Wind Farms and Fixed Links

Abstract: With a political push for green power there are increasing numbers of wind farms being deployed or planned. Radio waves can reflect off their blades causing interference or multi-path effects that can degrade licensed radio users. Approaches to analysing the impact of wind farms is considered in this white paper, focussing on point to point fixed links.

What is the problem?

There is concern that the rotating blades of the turbines would create reflections that could cause interference into licensed radio communication systems.

This was of limited concern when only small numbers of turbines were deployed. However their numbers are currently rapidly increasing in response to demand for renewable sources of energy.

A large number of services could be affected, including fixed, radar and broadcasting services. This White Paper will concentrate on point to point (PtP) fixed links.

Analysis Methods

A number of methods could be used to analyse the potential for wind turbines and wind farms to cause interference into PtP fixed links, including:

1. Determining whether there is line of sight between the wind farm and either the transmit or receive stations of the link
2. Identifying whether the wind turbines within a coordination zone around the path between transmit and receive stations. A key question for this analysis is what size of zone to use
3. Undertaking detailed analysis of near field, Fresnel zone, reflection and scattering effects for the link under consideration.

These three methods are considered further below.

Line of Sight Analysis

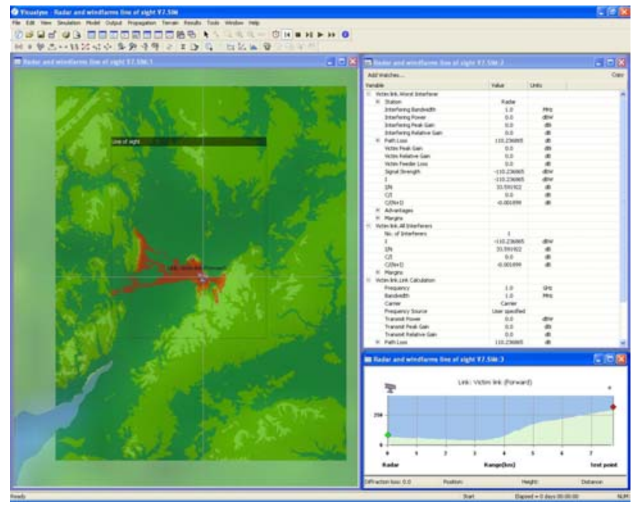
A simple approach is to identify if there is line of sight from a turbine to any of the license's transmitters and receivers. This approach can be considered a first cut in that it can often be possible to operate even when there is line of sight to the wind farm.

However line of sight analysis is useful as it is a generic approach that can be applied to many different services, not just fixed services, including (for example) radar systems.

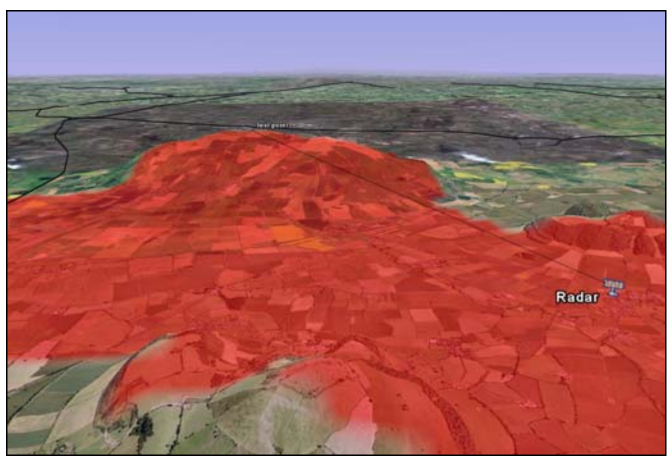
The figure below shows a Visualyse Professional simulation file in which an exclusion zone has been defined around an existing radar station within which wind farms should not located.

This uses the Visualyse Professional Area Analysis tool.

