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D2-3a: System simulator instruction manual

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Summary

VHF Data Exchange System (VDES) is a future maritime communication system. Its development is coordinated by the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA). The system has two main goals: To protect the anti-collision function of AIS, and to improve maritime communication applications.

Space Norway has formed a consortium with Kongsberg Seatex and the Norwegian Defence Research Establishment (FFI) to support the development of VDES. The consortium has won two European Space Agency contracts. This document is a part of the second contract, “AO/1-8282/15-NL/IA – Cost Effective VDE-SAT user terminal and ground component validation platform”, and is the user manual for the simulator described in “D2-2: System Simulator Design Description Document and Functional and Performance Validation Report”.

Sammendrag

VHF Data Exchange System (VDES) er et fremtidig maritimt kommunikasjonssystem. Utviklingen av systemet er koordinert av International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA). Hovedformålene med dette systemet er å beskytte antikollisjon-funksjonen i AIS og å øke kapasiteten til maritime kommunikasjonssystemer.

I denne sammenhengen har Space Norway dannet et konsortium med Kongsberg Seatex og Forsvarets forskningsinstitutt (FFI) for å støtte utviklingen av systemet. Den europeiske romfartsorganisasjonen har tildelt konsortiet to kontrakter. Dette dokumentet er en del av den andre kontrakten, “AO/1-8282/15-NL/IA – Cost Effective VDE-SAT user terminal and ground component validation platform”, og gir brukermanualen for systemsimulatoren beskrevet i “D2-2: System Simulator Design Description Document and Functional and Performance Validation Report”.

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1 Introduction

Norway has significant national maritime interests and activities in the North Atlantic Ocean, the Arctic and Barents Seas. Parts of these areas are beyond geostationary satellite coverage. Space Norway AS (SPN), Kongsberg Seatex (KSX) and Norwegian Defence Research Establishment (FFI) have formed a consortium for the delivery of a VHF Data Exchange Satellite (VDE-SAT) system simulator, physical layer simulator, prototype terminal and test-bed as described in the invitation to tender and the final proposal.

The Consortium is working in close cooperation with responsible and operational authorities in developing a VDE-SAT space based infrastructure, in particular the Norwegian Space Centre, the Norwegian Coastal Administration, the Norwegian Maritime Authority and the Norwegian Communications Authority.

This document is the VSS user manual. VSS is a software tool developed at FFI to simulate the uplink performance of a VDE-SAT system. It is based on AISDET[1], a tool developed to simulate the performance of reception of AIS message by satellite, and on Heliosat[2].

1.1 Change log

Date	Section	Comment
2017-10-23	N/A	Stop VSS from freezing while saving a scenario to a new folder.
2017-10-16	N/A	Removed a few ephemerides from installer to make it smaller. (VSS does not include the deep-space tracking plugin from HeliosatTK.)
2017-10-16	10.5	RID-D5-2-IP-2: Add refresh rate FOM (REQ-PER-240).
2017-09-27	N/A	Bug fix: Error when processing FOM from overlapping target areas.
2017-09-25	10.1	RID-D2-2-NA-15: Select vessel antenna pattern.
2017-09-11	10.1	Set range of terrestrial VDES. Vessels within this distance from a coastline will not use satellite VDES.
2017-09-11	5.1	Added support for GRASP antenna files
2017-08-13	N/A	Bug fix: VSS crash at end of SAR operations.
2017-08-06	N/A	Installer includes a simulator version with debug symbols.
2017-08-06	N/A	Updated LAM model.
2017-08-04	N/A	VSS now creates a file called vessel_list_summary.txt in the scenario folder.
2017-08-04	N/A	Bug fix: Internal task manager did not always restart
2017-07-30	N/A	Bug fix: Remove absolute paths saving scenario
2017-07-28	N/A	Bug fix: Task manager did not always receive task finished notification.
2017-07-26	N/A	Now uses LAM model.
2017-07-25	8	Possible to merge vessel lists.
2017-07-24	5.1	Can now run with NEC-WIN .NOU files, Figure 5.6.
2017-07-24	5.1	Show orientation of antenna relative to local horizon, Figure 5.4.
2017-07-20	10.1	Add AIS loading
2017-07-20	5.4	Load STK orbit files.
2017-07-20	10.2 - 10.3	RID-D2-2-NA-10: Added ASM loading and verified packet sizes.

2017-07-18	5.1	Describe how VSS track service areas.
2017-07-18	11	Added text to summary.
2017-07-18	10.5	Reports and figures of merit.
2017-07-18	10.4	Allow link configuration id 20 on random access logical channels.
2017-07-18	10.4	RID-D2-2-NA-11: Possible to generate bulletin boards in VSS.
2017-07-18	10.1	Moved adaptive coding to bulletin board tab.
2017-07-17	N/A	Bug fix: Possible to remove vertices from target areas.
2017-07-17	N/A	Bug fix: Simulator did not store transmissions with correct time stamps.
2017-07-17	N/A	Bug fix: Possible to copy scenario from one folder to another.
2017-07-17	10.6	Scenario viewer now shows ground tracks.
2017-07-17	N/A	Vessels participating in SAR operations transmit only SAR messages[3].
2017-07-17	10.1	RID-D2-2-NA-12: Possible to disable ACK.
2017-07-14	7	Added check box to horizon mask (interference source).
2017-07-14	6	Added check box to horizon mask (ground station).
2017-07-14	N/A	Bug fix: User can remove vertices from target and service areas.
2017-07-14	7	Radio interference source.
2017-07-14	10.6	Added section that describes the scenario viewer.
2017-07-14	10.1	Added comment about wave height.
2017-07-14	10.1	RID-D2-2-NA-18: Fading depends on vessel antenna height.
2017-07-13	N/A	RID-D2-3a-NA-3: Initial installer.
2017-07-13	2	RID-D2-3a-NA-4: New chapter, installation and requirements.
2017-07-13	1	RID-D2-3a-NA-5: History log, general information.
2017-07-13	2	RID-D2-3a-NA-6: Run time of included example.
2017-06-25	N/A	New icons.

2017-06-20		Initial release

1.2 Know issues

- Only supports internal vessel list format. Not possible to support other formats without examples.

2 Installation

The VSS installer is almost completely self-contained. The only external program it requires is Gnuplot.

The intention was to include Gnuplot with the VSS installer, but both programs use different version of some of the same libraries, and the Windows version of Gnuplot is a 32-bit application. To ensure that there are no conflicts, we decided to use the regular Guplot installer, which also puts Gnuplot into the expected 32-bit folder on 64-bit machines.

2.1 VSS

VSS was developed on Linux and Windows 7 and requires a 64 bit computer.

The provided installer has been tested on Windows 7 Professional 64 bit. A typical installation uses about 1.5GB of storage on the *C:* drive and it creates an entry called VSS in the **All Programs** menu.

The installer includes an example in *C:\Program Files\VSS\share\VSS\examples\demo.* To use this example, users must open the scenario in VSS and save it to a location where they have write access.

This scenario spans 24 hours and includes 12 satellites in a Walker constellation, but it has been configured to use only one satellite during the VDES simulation.

VSS requires about 700 MB of RAM, and it generates about 450 MB of data in the folder where the scenario was saved. The VDES simulation takes about 15 minutes to complete on a 7 year old HP Z400. The run – time and the amount of generated data is proportional to the number of satellites used during a VDES simulation and the number of vessels. It is also proportional to length of the simulation. A 16 satellite simulation spanning 7 days requires 3.5GB of RAM.

The number of satellites can be changed by the user, but the user must change the satellite selection in the **Compute access (service areas)** task and run that task, see section 5.3. This task takes about 30 seconds to complete with 12 satellites.

The main other task is to compute access to vessel lists. This takes about 15 minutes for the included demo example. This task is also proportional to the number of vessels and simulation time.

The remaining figures in this section show the different stages of the installation:

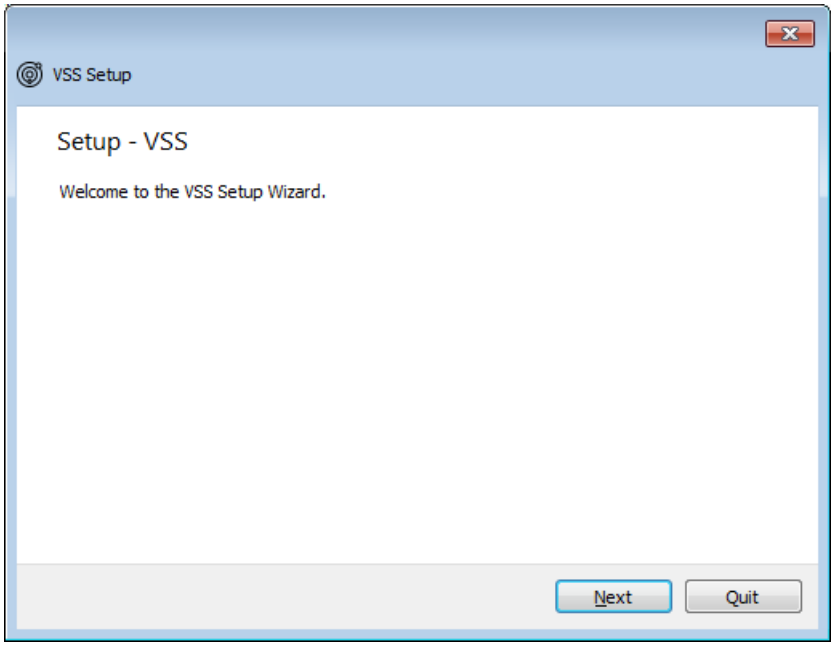

Figure 2.1 Welcome

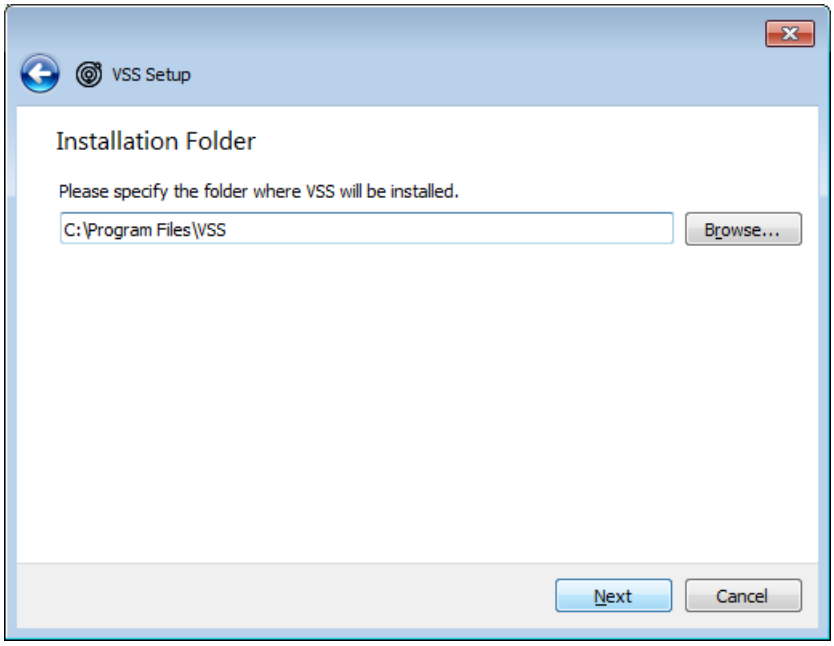

Figure 2.2 Installation folder

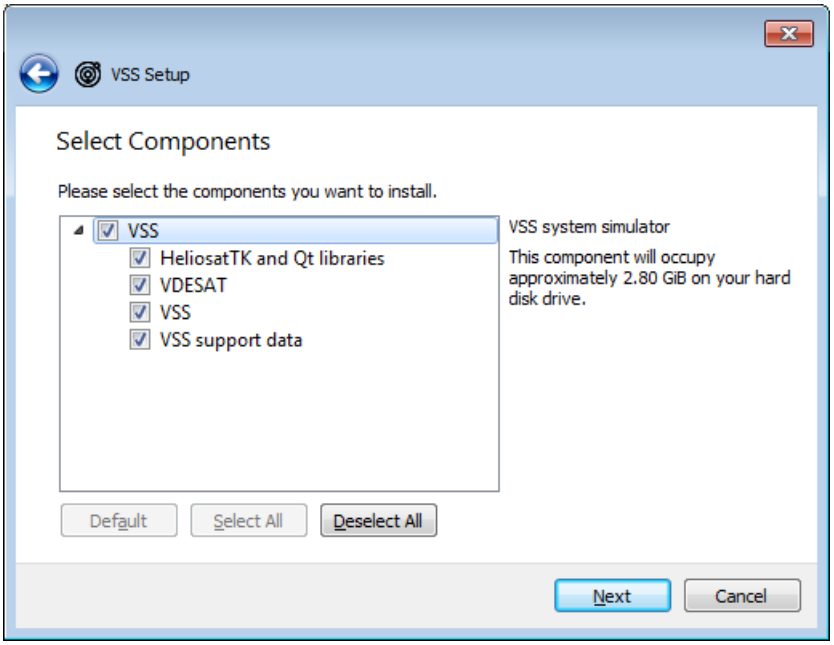

Figure 2.3 Required components

Figure 2.4 License agreement

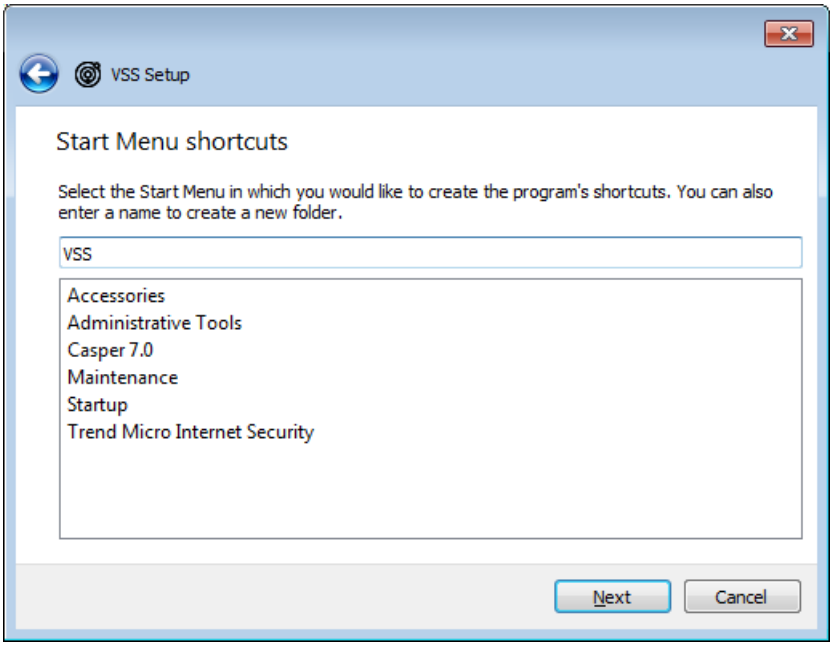

Figure 2.5 Start menu entry

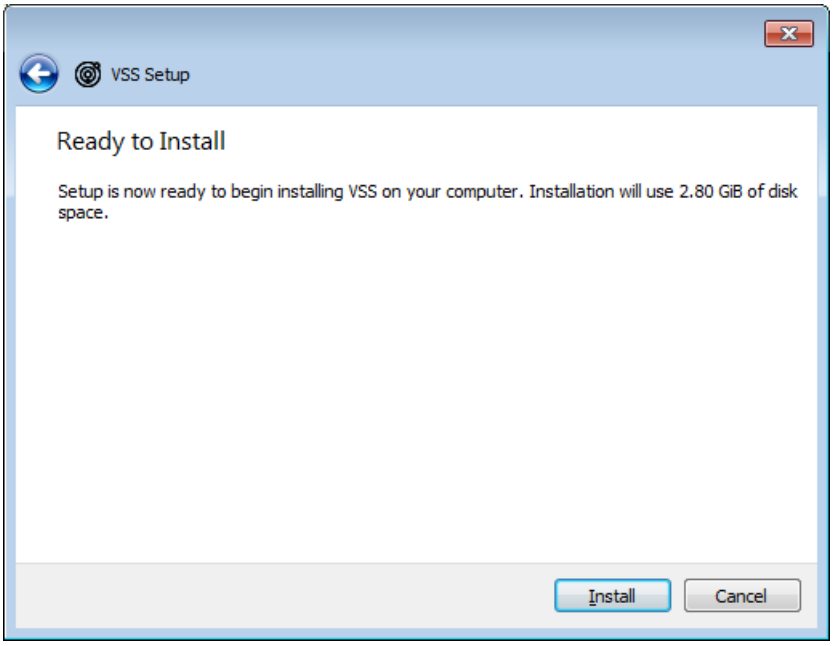

Figure 2.6 The installation takes about 10 minutes to complete.

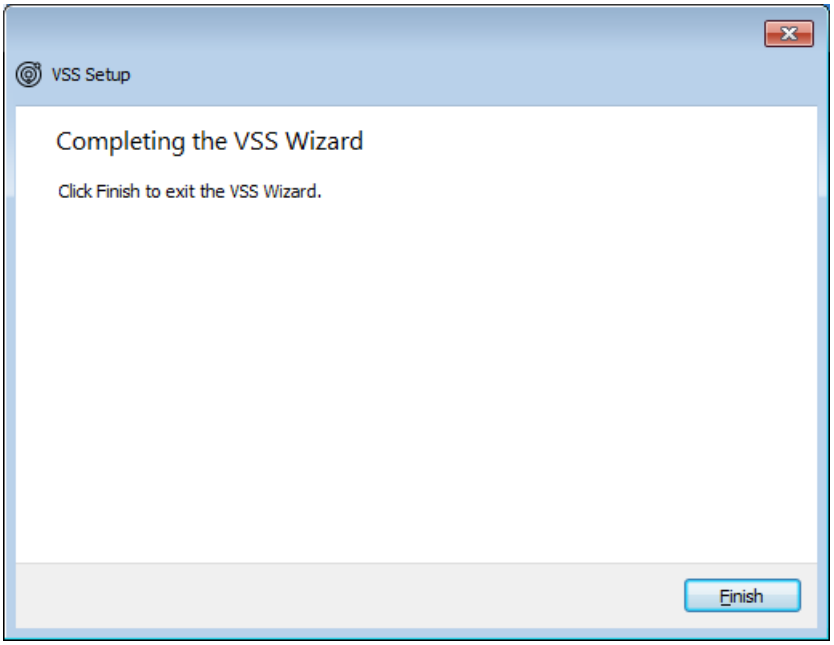

Figure 2.7 And we are done.

2.2 Gnuplot

VSS uses Gnuplot (http://www.gnuplot.info) to generate figures of merit. VSS has been tested with the latest release as of July 13th, 2017.

That version is a 32-bit application, and VSS expects it to be installed in *C:\Program File (x86)\gnuplot* as seen in Figure 2.8. (The installer default selections should be acceptable.)

We include this information in case a 64-bit version becomes available at a later time.

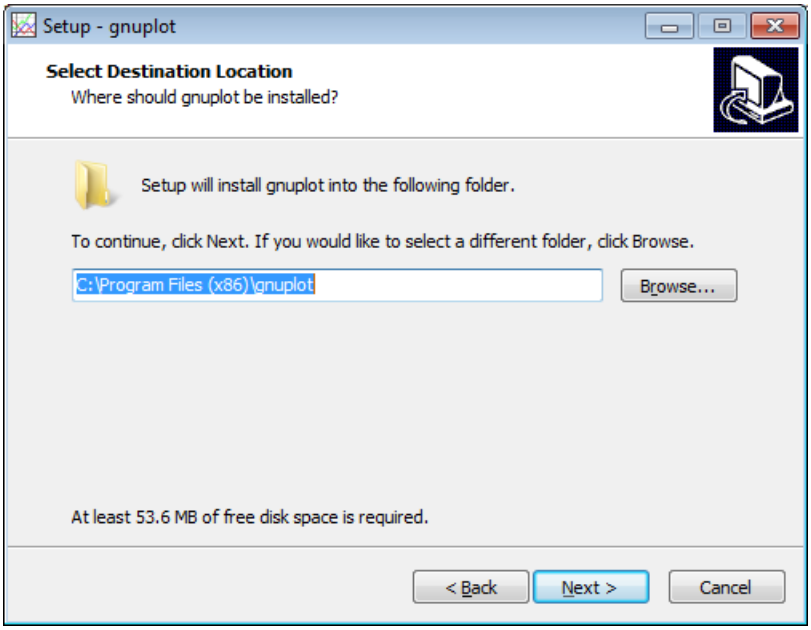

Figure 2.8 Gnuplot folder

3 GUI overview

VSS shows a main window when it launches. This window is the scenario editor. Figure 3.1 shows it with a typical scenario loaded. The tree view on the left displays a set of objects, while the area on the right contains object editors.

