Resolution 169 Analysis in Visualyse

Abstract: Two of the Agenda Items (AIs) at the forthcoming World Radiocommunication Conference 2023 (WRC-23) meeting relate to the operation of Earth Stations in Motion (ESIMs), namely AI 1.15 and AI 1.16. One of the issues to address under these AIs is the protection of terrestrial services and Resolution 169 (WRC-19), contains PFD limits that aeronautical ESIMS must meet to ensure that protection. This Technical Note (TN) describes how it could be verified that an aeronautical ESIMS meets these PFD limits using analysis undertaken with either Visualyse Professional or Visualyse Interplanetary.

Introduction

Requirements for the provision of broadband services to users on aircraft has led to a regulatory framework for ESIMs, whereby aeronautical stations operate within the Fixed Satellite Service (FSS) while in motion. Typically, a standard FSS Earth Station (ES) would be located at ground level at a fixed location and the regulatory framework had to be modified to take account of mobile operation and at a greater altitude. In particular, operation at this height leads to much greater distances over which there could be harmful interference, and operation on aircraft could lead to transmissions in international airspace rather than within the jurisdiction of a single administration.

Resolution 169, approved at WRC-19, covers "Use of the frequency bands 17.7-19.7 GHz and 27.5-29.5 GHz by earth stations in motion communicating with geostationary space stations in the fixed-satellite service". The uplink bands of 27.5 - 29.5 could also be used by terrestrial stations in the Fixed and Mobile Services and protection is covered by this Resolves (amongst others):

1.2.2 transmitting aeronautical and maritime ESIMs in the frequency band 27.5-29.5 GHz shall not cause unacceptable interference to terrestrial services to which the frequency band is allocated and operating in accordance with the Radio Regulations, and Annex 3 to this Resolution shall apply;

Part II of Annex 3 to Resolution 169 contains the following PFD masks for aeronautical ESIMS:

3.1 When within line-of-sight of the territory of an administration, and above an altitude of 3 km, the maximum pfd produced at the surface of the Earth on the territory of an administration by emissions from a single aeronautical ESIM shall not exceed:

$$\begin{array}{ll} pfd(\theta) = -124.7 & (dB(W/(m^2 \cdot 14 \ MHz))) & for & 0^\circ \le \theta \le 0.01^\circ \\ pfd(\theta) = -120.9 + 1.9 \cdot log\theta(dB(W/(m^2 \cdot 14 \ MHz))) & for & 0.01^\circ < \theta \le 0.3^\circ \\ pfd(\theta) = -116.2 + 11 \cdot log\theta \ (dB(W/(m^2 \cdot 14 \ MHz))) & for & 0.3^\circ < \theta \le 1^\circ \\ pfd(\theta) = -116.2 + 18 \cdot log\theta \ (dB(W/(m^2 \cdot 14 \ MHz))) & for & 1^\circ < \theta \le 2^\circ \\ pfd(\theta) = -117.9 + 23.7 \cdot log\theta & (dB(W/(m^2 \cdot 14 \ MHz))) & for & 2^\circ \\ < \theta \le 8^\circ & \\ pfd(\theta) = -96.5 & (dB(W/(m^2 \cdot 14 \ MHz))) & for & 8^\circ < \theta \le 90.0^\circ \end{array}$$

where θ is the angle of arrival of the radio-frequency wave (degrees above the horizon).

3.2 When within line-of-sight of the territory of an administration, and up to an altitude of 3 km, the maximum pfd produced at the surface of the Earth on the territory of an administration by emissions from a single aeronautical ESIM shall not exceed:

$pfd(\theta) = -136.2$	$(dB(W/(m^2 \cdot 1 MHz)))$	for	$0^\circ \le \theta \le 0.01^\circ$
$pfd(\theta) = -132.4 + 1.9$	$\cdot log\theta(dB(W/(m^2 \cdot 1 MHz)))$	for	$0.01^\circ < \theta \le 0.3^\circ$
$pfd(\theta) = -127.7 + 11$	$\cdot \log\theta (dB(W/(m^2 \cdot 1 MHz)))$	for	$0.3^\circ < \theta \le 1^\circ$
$pfd(\theta) = -127.7 + 18$	$\cdot \log\theta (dB(W/(m^2 \cdot 1 MHz)))$	for	$1^\circ < \theta \le 12.4^\circ$



2 | P a g e

$$pfd(\theta) = -108$$
 $(dB(W/(m^2 \cdot 1 MHz)))$ for $12.4^{\circ} < \theta \le 90^{\circ}$

where θ is the angle of arrival of the radio-frequency wave (degrees above the horizon).

