Radio Advisory Board of Canada (RABC)

Canadian Wind Energy Association (CanWEA)

Technical Information and Coordination Process Between Wind Turbines and Radiocommunication and Radar Systems

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Foreword

The contributors to this document are fully supportive of the development of wind projects and recognize that effective and appropriate development of wind projects is good for the environment and the economy.

At the same time, the contributors also recognize that radiocommunication[1] and radio detection and ranging (radar) systems are also important for Canadians and must be considered when evaluating proposed wind turbine locations.

This document has been written by a wide range of stakeholders, and it represents a general consensus in terms of analytical approach and acceptable thresholds for Canada. To the extent possible, it is consistent with documentation either existing or under development in other countries.

1. Introduction

The purpose of this document is to facilitate effective cohabitation between existing radiocommunication and radar systems on the one hand and wind projects on the other, through the effective and early sharing of information.

This document outlines a recommended process for wind project proponents to evaluate consultation zones for disclosed radiocommunication and radar systems (e.g., locations which are posted by Industry Canada) on a publicly available website. This document also identifies organizations that must be consulted with during the planning and development phase of a wind farm for non-disclosed systems (e.g., DND).

1.1 Recommended Process

In certain circumstances, wind turbines, either as single units or grouped together in a wind farm, can negatively affect radiocommunication and radar systems. Early consultation with stakeholders is recommended to ensure that a given installation does not bring about unacceptable interference, thereby leading to costly changes or delays at a later stage in the wind farm development process.

Industry Canada is responsible for the regulation of the radio frequency spectrum in Canada and studies have shown that the installation of a wind turbine has the potential to alter the pattern of nearby antenna systems. However, Industry Canada's authority does not extend to the compatibility between radiocommunication systems installed by users of the radio frequency spectrum and the placement of wind turbines or other physical structures such as electrical power transmission lines, silos or buildings. Industry Canada maintains a database of information on publicly available radio installations which is available to proponents of wind turbines. Where necessary, proponents of wind turbines may contact Industry Canada for further guidance regarding the availability of information on radiocommunication installations.

The locations of existing Radiocommunication and Radar systems within a given search area or consultation zone can be found by performing a radio frequency search using the Industry Canada Spectrum Direct internet-based service tool. Not all licensing records are available for public viewing. These non-disclosed database records are primarily licensed to agencies providing public safety of a National, Provincial or Municipal nature as well as the other mandatory contacts listed in Table 1. The wind turbine proponents must contact these agencies in order to allow them to assess the potential impacts on their radiocommunication or radar systems.

To avoid any potential difficulties, the following process is recommended:

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[1] Radiocommunication is the transmission, emission or reception of signs, signals, writing, images, sounds or intelligence of any nature by means of electromagnetic waves of frequencies lower than 3 000 GHz propagated in space without artificial guide.

Step 1 The wind project proponent develops a map showing the location of the proposed wind farm, to the extent that this information is available at that time. The proponent obtains and provides preliminary information for the proposed project, including project area coordinates, representative machine and proposed number of wind turbines.

Step 2 The proponent sends notices of consultation with the proposed wind farm location and preliminary project information to all mandatory contacts operating non-disclosed systems (see Table 1). These mandatory contact agencies will respond in a timely fashion, no more than 21 days after initial contact.

Step 3 The proponent determines whether any of the consultation zones for disclosed systems overlap/intersect the proposed project area, as described by these Guidelines.

Step 4 In the event that the guidelines or mandatory consultation contacts indicate that a given installation is located within a consultation zone, the proponent contacts the applicable authority/owner of the disclosed or non-disclosed systems to determine if, in fact, further investigation is warranted. The owners of disclosed or non-disclosed systems will respond to the proponent in a timely fashion, no more than 60 days from when the proponent first contacts the owners of respective disclosed or non-disclosed systems.

Step 5 The proponent and applicable authority/owner of the disclosed or non-disclosed systems undertake the necessary studies and identify mitigation measures to resolve the issue to the satisfaction of both parties. The wind project proponent develops a map showing the location of the proposed wind farm and all the wind turbines within it.

1.2 Guidelines Use

The present Guidelines address Steps 2 and 3 of the above process. As such, these Guidelines serve as a risk management tool that helps wind project proponents, and radar and radiocommunication system operators avoid any potential conflicts at an early stage in wind farm development. In essence, the Guidelines provide a series of analytical methodologies and thresholds that help to indicate where a potential interference *may* occur, thereby acting as a voluntary (but highly recommended) trigger for the proponent to notify the applicable authority. *The Guidelines are not intended as a regulatory document, nor should they be used as the basis for any regulatory decision.*

It is important to point out that the Guidelines themselves are not able to determine if unacceptable interference actually *will* occur. The determination of whether or not a proposed turbine or wind farm may create an unacceptable level of interference with existing radiocommunication and radar systems is very complex and it is not possible to categorically determine whether unacceptable interference will occur unless a site-specific analysis is undertaken. The scope of that site-specific analysis and any potential mitigation measures undertaken are not addressed in these Guidelines. Note that any analysis or report resulting from these guidelines does not supersede any other study that may be required as part of a broader approval process. Use of the information contained in Table 2 and the sample calculations in Section 3 should be considered to comprise only the first step, serving as an early indicator of potential interference; a detailed engineering study may also be needed to determine impacts and to address potential concerns[2].

