

RADIO PATH STUDY

Project: Sample

Company: DEMO

RACOM - Technical support

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Version: 1

1. INTRODUCTION

RACOM provides this RF Path Study to help establish reliable communications for your SCADA or Telemetry application. As a leading manufacturer of Radio modems, Microwave links and Industrial cellular routers, we have unparalleled expertise in the area of wireless communications. Our extensive RF and wireless communications experience provides us with the insight and foresight to ensure our product lines provide the most reliable communication links/systems. We conduct detailed radio path studies, to determine the feasibility of radio communications for your system. The study involves a digital terrain model, based on SRTM hgt and bil files (1 arc second - USA, 3 arc seconds - worldwide) as well as a Clutter 1 arc second Global Land Cover Characteristics (GLCC) model.

Path calculations are used to select a reliable mode for an application by optimizing the following:

- RipEX radio modem operation mode
- Repeater requirements
- Antenna/tower heights
- Antenna type and gain
- Coaxial feed line length
- RF network user bandwidth calculation

The RF path study was performed using the professional propagation software Pathloss v. 5.1. Pathloss is a comprehensive RF planning tool that is well-suited to planning and optimizing Point to Point microwave links or Point to Multipoint UHF/VHF/SHF radio links operating in the 30 MHz to 100 GHz frequency range.

Pathloss uses terrain and land cover databases to calculate radio path attenuation for each individual radio link. Antennas and radio data are used to calculate suitable scenarios for radio linking. All location dependent parameters are determined from the site coordinates and ruggedness of terrain is automatically calculated.

The ITU-R P837-3 database is included. Rain attenuation calculations are based on site coordinates for all rain data-sources. The reflections and multipath modules use a constant gradient ray trace method as a precursor to determine if the path geometry supports specular reflection and the location of the reflective plane.

The degree of accuracy relies on the publicly available SRTM3 data-set used in the terrain model. The availability indicators have been calculated using current ITU-R P.530-15 and references.

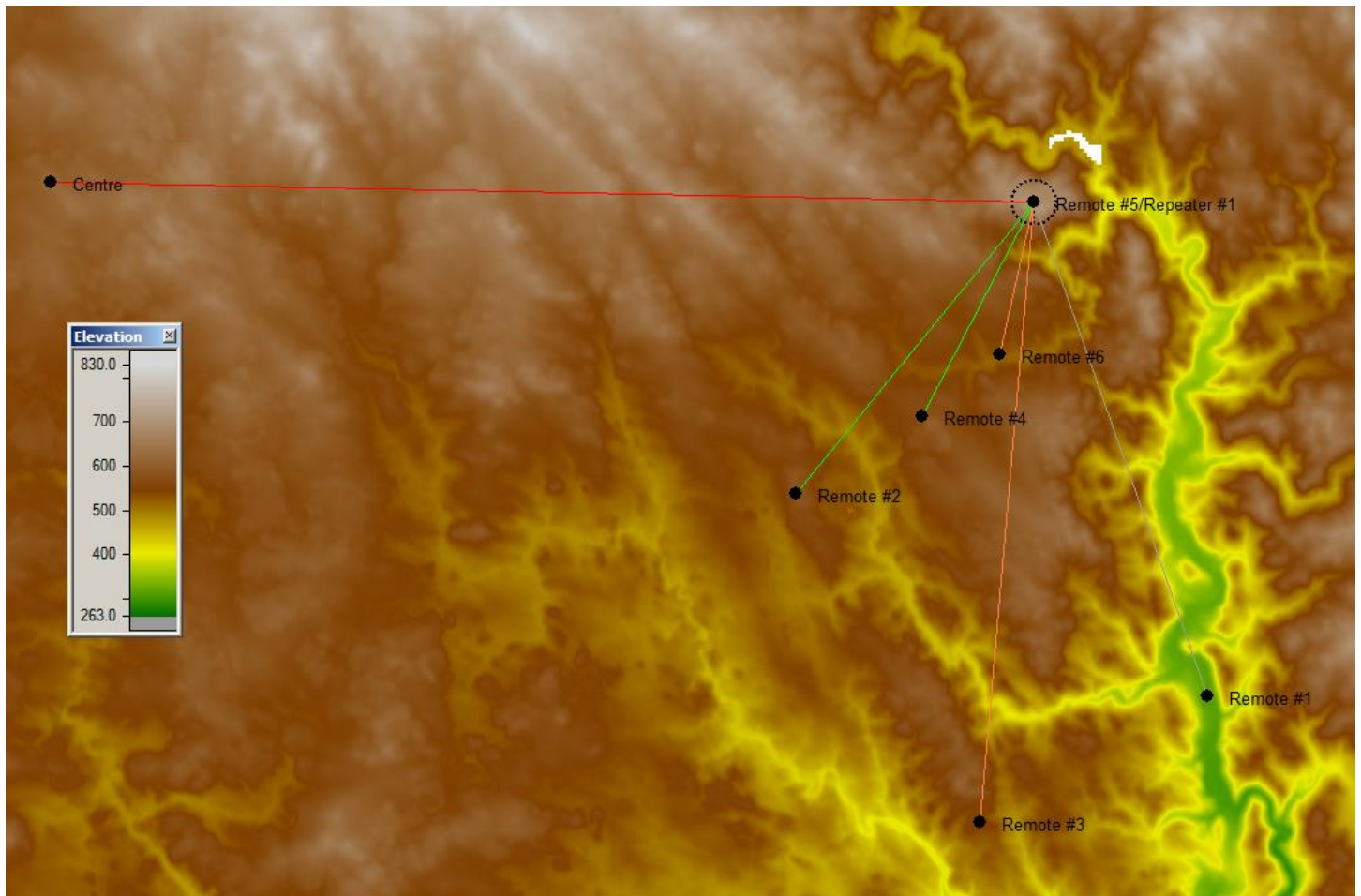
Notice:

RACOM provide these calculated values on an as-is basis. The study is intended to assist in your purchasing decisions by illustrating the capabilities of RipEX radio-modems.

3. Site list

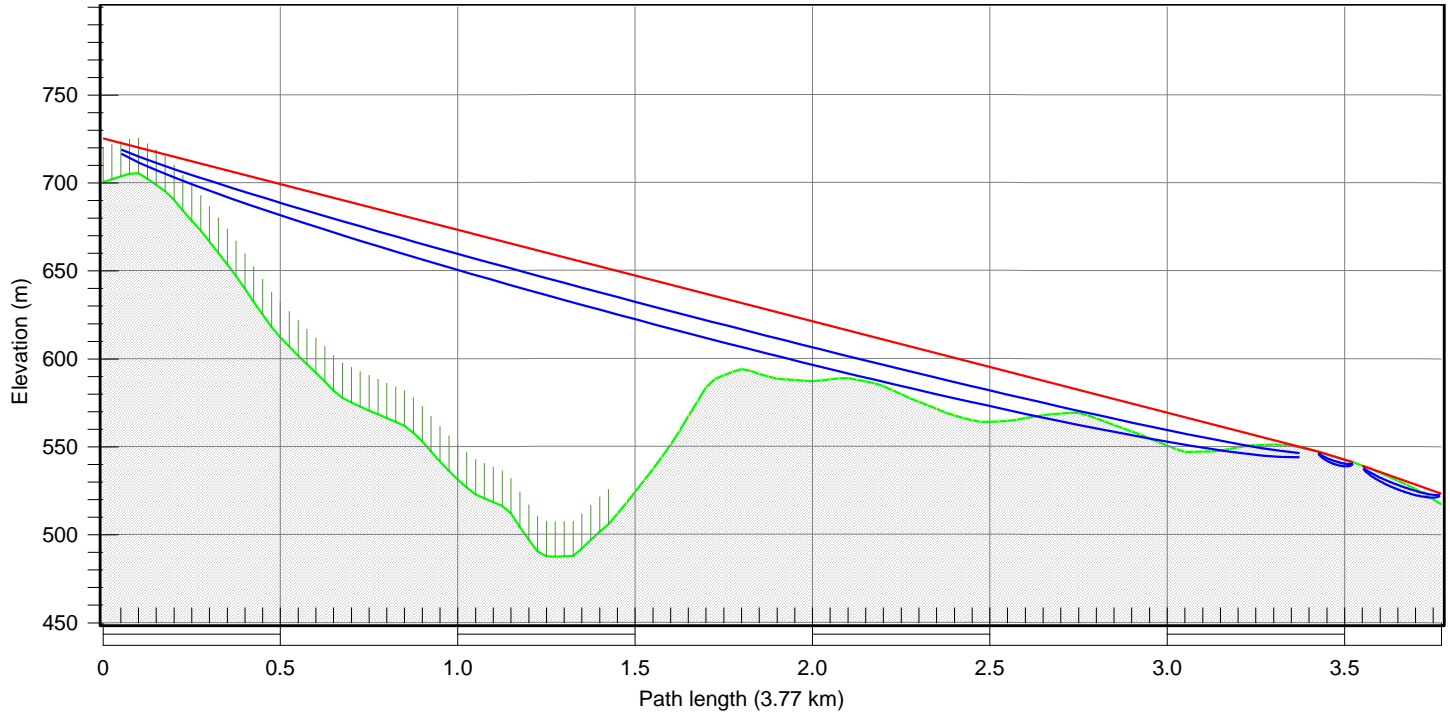
| Site name | Latitude | Longitude | Antenna height above ground (m) |
|-----------------------|---------------|----------------|---------------------------------|
| Centre | 49 33 42.01 N | 015 57 31.00 E | 25 |
| Remote #1 | 49 26 58.99 N | 016 20 43.01 E | 6 |
| Remote #2 | 49 29 39.01 N | 016 12 28.01 E | 6 |
| Remote #3 | 49 25 21.00 N | 016 16 09.01 E | 6 |
| Remote #4 | 49 30 38.99 N | 016 15 01.01 E | 6 |
| Remote #5/Repeater #1 | 49 33 27.00 N | 016 17 16.01 E | 25 |
| Remote #6 | 49 31 27.98 N | 016 16 34.00 E | 6 |

