ATDI

# Potential Effects of Wind Turbine Generators on Pre-Existing RF Communication Networks

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## Abstract

In an effort to help preserve the ozone and the availability of diminishing natural fuel sources, alternative energy sources are being investigated. In the case of wind powered energy, efforts have gone past investigation and the full scale implementation of wind turbine farms has become a dramatically growing business all over the world. Wind turbines convert the kinetic energy from wind into mechanical energy which is used to generate electricity. Although wind turbine technology ultimately has a positive impact on the environment, it has been assessed to possibly impair radio communications systems. In order to prevent such interference, intensive engineering studies must be performed to assess whether the potential interference on radio communications systems would be significant/intolerable by current radio equipment configurations. This paper presents how such a wind turbine interference prediction study on an RF communications system can be accomplished using ATDI's RF planning software packages ICS Telecom and HTZ warfare. ICS Telecom possesses the ability to model the effect of wind farms on any radio communications technologies such as broadcast, mobile, radar and satellite; however this paper will consider the potential impact of a wind turbine farm on microwave (MW) links as the example.

## Placement of MW Links in the Area of Interest

MW links can be imported or created on ATDI's high resolution 3D cartographic terrain data. Base station equipment and link parameters (Figure 1b) can be obtained as well as antenna pattern information (Figure 1a) and imported into the ICS Telecom platform for propagation and/or interference analyses.

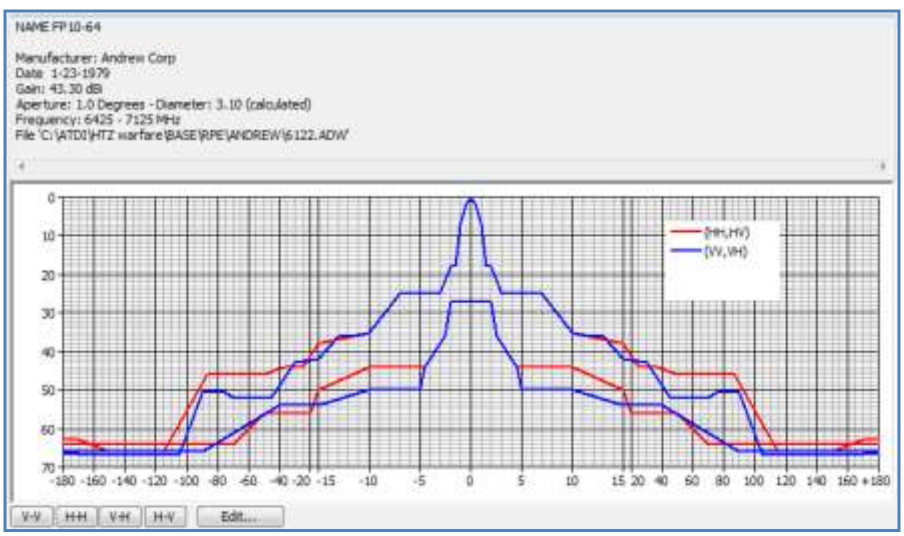



Figure 1a: Antenna Radiation Pattern.