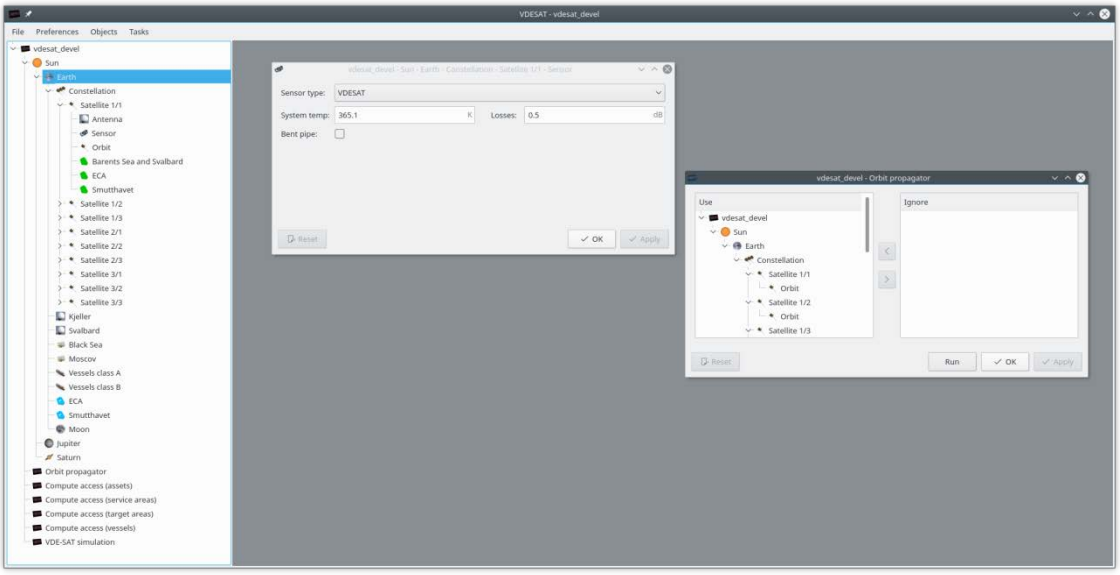

Figure 3.1 Scenario editor

The object list holds in this case two main types of objects: Tasks, which are the six last items in Figure 3.1, and a Solar System object.

In this scenario, the Solar System object contains the Sun, Earth, the Moon, Jupiter and Saturn. A constellation of nine satellites, two ground stations, two interference sources, two vessel lists and two target areas have been add to the Earth.

Typical task objects propagate orbits, compute accesses to assets, and computes coverage of target areas.

There is an editor associated with each object. To launch such an editor, you must double click on an object in the object lists.

There are two possible ways to add new solar system objects. You can either right-click on an object in the object list and select an entry from a popup menu, or you can click on an object in object list and then select an entry from the **Objects** menu. The entries in the menu depend on

which object you click on. You are not allowed to add a ground station to the moon for example.

Tasks are only available through the **Task** menu.

To delete an object, you must select the object and hit the **Delete** key on keyboard.

4 Scenarios

4.1 Create a new scenario or open existing scenario

The file menu holds action to either create a new scenario or to open an existing scenario. It also shows the last five scenarios that you have worked with.

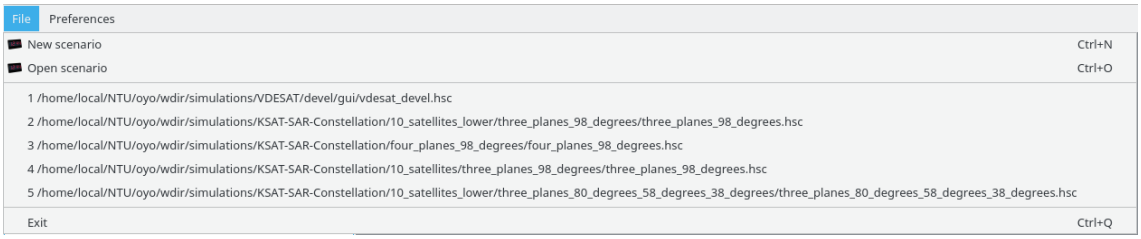

Figure 4.1 File menu just after launching VSS

4.2 Scenario name

To edit the scenario name, you must select the top level object and hit F2.

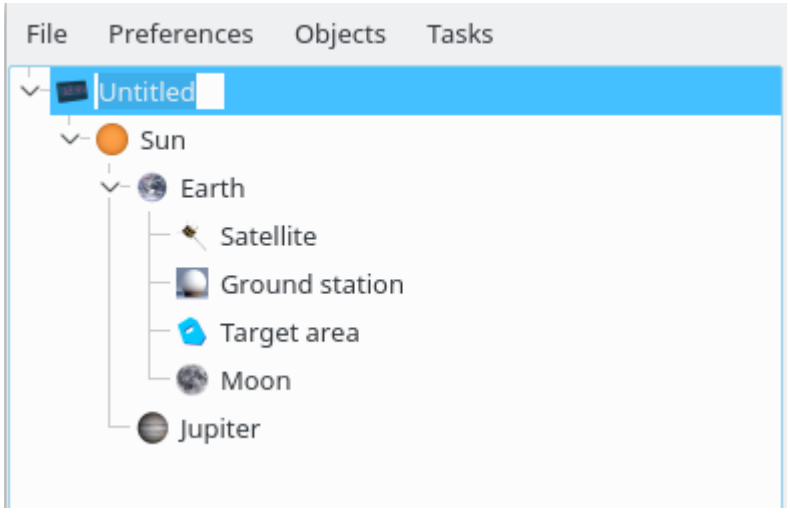

Figure 4.2 Editing the scenario name

4.3 Scenario start and stop

The editor associated with the top level object allows you to set the scenario start and stop times. After you have saved the scenario, you can add notes relevant for the current scenario.

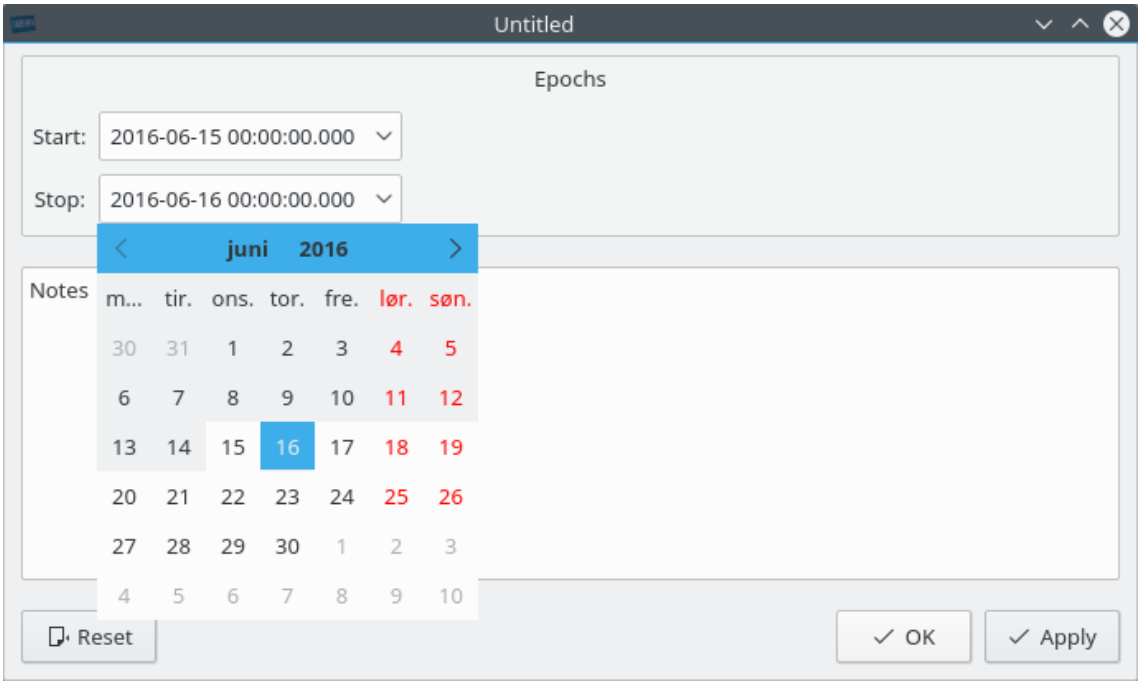

Figure 4.3 Scenario start and stop times

4.4 Save scenario

To save the scenario, you can either select **Save selected scenario** or **Save scenario as** from the file menu. VSS supports a shortcut (Ctrl+S) to quickly save the scenario as you keep editing it.

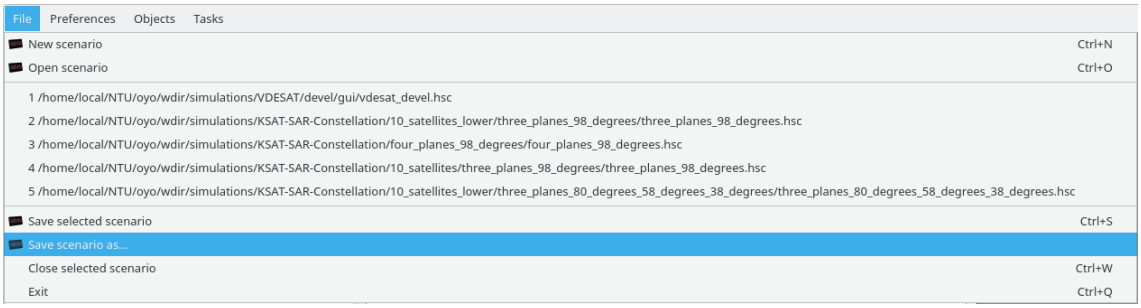

Figure 4.4 File menu with a scenario loaded into VSS

5 Satellites and orbits

5.1 Constellation wizard

To launch the constellation wizard, you can either right-click on Earth and select **Constellation** from the popup menu, or you can first select the Earth and then **Constellation** in the **Objects** menu as in Figure 5.1. The remaining figures in this section show the different elements of the constellation wizard.

VSS requires at least one service area per satellite, see Figure 5.7. Only vessels within a satellite's service area are allowed to transmit to that satellite. The track checkbox in that widget tells the satellite to track the center of the service area when the service area is visible. If checked, VSS first aligns the satellite with the local horizon system. VSS then rotates the satellite around its z-axis until the x-axis points towards the service area. Finally, VSS applies the rotations given in Figure 5.4.

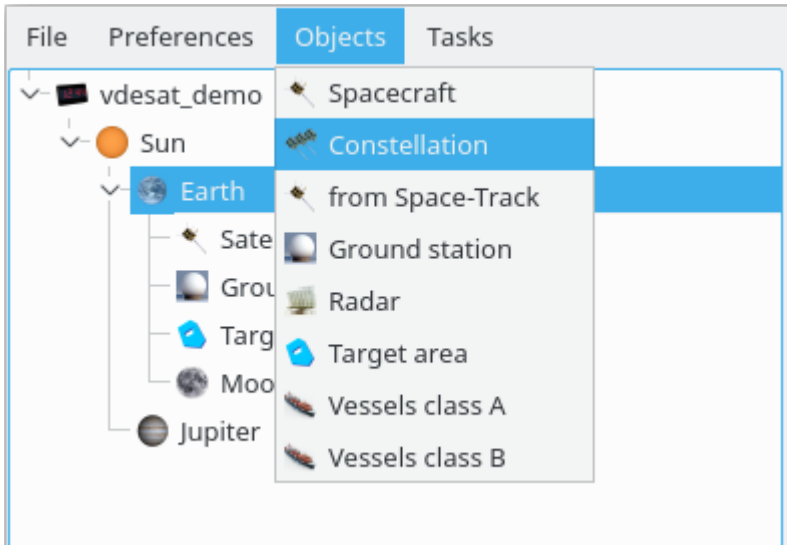

Figure 5.1 How to launch the constellation wizard from the Objects menu.

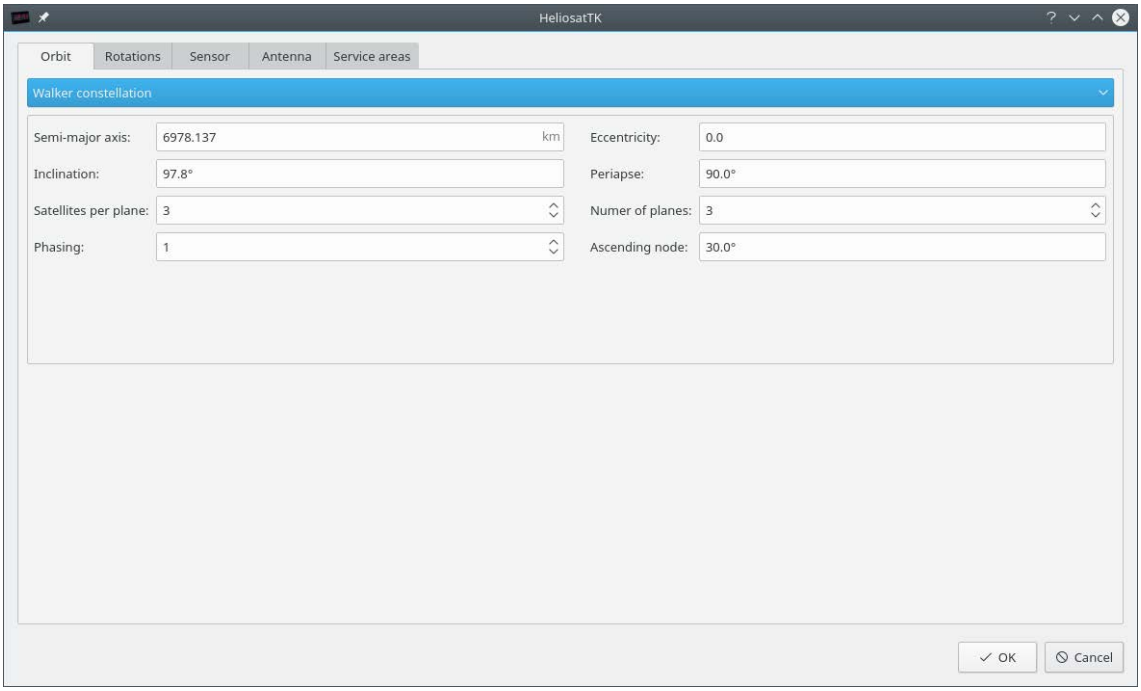

Figure 5.2 Walker constellation.

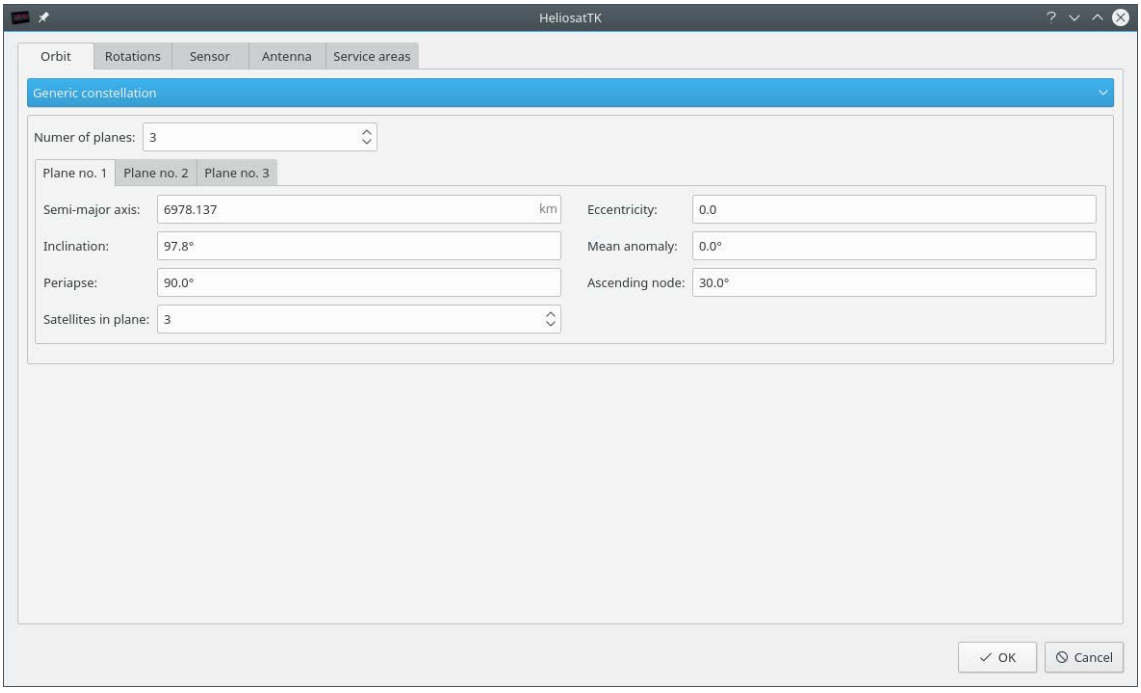

Figure 5.3 Generic constellation.

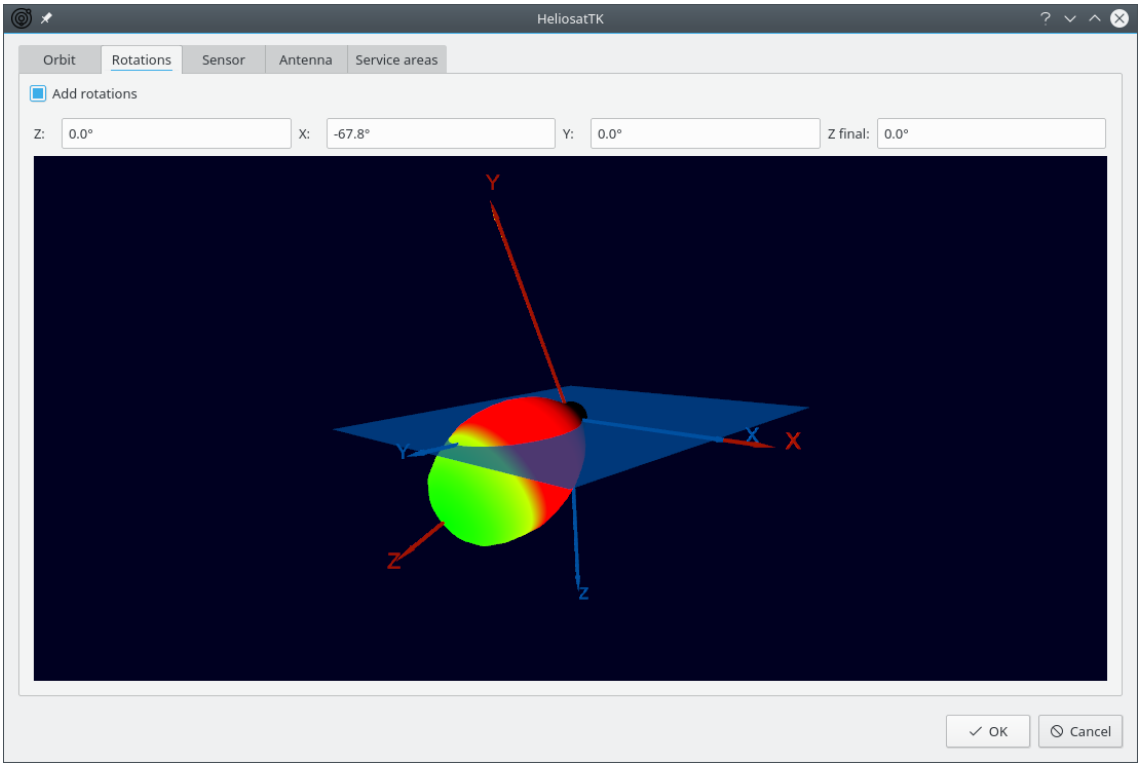

Figure 5.4 Satellite orientation and antenna pattern relative to the local horizon[3]. These values indicate a forward looking satellite. The blue coordinate axes represent the local horizon system, while the red axes represent the body fixed coordinate system. Blue Z points towards the center of the Earth, i.e. nadir, blue X is perpendicular to the orbital plane and blue Y is in the orbital plane. Blue Y is parallel to the orbit if the orbit is circular. Use arrows keys and arrow keys in combination with Shift or Alt to move the camera. The orientation of the body axes relative to the local horizon system depends on the angles set in the four angle editors. This widget will not show an antenna pattern until a supported file has been selected in the antenna tab.