4. Network topology



5. Individual links calculation

Transmission summary (Remote #5/Repeater #1-Remote #6.pl5)

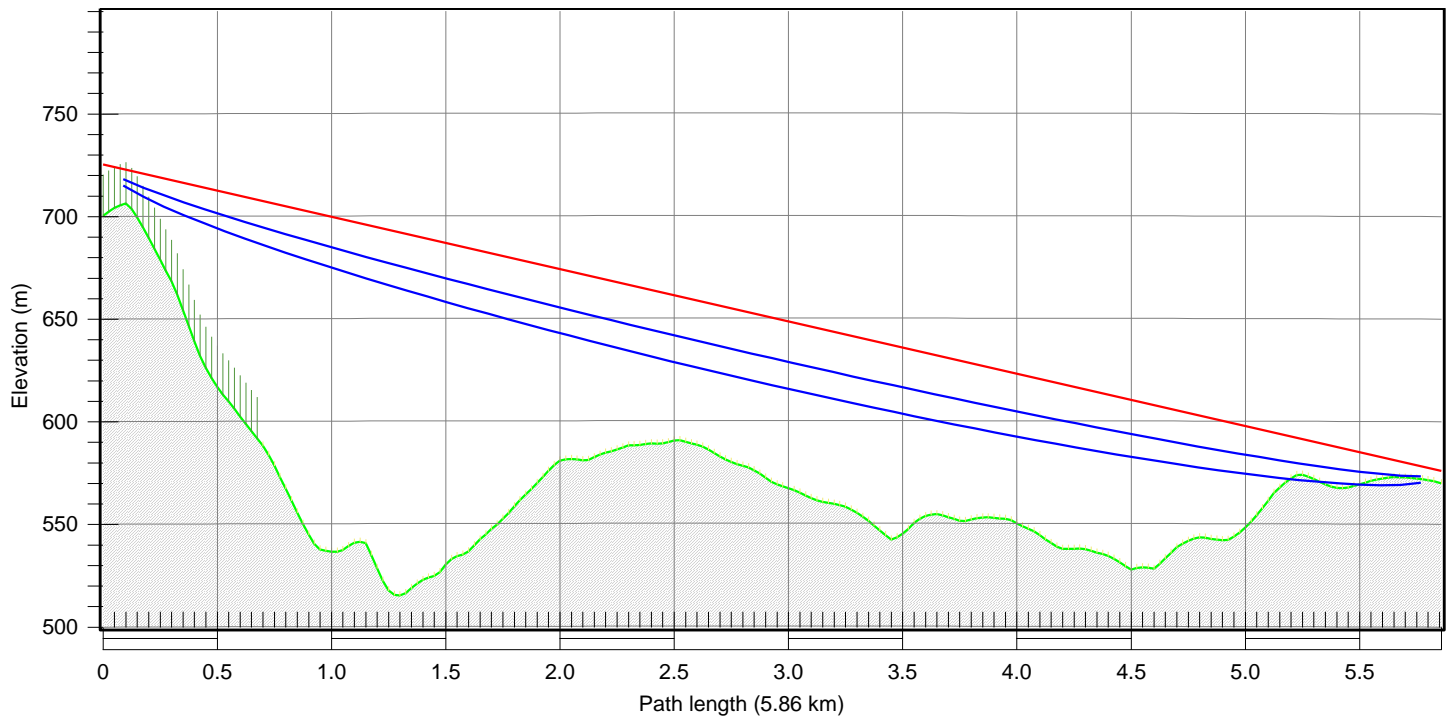


F = 406.00 MHz K = 1.33 %F1 = 100.0, 60.0

| | Remote #5/Repeater #1 | Remote #6 |
|---------------------|-----------------------|----------------|
| Latitude | 49 33 27.00 N | 49 31 27.98 N |
| Longitude | 016 17 16.01 E | 016 16 34.00 E |
| True azimuth (°) | 192.94 | 12.93 |
| Vertical angle (°) | -2.99 | 4.09 |
| Elevation (m) | 700.34 | 517.34 |
| Antenna model | Double dipole (TR) | SA400.5 (TR) |
| Antenna gain (dBd) | 5.10 | 6.00 |
| Antenna height (m) | 25.00 | 6.00 |
| TX line model | RG-213 | RG-213 |
| TX line length (m) | | 8.00 |
| TX line loss (dB) | | 1.22 |
| Connector loss (dB) | 0.50 | 0.50 |
| Frequency (MHz) | 406.00 | |

