Lab 3 - Radio communication theory
Introduction to Drone Technology

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1 Radio link budget

1.1 Unit conversion mW and dbm

The formula for converting mW (power) to dbm with a reference of 1mW is written in equation 1 [1].

$$P_{dbm} = 10 \cdot \log_{10}\left(\frac{P_m W}{10^{-3}}\right) \tag{1}$$

P_{mW}	P_{dbm}
100	20.00
500	26.99
1000	30.00

Table 1: Different values of mW converted to dbm

1.2 Free-space basic transmission loss

Free-space basic transmission loss is the reduction of the effect of radio energy between the feed points of two antennas that stem from the receiving antenna's capture area and the line-of-sight path through an open space which is free of obstacles. As the signal must cover a wider area, the conversation of the energy of the signal shows that energy in an area will lessen as the covered area increases.

1.3 Radio link budget

2 Near field absorption and Fresnel zones

2.1 Near field absorptions

The near-field absorption of radiation affects the load of the transmitter. In the parts closest to the antenna, the absorption of electromagnetic power can increase the load of the transmitter, with a second device that feeds back to the transmitter. This increases the load by decreasing the antenna impedance, and by this the transmitter can sense when power is being absorbed, and has to supply extra power to its antenna.

2.2 Fresnel zones

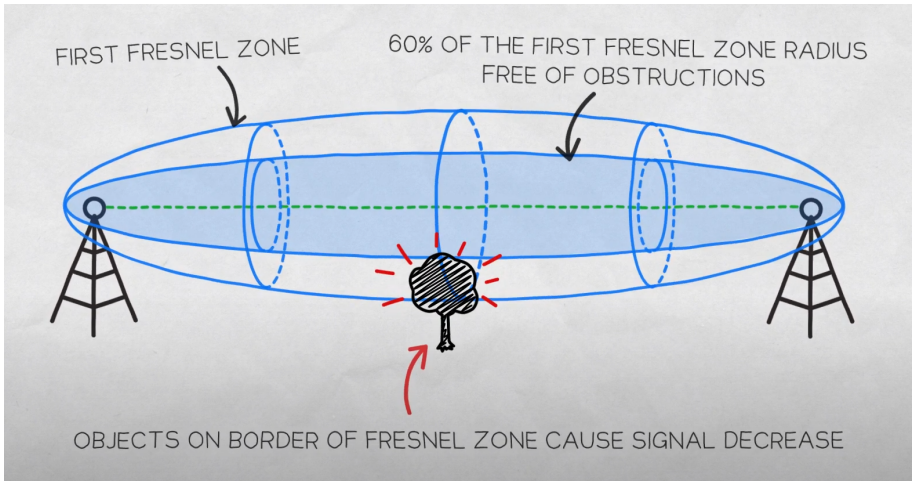

Figure 1: Illustration of the Fresnel Zone [2]

The Fresnel Zone is an ellipsoid encapsulating two communicating antennas around the line of sight (LoS) line. Having objects reflect the signal on the border of the Fresnel Zone can decrease the signal strength, as illustrated in figure 1. The formula for calculating the radius of the Fresnel Zone at a given point in the LoS is given by equation 2.

$$F_n = \sqrt{\frac{n\lambda(d_1 d_2)}{d_1 + d_2}} \tag{2}$$

Where F_n is the Fresnel Zone radius for the zone number n, λ is the frequency, d_1 and d_2 is the respective distances from the point in LoS to the two antennas [3].

C2 stands for command and control system, and links the ground station and the UAV [4].

2.3 Plotting Fresnel zones

Using equation 2 the different Fresnel Zones shapes for different frequencies are plotted in figure 2. It is clear that higher frequencies require a larger area of obstacle free space to have unobstructed communication.