The method is based upon using a terrain database together with the ITU-R Rec. P.526 diffraction model. Where there is no diffraction the path is classified as with the radio line of sight and hence should be part of the exclusion zone.



The masking effects of the terrain can be clearly seen in this figure, where the Area Analysis has been exported to Google Earth:



Coordination Zone Analysis

A more detailed approach is to define a coordination zone along the path from transmit to receive stations. The question is then what distance to use.

For example within the UK the regulator Ofcom uses a separation distance of 500m or less between the wind farms and the link path line as the trigger for discussions between the operators of the fixed link and windfarm, as described in documents at:

http://www.ofcom.org.uk/radiocomms/ifi/licensing/classes/fixed/Windfarms/

We can show what this would look like graphically in Google Earth for a test link.

We will use values from the test link constructed for the Transfinite Web Seminar on Point to Point Fixed Link Planning, namely:

Frequency: 18 GHz

Path length: 6.97 km

Antennas: Rec. F. 699

Peak gain: 40 dBi

For this link the coordination zone was generated and is shown as the shaded area in the figure below.

This is clearly a straight forward approach that could be implemented in a licence approval process, such as our Visualyse Spectrum Manager.

However it raises two interconnected questions, namely what size of coordination zone should be used, and how can we analyse proposals for wind farms within this zone?

If we answer the second question we should also be able to propose suitable values for the first.

Detailed Analysis

Detailed analysis must take into account the three mechanisms in which wind farms could impact PtP fixed links, namely:

a) Near field effects

b) Intrusion into the Fresnel Zones

c) Scattering or reflecting

The size of the near field zone can be calculated using:

$$D_{nf} = N_{nf} \eta D_a^2 / \lambda$$

Where:

N_{nf} = constant between 1 and 2

η = antenna efficiency between 0 and 1

D_a = antenna diameter (m)

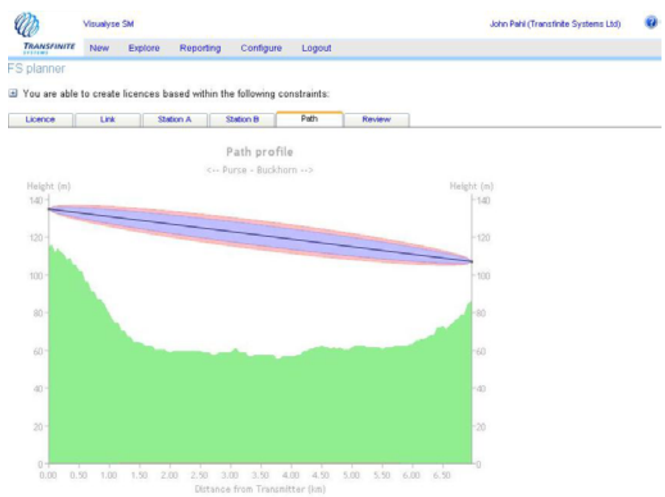
λ = wavelength (m)

For this link using suitable N_{nf} and η we get D_{nf} = 35m.

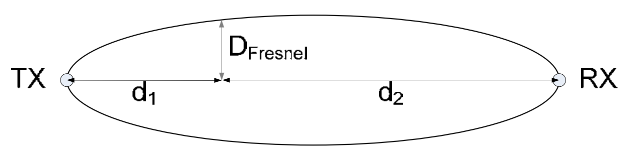
The next issue to consider is the diffraction effect that can come from intrusion into the 2nd Fresnel zone. This is similar to the analysis of the Fresnel zone for obstructions in the link. However that is a vertical zone and in this case we are considering a horizontal zone.

An example of the vertical zone is in the figure below which shows the path profile and Fresnel zone for the link under consideration.