Resolves 1.2.5 of Resolution states that:

1.2.5 for the application of Part II of Annex 3 as referred to in resolves 1.2.2 and 1.2.4 above, BR shall examine the characteristics of aeronautical ESIMs with respect to the conformity with the power fluxdensity (pfd) limits on the Earth's surface specified in Part II of Annex 3 and publish the results of such examination in the BR IFIC;

But how is that examination to be undertaken?

Analysis Methodologies

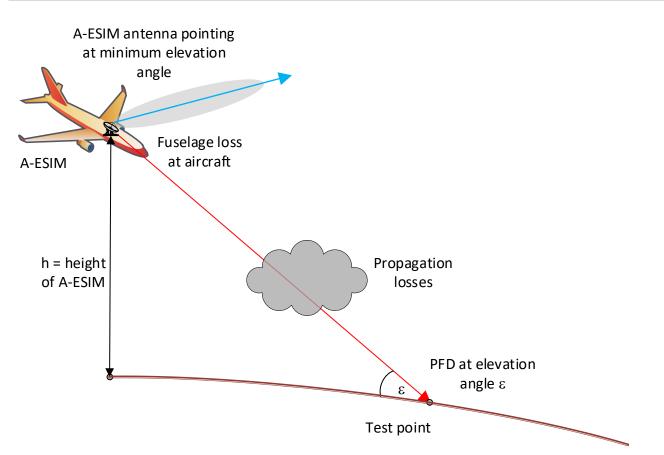
A Preliminary Draft New Recommendation (PDNR) is under development within WP 4A with the intention of providing a methodology by which the BR could examine the characteristics of aeronautical ESIMs (A-ESIM) to determine if they conform to the PFD limits in Annex 3 of Resolution 169. While this work is still ongoing, a useful document is the Report of the Correspondence Group (CG) on this topic in document WP 4A/883. This document also contains a draft methodology in Annex 3. The approach taken in this document is to work backwards from the PFD to the maximum EIRP that would be consistent with these limits, taking into account A-ESIM parameters such as:

- Antenna peak gain
- Gain pattern
- Carrier bandwidth
- Carrier power density
- GSO satellite longitude.

The analysis considers factors such as gaseous attenuation calculated using Rec. ITU-R P.676 and fuselage attenuation.

An alternative approach would be to calculate the PFD on the ground from an A-ESIM and compare it with the PFD thresholds for the relevant elevation angle= ε , and this approach is consistent with the calculation engine in Visualyse Professional and Visualyse Interplanetary and so is used in this TN.

The starting point is a simplified scenario as shown in the figure below:



In this analysis:

- An A-ESIM is operating at a height of *h* km above sea level
- The A-ESIM has an antenna that is pointing at its minimum elevation angle in the direction of the test point
- The A-ESIM antenna has a peak gain and gain pattern
- The A-ESIM carrier has defined (frequency, bandwidth, transmit power)
- The A-ESIM antenna is at the top of the aircraft and there can be fuselage loss towards points on the ground
- The PFD and elevation angle = ε is calculated at a test point and compared against the thresholds in Resolution 169 for an A-ESIM at height = *h*
- The geometry between the A-ESIM and test point is varied to check a range of elevation angles from 0° to 90°.

The PFD(ϵ) is calculated as follows:

$$PFD(\varepsilon) = P_{Tx} + G_{tx,peak} + G_{tx,rel} - L_f - L_{676} - L_s(d_m)$$

Where:

 P_{tx} = transmit power in dBW in the A-ESIM carrier, with bandwidth less than the 14 MHz reference

 $G_{tx,peak}$ = peak gain at A-ESIM in dBi

 $G_{tx,rel}$ = relative gain at A-ESIM towards test point in dB

 L_f = fuselage loss at A-ESIM in dB

 L_{676} = gaseous attenuation calculated using Rec. ITU-R P.676 in dB

 $L_s(d_m)$ = spreading loss from A-ESIM to test point in dB

 d_m = distance from A-ESIM to test point in metres

The spreading loss can be calculated using:

$$L_s(d_m) = 10 \log_{10}(4.\pi.d_m^2)$$

The next section describes how this analysis can be undertaken using Visualyse tools.

