



Surveyor User Guide

Version 1.1

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1. Overview

Surveyor is a path propagation calculator developed by 4RF Limited to assist path planners to quickly and efficiently verify the viability of individual radio paths deploying the 4RF Aprisa radio systems.

On entering Radio Data and Site Data, the program will calculate the anticipated link performance for the transmission system elements selected.

Note: The calculations are an estimate of performance and do not constitute a path survey. No guarantee of path performance is expressed or implied. The results of ITU-R availability are estimated and may differ from other availability standards. 4RF recommends that detailed path planning be performed for each link, including site investigations to confirm the viability of the linking path.

2. Operation

Application

The Surveyor application will operate on a PC or a MAC but both will need Java jre 1.8.0 or later installed. If you don't have Java jre installed, you can install it from:

<https://www.oracle.com/technetwork/java/javase/downloads/jre8-downloads-2133155.html>

Surveyor.jar

Surveyor.jar is a Java package file format. If Windows Default Apps setting for a .jar file is Java, the application will run when the Surveyor.jar is clicked. This file can be run on a MAC as long as the MAC has Java jre installed.

Surveyor.zip

The Surveyor.zip contains Surveyor.jar, and the icon Surveyor.ico.

Opening a Project

If a Surveyor project has been saved, it can be opened from Menu > File > Open File or by selecting the file from Menu > File > Recent Files.

Saving a Project

A Surveyor project can be saved in a file with a suffix *.sur (see 'Main Menu' on page 21). These files can be saved in any directory but defaults to the directory defined in Setup Options > Project Files Directory.

Recent files can be open by clicking on the file in Menu > File > Recent Files.



4RF Products

When the application opens, it opens with three tabs for the 4RF products:

Product	Function
Aprisa XE	The Aprisa XE is a Point-To-Point (PTP) digital radio with up to 64 Mbit/s of radio link capacity in frequency bands from 300 MHz up to 2.7 GHz carrying ethernet, voice and data traffic over distances up to 100 kilometres. It has customer-configurable interface options integrated within the radio platform.
Aprisa SR+	The Aprisa SR+ is a Point-To-Multipoint (PMP) and Point-To-Point (PTP) digital radio providing secure narrowband wireless data connectivity for SCADA, infrastructure, and telemetry applications. The radios carry a combination of serial data and Ethernet data between the base station, repeater stations and remote radios.
Aprisa SRi	The Aprisa SRi is a Point-To-Multipoint (PMP) digital radio providing 915 MHz Industrial Licence Free Spread Spectrum communications. The radios carry a combination of serial data and Ethernet data between the base station and remote radios.

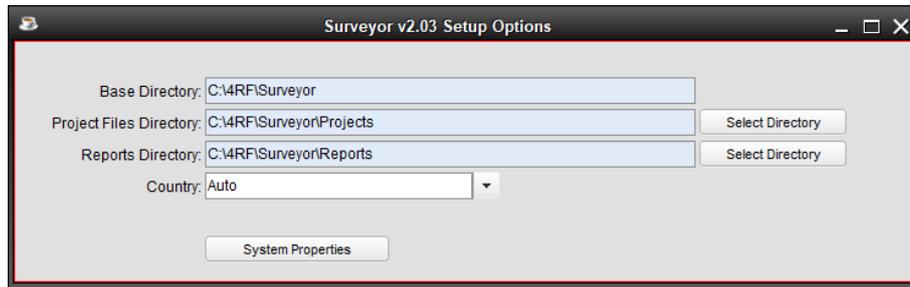
The application product tabs can be configured for the requirements of the project. Right click on one of the tabs. A popup provides the following options:

Selection	Function
Add Tab	The Add Tab allows any number of tabs to be entered for any of the products.
Copy Tab	The Copy Tab makes a copy of the selected product tab.
Delete Tab	The Delete Tab deletes the selected product tab.
Rename Tab	The Rename Tab renames the selected product tab. This can also be done by double clicking on the tab.

The order of the tabs in the workspace can be changed by moving them. This is done by clicking on the tab and dragging it to where you want it.

Setup Options

To open User Setup, click on the Main Menu > Setup > Options



Base Directory

This field shows the directory where setup property files are stored. It cannot be changed.

