Visualyse Interplanetary: General Satellite Dynamics Update and Lagrange Points

Abstract: Visualyse Interplanetary has recently been updated with improved general satellite dynamics definition and ability to specify spacecraft to be located at a Lagrange Points, as described in this Technical Note (TN).

General Satellite Dynamics

General Satellite's dynamics can be selected by a number of methods, such as:

- Orbit model of point mass
- Orbit model of point mass plus J2
- Two-line element set using SGP4/SDP4
- Position and velocity vectors.

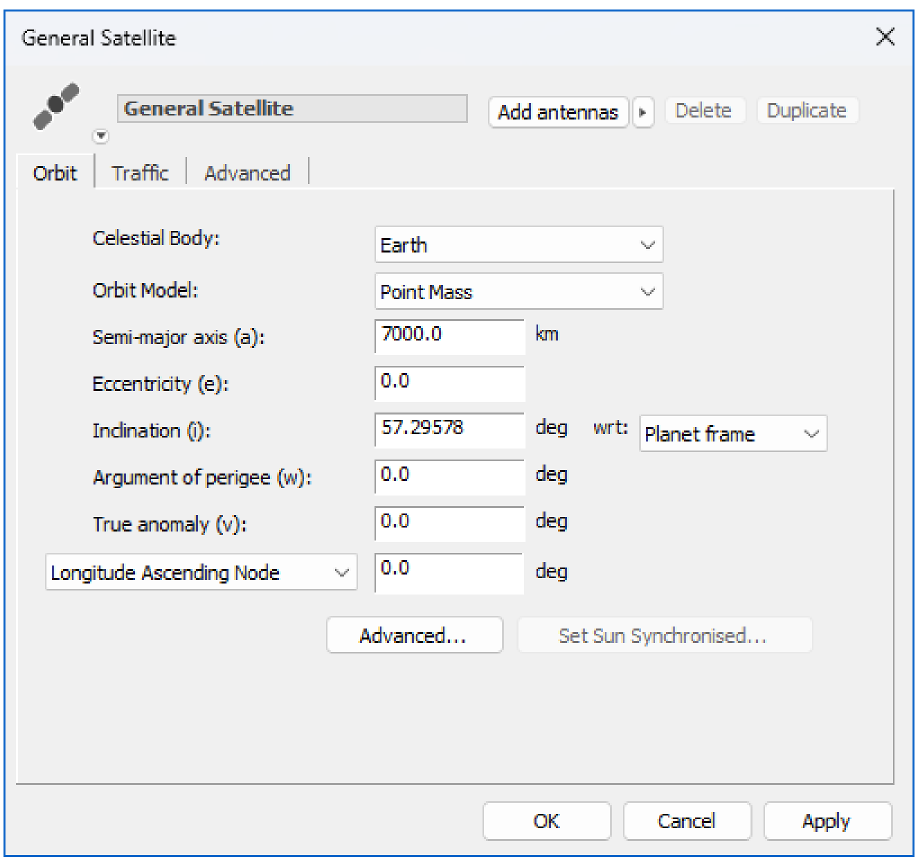
A new method is now available, namely:

- Selected as being located at a Lagrange point.

These are described further below.

Point Mass and Point Mass Plus J2 Orbit Models

General satellite station types are often defined using the standard Keplerian orbit elements, as shown below:



There are also options to define the reference from the ascending node and equatorial plane.

For Earth orbiting stations where the orbit modal is Point Mass plus J2, it is also possible to use the tool to set the orbit to be sun-synchronised.

Two-line element set using SGP4/SDP4

Another way to define orbit elements is via the Two-Line Element (TLE) which looks a bit like this:

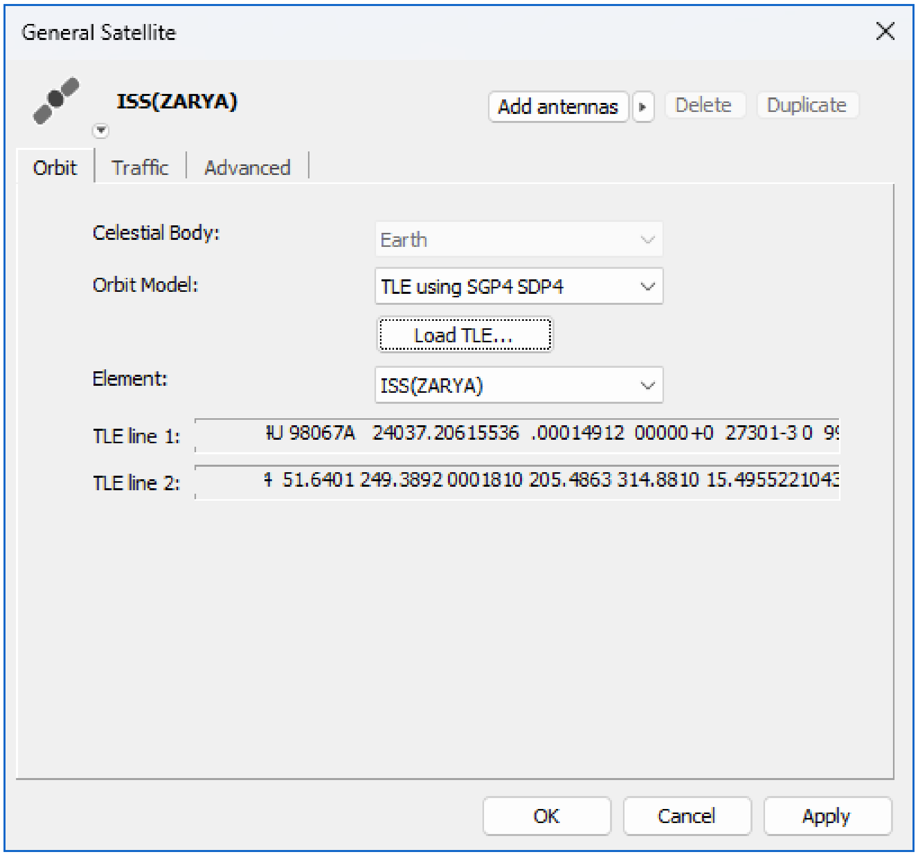
ISS (ZARYA)

