Link Estimator User Manual

MOTOROLA POINT-TO-POINT WIRELESS SOLUTIONS

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PTP Link Estimator

User Manual

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1 Introduction

The Motorola PTP400 and PTP600 Series of point-to-point wireless Ethernet bridges are designed to operate in non-line-of-sight (NLoS) and line-of-sight (LoS) environments. Link planning and estimation enables a link of known quality to be installed. This involves the acquisition of path profile data and use of the PTP Link Estimator to predict the data rates and reliability over this path, through adjustment of antenna height and RF power. When the link is installed the mean path loss can be checked to confirm these data rates and reliability performance.

The PTP Link Estimator uses Microsoft Excel either on Windows or Macintosh. It performs the calculations from the ITU recommendations ITU-R P.526-9 and ITU-R P.530-10 to predict NLoS and LoS paths for anywhere in the world. Path profile data can be obtained in a number of different ways depending upon global location. Motorola provides a method for obtaining path profile data; see section 7 “Path Profiles”. Trees and buildings (clutter) will modify this profile, and often the path must be surveyed to establish the correct estimation.

The PTP Link Estimator provides results specific to the PTP400 and PTP600 families of wireless bridges, giving the data rates and reliability that can be expected given the specific design features of these products.

2 Path Loss Considerations

The path loss is the amount of attenuation the radio signal undergoes between the two ends of the link. The path loss comprises the sum of the attenuation of the path if there were no obstacles in the way (Free Space Path Loss), the attenuation caused by obstacles (Excess Path Loss), a margin to allow for possible fading of the radio signal (Fade Margin), and an allowance for the seasonal effects of foliage growth, to achieve a reliable link. This path loss must be lower than the equipment capability for the data rate required.

$$L_{FreeSpace} + L_{Excess} + L_{Fade} + L_{Season} < L_{Capability}$$

Where

$L_{FreeSpace}$	= Free Space Path Loss see section 2.1	dB
L_{Excess}	= Excess Path Loss see section 2.2	dB
L_{Fade}	= Fade Margin Requirement see section 2.3	dB
L_{Season}	= Seasonal Fading	dB
$L_{Capability}$	= Equipment Capability	dB

Equation 1 - Path Loss

Aggregate Ethernet Throughput Rate (Mbps)				Maximum path budget (dB)
Mode				
0-5km	**0-40km**	**0-100km**	**0-200km**	
3.60	3.34	2.98	2.52	166.5
8.10	7.52	6.70	5.67	161.3
10.80	10.03	8.93	7.56	159.2
16.20	15.04	13.40	11.34	154.6
24.29	22.56	20.10	17.01	150.1
32.39	30.08	26.80	22.68	144.7
36.44	33.84	30.15	25.51	142.8
42.51	39.48	35.17	29.76	138.1

Table 1 - PTP400 5.8 & 5.4 GHz Series Bridges Aggregate Ethernet Throughput Rate vs Maximum Link Loss With Integrated Antennas

Aggregate Ethernet Throughput Rate (Mbps)				Maximum path budget (dB)
Mode				
0-5km	0-40km	0-100km	0-200km	
2.55	2.37	2.11	2.78	163.6
6.3	5.85	5.21	4.41	158.7
8.39	7.79	6.95	5.88	155.5
12.59	11.69	10.42	8.82	152.5
18.89	17.54	15.63	13.22	148.1
26.38	24.50	21.83	18.47	142.8
29.68	27.56	24.56	20.78	140.9
34.63	32.15	28.65	24.24	137.1

Table 2 - PTP400 4.9 GHz Series Bridges Aggregate Ethernet Throughput Rate vs Maximum Link Loss With Integrated Antennas

Modulation Mode and Payload Type	Maximum Aggregate Data Rate (Mbits/s)[1]	Maximum path Budget (dB)
256QAM 0.81 dual	300.2	124.1
64QAM 0.92 dual	252.9	127.0
64QAM 0.75 dual	206.7	133.1
16QAM 0.87 dual	160.8	138.0
16QAM 0.63 dual	115.6	144.2
16QAM 0.63 single	57.8	148.3
QPSK 0.87 single	40.2	151.6
QPSK 0.63 single	28.9	155.6
BPSK 0.63 single	14.4	160.1
256QAM 0.81 single	150.1	129.0
64QAM 0.92 single	126.4	130.9
64QAM 0.75 single	103.3	136.7
16QAM 0.87 single	80.4	141.8

Table 3 - PTP600 5.8 & 5.4 GHz Series Bridges Aggregate Ethernet Throughput Rate vs Maximum Link Loss With Integrated Antennas

The equipment capabilities are given in Table 1, Table 2 and Table 3. They show the Ethernet throughput rate versus link loss for PTP400 and PTP600 bridges. Adaptive modulation will ensure that the highest throughput that can be achieved instantaneously will be obtained taking account of propagation and interference. Note the Ethernet throughput for Lite version of the PTP400 bridge is exactly half of the quoted throughput and the Ethernet throughput for the Lite version of the PTP600 bridge is exactly half of the quoted throughput.

The calculation given in Equation 1 needs to be performed to judge whether a particular link can be installed. When the link has been installed web pages provide information about the

[1] Aggregate data rate in 40:40 mode for a 1km (0.6 mi) link length

link loss currently measured by the equipment both instantaneously and averaged. The PTP400 Series User Guide section 6.2 and PTP600 Series User Guide section 6.2 describes this status.

2.1 Free Space Path Loss

The Free Space Path Loss is the loss incurred along a line-of-sight path between the two end points of the radio link. Figure 1 gives a graph of the value in dB by range at the frequency used by PTP400 and PTP600 bridges .

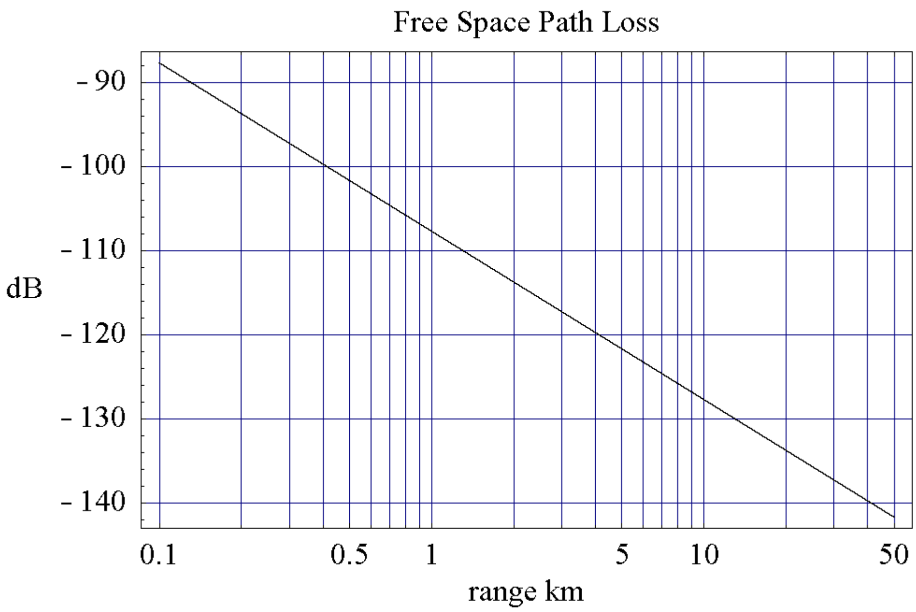


Figure 1 - Free Space Path Loss at 5.8GHz

2.2 Excess Path Loss

The Excess Path Loss is the loss incurred due to obstacles between the two end points of the radio link. This loss is best calculated using the PTP Link Estimator. Trees and foliage create a number of problems;

- they are often not marked on the path profiles — producing optimistic results,
- they are not completely solid — producing pessimistic results,
- they are responsible for seasonal variation.

