# White Paper: Visualyse Interplanetary

Abstract The aim of Visualyse Professional is to be able to model as wide range of radio systems as possible. Until recently, a restriction has been that all stations, both transmit and receive, are located either on the Earth's surface or in orbit around the Earth. With increasing interest in missions to the Moon, Mars and other celestial bodies in the Solar System, Transfinite have been working on how to model these deep space systems. This White Paper describes in overview the new product, Visualyse Interplanetary, that will allow modelling of missions to and around the Moon and other planetary bodies.

## Introduction

This White Paper is aimed at users that are familiar with Visualyse Professional who wish to try Visualyse Interplanetary, a new software product from Transfinite able to model radio interference problems in space, beyond the satellite systems orbiting Earth.

#### What is Visualyse Professional?

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



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## 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.

The update to the geometric layer of Visualyse was an opportunity to include additional features, in particular:

- Modelling how the frequency at the receiver is altered due to Doppler shift
- tools support sun-synchronous orbit satellites
- a constellation collision prediction tool
- inclusion of the full TLE orbit prediction model.

These enhancements allow a wide range of new scenarios to be modelled, such as:

- Checking there'd be no issues with harmful interference from crewed missions to the Moon or Mars using 4G and 5G mobile systems
- Checking that missions to the Moon or Mars from one space agency would not cause harmful interference into those
   of another
- Using more detailed orbit models to predict satellite positions and antenna pointing angles during the satellite or Earth station coordination process.

#### Installation and Configuration

The installation program should create a new directory and icon for the new version of Visualyse.

Visualyse Interplanetary uses a new set of overlays, which should be located in the relevant overlays directory. Note these overlays have an additional field in each of the XML files which defines the relevant celestial body. An example of the overlays is shown below:



It is also necessary to have access to one of the JPL ephemeris data files. This file is called something like:

Inxm13000p17000.431

This can be downloaded from here:

ftp://ssd.jpl.nasa.gov/pub/eph/planets/Linux/

The first time that Visualyse Interplanetary is run it should be configured to point to this file using the menu option File|Solar System Settings. This will open the following dialog:

Solar System Data Settings	×	
UTC to TT offset (seconds): 69.184		
Enter or browse to the path where JPL Ephemeris data t	file is kept:	
	OK Cancel	

The UTC to Terrestrial Time (TT) offset allows the dynamic time to be defined relative to UTC.

#### Solar System Objects

This version includes an additional list of objects to define the Solar System. This can be found under menu option Model|Solar System. If the JPL ephemeris file is not specified, then Visualyse Interplanetary will work in legacy mode. In this case, the list will only contain the standard Visualyse Professional Earth which is a sphere of radius  $R_e = 6378.145$  km.

If the JPL ephemeris file is specified, then this will show the list of available celestial bodies:

Celestial Body List		×
Celestial Body List Filt	er:	
Sun Mercury Venus Earth Mars Jupiter Saturn Uranus Neptune Pluto Moon	× Delete	
✓ Open for editing		
	Close	Help

You can add, edit, duplicate and delete celestial bodies, allowing moons of the major planets and asteroids to be entered.

In the future, this could be extended to include the ability to import additional celestial bodies using a text file format (e.g. using orbit elements or J2000.0 state vectors). Each object can be viewed or edited using a dialog similar to this:

Edit Celestial Body				×
Name:	Earth		Epoch	
Orbits:	Sun	~	Orbit	
GM (km/s2):	398600.4418	Polar axis right ascension (deg):	0.0	
J2:	0.001083	Polar axis declination (deg):	90.0	
Ellipsoid a (km):	6378.137	W at epoch (deg):	Not available	
Ellipsoid b (km):	6356.752314	Rotation rate (deg/s):	0.004178	
Calculate mean radius:	$\checkmark$	Has ground:	$\checkmark$	
Mean radius (km):	6371.0	Has atmosphere:	$\checkmark$	
	Select colour	Has seas:	$\checkmark$	
	ОК	Cancel		

The watch window can also be used to view the configuration parameters and also calculated parameters:

😞 TN.ISIM:2		-		×
+ Modify Watches			ſ	ြ Copy
Variable	Value	Units		
Solar System.Earth				,
Is active	True			
Orbits	Sun			
Calc radius	True			
Mean radius	6367.453635	km		
GM	398600.4418	rad/s		
J2	0.001083	rad/s		
Has ground	True			
Has stationary orbit	True			
Has atmosphere	True			
Has seas	True			
Reference Angles				
Parameter set	Default			
Туре	Earth Extended			
Right ascension of axis	0.0	deg		
Declination of axis	90.0	deg		
Rotation rate	0.004178	deg/s		
Current W angle	26.345746	deg		
Gamma bar	0.000676	deg		
Phi bar	23.436253	deg		
Psi	0.323112	deg		
Eta	23.438469	deg		
Equinox Delta	-0.002672	deg		
* Time				
Ellipsoid				
Semi major axis	6378.137	km		
Semi minor axis	6356.752314	km		
± Current Orbital				
± Inertial Frame				
Rotating Frame				
🗄 Planet Frame				
VectVP Local				
VectVP Solar				

The Earth model in Visualyse Interplanetary is the standard WGS84 ellipsoid and that each object has defined what object it orbits. Each celestial object has flags to identify if it has {Ground, Atmosphere, Seas}. This field is used to identify what types of station are permitted – so, for example, aircraft would not be permitted on the Moon.

#### File Save and Load

It is possible to save and load Visualyse Interplanetary simulations and load existing Visualyse Professional version 7.x files. It is not possible to save Visualyse Interplanetary simulations to Visualyse Professional file format.

#### **Station Types**

Station types have been relabelled to make them more generic and not Earth specific, as can be seen from the following dialog:



This is also visible in other places, such as right clicking on the map view:



And also in the model view:



# **Station Dialog**

Each station dialog's position page has an additional field to specify which celestial body this station is defined relative to. Here it is possible to select a new celestial body:

Ground Station	I							$\times$
Position Tra	und Station	d		Add antennas	•	Delete	Duplicate	
Celestial	Body:		Earth Sun Mercury		~			
Latitude:	0.0	deg	Venus			10.0	m	
Longitude:	0.0	deg	TMars			0.0	m	
	positive East		Jupiter Saturn Uranus Neptune Pluto Moon					
				ОК	(	Cancel	Apply	

Note there are checks that the celestial body and station type are compatible. For example, selecting Jupiter here will result in the following error:

Visualyse Interplanetary Problem	×
Problem: Invalid Celestial Body for this Station type	
Explanation:	
The Celestial Body must be valid for the given Station type. For example, The RB of a Ground, Fixed or Mobile station must have ground, while the RB of a Maritime Station must have seas and the RB of an Air Station must have an atmosphere	
Suggestion:	
Select a different Celestial Body	
Close Help	

The location of each station is converted into position and velocity vectors relative to the selected celestial body. These are then converted into a common J2000.0 coordinate system which is sun centred using the mean equatorial plane.

These vectors are visible in the watch window:

TN.ISIM:3			×
<ul> <li>Modify Watches</li> </ul>			🗅 Сору
Variable	Value	Units	
Ground Station			
* Position			
* Traffic			
Advanced			
Orientation			
Cartesian position vector			
х	5730.185449	km	
У	2800.993804	km	
Z	-12.945702	km	
r	6378.147	km	
Cartesian velocity vector			
Solar coordinates position vector			
x	-132755521.983	km	
У	-64442179.7142	km	
Z	-27935324.3589	km	
r	150190563.9192	km	
Solar coordinates velocity vector			
* Frame			

Satellite position and velocity vectors can be loaded via a CSV file to allow more advanced orbit types to be modelled including interplanetary transfer and halo orbits. The general satellite dialog (below) also allows the reference frame for the equator to be defined and includes a tool to create Sun synchronised orbits:

General Satellite		×
General Satellite       ▼       Orbit     Traffic	Ac	Id antennas   Delete Duplicate
Celestial Body:	Earth	~
Orbit Model:	Point Mass plus J	2 ~
Semi-major axis	7000.0	km
Eccentricity (e):	0.0	
Inclination (i):	57.29578	deg wrt: Planet frame $\vee$
Argument of perigee (w):	0.0	deg
True anomaly (v):	0.0	deg
Longitude Ascending Node $\qquad \qquad \lor$	0.0	deg
,	Advanced	Set Sun Synchronised
Lo	ad Vectors	
		OK Cancel Apply