1 25544U 98067A   24037.20615536 .00014912 00000+0 27301-3 0 9996

2 25544 51.6401 249.3892 0001810 205.4863 314.8810 15.49552210438086

These specify the measured dynamics of satellites actually orbiting the Earth.

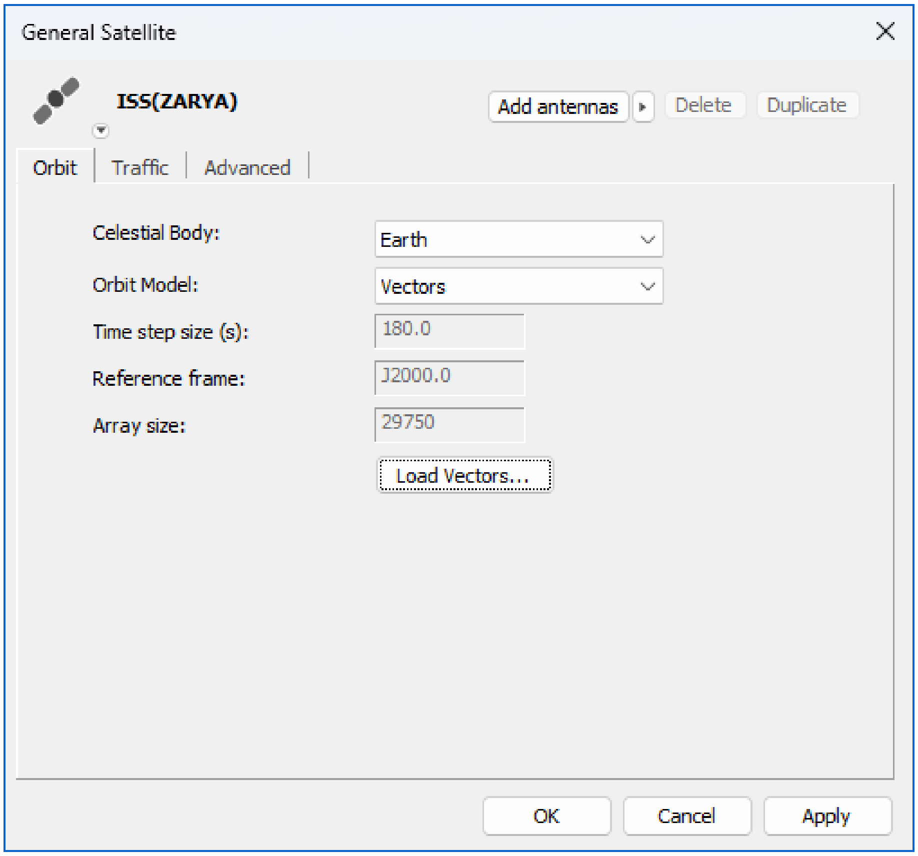
If the TLE option is selected, the dialog changes to allow a TLE to be loaded from a text file, as shown here:



The orbit model is then the SGP4/SDP4 from Space-Track.

Position and Velocity Vectors

Another method to define the station’s location is directly via the spacecraft’s position and velocity vectors.