| | | |
|-----------------------------------|-----------|-----------|
| Polarization | Vertical | |
| Path length (km) | 3.78 | |
| Free space loss (dB) | 96.18 | |
| Atmospheric absorption loss (dB) | 0.01 | |
| Radio model | RipEX | RipEX |
| TX power (watts) | 5.01 | 5.01 |
| Receive signal (dBm) | -88.39 | -88.39 |
| Thermal fade margin (dB) | 22.61 | 22.61 |
| Annual location availability (%) | 100.00000 | 100.00000 |
| Annual multipath availability (%) | 99.45303 | 99.45303 |

Transmission summary (Remote #5Repeater #1-Remote #4.pl5)

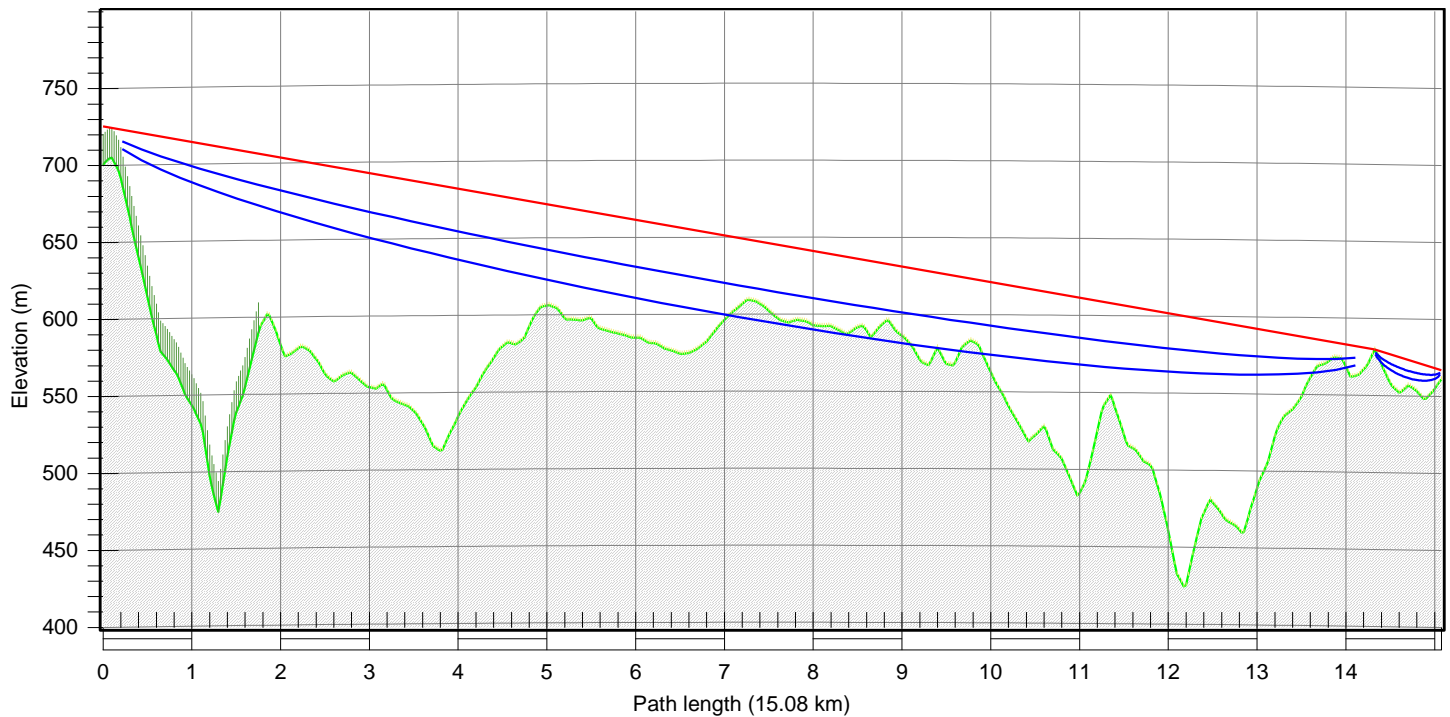


F = 406.00 MHz K = 1.33 %F1 = 100.0, 60.0

| | Remote #5/Repeater #1 | Remote #4 |
|--------------------|-----------------------|----------------|
| Latitude | 49 33 27.00 N | 49 30 38.99 N |
| Longitude | 016 17 16.01 E | 016 15 01.01 E |
| True azimuth (°) | 207.62 | 27.59 |
| Vertical angle (°) | -1.48 | 1.44 |
| Elevation (m) | 700.34 | 570.00 |
| Antenna model | Double dipole (TR) | SA400.5 (TR) |
| Antenna gain (dBd) | 5.10 | 6.00 |
| Antenna height (m) | 25.00 | 6.00 |

