

Wind Power GeoPlanner™

Microwave Study

Timber Road 3



Prepared on Behalf of
Paulding Wind Farm III
LLC

November 9, 2015



COMSEARCH
A CommScope Company

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1. Introduction

Microwave bands that may be affected by the installation of wind turbine facilities operate over a wide frequency range (900 MHz – 23 GHz). Comsearch has developed and maintains comprehensive technical databases containing information on licensed microwave networks throughout the United States. These systems are the telecommunication backbone of the country, providing long-distance and local telephone service, backhaul for cellular and personal communication service, data interconnects for mainframe computers and the Internet, network controls for utilities and railroads, and various video services. This report focuses on the potential impact of wind turbines on licensed, proposed and applied non-federal government microwave systems.

2. Project Overview

Project Information

Name: Timber Road 3

County: Paulding

State: Ohio

Number of Turbines: 60

Blade Diameter: 114 meters

Hub Height: 93 meters

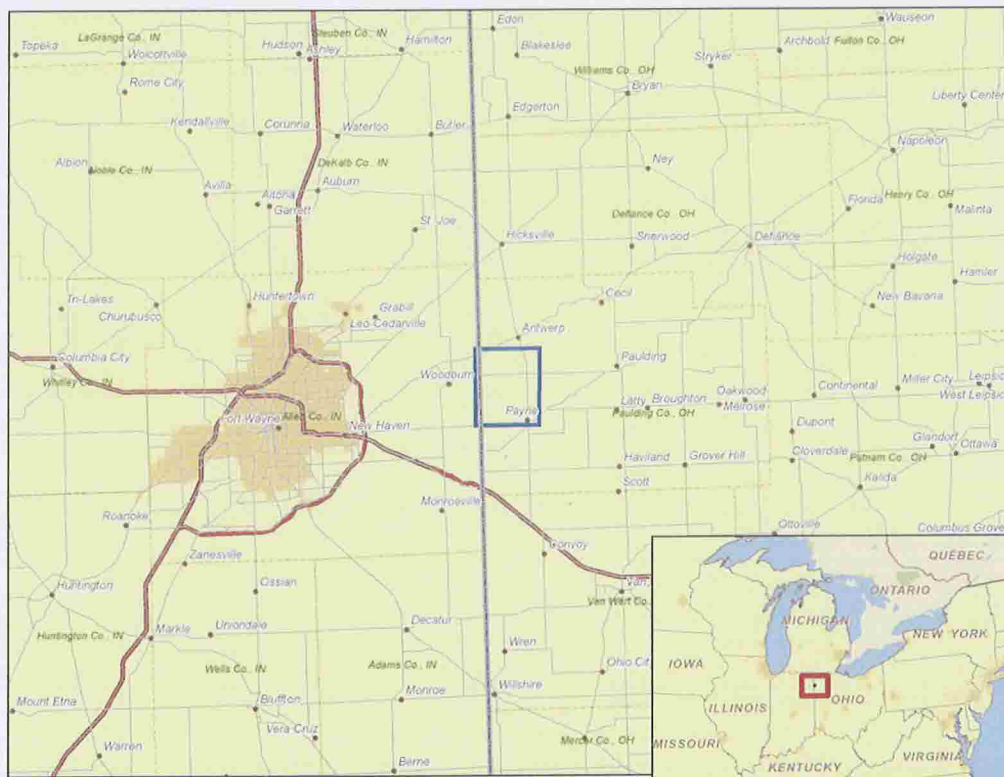


Figure 1: Area of Interest

3. Fresnel Zone Analysis

Methodology

Our obstruction analysis was performed using Comsearch's proprietary microwave database, which contains all non-government licensed, proposed and applied paths from 0.9 - 23 GHz¹. First, we determined all microwave paths that intersect the area of interest² and listed them in Table 1. These paths and the area of interest that encompasses the planned turbine locations are shown in Figure 2.