Project Files Directory

This field sets your default directory to store project files. It can be changed to any directory you like.

Reports Directory

This field sets your default directory to store project reports. It can be changed to any directory you like.

Country

This field sets your country location which determines radio and site defaults. The default is 'Auto' which tells the program to use the country from your computer locale.

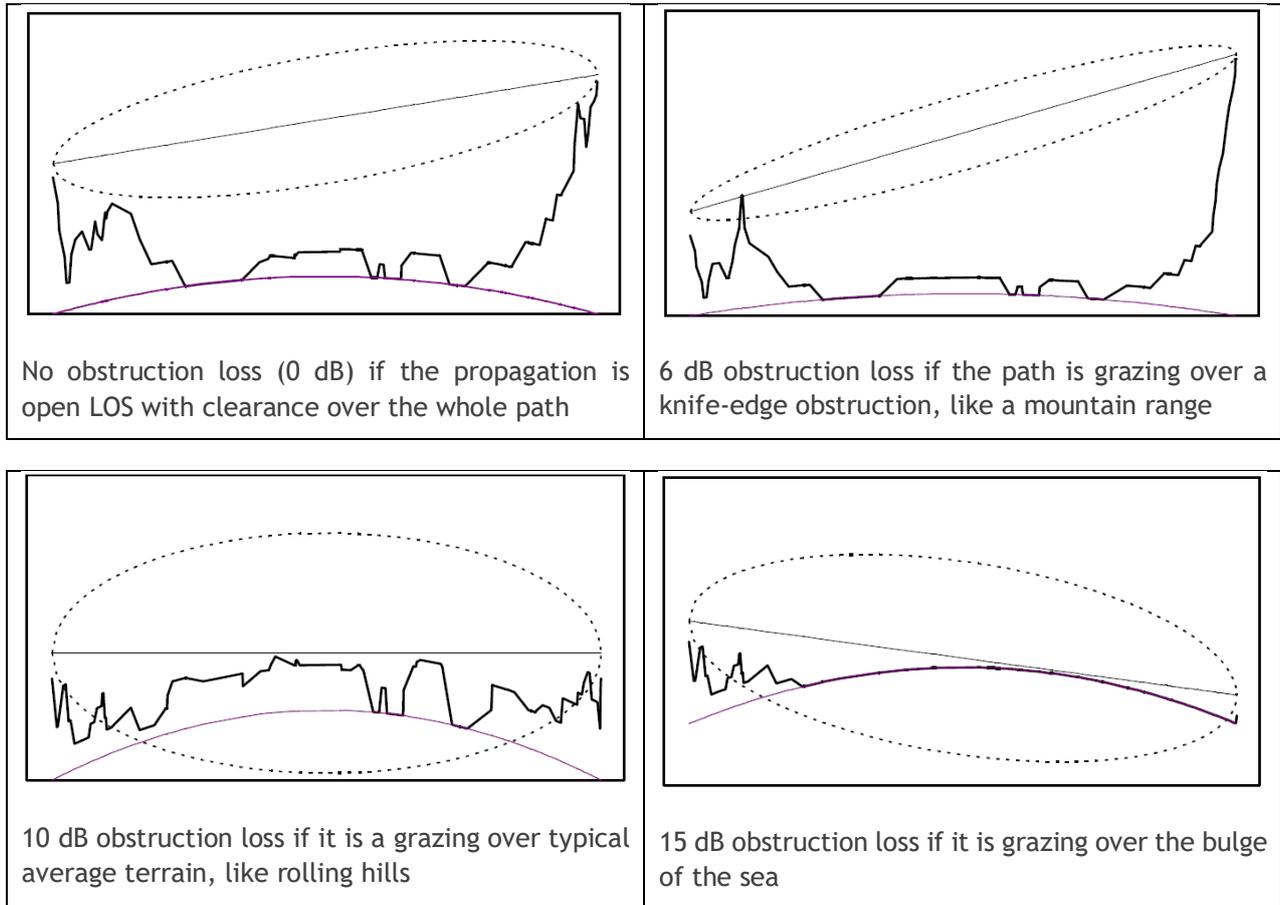
3. Path Propagation

Introduction

Typically, Surveyor results are dependent on the accuracy of the site data.

