

# Technical Note: Using Population Data in Visualyse Professional

Abstract: It can be useful to consider population when undertaking radio communication system design or interference analysis. This can be to identify the population that is able to receive a service or would suffer harmful interference and analyse how much interference would be generated based upon population density and average EIRPs. Recently, some new features have been added to Visualyse Professional to allow this type of analysis, as described in this Technical Note.

## Introduction

Some interference analysis studies can depend upon population levels. For example, a study could aim to answer questions such as:

- How to model aggregate interference where the level of interference depends upon the population?
- What is the population that would suffer reduced service due to interference?

To allow Visualyse Professional to analyse these types of scenarios, version 7.9.9.0 included new features to handle population data.

This Technical Note (TN) describes:

- The source of population data used
- How to download and interface to this population data
- How to process an Area Analysis using the population data
- How to use population data with the grid service area wizard
- How to use population data as a source of interference using a new traffic feature
- How to use population data with station groups as victims of interference

## Population Data Source

The population database is the NASA gridded population of the World (GPW). This gives the population in each 30 arc-second pixel over the Earth's surface from 60°S to 85°N.

The data was downloaded from the Centre for International Earth Science Information Network (CIESIN) at Columbia University as described here:

<http://sedac.ciesin.columbia.edu/data/set/gpw-v4-population-count-rev10>

Note the recommended citation for use of this data is:

*“Center for International Earth Science Information Network - CIESIN - Columbia University. 2017. Gridded Population of the World, Version 4*

*(GPWv4): Population Count, Revision 10. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC)”*

The data was provided as 8 text format tiles of size 90° x 90° in (latitude, longitude), nearly 5 GB of data in total. To facilitate its use within Visualyse Professional, this data was converted into just over a thousand binary files covering 5° x 5°, each just over a megabyte in size, then collected into a zip file.

Two versions of this data were processed, namely that for 2015 and that extrapolated to 2020. These can be downloaded from the Transfinite web site using one of these links:

[https://www.transfinite.com/population/5\\_deg\\_population\\_files\\_2015.zip](https://www.transfinite.com/population/5_deg_population_files_2015.zip)

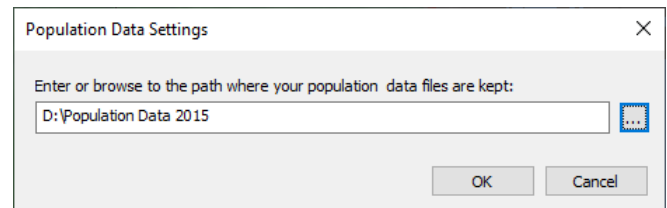
[https://www.transfinite.com/population/5\\_deg\\_population\\_files\\_2020.zip](https://www.transfinite.com/population/5_deg_population_files_2020.zip)

Having downloaded the relevant zip, the files it contains should be extracted into a directory on your PC, for example something like:

*D:\Population Data 2015*

*D:\Population Data 2020*

Then in Visualyse Professional, use the menu option “File | Population Data Settings” to open the dialog that allows you to select the directory containing these files, as shown here:

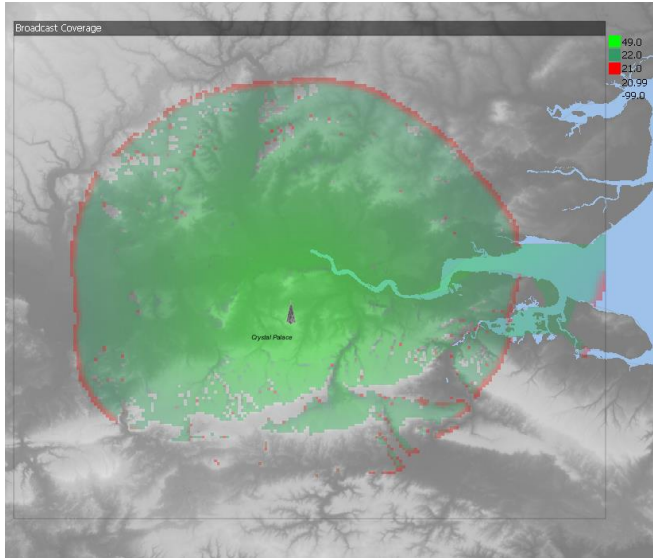


Note that Visualyse Professional checks the directory to ensure there are the required number of files and they all are the right size.