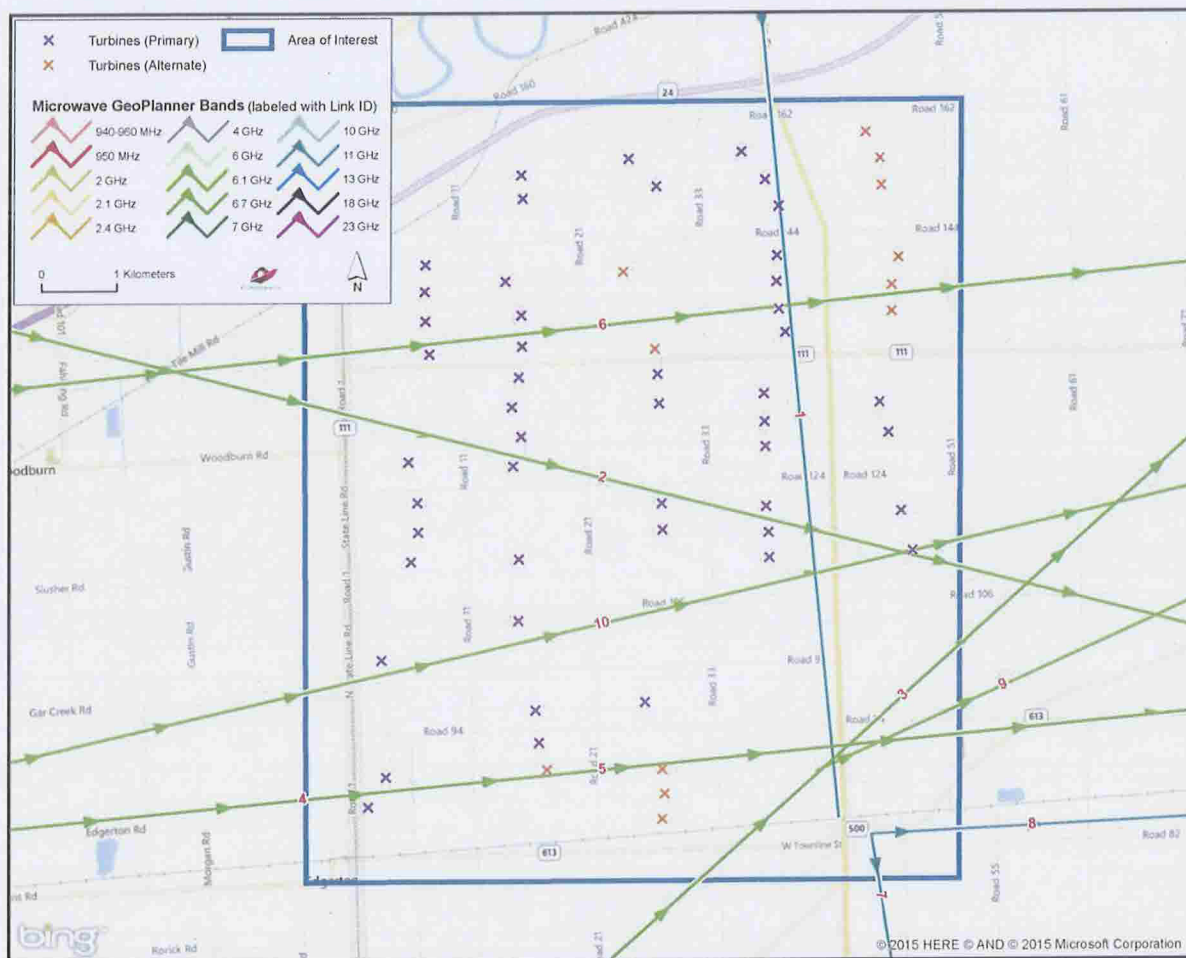


Figure 2: Microwave Paths that Intersect the Area of Interest

¹ Please note that this analysis does not include unlicensed microwave paths or federal government paths that are not registered with the FCC.

² We use FCC-licensed coordinates to determine which paths intersect the area of interest. It is possible that as-built coordinates may differ slightly from those on the FCC license.

