Visualyse Professional

What Can Visualyse Do?

Issue 1

Introduction

This document introduces the capabilities of Visualyse Professional through the examination of some issues on the WRC07 Agenda.

Agenda Items provide the context, but do not represent the limits to the capability of our software.

At the time of writing – April 2007 – the Agenda Items are live issues and subject to much debate and change. As far as possible I have tried to demonstrate the software in a general sense for each item, but please be wary of using any of the information contained here for other purposes – please, please check the 'facts' in other places.

If these examples arouse your curiosity but do not satisfy your specific requirement, please contact me. It is more than likely that I have some example models that are similar to your requirement, or that I can develop these quickly.

I would be delighted to receive any questions, comments or feedback on whether you find this sort of document useful.

Regards

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Document Contents

What's on Our Agenda?

The Agenda Items that I will use are grouped by service types that need to share, as follows.

GSO – GSO scenarios

AI 1.2 – Ka GSO Meteorological satellite service

GSO – terrestrial groups scenario

AI 1.4 – Systems beyond IMT-2000 in C band

HEO scenarios

AI 1.9 – HEO BSS in 2.5 – 2.69 GHz

AI 1.18 – HEO FSS in Ka band

Non-GSO scenarios

AI 1.6 – Aeronautical Telemetry at 5 GHz

AI 1.17 – non-GSO MSS feeder links at 1.4 GHz

GSO – other scenario

AI 1.8 – HAPS

Each Agenda Item is described below.

- Item 1.2 -- *"to consider allocations and regulatory issues related to the Earth exploration-satellite (passive) service, space research (passive) service and the meteorological satellite service in accordance with Resolutions **746 (WRC-03)** and **742 (WRC-03)**"*
- Item 1.4 -- *"to consider frequency-related matters for the future development of IMT-2000 and systems beyond IMT-2000 taking into account the results of ITU-R studies in accordance with Resolution **228 (Rev.WRC-03)**"*
- Item 1.6 - *"to consider additional allocations for the aeronautical mobile (R) service in parts of the bands between 108 MHz and 6 GHz, in accordance with Resolution **414 (WRC-03)** and, to study current satellite frequency allocations, that will support the modernization of civil aviation telecommunication systems, taking into account Resolution **415 (WRC-03)**"*

- Item 1.8 - *"to consider the results of ITU-R studies on technical sharing and regulatory provisions for the application of high altitude platform stations operating in the bands 27.5-28.35 GHz and 31-31.3 GHz in response to Resolution* ***145 (WRC-03),*** *and for high altitude platform stations operating in the bands 47.2-47.5 GHz and 47.9-48.2 GHz in response to Resolution* ***122 (Rev.WRC-03)"***
- Item 1.9 - *"to review the technical, operational and regulatory provisions applicable to the use of the band 2 500-2 690 MHz by space services in order to facilitate sharing with current and future terrestrial services without placing undue constraint on the services to which the band is allocated"*
- *Item 1.17 - "to consider the results of ITU-R studies on compatibility between the fixed-satellite service and other services around 1.4 GHz, in accordance with Resolution* ***745 (WRC-03)"***
- Item 1.18 - *"to review pfd limits in the band 17.7-19.7 GHz for satellite systems using highly inclined orbits, in accordance with Resolution* ***141 (WRC-03)"***

General Considerations about the Use of Visualyse Professional in the ITU Arena

The build up to WRC07 is a long process and the Agenda this time is quite full. This is normal and unlikely to change in the future.

Decrease in the available time to do real technical studies has lead to an increase in the gap between conferences, but the amount of work required simply expands to fill the time.

So, in such an environment how can we decide what position to take on each issue?

This is where software tools are invaluable. Visualyse simulations allow you to perform multiple What If? Analyses, varying scenarios and scenario parameters and assessing the potential impact of these variations.

The output of these studies can be used to determine

1. Is sharing feasible under current assumptions
2. What form of constraint (pfd, EPFD, EIRP etc) might enable sharing
3. What level of constraint should be imposed
4. Does this level allow both sharing systems to operate

Visualyse Professional is the ideal tool for this kind of study – the key benefits of using Visualyse Professional are

- Powerful calculation engine that is proven with over 10 years of use within ITU-R Study Groups
- A range of maintained propagation models and antenna models that ensure your results reflect the latest international standards
- Software is widely accepted as a benchmark
- Graphical user interface that allows you to add new data, vary existing parameters and see the results in numerical and graphical form immediately
- External connectivity options for importing and exporting data and results
- Graphical interface allows for easy presentation of results in reports and meetings – all outputs available to cut and paste into Word, Powerpoint etc.
- Full professional support from Transfinite Systems
- Hassle free maintenance, software remains up to date

GSO –GSO Scenarios

Agenda Item 1.2

*"to consider allocations and regulatory issues related to the Earth exploration-satellite (passive) service, space research (passive) service and the meteorological satellite service in accordance with Resolutions **746 (WRC-03)** and **742 (WRC-03)**"*

The CPM Report (2/1.2/1.2.1) discusses sharing between GSO MetSat and GSO FSS, both in the space-to-earth direction. The same report (2/1.2/1.2.2) also considers MetSat space-to-earth sharing with BSS Feeder Links (earth-to-space).