1.3 Publishers Contact Information

Radio Advisory Board of Canada	RABC Website: http://www.rabc.ottawa.on.ca/e/index.cfm E-mail: david@rabc-cccr.ca Phone: 1-888-902-5768 or 613-230-3261
Canadian Wind Energy Association	CanWEA Website: http://www.canwea.ca/en/ E-mail: info@canwea.ca Phone: 1-800-922-6932 or 613-234-8716 Fax : 613-234-5642

[2] The geographic coordinates of radiocommunication towers and radar locations posted in Industry Canada's database need to be verified prior to any analysis.

2. Impact of Wind Turbines on Radiocommunication and Radar Systems

2.1 General

Studies[3], have shown that the rotating blades and support structure of a wind turbine can impact AM (amplitude modulated) RF (radio frequency) signals. FM (frequency modulated) signals are much more immune to this phenomena and may only become impaired in very close proximity to a wind turbine.

Experience and studies in Europe and the United States have indicated that both the physical structures of the tower/turbine and the rotating blades can cause interference on conventional and Doppler radar signals (see references). Wind turbines, which are within the "Line of Sight" (LOS) of radars, can have a negative impact on radar data.

Based on this, the following systems could be negatively impacted by the proximity of wind turbines:

- Cable distribution off-air (over-the-air, OTA) receive systems (Head-ends);
- Satellite uplinks and receive systems;
- Direct-to-home (DTH) receive systems (Shaw Direct, Bell TV);
- Radar (weather, defence and air traffic);
- Airport communications and guidance systems;
- Broadcasting – radio (AM, FM) and TV (analog and digital);
- Coast Guard communications and vessel traffic radar systems;
- Point-to-point radiocommunication systems;
- Point-to-multipoint radiocommunication systems, and
- Cellular and land mobile networks.

Wind turbines can affect radiocommunication and radar signals in a number of ways including shadowing, mirror-type reflections, clutter or signal scattering.

2.2 Impact on Radiocommunication Systems

Impact on radiocommunication systems can be divided in two parts: impact on broadcast-type systems (including cellular type networks) and impact on point-to-point systems (including local microwave, studio to transmitter links (STL) and transmitter to transmitter links[4] (TTL); either one-way or two-way) and point-to-multipoint systems). Propagation effects are associated with the type of modulation used (AM [e.g., AM radio, Analog TV & Digital TV] or FM/PM [e.g., FM radio]) as well as path obstructions; thus the impacted areas and mitigation measures differ.

Path Obstruction – Point-to-point Systems

Point-to-point microwave radio systems require "line-of-sight" clearance between the two antennas. Any obstruction along this optical path will greatly attenuate the radio signal and will make the path unusable. In addition, line-of-sight does not simply mean that from one site you can "see" the other; the first Fresnel zone[5] clearance is also required.

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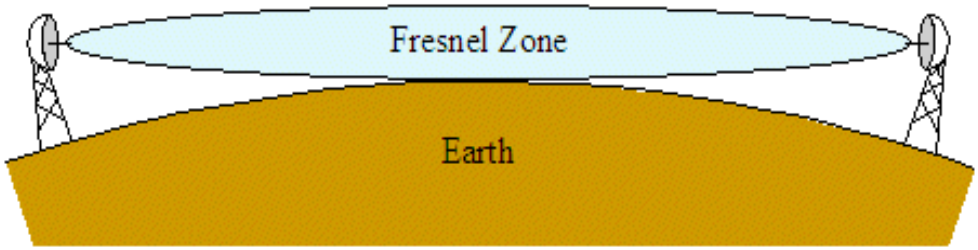
[3] Effects of Wind Turbines on UHF Television Reception, Field tests in Denmark, D. T. Wright, 1991; TV Measurements near Lendrum's Bridge Wind Turbines, J. E. Goodson, 2003.

[4] A transmitter to transmitter link is the wireless path between two transmitters where one of the sites receives its input signal off air from the other.

[5] The first Fresnel zone is defined as an ellipsoid between the two antennas within which all possible propagation paths are within less than half a wavelength in total length from the direct path.