ID	Status	Callsign 1	Callsign 2	Band	Path Length (km)	Licensee
1	Applied	ANTWERP	PAYNE	11 GHz	11.03	MetaLINK Technologies, Inc.
2	Proposed	GTPIN-52	OH03415-	Lower 6 GHz	54.80	Wireless Internetwork LLC
3	Licensed	KJI65	KYK81	Upper 6 GHz	55.74	Panhandle Eastern Pipe Line Company, L.P
4	Proposed	WAZ563	WAZ596	Lower 6 GHz	31.41	Norfolk Southern Railway
5	Licensed	WAZ563	WAZ596	Upper 6 GHz	31.41	Norfolk Southern Railway
6	Licensed	WQOD566	WQOD564	Lower 6 GHz	51.96	Appalachian Broadcasting
7	Licensed	WQRY696	WQRX772	11 GHz	18.18	Sprintcom, Inc
8	Licensed	WQRY696	WQRY695	11 GHz	12.61	Sprintcom, Inc
9	Licensed	WQTF467	WQTF470	Lower 6 GHz	12.85	Verizon Wireless (VAW) LLC - Ohio
10	Licensed	WQVT311	WQVT312	Lower 6 GHz	31.85	Paulding-Putnam Electric Cooperative

Table 1: Summary of Microwave Paths that Intersect the Area of Interest

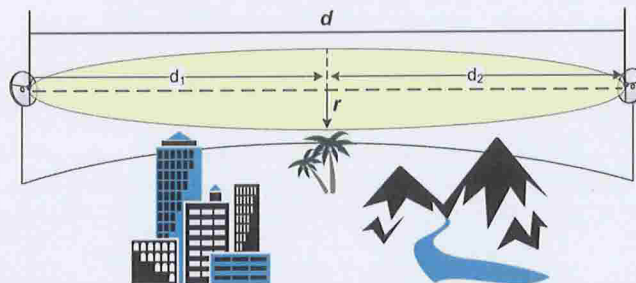
(See enclosed mw_geopl.xlsx for more information and
GP_dict_matrix_description.xls for detailed field descriptions)

Verification of Coordinate Accuracy

It is possible that as-built coordinates may differ from those on the FCC license. For this project, path IDs 1-2, 4-6 and 10 cross within close proximity of the proposed turbines and the tower locations for these paths will have a critical impact on the result. Therefore, we verified these locations using aerial photography. Some of the towers were found to be slightly off and were moved to their locations based on the aerial photos³.

Next, we calculated a Fresnel Zone for each path based on the following formula:

$$r \cong 17.3 \sqrt{\frac{n}{F_{GHz}} \left(\frac{d_1 d_2}{d_1 + d_2} \right)}$$



³ See enclosed mw_geopl.shp and mw_geopl_fcc.shp for details.

Where,

- r = Fresnel Zone radius at a specific point in the microwave path, meters
- n = Fresnel Zone number, 1
- F_{GHz} = Frequency of microwave system, GHz
- d_1 = Distance from antenna 1 to a specific point in the microwave path, kilometers
- d_2 = Distance from antenna 2 to a specific point in the microwave path, kilometers

In general, this is the area where the planned wind turbines should be avoided, if possible. A depiction of the Fresnel Zones for each microwave path listed can be found in Figure 3, and is also included in the enclosed shapefiles^{4,5}.