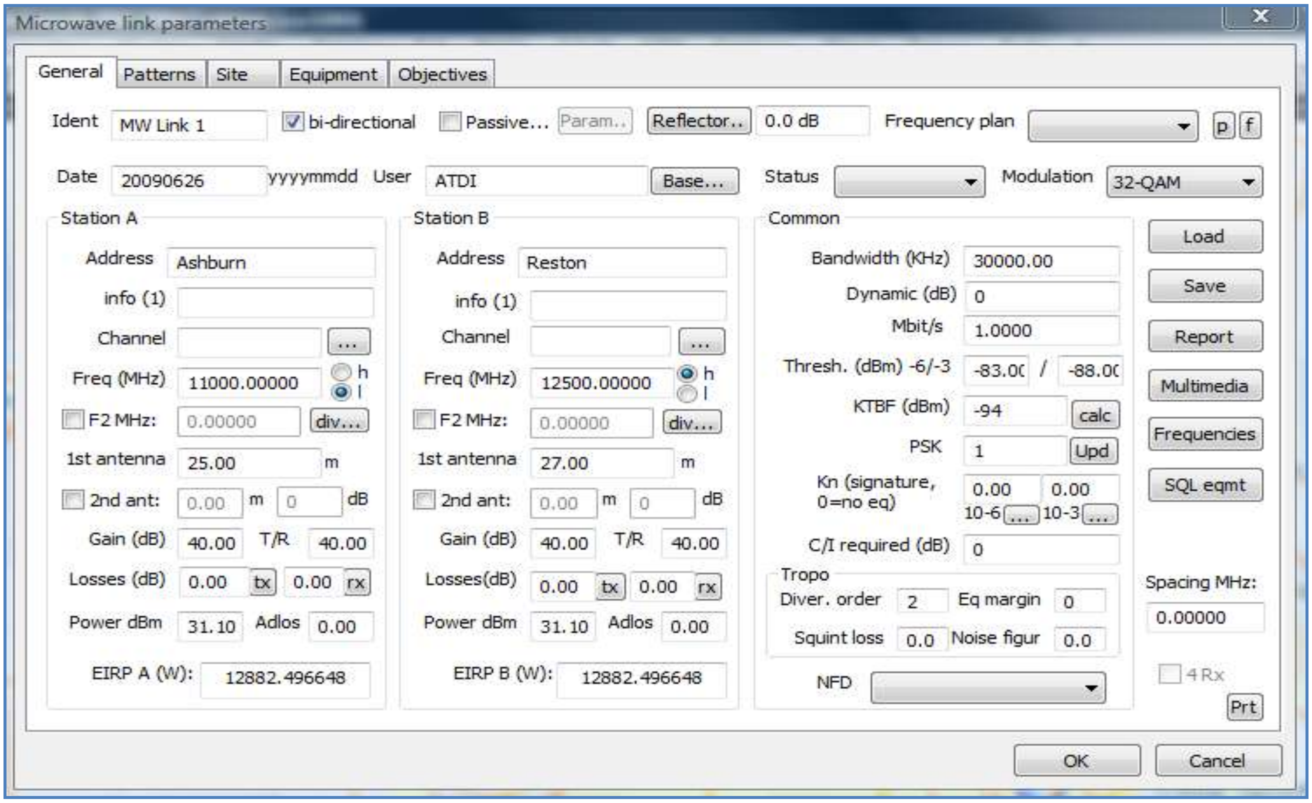
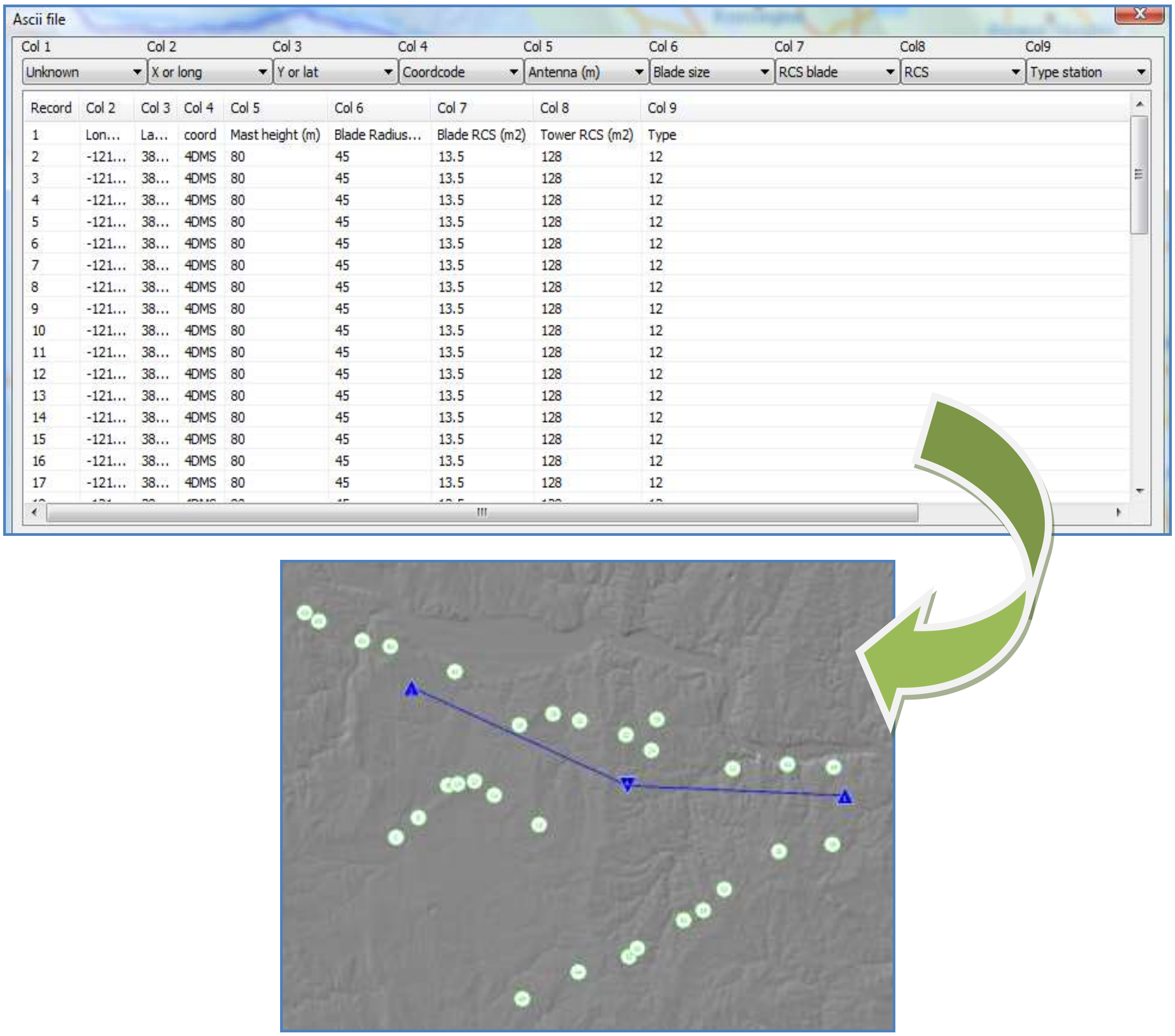