| | | |
|-----------------------------------|-----------|-----------|
| TX line model | RG-213 | RG-213 |
| TX line length (m) | | 8.00 |
| TX line loss (dB) | | 1.22 |
| Connector loss (dB) | 0.50 | 0.50 |
| Frequency (MHz) | 406.00 | |
| Polarization | Vertical | |
| Path length (km) | 5.86 | |
| Free space loss (dB) | 100.00 | |
| Atmospheric absorption loss (dB) | 0.02 | |
| Radio model | RipEX | RipEX |
| TX power (watts) | 5.01 | 5.01 |
| Receive signal (dBm) | -59.26 | -59.26 |
| Thermal fade margin (dB) | 51.74 | 51.74 |
| Annual location availability (%) | 100.00000 | 100.00000 |
| Annual multipath availability (%) | 99.99933 | 99.99933 |

Transmission summary (Remote #5Repeater #1-Remote #3.pl5)

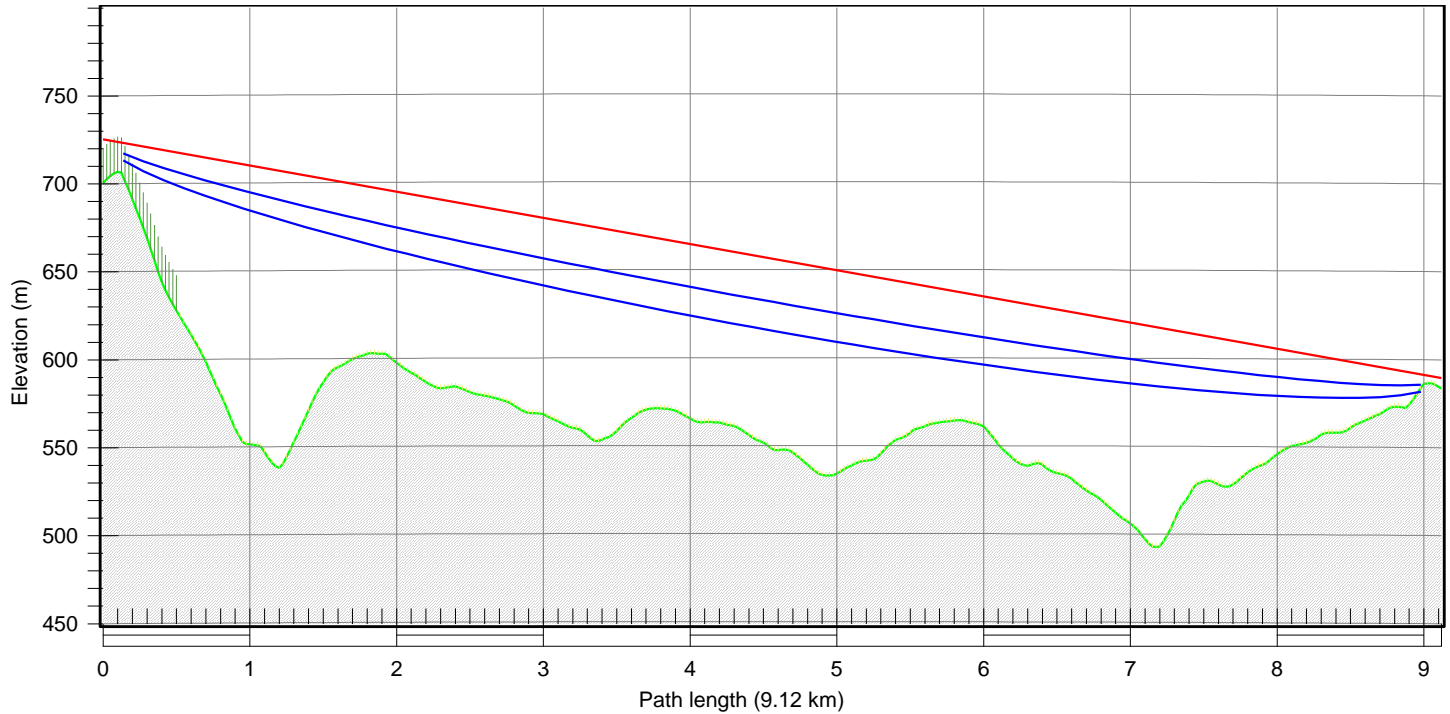


F = 406.00 MHz K = 1.33 %F1 = 100.0, 60.0

| | Remote #5/Repeater #1 | Remote #3 |
|-----------|-----------------------|----------------|
| Latitude | 49 33 27.00 N | 49 25 21.00 N |
| Longitude | 016 17 16.01 E | 016 16 09.01 E |