It is recommended that they be treated as solid objects thus giving worst case results, and when the link is installed the mean path loss indicated should be given an allowance for the seasonal variation that will occur.

2.2.1 Fresnel Zone

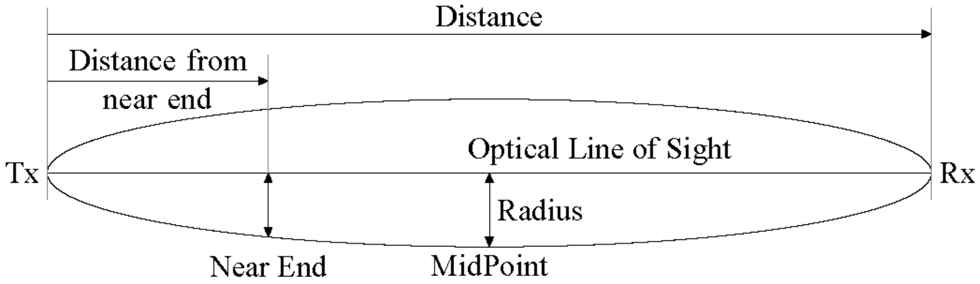
There is a theoretical area around the line-of-sight of an antenna, called the Fresnel Zone. Objects that penetrate the Fresnel Zone block some of the signal travelling from transmitter to receiver, causing the path loss to increase. The Fresnel radius at a point along the path is defined as follows::

$$\text{Fresnel Zone Radius} = 0.227\sqrt{\frac{d1 \cdot d2}{d1 + d2}}$$

in meters where

$d1$ = distance from one end in meters

$d2$ = distance from the other end in meters



Equation 2 - Fresnel Zone Radius

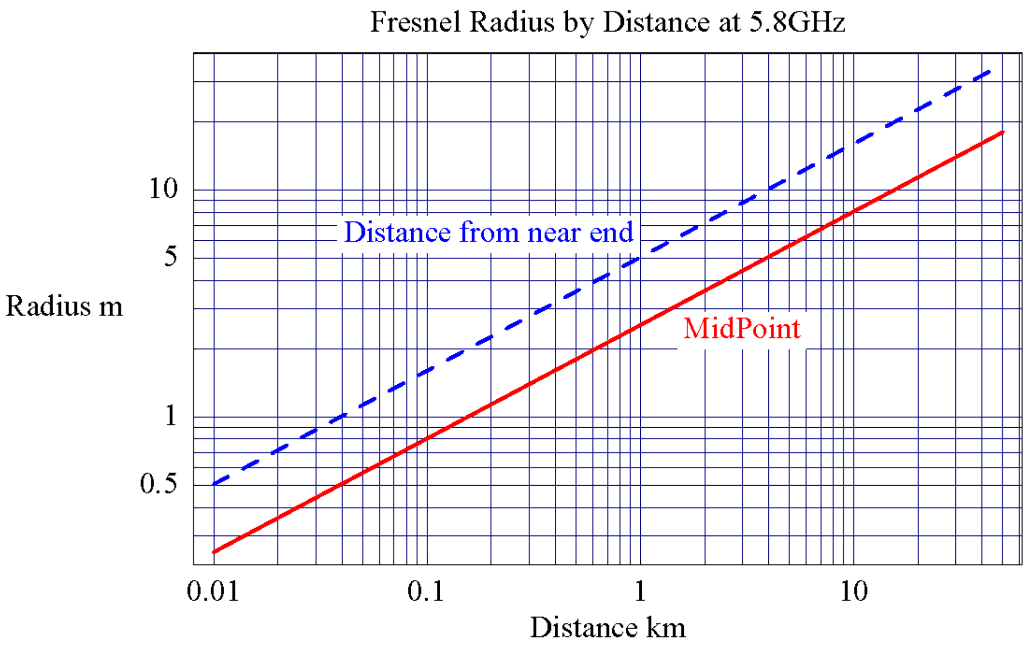


Figure 2 - Fresnel Radius for Zone 0.5

The two graphs in Figure 2 give the radius of the mid point of a link and also give the radius of any link near one end. Thus for a link longer than 1 km (0.6 mi), the radius of the Fresnel Zone at 100 meters (330 ft) is 1.7 meters (5.6 ft). This is useful to know since the objects nearest the ends of the link tend to have a greater influence on the link losses than objects at the middle of the link. For a thorough understanding of the Fresnel Zone refer to ITU-R P.526-9.

2.3 Fade Margin

A Fade Margin needs to be applied to the link budget to take into account changes in the radio path caused by changes in objects surrounding or in the path, e.g. moving objects such as traffic or the changes in foliage brought on by seasonal change. The Fade Margin for NLoS links used in the calculation is a function of excess path loss, and is taken from Figure 3. The Fade Margin for LoS links is a function of location, path length, antenna heights, and spatial diversity, and it is computed using ITU-R P.530-10. The estimation tool adds together the probabilities for the NLoS fading and the LoS fading.

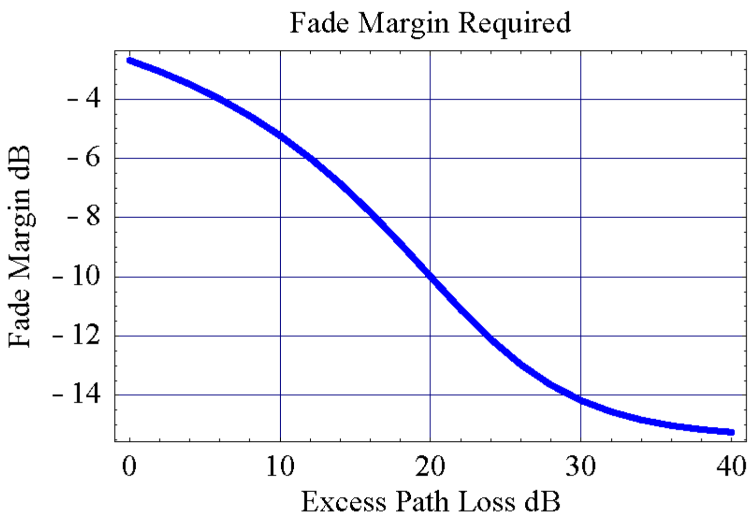


Figure 3 - Fade Margin vs Excess Path Loss for 99.99% Link Availability

2.4 Maximum Path Loss

The Maximum Path Loss is the total path attenuation that the system can withstand and still maintain 99.99% availability. Due to different spectrum licensing conditions in different countries the Maximum Path Loss varies from country to country due to allowable output power differences. Table 1, Table 2 and Table 3 give the maximum loss that the equipment can withstand in each mode when deployed in a region[2] that uses a power of 25dBm. Deployment considerations may limit the maximum power which is used. An example is given in the Application Note: 'How to Deploy PTP400 Bridges with Canopy' available from the Motorola Web site. Also, there may be local interference sources from other users of the 5.8 GHz band.