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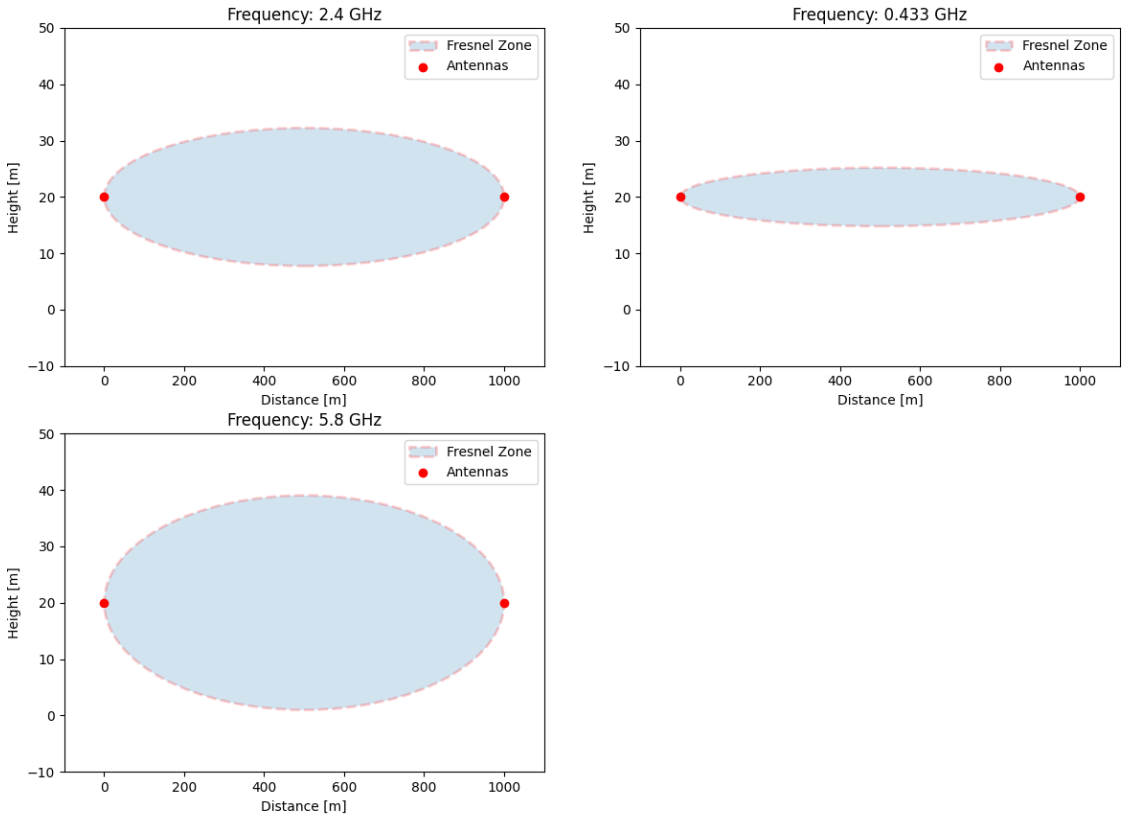

Figure 2: Plot of the Fresnel Zones at different frequencies between two antennas 1 km apart.

2.4 Fresnel zone loss

3 Simulation of path loss based on terrain contours

Link

Radio link study 1			
HCA Airport (1)		(2) Svanninge Bakker	
Latitude	55.472315 °	Latitude	55.125038 °
Longitude	10.328792 °	Longitude	10.253127 °
Ground elevation	15.8 m	Ground elevation	76.2 m
Antenna height	2.0 m	Antenna height	2.0 m
Azimuth	187.10 TN | 183.82 MG °	Azimuth	7.04 TN | 3.79 MG °
Tilt	-0.09 °	Tilt	-0.26 °
Radio system		**Propagation**	
TX power	43.01 dBm	Free space loss	107.49 dB
TX line loss	3.00 dB	Obstruction loss	73.23 dB
TX antenna gain	6.00 dBi	Forest loss	1.00 dB
RX antenna gain	2.00 dBi	Urban loss	1.00 dB
RX line loss	0.50 dB	Statistical loss	5.67 dB
RX sensitivity	-113.02 dBm	Total path loss	188.40 dB
Performance			
Distance		**38.911 km**	
Precision		19.5 m	
Frequency		146.000 MHz	
Equivalent Isotropically Radiated Power		39.905 W	
System gain		160.53 dB	
Required reliability		70.000 %	
Received Signal		-140.89 dBm	
Received Signal		0.02 µV	
Fade Margin		**-27.87 dB**	