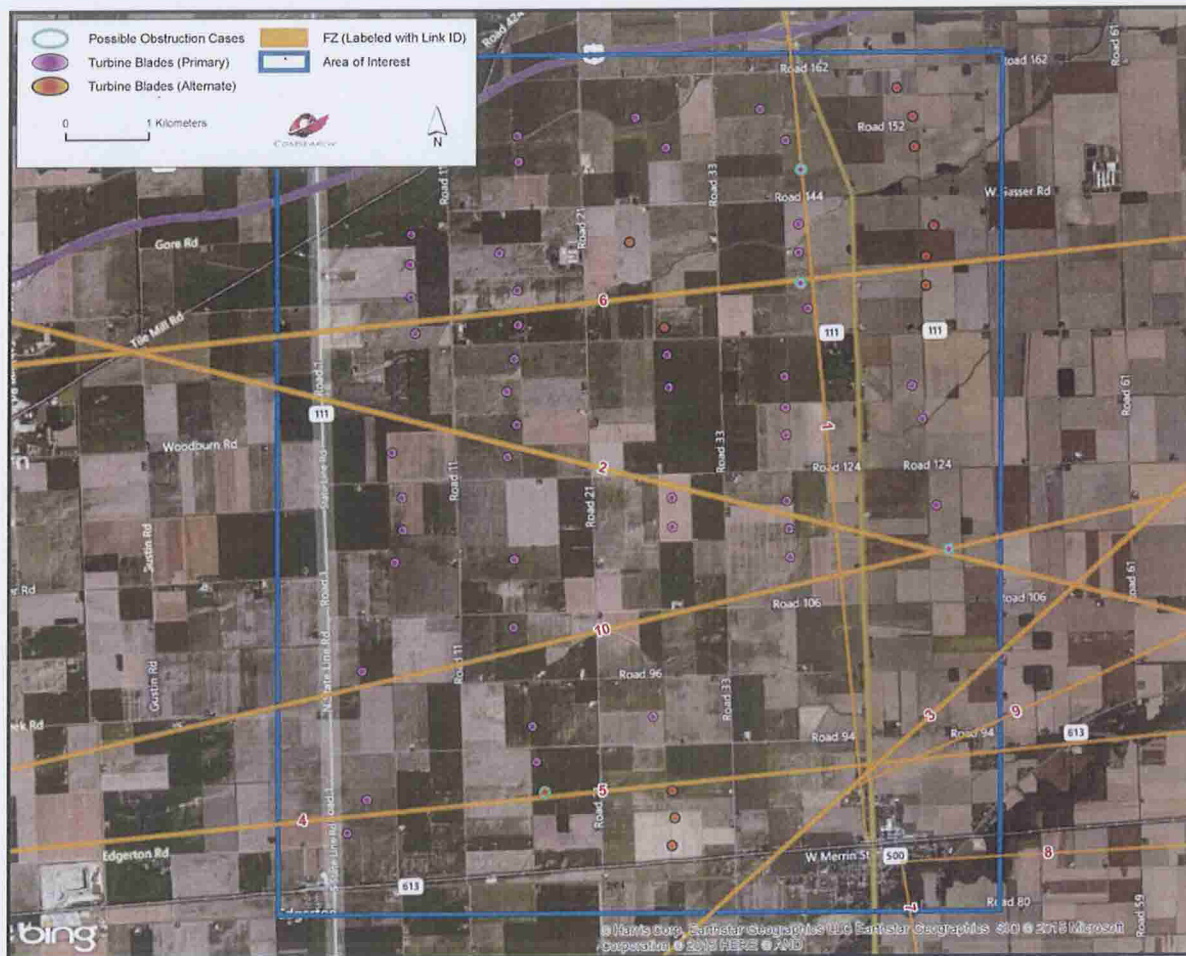


Figure 3: Fresnel Zones in the Area of Interest

⁴ The ESRI® shapefiles enclosed are in NAD 83 UTM Zone 16 projected coordinate system.

⁵ Comsearch makes no warranty as to the accuracy of the data included in this report beyond the date of the report. The data provided in this report is governed by Comsearch's data license notification and agreement located at http://www.comsearch.com/files/data_license.pdf.

Discussion of Potential Two Dimensional Obstructions

Total Microwave Paths	Paths with Affected Fresnel Zones	Total Turbines	Turbines intersecting the 2D Fresnel Zones
10	6	60	4

Table 2: Fresnel Zone Analysis Result

For this project, 60 turbines were considered in the analysis, each with a blade diameter of 114 meters and turbine hub height of 93 meters. Of those turbines, four were found to intersect the Fresnel Zones of six microwave paths. Figure 4 through Figure 6 contain a detailed depiction of the potential obstruction scenarios and Table 3 contains a summary of the affected turbines. A cross sectional analysis was performed in Section 4 to determine the diagonal clearance value for these cases.

Turbine ID	Status	Latitude (NAD83)	Longitude (NAD83)	Affected Microwave Path ID	Fresnel Zone Width at Turbine Location (m)	Horizontal off-path Distance (m)	Distance along the path from site 1 (km)	Horizontal Clearance (m)
40	Primary	41.15390377	-84.73433316	1	7.56	8.10	2.90	-56.46
60	Primary	41.11232382	-84.71455659	2	21.58	55.48	42.37	-23.11
25	Alternate	41.08743298	-84.77307932	4	17.66	63.85	22.37	-10.81
25	Alternate	41.08743298	-84.77307932	5	16.96	63.85	22.37	-10.11
43	Primary	41.14163260	-84.73474704	6	21.86	35.50	38.74	-43.36
60	Primary	41.11232382	-84.71455659	10	18.54	1.54	21.20	-74.00