2.5 Paths Over Sea or Very Flat Ground

Paths over the sea are subject to a special problem due to the very strong reflection from the water. This reflection can add an anti-phase signal to the direct wave and cancel it out completely. This may not happen all of the time because the effective curvature of the earth changes depending upon the temperature gradient in the atmosphere. This gradient can change and in certain circumstances causes the signal to travel a long way in ducts. Figure 4 illustrates the problem and the solution using a PTP400 or PTP600 bridge. The background

[2] In other regions, the output power allowed may be lower than the 25 dBm assumed in the tables.

of the diagram is shaded to illustrate the changing density and therefore refractive index. The upper antennas are in a signal inversion.

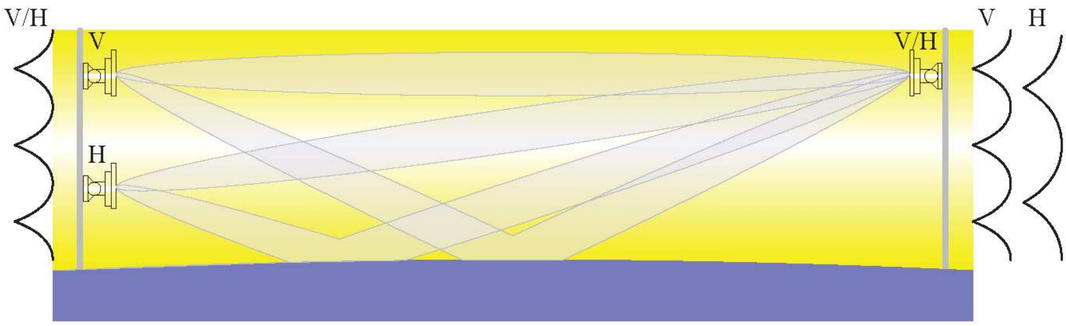


Figure 4 - Propagation Over The Sea

The signals pass from one antenna to the other through two paths. One path is the direct path and the other is reflected from the sea. The mean path loss of the two components is almost identical. The graph adjacent to the mast illustrates the signal level that will occur as an antenna is moved vertically on the mast. In this case the x-axis illustrates the amplitude received while the y-axis illustrates the height.

The polarization selected for the antennas are single V and H polarization on the left and a dual polarized antenna on the right. The two graphs on the right illustrate the signal received on each polarization while on the left the individual antennas will receive the same signal level independent of polarization but instead will only depend upon the height.

There is an optimum vertical spacing of the two antennas on the left which is found from the geometry of the two paths. The important parameters are the length of the path, the height of the right single antenna and to a lesser extent the height of the pair of antennas on the left. An allowance should normally be made for the apparent height of the middle of the path due to the mean radio curvature of the earth (4/3). The PTP Link Estimator provides a utility for calculating the optimum vertical spacing for antennas for paths with strong reflections – see section 6.18.

3 PTP400 and PTP600 Equipment Features

There are some specific features of the PTP400 and PTP600 equipment which ensure that the products work as reliably as possible in LoS and NLoS environments. These are;

- Large System Budget for long range LoS or deep penetration in NLoS Applications,
- Multiple-Input Multiple-Output (MIMO) to enable operation with reduced allowance for fade margin. In NLoS links this is effective using the integrated antenna, and in long range LoS links this is most effective using separated antennas at one end of the link,
- Adaptive Modulation to ensure that the fastest instantaneous data rate is achieved in varying conditions,
- Use of a wide range of external antennas for difficult applications,
- Automatic Frequency Management to ensure that the optimum frequency is being used for communications in respect of interference, and
- Comprehensive measurements to ensure that a link will remain reliable after installation.

4 Description of Path used in this User Guide

The pictures in this handbook come from the path file Handbook.dat delivered in the installation. The PTP Link Estimator uses the methods of ITU-R P.526-9 (Deygout method) to calculate the excess path loss. This example path is 6 miles (9.7 km) long with a major obstruction at 3 miles (4.8 km) and two minor obstructions at 1.0 and 3.8 miles (1.6 and 6.1 km). See section 6.5 “Path Visualization” for a pictorial representation of this path.

5 Path Profile Data Availability

The accuracy of the results depends upon obtaining accurate path data. In the US this data is readily available from recent 1 arc second data (20m) obtained by NASA. In the rest of the world 30 arc second data (500m) is freely available but NASA is gradually providing 3 arc second data (50m) for the world between Latitudes 60 north and 60 south. (See section 7 “Path Profiles”). Even with accurate path data the losses over certain objects depends upon the curvature of the top of those objects. Nevertheless the tool gives a good idea of the performance to be expected and by doing a what/if analysis gives an inexperienced person a good feel for what Motorola means by non-line-of-sight.

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6 PTP Link Estimator

With the PTP400 and PTP600 Series equipment you are provided with a PTP Link Estimator to help predict where and how well the equipment will work. These instructions apply to the file PTP-Link_Estimator_8v00.xls. The PTP Link Estimator performs calculations in accordance with ITU-R P.526-9 and ITU-R P.530-10.

The PTP Link Estimator requires Microsoft Excel to operate. Macros must be enabled to allow the program to work (If you do not see the window showing the contents of figure 5 then macros have not been enabled. Check in the Excel menus that Excel-Tools-Macro-Security is set to Medium (PC only)). The PTP Link Estimator has been tested on Excel 97, Excel 2000, Excel vX and Excel 2003. The facilities provided are:

- Path profile entry.
- Obstruction entry.
- Saving and recalling paths.
- Path visualization.
- Path loss.
- Link reliability.
- Average data rate.
- Reliability for a given data rate.
- Outage prediction.
- Worst case analysis.
- Region adjustment.
- Maximum power adjustment.
- TDD Synchronisation
- Maximum EIRP adjustment.
- Antenna and feeder type selection.
- Space diversity.
- Link optimizations.
- Import wizard from other data sources.
- Profile helper.
- Reflection calculations.
- Link symmetry control.
- Power asymmetry.
- Latitude longitude path calculator.
- Other conversions.
- Output Report.