The figure below shows a Visualyse example where MetSat and FSS downlinks are sharing. The file can be found in AI 1-3b.sim and can be viewed and modified in the demonstration version of the software

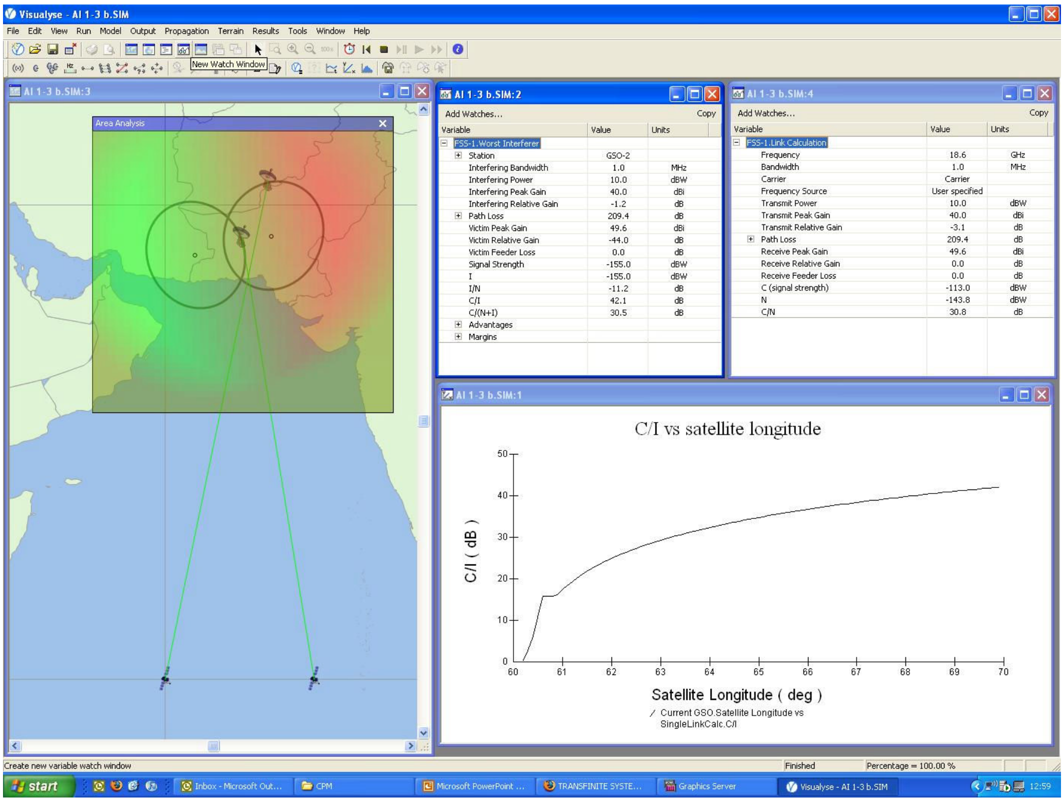

Figure 1 – An Example GSO-GSO Downlink Sharing Scenario

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This view shows a C/I analysis based on a variable satellite orbital separation. The figure shows

- (left) the instantaneous C/I over a wide area. Red indicates C/I below threshold – a user definable level
- the top windows top right show numerical views of the instantaneous interference link budget into the MetSat and the C/N calculation for the FSS downlink
- The bottom right shows the C/I at a selected point (close to edge of coverage in this case) as a function of the FSS satellite orbital location.

The results depend on several factors that you can examine and change in the provided Visualyse files. These include

Antenna Gain patterns – in our model we have used Recommendation ITU-R .465 and 580 for the earth stations and Recommendation ITU-R 672 for the satellite.

You may change beamwidths, dish size, D/λ or even change the roll-off model used. For the satellites you can use GIMS shaped beams imported directly from the GIMS database

Propagation Models – in our file we have used Recommendations ITU-R 525 (free space loss), 618 (rain fade) and 676 (atmospheric gases). These are pretty much a standard set of models for GSO downlinks, but you can vary the % time associated with the rain model.