| | | |
|-----------------------------------|--------------------|--------------|
| True azimuth (°) | 185.14 | 5.12 |
| Vertical angle (°) | -0.63 | 0.98 |
| Elevation (m) | 700.34 | 560.99 |
| Antenna model | Double dipole (TR) | SA400.5 (TR) |
| Antenna gain (dBd) | 5.10 | 6.00 |
| Antenna height (m) | 25.00 | 6.00 |
| TX line model | RG-213 | RG-213 |
| TX line length (m) | | 8.00 |
| TX line loss (dB) | | 1.22 |
| Connector loss (dB) | 0.50 | 0.50 |
| Frequency (MHz) | 406.00 | |
| Polarization | Vertical | |
| Path length (km) | 15.08 | |
| Free space loss (dB) | 108.20 | |
| Atmospheric absorption loss (dB) | 0.04 | |
| Radio model | RipEX | RipEX |
| TX power (watts) | 5.01 | 5.01 |
| Receive signal (dBm) | -76.90 | -76.90 |
| Thermal fade margin (dB) | 34.10 | 34.10 |
| Annual location availability (%) | 100.00000 | 100.00000 |
| Annual multipath availability (%) | 99.96115 | 99.96115 |

Transmission summary (Remote #5Repeater #1-Remote #2.pl5)