Surveyor assumes a LOS (line-of-sight) linking path. For a good LOS linking, there should be near full first-fresnel zone (F1) clearance, as shown by the dotted lines in the first profile plot below. However, it does have an option to include an estimated obstruction loss figure (see Aprisa XE Site Data on page 9). This may be used to account for any path obstructions or effects that introduce RF attenuation into the propagating signal.

Typically, terrain obstructions cause most RF losses to the propagating signal. Typical examples could be:



Note: Grazing implies that only some of the propagating signal is obstructed.



Aprisa XE

Aprisa XE Radio Data

Compliance Body	Select the Compliance Body
Frequency Band	The frequency band dropdown list will show the frequency bands available for the product and compliance body.
Channel Size	The channel size dropdown list will show the channel size available for the product, compliance body and frequency band.
Modulation	The modulation dropdown list will show the modulations available for the product, compliance body, frequency band and channel size.
Transmit Power	The transmit power is automatically set to the maximum level for the product variant selected. The actual transmitter power level will depend on the radio platform chosen, the operating frequency band and the modulation selected.
Gross Capacity	The maximum amount of data transported over the radio link in kbit/s.
Frame Capacity	The number of 64 kbit/s timeslots possible in the gross capacity. If the gross capacity is more than the frame capacity, then the number of E1 / T1 frames is shown.
Wayside Capacity	The wayside capacity is the remainder capacity; Wayside Capacity = Gross Capacity - Frame Capacity
Bit Error Rate	The receiver sensitivity is shown for a bit error rate (BER) of 10^{-3} and 10^{-6} . The receiver sensitivity is increased by 1 dB for BER of 10^{-3} .
Receiver Sensitivity	The receiver sensitivity of the radio for the selected compliance body, frequency band, channel size, modulation, and bit error rate.