You can also vary the rain rate, but by default this is determined according to Recommendation 837 using the IDWM database.

Interference Measures – we chose C/I, but you could equally do this analysis in terms of I/N or C/N+I

The FSS satellite location is varied using the Define Variable Module, which allows you control over any variable in the simulation. In this case the control is just a linear increase in longitude with time, but this module has many other applications including the generation of Monte-Carlo scenarios.

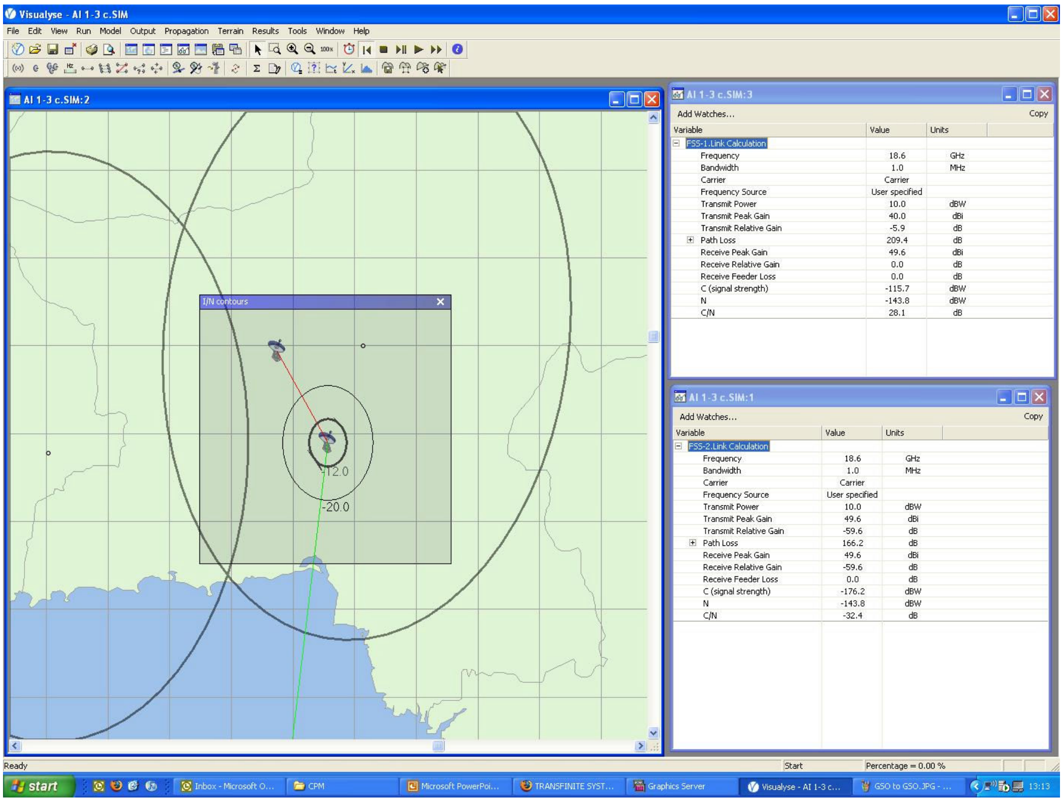

Figure 2 – Example Uplink Sharing in Visualyse Professional – example file is AI 1-3c.sim

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GSO vs Terrestrial Networks

Agenda Item 1.4

"to consider frequency-related matters for the future development of IMT-2000 and systems beyond IMT-2000 taking into account the results of ITU-R studies in accordance with Resolution ***228 (Rev.WRC-03)"***

Agenda Item 1.4 covers many potential sharing scenarios. One key issue is the use of part of the C-band currently allocated to satellite downlinks. Visualyse can be used to study the types of constraint that may need to be placed on IMT2000 systems in order to mitigate interference in these scenarios.

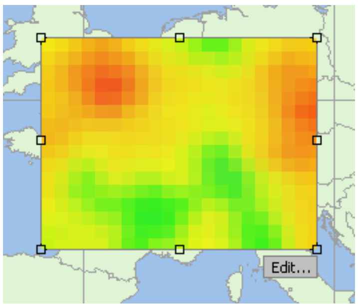
The CPM Report considers this in Section 1/1.4/5 Candidate bands for the future development of IMT-2000 and systems beyond IMT-2000.

In our example file AI 1-4.sim, we have modelled a WiMax network operating in the vicinity of a satellite earth station. WiMax parameters are assumed to be consistent with IMT2000 standards.