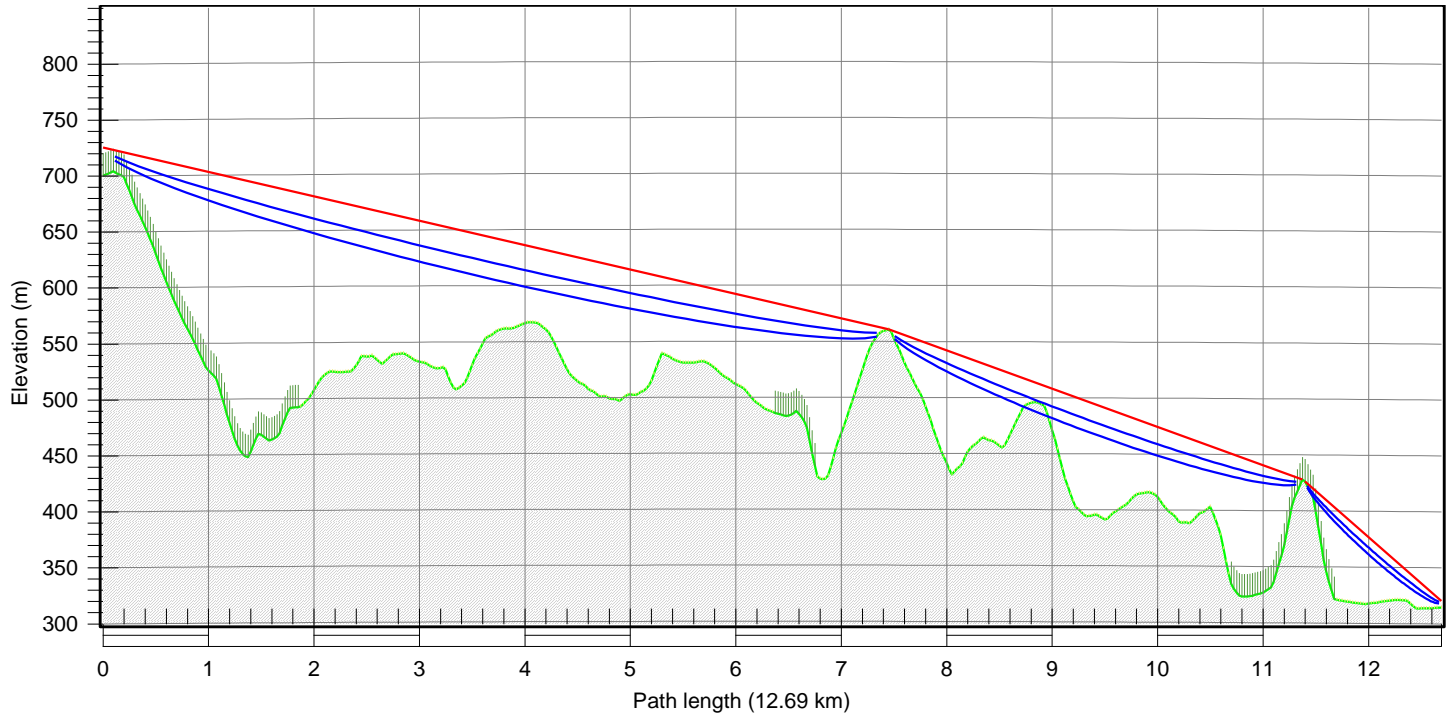


F = 406.00 MHz K = 1.33 %F1 = 100.0, 60.0

| | Remote #5/Repeater #1 | Remote #2 |
|----------------------------------|-----------------------|----------------|
| Latitude | 49 33 27.00 N | 49 29 39.01 N |
| Longitude | 016 17 16.01 E | 016 12 28.01 E |
| True azimuth (°) | 219.46 | 39.40 |
| Vertical angle (°) | -0.88 | 0.82 |
| Elevation (m) | 700.34 | 583.67 |
| Antenna model | Double dipole (TR) | SA400.5 (TR) |
| Antenna gain (dBd) | 5.10 | 6.00 |
| Antenna height (m) | 25.00 | 6.00 |
| TX line model | RG-213 | RG-213 |
| TX line length (m) | | 8.00 |
| TX line loss (dB) | | 1.22 |
| Connector loss (dB) | 0.50 | 0.50 |
| Frequency (MHz) | 406.00 | |
| Polarization | Vertical | |
| Path length (km) | 9.12 | |
| Free space loss (dB) | 103.84 | |
| Atmospheric absorption loss (dB) | 0.02 | |
| Radio model | RipEX | RipEX |
| TX power (watts) | 5.01 | 5.01 |
| Receive signal (dBm) | -64.42 | -64.42 |

| | | |
|-----------------------------------|-----------|-----------|
| Thermal fade margin (dB) | 46.58 | 46.58 |
| Annual location availability (%) | 100.00000 | 100.00000 |
| Annual multipath availability (%) | 99.99780 | 99.99780 |

Transmission summary (Remote #5 Repeater #1-Remote #1.pl5)