Shadowing

Large obstacles, such as buildings, hills or wind farms can create shadowed areas blocking the LOS from the receiver to the transmitter. These areas can be broken down into two regions: Region “A” where signal loss, due to the blockage, is high and receiving a usable signal is difficult if not impossible; and Region “B” where the signal is attenuated but to a lesser degree than in “A” allowing the receiver to continue to pick up a usable signal. The size of each of the areas depends upon the shape and composition of the obstacle. Typically, Region “B” can extend up to 10 km from the obstacle.

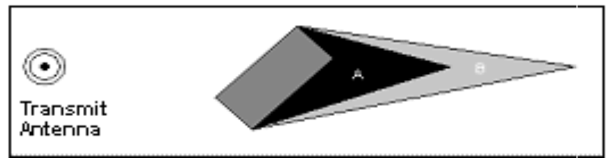


Figure 1.1 – **Shadowed areas due to structures**

Mirror-Type Reflections

Mirror-type (specular) reflections are caused when the signal from the transmitter bounces off an obstacle before being received at the antenna. This bounced signal has a longer path than the direct signal, causing it to be delayed in time at the receiver. In a conventional AM receiver, when the two signals are received simultaneously and one is delayed, the delayed signal can degrade the direct signal. In extreme cases, degradation can also occur in FM receivers. These reflections mainly occur in the back scatter zone.

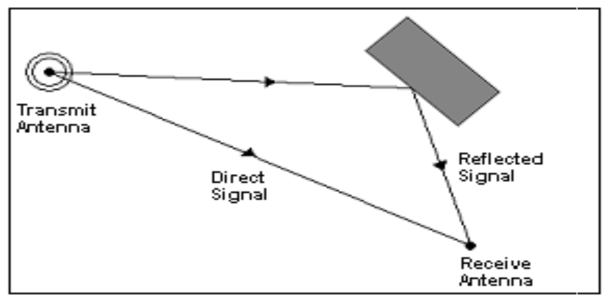


Figure 1.2 – **Mirror-Type Reflections**

Scattering

When a radiocommunication signal reaches a wind turbine, the support tower and the rotating blades of the turbine can produce a pulsed scattering of this signal synchronized with the rotational speed of the blades. These scattered pulses include a Doppler component, which produces variations of the resulting signal phase and amplitude reaching a receiver. This scattering occurs all around the wind turbine but presents different characteristics in the forward scatter and back scatter zones.

In the forward scatter zone which encompasses a relatively narrow sector behind the wind turbine as seen from the transmitter, the effect is analogous to shadowing, with the signal varying in amplitude and phase synchronously with the rotation of the blades.

In the back scatter zone, which encompasses a wider sector on the sides and in front of the wind turbine when looking at the transmitter, the effect is similar to a mirror

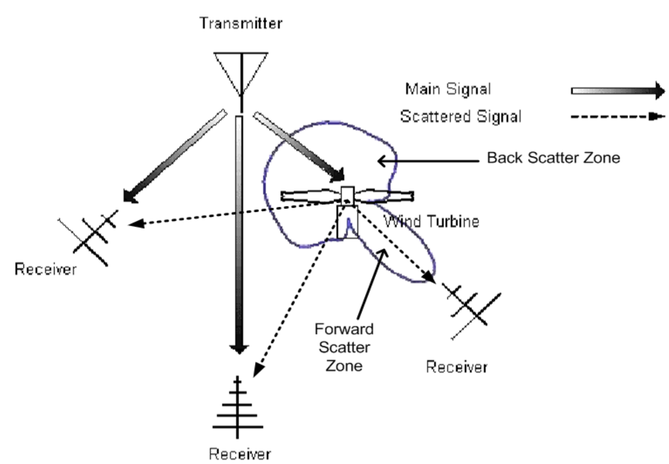


Figure 1.3 – **Forward and Back Scatter Zones**

reflection. However, here again, the scattered signal contains both phase and amplitude variations when the wind turbine is operating.

AM Re-radiation

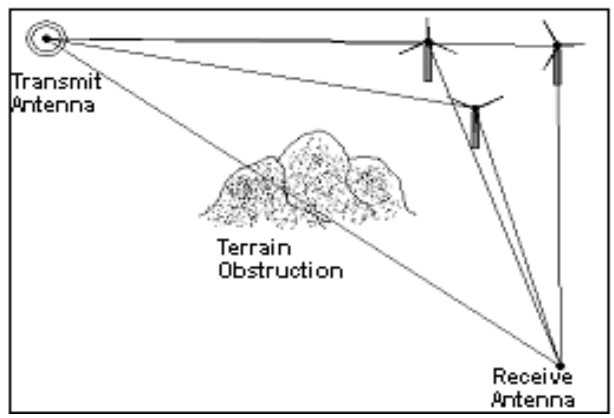
AM radio antenna systems are sensitive to any tall structures made of conductive material. Re-radiation from steel turbine support structures can modify the radiation patterns of AM stations and cause interference to other stations.