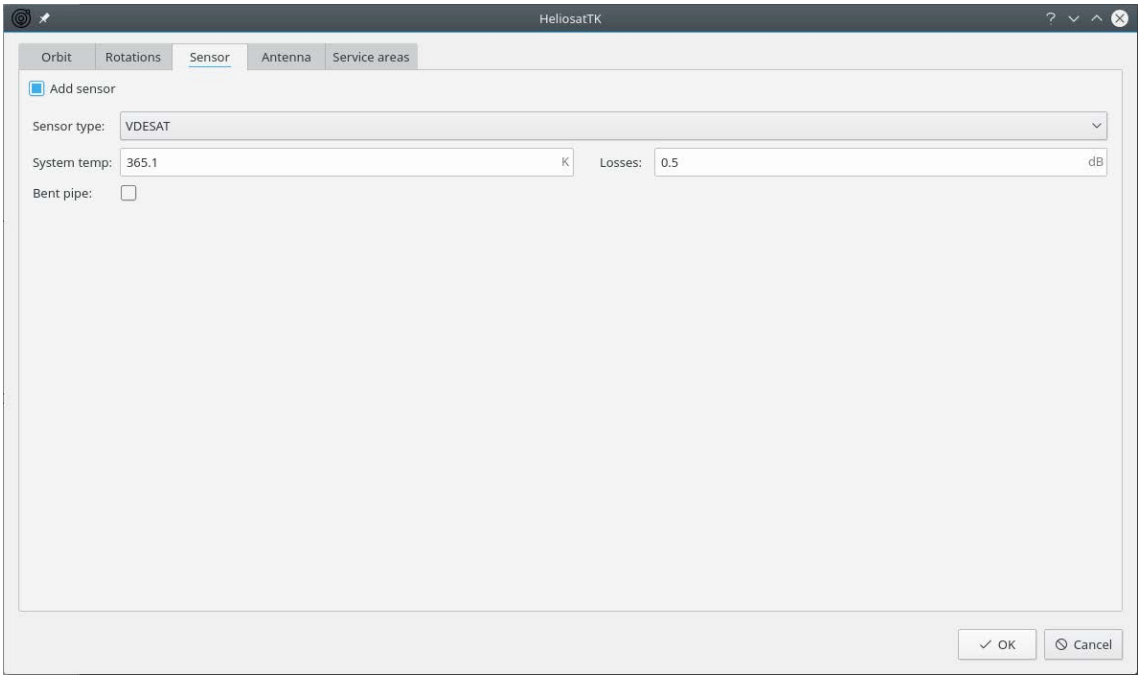

Figure 5.5 VSS requires that you select the VDESAT sensor from the dropdown box.

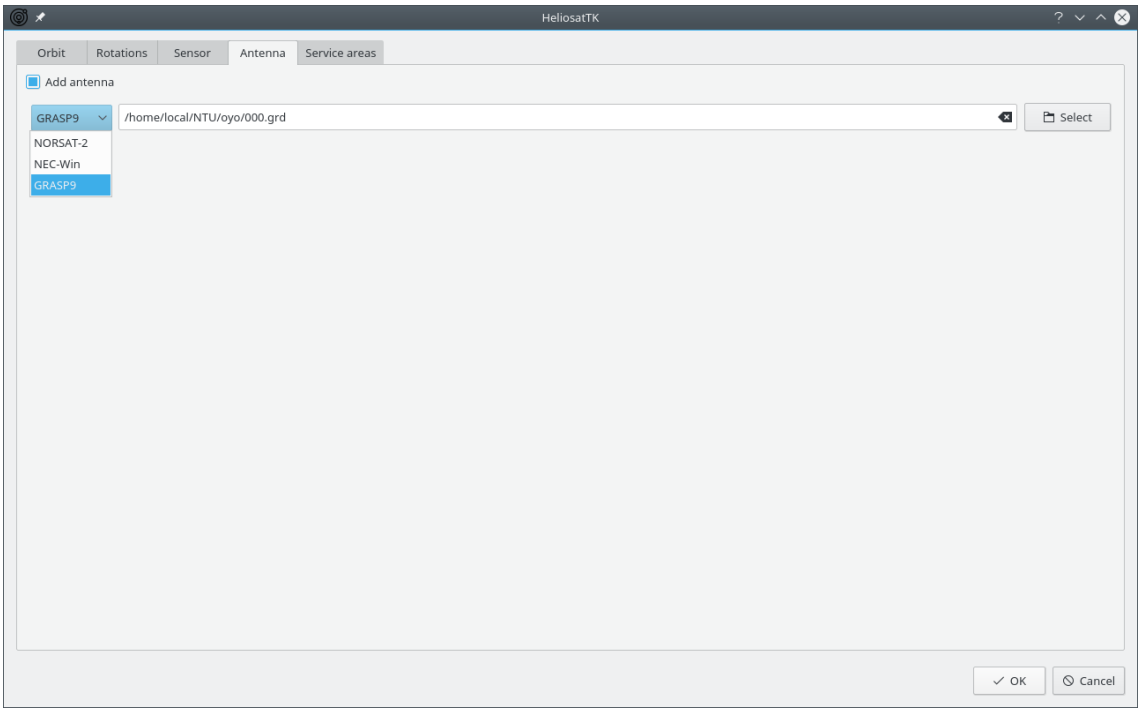

*Figure 5.6 VSS requires an antenna on each satellite. The **Select** button launches a file browser.*

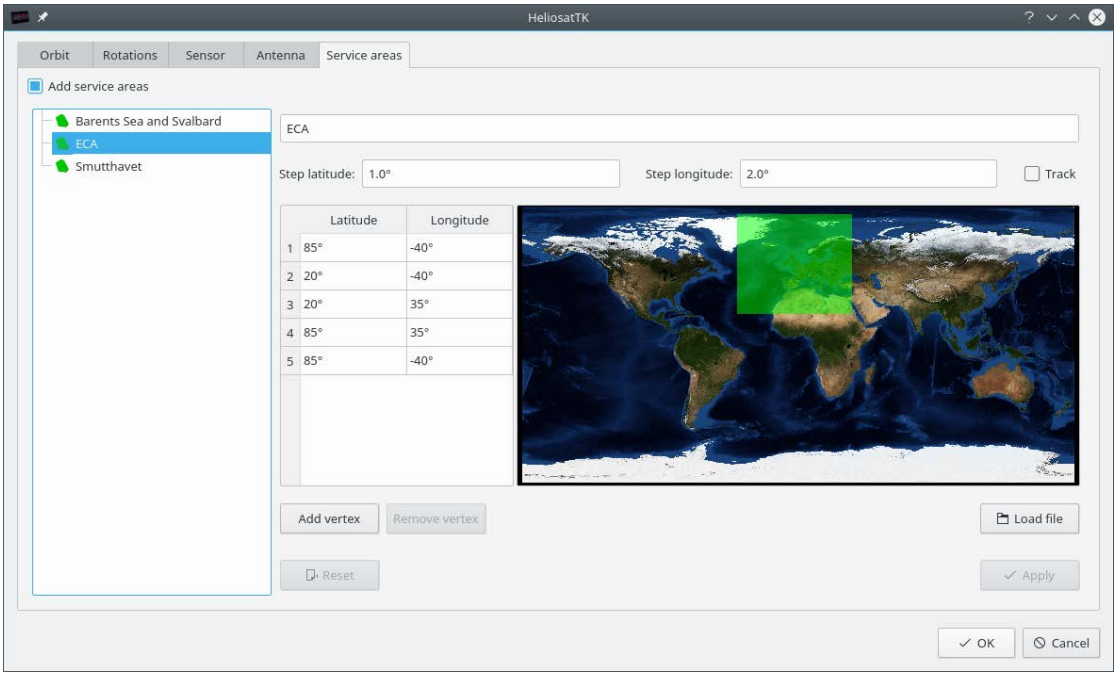

Figure 5.7 You can add service areas by right clicking on the small object browser. The track check box tells the satellite to rotate around its z-axis to keep its x-axis pointed towards the center of the service area when it is visible.

5.2 Orbit propagator

Now we are ready to launch the orbit propagator. It is available from the **Tasks** menu, see Figure 5.8. This will add an object called **Orbit *propagator*** at the bottom of the object list.

Figure 5.9 shows the editor associated with the propagator object. It allows you to select which orbits you want to propagate. To run the propagator, simply click the **Run** button.

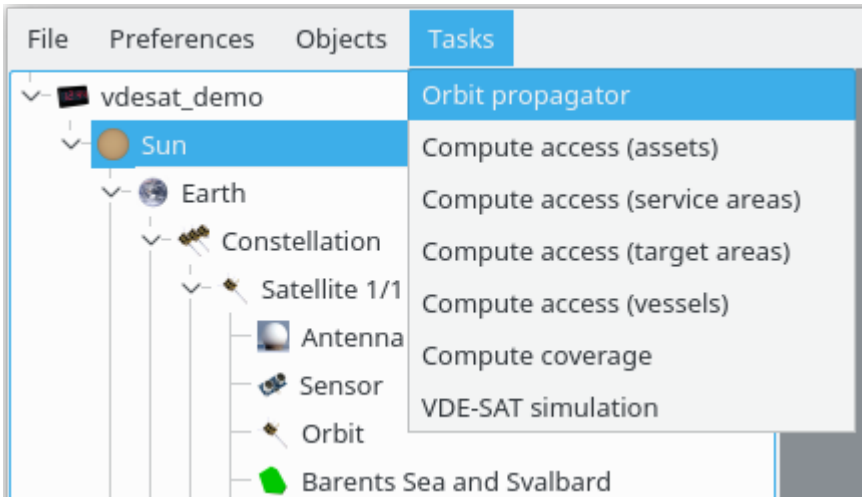

Figure 5.8 Adding an orbit propagator to the object browser.

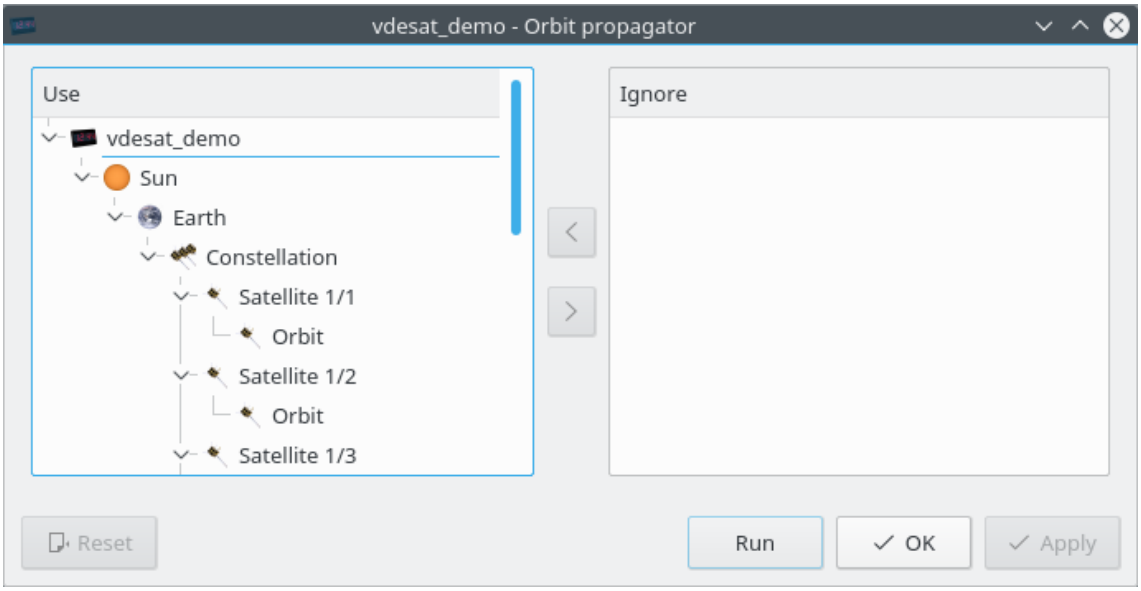

*Figure 5.9 VSS will propagate the orbits of the selected satellites, i.e. the satellite in the **Use** window.*

5.3 Access to service areas

At this time, you might as well compute accesses to the satellites' service areas. This is also a task available from the **Tasks** menu.

Figure 5.11 shows its editor. The settings tab is identical to the settings tab in the ground station access editor (Figure 6.4). This editor allows you to select satellites with a propagated orbit and to select service areas.

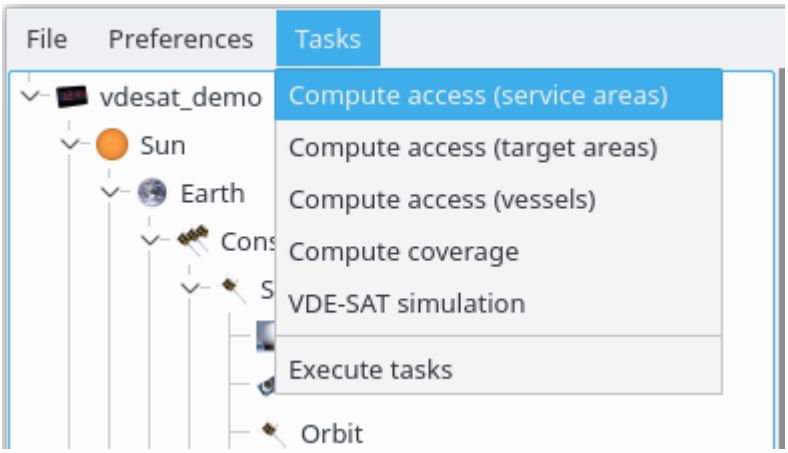

Figure 5.10 Adding a task to compute service area accesses times.

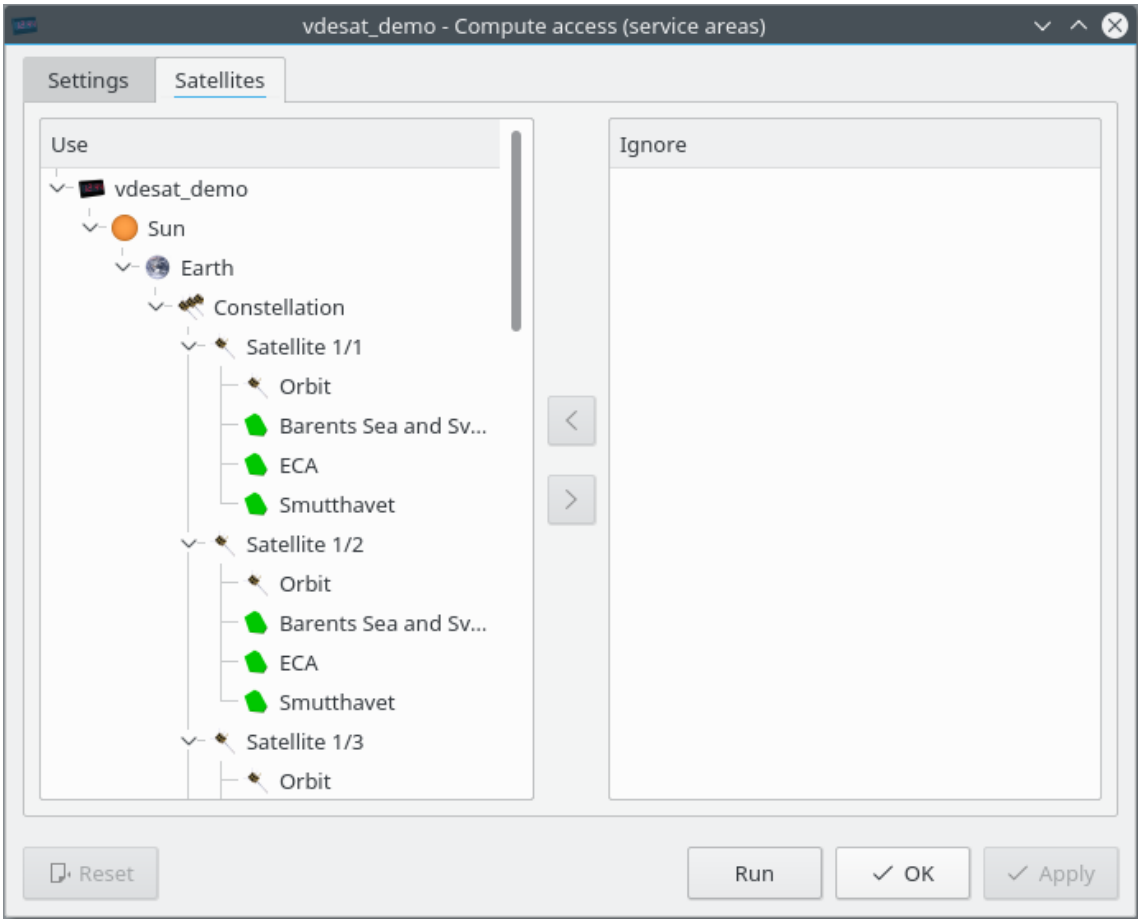

Figure 5.11 Select satellites and service areas.

5.4 Manually adding a satellite

You can create satellites manually as shown in Figure 5.12. VSS requires that you also add an orbit, an antenna, a sensor and at least one service area to each satellite (Figure 5.13). With the exception of the orbit editor, the other editors are identical to the corresponding widgets in the constellation editor.

Figure 5.14 shows the orbit editor with the recommended propagator. It is fast with reasonable accuracy. The installer includes a high precision propagator and a TLE propagator from the drop-down menu.

Another option is to use external orbit files, which you can select from the same drop-down menu. VSS supports STK Ephemeris files. In STK launch the **Export Ephemeris/Attitudes** tool and select the options shown in Figure 5.15. (This has only been tested with STK 11.2.) Another option is to let STK generate a TLE and use the TLE propagator.

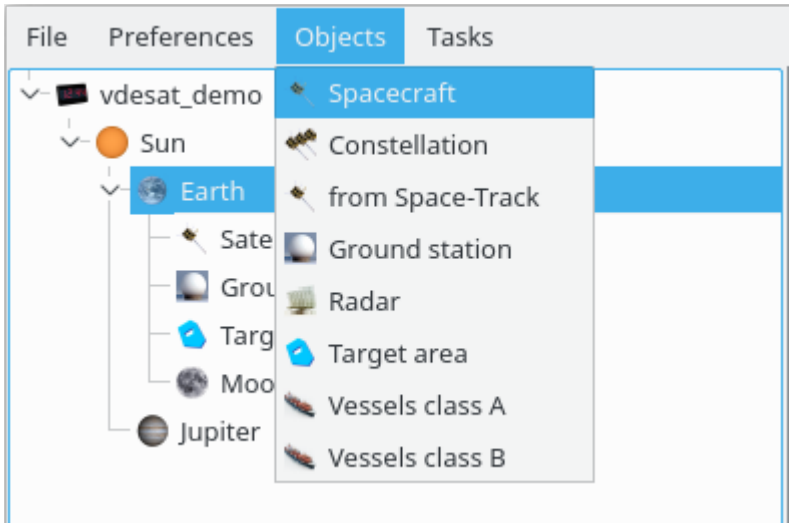

Figure 5.12 Manually adding satellites to the scenario.

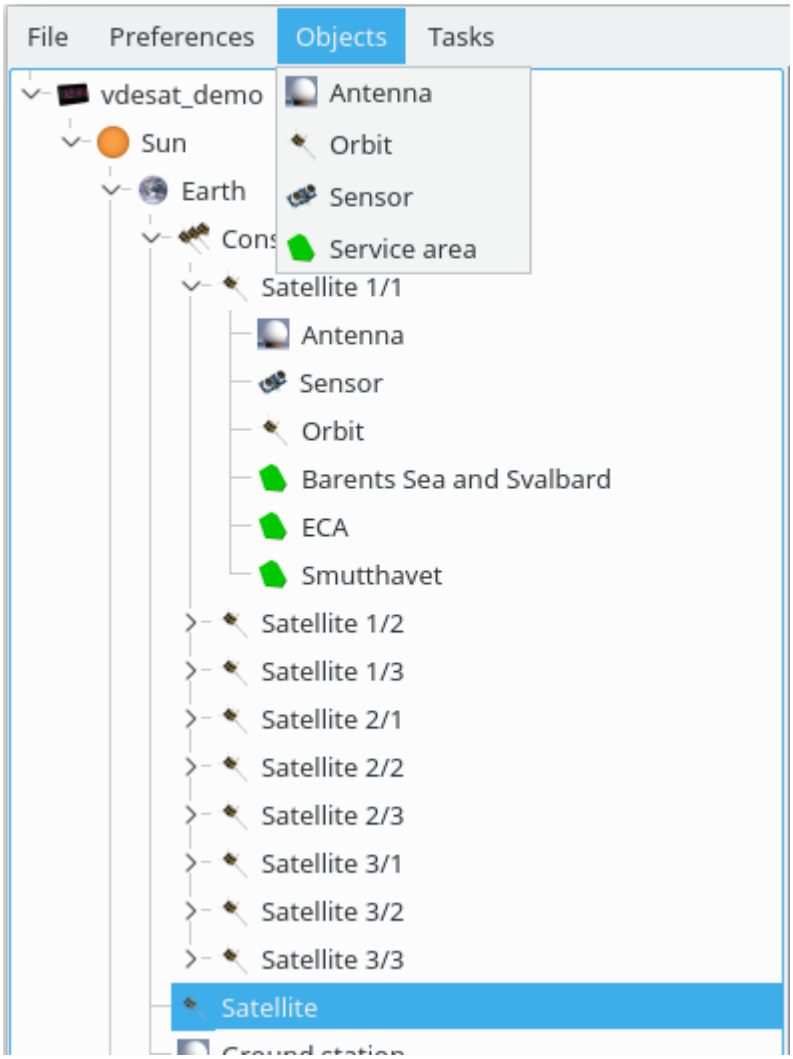

Figure 5.13 Objects that you can add to a satellite.