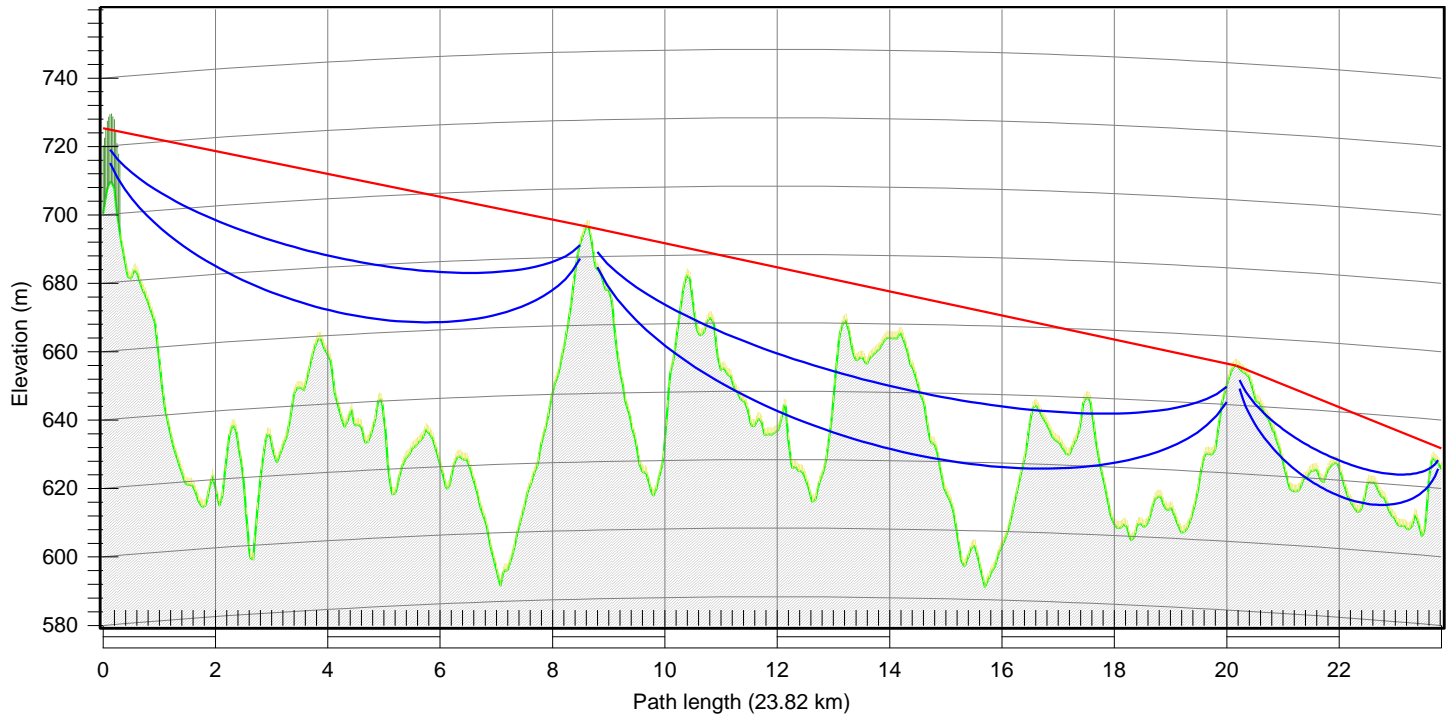


F = 406.00 MHz K = 1.33 %F1 = 100.0, 60.0

| | Remote #5/Repeater #1 | Remote #1 |
|---------------------|-----------------------|----------------|
| Latitude | 49 33 27.00 N | 49 26 58.99 N |
| Longitude | 016 17 16.01 E | 016 20 43.01 E |
| True azimuth (°) | 160.82 | 340.86 |
| Vertical angle (°) | -1.29 | 4.69 |
| Elevation (m) | 700.34 | 314.33 |
| Antenna model | Double dipole (TR) | SA400.5 (TR) |
| Antenna gain (dBd) | 5.10 | 6.00 |
| Antenna height (m) | 25.00 | 6.00 |
| TX line model | RG-213 | RG-213 |
| TX line length (m) | | 8.00 |
| TX line loss (dB) | | 1.22 |
| Connector loss (dB) | 0.50 | 0.50 |
| Frequency (MHz) | 406.00 | |
| Polarization | Vertical | |
| Path length (km) | 12.70 | |

| | | |
|----------------------------------|---------|---------|
| Free space loss (dB) | 106.71 | |
| Atmospheric absorption loss (dB) | 0.03 | |
| Radio model | RipEX | RipEX |
| TX power (watts) | 5.01 | 5.01 |
| Receive signal (dBm) | -119.79 | -119.79 |
| Thermal fade margin (dB) | -8.79 | -8.79 |

Transmission summary (Remote #5Repeater #1-Centre.pl5)



F = 406.00 MHz K = 1.33 %F1 = 100.0, 60.0

| | Remote #5/Repeater #1 | Centre |
|---------------------|-----------------------|----------------|
| Latitude | 49 33 27.00 N | 49 33 42.01 N |
| Longitude | 016 17 16.01 E | 015 57 31.00 E |
| True azimuth (°) | 271.24 | 90.99 |
| Vertical angle (°) | -0.27 | 0.30 |
| Elevation (m) | 700.34 | 625.66 |
| Antenna model | Double dipole (TR) | SA400.5 (TR) |
| Antenna gain (dBd) | 5.10 | 6.00 |
| Antenna height (m) | 25.00 | 6.00 |
| TX line model | RG-213 | RG-213 |
| TX line length (m) | | 8.00 |
| TX line loss (dB) | | 1.22 |
| Connector loss (dB) | 0.50 | 0.50 |

| | | |
|-----------------------------------|----------|----------|
| Frequency (MHz) | 406.00 | |
| Polarization | Vertical | |
| Path length (km) | 23.82 | |
| Free space loss (dB) | 112.18 | |
| Atmospheric absorption loss (dB) | 0.06 | |
| Radio model | RipEX | RipEX |
| TX power (watts) | 5.01 | 5.01 |
| Receive signal (dBm) | -94.85 | -94.85 |
| Thermal fade margin (dB) | 16.15 | 16.15 |
| Annual location availability (%) | 99.99729 | 99.99729 |
| Annual multipath availability (%) | 97.60052 | 97.60052 |

6. Summary & Recommendations

| Radio path | | Antenna model | | Radio model | TX power (watts) | Main receive signal (dBm) | Thermal fade margin (dB) |
|---------------------------|-----------|--|-------------------------------------|-------------|------------------|---------------------------|--------------------------|
| Remote #5/ Repeater #1 | Centre | Double Double dipole OV400.2R (TR) | Directional YAGI SA400.5 (TR) | RipEX | 5 | -94,85 | 16,15 |
| | Remote #1 | | | | | -119,79 | -8,79 |
| | Remote #2 | | | | | -64,42 | 46,58 |
| | Remote #3 | | | | | -76,9 | 34,1 |
| | Remote #4 | | | | | -59,26 | 51,74 |
| | Remote #6 | | | | | -88,39 | 22,61 |

Link signal strength must have a 20 dBm fade margin as an absolute minimum, to provide better than 99% communications reliability. Highly reliable systems (99.9% reliability) have fade margins of 25 dBm or higher: the signal strength must be 25 dB higher than radio receiver sensitivity.

Direct links would result in successful and reliable communications - signal strength (RSS) numbers would be between -40 dBm and -95 dBm for 2 level CPFSK. Calculated signal strengths over -95 dBm would not result in reliable communications.

If the path is longer than 10 kms, we recommend verification of link availability by field test.