Figure 1b: MW Station Parameters

MW link performance can be simulated by path profile calculations in ICS Telecom which can consider variability as defined in ITU-R P.530-11 recommendation before carrying out a wind turbine analysis.

## Automatic Import of Wind Turbines

ICS Telecom allows for the automatic placement of candidate wind turbine sites through dedicated import features that even include the ability to import wind turbine specific parameters such as RCS (Radar Cross Section).




| Record | Col 2 | Col 3 | Col 4 | Col 5 | Col 6 | Col 7 | Col 8 | Col 9 |
|---|---|---|---|---|---|---|---|---|
| 1 | Lon... | La... | coord | Mast height (m) | Blade Radius... | Blade RCS (m2) | Tower RCS (m2) | Type |
| 2 | -121... | 38... | 4DMS | 80 | 45 | 13.5 | 128 | 12 |
| 3 | -121... | 38... | 4DMS | 80 | 45 | 13.5 | 128 | 12 |
| 4 | -121... | 38... | 4DMS | 80 | 45 | 13.5 | 128 | 12 |
| 5 | -121... | 38... | 4DMS | 80 | 45 | 13.5 | 128 | 12 |
| 6 | -121... | 38... | 4DMS | 80 | 45 | 13.5 | 128 | 12 |
| 7 | -121... | 38... | 4DMS | 80 | 45 | 13.5 | 128 | 12 |
| 8 | -121... | 38... | 4DMS | 80 | 45 | 13.5 | 128 | 12 |
| 9 | -121... | 38... | 4DMS | 80 | 45 | 13.5 | 128 | 12 |
| 10 | -121... | 38... | 4DMS | 80 | 45 | 13.5 | 128 | 12 |
| 11 | -121... | 38... | 4DMS | 80 | 45 | 13.5 | 128 | 12 |
| 12 | -121... | 38... | 4DMS | 80 | 45 | 13.5 | 128 | 12 |
| 13 | -121... | 38... | 4DMS | 80 | 45 | 13.5 | 128 | 12 |
| 14 | -121... | 38... | 4DMS | 80 | 45 | 13.5 | 128 | 12 |
| 15 | -121... | 38... | 4DMS | 80 | 45 | 13.5 | 128 | 12 |
| 16 | -121... | 38... | 4DMS | 80 | 45 | 13.5 | 128 | 12 |
| 17 | -121... | 38... | 4DMS | 80 | 45 | 13.5 | 128 | 12 |

Figure 2: Wind Turbines imported into ICS Telecom on digital terrain model.

