to using the mouse, editing windows can be accessed using the icons and menus at the top of the map.



Figure 3-13 Navigation Menus and Icons

The lower group of three icons depicted here are, from left to right:

- Parameter File Setup
- Link Configuration
- Generate Data

These icons can be used in lieu of the right mouse button.

The Scenario menu icon is an alternative to selecting Edit Scenario with the right mouse button.

The Database menu provides quick access to all of the entities stored in the SATGEN II database.



Figure 3-14 Database Menu

The Help menu provides access to information about the version of SATGEN II, and Registration.

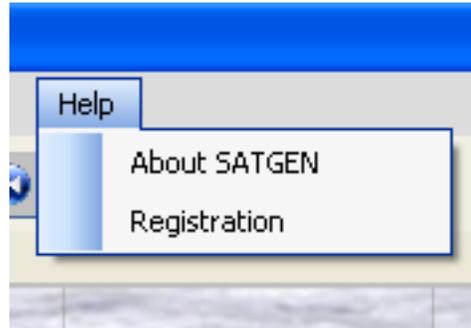


Figure 3-15 Help Menu

3.7. Using the Animation Player

3.7.1. General Description

The SATGEN II Animator provides a graphic preview of the currently loaded scenario. Entities move from their start to stop locations. When line of sight exists between two entities that are configured to communicate with each other via the Link Configuration window, a rubber banding line is drawn between them. Four colors of rubber bands are used to designate which channel the entities are associated with: red is channel 1, yellow is channel 2, turquoise is channel 3, and violet is channel 4.

3.7.2. Animation Controls

The Animation controls are displayed below.



Figure 3-16 Animation Controls

The leftmost group of icons are the Reset, Play, and Fast Forward controls. Reset returns the animation to the Start Time. Each press of Fast Forward causes the animation to jump forward in time.

The multiplier control causes the animation to run in real time (x1) up to x10,000 faster than real time.

The Start Time is relative to the total Scenario Duration time. For example, a Start Time of 1:00:00.000 will cause the animation to start at one hour into the total Duration of the Scenario. (Duration is set in the Parameter File Setup window).

The Stop Time is relative to the total Scenario Duration time. For example, a Stop Time of 6:00:00.000 will cause the animation to stop six hours into the total Duration of the Scenario.

Elapsed Time is the current Animation time, relative to the Start Time.

Animation Time cannot exceed the total Duration time.

4. Parameter Data File Descriptions

4.1. File Names

All parameter file names are limited to 10 characters excluding the extension. The first three characters of the file name allow the SLE to determine the type of file, and must be one of the following: a) DLY b) FRQ or c) ATN. Each file must have an extension of ".dat".

The default directory in which data files are stored is c:\dbm\satgen\data.

4.2. File Format

Parameter data files must be generated in ASCII format. The first line in the file is a value that represents the number of sample points in the file. Each subsequent line contains one data value. Lines are separated by a carriage return. An example of a delay file with 3 points is:

```
3
12.456789
12.456788
12.456787
```

The ASCII parameter files must have a file extension of ".dat" in order to be recognized by the SleControl program and SLE dll. The SATGEN II satellite data generation program automatically generates the correct file extension. User generated files should be created with the .dat extension also. The first three letters of the file name must be one of DLY, FRQ, ATN, or PHA to represent delay, frequency offset, attenuation, or phase offset files. (The SLE accepts PHA files, but SATGEN II does not create phase files). Up to 7 alphanumeric characters can follow the first three letters in the file name.

4.2.1. Delay File Data Format

Dynamic delay resolution has 5 possible cases. The resolution is determined by the number of digits to the right of the decimal place in the 1st data point in the file. The number of digits in successive data points has no effect on the adopted resolution.

| <u>Format</u> | <u>Resolution</u> | <u>Minimum slew rate</u> |
|-----------------------|-------------------|--------------------------|
| ms (no decimal point) | 1 nsec | 1 nsec/sec |
| ms.123456 | 1 nsec | 1 nsec/sec |
| ms.1234567 | 100 psec | 0.1 nsec/sec |
| ms.12345678 | 10 psec | 0.01 nsec/sec |
| ms.123456789 | 1 psec | 1 psec/sec |
| ms.1234567890 | 0.5 psec | 0.5 psec/sec |

The maximum step size between two adjacent delay points must be limited to 32,676 times the resolution to remain compatible with the SLE. The update interval (rate at which data files are implemented) also affects the achievable delay slew rate. The different cases of delay resolution are created to allow the ability to have any delay slew rate from 16384 usec/sec down to 0.5 psec/sec. Refer to the SLE manual for more details on these ranges.

4.2.2. Attenuation File Data Format

The attenuation file generated by SATGEN II represents the sum of the atmospheric gaseous losses and the free space path loss.

- Range is 0 to 60 dB in 0.25dB steps
- Step size between any two adjacent points can be up to 60 dB

4.2.3. Frequency Offset Data Format

The frequency offset file generated by SATGEN II represents the Doppler frequency shift at the carrier frequency defined for a link. When a channel is comprised of multiple links, the composite Doppler shift for all links is summed and applied in the data file.

Frequency file resolution has two possible cases. The resolution is determined by the number of digits to the right of the decimal place in the 1st data point in the file. The number of digits in successive data points has no effect on the adopted resolution.

Case 1 – Resolution is 1 Hz. This case occurs when the first dynamic data point has any number of digits, other than five, to the right of the decimal point.