The figure below shows the Sun synchronous tool dialog:

Set Sun Synchronised		×		
Repeating track:	$\checkmark$			
Number of orbits:	16	Valid		
Days for these orbits:	1	Valid		
Semi-major axis:	6646.291474	km		
Inclination:	96.585416	deg		
Longitude of ascending node:	0.0	deg		
Date and time satellite at equa	ator for this longitude:			
Date:	18/04/2023 💌			
Time:	12:00:00.000			
Set	Orbit to This			
Close				

#### **Station Wizards**

These are celestial body aware: in most cases this is set via the template station (or, where available, an existing station). The preview window updates to reflect the celestial body in question e.g. default colour and whether to show country borders.

Note that when the Constellation Wizard uses an imported TLE file it is only applicable for Earth. The TLE import also uses the full SGP4 / SDP4 orbit prediction code.

#### **Import Tools**

The following approaches have been used when updating the import tools:

- SRS import: has to be Earth
- Terrestrial import: has to be Earth
- Import non-GSO: select via the satellite properties
- FS import: has to be Earth
- TX import: additional field to define celestial body
- RX import: additional field to define celestial body.

#### **Propagation Models and Terrain Data**

Most propagation models are only applicable for either terrestrial paths or Earth to space paths. The exception is free space path loss and the Extra Models (fixed loss and fixed loss / km) which are applicable for all paths. Earth to space paths that go from Earth to another planetary body e.g. Mars would only use those models at the Earth end of the link.

Terrain data and path profiles only work on terrestrial paths on Earth.

### **Doppler Shift**

Features allow Doppler shift to be activated and included in the simulation:

Simulatio	on Settings	$\times$
Name	and Description	
	Name:	
	c:\temp\tn.isim	
	Description:	
	Radio Interference Simulation	
	$\sim$	
	ISIM file last saved with Visualyse Interplanetary version:0.0.14.2	
Dopple	er effect	—
	Include Doppler shift:	
Rando	misation	
	Maintaining the same random number seed will produce the same results every time the simulation is run. If you change the seed, the random elements of your simulation will produce different results.	
	Random number seed = 12345678	
	OK Cancel	

There are additional fields visible in the watch window that show how the various frequencies involved available in the Link Transmitter and Receiver objects:

😞 Simple doppler.ISIM:4			×
+ Modify Watches			Сору
Variable	Value	Units	
TTC DL.(start-end).Transmitter			
± Station	General Satellite		
Power Type	Fixed power level		
Transmit Power	-10.0	dBW	
Wanted transmit frequency	2.1	GHz	
□ TTC DL.(start-end).Receiver			
± Station	Ground Station		
Noise Figure	3.0103	dB	
Calculate Rain Noise	False		
System Noise Temperature	300.0	К	
Wanted receive frequency	2.1000473	GHz	
Wanted listen frequency	2.1	GHz	
Wanted bandwidth adjustment	-3000.0	dB	

There can be large differences in frequency if Stations are moving relative to each other. Hence many systems adjust their transmit or receive frequencies to automatically adjust. In Visualyse Interplanetary, this can be modelled by using one of the following two options:



In cases where there is no adjustment of the transmit or receiver frequency, there can be reduction in the wanted receive signal. This can be modelled using the net filter discrimination (NFD) of the wanted transmit spectrum mask and receiver filter, such as in this example:



# Time Dialog

There have been minor changes to the time dialog:

- 1. It is emphasized that all times are UTC
- 2. There is an option to define the start time as a Julian date
- 3. An option has been added to default the station creation time to be the start time.

The new dialog is shown below.