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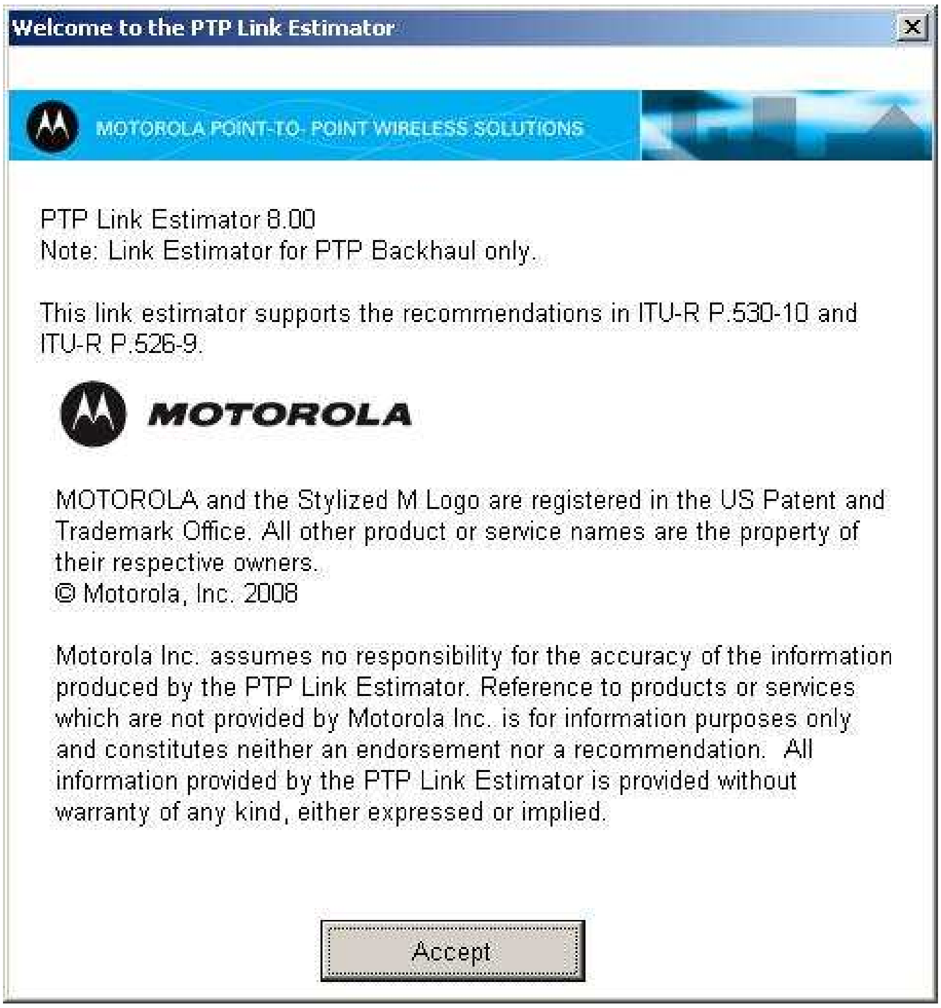
6.1 Path Input

On opening the PTP Link Estimator you are presented with a splash screen with a standard disclaimer



After clicking on Accept, the following prompt is displayed:

Figure 5 - Opening Question

New Link takes you to a ten step wizard (also available from ‘Link Wizard’ button on the data entry sheet) to set initial link parameters. (see Section 6.2 ”Link Wizard”).

Load Existing presumes that you have an existing path profile that you have saved on your hard disk from this PTP Link Estimator . (see Section 6.11.1 ”Save Path and Load Path”).

Cancel causes the program to continue from where you left off from previous PTP Link Estimator work using the saved workbook state.

6.2 Link Wizard

This wizard has twelve pages which can be accessed in any order using the tabs. It may be necessary to enter the link wizard more than once before a satisfactory link estimation is obtained since some variables are only available in the wizard.

6.2.1 Link Name & Unit Type Page

On the first page (Figure 6) the "Link Name"[3] and site names are entered and the "Product Type" and "Frequency Band" selected.

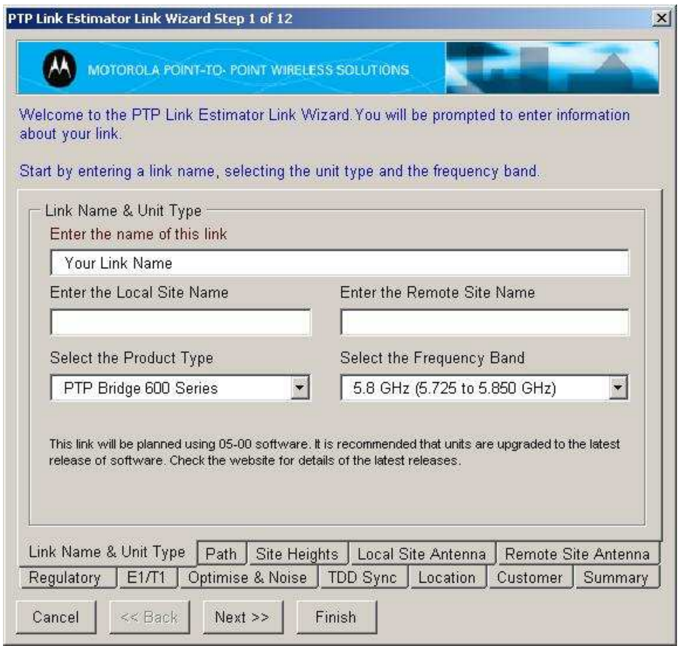


Figure 6 - Link Wizard - Page 1 – PTP600 Series Bridge

The text indicates which version of software will be used to plan the link

[3] This will appear at the top of the graph and also will be the default name for the saved data file.

6.2.2 Path Length Page

On the second page (Figure 7) you select the units for distance and then enter the Path Length and the Path Increment. The increment is the step size of the path data.

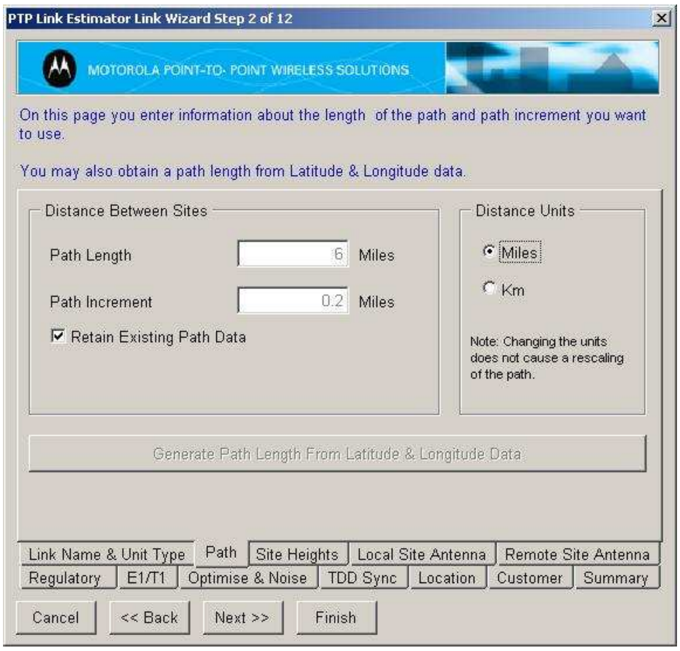


Figure 7 - Link Wizard - Page 2 - Path

The path length can be computed from the Latitude and Longitude information using the Latitude and Longitude data entry page (Figure 8) accessed by pressing the “Generate Path Length From Lat & Long” button. The Retain Existing Path Data check box must be unchecked to change the path length. Changing the path length will cause any existing path data to be lost.