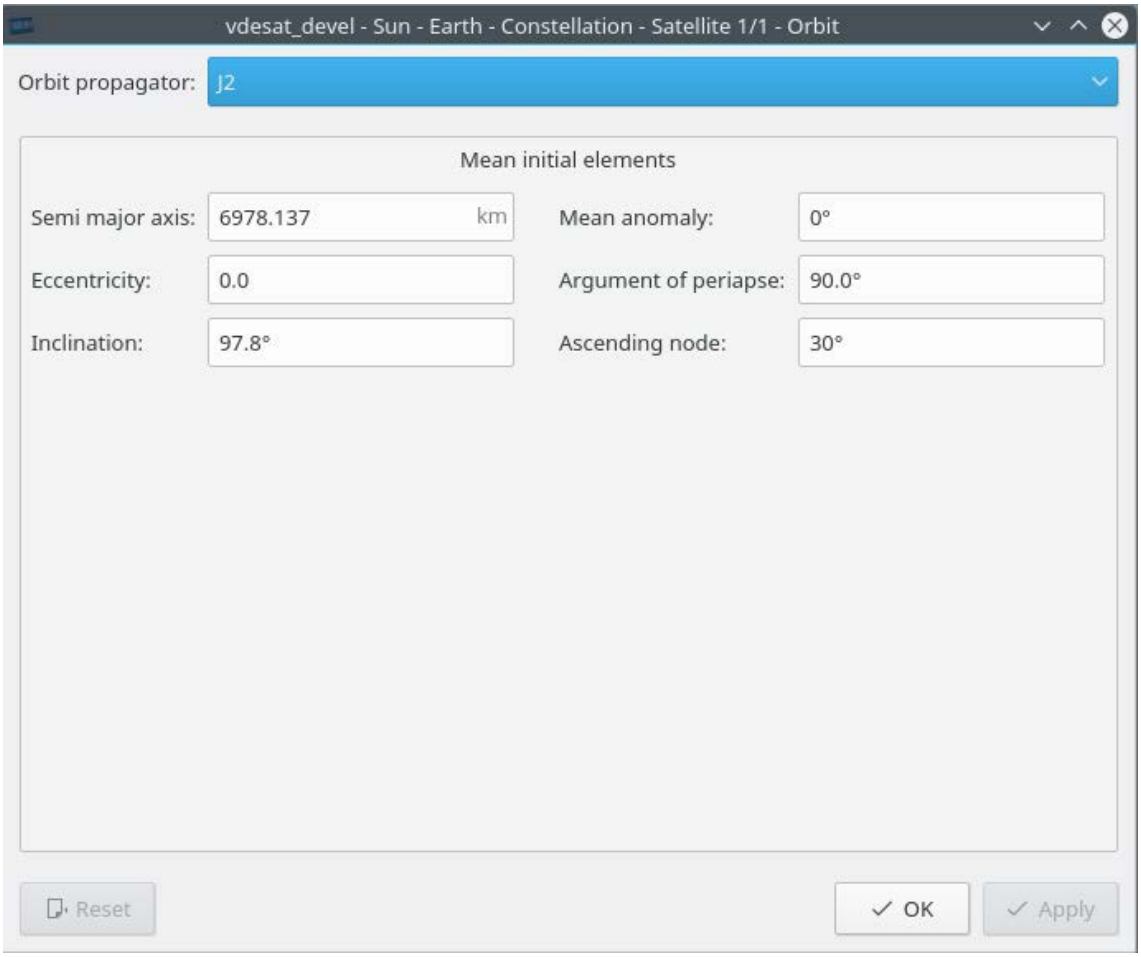

Figure 5.14 Orbit editor with the recommended propagator.

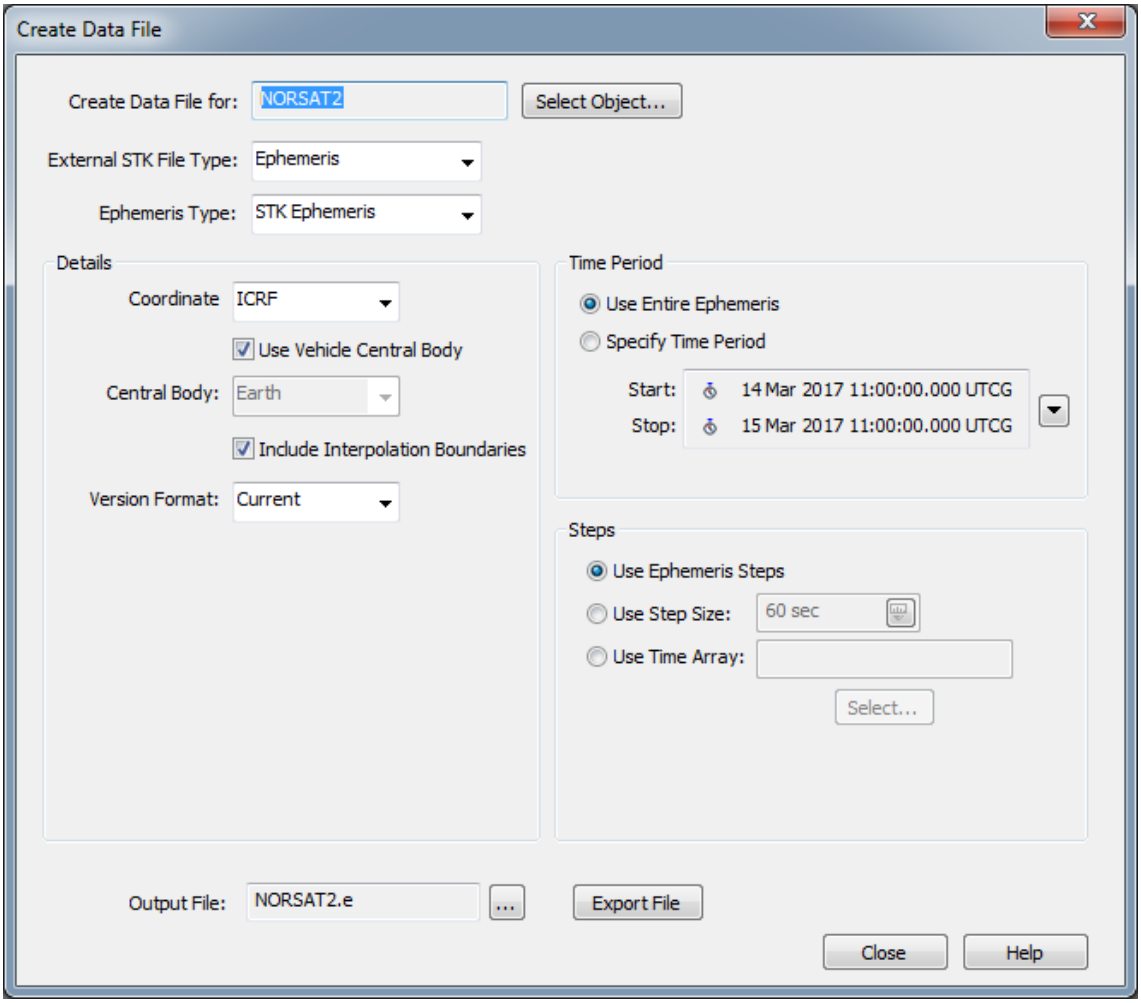

Figure 5.15 Create STK ephemeris file.

6 Ground stations

VSS needs a set of ground stations to compute when data is available at the users. To add a ground station, you can either right-click on Earth and select **Ground station** from the popup menu, or you can first select the Earth and then **Ground station** in the **Objects** menu as in Figure 6.1.

You must double click on the new ground station object to launch a ground station editor, see Figure 6.2. VSS requires at least one antenna at each site.

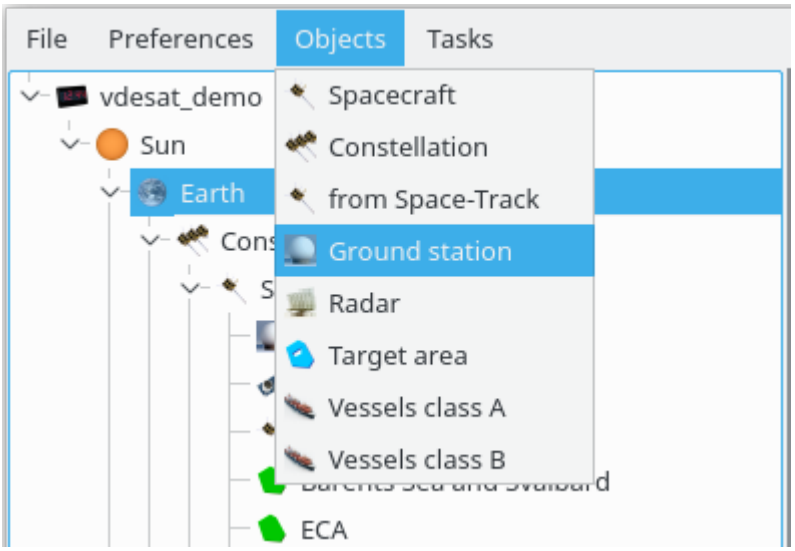

*Figure 6.1 Adding a ground station from the **Objects** menu.*

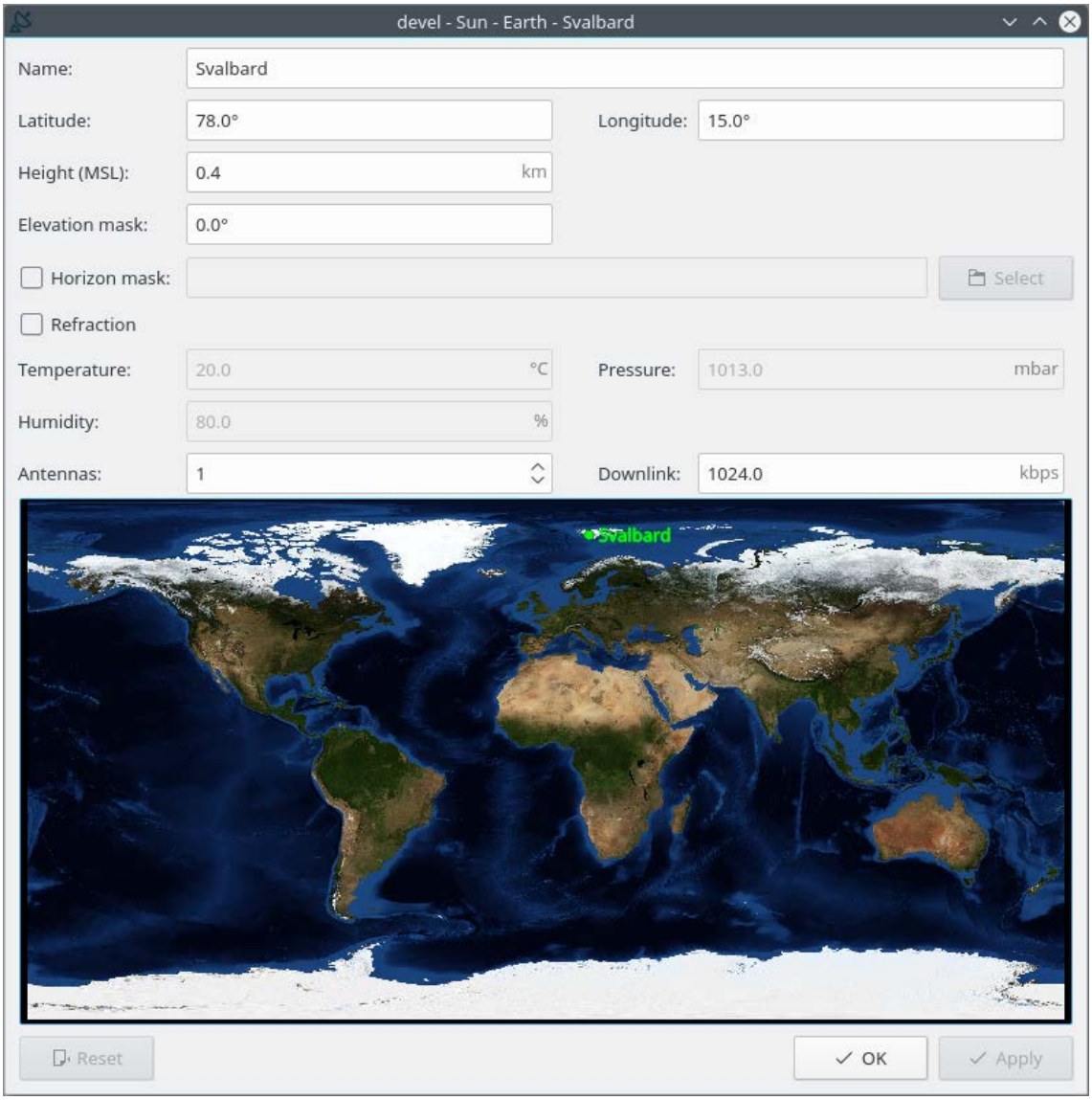

Figure 6.2 Ground station editor

6.1 Access to ground station

The task that computes accesses to ground stations, Figure 6.1 and Figure 6.2, also computes accesses to interference sources. Hence, you might as well add interference sources before you launch this task.

The settings tab, Figure 6.4, has two values. The first value is used to do an initial search for accesses. The final value is the accuracy of the access times. This value is also use to search for accesses shorter than the initial search window. The default values are reasonable in most cases.

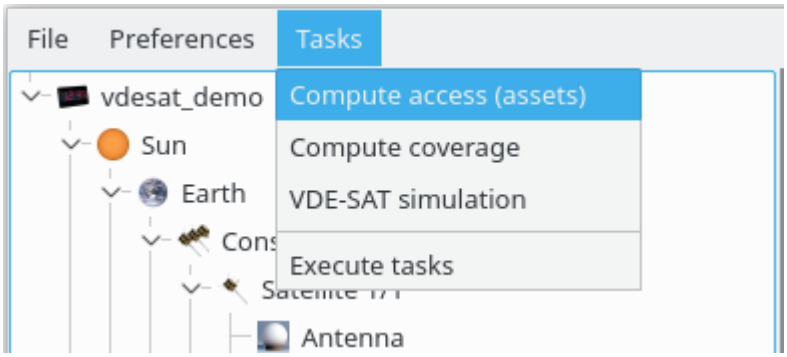

Figure 6.3 Adding a task to compute ground station access times.

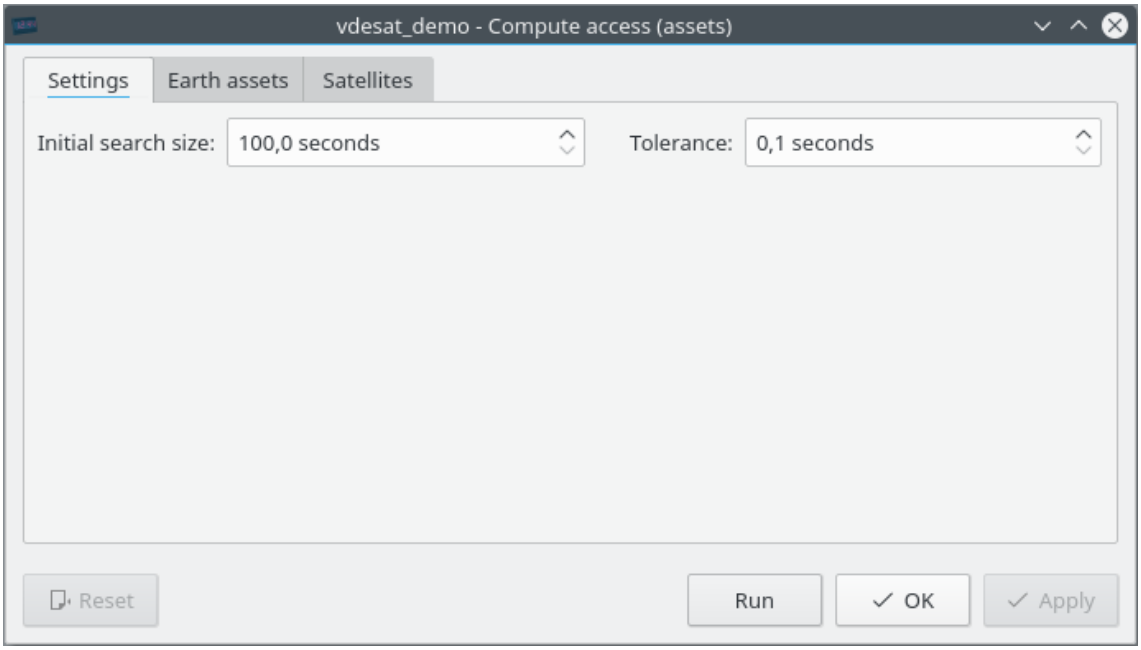

Figure 6.4 The settings that determine the accuracy of the access times.

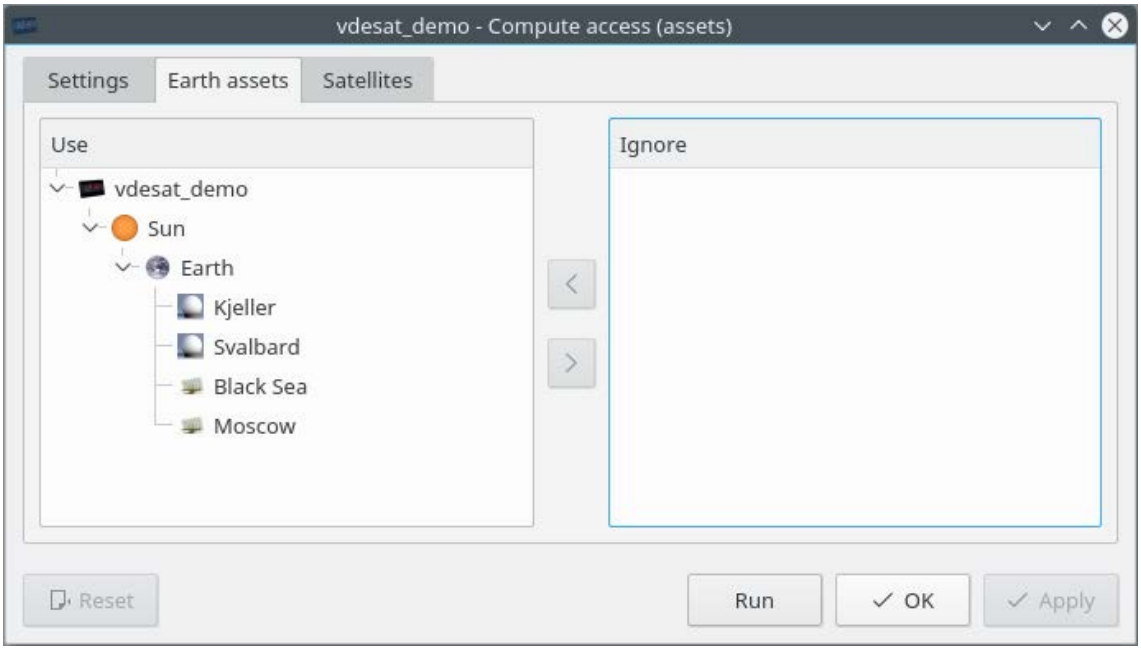

Figure 6.5 VSS will compute access times for the assets you select in this widget.