In this Technical Note, we make use of the 2015 data.

## Using Population Data in an Area Analysis

One way to use the population data is when combined with an Area Analysis (AA). An example AA is shown below, which is the coverage of a broadcast transmitter in the London area:



The coverage is colour coded so that:

C/N > 22 dB is shown in green

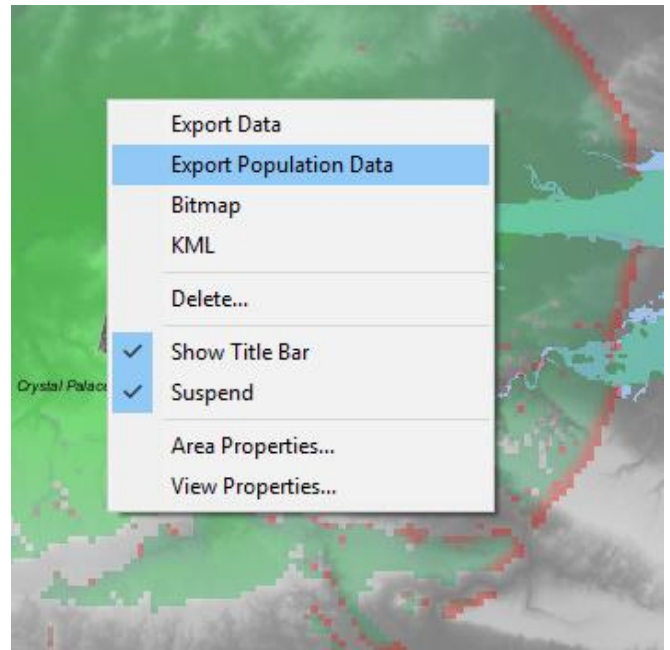
C/N = 21 is shown in red

C/N < 21 is transparent (i.e. not plotted).

An existing option for the AA is to export the raw data as a CSV file. This can be post processed to identify the area covered by this DVB-T transmitter. In this case the analysis would show that the area for which the C/N ≥ 21 dB would be 3,269 km<sup>2</sup>.

While an interesting metric, another that would be of use to broadcast planners, radio system designers and policy makers is the population covered by this transmitter.

This metric can be determined by the new AA population data feature:



Selecting the Export Population Data option allows a .CSV file to be created which contains the population in the ranges used in the AA display. For example, in this case using the 2015 database it would be:

C/N Range (dB)	Population
< -99.0	0
-99.0 to 20.99	269,7150
20.99 to 21.0	4,763
21.0 to 22.0	288,511
22.0 to 49.0	9,094,575
> 49.0	805,700

From this table it can be calculation that the population with C/N ≥ 21 dB is about 10.19 million.

This feature allows additional analysis to be undertaken for example, what would be the loss of coverage (in population) of allowing an interference threshold:

$$T(I/N) = -10 \text{ dB}$$

One way to assess this would be to consider the implications of a loss of link margin resulting from this I/N. This can be calculated to be 0.41 dB, and the coverage plot can be re-calculated using either lower transmit power or higher receiver noise and a new population analysis undertaken.

In this case the population served by this DVB-T transmitter decreased by 0.12 million which equates to a reduction of 1.2 %.

It would then be for policy makes to assess whether they consider this acceptable taking into account other factors (e.g. alternative transmitters, mitigation methods etc.) and other policy objectives.

## Using Population Data to Define Transmit Power Levels

Consider the sharing scenario in the 5 150 – 5 250 MHz band where:

Victim service = non-GSO MSS feeder link

Interfering service = RLANs

The non-GSO MSS feeder link receiver is on a satellite at an altitude of over a thousand kilometres, so it can see a very wide area. Over that area there could be many millions of RLANs – but how many?