Simulation Run Time		$\times$
Start Time Begin on:	18/04/2023 at 12:00:00.000	
:01	2400053.000000	
limestep Resolution	n —————	
Step size:	00:01:00.000 = 1 min	
Run Duration		
✓ Time steps:	1000	
Elapsed time:	16:40:00.000	
End time:	19/ 04 /2023 • at 04:40:00.000	
Station Creation Tir	ne ————	
Station creatio	n time the same as start time	
18/ 04 /2023	▼ at 12:00:00.000	
All times UTC	OK Cancel	

## Map and 3D View

These have an additional tab to define parameters related to the celestial body. Each of the overlays is checked to ensure it is compatible with the selected celestial body. Hence it is possible to specify these for multiple celestial bodies, but only the one(s) for the selected celestial body will be shown. This makes it easier to switch celestial body in the view without changing overlays:

Map View Properties	×
Scheme: <no available="" schemes="">       S         CB       Features       Adornments       Overlays       Path         The following overlays have been defined in Visualyse this view:       S</no>	ave as Delete Profiles Countries e. Select which ones you wish to see in
Terrain Regions     Land Use Regions     User Defined Overlays     Grids     JD Map (Legacy)     D Map     Capital Cities of the World     World Map     Lunar Map 4k     Jupiter Map     Lunar Map     Stars     Mars Map High Res     Mars Map     Melbourne Area	Transparency Transparency 0 100%
OK Cancel Apply	Help

Countries etc. are only visible when the selected celestial body is Earth. The 3D viewpoint option is now defined as "fixed inertial viewpoint". The 3D view also shows links to other celestial bodies.

## **Example Simulation**

This simulation shows a ground station on Earth selecting a satellite from a constellation around Mars. The constellation around Mars is also communicating with a lander on the moon Phobos.



#### **Libraries Used**

Components from the following libraries are used by Visualyse Interplanetary:

Project Pluto:

https://www.projectpluto.com/

Standards of Fundamental Astronomy (SOFA):

https://www.iausofa.org/

Revisiting Spacetrack Report #3:

https://www.celestrak.com/publications/AIAA/2006-6753/

#### **Further Development**

Visualyse Interplanetary is intended to operate in parallel with Visualyse Professional as a separate install.

Further development of both products will take account of feedback from users. Please contact us for more information.

#### **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

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## Visualyse Interplanetary

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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.