The actual impact of single and multiple wind turbine structures on the radiation patterns of AM antenna systems has not yet been documented to our knowledge. However, as these structures are often similar in height to AM antenna radiators, proponents should be cautious when planning wind farms in proximity to AM transmitter sites.

Modeling using conservative assumptions indicates that, to keep antenna pattern deformation within limits set by domestic regulations and international agreements, consultation zones of 5 km radius are required for omnidirectional stations and 15 km for directional stations. It may be possible to locate wind turbines much closer than these distances, especially with directional stations; however, a detailed study would be required to establish compatibility in each case.

Terrain Obstructions

With the exception of radar systems, the possible impact to a radio communication signal caused by the proximity of wind turbines is magnified when the main signal path between the transmitter and the receiver is partially obstructed, while the signal paths between the transmitter and the wind turbines and between the wind turbines and the receivers have no obstructions. In these situations, the desired to undesired signal (D/U) ratio at the receiver is reduced, making any detrimental effects from the wind turbines more pronounced.



2.3 Impact on Radar Systems

There are a number of different radar systems in use for detecting aircraft targets, marine targets or meteorological phenomena. All of these can be impacted by wind farm installations. The effect of wind turbines on radar systems is not easy to determine. If a wind farm is in direct LOS to radar it may have a detrimental effect upon radar performance, as the support structure and rotating blades can be a source of interference. Where wind turbines are in direct LOS to the radar, the turbines could mask real targets, create false targets, or desensitise (raise the noise floor) the radar within the radar sector containing the wind farm thereby potentially creating interference and flight safety issues.

Each proposed site would have to be reviewed on a case-by-case basis. Each radar has a different coverage footprint, depending on its location and the topographical layout of the surrounding area.

Blockage

A single turbine in close proximity to a radar site or a group of turbines at a distance can block a certain angular sector of the radar beam. The blockage should not be more than 10% occultation of the beam width to cause insignificant impact on a radar, according to the European OPERA (Operational Programme for the Exchange of Weather Radar Information) standard. Potential severe blockage could lead to a loss of meteorological data, which could affect the radar's operational performance (e.g. storm detection, rainfall/snowfall rate and lower level wind shear) hence potentially causing extreme weather conditions to go undetected. Given the operational importance of Air Defence (AD), Marine and Air Traffic Control (ATC) Radars, the threshold for an unacceptable level of blockage would likely be even less than the 10% occultation quoted above.

Clutter

Clutter is defined as unwanted echoes on radar display. In this case “clutter” is unwanted echoes from wind turbines. The impact of clutter depends on the radar cross section (RCS) of the supporting structure, the nacelles and the cross section area of the rotating blades, which in turn, depends on the orientation of the turbine. Since the turbine can rotate 360 degrees azimuthally in order align itself with the prevailing wind direction, the RCS changes with the wind direction, with a maximum possible RCS approximately equal to that of a 747 aircraft. This can have a negative impact on radar data.

Doppler Signal

Weather radars can use the Doppler effect to detect the motion of targets, and this motion is used in various meteorological techniques. Radar picks up non-meteorological Doppler signals from the tips of rotating blades, as well as the wake turbulence produced by the blades. The degradation of Doppler signal can reduce the ability to detect a rotating storm (usually associated with severe weather) and low-level wind shear (which is especially important for aviation purposes). The weather radars have some Doppler-based filters to remove stationary clutter due to ground targets, but turbines defeat those filters because the rotors and blades move. Any organization considering constructing a wind turbine within 50 km of a Meteorological Radar should contact Environment Canada regarding possible impacts and mitigation measures.

Air Defence Radar Concerns

The role of the Canadian Air Defence System (ADS) is to provide aerospace surveillance contributing to the defence of North America. The Canadian ADS constitutes Canada’s commitment to the North American Aerospace Defence (NORAD) Atmospheric Early Warning System (AEWS). The ADS in Canada is comprised of 52 radars. These radars are located throughout Canada’s arctic, coastal, and inland regions.

AD radars must be capable of tracking friendly and hostile targets within Canada’s aerospace. Detailed studies have shown that wind turbines cause a number of serious problems with respect to AD radars. These problems include blanking, reducing the radar’s ability to detect real targets, clutter, false targets, and reporting inaccurate positional information on real targets.

Any organization considering establishing a wind turbine site should contact the Department of National Defence (DND) to determine whether it is within a 100 km radius of an AD radar. DND can determine if the proposed wind turbine is within LOS of the radar beam and/or if interference problems are likely. In order to avoid potential interference with Air Defence radars used in support of national sovereignty, it is important to consult with the appropriate authority prior to establishing a wind turbine site.