Calculation of the RCS for a wind turbine for both the blade and the tower structure is essential due to the fact that it provides a reflectivity/scattering area which is critical for determining the effect of possible reflected interfering signals traveling into the receiving antenna.  Furthermore, each turbine's parameters window (Figure 3) is accessible for verification and/or allowing for any additional changes.

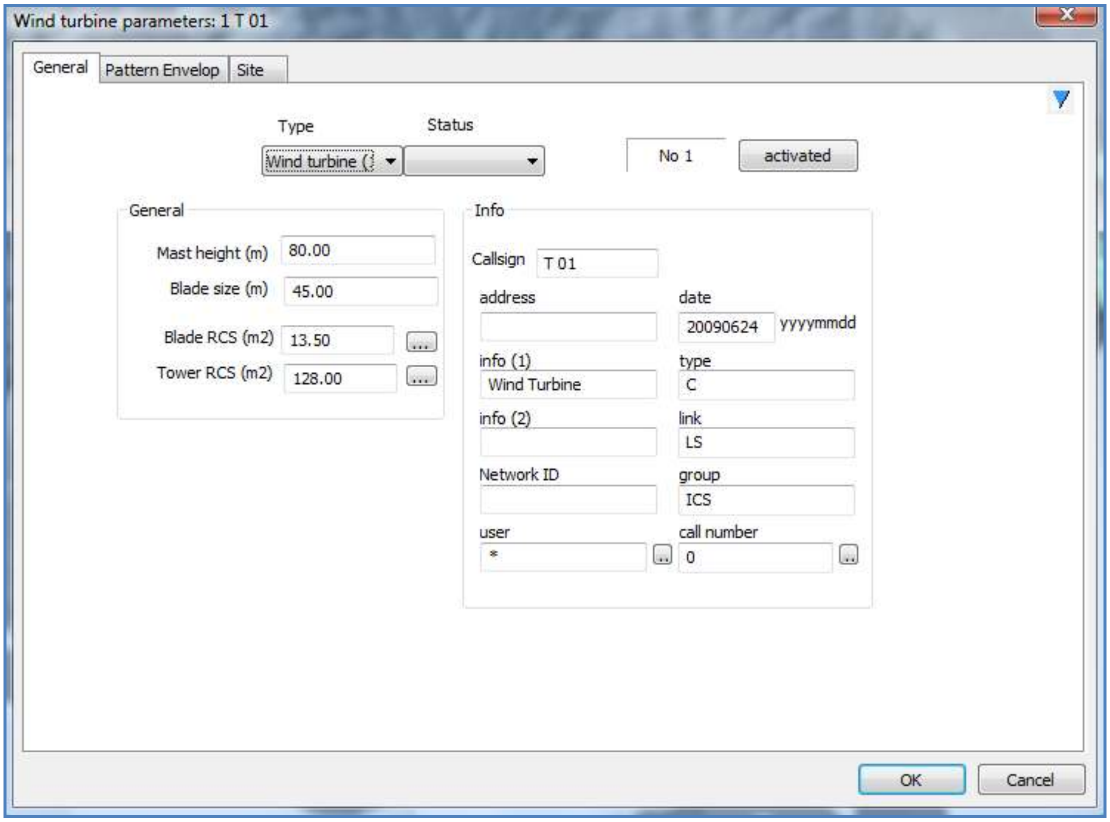



Figure 3: Wind Turbine Parameters Window.