Ele Edit VisualyseG	su Helo									sea کر	een quan+op	ψ - # ×
		DC SBE SF	PM									•
ific2983.mdb			Overlaps with INMARSAT-8-73E						Beam Overlaps			
		Q	V USGOVSAT-10	336-21 %	Separation = 13.0 deg				USD3 of INMARSAT-6-73E -+ TR	BR of USGOVSAT-10		
CHEVEN			T AS VICTIM	336.21 %								Q → Q 📀
			▶ ! Downink (20.200000 - 21.200000)	336.21 %	Outside Coordination Arc by 5.0 deg		32 beam pars	Detailed Coordinate				7
CITEMEN CITEME			> Uplink (30.000000 - 31.000000)	24.73.%	Dutside Coordination Arc by 5.0 deg		32 beam pairs	Detailed Coordinate				
		>	V AS INTERFERER	342.47 %					1			
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			> Upink (30.00000 - 31.00000)	8.07.%	Dutede Coordination Arc by 5.0 deg		32 beam pars	Detailed Coordinate	1	10 MG	A.C.	-000 SA
			V USGOVSAT-8	11.99 %	Separation = 85.0 deg					Mar Sh		
	C.C		V AS VECTER	11.99 %					1	01-1	North 1	
			Downlink (20.200000 - 21.200000)	11.99 %	Duteide Coordination Arc by 77.0 deg		32 beam pairs	Detailed Coordinate				
				1.75 %	Dutade Coordination Arc by 77.0 deg		32 beam pars	Detailed Coordinate	1		· · · · · · · · · · · · · · · · · · ·	
			▼ ✓ AS INTERFERER	5.08.%					1			
			► J Downlink (20.200000 - 21.200000)	5.08 %	Dutade Coordination Arc by 77.0 deg		32 beam pairs	Detailed Coordinatio				
			> √ Uplink (30.000000 - 31.000000)	0.57 %	Outside Coordination Arc by 77.0 deg		32 beam pairs	Detailed Coordinatio				
			V USGOVSAT-12	11.75	Separation = 102.0 deg				1			
			V AS VECTER	11%					1			
			Downlink (20.200000 - 21.200000)	11.55	Outside Coordination Arc by 94.0 deg		32 beam pairs	Detailed Coordinate	1			
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			V 🖌 AS INTERFERER	4.05 %					Coordination Trinsor			
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			► J Ublink (30.000000 - 31.000000)	0.53 %	Outside Coordination Arc by 94.0 deg		32 beam pairs	Detailed Coordinate	Interfering Network	INNARSAT-6-73F		
Interference direction(s)	hy Networks <-> Coordinating ~	Sort by Ranking v	V USGOVSAT4R	9.92.%	Separation = 125.5 deg				Administration	6		
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MADAR-47.5E UKE	WantDT/T < 1.516.%	161612	∀ √ AS INTERFERER	4.22 %					Dated	01 November 2022		
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5E-KA-83.5E NOR	West DT/T < 72.53 %	151511 (872			12.0 18.25 10.1825	19.5 19.95 20.7			Notice ID	110500139		
SE-KA-83.5E NOR	WantDTIT CTT53 %	151511 (ME			KAD2 / G. K7GD. KAD	KAD / O_ GKAD / GKAD			Orbital Location	60.00 deg E		
USGAE-25A USA	West DT/T K 67.12 %	260123			K7GD / /KA /K7 / K7 / K7GD / GEAD	USD3 / KAD4 / USD4 / KAD3			Orbital Separation	13.00 deg		
5 FM36-21.5E /	Want DT/T < \$9.68 %	31.05/22 08			17.95 18.15 18.3 18.5 18.7 19.05	20.15 20.7			Overlap Frequency	20.200000-21.200000 GHz		
AMS-CB-113E IR	WashDT/T < 53.13 %	260123							Coordination Arc Trigger     Coordination for Exists	Var		
INMARSAT-4-98W-R	G West DT/T < 22.93 %	010622							Size of Arc	8.0 deg		
ASIASAT-AAA CHI	Want DT/T 5 18 18 %	19/14/11							Inside Coordination Arc	No		
F-SAT-N10-39W /	Want DT/T < 16.85 %	02/06/22 CR							v DT/T Trigger			
5-SAT-N10-3E /	Water DT/T 4 12:32 N	010622							Interfering Group	122657030 20.200000 GHz		
CHINASAT-D-87.5E	NN WatEDT/T < 12/69 %	260123 NTF							Emission	4K98G7W		
F-SAT-N10-162W =	WassEDT/T < 9.41 %	170622 CR							Satelike	INMARSAT-6-73E		
AMS-87-13.8E	WentDT/T <9.54%	170015 NTF							Satelite Location	73.00 deg E		
AMS-87-13.8E ==	Want DT/T < 9.54 %	170015 MTF				17/03/05 [7]			▼ Satelite Off-axis Gain	43.00 dBi		
✓ F-SAT-N10-9E F	WestDT/T < 5.5 %	020622				26.7			Deam	0503		
✓ F-SAT-N10-10E /	Want DT/T < 4.88 %	3105/22 08				The Probability of the Probabili			Antenna Sidelobe Type Satellite Beak Galo	Using peak gain 43.00 dtu		
F-SAT-N10-84W F	West DT/T < 1.93 %	170622							Satellite Off-axis Angle	2.29 deg		
AMS/CB/113E IS	Na Frankastriv Osoriaa	28-11/15 INTE	USGOVSAT-10 (victim) KA 1					Show Priorities	<ul> <li>Freespace loss</li> </ul>	209.89 d8		
	No Forestative Overlag	2601/23 NTF							Detance	339978.14 km		
	the confidence consult.	Louis And										Report