ATC Radar Concerns

Aircraft operating under Instrument Flight Rules (IFR) rely on ATC for safe separation from other aircraft. Wind turbines in LOS of an air traffic control radar may have a significant impact on the ability to support air traffic services (ATS). These effects take the form of obscuration and displayed false target reports which are a result of strong radar reflections from moving objects that have a high Radar Cross Section (RCS). Air traffic controllers must always honour the presence of a displayed radar return on their screen and treat it at as a real aircraft. As such, flying near sources of radar interference can hamper the ability of an ATC operator to safely provide ATS because it is not possible to differentiate real and false targets.

There are many potential sources of interference to radar. However, there are several factors which cause wind farms to be of special concern to ATC over typical sources of interference. Firstly, wind turbines can be detected at great distance by radar due to their height and high RCS. Second, a wind farm can occupy a large amount of land, creating a constant source of interference affecting a large volume of airspace.

NAV CANADA and DND, providers of ATS within Canada operate two types of surveillance radars: Primary Surveillance Radar (PSR) and Secondary Surveillance RADAR (SSR). Additionally, DND operates Precision Approach Radar (PAR) at many of its airfields. PSR and SSR have consultation zones of 80 km and 10 km, respectively while a PAR has a consultation zone of 40 km. Wind farm proponents should contact NAV CANADA and DND to determine whether a wind turbine site is within the consultation zones noted above. An assessment by the affected agency (**see Table 1**) may be required to determine the effect upon the provision of Air Traffic Services.

Vessel Traffic Control Radar Concerns

Wind turbines in or near the line of site of a Vessel Traffic Services (VTS) radar installation can have an impact on the ability of a Marine Communications and Traffic Services Operator (MCTSO) to distinguish real targets from false targets as a result of the scattering effect of nearby wind turbine installations.

Interference to marine VTS radars is primarily due to the RCS of the support structure and the nacelles of the wind turbines. The severity of this effect depends upon the incident angle of the radar beam to the wind turbine. At the present time, VTS marine radars are pulse type magnetron radars. In the future, as the technology changes to all solid-state radars, it is quite possible that the Coast Guard will be using Doppler type radars. This would mean that the rotating blades would have some impact on resulting targets.

A wind developer considering building a wind turbine or wind farm, within 60 km of a marine vessel traffic radar, should contact the Canadian Coast Guard to discuss potential impacts and mitigation measures.

2.4 Impact on Air Navigation Systems

The VHF OmniRange (VOR) is a short-range air navigation beacon. The primary objective of the VOR is to provide navigational signals which enable a pilot to fly a predetermined course or obtain a geographic fix. The VOR signal allows airborne receiving equipment to measure its bearing relative to the beacon. VOR facilities are located near airports, or at waypoints between them, so that they can be used to establish a network of air traffic corridors (airways). The VOR is the foundation of the present-day Victor Airway System. Sometimes, VORs are also used in approach and landing procedures.

VOR is highly susceptible to reflection interference from a variety of metallic or non-metallic objects. Wind turbines are a special case that merits extra attention due to the height. As such, turbines can cause deflections in the bearing measured by the airborne receiver with the severity depending on the turbines proximity, elevation and size. Clustered together, each turbine in a wind farm can have a cumulative effect.

The shutdown of one VOR facility may disrupt the smooth and expedient control of all IFR air traffic within an operational radius of 200 km (100 nautical miles) or more. Note that the consultation zone around a VOR beacon is 15 km.

3. Coordination Information

The following table lists contacts within different organisations that coordinate the assessment of possible wind turbine effects on radiocommunication and radar systems.

Table 1 – Coordination Mandatory Contact List

Agency	Contact Information
Industry Canada	- General Radiofrequency database: http://spectrum.ic.gc.ca/tafl/taflindex.html - Spectrum Direct: http://www.ic.gc.ca/eic/site/sd-sd.nsf/eng/home - Broadcasting database: http://www.ic.gc.ca/eic/site/sp_dgse-ps_dggs.nsf/eng/gg00026.html - Integrated Spectrum Observation Centre (ISOC): Contact RIC-66: http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf01742.html **NOTE**: The Industry Canada website listed above does not list non-disclosed (protected) assignments for public safety systems, including the Federal DND and RCMP, and the Provincial and Municipal Police Service, Fire and Ambulance Service radiocommunication users.
Department of National Defence (DND)	**Military Radiocommunication Users** **Website: http://www.rcaf-arc.forces.gc.ca/en/services/wind-turbine-impact-assessment-for-industry.page** **E-mail: +WindTurbines@forces.gc.ca**
	Military Air Defence and Air Traffic Control Radars **Website: http://www.rcaf-arc.forces.gc.ca/en/services/wind-turbine-impact-assessment-for-industry.page** **E-mail: +WindTurbines@forces.gc.ca**
Royal Canadian Mounted Police	E-mail: Windfarm_Coordinator@rcmp-grc.gc.ca Tel: (613)-949-4519 Fax: (613)-998-7528
Canadian Coast Guard	**Vessel Traffic System Radars** Website : http://www.ccg-gcc.gc.ca/eng/CCG/Contact_Us E-mail: windfarm.coordinator@dfo-mpo.gc.ca
Environment Canada	**Weather Radars** Website: http://weatheroffice.ec.gc.ca/radar/index_e.html E-mail: weatherradars@ec.gc.ca
NAV CANADA	**Civilian Radar and Air Navigation Equipment** Land Use Office, Aeronautical Information Services Website: http://www.navcanada.ca/ E-mail: landuse@navcanada.ca Phone : +1 (866) 577-0247 Fax : +1 (613) 248-4094
Public Safety Agencies	Public Safety Agencies include Provincial, Regional and Municipal Police, Ambulance and Fire Services having jurisdiction in the proposed wind turbine project location.