7 Interference sources

VSS can take into account any number of interference sources. To add an interference source, you can either right-click on Earth and select **Radar** or **Radio** from the popup menu, or you can first select the Earth and then **Radar** or **Radio** from the **Objects** menu.

The main difference between radars and radios is that radios are always on and that the radar antenna pattern is unknown. Hence, user must for radars specify EIRP instead of transmit power. Their corresponding editors are identical with except for these differences.

Users must double click on a radar object to launch its editor, see Figure 6.2. VSS requires that you specify seconds between each time the radar lights up one of your satellites, how long each satellites is in the beam, Effective Isotropic Radiated Power (EIRP) and interference model. VSS supports two interference model, Additive Gaussian White Noise (AGWN) and single tone. The last model requires a transmission frequency too.

The transmit power/EIRP is given in dBm per 50 KHz for the AGWN model and in dBm for the single tone model.

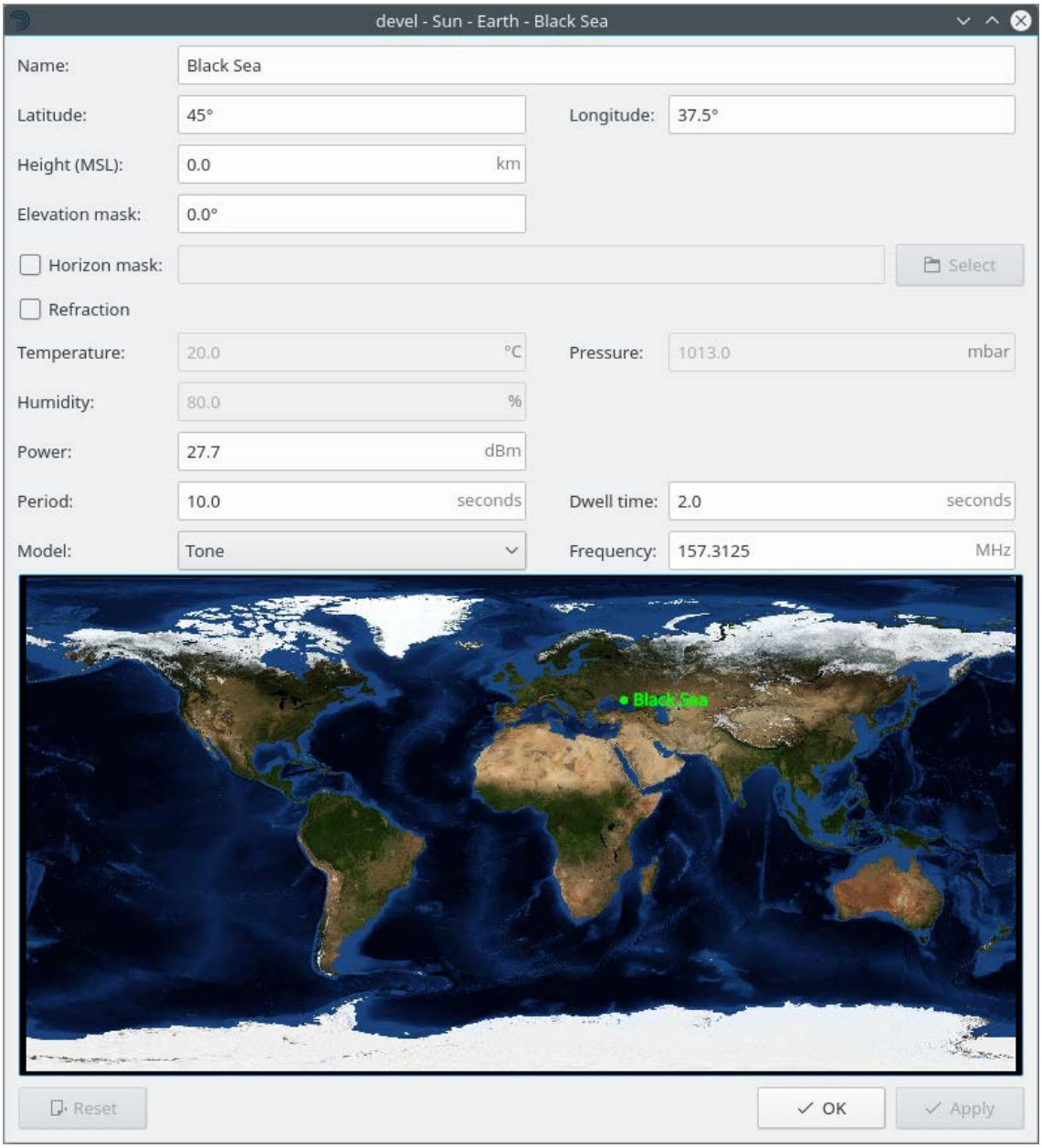

Figure 7.1 Radar editor

7.1 Access to interference sources

See section 6.1.

8 Vessel lists

VSS has two classes of vessel lists: A and B. Class A is necessary. The vessels in this list transmit on the regular VDES channels. Class B is only used together with the M2M use case[3].

To add a vessel list, you can either right-click on Earth and select **Vessel list class A** or **Vessel list class B** from the popup menu, or you can first select the Earth and then select **Vessel list class A** or **Vessel list class B** in the **Objects** menu as

You must double click on the vessel list object to launch a vessel list editor, see Figure 8.2. The editor is empty at first launch. To load a vessel list from a text file, you need to click **Add** which will add a file selector to the editor, see Figure 8.3. You can now launch a file browser by clicking on the **Select** button.

VSS allows the user to merge vessel lists. Figure 8.4 shows an example of single vessel list that VSS will use in the simulations.

Figure 8.5 demonstrates two merged vessel list files. The second file has a few vessels only in the upper right corner. The vessel list file format starts with a polygon, which VSS uses to remove vessels from the preceding lists, and we are left with an almost empty upper right corner in that figure.

The **Remove** button removes unchecked vessel list files.

You can override the default transmission strength and variance. By default, VSS assumes a normal distribution when setting transmission strengths, but you can optionally specify a custom distribution. This model requires that you load a text file with a large number of samples from the desired distribution. VSS will scale the samples to the given variance and mean transmission power.

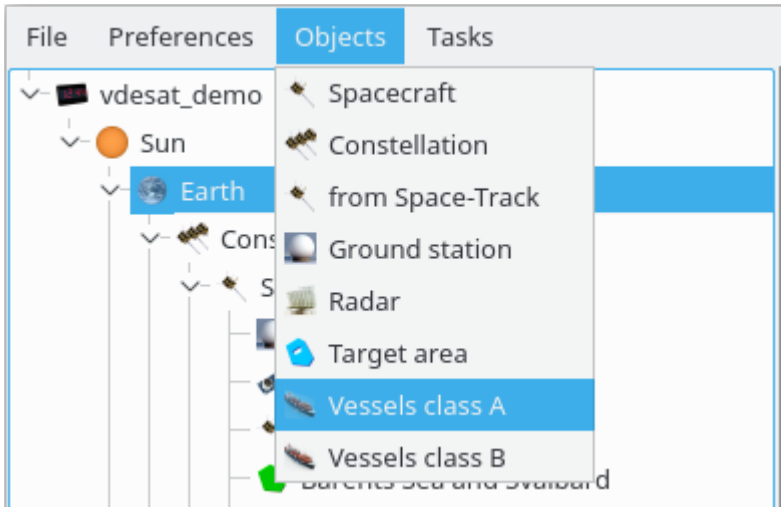

Figure 8.1 Adding a vessel list object from the **Objects** *menu.*

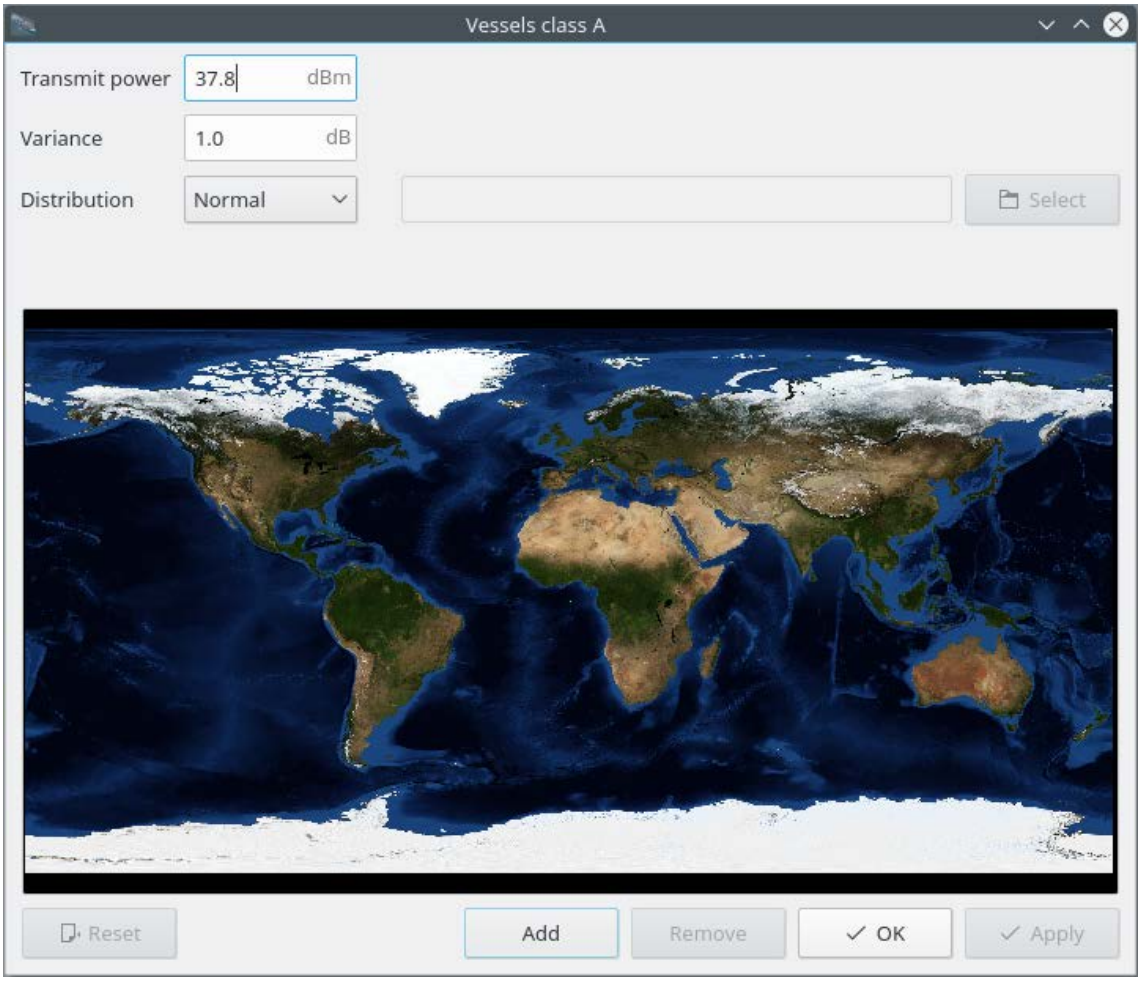

Figure 8.2 Initial vessel list editor

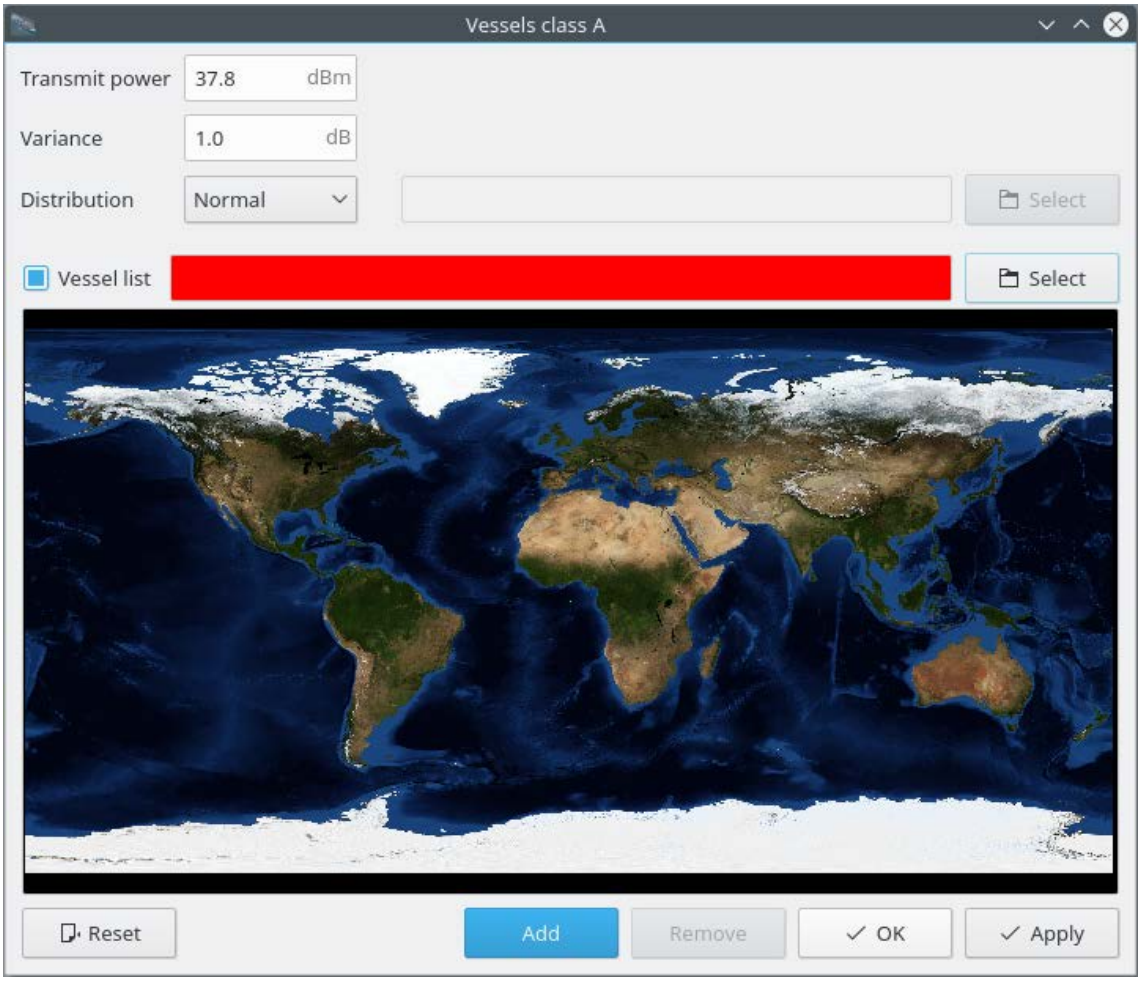

Figure 8.3 Vessel list editor with an empty file selection widget

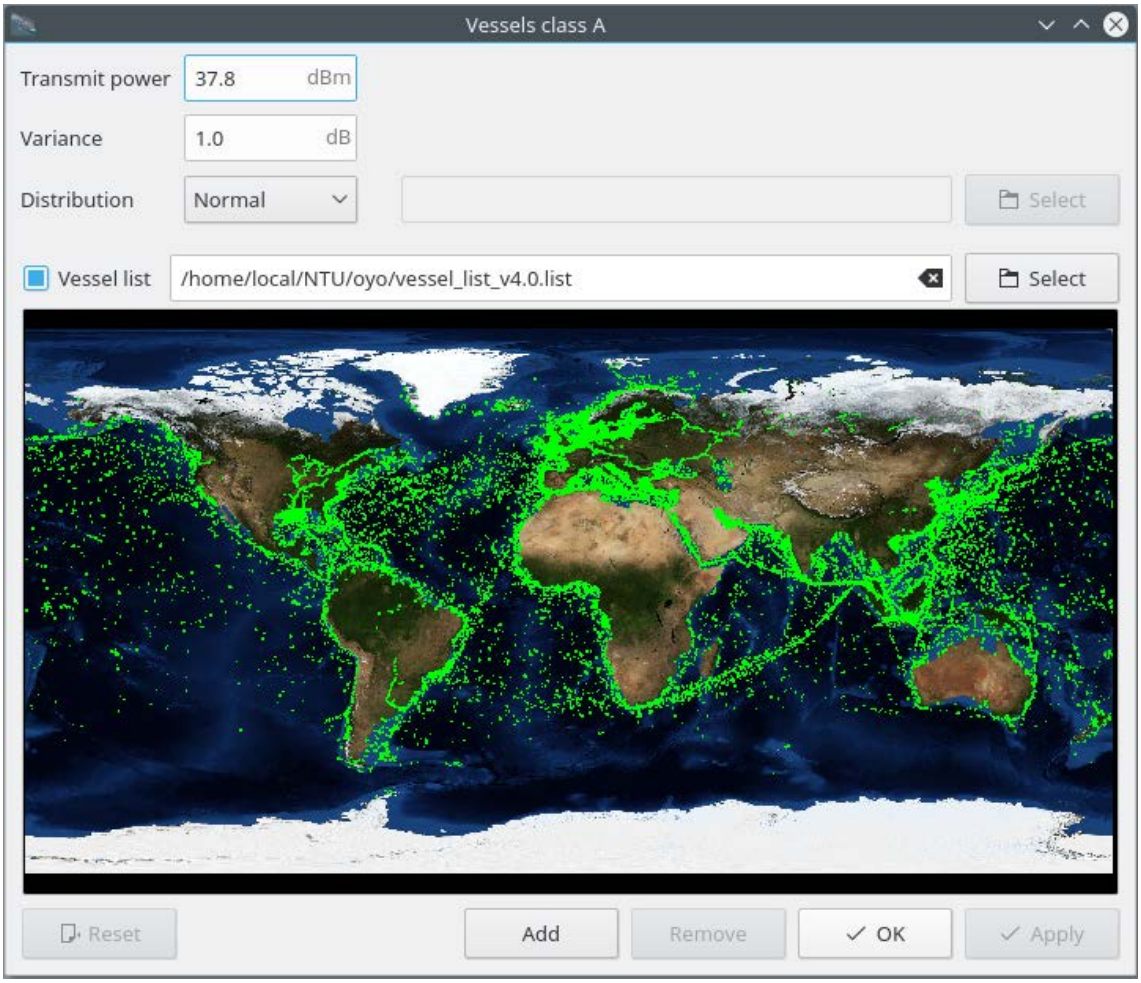

Figure 8.4 Vessel from all files

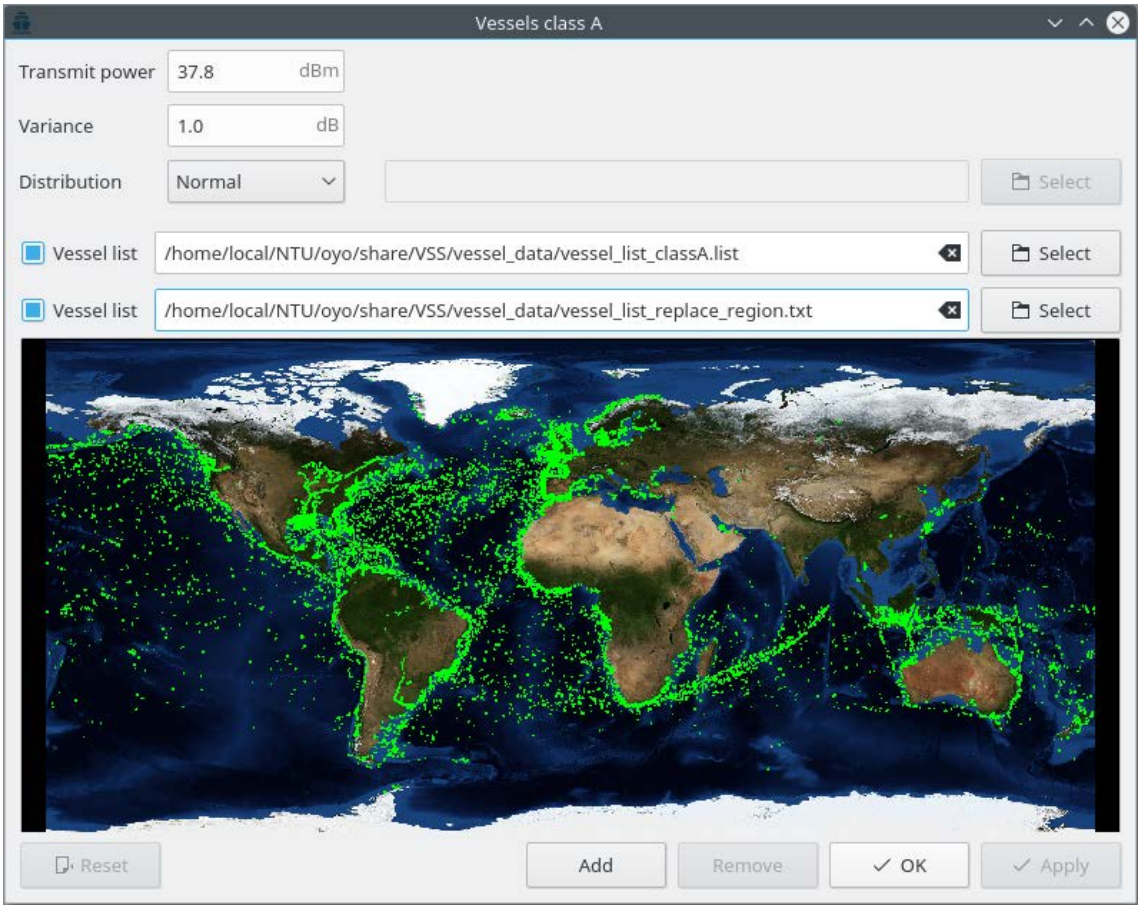

Figure 8.5 Two merged vessel list files. The second vessel list file is just to demonstrate this feature. It has a few vessels only in the upper right corner.