Figure 3: Screenshot from Radio Mobile Online tool

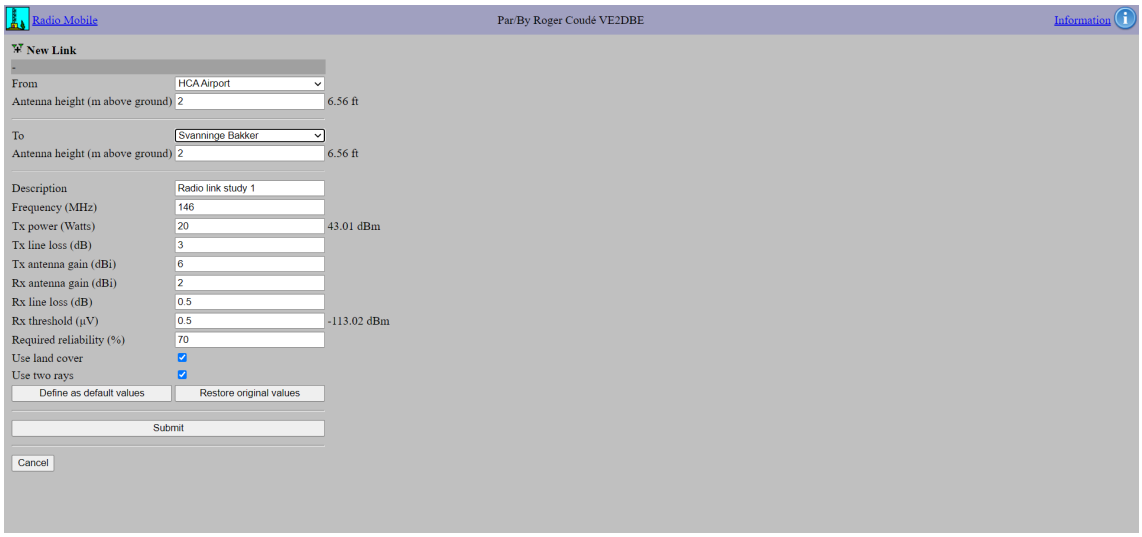

Figure 4: Screenshot from Radio Mobile Online tool

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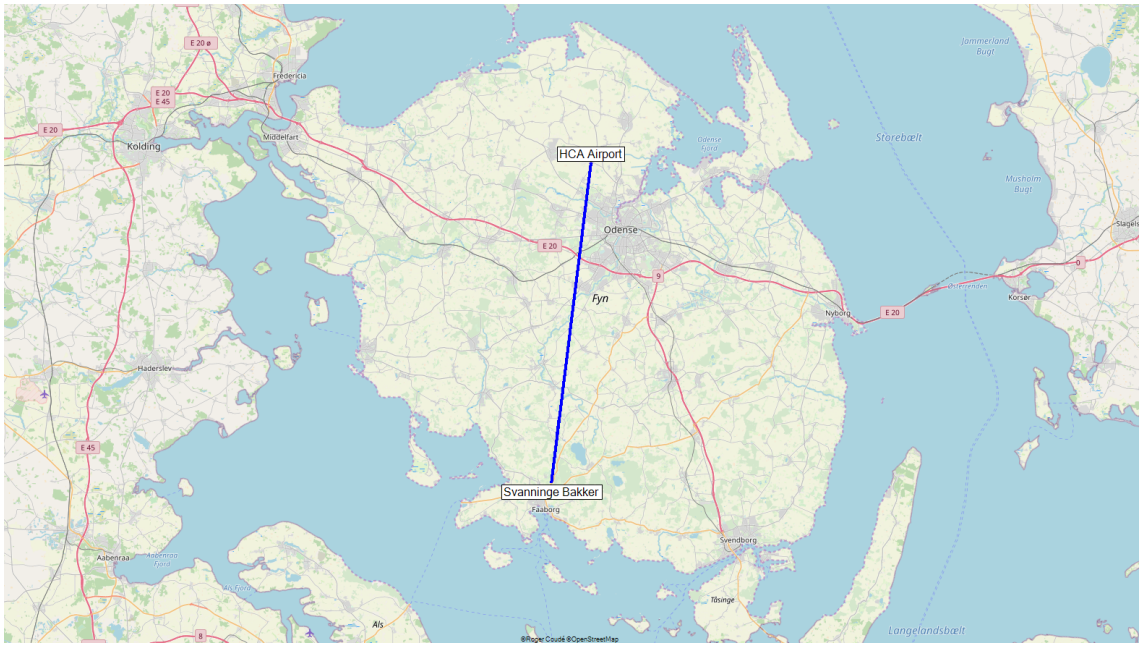