Analysis in Visualyse Tools Calculation of PFD vs Elevation Angle

Visualyse can be used to calculate PFD vs. the elevation angle at which it is being received. One way to do this is shown in the simulation file shown in the figure below:

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The simulation contains the following elements:

A-ESIM

- Aeronautical Station located at a (lat, long) = (0°, 0°) and height of 10 km with an Antenna pointing at an (az, el) = (90°, 20°), where 20° is assumed to be the minimum elevation angle
- Antenna Type using the gain pattern in Rec. ITU-R S.580 with dish size 0.6m and efficiency of 0.6

Test Point

- Mobile Station located at a (lat, long) = (0°, 0°) and moving in direction 90° with speed 10m/s using an Antenna pointing at the A-ESIM
- Antenna Type using the PFD Area gain pattern which converts the wanted signal into a PFD

Link-1

• From the A-ESIM to Test Point

- Carrier = 6 MHz
- Power = -61 dBW/Hz \Rightarrow 6.8 dBW in the carrier bandwidth
- Propagation model = free space path loss plus Rec. ITU-R P.676

Link-2

• As for Link-1, but adding the fuselage loss model described below.

The run was 600 time steps of 1 minute and the following windows were opened:

- Model view to show the components of the simulation
- Map view to show the location of the A-ESIM and test point
- Table view showing the link budget calculations
- Plots of PFD vs elevation angle for the two cases, Link-1 and Link-2, compared against the Resolution 169 PFD limits (defined via a Marker array).

The fuselage attenuation model was the following:

$L_{fuse}(\gamma) = 3.5 + 0.25 \cdot \gamma$	dB	for	$0^{\circ} \le \gamma \le 10^{\circ}$
$L_{fuse}(\gamma) = -2 + 0.79 \cdot \gamma$	dB	for	$10^{\circ} < \gamma \le 34^{\circ}$
$L_{fuse}(\gamma) = 3.75 + 0.625 \cdot \gamma$	dB	for	$34^{\circ} < \gamma \le 50^{\circ}$
$L_{fuse}(\gamma) = 35$	dB	for	$50^{\circ} < \gamma \le 90^{\circ}$

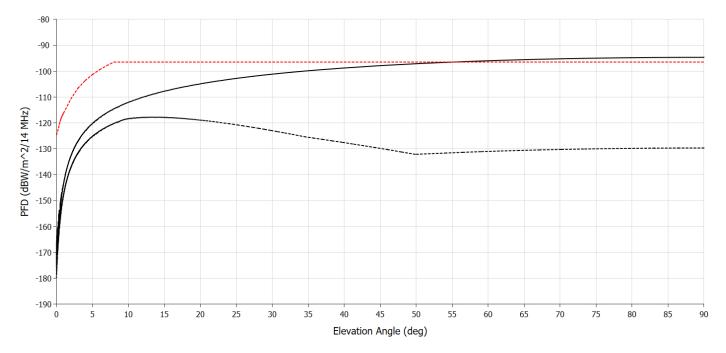
This was modelled in Visualyse by including an elevation dependent clutter loss (i.e. we make use of the "Clutter loss by elevation" model to define the elevation angle dependent fuselage attenuation required here) as in the figures below:

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Tx Model: Clutter loss by elevation ~ Edit table	
Rx Model: None ~	
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Elevation angle (deg)	Clutter loss (dB)	
-90.0	35.0	
-50.0	35.0	
-49.0	34.375	
-48.0	33.75	
-47.0	33.125	
-46.0	32.5	
-45.0	31.875	
-44.0	31.25	
-43.0	30.625	
-42.0	30.0	
-41.0	29.375	
-40.0	28.75	
-39.0	28.125	
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The resulting PFD vs elevation angle for the two cases are shown in the figure below:



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It can be seen that the Resolution 169 PFD limits are exceeded at high elevation angles in the case where no fuselage loss is included (solid line) but met for all elevation angles when fuselage loss is included (dashed line).

This approach could be automated to check many configurations in a filing (e.g. A-ESIM gain patterns, beamwidths, powers) by using the Visualyse text file format and batch mode.

Calculation of PFD over an Area

In the example above, the gain pattern was the same in all azimuths, hence its only necessary to calculate how the PFD varies by elevation. However, in some circumstances the PFD can vary by azimuth and elevation – for example, there could be asymmetric gain patterns or a non-GSO system could have a minimum elevation angle that varies by azimuth.