Table 3: Turbines that Intersect Fresnel Zones

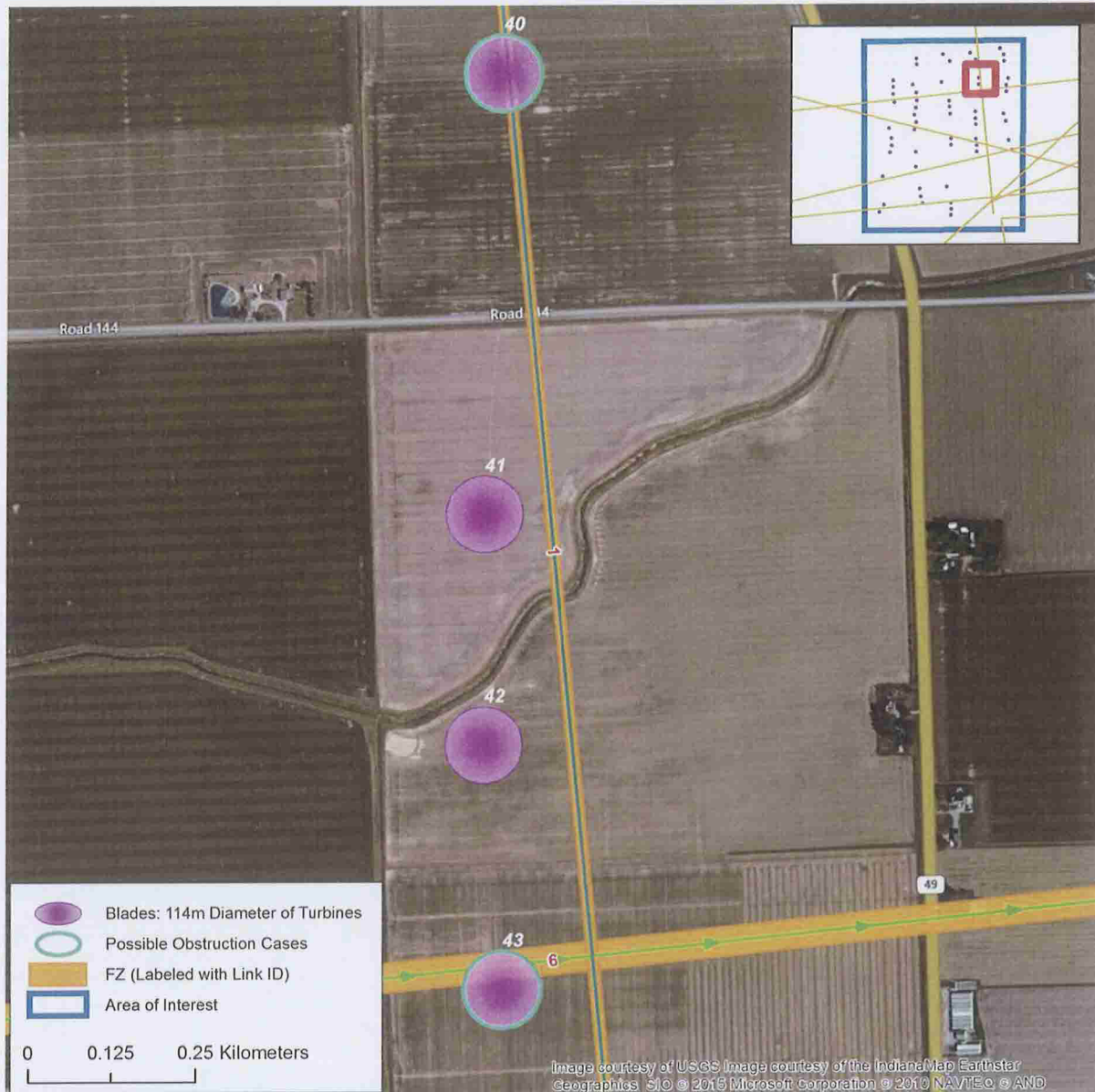


Figure 4: Potential Obstruction Cases (Turbine 40 and 43)