Figure 5: Screenshot from Radio Mobile Online tool

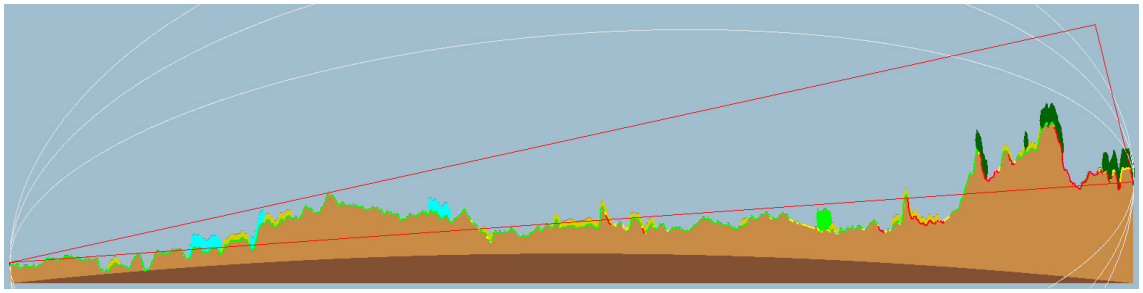

Figure 6: Screenshot from Radio Mobile Online tool

Coverage

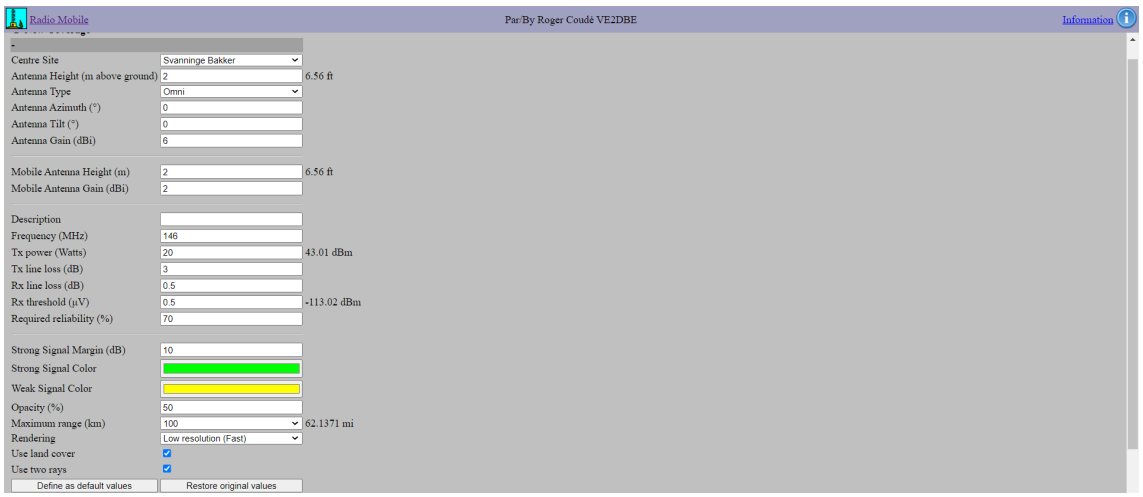

Figure 7: Screenshot from Radio Mobile Online tool

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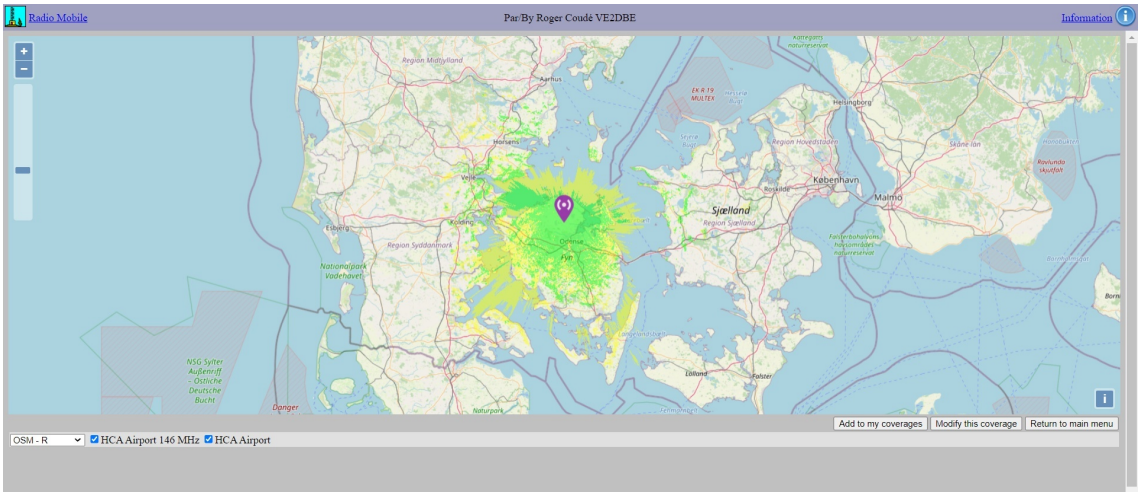

Figure 8: Screenshot from Radio Mobile Online tool (Coverage from HCA Airport)