The interference from RLANs will vary depending upon the number of transmitters, which will in turn depend upon the population.

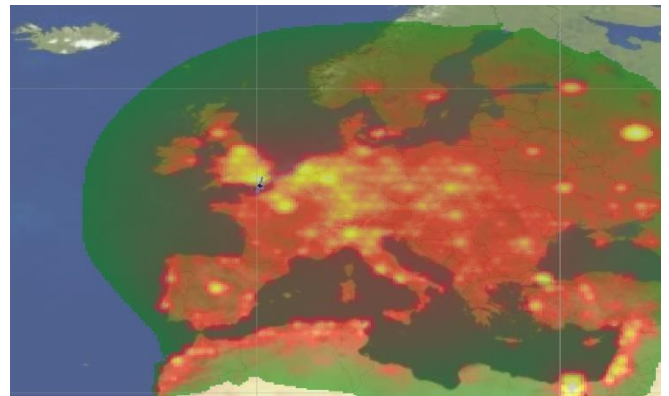
Consider how to model a non-GSO MSS satellite over Europe. One, simplistic approach would be to model RLANs deployed uniformly across the land mass, as in this example deployment:



Each test point is separated by 100 km, so each represents all emissions within an area of 10,000 km<sup>2</sup>. There are 990 test stations in total representing a total population of 810 million. This would represent, on average, 0.81 million per test station.

However, this is clearly unrealistic: the example transmitters in dense urban areas such as London will result in much higher emissions than low density areas including deserts.

A better way is therefore to model the emissions from each of these test stations taking into account the population density at each point and the area each test station represents, to allow transmit power to vary by location similar to that in this figure:



This can be done in the following options within the Service Area Station Wizard:

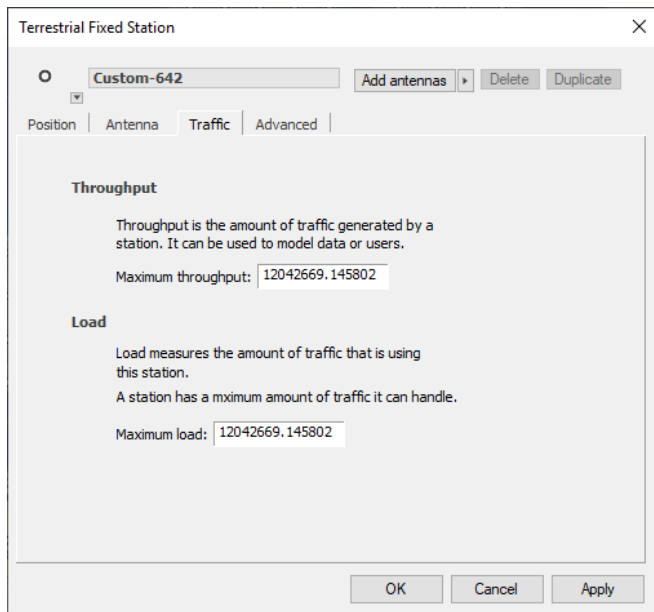
- Service area defined by region, beam footprint or country
- Fill option: fill the area with stations only
- Grid definition: either stations number north/east or spacing distance north/east.

There is then a new option to “Get population data”, as can be seen in the dialog below:

## Getting Population Data into Stations

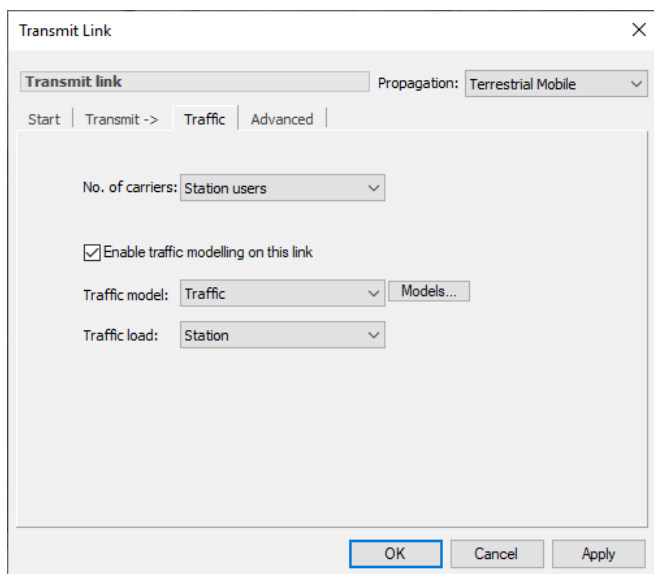
Having run the wizard with the options above, [Visualyse Professional](#) can then calculate the population within the defined area – in this case a 100 x 100 square – surrounding each station.