8.1 Vessel list access times

Computing accesses for every vessel in the vessel list is similar to how you compute accesses to ground stations. This task takes a long time, i.e. about 15 minutes per day of simulation time.

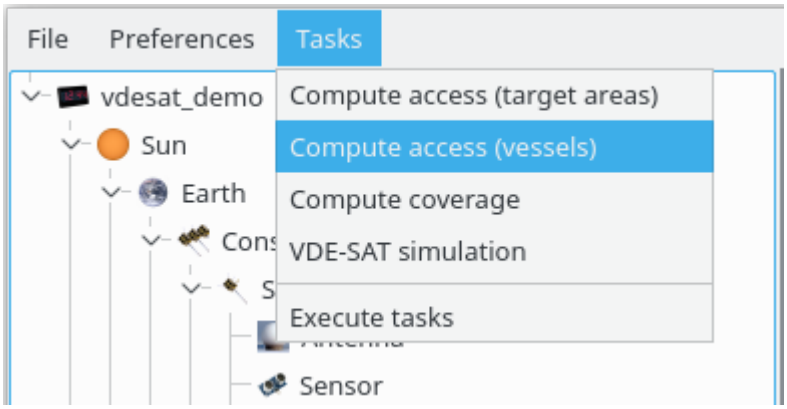

Figure 8.6 Adding a task to compute access times for each vessel.

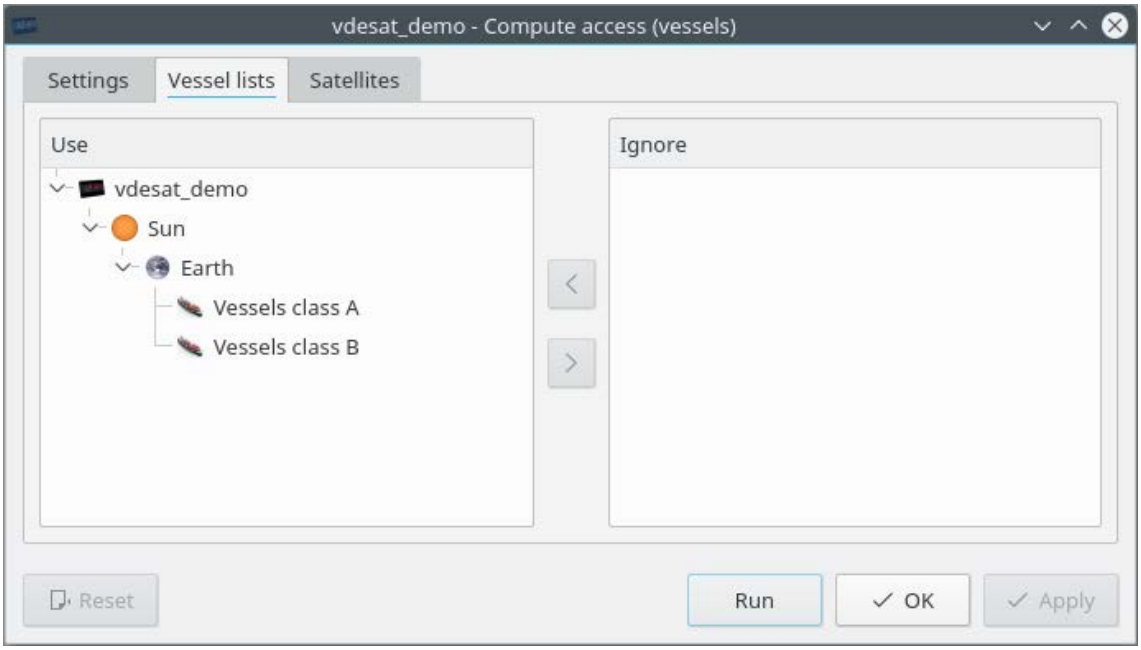

Figure 8.7 VSS will compute access times for the vessel lists you select in this widget.

9 Target areas

VSS uses target area to generate some figures of merit, section 10.5, and in the search and rescue use case, section 10.3.

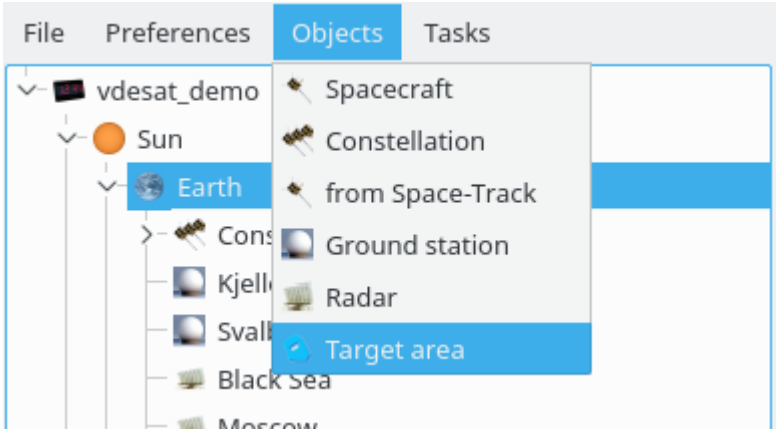

Figure 9.1 Adding a target area from the **Objects** *menu.*

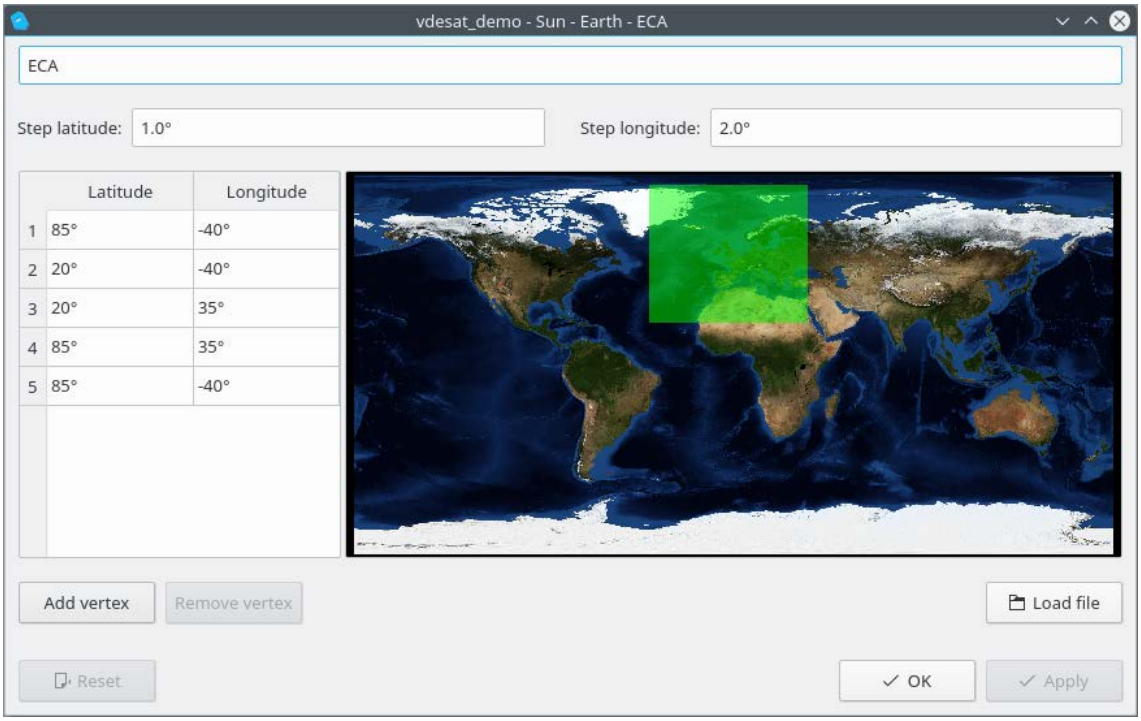

Figure 9.2 Target area editor

9.1 Target area access times

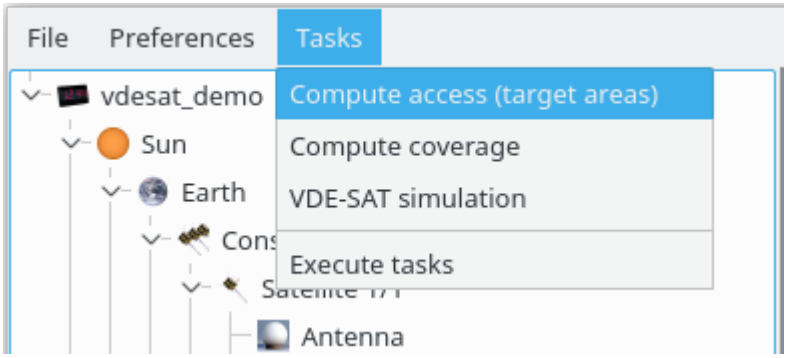

Figure 9.3 Adding a task to compute target areas access times.

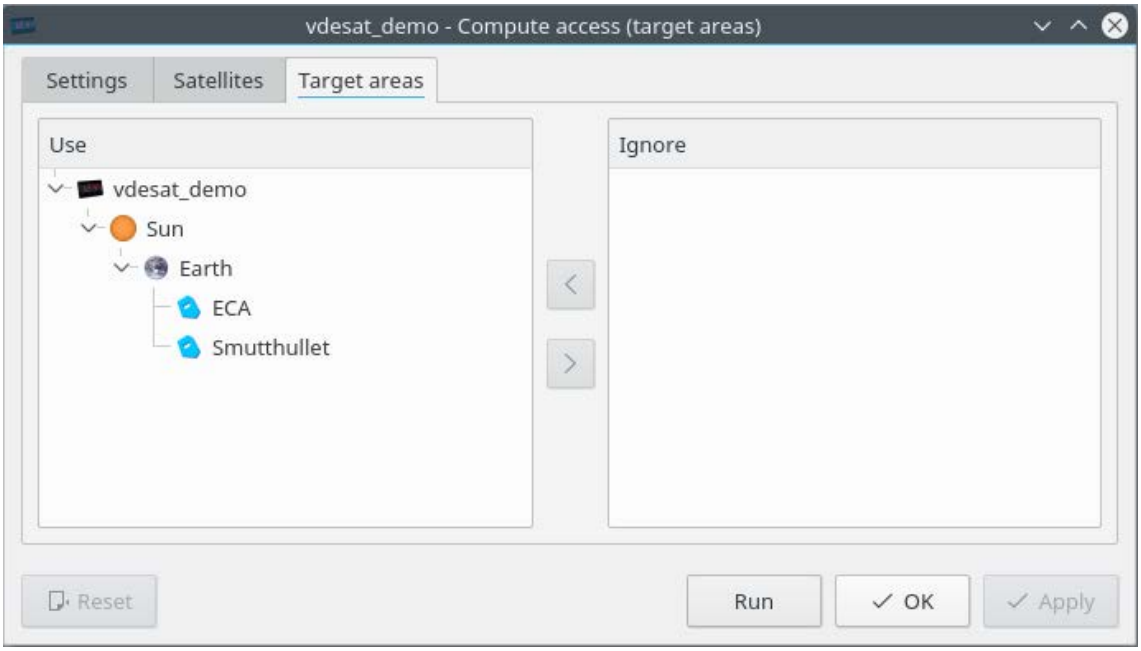

Figure 9.4 VSS will compute access times for the target areas you select in this widget.

10 VDES simulation

The final task is the VDES uplink simulation task, Figure 10.1. Its editor has several tabs, but most of them are identical to tabs shown in other task. This chapter therefore only shows the new tabs and the scenario viewer.

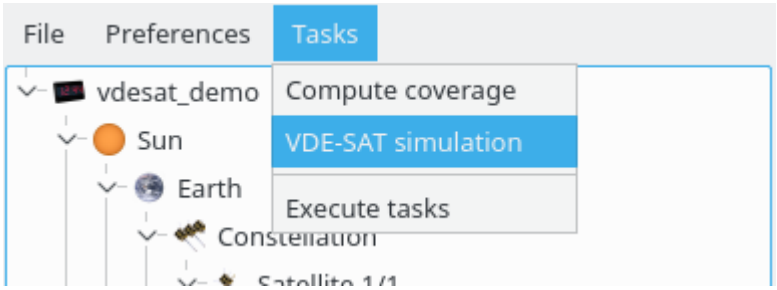

Figure 10.1 Adding the VDES uplink simulation task.

10.1 Settings

The first tab in the editor contains a few settings that did not really fit on any of the other tabs. Here you can enable output to PLS, set ionospheric model, mean wave height, height of vessel antenna above sea level, vessel antenna pattern, terrestrial VDES range and how satellites respond to random access and ASM transmissions.

Users can either select a single antenna pattern for all vessels or a set of patterns provided by ESA from the vessel antenna pattern drop-down box. ESA has provided three different patterns that VSS assigns to randomly to each vessel.

By default, satellites acknowledge random access and ASM messages. Vessels will retransmit such messages until they either receive an ACK or the number of retries exceeds the retry values specified in this tab. Setting either of these values to zero implies that the satellites do not ACK corresponding transmissions.

Checking the AIS loading check-box stops vessels from transmitting when they expect to receive an AIS message. Each vessel is given a probability of receiving an AIS message when they want to transmit a VDE packet. That probability depends on the location of the vessel, and it is derived from AISDET[1] simulations.

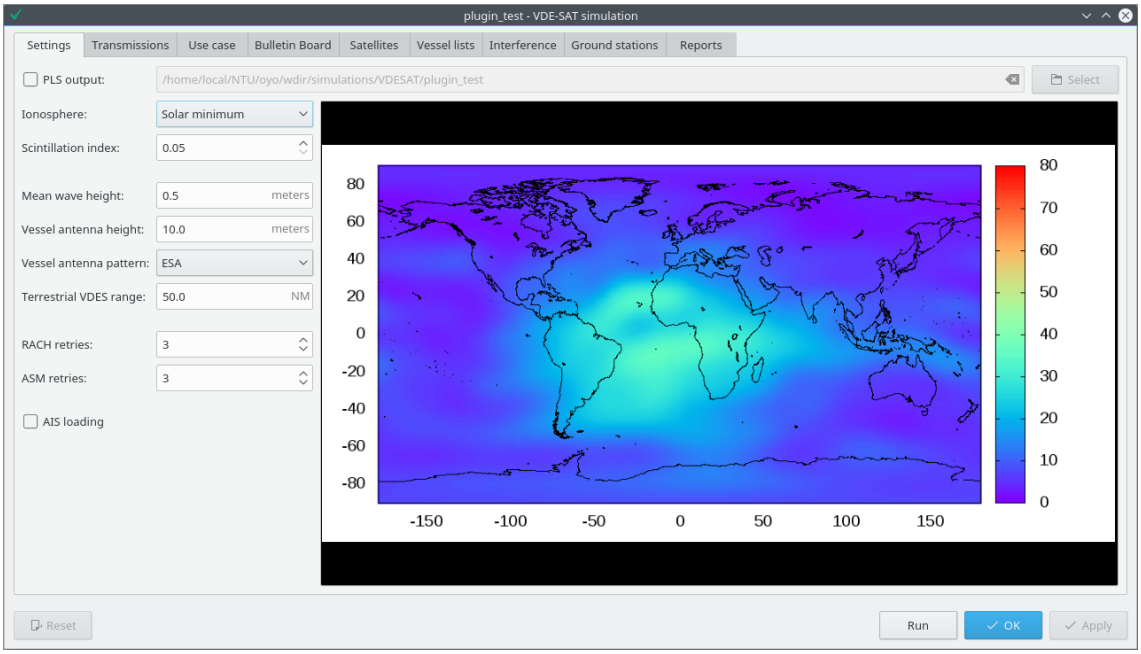

Figure 10.2 General settings

10.2 Transmissions

VSS has by default five different types of data transmissions, see Figure 10.3. Users can set the size of each data type, the fraction of vessels generating each data type and how often they generate data of a specific type. VSS selects random vessels for each data set. Hence, vessels may generate more than one type of data.

The first four transmission types are multi-packet transmissions[4] and require that each vessel requests and receives an uplink resource before it starts transmitting. The uplink resource request is transmitted on the random access logical channels. The final transmission type is a short message transmitted on the random access channels. The transmission length will say 1 slot even if you use link configuration 20 for the random access channels. Internally, VSS then uses 5 instead of 1 slot message lengths.

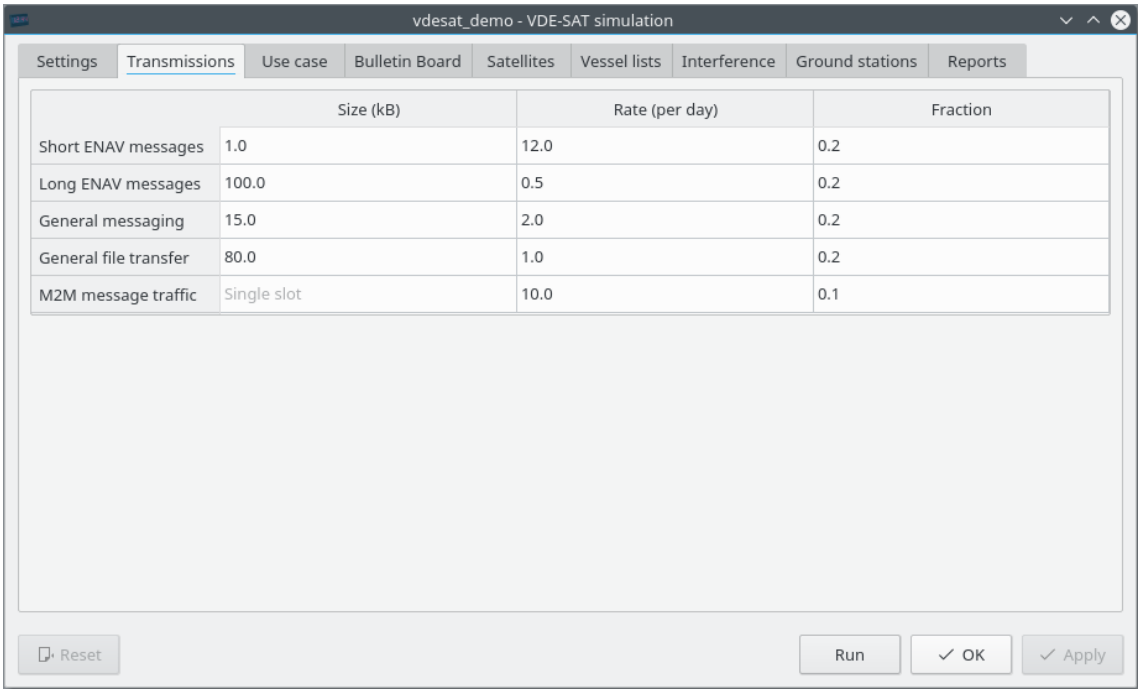

Figure 10.3 Default background data traffic

10.3 Use case

VSS includes three use cases. The search and rescue use case, Figure 10.4, modifies the data transmitted by the participating vessels. The other use cases add additional uplink data to the default transmissions.

In the search and rescue use case, VSS assumes that one randomly selected vessel within a target area has an event that triggers search and rescue operations. VSS then tells a number of nearby vessels to start transmitting status reports from their search and rescue operations. VSS reports the throughput and timeliness of these status reports in addition to the regular figures of merit. VSS will not run if the user selects more than one target area

The ship report use case adds an additional type of regular transmissions, and VSS generates figures of merit for this data together with the regular transmissions.