In this case it is possible to calculate the PFD over an area and then display the results using the Area Analysis tool. One point to consider is how to show the results, as simply plotting PFD won't be sufficient as the threshold varies by elevation angle. One way to handle this in Visualyse is to add an elevation angle dependent clutter loss that is the same as the PFD threshold, and hence the wanted signal i.e. the PFD plotted is actually the margin compared to the Resolution 169 thresholds.

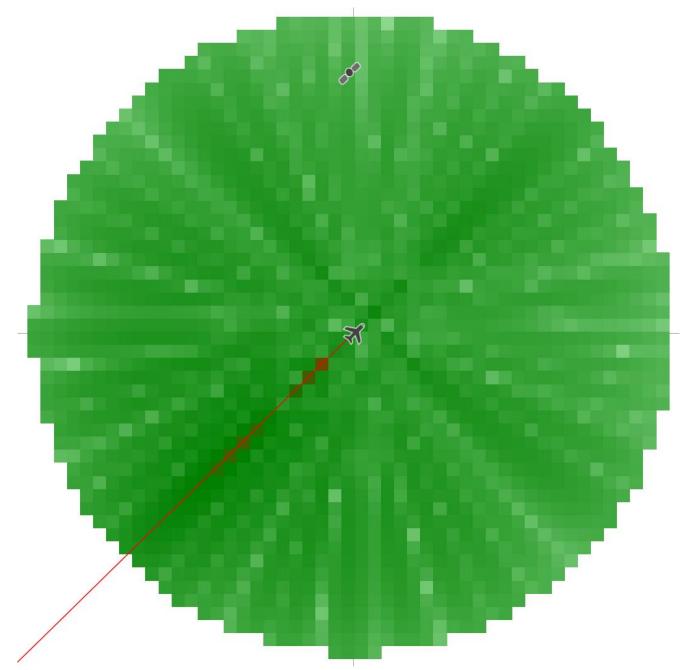
Elevation angle (deg)	Clutter loss (dB)	^
0.01	-124.7	
0.3	-121.89347	
0.4	-120.57734	
0.5	-119.51133	
0.6	-118.640336	
0.7	-117.903922	
0.8	-117.26601	
0.9	-116.703332	
1.0	-116.2	
2.0	-110.78146	
3.0	-106.592226	
4.0	-103.631178	
5.0	-101.334411	\checkmark

An example elevation dependent clutter table is shown below:

Area PFD Plots for an A-ESIM communicating with a non-GSO System

Consider the case of an A-ESIM communicating with a non-GSO constellation using a beamforming antenna. This could result in PFDs that vary in azimuth and also elevation as beamforming antennas can generate gain patterns that are not monotonically decreasing. The resulting PFD depends upon the positions of the satellites and the various sidelobes of the beamforming antenna, and hence can vary over time. To get the maximum PFD possible at each location it is therefore necessary to undertake a simulation over multiple time steps and constellation configurations.

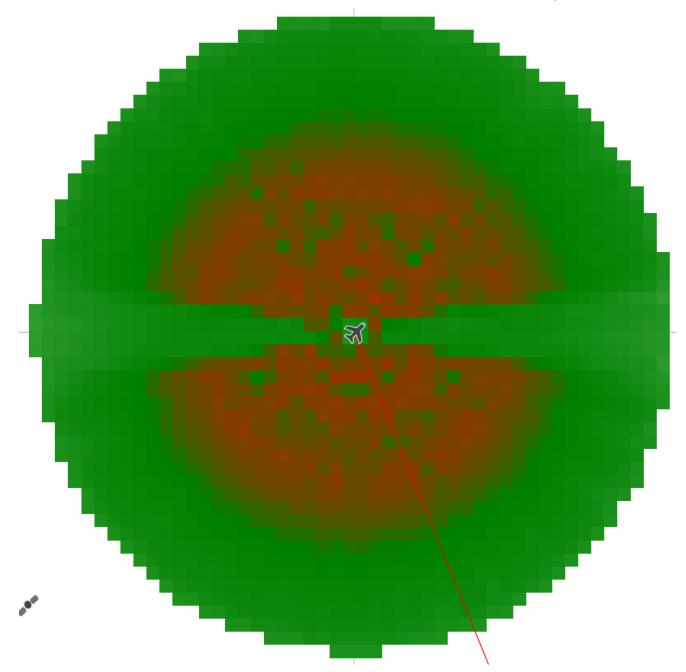
In the example below, where the antenna is modelled using Rec. ITU-R M.2101, the A-ESIM's PFD margin against threshold is shown for a single time step, where an A-ESIM located on the equator is communicating with a satellite towards the south-west:



The peaks and troughs of the M.2101 gain pattern can be seen around the A-ESIM, and a zone of higher PFD in the direction of transmission.