Note: Selecting between Miles & Km only changes the units in which the path is displayed. It does not cause a rescaling of the path.

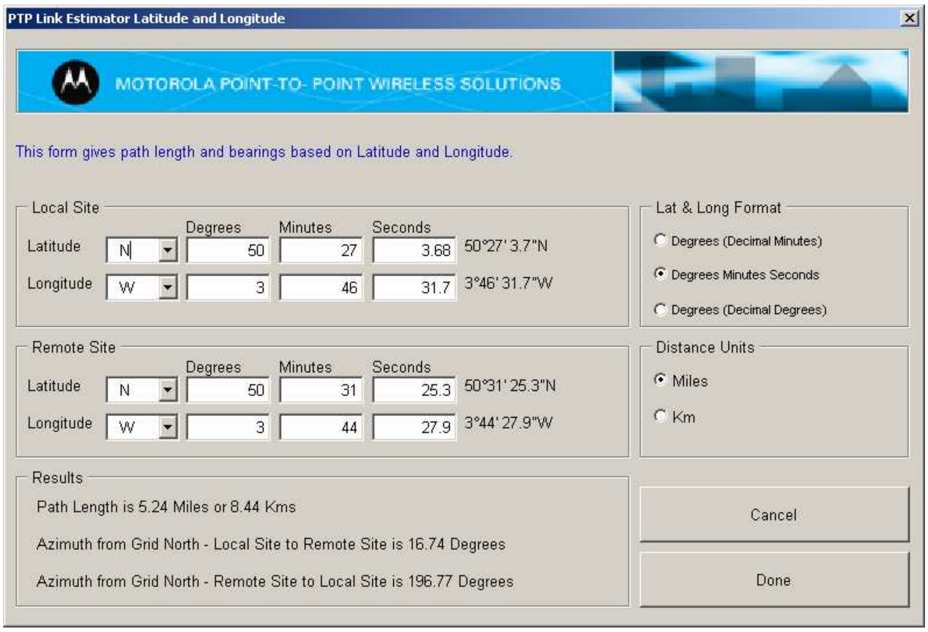


Figure 8 - Latitude and Longitude Data Entry

6.2.3 Site Heights Page

On page three (Figure 9) you select the height units and then enter the local and remote site elevations Above Mean Sea Level (AMSL) and the antenna heights Above Ground Level (AGL). These can both be adjusted later.

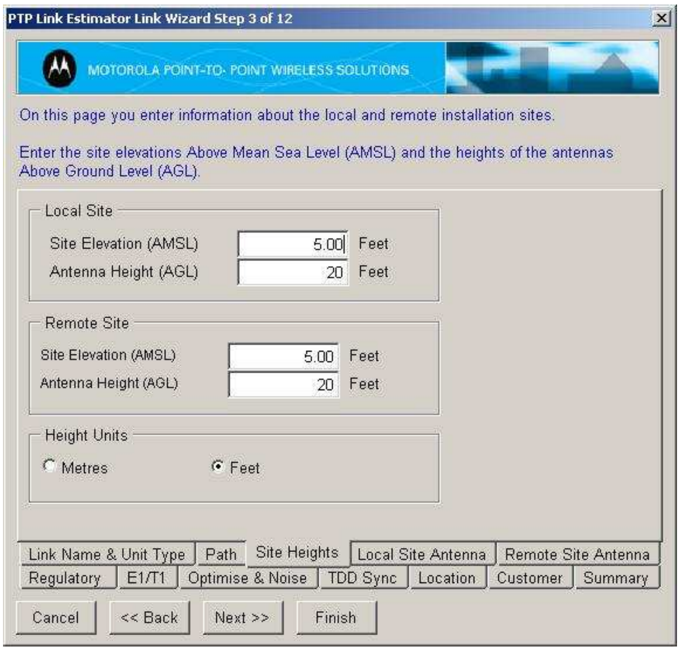


Figure 9 - Link Wizard - Page 3 – Site Heights

6.2.4 Local Site & Remote Site Antenna Pages

On the fourth and fifth pages (Figure 10 and Figure 11) you select an antenna type. If an external antenna is selected the feeder loss options become available (Figure 12).