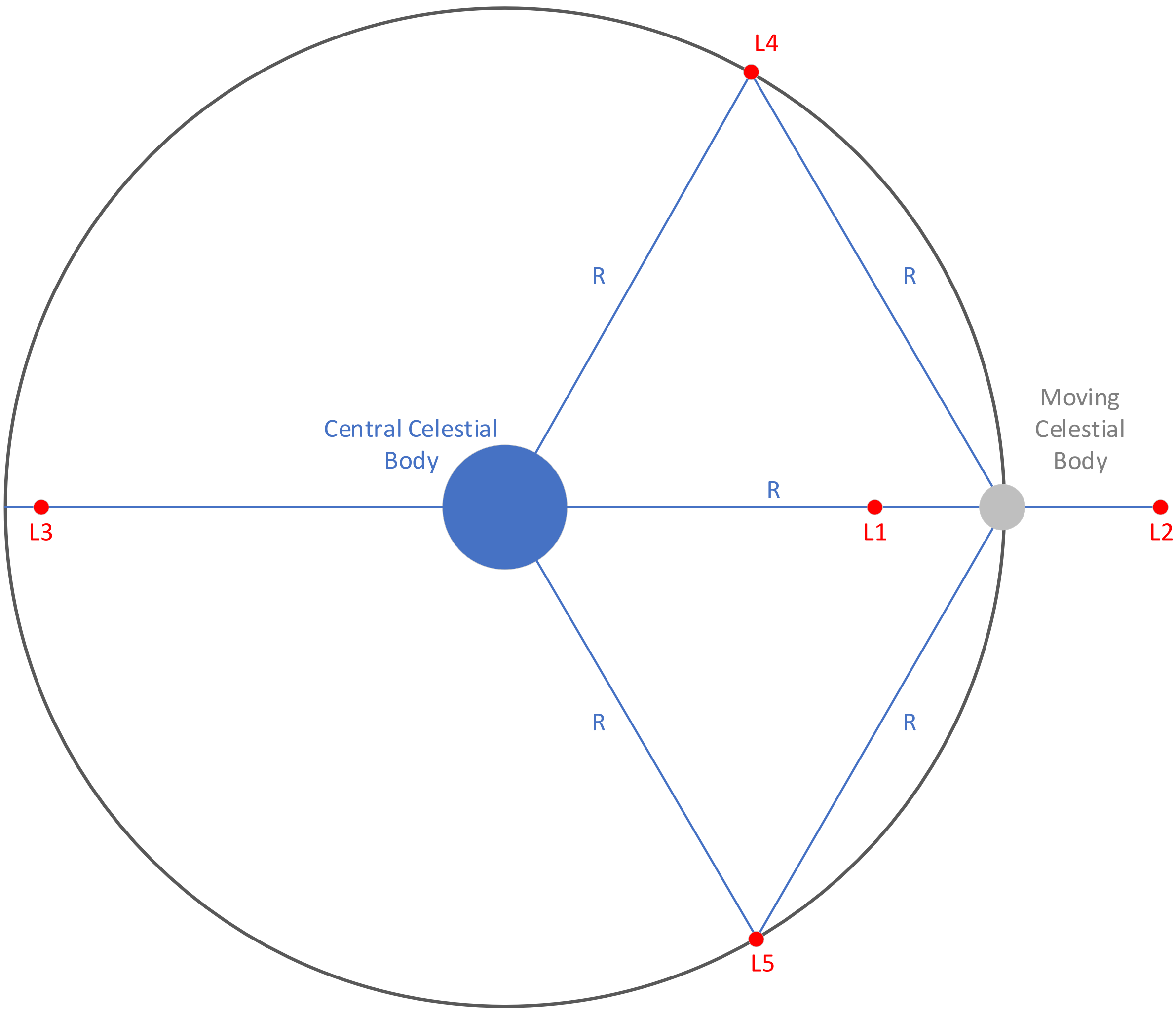


This enables the position and velocity of the spacecraft to be specified in J2000.0 vectors centred on the specified celestial body. The format of the data is comma separated values (CSV), with example:

100					
2458857					
0.51458					
180					
0					
29750					
-2317.25	-990.679	2798.663	-1.49353	0.369327	-0.36886
-2582.61	-922.797	2728.248	-1.45465	0.384531	-0.41276
-2840.88	-852.38	2650.343	-1.415	0.397526	-0.45212

Specify Station at Lagrange Point

Lagrange points are locations within the gravitational influence of two celestial bodies where there is equilibrium. Spacecraft can be located at these points and remain stationary relative to the two celestial bodies. The locations are shown in the figure below:

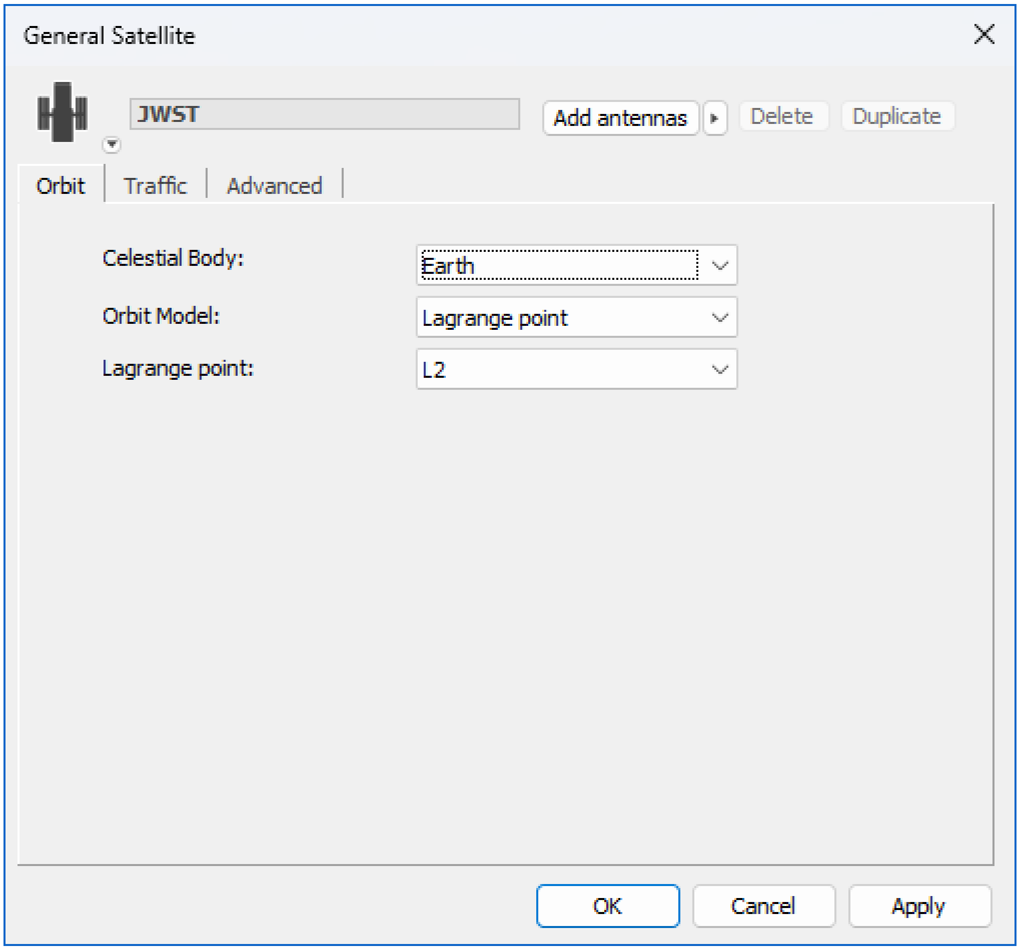


Examples of Lagrange points include those within the Earth-Moon system and the Sun-Earth system.

In Visualyse Interplanetary, a General Satellites can be selected as being located at one of these points by identifying the moving celestial body and then the Lagrange point of interest. The central celestial body is then automatically identified as will be the one that the moving celestial body orbits around. So, for example:

- to locate a General Satellite in one of the Earth-Moon Lagrange points, select as celestial body the Moon.
- to locate a General Satellite in one of the Sun-Earth Lagrange points, select as celestial body the Earth.

An example is shown in the figure below:



Note it is not possible to locate a Lagrange point when the celestial body is the Sun or Earth in ECI mode as there is no central celestial body in either case.

The Lagrange points are calculated using the approximation that the moving celestial body mass is significantly less than that of the central celestial body. More information is available in this reference:

http://physics.wku.edu/~gibson/astr414/lab/lagrange/L_calc_cornish.pdf

The Lagrange points are assumed to be in the plane of the moving celestial body's orbit around the central celestial body.

About Transfinite

We are one of the leading consultancy and simulation software companies in the field of radiocommunications. We develop and market the leading Visualyse products:

- Visualyse Professional
- Visualyse Interplanetary
- Visualyse GSO
- Visualyse EPFD

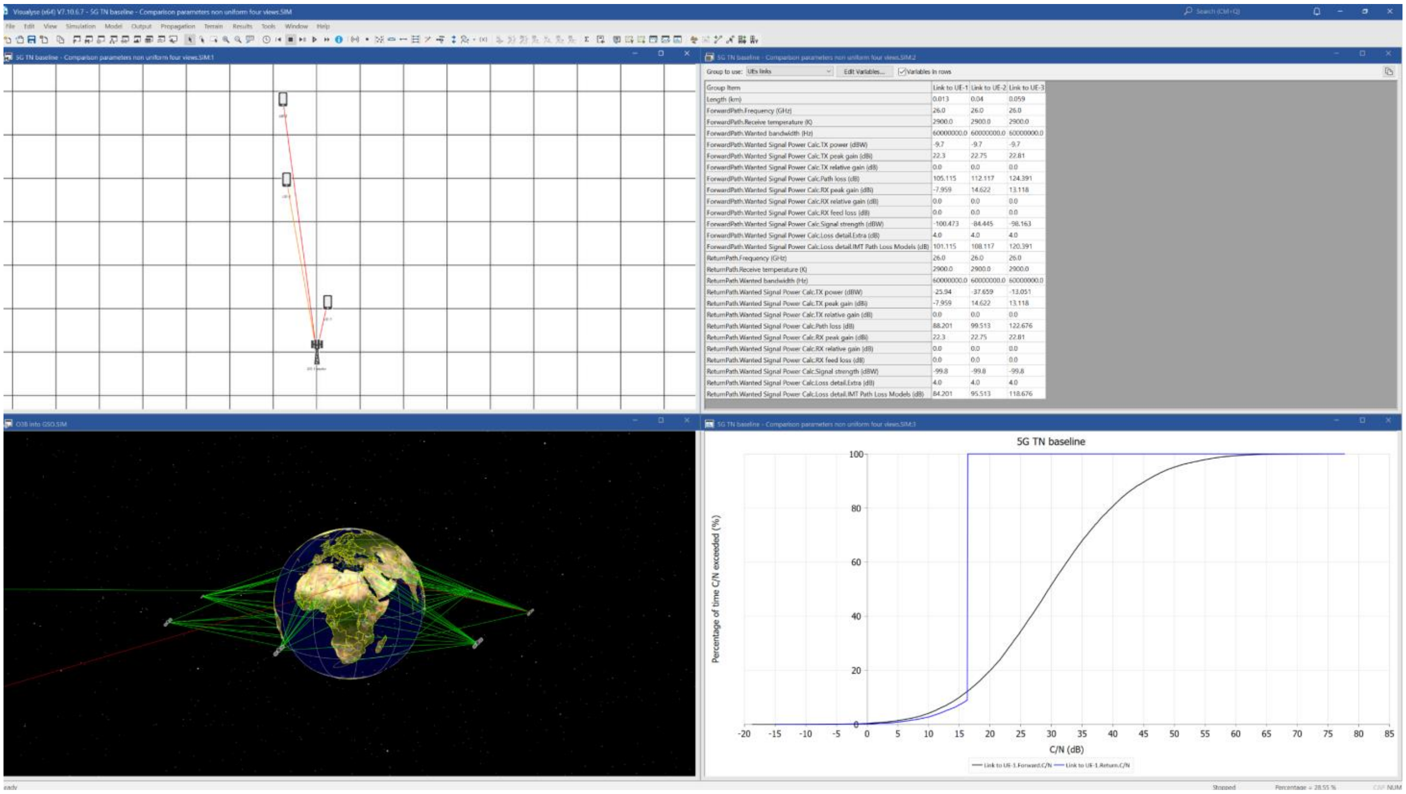
These are described further below.