## Wind Turbine Interference Calculation Methodologies

ATDI has developed a high degree of competence and capability into ICS Telecom for modeling Wind Turbine Interference derived from experiences gained through working with its international customer base, in particular those in the United Kingdom and Europe. Practical wind turbine analyses should carefully consider three different criteria that can cause potential worst-case performance degradation of an RF communications system. These criteria include: i) near-field propagation, ii) diffraction propagation, and iii) reflection/scattering propagation effects that can lead to possible interference scenarios.

i). In the **near-field zone**, the average electromagnetic energy density remains fairly constant at different distances from the antenna. So any wind turbine within the near-field range should cause concern for possible interference effects. As a function of frequency, wavelength, and the diameter of the antenna, the near-field distance is calculated in ICS Telecom as shown in Figure 4 below.

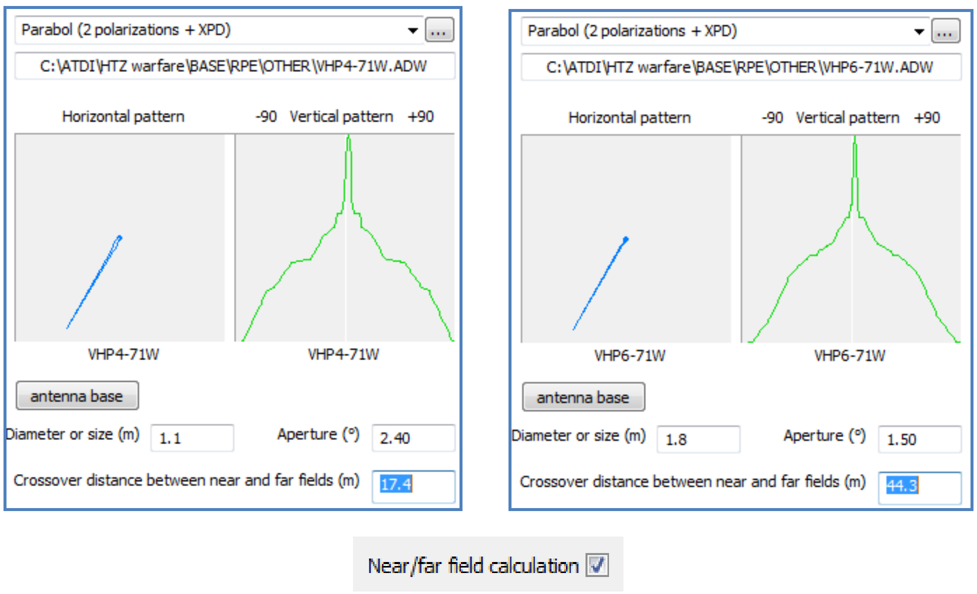
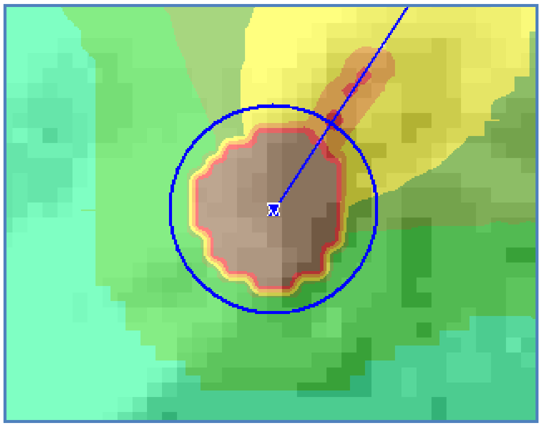



Figure 4: Near-field region calculation.

In Figure 5 below, the near-field regions for both sites are graphically plotted and represented with a blue circle showing no presence of any proposed wind turbines in the area. Within these ranges, the tool models the radiation as even in all directions until the radiation crosses over the near-field range, at which point the tool assumes the directivity of the antenna radiation pattern.