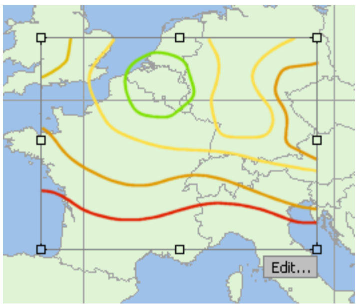
Area Analysis

We have used Visualyse's powerful area analysis tool to create a colour coded plot showing locations where a earth station would experience excess interference from a specific WiMax base station

Area analysis can be used to show these colour coded plots or contours of any link parameters (e.g. received signal, interference C/I, pfd etc).



block plot



contour plot

The figure below shows the exclusion zone that results from basic analysis under the assumption of path loss occurring for 20% time in Recommendation ITU-R 452-12 (at this stage, no terrain is included)

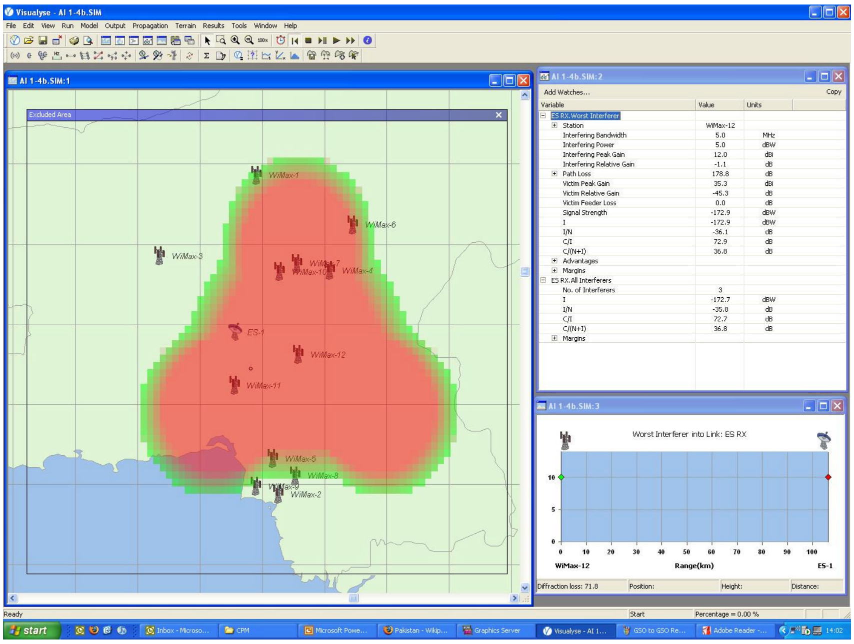


Figure 3 – Exclusion zone around a WiMax deployment in South East Asia – example file is AI 1-4b.sim

Key Modelling Features

The Key features of Visualyse Professional that have been used in this model are.

Antenna Gain patterns – in our model we have used Recommendation ITU-R .465 for the earth stations. For the WiMax system we haved used both Recommendation ITU-R 1336 and also a Visualyse Gain Table. This latter option allows you to enter specific antenna performance that is not included in Visualyses large list of roll-off masks.

The WiMax base station antenna is modelled with multiple sectors – this is reflected in the shape of the exclusion zone around the base station.

You may change beamwidths, dish size, D/λ or even change the roll-off model used. You can edit the entries in the gain table.

Antenna Pointing – Visualyse allows you to point antennas based on azimuth and elevation of the antenna mechanical boresight. In this simulation these are defined directly – (the base station downtilt is an important parameter). In other simulations, antennas may be pointed towards other stations or can be made to scan between defined angles.

Propagation Models – in this type of scenario the propagation model used and the model parameters are of vital importance. This is an area where the power of Visualyse becomes apparent. The baseline scenario uses Recommendation ITU-R P 452 with no terrain, under assumptions of short term loss conditions (i.e. 0.1% of time). Below there is discussion of the impact of varying model scenarios.

You can also vary the rain rate, but by default this is determined according to Recommendation 837 using the IDWM database.

Deploying the WiMax Network – Visualyse allows you to define deployments of a large number of stations in several ways. In this case we have imported the locations at defined latitudes and longitudes using the import facility in the Service Area Wizard.

In other scenarios, you could scatter stations over a regular grid, drag and drop using the mouse or even move stations randomly over a defined area using the Define Variable module (allowing you to do statistical analysis using location as Monte-Carlo variable).

Propagation Model Variations and Nuances

Propagation loss is the key factor in determining the size of exclusion zone around a station. In Recommendation 452-12 anomalous propagation modes dominate for short time scales and these lead to relatively low loss and large exclusion zones.

Normally, planning criteria for earth stations are required to address short term statistics for availability and this may require, under worst case assumptions, short term statistics for interference.