Table 2 - Guidelines for Determining Consultation Zone

This table provides general area sizes (the "consultation zones") around specific equipment that would require consultation between a potential developer and the appropriate system operator (see Table 1 above for contact information of agencies operating non-disclosed systems). Section 3 gives examples of how these consultation zones may be determined. Any mitigating techniques contemplated should be discussed among the relevant parties.

Systems	General guidelines
Point-to-Point Systems above 890 MHz: Microwave Links An example of a typical point-to-point consultation zone is shown in Section 3.1.	1) The radius of the consultation zone around both the transmit and receive locations is 1.0 km, plus 2) Outside this 1.0 km, a cylinder of diameter "L_c ", between the transmit and receive locations, should be considered, where: $$L_C = R + 52\sqrt{\frac{D}{F}}$$ ***D*** = Path length in kilometers (km) ***F*** = Frequency in gigaHertz (GHz) L_c = Diameter of the cylinder in meters (m) ***R*** = Wind turbine rotor diameter in meters (m) Note: The above equation is based on 3 times the maximum first Fresnel zone clearance.
Broadcast transmitters AM, FM and TV stations Multi-channel Multipoint Distribution Service (MMDS) Systems	**AM station:** To avoid antenna pattern distortion and the associated interference issues, the radius of the consultation zones around an AM station is 5 km for an omnidirectional (single tower) antenna system and 15 km for a directional (multiple towers) antenna system. **FM station**: The radius of the consultation zone around an FM transmitter is 2.0 km. **TV station**: The radius of the consultation zone around a TV transmitter is 2.0 km.
Over-the-Air Reception TV off-air pickup Consumer TV receivers An example of a typical TV reception quality assessment zone is shown in Section 3.2	When a TV station's service contour overlaps the wind farm area, including the following consultation distances, and residences are located within the area, a detailed quality of reception analysis is recommended. Coverage information can be found at: http://www.ic.gc.ca/eic/site/sp_dgse-ps_dggs.nsf/eng/gg00026.html. There are two possible cases to be considered for the detailed analysis, the reception of analog TV stations and the reception of digital TV stations. **Analog TV station (NTSC)**: The extent of the consultation zone around a wind farm is 15 km from the closest wind turbine. **Digital TV (DTV) station (ATSC)**: The extent of the consultation zone around a wind farm is 10 km from the closest wind turbine.
Cellular type networks, **Land Mobile Radio networks** **and** **Point-toPoint Systems below 890 MHz**	The radius of the consultation zone for fixed Land Mobile Radio (LMR) stations, point-to-point stations below 890 MHz, cellular and other wireless mobile service provider stations is 1.0 km.

Satellite Systems Direct-to-Home (DTH), Satellite Ground Stations An example of a typical satellite ground station consultation zone is shown in Section 3.3	1) The radius of the consultation zone around a satellite transmit/receive location is 500 m. 2) Beyond this 500 m, the consultation zone should also include a cone of width "L_c" defined as: $$L_C = R + 104\sqrt{\frac{D}{F}}$$ ***D*** = Distance from the ground satellite antenna in kilometers (km) (max distance = 10 km) ***F*** = Frequency in gigaHertz (GHz) L_c = Width of the cone in meters (m) ***R*** = Wind turbine rotor diameter in meters (m)
Air Defence Radars, **Vessel Traffic Radars,** **Air Traffic Control Radars** **and** **Weather Radars**	1) The radius of the consultation zone around any DND Air Defence Radar is 100 km; 2) The radius of the consultation zone around any DND or Nav Canada Air Traffic Control Primary Surveillance Radar (PSR) is 80 km; 3) The radius of the consultation zone around any DND or Nav Canada Air Traffic Control Secondary Surveillance Radar (SSR) is 10 km 4) The radius of the consultation zone around any DND Precision Approach Radar (PAR) is 40 km; 5) The radius of the consultation zone around any Canadian Coast Guard Vessel Traffic Radar System is 60 km; 6) The radius of the consultation zone around a military or civilian airfield is 10 km; 7) The radius of the consultation zone around an Environment Canada Weather Radar is 50 km.
VHF OmniRange (VOR)	The radius of the consultation zone around a VOR beacon is 15 km.