Having calculated the population represented by a station, that value was stored in the Station’s traffic field maximum Throughput as in this figure:



The Maximum load field is set to this Throughput figure.

This value can be used in a transmit link via a new option in the traffic field, namely “Station users” as in:



A default Traffic object should be created and selected to activate the features which derive total power and bandwidth from loading and access method.

If these options are selected, then the transmit power  $P_{tx}$  used for this link is:

$$P_{tx} = P_{tx,0} + 10 \log_{10}(N_{users})$$

Here:

$P_{tx,0}$  = power level given in the Transmit Link “Transmit->” tab

$N_{users}$  = for each station selected on the Transmit Link “Start” tab, the number of users given in its “Throughput” field

For example, if:

$$P_{tx,0} = 10 \text{ dBm / user}$$

$$N_{users} = 150 \text{ users}$$

Then:

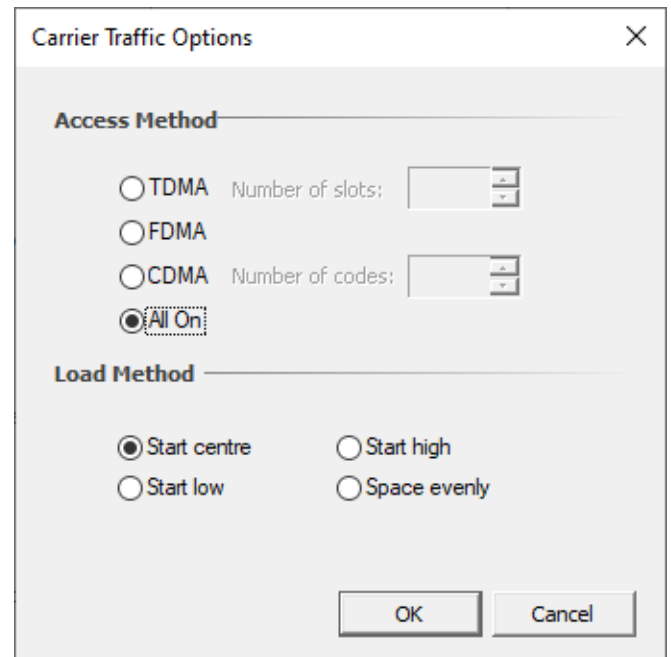
$$P_{tx} = 10 \text{ dBm} + 10 * \log_{10}(150)$$

$$= 31.76 \text{ dBm}$$

$$= 1.76 \text{ dBW}$$

Note that if the carrier access method is set to TDMA, then [Visualyse Professional](#) will reduce the number of users by the number of time slots as this would be the number of active carriers.

Hence it is typically better to set the access method to another option – the best one is “All on” as that ensures that all transmitters are allowed to simultaneously access the radio spectrum on the same frequency.



## Example Analysis

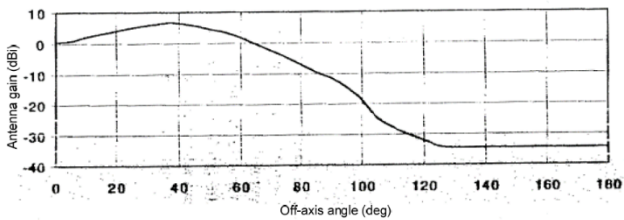
This section looks at using the population data to analyse interference from RLANs into non-GSO MSS feeder links in the band 5 150 – 5 250 MHz using parameters from Recommendation ITU-R M.1454 and Report ITU-R M.2211.