<p>1+1 MHSB</p>	<p>This configuration uses two Aprisa XE radios and a protection switch. The RF fade margin and availability of this option is reduced as the two receive paths are split via an RF passive splitter, introducing typically 4 dB of loss in the receive paths. The transmit path also introduces 0.5 dB of loss as a coaxial relay switch is used to switch between the active and standby radios. Surveyor includes this loss in the calculations.</p>																														
<p>1+1 Space Diversity</p>	<p>This option improves the RF path availability. Space diversity relies on the improvement factor that is obtained where there are two separate antennas at each end of the link receiving the signal. They must be spaced far enough apart so they receive entirely separate signals. As there are now effectively two RF linking paths to the same site, there is more chance that a strong received signal is available from one of them giving an overall improvement in availability.</p> <p>Space diversity is particularly beneficial if the linking path is;</p> <ul style="list-style-type: none"> • Exposed to a large body of water where there are strong path reflections • Both linking sites are elevated and very far apart • Any location with a history of poor atmospheric activity <p>Space diversity may be used in any frequency band but is less effective in the UHF bands and is typically used in the 1400 MHz band, or higher. Space diversity also requires two separate radios and a ‘hitless’ data switch. This allows for seamless errorless switching between the two receive antenna systems.</p>																														
<p>Diversity Spacing</p>	<p>Entry for the diversity spacing. The recommended diversity spacing for the frequency band is:</p> <table border="1" data-bbox="443 1032 903 1509"> <thead> <tr> <th>Band</th> <th>LL (m)</th> <th>UL (m)</th> </tr> </thead> <tbody> <tr> <td>300 MHz</td> <td>52</td> <td>197</td> </tr> <tr> <td>400 MHz</td> <td>43</td> <td>166</td> </tr> <tr> <td>600 MHz</td> <td>34</td> <td>131</td> </tr> <tr> <td>700 MHz</td> <td>25</td> <td>96</td> </tr> <tr> <td>800 MHz</td> <td>23</td> <td>89</td> </tr> <tr> <td>900 MHz</td> <td>21</td> <td>82</td> </tr> <tr> <td>1400 MHz</td> <td>13</td> <td>50</td> </tr> <tr> <td>2000 MHz</td> <td>9</td> <td>36</td> </tr> <tr> <td>2500 MHz</td> <td>8</td> <td>29</td> </tr> </tbody> </table>	Band	LL (m)	UL (m)	300 MHz	52	197	400 MHz	43	166	600 MHz	34	131	700 MHz	25	96	800 MHz	23	89	900 MHz	21	82	1400 MHz	13	50	2000 MHz	9	36	2500 MHz	8	29
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Site Names	Freeform text for the name of the site
Antenna	The antenna dropdown list will show the antennas suitable for the product and frequency band. The antenna types, sizes and gains are show in the list for the selected frequency band.
Antenna Stacking	Stacking the antennas improves the overall gain of the antenna system. The stacked antennas are co-axially combined and fed to the radio terminal via a single co-axial feeder. The antenna stacking dropdown list will show the options available for the selected frequency band and antenna type. Yagis may be stacked vertically or side-by-side, or in a combination of both.
Feeder Type	Select the feeder type. The dB / 100m is shown for the selected frequency band.
Feeder Length	Specify the feeder cable length from the radio installed in the equipment rack, out to the tower, and up the tower to the antenna.
Site Height Above Sea Level	Specify the site height above sea level (asl), excluding the tower height.
Antenna Height Above Ground	Specify the antenna height above ground level (agl).
Duplexer (split)	The duplexer dropdown list will show the duplexers available for the product and frequency band. The transmit / receive split is displayed. The duplexer is selected from the Site A dropdown list and is always the same at both sites. Note: some duplexers are fixed split e.g. FCC 900 MHz G2 and the others are minimum split.
Transmit Frequency	By default, the transmit frequencies are set from calculated mid band frequencies for the selected frequency band and duplexer. The transmit frequencies can be manually entered but a warning will show if they are beyond the frequency range.
Transmit Power Reduction	A reduction in transmitter power may be required for RF licensing, or on-site interference reasons. This can be between 1 and 12 dB.
Obstruction Loss	The obstruction loss considers all steady-state propagation losses over and above the normal spreading loss, indicated below. Typically, terrain obstruction causes the most significant loss to the propagating signal: <ul style="list-style-type: none"> • Leave as 0 dB if the propagation is open and line-of-sight i.e. with better 0.6F1 clearance over the whole path. • Use 6 dB if the propagation is a grazing over a knife-edge obstruction, like a mountain range. • Use 10 dB if it is a grazing over typical 'average' terrain, like rounded hills. • Use 15 dB if it is grazing over the bulge of the sea.
Distance Type	The three distance type options are: <ul style="list-style-type: none"> • Manual entry of the distance and grid bearing • Using metric grid references to calculate the distance between sites • Using latitude/longitude to calculate the distance between sites (Modelled to the Haversine method and WGS84. The actual distance may vary slightly when compared to the various mapping models that are available). See 'Google Earth' on page 20.
World Region	The location will typically have a localized atmospheric behaviour that will influence the availability of the link. This factor does not influence the calculated RSSI and fade margin. It only affects the availability calculation.

Terrain Type	This selection also influences the availability of the link. It also does not influence the calculated RSSI and fade margin.
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Aprisa XE System Results

Transmit Frequencies	This is the site mid band or manually entered transmit frequency used for path loss calculation.
Antenna Gain	The gain of the antenna system including antenna stacking gain if used.
Feeder System Loss	The calculated feeder system loss for the type / length of feeder cable entered. It includes between 0.2 dB to 0.5 dB of fixed loss to account for the essential connectors and lightning arrestor in the feeder system.
Transmit Power	The transmit power at the Aprisa XE radio measurable at the duplexer output connector but is reduced by transmit power reduction (if used).
Effective Radiated Power (EIRP)	Effective radiated power out of the antenna. It is a calculation of transmit power minus feeder system loss plus antenna gain minus protection loss TX (if used).
Path Loss	The theoretical loss of the RF signal as it propagates through space. It is sometimes referred to as 'spreading loss'.
RSSI	Received Signal Strength Indication - is a measurement of the power present in a received radio signal. e.g. $RSSI = \text{effective radiated power} - \text{obstruction loss} - \text{path loss} + \text{antenna gain} - \text{feeder system loss} - \text{protection loss RX (if used)}$ A higher RSSI is always more desirable as it allows the receiver to process a signal with a good Signal-to-Noise Ratio.
Fade Margin	The amount by which a received signal level may be reduced without causing system performance to fall below a specified threshold value. The larger the fade margin the more the link will be available for data transmission. Typically, a fade margin of 20 dB or more is considered acceptable for most installations in the sub 3 GHz frequency band.