Visualyse Professional

Visualyse Professional is a flexible study tool able to model a very wide range of radiocommunications systems, that can be used to analyse system performance including the impact of interference. Visualyse Professional can model transmit and receive stations located at fixed positions, mobile stations, aircraft, ships and also satellite systems including Earth stations, geostationary orbit, GSO satellites, non-GSO satellites and highly eccentric orbit (HEO) satellites.

It can be configured to analyse spectrum sharing scenarios using a wide range of methodologies, including static, input parameter variation, area, dynamic, Monte Caro and combinations such as area Monte Carlo.

Visualyse Professional includes a wide range of advanced features to enable it to analyse both co-frequency and non-co-frequency scenarios, the impact of terrain or clutter, the impact of traffic and complex handover strategies between satellites. These features allow it to model anything from a 5G network to a non-GSO mega-constellations such as SpaceX's Starlink or OneWeb. An example screenshot of Visualyse Professional is shown below:

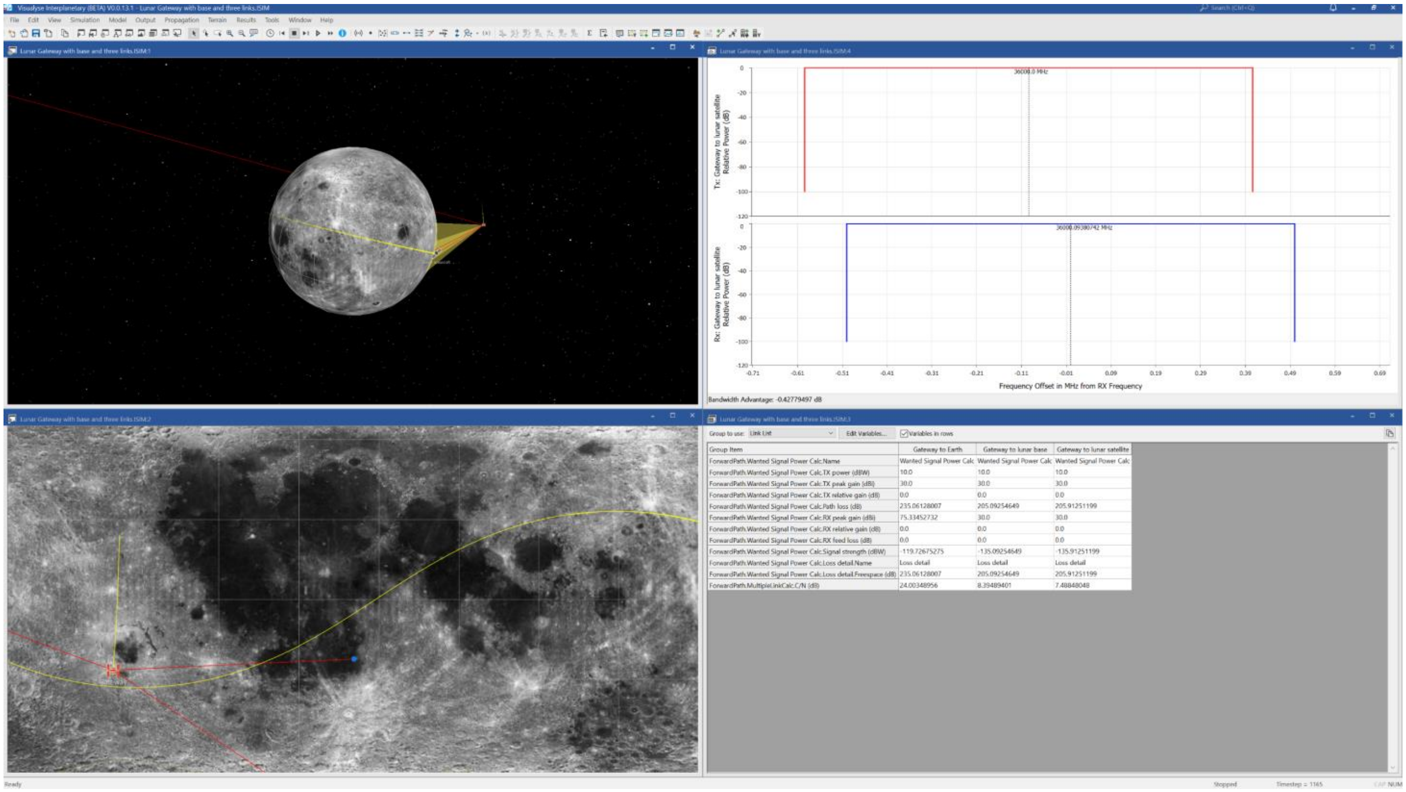


Visualyse Interplanetary

The objective of Visualyse Interplanetary is to extend the simulation ability of Visualyse Professional to allow:

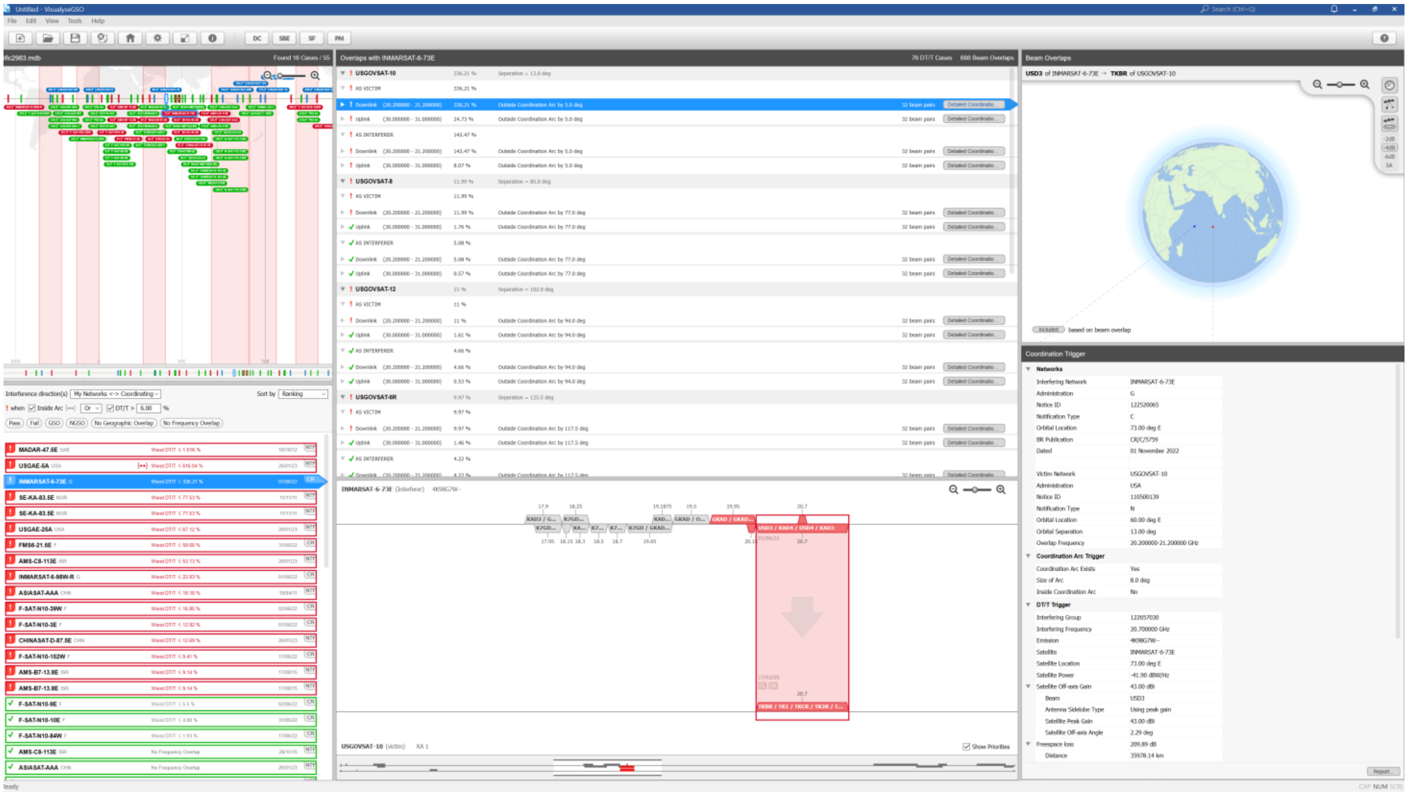
1. Modelling of stations around other celestial bodies including the Moon and Mars
2. Enhance the geometric framework with a more detailed description of the Earth's shape and rotation characteristics.

An example screenshot of Visualyse Interplanetary is shown below:



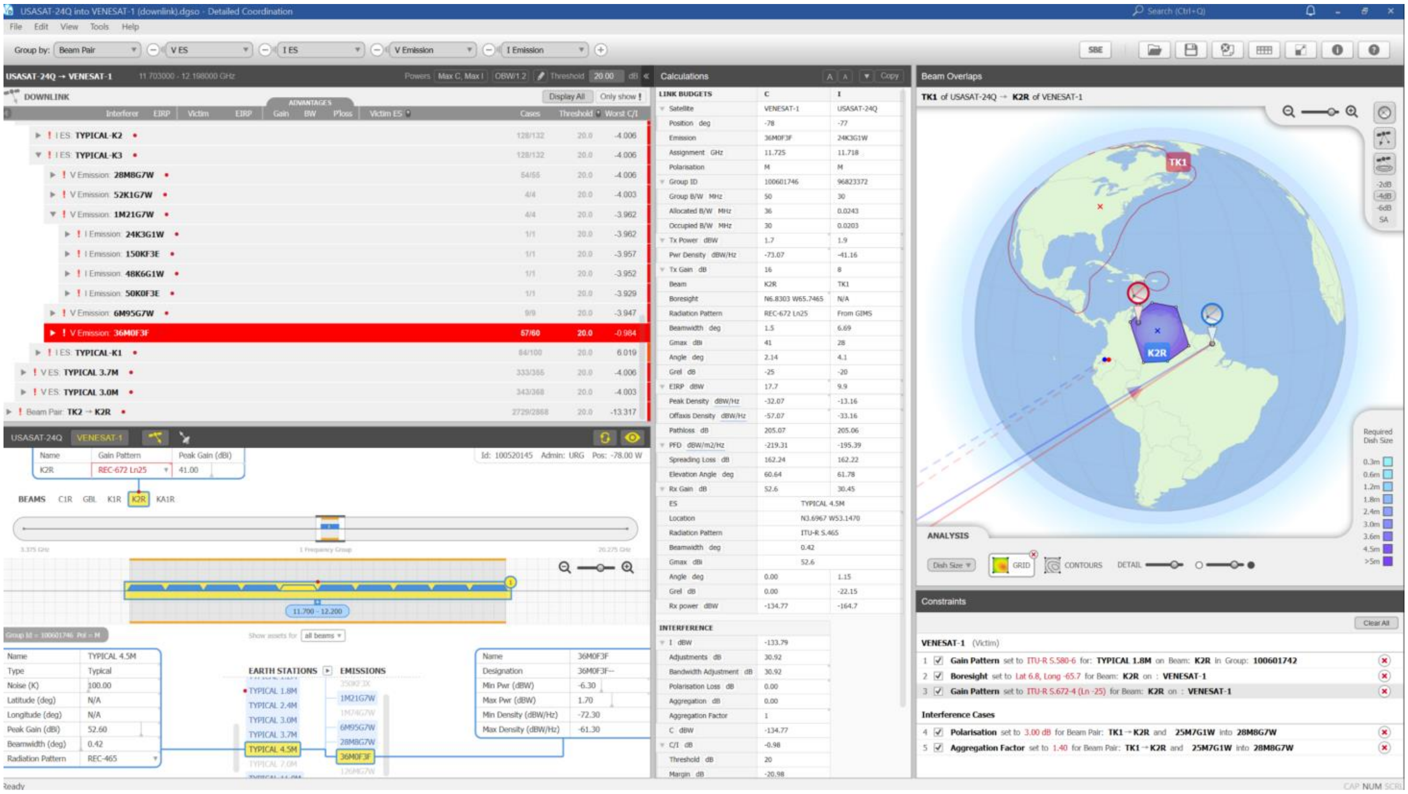
Visualyse GSO

We have developed Visualyse GSO to support satellite coordination tasks, in particular for GSO satellites. It includes IFIC checking, detailed C/I calculations and integrates with ITU databases such as the SRS/IFIC and GIMS. It can be also used to identify coordination requirements of non-GSO satellites.



The figure above shows the coordination trigger tool while the figure below shows the detailed coordination tool.

Email us at info@transfinite.com for further information or to give your views on this Technical Note