Case 2 – Resolution is 0.01 Hz. This case occurs when the number of digits to the right of the decimal is five.

| <u>Data Point format</u> | <u>Frequency resolution</u> |
|--------------------------|-----------------------------|
| kHz (no decimal point) | 1 Hz |
| kHz.1 | 1 Hz |
| kHz.12 | 1 Hz |
| kHz.123 | 1 Hz |
| kHz.1234 | 1 Hz |
| kHz.12345 | 0.01 Hz |
| kHz.123456 | 1 Hz |

4.2.4. Position and Velocity File

SATGEN II can generate positional and velocity data for each entity at each time increment. This file is generated if selected via the check box in the Parameter File Setup window.

The file is stored in tabular form. Columns from left to right are as follows:

1. Entity name
2. Latitude
3. Longitude
4. X position
5. Y position
6. Z position
7. X velocity
8. Y velocity
9. Z velocity

Values are generated for each time increment. The entity is identified by the channel it is associated with and the entity name. For example, a row labeled “Ch1-et1” would correspond to an entity called “et1” which exists within channel 1.

5. Glossary of Terms

Argument of Perigee: The angle in the orbital plane between the line of nodes and the perigee of the orbit. Shown as ω in Figure 5-2.

Azimuth: The angle between true north and the direction of the satellite measured in the clockwise direction.

Eccentricity: The ellipticity of the orbit, calculated as

$$e = \sqrt{1 - \left(\frac{b}{a}\right)^2}$$

where a is the semi-major axis and b is the semi-minor axis of the elliptical orbit (see Figure 5-1).

Elevation: The angle from the horizon to the satellite.

Inclination: The angle between the orbital plane and the equatorial plane. Shown as i in Figure 5-2.

Initial Mean Anomaly: The initial angle from the perigee of the satellite.

Mean Anomaly: The angle from the perigee that the satellite would traverse in at any given time. Shown as θ in Figure 5-1.

Right Ascension: The angle between the X-axis and the ascending node. Shown as ω in Figure 5-2.

Perigee: The point of orbit closest to the Earth.

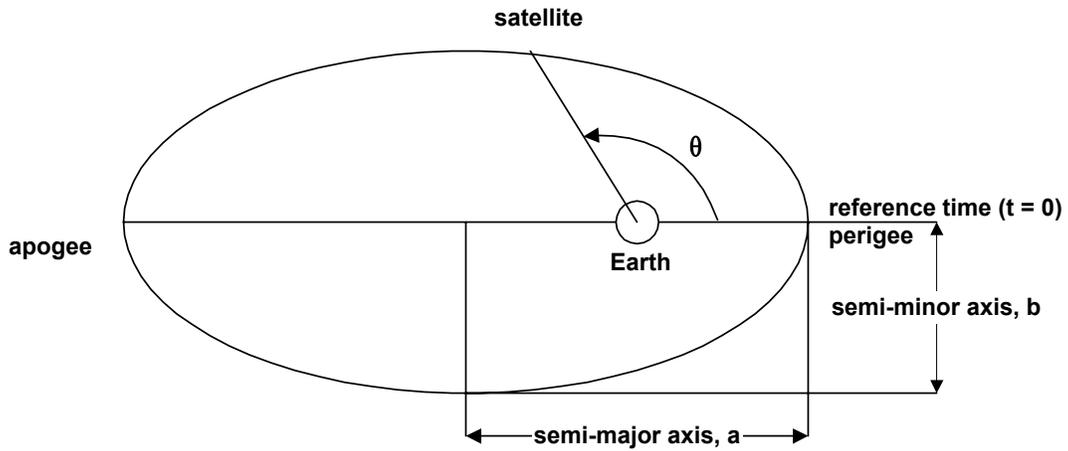


Figure 5-1. Parameters in an Elliptical Orbit.

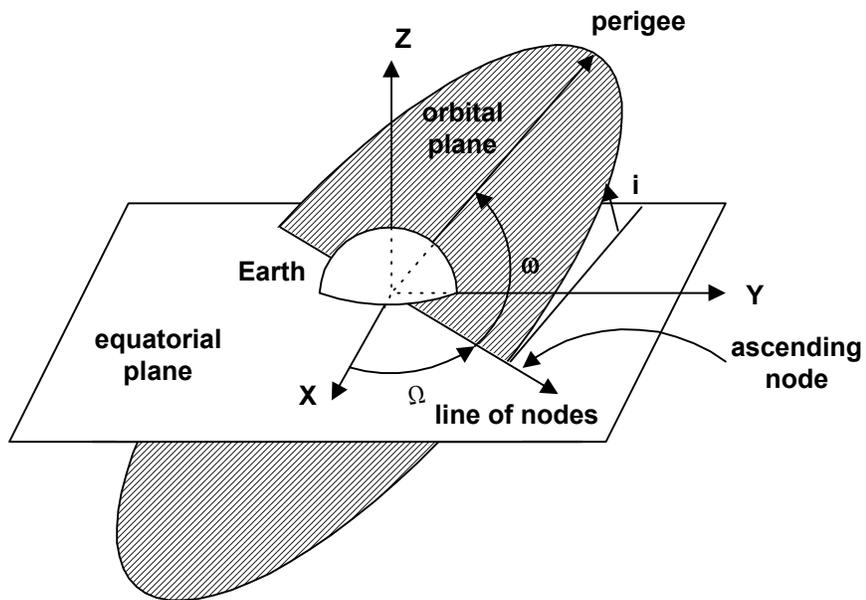


Figure 5-2. Orbital parameters