The Machine to Machine (M2M) communication use case adds uplink transmissions on the ASM channels. This is the only use case that generates traffic on the ASM channels, and this is the only use case that uses class B vessels. VSS has two classes of ASM messages: Satellite and terrestrial. Satellite messages are only transmitted when a satellite is within a vessel's field of view. Vessels transmit only the newest satellite ASM message if it has generated more than one message between satellite passes. The terrestrial ASM messages are intended for other vessels

or shore, and are transmitted whether a satellite can receive them or not. VSS does not compute statistics for terrestrial ASM messages, but these messages can interfere with the reception of satellite ASM messages.

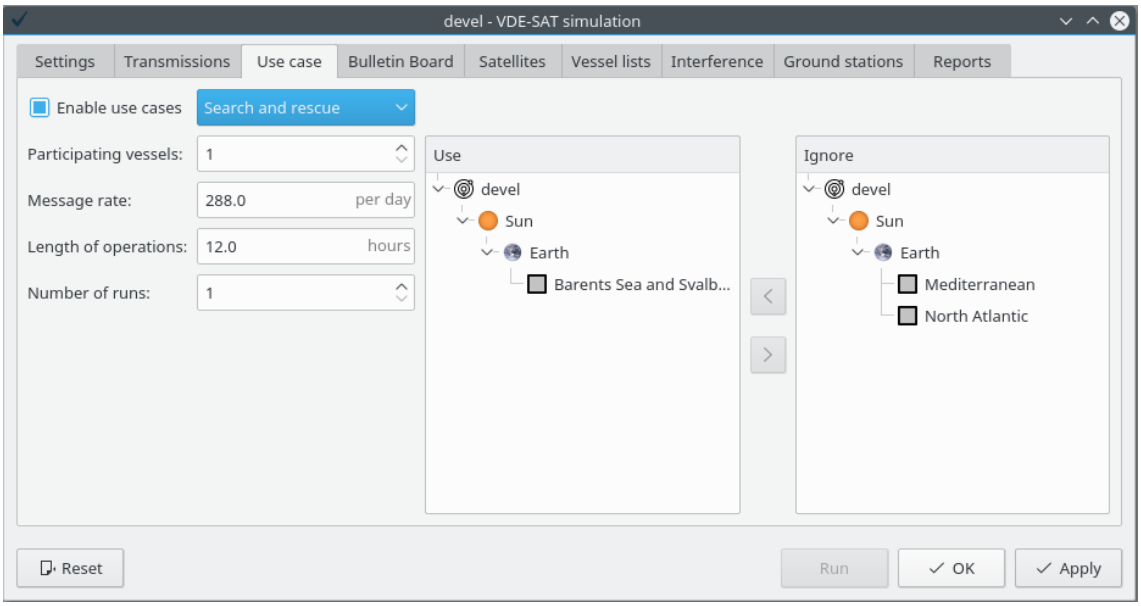

Figure 10.4: Search and rescue use case.

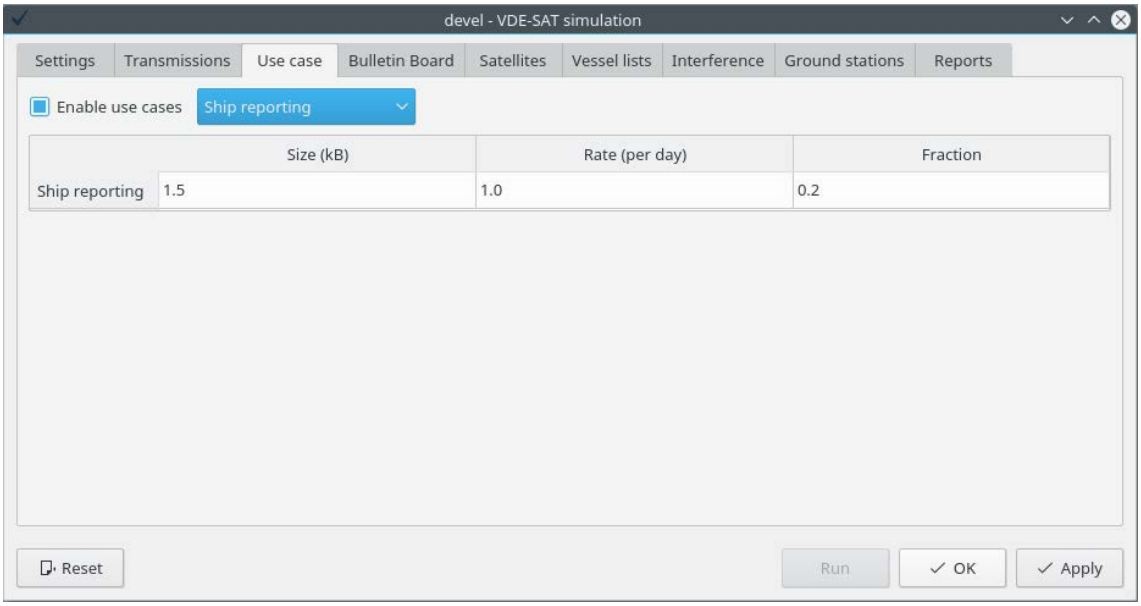

Figure 10.5 Ship reporting use case.

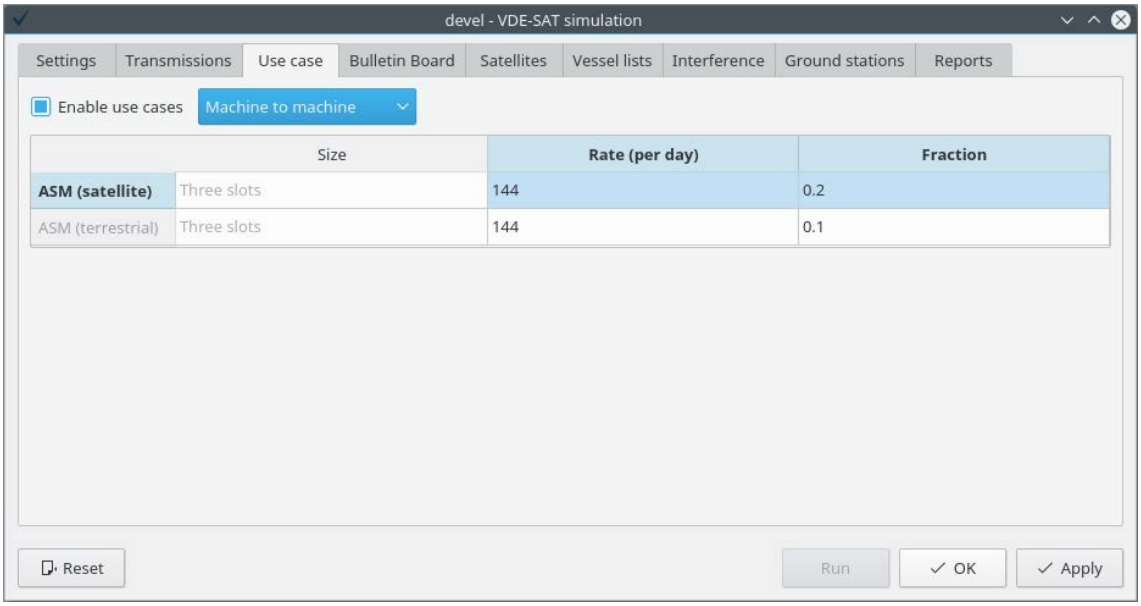

Figure 10.6 Machine to machine communication use case.

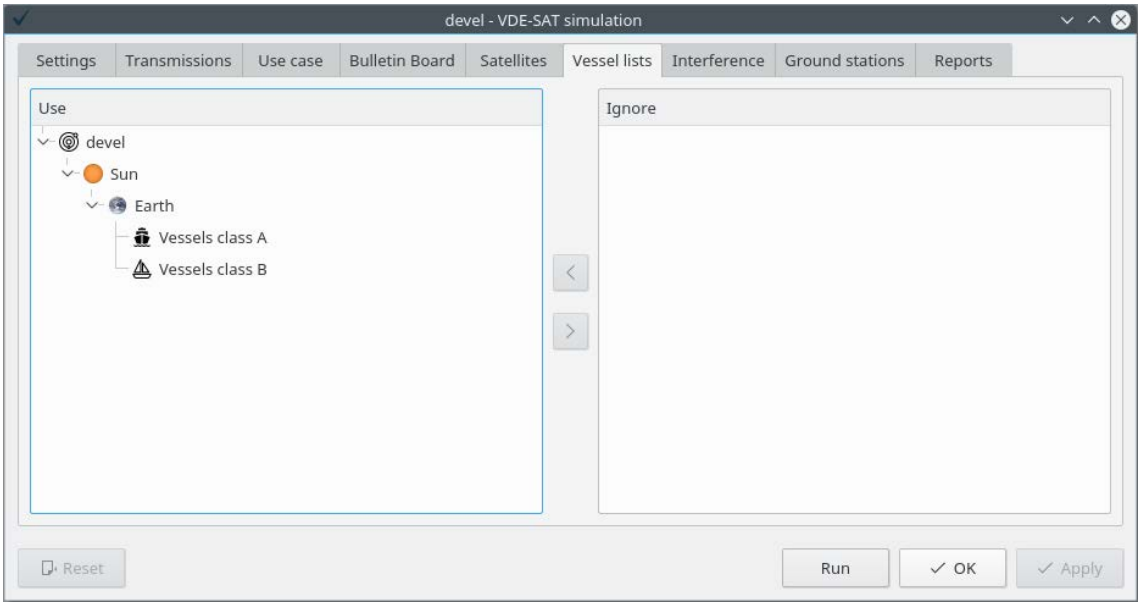

Figure 10.7 The M2M use case requires the class B vessel list.

10.4 Bulletin Board

This tab allows users to either select between three different bulletin boards, or they can set up their own bulletin board. These options are all available from the **Bulletin Board** drop-down box. The last entry in the drop-down menu enables editing of the bulletin board through the greyed out widgets in Figure 10.8.

In addition to the default bulletin board, there is a bulletin board optimized for latency and one for upload capacity. The bulletin board maximized for upload capacity is equivalent to a full duplex satellite. (VSS does not simulate downlink and this implies that the downlink happens on a different channel.)

Bulletin boards are static during the entire simulation. To see the effect of changes to a bulletin board, users must therefore run a new simulation with the updated bulletin board.

This tab includes a few other options that are not directly related to bulletin boards. The default link configuration id is used by vessels when uploading data in any of uplink logical channels. It is constant during a simulation unless adaptive coding is enabled. With adaptive coding, vessels might be told by the satellites to change their link configuration id to either overcome high interference or to increase the data rate at time with low signal to noise.

VSS supports transmission in the random access channel on link configuration id 20 and 21 (default). This value is not affected by the adaptive coding checkbox, and the value is constant during each simulation. The dispersion checkbox tells vessels to select a random access slot from the given number consecutive repeat cycles. The effect is to further randomize the transmission times on random access logical channels.

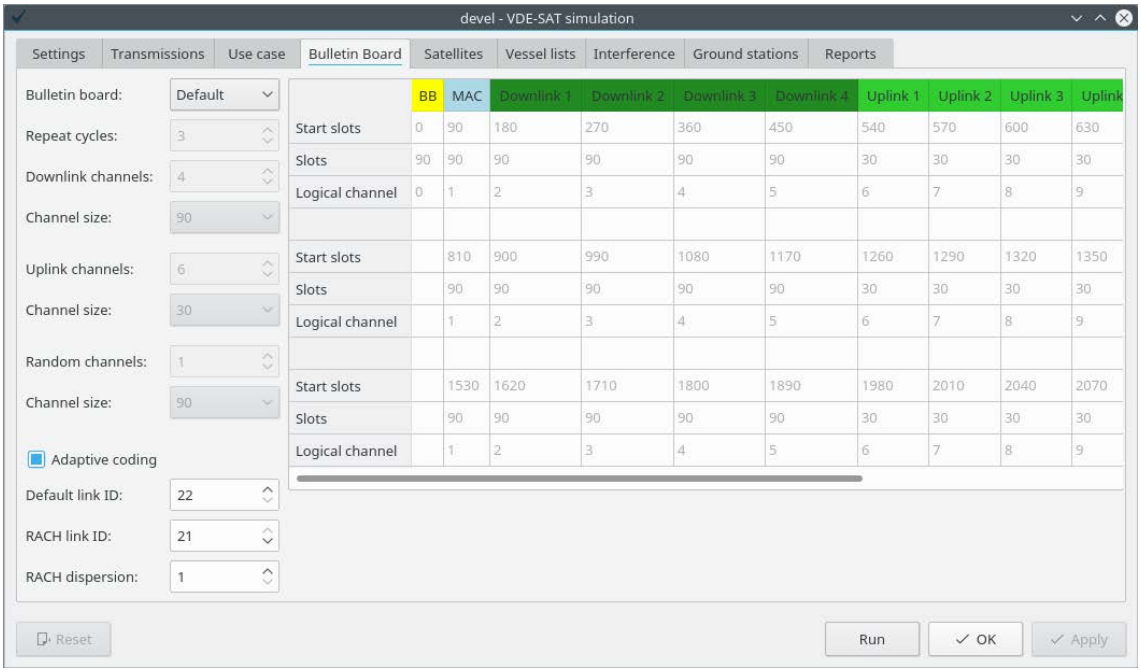

Figure 10.8 Default bulletin board.

10.5 Reports and figures of merit

The last tab is used to generate figures of merit and to create reports, see Figure 10.9. There are two main types of figures of merit: Latency and throughput. The buttons in the upper left corner launches a program that generates these reports. The **Latency** button also generates refresh rate figures of merit. They are generated at the same time as the latency figures of merit.

There will be three latency figures of merit for each target area in the object browser. The first figure gives cumulative distributions of the time from data generation until the first successful transmission, see Figure 10.10. These filenames are always on the format: *first_transmission_report_targetarea.png.*

The second figure gives cumulative distributions of the time from data generation until the entire message has been uploaded, see Figure 10.11. These filenames are always on the format: *final_transmission_report_targetarea.png*. Notice that some of the longer messages are not completely uploaded to the satellite. This simulation ran for only one day, and it included large files that were generated once per day at a random time. Hence, there were files generated just before the end of the simulation which therefore were not uploaded. Simulations should run for a significantly longer time than the longest data generation interval, see section 10.2, to minimize such effects.

These two figures display the contents of a corresponding text file: *report_upload_targetarea.txt*. The header in this file gives the number of vessels in the target

area and number of started and completed transmissions for each messages type. Users can estimate the number of discarded random access transmissions and the number of not started multi-packet transmissions from the data generation rates and the simulation length. A large number of not started multi-packet transmissions indicate that the simulated VDES system is unable to cope with amount of generated data.

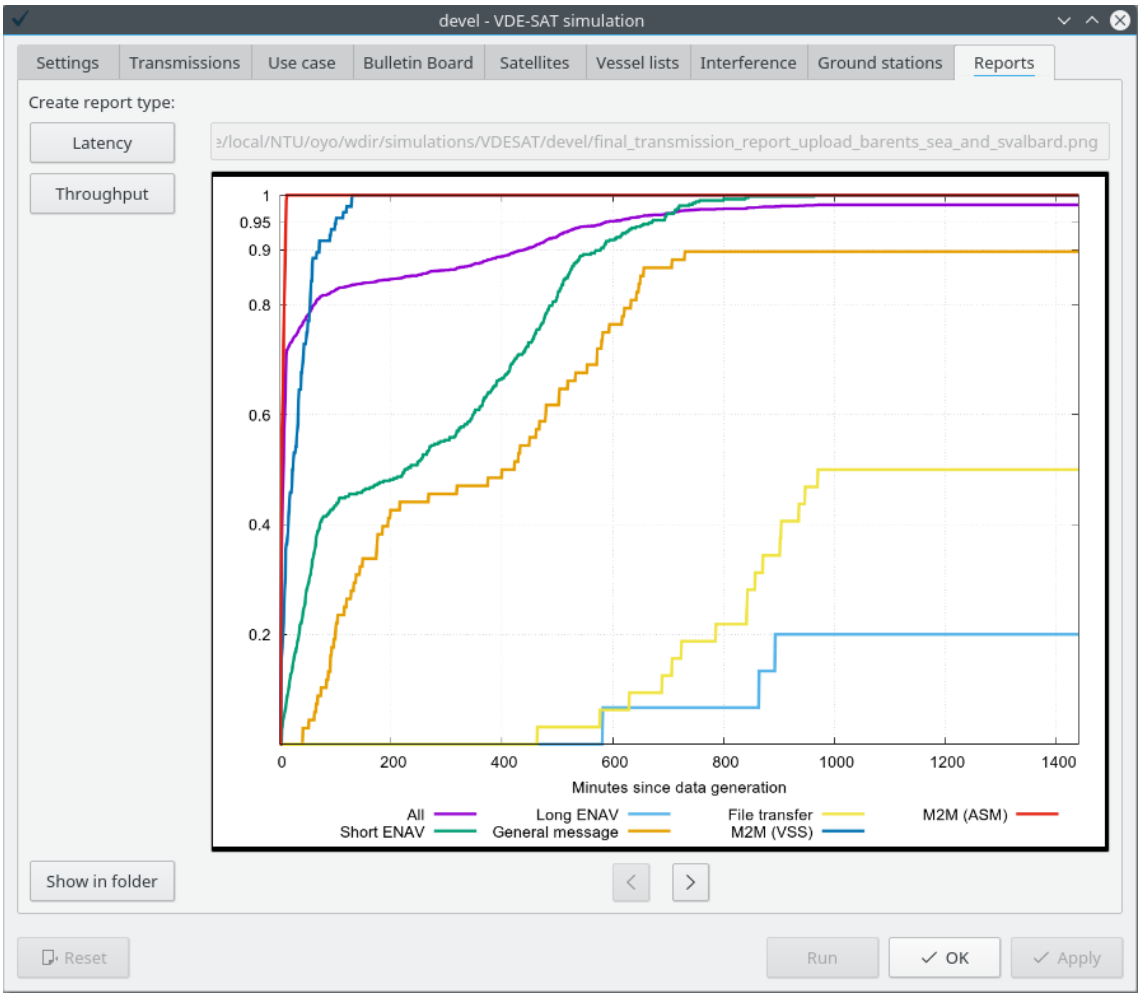

Figure 10.9 Generate figures of merit and reports.

The third figure gives cumulative distributions of the time from first transmission until the entre message has been downloaded to ground, see Figure 10.12. These filenames are always on the format: *ongroud_report_targetarea.png.*

Figure 10.13 gives distributions of refresh rate intervals, i.e. the time between the receptions of consecutive messages from a vessel. These filenames are on the format: *refresh_interval_report_refresh_rate.png*.

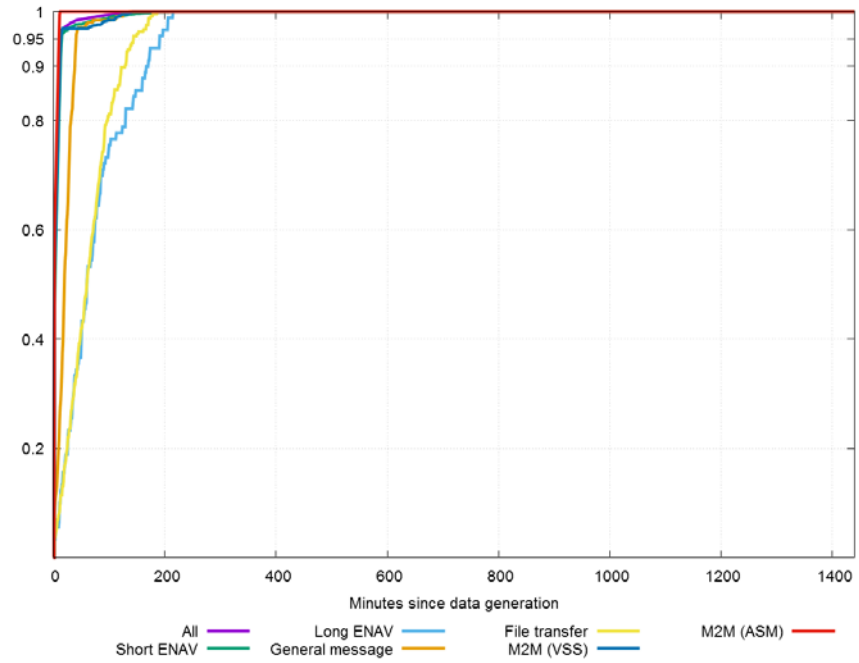

Figure 10.10 Time from data generation until first transmission.