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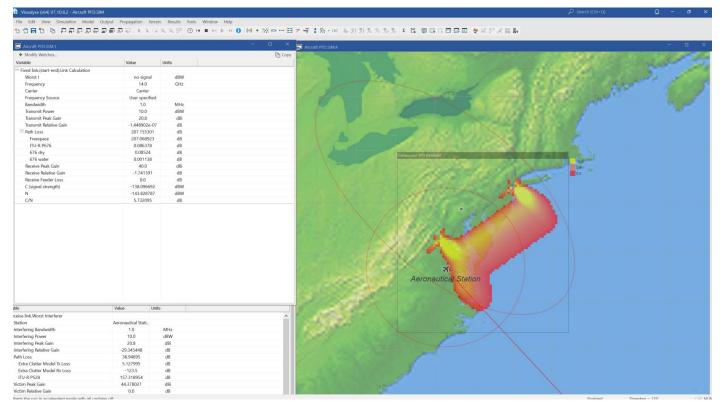
This analysis can be repeated for many different constellations positions to determine the highest PFD at each pixel of the Area Analysis (AA) after one-thousand time steps, as shown in the figure below:



The PFD margin over threshold can be seen to be lowest (and possibly over) for a range of elevation angles, but with a distinct zone in the middle where the PFD is much lower. This zone reflects the GSO arc exclusion zone, as the A-ESIM cannot point towards a non-GSO satellite that could result in its antenna also pointing towards the GSO arc. In this case the A-ESIM is on the equator, so the exclusion zone is along the east-west line below the aircraft. The geometry of this zone varies by latitude, so the PFD analysis might have to be repeated multiple times.

Area PFD Plots for an A-ESIM Travelling along a Coastline

This Area Analysis approach would also allow the modelling of the maximum PFD margin over an area such as a seaboard as an A-ESIM flies along the coastline. An example of this is shown below:



Use in Visualyse Interplanetary

Note that these features are available in both Visualyse Professional or Visualyse Interplanetary and hence could be used to analyse A-ESIMs features around other celestial bodies, for example as part of regulatory regime for aircraft flying on Mars!

Consultancy Support

We can also use our Visualyse tools to undertake studies relating to ESIMS for ITU-R studies and to support regulatory and licensing activities.

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

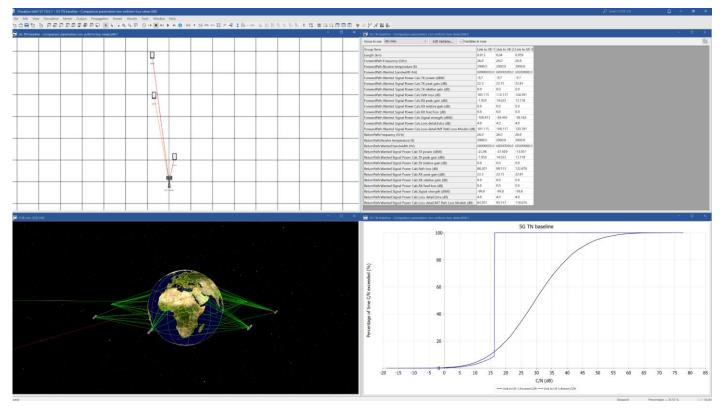
These are described further below.

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:

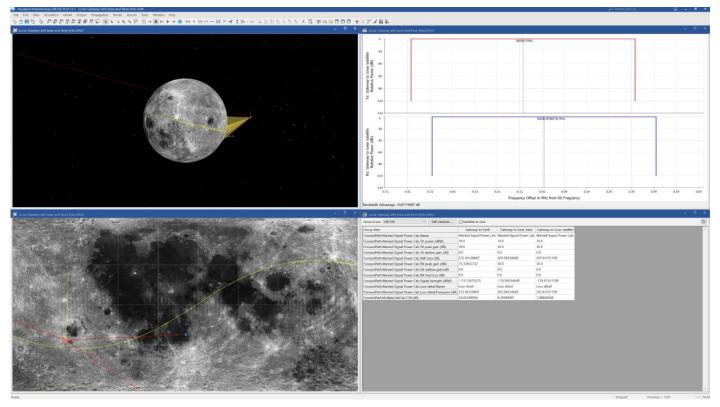


Visualyse Interplanetary

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

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- 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.