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

SASAT-24Q into VENESAT-1 (dow	mlink).dgso - Detailed Coon	dination									P Search	(Ctrl+Q)	<b>Q</b> -
Edit View Tools Help													
oup by: Beam Pair 🔹 🔹	(VES *)	-) (IES	* • V Emission	* Of I Emission	v) (+						SBE 📄	89 .	20
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▶     Emission 48K6G1	w •			10	20.0	-3.952	v Tx Gain dB	16	38		17-00		
h I Desiration Fortering					20.0	2 0 20	Beam	K2R	ткі		0		
P 1 Emission SOKOF3					20.0	-3.929	Boresight	N6.8303 W65.7465	N/A				19
VEmission 6M95G7W	5. <b>*</b> 2			9.9	20.0	-3.947	Radiation Pattern	REC-672 Un25	From GIMS		The second		
► 1 V Emission: 36M0F3F				57/60			Beamwidth deg	1.5	6.69		×	VV	
► LIES TYPICAL-K1 .				84/100	20.0	6.019	Gmax dBi	41	28		K2R		
				315/352	70.0	4.000	Crel de	.25	4-1			1 Strong	
P TYES THREE SAME				202.000		14.000	T FIRP dBW	17.7	9.9		12 4		
VES TYPICAL 3.0M				343/368	20.0	-4.003	Peak Density dBW/Hz	-32.07	-13.16	11			
Beam Pair: TK2 -+ K2R ·				2729/2868	20.0	-13.317	Offaxis Density dBW/Hz	-57.07	-33.16	15	1		
							Pathloss dB	205.07	205.06				
ASA1-24Q VENESALD	N						v PFD dBW/m2/Hz	-219.31	-195.39				
Name Gain Pattern	Peak Gain (dBl)			Id: 100520145 Adm	nin: URG Pos	c -78.00 W	Spreading Loss dB	162.24	162.22				
KZR REC-672 LINS	* 41.00						Elevation Angle deg	60.64	61.78		( ))	0	
FAMS CIR GEL KIR KR	KA1R						* Rx Gain dB	52.6	30.45		1.5		
							15	TYPICA	L 4.5M				
			0				Radiation Pattern	MJ.696	/ W53.14/0				
		_	u Const				Beamwidth deg	0.42		ANALYSIS			
313 1014			c'y want		0 -	0	Gmax dBi	52.6				~ ~ ~ ~ ~	
				0	Q -0	- Q	Angle deg	0.00	1.15	Constate 0	CONTOURS DETRIL -		
	V V V	V V	V V V				Grel dB	0.00	-22.15				_
		11.700 - 12	200				Rx power dBW	-134.77	-164.7	Constraints	(,		<u> </u>
		Consection of					INTERFERENCE						
1d = 100601746	Show	vasets for all bear	TIS W				⊤ 1 dBW	-133.79		VENESAT-1 (Victim)			
e TYPICAL 4.5M				Name	36M0F3	F	Adjustments dB	30.92		1 Z Gain Pattern set to III-855	80-6 for: TYPICAI 1.8M on F	leam: K2R in Group: 10060	1742
Typical	EAF	TH STATIONS	EMISSIONS	Designation	36M0F3	F	Bandwidth Adjustment dB	30.92		2 Z Boresight set to 1at 6.8 Long	-65.7 for Beam: K2R on : VE	NESAT-1	
e (K) 100.00	TYP	ICAL 1.8M		Min Pwr (dBW)	-6.30		Polarisation Loss dB	0.00		3 Gain Pattern set to ITH-R S.6	72-4 (Ln -25) for Beam: K2P a	n : VENESAT-1	
tude (deg) N/A	TYP	ICAL 2.4M	1M21G7W	Max Pwr (dBW)	1.70	1	Aggregation dB	0.00		The state of the s	ner of the second her of		
gitude (deg) N/A	TYP	ICAL 3.0M	1M74G7W	Min Density (dBW/Hz	) -72.30		Aggregation Factor	I		Interference Cases			
k Gain (dBi) 52.60	TYP	ICAL 3.7M	OPP/SG/W	Max Density (dBW/Hu	:) -61.30		C dBW	-134.77		4 🗹 Polarisation set to 3.00 dB for	I Beam Pair: TK1 -+ K2R and	25M7G1W into 28M8G7W	
inwidth (deg) 0.42	Түр	ICAL 4.5M	20MBG/W				≠ C/I d8	-0.98		5 S Aggregation Factor set to 1.	.0 for Beam Pair: TK1→K2R a	and 25M7G1W into 28M8G	57W
diation Pattern REC-465 *	TYP	ICAL 7.0M	N. WHOL				Threshold dB	20					

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

# 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 and 9.7B cases.

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.



The Visualyse EPFD software is also capable of undertaking analysis using the methodology in Resolution 770 and includes methods being proposed for inclusion in a revision to Recommendation ITU-R S.1503, such as the Alpha Table Methodology.

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.

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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
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