Hence our baseline uses 0.1% time. However, the earth station performance is defined in terms of C/I and the 0.1% statistics could be driven by fading on the satellite link.

Technically, we should perform a numerical correlation between C and I, which we can do in Visualyse. However, to illustrate the effect, we have re-run the static analysis for 1% and 20% time in the propagation model

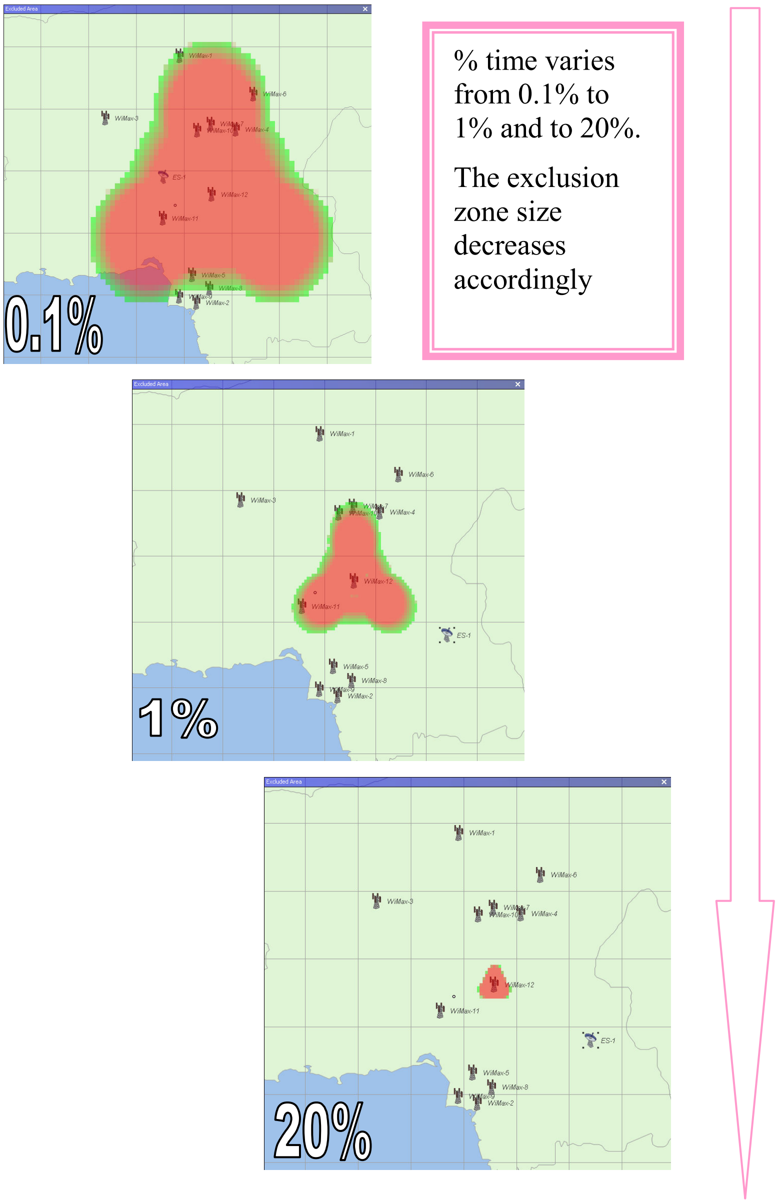


Figure 4 – variation of exclusion zone size with percent time.

Terrain

Another important factor in the propagation is the effect of terrain. Visualyse allows you to use any lat/long/height terrain data with a minimum of fuss.

We interface directly to several public domain data sources, including the popular Space Shuttle data which covers most of the world.

Introducing terrain can have a radical effect on the exclusion zone and whilst this may not be used in initial planning/coordination triggering, it can certainly be used in site specific coordination.

The figure below shows, for completeness, how the short term exclusion zone would look if 90m terrain data and Deygout Diffraction Loss is included. More colour levels, and discontinuous areas of colour reflect the wider variation in interference level due to terrain blocking and addition diffraction loss.