Aprisa SR+

Aprisa SR+ Radio Data

Compliance Body	Select the Compliance Body
Frequency Band	The frequency band dropdown list will show the frequency bands available for the product and compliance body.
Channel Size	The channel size dropdown list will show the channel size available for the product, compliance body and frequency band.
Modulation	The modulation dropdown list will show the modulations available for the product, compliance body, frequency band and channel size.
Transmit Power	The transmit power is automatically set to the maximum level for the product variant selected. The actual transmitter power level will depend on the radio platform chosen, the operating frequency band and the modulation selected.
Gross Capacity	The maximum amount of data transported over the radio link in kbit/s.
Bit Error Rate	The receiver sensitivity is shown for a bit error rate (BER) of 10^{-3} and 10^{-6} . The receiver sensitivity is increased by 1 dB for BER of 10^{-3} .
Receiver Sensitivity	The receiver sensitivity of the radio for the selected compliance body, frequency band, channel size, modulation and bit error rate.

Site Names	Freeform text for the name of the site
Antenna	The antenna dropdown list will show the antennas suitable for the product and frequency band. The antenna types, sizes and gains are shown in the list for the selected frequency band.
Antenna Stacking	Stacking the antennas improves the overall gain of the antenna system. The stacked antennas are co-axially combined and fed to the radio terminal via a single co-axial feeder. The antenna stacking dropdown list will show the options available for the selected frequency band and antenna type. Yagis may be stacked vertically or side-by-side, or in a combination of both.
Feeder Type	Select the feeder type. The dB / 100m is shown for the selected frequency band.
Feeder Length	Specify the feeder cable length from the radio installed in the equipment rack, out to the tower, and up the tower to the antenna.
Site Height Above Sea Level	Specify the site height above sea level (asl), excluding the tower height.
Antenna Height Above Ground	Specify the antenna height above ground level (agl).
Duplexer (split)	The duplexer dropdown list will show the duplexers available for the product and frequency band. The transmit / receive split is displayed. The duplexer split is always the same at both sites but a duplexer can be selected independently at both sites if required. If a duplexer is selected, the duplexer insertion loss is subtracted from the transmit power and added to the path loss.
Transmit Frequency	By default, the transmit frequencies are set from calculated mid band frequencies for the selected frequency band and duplexer. The transmit frequencies can be manually entered but a warning will show if they are beyond the frequency range.
Transmit Power Reduction	A reduction in transmitter power may be required for RF licensing, or on-site interference reasons. This can be between 1 and 12 dB.
Obstruction Loss	The obstruction loss considers all steady-state propagation losses over and above the normal spreading loss, indicated below. Typically, terrain obstruction causes the most significant loss to the propagating signal: <ul style="list-style-type: none"> • Leave as 0 dB if the propagation is open and line-of-sight i.e. with better 0.6F1 clearance over the whole path. • Use 6 dB if the propagation is a grazing over a knife-edge obstruction, like a mountain range. • Use 10 dB if it is a grazing over typical 'average' terrain, like rounded hills. • Use 15 dB if it is grazing over the bulge of the sea.
Distance Type	The three distance type options are: <ul style="list-style-type: none"> • Manual entry of the distance and grid bearing • Using metric grid references to calculate the distance between sites • Using latitude/longitude to calculate the distance between sites (Modelled to the Haversine method and WGS84. The actual distance may vary slightly when compared to the various mapping models that are available). See 'Google Earth' on page 20.
World Region	The location will typically have a localized atmospheric behaviour that will influence the availability of the link. This factor does not influence the calculated RSSI and fade margin. It only affects the availability calculation.