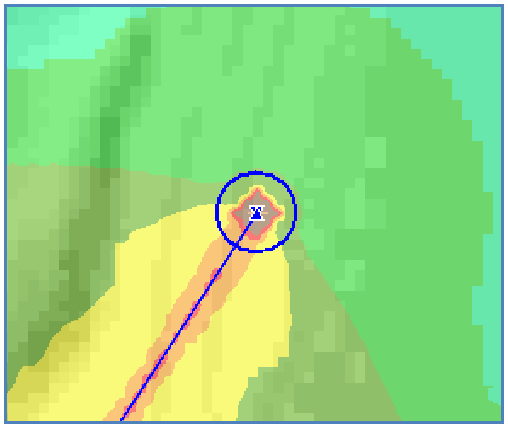


Figure 5: Near-field Region.

ii). When a transmitted radio wave is physically obstructed by a wind turbine causing **diffraction**, a significant negative effect is expected to impact the radio wave. In wind turbine analyses, a complete 2nd Fresnel zone clearance is required in order to provide a more conservative, and realistic, approach toward modeling the varying characteristics of wind turbines.

ICS Telecom offers a working environment that allows the user the ability to visualize the clearance of the 2nd Fresnel zone from wind turbines. Figure 6 shows the proposed T50 turbine closest to the 2nd Fresnel zone (in blue) with the direct path in red. This visual check also confirms that diffraction related degradation of RF communications is not a concern.

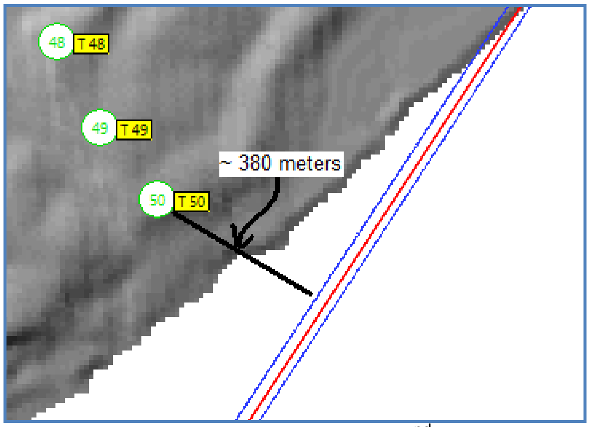



Figure 6: Turbine T50 Location from 2nd Fresnel Zone.

iii). **Signal reflection** from the physical structure of a turbine propagating into the receiver can potentially result in TD (Threshold Degradation – i.e. rise in noise level) in the receiver system, thus resulting in an critical increase in the C/I ratio requirement for service. Reflected electromagnetic waves arriving in various directions are analyzed for each turbine to calculate a power sum of the multiple reflected rays arriving at the receiver. Then a C/sum(I) calculation is performed per receiver to determine the effect on system performance. Since ICS Telecom can implement antenna discrimination as one of the elements of a C/sum(I) calculation, the best approach is to import a precise NSMA formatted antenna pattern from the manufacturer as described in Figure 2 on page 1.

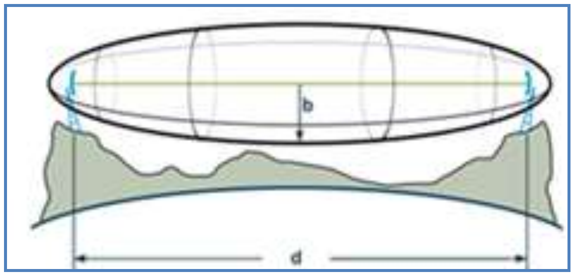



Figure 7: Fresnel Zone Diagram

As shown in the figure below, the tool also can consider the Fresnel ellipse in 3D and via a ray tracing engine, model the reflected multipath rays from all possible directions. Ultimately, a list of interference power received at each turbine is generated.