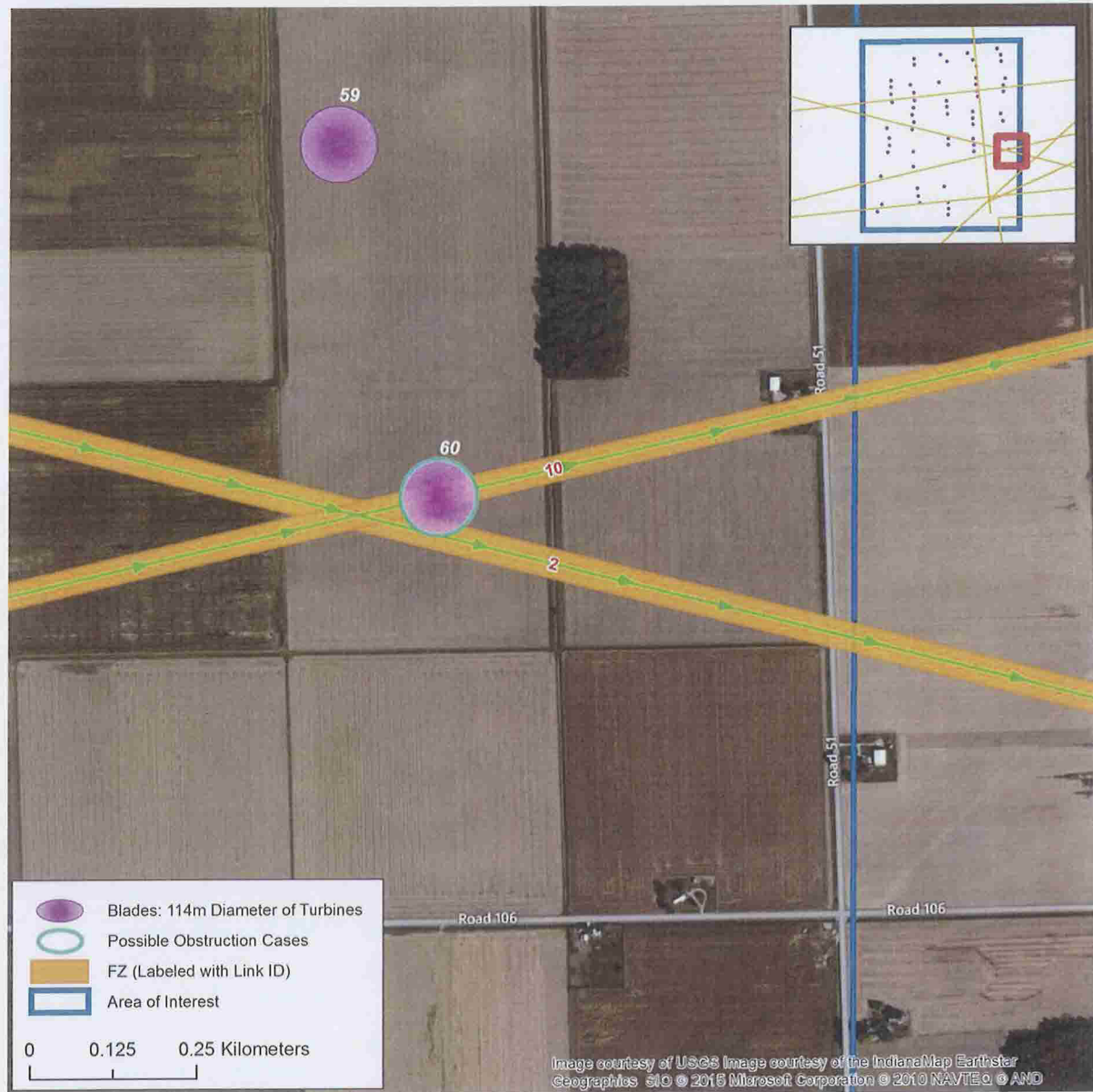


Figure 5: Potential Obstruction Cases (Turbine 60)