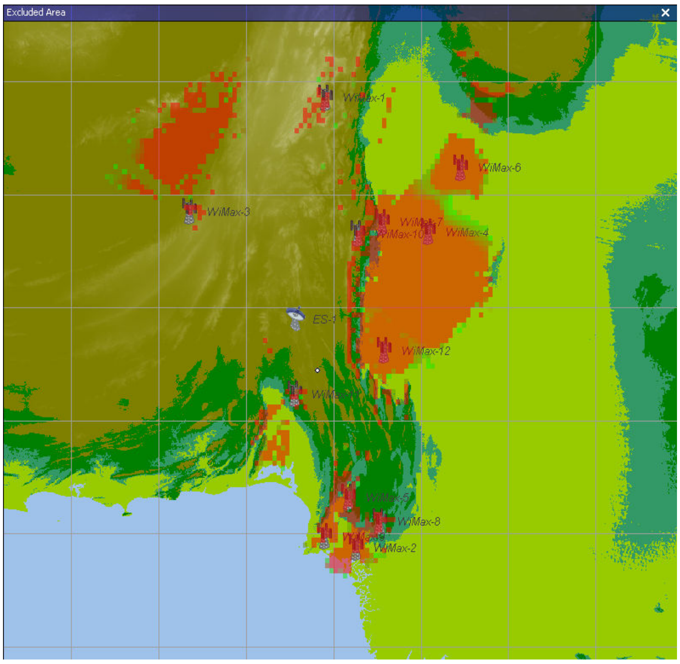


Figure 5 – typical 'exclusion zone' once terrain is included in the simulation.

Site Specific Coordination

As well as helping to identify general problems and sharing constraints, Visualyse Professional is also well suited to allowing you to investigate site specific coordination problems.

The figure below shows three useful views

1. The area analysis – explicitly showing the sectoral coverage of the WiMax base station
2. The interference link budget to the WiMax base station
3. The terrain profile along the interference path.

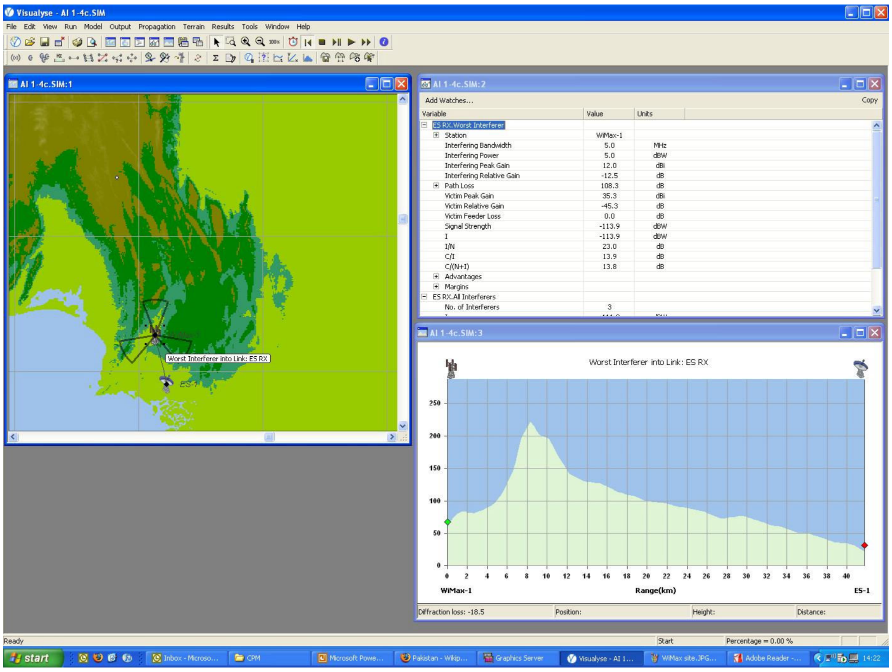


Figure 6 – Visualyse views that are useful in investigating site specific coordination issues

Visualyse is the ideal tool for What If? analysis – allowing you to see the impact of varying key parameters.

In this case, we could think of the following mitigation options which can be assessed easily in Visualyse.

- Move ES
- Move BS
- BS antenna downtilt
- BS antenna pointing
- BS power reduction
- ES site shielding

There are probably many others.

In the simulation files provided, you can try these variations for yourself.

HEO Satellite Issues

Visualyse has tools which allow you to treat multiple stations and links as if they were grouped together. We call these tools 'Wizards' in common with many other windows applications.

One Wizard allows you to create a certain useful subclass of HEO constellation, which is currently popular for proposed regional communications systems such as S-DMB and S-DARS systems.

These systems are popular for several reasons, but one reason is that their design is such there is usually a large angular separation between the geostationary arc and the HEO satellite when it is operational. This facilitates sharing.

A couple of agenda items relate to HEO satellites

Agenda Items 1.9 and 1.18

Agenda Item 1.9

"to review the technical, operational and regulatory provisions applicable to the use of the band 2 500-2 690 MHz by space services in order to facilitate sharing with current and future terrestrial services without placing undue constraint on the services to which the band is allocated"

Agenda Item 1.18

"to review pfd limits in the band 17.7-19.7 GHz for satellite systems using highly inclined orbits, in accordance with Resolution ***141 (WRC-03)"***

The sharing services are different – 1.9 relates to terrestrial base stations, 1.18 refers to microwave fixed services and fixed satellite service earth stations.