The picture was generated using our web based licensing portal, Visualyse Spectrum Manager:



The horizontal Fresnel zone is very similar, and the figure below shows the geometry involved:



The size of the Fresnel zone can be derived along the path using:

$$D_{Fresnel} = \sqrt{\frac{2\lambda d_1 d_2}{d_1 + d_2}}$$

where:

λ = wavelength (same units as the distances)

d_1 = distance along path from TX station

d_2 = distance along path from RX station

$D_{Fresnel}$ = distance from path of Fresnel zone

For the link under consideration this is around 7.5m at its widest point.

Finally the C/I that would be generated due to reflections and scattering can be derived using:

$$\frac{C}{I} = \frac{4\pi s_1^2 s_2^2 g_1(0) g_2(0)}{\sigma D_p^2 g_1(\theta_1) g_2(\theta_2)}$$

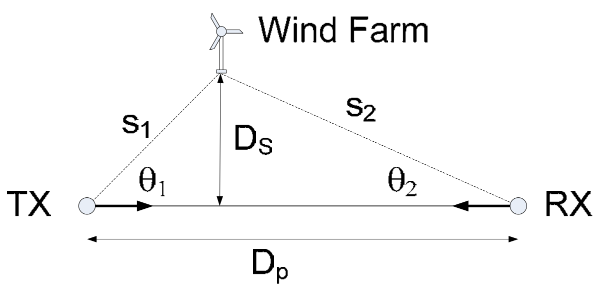
Where:

C/I = threshold for acceptability

σ = radar cross section

g(θ) = antenna gain for specified offaxis angle

The geometric terms D_p, s_1, s_2, θ_1 and θ_2 are shown in the figure below. The value of D_S that just meets the required C/I must be derived using iteration.



Note that all distances and areas must use the same units (i.e. all in metres or all in kilometres).

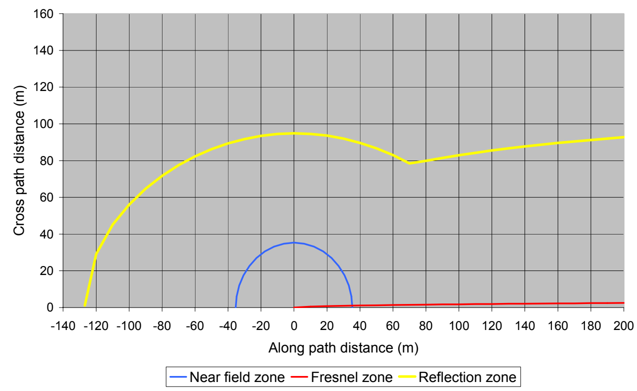
Critical factors would be the required C/I and size of the wind farm, which would effect it's radar cross section (RCS), σ.

The RCS is a hard term to determine, and it will depend upon a number of factors including:

- The size of the wind turbine(s)
- The pointing angle of the wind turbine(s)
- The pitch of the wind turbine(s) blades
- The number of wind turbines – one study suggests that a 10log10(Number) approach can be used to aggregate multiple turbines in a wind farm
- The orientation of the wind turbine with respect to the path, as the radar cross section will vary by angle. The greatest RCS is typically due to forward scatter
- Frequency: the RCS tends to be lower at higher frequencies

In our analysis we assumed the RCS to be a constant = 50 dBm^2, which made the scattering zone about 100m wide.

These values were used to derive more detailed zones for each of the three effects, starting with an analysis of the zones around the transmit station, as in the figure below:



It can be seen that the near field and diffraction effects are significantly smaller than the reflecting and scattering exclusion zone.