In particular, the following parameters were taken for the satellite system

- Receive temperature = 550 K
- Receive feed loss = 2.9 dB
- Satellite height = 1414 km
- Maximum latitude = 52° N
- Satellite antenna pattern:



FIGURE 3.1-1  
Satellite antenna pattern for HIBLEO-4



The parameters to use for the RLAN systems depends upon a wide range of assumptions on service, traffic variation, indoor vs. outdoor use, bandwidth, loading on other bands. It can be hard to get agreement on which set to use – for example in Rec. ITU-R M.1454 there are a significant number of parameters in Table 3 which are identified as “for further study.”

A possible source of additional parameters is document 5A/298 Annex 25, dated 18<sup>th</sup> November 2016. This gives a range of EIRPs, propagation, bandwidths, and activity assumptions.

For an initial study, the following values were used:

$$EIRP = 80 \text{ mW}$$

$$\text{Bandwidth} = 80 \text{ MHz}$$

$$\text{Activity} = 0.008 \text{ active devices per } 20 \text{ MHz channel per inhabitant}$$

$$\text{Percentage outdoor} = 5 \%$$

$$\text{Indoor-outdoor loss} = 17 \text{ dB}$$

Further study could consider a range of values and aggregate different traffic models together.

The propagation models used were:

- Free space path loss
- P.676 gaseous attenuation

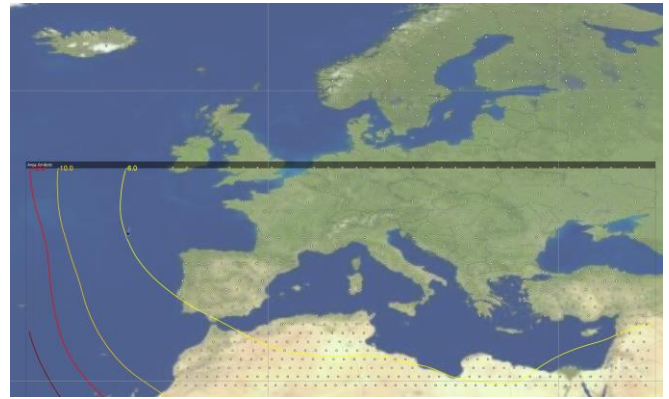
In addition, a clutter loss was included for low elevation angles. This was included via a gain table for the RLAN devices which was zero toward zenith and -17 dB towards the horizon.

The transmit power to use in dBW was derived from the EIRP per device \* bandwidth correction \* activity per 20 MHz per inhabitant to be:

$$EIRP = 10\log_{10}(80/1000) + 10\log_{10}(20 \text{ MHz}/80 \text{ MHz}) + 10\log_{10}(0.008) = -38 \text{ dBW} / 20 \text{ MHz} / \text{inhabitant}$$

Taking into account the percentage indoor / outdoor and the indoor to outdoor loss, the transmit power to use is  $P_{tx,0} = -49.6 \text{ dBW} / 20\text{MHz} / \text{inhabitant}$ .

Using these parameters, the I/N at the satellite can be plotted as shown in the figure below:



It can be seen that the I/N > -6 dB for large parts of the satellite orbit over Europe.

This analysis could be extended to include time of day variation reflecting the fact that not all time-zones will be simultaneously at busy hour and additional factors such as polarization loss.

## Conclusion

This WP has shown how to use [Visualyse Professional](#) to include population data in the calculations. In particular:

- To process an Area Analysis to identify the population at or above/below the given criteria level per pixel
- To generate EIRPs that depend upon the population within the area around each station
- To determine the population in a region that might be affected by interference.

## About Transfinite

We are one of the leading consultancy and simulation software companies in the field of radio communications. We develop and market the leading [Visualyse](#) products:

- [Visualyse Professional](#)
- [Visualyse GSO](#)
- [Visualyse Coordinate](#)
- [Visualyse EPFD](#)

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

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

<http://www.transfinite.com>

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