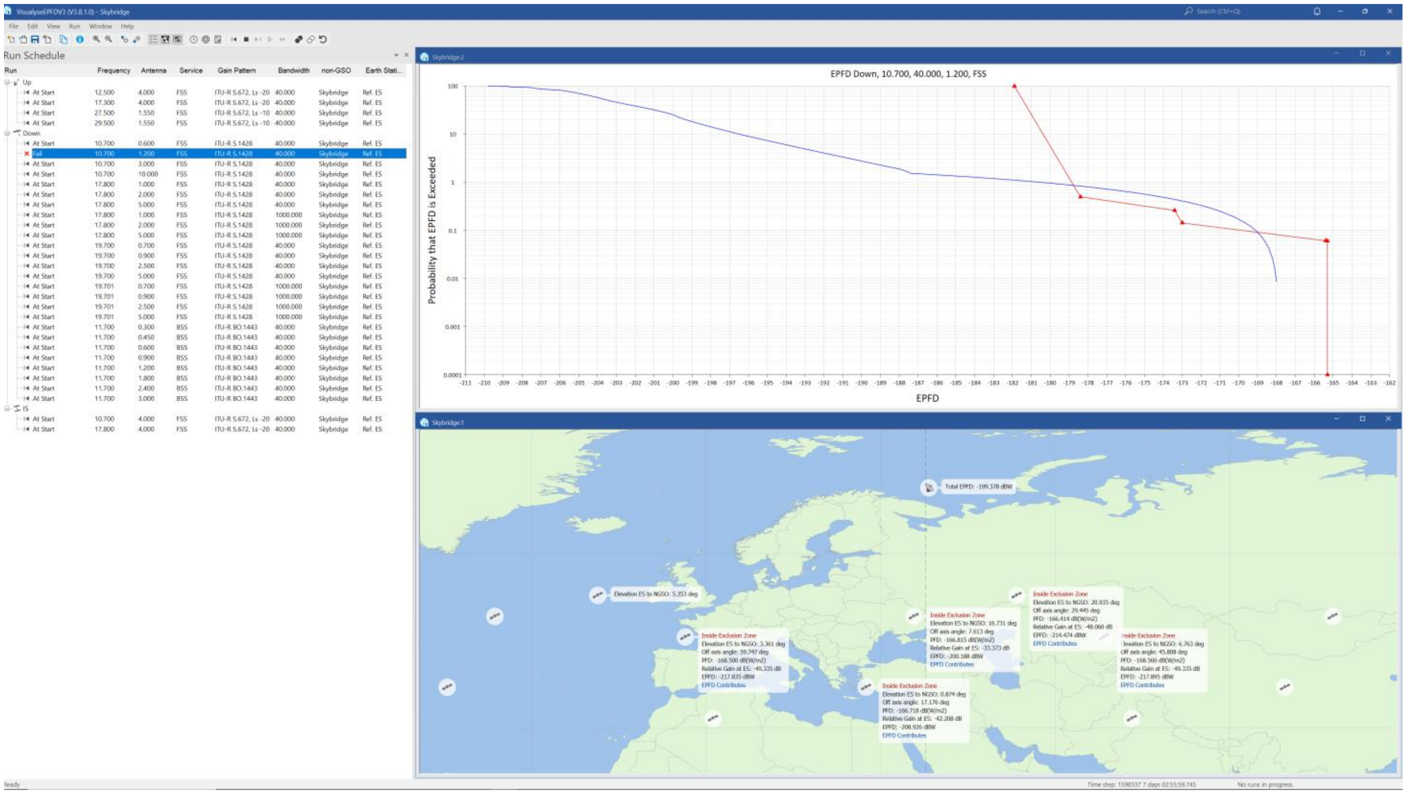
Visualyse EPFD

Our Visualyse EPFD software is the leading implementation of the algorithm in Rec. ITU-R S.1503. It has been verified during testing with the ITU BR and can calculate:

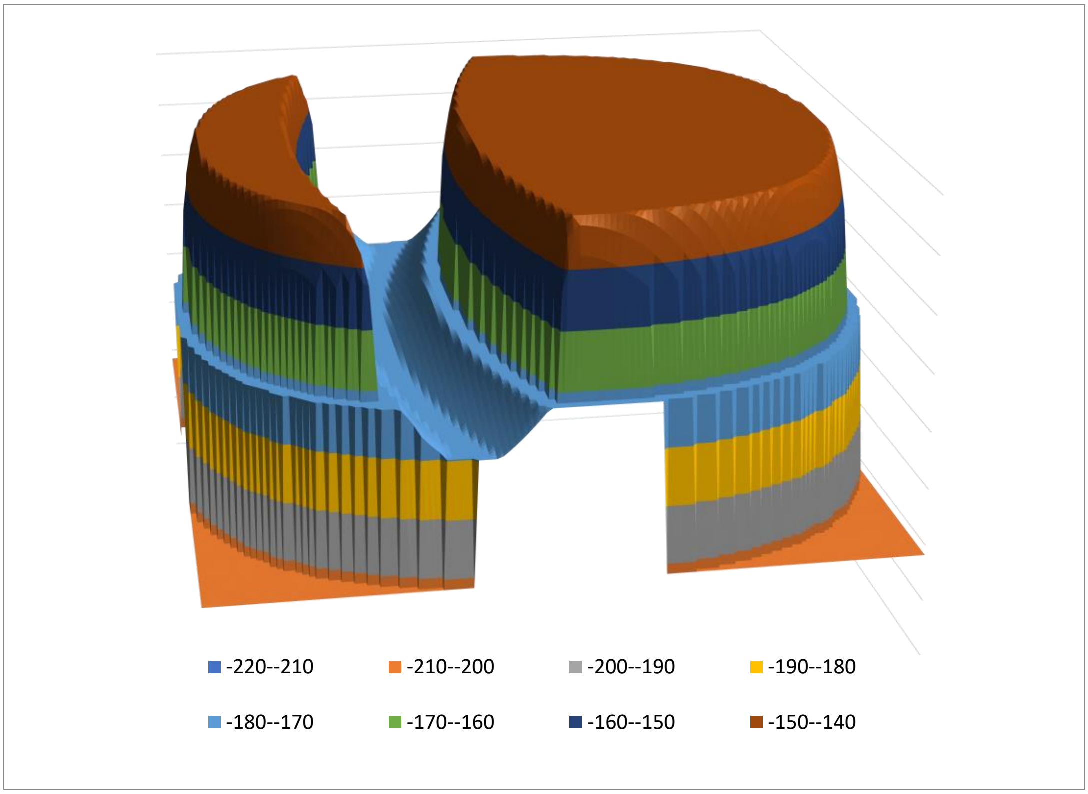
- EPFD (Up)
- EPFD (Down)
- EPFD (IS)

It can also analyse both the Article 22 and Articles 9.7A / 9.7B cases and also undertake Resolution 770 analysis using the algorithm in Recommendation ITU-R S.2157.

It is available in two versions, one the ITU's "black-box" for pass/fail decisions and the other a product with graphical user interface that provides feedback on the calculation process and allows additional options to be modified.



An additional tool is available to assist in the generation of PFD masks:



Training Courses

We also provide training courses in the use of our products including advanced training that can cover modelling of specific systems and scenarios.

Consultancy Services

We can provide a wide range of consultancy services using our world-leading experts and software tools to rapidly generate solutions, including:

- Interference analysis and spectrum sharing studies
- Coordination support and meeting representation
- ITU-R and CEPT meeting representation and support
- Strategic consultancy to achieve regulatory goals.

Contact us

More information about these products and services is available at our web site:

https://www.transfinite.com

If you have any questions or comments about this Newsletter or would like more information, please do not hesitate to contact us at:

info@transfinite.com