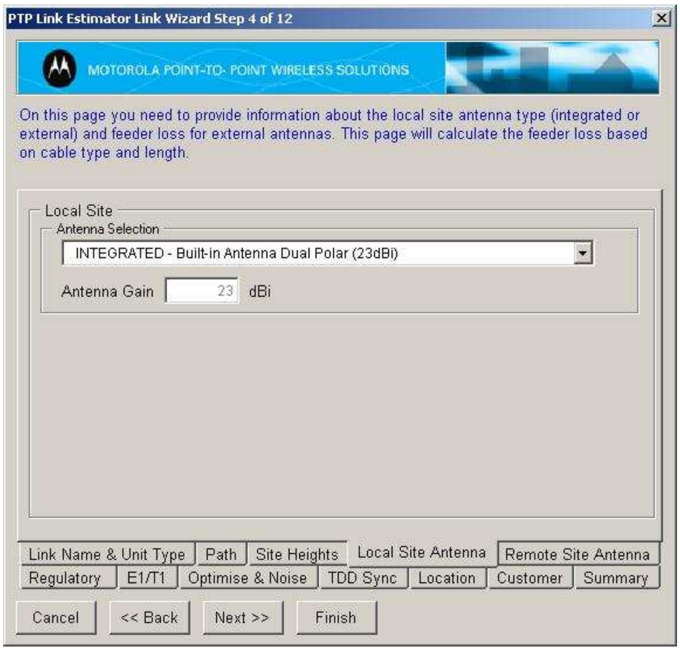


Figure 10 - Link Wizard - Page 4 - Local Site Antenna

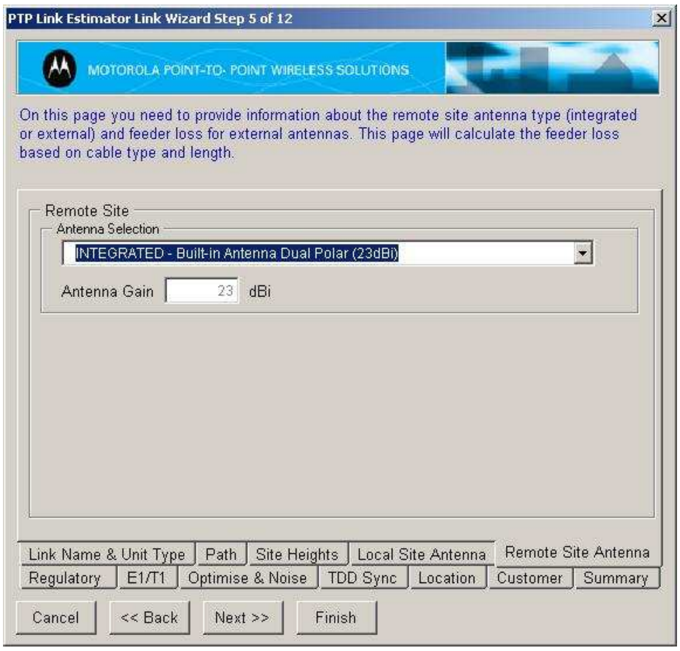


Figure 11 - Link Wizard - Page 5 - Remote Site Antenna

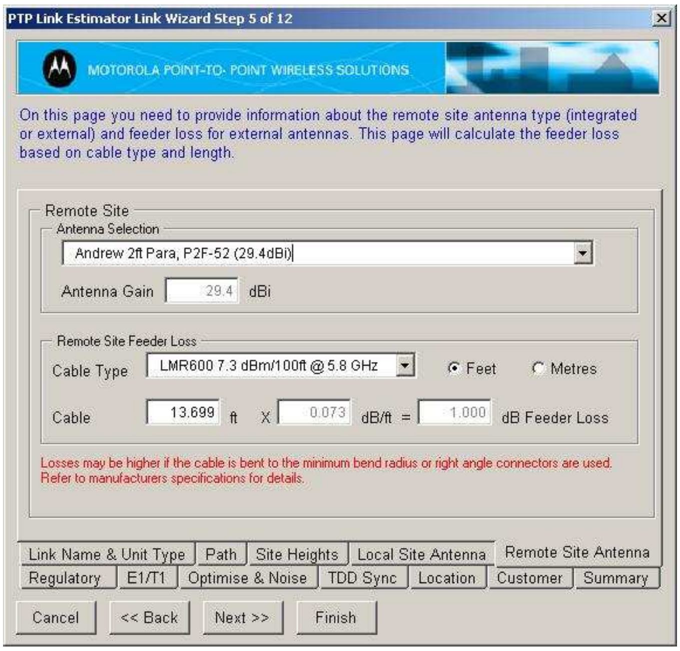


Figure 12 – Link Wizard – Page 5 Remote Site Antenna with the Feeder Loss Options

6.2.5 Regulatory Page

On page six (Figure 13) the regulatory options can be selected. Either select the region or a User Defined Power/EIRP and then if necessary enter a lower maximum EIRP or Power Limit if there are specific reasons for reducing power levels.

For a PTP600 the channel bandwidth can be selected. For most regions the channel bandwidth can be 30MHz, 15MHz, 15MHz or 5MHz but there are some regions where the channel bandwidth is restricted. The combo box will automatically update to present the available channel bandwidths for the selected region.

If a PTP600 has been selected in the 2.5GHz band, there is an additional combo box which allows the sub-band to be selected. There are further regulatory conditions which are automatically taken in account when the sub-band is selected.

When using a PTP400 series bridge in the 4.9 GHz band, the maximum allowable antenna gain is 26dBi. When an external antenna is selected with a gain greater than 26dBi, the output power is automatically reduced in proportion.

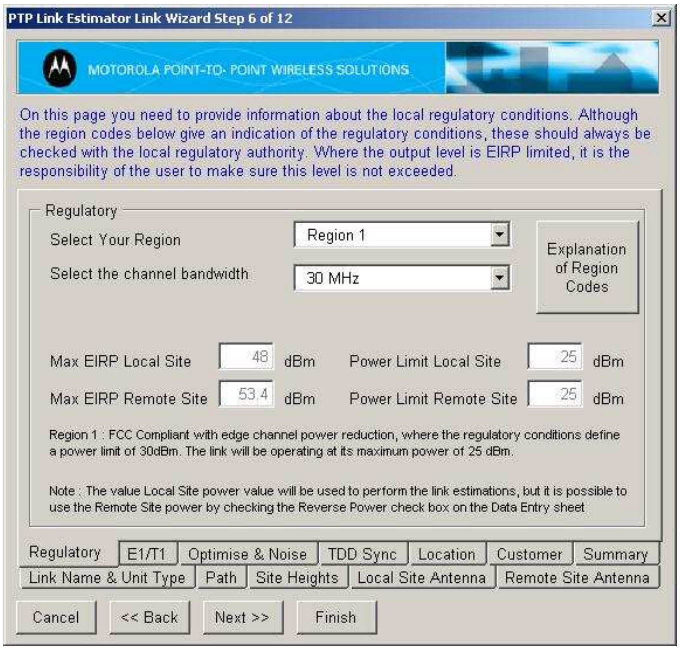


Figure 13 - PTP Link Estimator - Page 6 - Regulatory

When entering the regulatory information, the “Explanation of Region Codes” button provides access to a description of the available region codes.

Where the regulatory conditions specify an EIRP limit, it is the responsibility of the user to make sure that this level is not exceeded by setting the output power correctly. This is particularly important when using an external antenna.

6.2.6 E1/T1 Page

On page seven the internal or external E1/T1 details can be entered. A user defined external data rate can be selected. When a PTP600 Series bridge is selected the internal TDM channels are also available. A summary of the data rate reserved for TDM channels is presented. When TDM Mode is enabled, the ability to alter the channel bandwidth on the Data Entry page is removed.

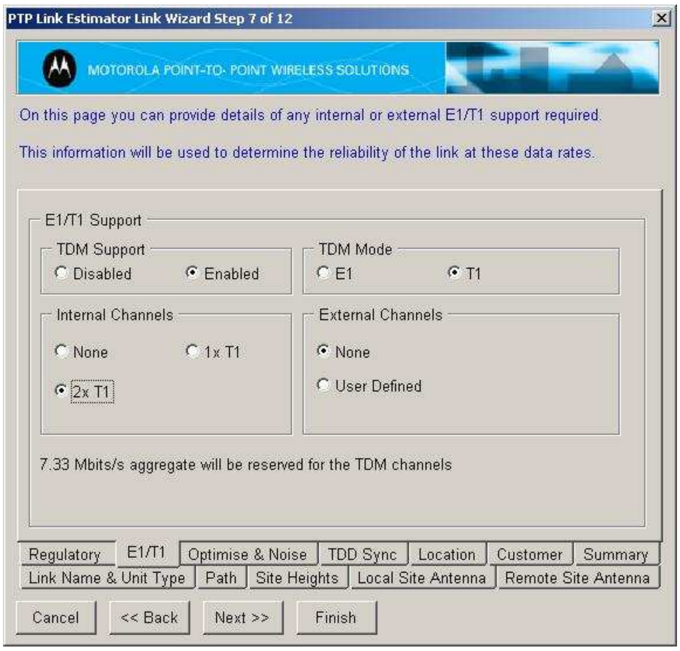


Figure 14 - E1/T1 Configuration – Page 7 – E1/T1

6.2.7 Optimise & Noise Page

On page eight (Figure 15) link optimisations and the environmental noise are entered.

The optimisation for the link, either for IP Traffic or TDM Traffic may be selected. If TDM has been enabled then the link will automatically be optimised for TDM traffic/Latency.