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		738	▷ J Downink (20.300000 - 21.200000)		Dutade Coordination Arc by 14.0 deg			Detailed Coordinate	Coordination Trigger			
1.11.1.1.1.1			> ✓ Uplink (30.000000 - 31.000000)		Dutside Coordination Arc by 94.0 deg			Detailed Coordinate	Networks Interfering Network	INMARSAT-6-73E		
Interference direction(s) My Networks <	> Coordinating -	Sort by Ranking ~	T I USGOVSATAR	9.92.55	Separation = 125.5 deg		a company (ocardo coso a rate	Administration	G		
when V Inside Arc (++) Or V				9.97.55	Separation = L25.5 deg				Notice ID	122520065		
(Pess) (Fall) (GSO) (NGSO) (No Geo									Notification Type	c		
			Downlink (20.200000 - 21.200000)		Outside Coordination Arc by 117.5 deg			Detailed Coordinatio	Orbital Location IRE Publication	73.00 deg E CRIC/5259		
MADAR-47.5E UNE	West DT/T < 1.51K %	10/10/12	▷ ✓ Uplink (30.000000 - 31.000000)		Outside Coordination Arc by 117.5 deg		32 beam pairs	Detailed Coordinatio	Dated	01 November 2022		
USGAE-6A USA	(++) West07/T < 616.04 %	2601(2) NTP	∀ ✓ AS INTERFERER	4.22 %								
I INMARSAT-6-73E G	West 01/1 < 336.21 N	0109/22	🕒 🖌 finaniká – (20.300000 - 21.300000		Duttide Coordination Arr In: 112.5 dec.			Detailed Coordinate	Victim Network	USGOVSAT-10		
SE-KA-83.5E HOR	West07/T < 77.53 %	111111 117	INMARSAT-6-73E (Interferer) 49980	7W				ର୍ 🛶 ଡ୍	Administration Notice ID	USA 110500139		
SE-KA-83.5E NOR	WestDT/T C 77.53 %	INTE			17.9 18,25 19,1875 19,5	19,95 20,7			Notification Type	N		
					KAD2 / G K7GD KAD (SKAD / O	GKAD / GKAD			Orbital Location	60.00 deg E		
USCAE-25A USA	Went DT/T < 67.12 %	201123			KFGD	20.1 01/06/22 20.7			Orbital Separation	13.00 deg		
1 FM36-21.5E /	Want DT/T K 59-58 %	31/05/22			17.95 10.15 10.1 10.5 10.7 19.05	212			Overlap Frequency	20.200000-21.200000 GHz		
AMS-C8-113E IRR	WaseDT/T < 53.13 %	26/01/23							Coordination Arc Frigger	Yes		
INMARSAT4-98W-R	Wast 07/7 < 22:93 %	010622							Size of Arc	8.0 deg		
ASIASAT-AAA CHN	WarshDT/T < 18.18 %	13/14/11							Inside Coordination Arc	No		
F-SAT-N10-JØW	Want DT/T < 16-85 %	60/06/22 CR							V DT/T Trigger			
F-SAT-N10-JE r	Went DT/T < 12:32 %	010622							Interfering Group Interfering Frequency	122857030 20.700000 GHz		
CHINASAT-D-87.5E CHN	WaterDT/T < 12/99 %	260123 NTF							Emission	4K98G7W		
F-SAT-N10-152W /	WassDT/T C 9.45 %	170622							Satelike	INMARSAT-6-73E		
AMS-87-13.8E	Www.DT/T < 9.54%	170015 NTF							Satelite Location	73.00 deg E		
AMS-87-13.8E ER						12703/05			Satelite Power	-41.90 dBW/Hz 43.00 dBi		
	Want DT/T K 9.54 %	170215				20.7			Satelite Off-aks Gain Beam	43.00-08		
✓ F-SAT-N10-9E	Want 07/T < 5.5 %	62/06/22 CR				DEDR / DEL / DECR / DEDR / T			Antenna Sidelobe Type	Using peak gain		
✓ F-SAT-N10-10E =	Want DT/T < 4.85 %	310522 08							Satelite Peak Gain	43.00 dB		
✓ F-SAT-N10-84W F	Warst DT/T < 1.93 %	170622							Satellite Off-axis Angle	2.29 deg 209.89 dB		
✓ AMS-C8-113E ===	No Trinquency Ovisiap	28/10/16 (NTF	USGOVSAT-10 (victim) KA 1					Show Priorities	Preespace loss Distance	35978.14 km		
ASIASAT-AAA ON	No Frequency Overlap	2601023 NTP	·····									Report
leady		land.										CAP NUM SCR
												Cree How SUNC