The figure below shows a scenario analysing I/N against receiver azimuth in 17.7-19.3 GHz. This can be found in the file AI 1-18a.

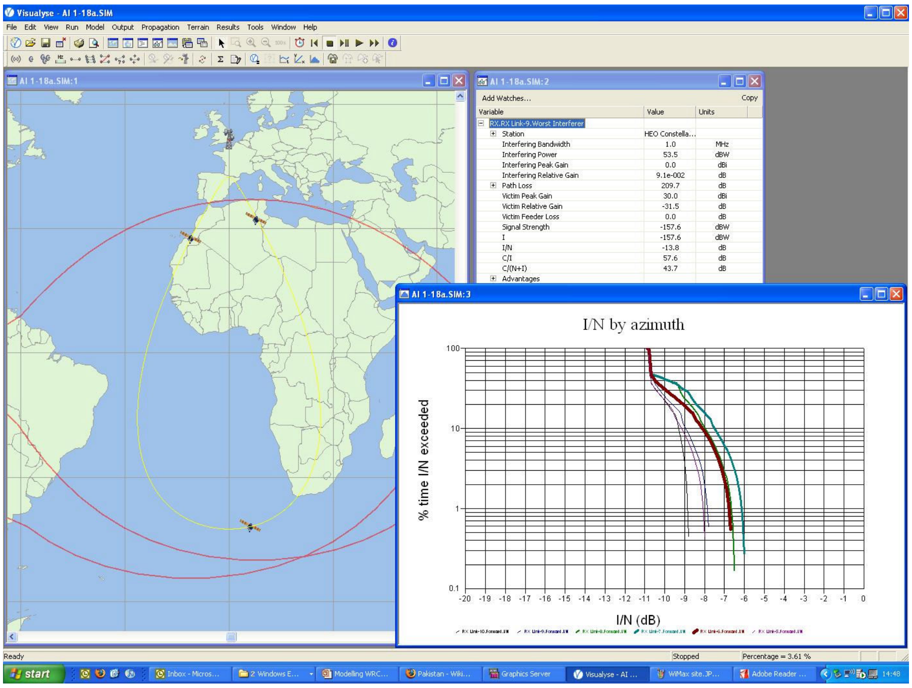


Figure 7 – HEO constellation interfering to a Fixed Service Receiver in 17.7-19.3 GHz. I/N distributions are given for various receive antenna azimuths.

This scenario is covered by Recommendation ITU-R F 1495. Long and short term criteria are given in this Recommendation so statistical distributions (shown bottom right in the figure) are required.

The key elements in these simulations are:

Antenna Patterns – the HEO satellites are modelled using PFD masks consistent with Recommendation ITU-R 672. Other antennas use pre-defined roll-off masks or user defined gain tables

Interference Measures – here we are using I/N as the measure of interference. Because there are three criteria points in Rec 1495 (at 0.003%, 0.01% and 20% time), the output is in terms of a cumulative distribution of I/N from which all three points can be read.

In addition a measure called Fractional Degradation of Performance is also recorded – this is simply the average value of I/N over the course of some defined period.

It is also worth noting that the graphic output for the cumulative distribution shows results for six different receive antenna azimuths. The FS beam is very narrow and this parameter is key. Visualyse can include as many receivers, on different azimuths, as required by the simulation.

HEO Constellation – it's clear that the operational parameters of the HEO constellation are important. Orbit, size shape and location (relative to earth coordinates) are all needed. However, a subtle difficulty is that the specification of an orbit is often linked with the type of orbit propagator (simulator) that the designer prefers.

In addition, station keeping activities will mean that the orbit does not propagate freely, so that there are many ways in which an orbit defined by one set of parameters could be unrepresentative of the way in which the network will operate.

The Visualyse **HEO Wizard** captures the essential operational points about HEO networks and defines the orbit parameters in such a way that these points are reflected in the simulation. For example

- Single or multiple repeating ground tracks
- Multiple satellites per ground track defined such that smooth hand over from one satellite to next can always be achieved
- Orbits defined by orbital period

The result is a simulation that is representative of the operational mode of the network.

Non-GSO Satellite Issues

Non-GSO Mobile Satellite Service feeder links are prominent in the WRC Agenda. Item 1.6 and 1.17 are both relevant.