The environmental noise is the amount of site noise in the selected channel bandwidth for a PTP600 Series bridge and the 10 MHz channel bandwidth for a PTP400 Series bridge, expected at the antenna connector. This noise is assumed to be a constant power added to the thermal noise of the front end of the wireless. If mean power measurements from DFS are available then a close approximation is to use this value which will then be taken into account, this is only possible after link set up.

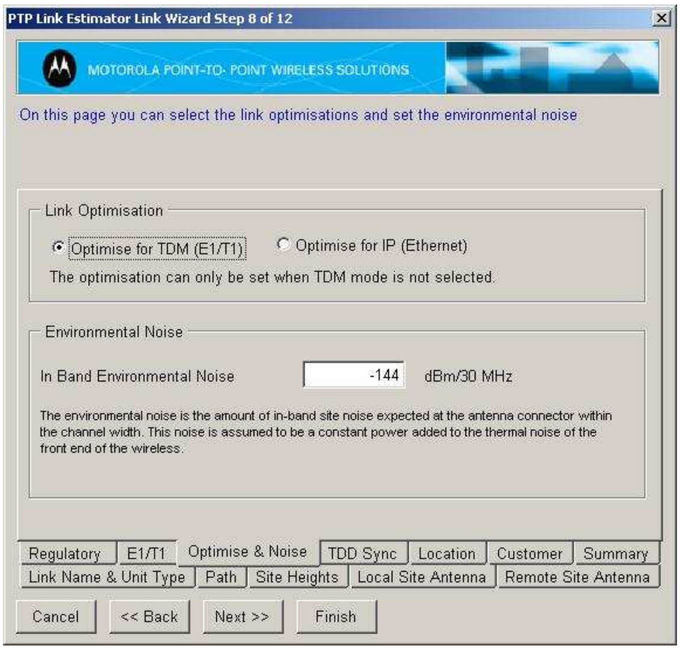


Figure 15 - Link Wizard - Page 8 – Optimise & Noise

When changing the channel bandwidth, it may be necessary to scale the environmental noise figure accordingly. When noise powers are above -100dBm, a reminder is displayed when the channel bandwidth is changed.

6.2.8 TDD Sync Page

On page nine (Figure 16), TDD synchronisation can be set-up. The TDD synchronisation feature, only available on the PTP600, introduces a fixed TDD framing mode that allows frame timing in a PTP600 link to be synchronised with an external reference. This means that all PTP600 links in a network may be made to transmit and receive in synchronism, implying reduced RF interference between links.

The Link Wizard presents the TDD synchronisation parameters in the expert mode. This is an option recommended only for experienced network and cell planners to configure large and complex networks, see the PTP600 User Guide for a detailed description of the parameters to configure. Alternatively, the Link Estimator provides a TDD Synchronisation Wizard that gathers information about the RF Network and determines the optimum set of TDD

Synchronisation parameters. This is accessed from the TDD synchronisation page of the Link Wizard and is described in more detail in section 6.3.

When TDD synchronisation is enabled, the ability to alter the region code and the channel bandwidth on the Data Entry sheet is removed.

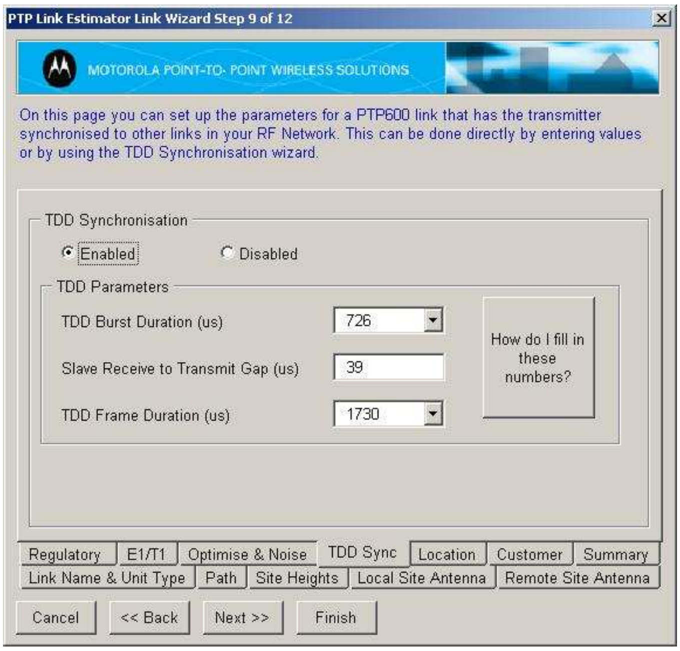


Figure 16 - Link Wizard - Page 9 –TDD Synchronisation

6.2.9 Location Page

On page ten (Figure 17) the link location is selected. This value will determine the constants used for long range fading. It is necessary to know the location of the link to an accuracy of 0.5° Latitude and Longitude because the likelihood of ducting varies across the globe.

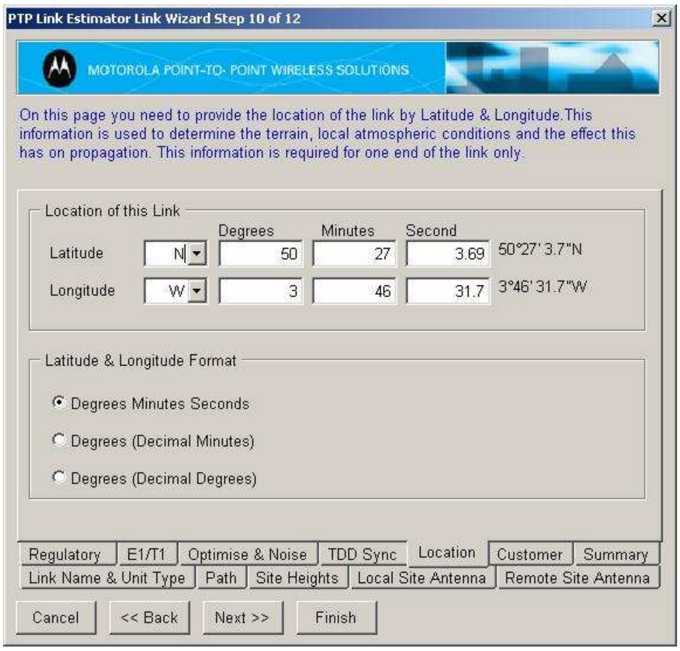


Figure 17 - Link Wizard - Page 10 - Location

6.2.10 Customer Details Page

On page eleven (Figure 18) the customer's details can be entered. These details will be output in the report summary.