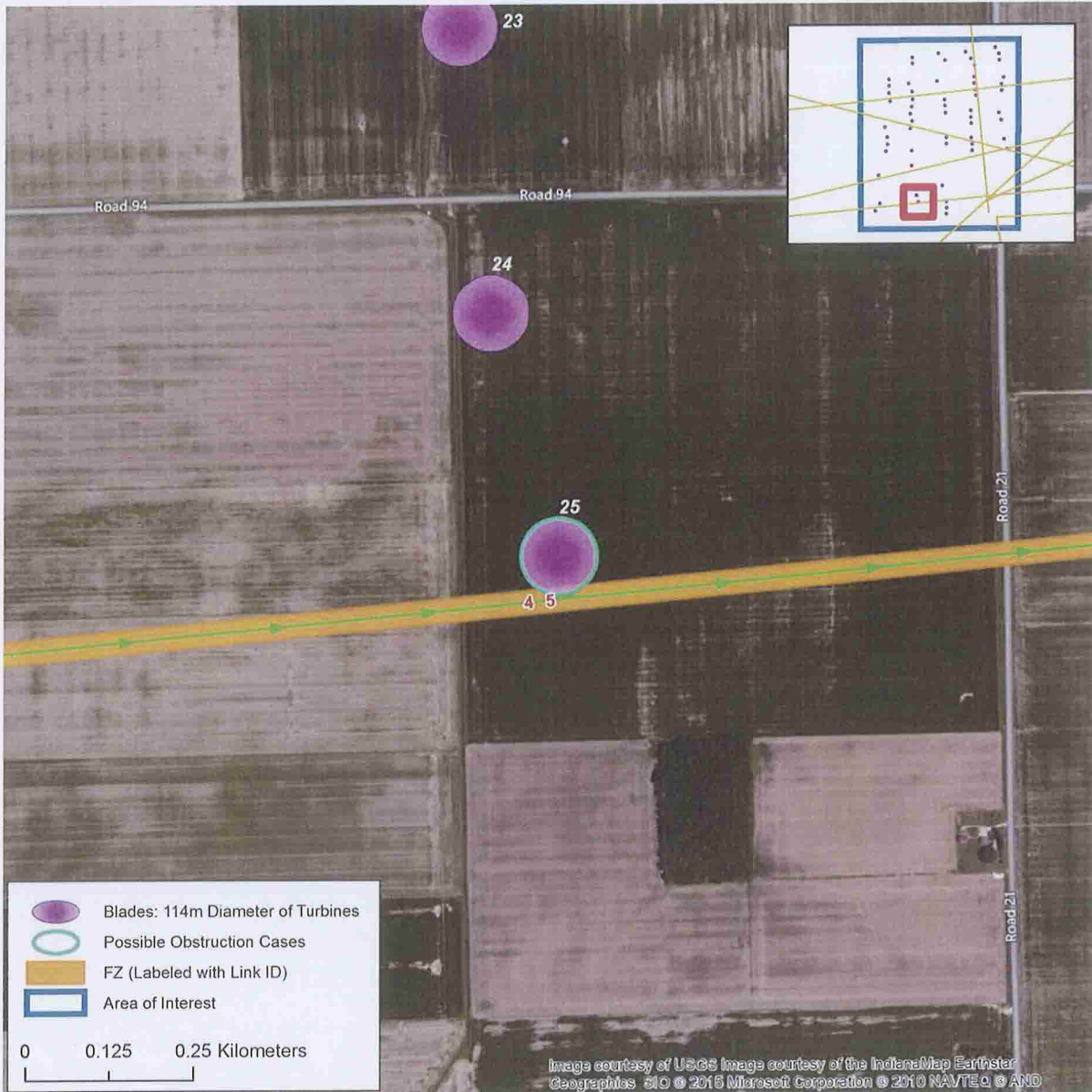
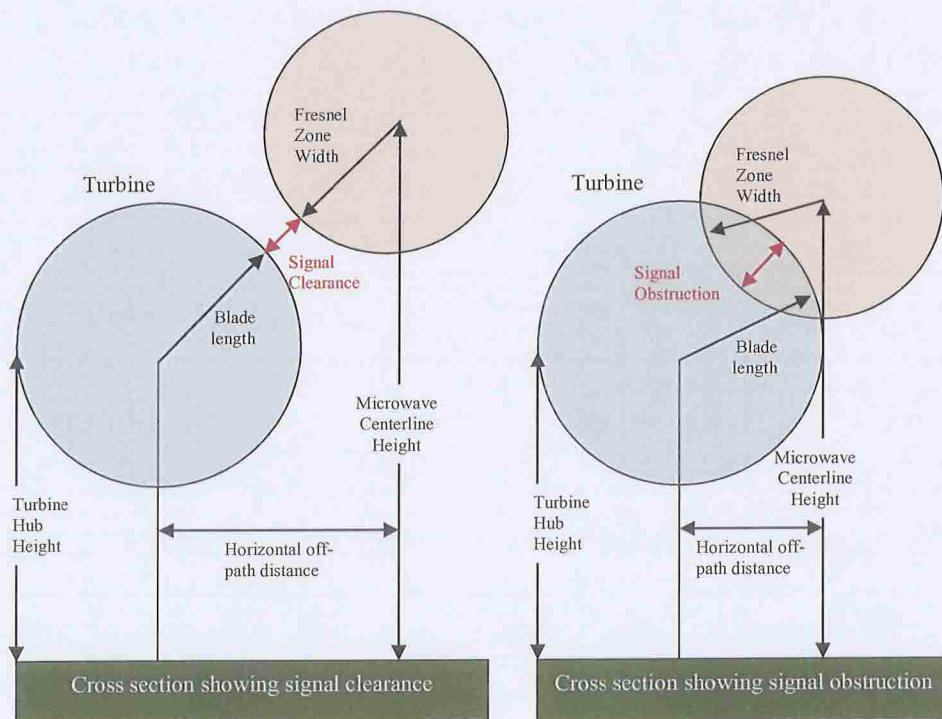