3. Consultation Zone Calculations

3.1 Point-to-Point Radiocommunication Links

These are defined as any point-to-point radiocommunication transmission system operating at frequencies above 890 MHz. It includes links such as STLs (Studio-to-Transmitter Links) and Point-to-Multipoint links operating licensed outstations.

The consultation zones related to these systems are based on the path's Fresnel zone clearance and can be determined from the following two conditions stipulated in Table 2:

a) A 1.0 km radius around the transmit and receive antennas, plus

b) A cylinder between the transmitter and receiver defined by:

$$L_C = R + 52\sqrt{\frac{D}{F}}$$

Example:

For a 25 km, 7.0 GHz microwave point-to-point hop, the consultation zone, assuming the wind turbines have an 80 m rotor diameter, are:

a) 1.0 km around the transmitter and receiver, plus

b) $L_C = 80 + 52\sqrt{\frac{25}{7}}$

$\boldsymbol{L_c = 178\ m}$

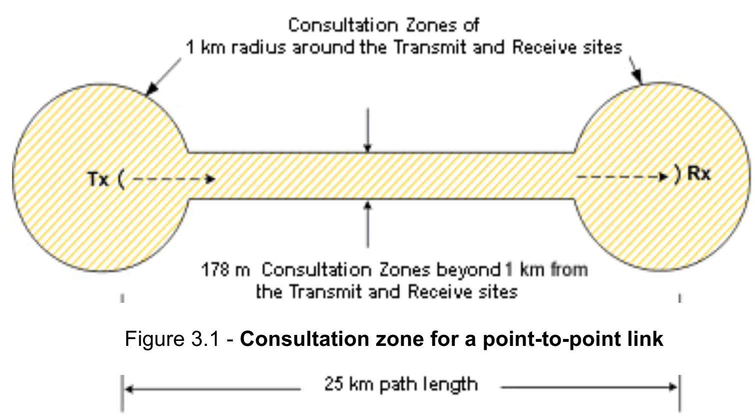


Figure 3.1 - **Consultation zone for a point-to-point link**

If there are any wind turbines within these boundaries, then it is recommended that a detailed impact analysis be undertaken by a qualified Radiocommunication Engineer.

3.2 TV Reception Near Wind Turbines

Analogue and Digital TV Receivers Including Consumer Broadcast Receivers

For proposed wind farms located in populated areas (or in proximity to populated areas) served by analog or digital TV broadcast stations, a reception analysis is recommended. Such analysis should be performed when there are residences located within an official television service contour and within a consultation zone of:

- 10 km extending from the closest wind turbine for digital TV;
- 15 km extending from the closest wind turbine for analog TV;

Example:

The following example shows a typical situation where an analysis may be warranted even if the wind turbines themselves are located outside the official television coverage area. Nearby residences, both within and outside the official service contour, may currently be receiving reliable TV service and could be affected by the presence of new turbines.