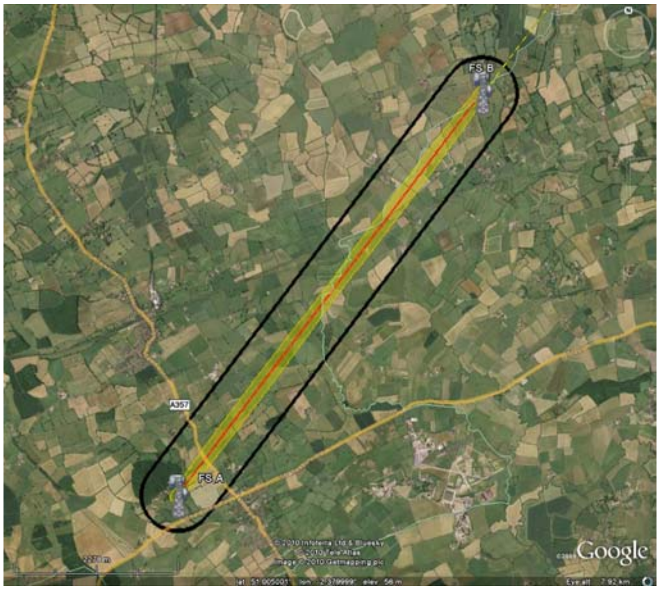
These three zones in the figure above around the transmit station can then be shown on the Google Earth map as follows:

In this figure the three zones are colour coded as:

- Near Field zone in blue
- Fresnel zone in red
- Reflections zone in yellow

They can also be viewed over the course of the complete link and compared against the provisional 500m coordination zone calculated earlier.

The resulting zones can be seen in the figure below.



It was concluded that a 500m coordination zone should provide sufficient protection for links such as this.

If wind farms were proposed that would protrude into this 500m coordination zone then it might still be feasible to operate, but detailed analysis of the form presented here would be required.

How We Can Help

Transfinite can assist you analyse the effect of one or more wind turbines by:

Consultancy projects and studies: our experts can support you by undertaking studies using the methodology above to predict the impact of one or more wind turbines on radio communication systems.

Analysis and planning software: our Visualyse Professional study tool can be used to analyse a wide range of sharing studies including the impact of wind turbines.

Licence management: our Visualyse Spectrum Manager provides an integrated web based solution to support licence application and management of a wide range of spectrum products including fixed and mobile services.

Planning Services: we can provide owners of blocks of spectrum a management service where by we provide you with access to our Visualyse SM server configured for your block which therefore undertakes planning, licence management and database management tasks.

About Transfinite

We are one of the leading consultancy and simulation software companies in the field of radio communications.

Our business activities can be broadly categorized into four main areas:

- Consultancy services
- Visualyse software products
- Technical training
- Spectrum management

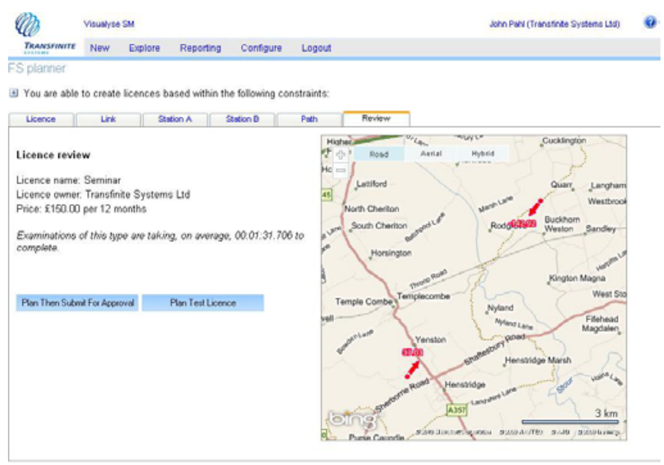
We develop and market the market leading Visualyse products:

- Visualyse Professional
- Visualyse GSO
- Visualyse Coordinate
- Visualyse Spectrum Manager

Our software has been installed at hundreds of sites, including leading administrations like Ofcom and the ACMA.

We are owners of a block of spectrum in the UK in the 28 GHz band which we manage as a private Spectrum Management Organisation (SMO). We can provide access to our spectrum using our Visualyse SM solution.

Operators can apply online for PtP fixed links, PtMP cells or satellite earth stations via our web site as in the figure below.



More information about these products and services is available at our web site or by contacting us as:

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