Figure 6: Potential Obstruction Cases (Turbine 25)

4. Cross Sectional Analysis

Our Fresnel Zone analysis in the previous section identified six potential obstruction cases that need to be further examined from a cross sectional perspective. The cases that will be analyzed in this section can be found in Table 3.

Our cross sectional analysis calculates the precise height and width of 100% of the first Fresnel Zone at the turbine location based on the antenna heights of the two link endpoints and the earth curvature bulge at the specific turbine location. The horizontal off-path distance was calculated in the previous section and the turbine hub height and blade length were provided by the client. The cross sectional analysis uses these values to calculate the clearance between the blades and the microwave Fresnel Zone as shown in the two diagrams below.



The results of the cross sectional calculations can be seen in Table 4 below. It shows positive clearance values indicating clearance of the Fresnel zones and negative clearance values indicating obstruction of the Fresnel zones.

Microwave Path ID	Fresnel Zone Width at Turbine Location (m)	Microwave Centerline Height at Turbine Location (m)	Turbine ID	Turbine Status	Hub Height (m)	Blade Length (m)	Cross Sectional Clearance (m)
1	7.56	34.44	40	Primary	93	57	-5.44
2	21.58	51.93	60	Primary	93	57	-9.56
4	17.66	51.51	25	Alternate	93	57	1.48
5	16.96	51.51	25	Alternate	93	57	2.19
6	21.86	54.12	43	Primary	93	57	-26.21
10	18.54	52.73	60	Primary	93	57	-35.24

Table 4: Cross Sectional Analysis Results

5. Conclusion

Our study identified 10 microwave paths intersecting the Timber Road 3 project area. The Fresnel Zones for these microwave paths were calculated and mapped. Based on the 2-dimensional and cross-sectional Fresnel Zone analysis, it was determined that three turbines (40, 43 and 60) may obstruct four microwave paths and potentially cause signal degradation. A possible mediation procedure is to move these turbines away from the microwave paths by the distances and directions listed in Table 5.

Turbine ID	Affected Microwave Path ID	Distance to Move Turbines	Azimuth (southerly) to Move Turbines
40	1	56.46	265.97
43	6	43.36	175.24
60	2 & 10	77.08	348.24

Table 5: Possible Mediation Procedures



6. Contact

For questions or information regarding the Microwave Study, please contact:

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Summary: Application Exhibit F - Microwave Study electronically filed by Mr. Michael J. Settineri on behalf of Paulding Wind Farm LLC and Paulding Wind Farm III LLC