Terrain Type	This selection also influences the availability of the link. It also does not influence the calculated RSSI and fade margin.
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Aprisa SR+ System Results

Transmit Frequencies	This is the site mid band or manually entered transmit frequency used for path loss calculation.
Antenna Gain	The gain of the antenna system including antenna stacking gain if used.
Feeder System Loss	The calculated feeder system loss for the type / length of feeder cable entered. It includes between 0.2 dB to 0.5 dB of fixed loss to account for the essential connectors and lightning arrestor in the feeder system.
Transmit Power	The transmit power at the radio but is reduced by transmit power reduction (if used) and the duplexer loss (if used).
Effective Radiated Power (EIRP)	Effective radiated power out of the antenna. It is a calculation of transmit power minus feeder system loss plus antenna gain minus protection loss TX (if used).
Path Loss	The theoretical loss of the RF signal as it propagates through space. It is sometimes referred to as 'spreading loss'.
RSSI	Received Signal Strength Indication - is a measurement of the power present in a received radio signal. e.g. $RSSI = A - B - C + D - E$ A higher RSSI is always more desirable as it allows the receiver to process a signal with a good Signal-to-Noise Ratio.
Fade Margin	The amount by which a received signal level may be reduced without causing system performance to fall below a specified threshold value. The larger the fade margin the more the link will be available for data transmission. Typically, a fade margin of 20 dB or more is considered acceptable for most installations in the sub 3 GHz frequency band.



Aprisa SRi

Aprisa SRi Radio Data

Compliance Body	Select the Compliance Body
Frequency Band	The frequency band dropdown list will show the frequency bands available for the product and compliance body.
Channel Size	The channel size dropdown list will show the channel size available for the product, compliance body and frequency band.
Modulation	The modulation dropdown list will show the modulations available for the product, compliance body, frequency band and channel size.
Transmit Power	The transmit power is automatically set to the maximum level for the product variant selected. The actual transmitter power level will depend on the radio platform chosen, the operating frequency band and the modulation selected.
Gross Capacity	The maximum amount of data transported over the radio link in kbit/s.
Frequency Ranges	Displays the frequency ranges allowed by the compliance body.
Channels Per Hop Zone	Displays the frequency hopping spread spectrum (FHSS) randomly shifted channels per hop zone. Channels Per Hop Zone = Full Band Option / Standard Hop Zones
Standard Hop Zones	Displays the number of standard non-overlapping hop zones. This is the minimum number of channels that can be grouped together without any overlapping channels.
Full Band Option	Displays the full band single zone option. The radio can hop over all available channels.
Bit Error Rate	The receiver sensitivity is shown for a bit error rate (BER) of 10^{-3} and 10^{-6} . The receiver sensitivity is increased by 1 dB for BER of 10^{-3} .
Receiver Sensitivity	The receiver sensitivity of the radio for the selected compliance body, frequency band, channel size, modulation and bit error rate.

Site Names	Freeform text for the name of the site
Antenna	The antenna dropdown list will show the antennas suitable for the product and frequency band. The antenna types, sizes and gains are show in the list for the selected frequency band.
Antenna Stacking	Stacking the antennas improves the overall gain of the antenna system. The stacked antennas are co-axially combined and fed to the radio terminal via a single co-axial feeder. The antenna stacking dropdown list will show the options available for the selected frequency band and antenna type. Yagis may be stacked vertically or side-by-side, or in a combination of both.
Feeder Type	Select the feeder type. The dB / 100m is shown for the selected frequency band.
Feeder Length	Specify the feeder cable length from the radio installed in the equipment rack, out to the tower, and up the tower to the antenna.
Site Height Above Sea Level	Specify the site height above sea level (asl), excluding the tower height.
Antenna Height Above Ground	Specify the antenna height above ground level (agl).
Duplexer (split)	The duplexer dropdown list will show the duplexers available for the product and frequency band. The transmit / receive split is displayed. If a duplexer is selected, the duplexer insertion loss is subtracted from the transmit power and added to the path loss.
Transmit Frequency	Not applicable.
Transmit Power Reduction	A reduction in transmitter power may be required for RF licensing, or on-site interference reasons. This can be between 1 and 12 dB.
Obstruction Loss	The obstruction loss considers all steady-state propagation losses over and above the normal spreading loss, indicated below. Typically, terrain obstruction causes the most significant loss to the propagating signal: <ul style="list-style-type: none"> • Leave as 0 dB if the propagation is open and line-of-sight i.e. with better 0.6F1 clearance over the whole path. • Use 6 dB if the propagation is a grazing over a knife-edge obstruction, like a mountain range. • Use 10 dB if it is a grazing over typical 'average' terrain, like rounded hills. • Use 15 dB if it is grazing over the bulge of the sea.
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World Region	The location will typically have a localized atmospheric behaviour that will influence the availability of the link. This factor does not influence the calculated RSSI and fade margin. It only affects the availability calculation.
Terrain Type	This selection also influences the availability of the link. It also does not influence the calculated RSSI and fade margin.