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

	nto VENESAT-1 (downlink).dgso - i	Detailed Coordination								P Search (Ctrl+Q) Q	- 8
le Edit View	r Tools Help										
Group by: Bean	Pair * • • • VES	*) ()(IES	* O V Emission	*) - I Emission	* +					se 🗃 🖻 😕 📟 🖌	0
ASAT-240 → VI	NESAT-1 11 703000 - 12 1980	00 GHz	Powers, Ma	x C, Max I OBW/1,2 / The	Habold 20.00	di K	Galculations		A A V Copy	Beam Overlaps	
DOWNLINK					lay All Only s	-	LINK BUDGETS	с	I	TK1 of USASAT-24Q → K2R of VENESAT-1	
DOWNLINK	Interference FIRE Media	EIRP Gain BW	S		hreshold • Wor	inter 1	v Satelite	VENESAT-1	USASAT-24Q	Q	- @
		LID Gail Dir	Pros Weather				Position deg	-78	-77	-	
▶ 1 IES	TYPICAL-K2 •			128/132	20.0 -4	.006	Emission	36M0F3F	24K3G1W		
* 11ES."	TYPICAL-K3 •			128/132	20.0 -4	006	Assignment GHz	11,725	11.718	TKI	
▶ ! V	Emission 28M8G7W .			54/55	20.0 -4	006	Polarisation * Group ID	M 100601746	M 96823372		
+ IV	Emission 52K1G7W .			4/4	20.0 -4	003	Group B/W MHz	50	30	The	
	Emission 1M21G7W .			4/4	20.0 -3	962	Allocated B/W MHz	36	0.0243	×	
							Occupied B/W MHz	30	0.0203		
•	Emission: 24K3G1W •			1/1	20.0 -3	962	* Tx Power dBW	1.7	1.9		
P.S.	Emission: 150KF3E •			-1/1	20.0 -3	957	Pwr Density dBW/Hz	-73.07	-41.16		
	Emission 48K6G1W .			1/1	20.0 -3	952	v Tx Gain dB	16	.8		
•	I Emission: SOKOF3E .				20.0 -3	929	Beam	K2R	TKI		
	Emission 6M95G7W .			9.9		947	Boresight Radiation Pattern	N6.8303 W65.7465 REC-672 1.025	N/A From GIMS		63
							Beamwidth deg	REC-672 UN25	6.69		N.
► ! V	Emission: 36M0F3F			57/60	20.0 -0	984	Gmax dB	41	28		
▶ 11ES."	TYPICAL-K1 •			84/100	20.0 6	.019	Angle deg	2.14	4.1	K2R	
. I VES TH	PICAL 3.7M ·			333/365	20.0 -4	006	Grel d8	-25	-20	AD AT AM	
VES TYP	1CAL 3.0M .			343/368	20.0 -4	003	T EIRP dBW	17.7	9.9		
							Peak Density dBW/Hz	-32.07	-13.16		
Beam Pair: TK	2 K2R •			2729/2868	20.0 -13	317	Offaxis Density dBW/Hz	-57.07	-33.16		
	VENESAT-1				8	0	Pathioss dB	205.07	205.06		
Name	Gain Pattern Peak Gai	n (dBi)		Id: 100520145 Admin	URG Post -78	.00 W	v PFD dBW/m2/Hz	-219.31 162.24	-195.39 162.22		
K2R	REC-672 Ln25 * 41.00						Spreading Loss dB Elevation Angle deg	60.64	61.78		
	10					- 1	* Rx Gain dB	52.6	30.45		
BEAMS C1R	GEL KIR KAIR					- 1	65	TYPICA	L 4.5M		
		-					Location	N3.696	7 W53.1470		1
-						-)	Radiation Pattern	ITU-R S	i.465	ANALYSIS	_
3.375 (29)		1 Propan	cy Group		20.225 (DR .	Beamwidth deg	0.42		· · · ·	
				(2-0-	Q	Gmax dBi	52.6		Dish Size * GRID GRID CONTOURS DETAIL - O - O	
						-	Angle deg Grel d8	0.00	-22.15		
							Rx power dBW	-134.77	-164.7	Constraints	
		(11.700 - 12	2.200					-126.17	100.5		1
up 1d = 100601746	Pri = M	Show assets for all beau	ns v				INTERFERENCE				
TH ²	TYPICAL 4.5M			Name	36M0F3F		+ 1 dBW Adjustments dB	-133.79 30.92		VENESAT-1 (Victim)	
182	Typical	EARTH STATIONS	EMISSIONS	Designation	36M0F3F		Adjustments dB Bandwidth Adjustment dB	30.92		1 Gain Pattern set to TTU-R 5.580-6 for: TYPICAL 1.8M on Beam: K2R in Group: 100601742	
se (K)	100.00	1.11 State 10, Aug. 11	250733	Min Pwr (dBW)	-6.30	- 1	Polarisation Loss dB	0.00		2 J Boresight set to Lat 6.8, Long -65.7 for Beam: K2R on : VENESAT-1	
stude (deg)	N/A	TYPICAL 1.8M TYPICAL 2.4M	1M21G7W	Max Pwr (dBW)	1.70	- 1	Aggregation dB	0.00		3 ✓ Gain Pattern set to ITU-R \$.672-4 (Ln-25) for Beam: K2R on : VENESAT-1	
ngitude (deg)	N/A	TYPICAL 2.4M TYPICAL 3.0M	1M74G7W	Min Density (dBW/Hz)	-72.30		Aggregation Factor	1		Interference Cases	
ık Gain (dBi)	52.60	TYPICAL 3.7M	6M95G7W	Max Density (dBW/Hz)	-61.30		C dBW	-134.77		4 Ø Polarisation set to 3.00 dB for Beam Pair: TK1→K2R and 25M7G1W into 28M8G7W	
amwidth (deg)	0.42	TYPICAL 4.5M	28MBG7W				∀ C/I dB	-0.98		5 ✓ Aggregation Factor set to 1.40 for Beam Pair: TK1→K2R and 25M7G1W into 28M8G7W	
diation Pattern	REC-465 T	- TYPICAL 7.0M	36M0F3F			_	Threshold dB	20			
dy		NAMES AL AL PAR					Margin dB	-20.98			CAPT