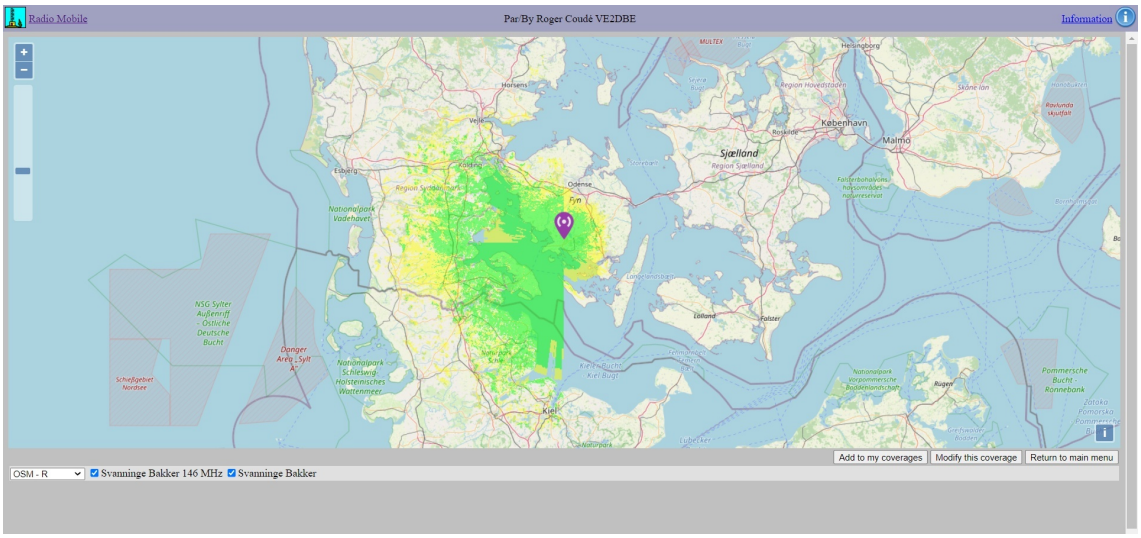

Figure 9: Screenshot from Radio Mobile Online tool (Coverage from Svanninge Bakker)

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4 Bibliography

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[3] Editorial Team everything RF. What is the fresnel zone? https://www.everythingrf.com/community/what-is-the-fresnel-zone. Online; accessed 03 October 2021.

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