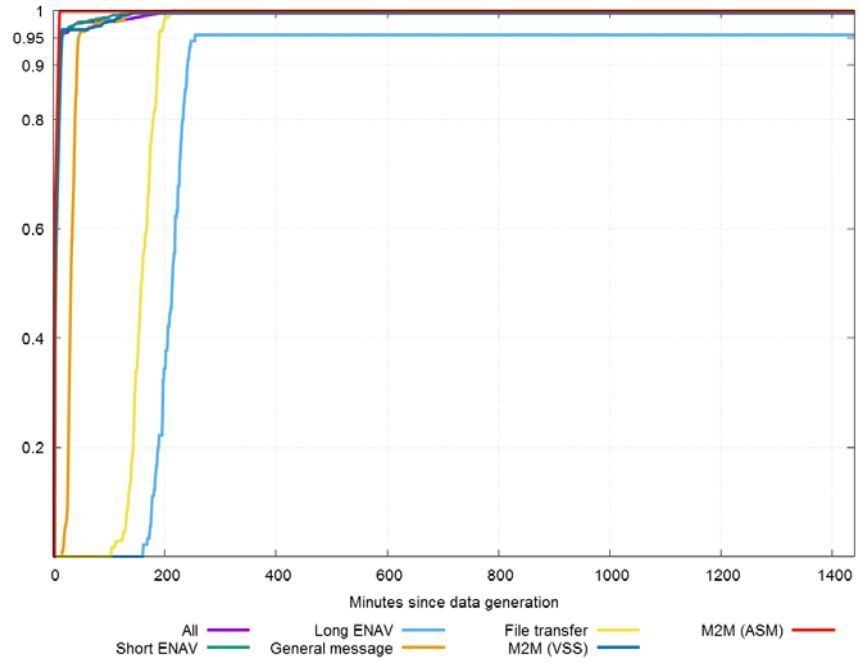

Figure 10.11 Time from data generation until entire message has been uploaded.

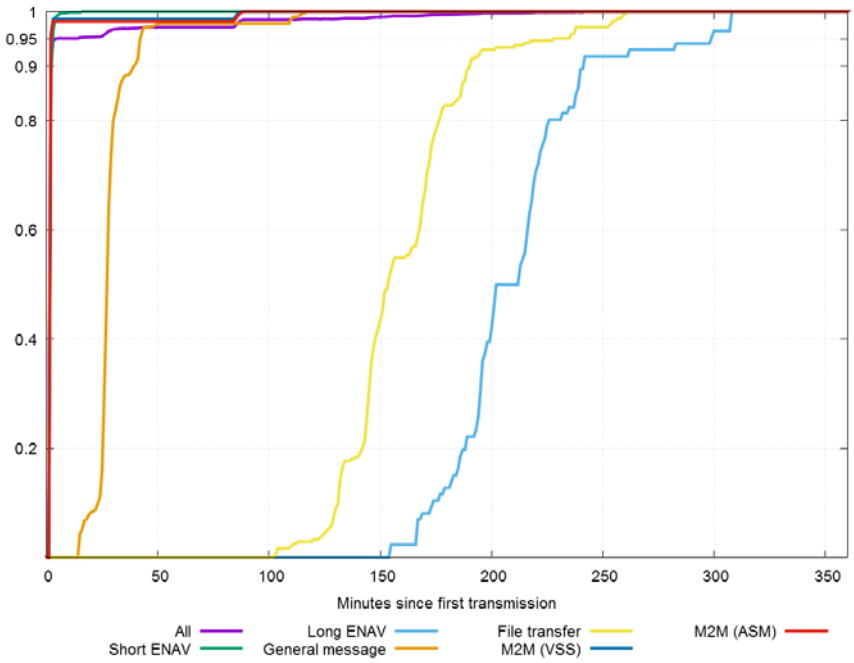

Figure 10.12 Time from first transmission until data is downloaded.

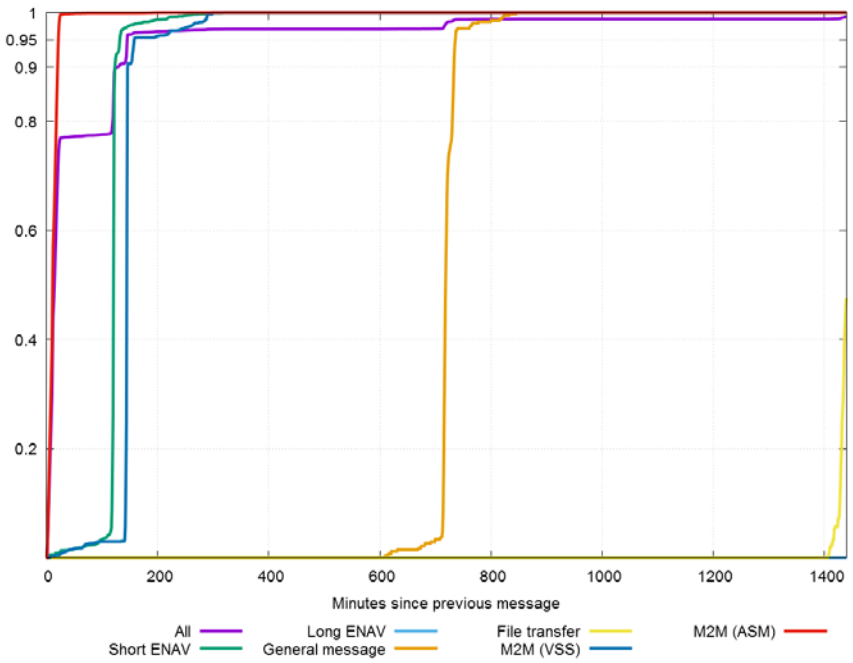

Figure 10.13 Refresh rate, i.e. the time between receptions of two consecutive messages from a vessel.

The second main type of figures of merit gives throughput, which either may be data rates or success rates. These figures are global and are given as a function of satellite ground track.

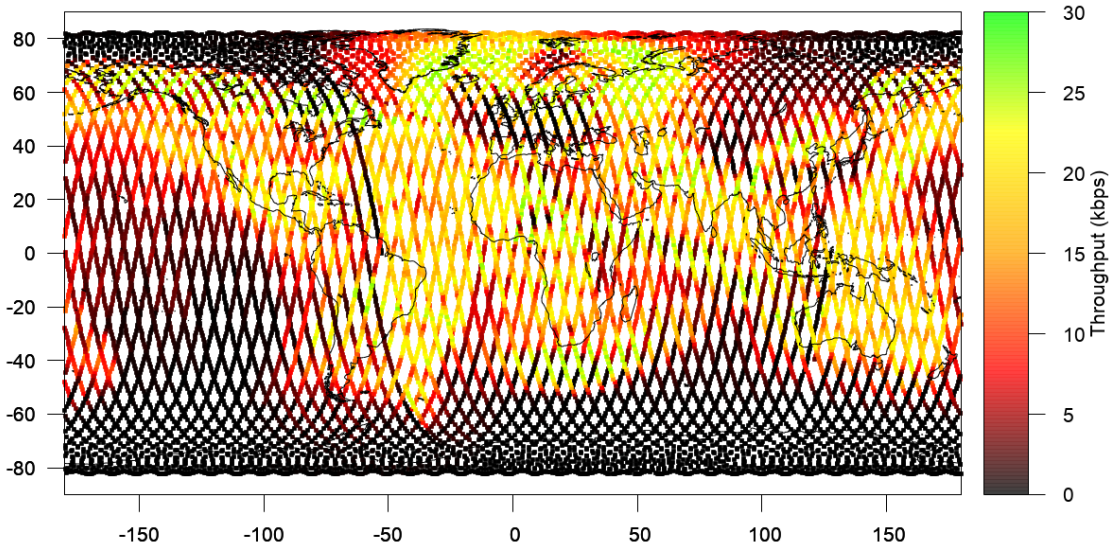

Figure 10.14 Uplink data rate as function of satellite ground track.

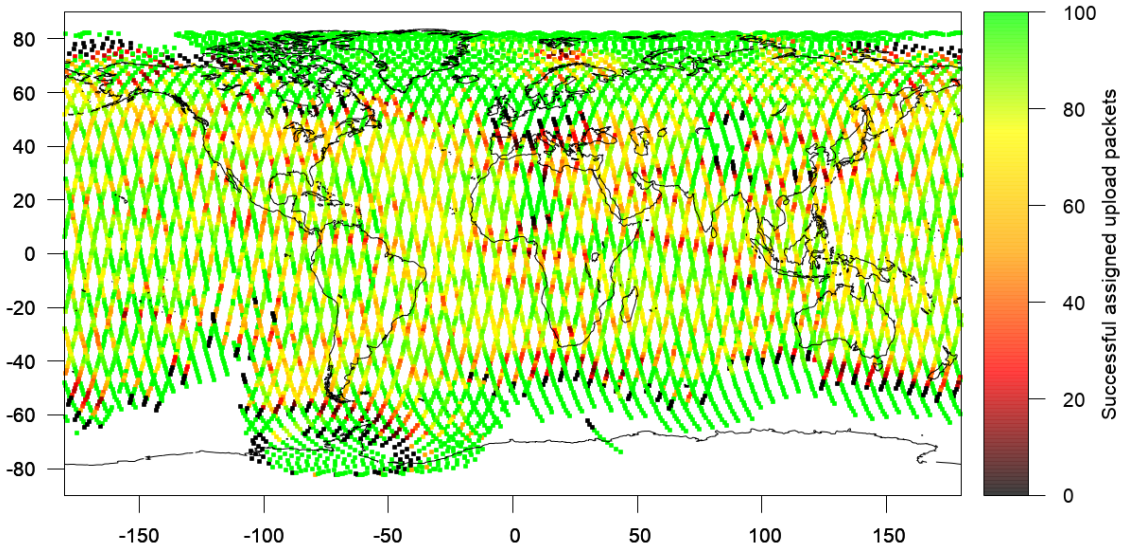

Figure 10.15 Fraction of received packets in assigned slots to transmitted packets in assigned slots as a function of sub-satellite point.

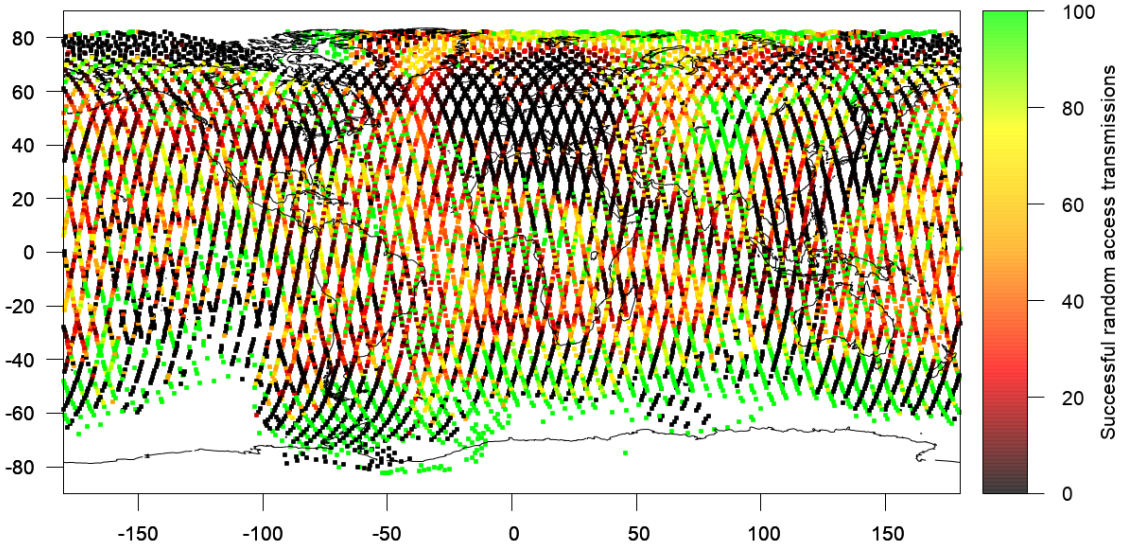

Figure 10.16 Fraction of received packets in random access slots as a function of sub-satellite point. This includes short messages and requests for upload resources.

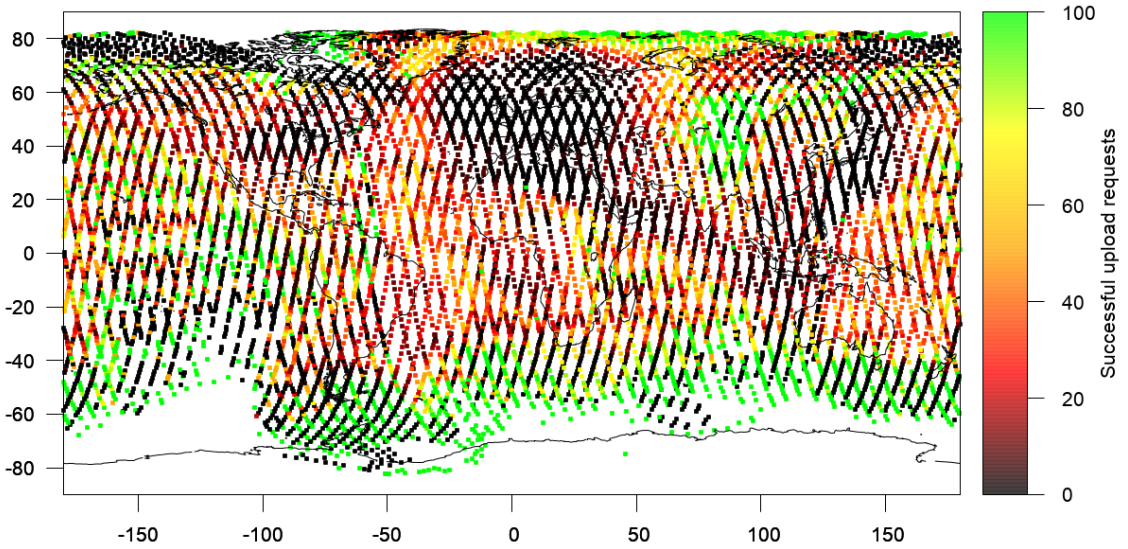

Figure 10.17 Fraction of received upload requests as a function of sub-satellite point.

10.6 Scenario viewer

The scenario viewer can be launched from the main window's **View** menu. This viewer is shown in Figure 10.18.

The **Show** menu is empty until the simulation is done loading data and started processing data. It then holds an entry that launches the map shown in Figure 10.18. This map shows the position

of each satellite at the current simulation time. Each satellite is given a color that depends on the received data rate. Red implies 0 kbps, while the window title gives the data rate corresponding to green.

The status bar holds a pop-up menu with a progress bar and a button to cancel the simulation.

This viewer and task bar is available for other task too, but those maps are empty. Furthermore, only the task that computes access to vessel lists and the task that generates reports are slow enough to generate a progress bar.

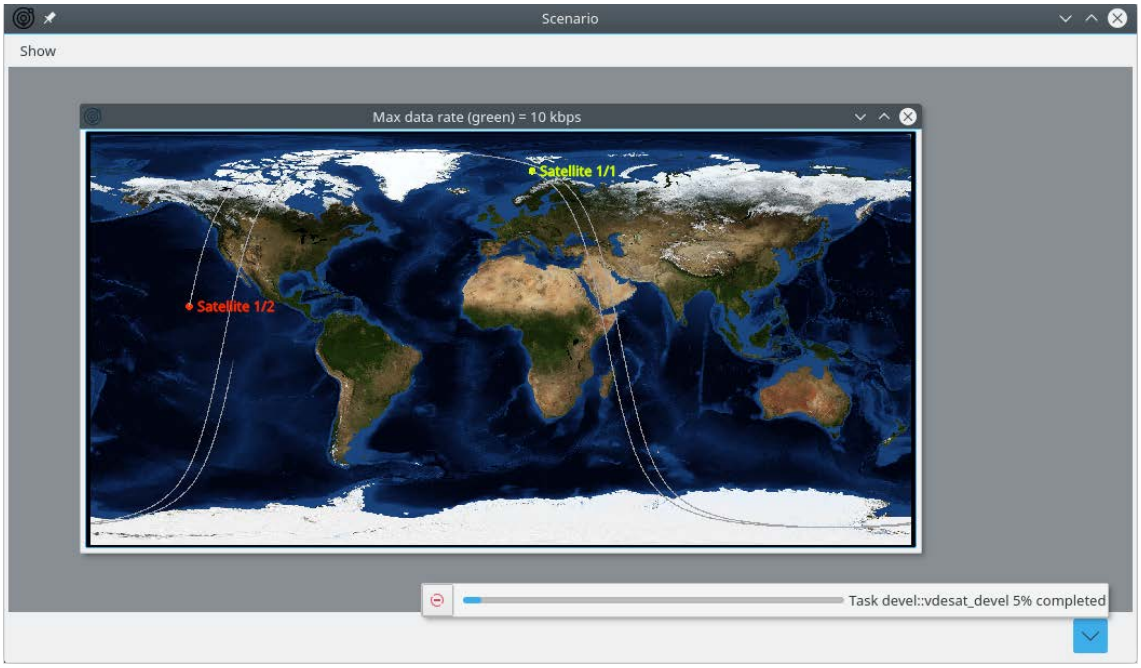

Figure 10.18 Scenario viewer and a progress bar during a VDES simulation.

11 Summary

This document is the VSS user manual. VSS is a software tool developed at FFI to simulate the uplink performance of a VDE-SAT system. It is based on AISDET[1], a tool developed to simulate the performance of reception of AIS message by satellite, and on Heliosat[2].

Any bug reports may be sent to oystein.olsen@ffi.no. New features will not be added unless it is required by the work done at FFI, or unless it is required by projects that FFI participates in.

Bibliography

[1] Øystein Olsen, Torkhild Eriksen, and Bjøn T.Narheim, "Observation Modeling of AIS Message Reception with Satellite," in *FFI report 07/00306* 2007.

[2] Øystein Olsen, "HELIOSAT: An orbit determination software with applications to deep space mission," Institute for Theoretical Astrophysics: University of Oslo, 2007.

[3] Øystein Olsen, "D2-2: System Simulator Design Description Document and Functional and Performance Validation Report," in *ESA ARTES 5.1 AO 8282: Cost Effective VDE-SAT User Terminal and Ground Component Validation Platform* 2017.

[4] "Working version - Technical characteristics for a VHF data exchange system in the VFH maritime mobile band," in *Recommendation ITU-R M.2092-0+* 17 A.D..

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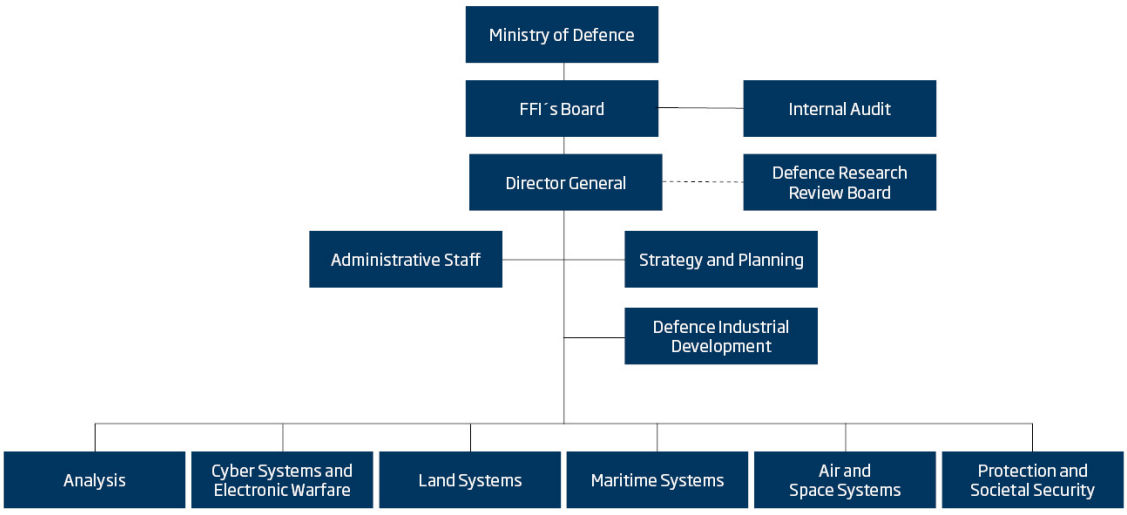

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