Aprisa SRi System Results

Transmit Frequencies	The mid-band frequency is used for path loss calculation.
Antenna Gain	The gain of the antenna system including antenna stacking gain if used.
Feeder System Loss	The calculated feeder system loss for the type / length of feeder cable entered. It includes between 0.2 dB to 0.5 dB of fixed loss to account for the essential connectors and lightning arrestor in the feeder system.
Transmit Power	The transmit power at the radio but is reduced by transmit power reduction (if used) and the duplexer loss (if used).
Effective Radiated Power (EIRP)	Effective radiated power out of the antenna. It is a calculation of transmit power minus feeder system loss plus antenna gain minus protection loss TX (if used).
Path Loss	The theoretical loss of the RF signal as it propagates through space. It is sometimes referred to as 'spreading loss'.
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Fade Margin	The amount by which a received signal level may be reduced without causing system performance to fall below a specified threshold value. The larger the fade margin the more the link will be available for data transmission. Typically, a fade margin of 20 dB or more is considered acceptable for most installations in the sub 3 GHz frequency band.

Path Availability

The received signal is continuously fading to some extent. Occasionally it may fade below the receiver threshold and be momentarily lost. This is referred to as an outage. Therefore, the higher the availability figure, the less chance there is for an outage.

The availability indicates the percentage of time the received signal is above the threshold. It can never be 100% as this implies a perfect link.

The availability calculation is derived from ITU-R standards based upon statistically processed measurements. As there are so many variables affecting RF propagation, it is impossible to provide predictions for all linking environments

The Surveyor program incorporates:

- Aprisa radio frequency band, channel size, transmit power and receiver sensitivity figures
- Averaged atmospheric gradients
- Typical terrain factoring
- ITU-530-10 outage predictions based on time rather than errored seconds (ES) or seriously errored seconds (SES)

It does not consider rain fading, as the effects are negligible at sub-3 GHz frequency bands.

Space Diversity Improvement Factor	Improvement factor achieved by using Space Diversity protection (only Aprisa XE).
ITU-R P.530-16 Availability (worst month of the year)	The availability prediction considers the month of the year when atmospheric behaviour is at its worst. This is referred to as 'the worst month of the year'. The percentage of time has been converted to unavailable seconds per month
Unavailable seconds (worst month of the year)	The unavailable seconds in the worst month of the year.
ITU-R P.530-16 Availability per Year	The availability per year considers the availability over a year-long period, rather than a single month. The result is always slightly better than the worst month of the year figure.
Unavailable Seconds per Year	The unavailable seconds over a year-long period.



Reports

A PDF printout of the current product tab data can be generated from Menu > Reports Project Report. These PDF files are stored in the Reports Directory (see Reports Directory on page 5).

Google Earth

The Google Earth button will attempt to find and open the installed application Google Earth Pro on your PC or MAC and display the path between the coordinates specified.

If Google Earth Pro is not installed on your computer, it can be installed easily by clicking the link <https://www.google.com/earth/versions/> and using the 'Google Earth Pro on Desktop' option.

When Google Earth Pro opens, the Elevation Profile can be shown by selecting Edit > Show Elevation Profile from the Google Earth Pro menu.

Clicking the Google Earth button on the other product tabs will display the links on the same Google Earth screen.



4. Main Menu

File

- Open File - opens a *.sur Surveyor config file from the Project Files Directory
- Save File - saves the Surveyor config to the current *.sur file in the Project Files Directory
- Save File As - saves the Surveyor config to a new *.sur file in the Project Files Directory
- Close File - closes the current Surveyor config file and restores all project settings to the default setting.
- Exit - closes the program.
- Recent Files - shows all recent files. Click on a file to open it.

Setup

- Project Files Directory - sets your default directory to store project files.
- Reports Directory - sets your default directory to store report files.
- Country - sets your country location which determines radio and site defaults.

Reports

- Project Report - a PDF printout of the current product tab data. These PDF files are stored in the Reports Directory (see Reports Directory on page 5).

Help

- About - shows the program details and the java JRE version operating on your PC
- User Guide - this document