Agenda Items 1.6 and 1.17

Agenda Item 1.6:

*"to consider additional allocations for the aeronautical mobile (R) service in parts of the bands between 108 MHz and 6 GHz, in accordance with Resolution **414 (WRC-03)** and, to study current satellite frequency allocations, that will support the modernization of civil aviation telecommunication systems, taking into account Resolution **415 (WRC-03)**"*

An example scenario that can be modelled in Visualyse is, aeronautical telemetry interfering into non-GSO MSS feeder uplinks at 5 GHz. An example file can be found in MSS feeder into FS.sim.

Visualyse is able to model the dynamics of both systems plus all the key parameters for the interference calculation

Agenda Item 1.17:

"to consider the results of ITU-R studies on compatibility between the fixed-satellite service and other services around 1.4 GHz, in accordance with Resolution **745 (WRC-03)**"

Example sharing scenarios covered by this item are sharing of NGSO Feeder uplinks with FS microwave links and the NGSO feeder downlinks interfering to FS links.

The former case is illustrated in the figure below.

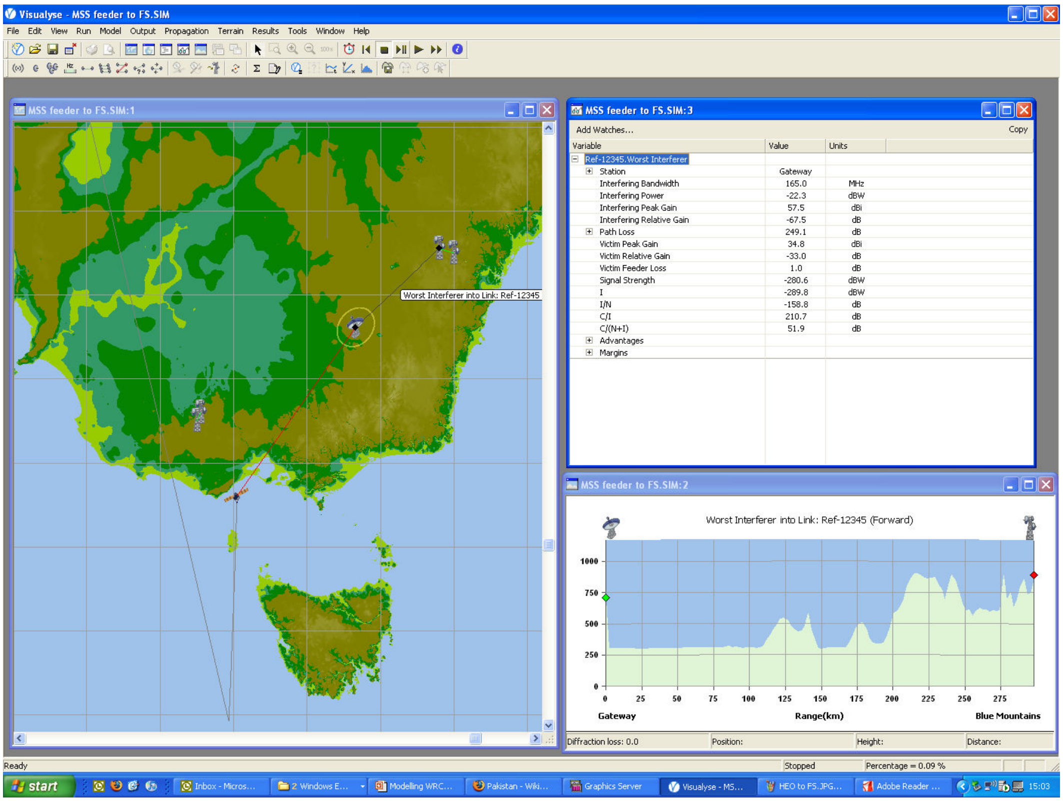


Figure 8 – Visualyse simulation, illustrating the study of interference from a NGSO earth station uplink, into surrounding FS Links

The key elements of this simulation, and the other MSS Feeder link simulations, are

Propagation Models – terrain based Recommendation 452 is used on all terrestrial paths.

MSS Constellation Modelling – Visualyse includes a Wizard that allows you to model multiple circular orbiting satellites as one group

Mulitple Fixed Link Modelling – Visualyse allows you to import multiple fixed links from an Excel type spreadsheet. Typically this is used to exchange data with external databases.

The simulation is modelling I/N and displaying an area analysis of average I/N (Fractional Degradation of Performance against) FS location, assuming worst azimuth.

It is also displaying a detailed interference link budget snap shot for a specific case – useful in site specific detailed coordination.

Other Applications?

It is our view that Visualyse can be used to gain valuable insight into almost any frequency sharing scenario. The applications contained in this document, and the WRC Agenda Items used to set the context are merely examples.

If you have some other ideas what we should address in future documents, we would be very happy to try to do so.

Please email me with any comments, suggestions or feedback at parker@transfinite.com .