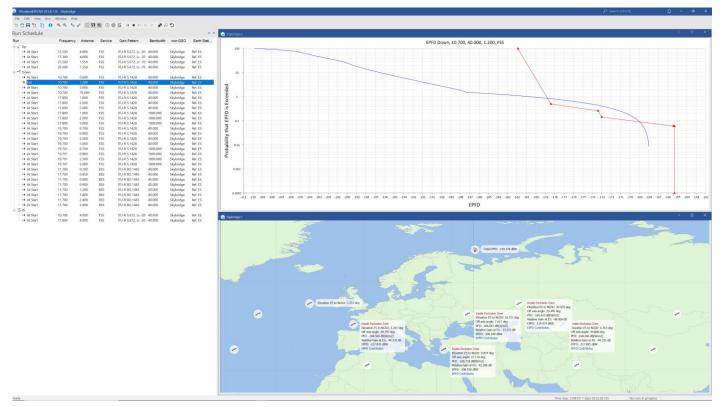
Visualyse EPFD

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)

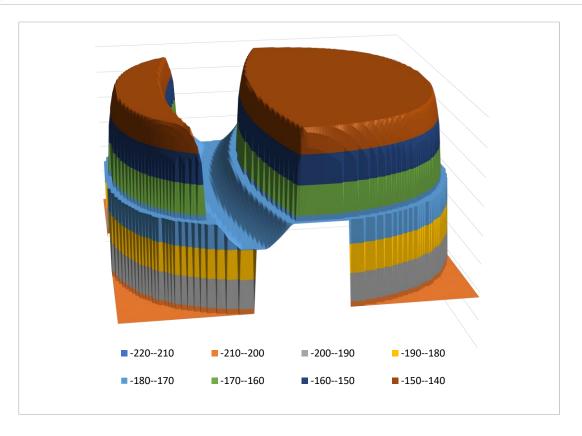
It can also analyse both the Article 22 and Articles 9.7A and 9.7B cases.

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.

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 Technical Note or would like more information, please do not hesitate to contact us at:

info@transfinite.com