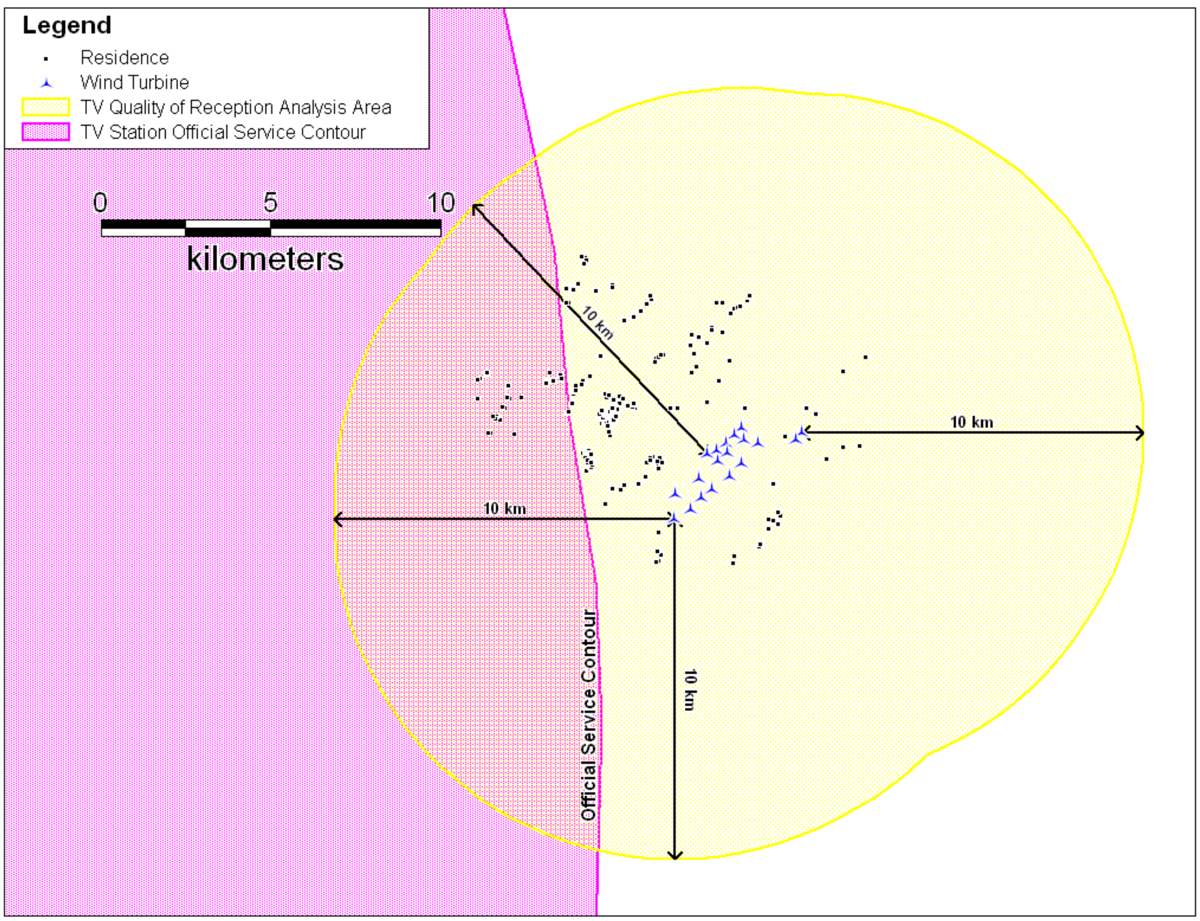


Figure 3.2 – **TV reception analysis area**

3.3 Satellite Ground Stations

Satellite Ground Stations Including DTH Receivers

Satellite ground stations are locations where operators either receive RF signals from, or transmit signals to, geo-stationary orbiting satellites. The consultation zones related to these systems are defined in Table 2 as:

a) A 500 m radius around the transmit and receive antennas, plus

b) A cone of width L_c defined as:

$$L_C = R + 104\sqrt{\frac{D}{F}}$$

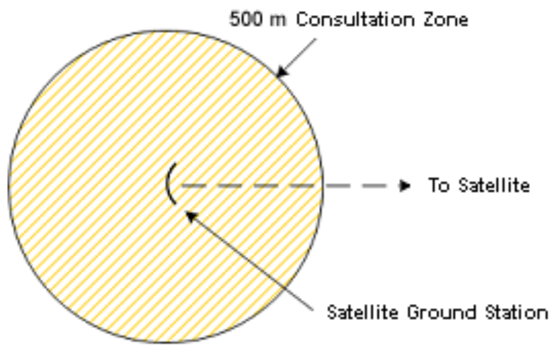


Figure 3.3 - **Consultation zone within 500 m of a satellite ground station**

Example:

For a satellite ground station operating at 4.0 GHz, the consultation zone, assuming the wind turbines have an 80 m rotor diameter, would be:

a) A 500 m radius around the satellite ground station, plus

b) A conical shaped zone starting from the satellite ground station and extending out up to 10 km defined by:

$$L_C = 80 + 104\sqrt{\frac{10}{4}}$$

At 10 kilometres from the satellite ground station, the consultation zone would be:

$$L_c = 244m$$

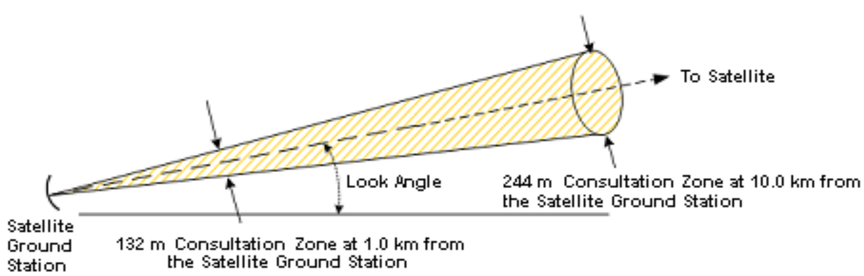


Figure 3.4 - **Consultation zone for a ground station from the antenna to 10 km**

If there are any wind turbines inside these areas, then it is recommended that a detailed impact analysis be undertaken by a qualified Radiocommunication Engineer.

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