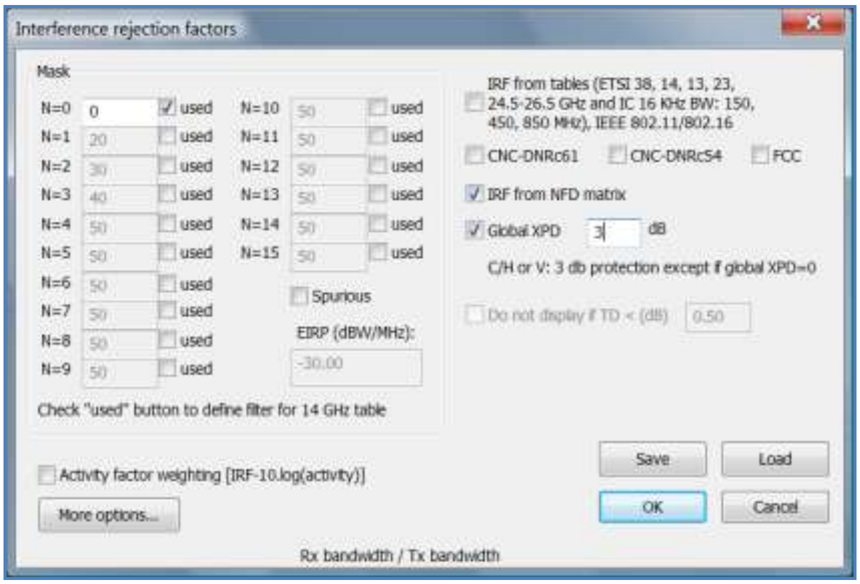



Figure 8: Interference Rejection Filter

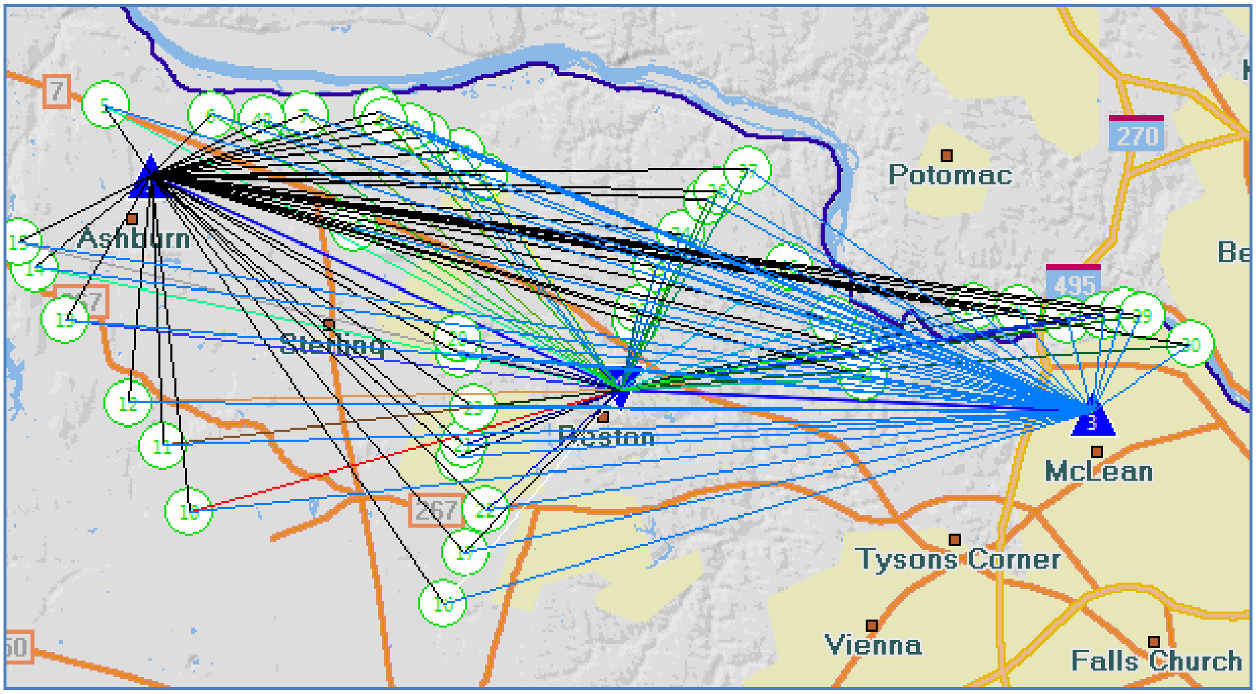



Figure 9: Multipath Effects Due to Reflection from Wind Turbines.

Simulation of reflection/scattering effects in the function of RCS of structures (blade and tower) performs intensive calculations then a complete report list is created consisting of all interference powers received from any turbines.

## References


1. David F. Bacon. “Fixed-link wind-turbine exclusion zone method”. Ofcom UK, October 2002.
2. CAP 764. “CAA Policy and Guidelines on Wind Turbines”. CAA, July 2006.