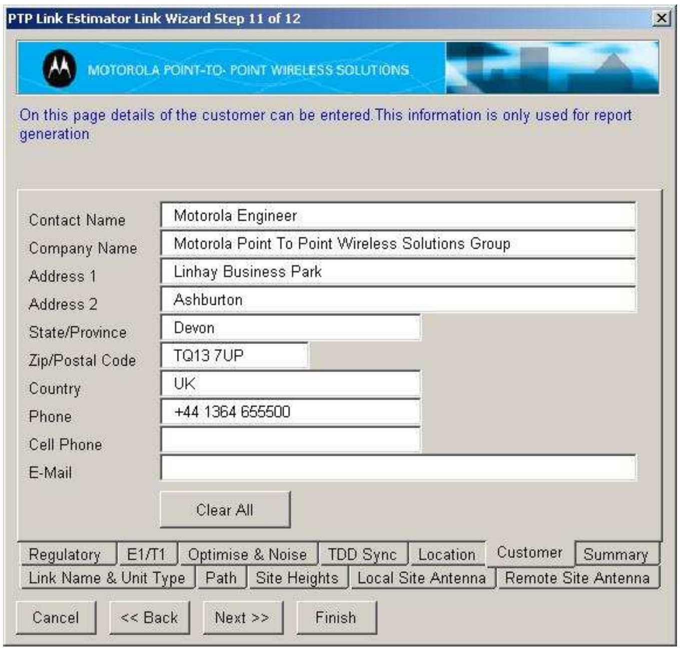


Figure 18 - Link Wizard - Page 11 – Customer Details

6.2.11 Summary Page

On page twelve (Figure 19) a summary of the settings is given to confirm your intention. You can now go “Back” , “Cancel” or “Finish” the wizard.

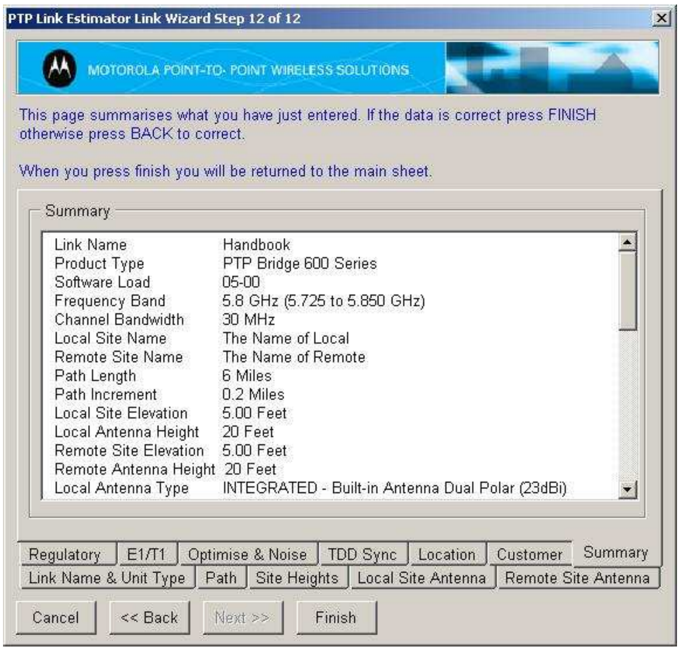


Figure 19 - Link Wizard - Page 12 - Summary

6.3 TDD Synchronisation Wizard (PTP600 only)

The TDD synchronisation feature introduces a fixed TDD framing mode that allows frame timing in a PTP660 link to be synchronised with an external reference. This means that all links in a network may be made to transmit and receive in synchronism, implying reduced RF interference between links. Using this feature, a single frequency channel is assigned to both the transmitter and the receiver. This has many advantages such as:

- Minimising interference between multiple links on a single mast.
- Improving frequency re-use
- Reducing spatial / angular separation between PTP600 links when installed on the same mast
- Improving Link Budgets, when using higher transmit power

TDD Synchronisation is set by three parameters

- Burst Duration – the duration time in us for both the transmit burst and the receive burst
- Slave Receive to Transmit Gap – the time in us that slave waits after receiving data before going into transmit
- Frame Duration – the duration in us of the complete frame

The Frame Duration must be more than twice the value of Burst Duration plus the Slave Receive to Transmit Gap.

The Link Wizard allows the user to enter these numbers directly. This should only be attempted by experienced network and cell planners to configure large and complex networks.

To make the process of determining the TDD Synchronisation parameters easier, a TDD Synchronisation Wizard has been provided. This wizard calculates the optimum set of parameters for a given RF Network by asking a series of questions.

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6.3.1 TDD Wizard Page 1 - Introduction

This page introduces TDD synchronisation and verifies that TDD synchronisation is required. Answering “Yes” progresses through the rest of the wizard, whereas answering “No” will progresses directly to the summary page.

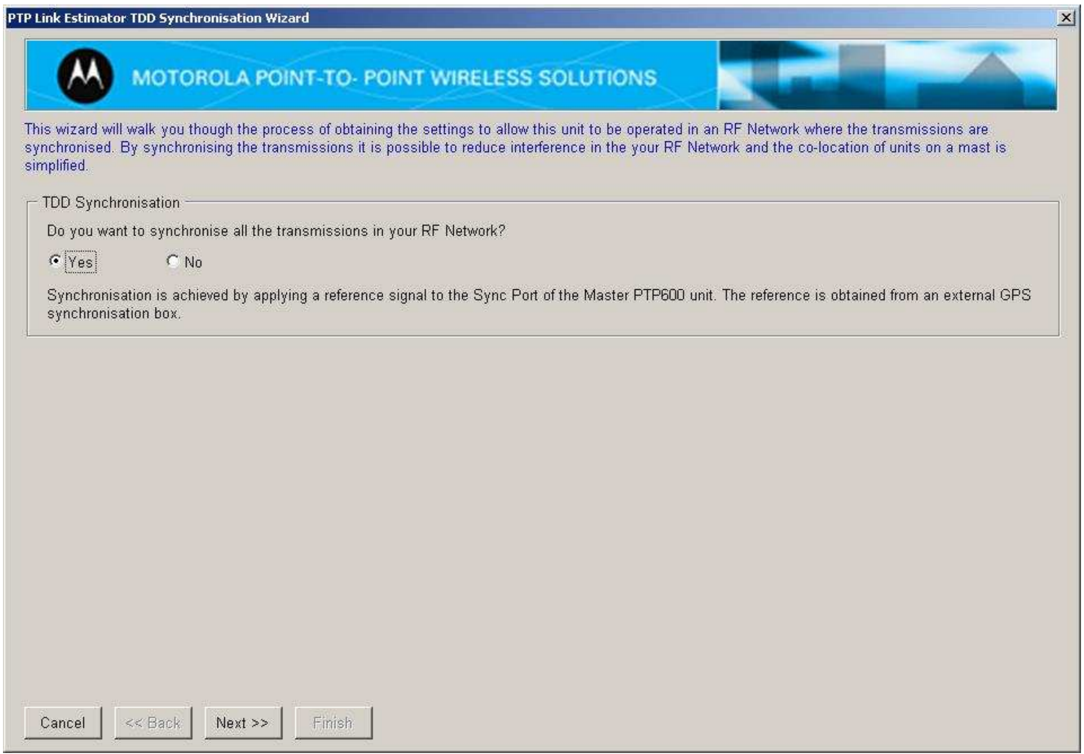

Figure 20 – TDD Synchronisation Wizard - Page 1 - Introduction

6.3.2 TDD Wizard Page 2 – RF Network Topology

On this page you are required to identify your RF Network topology. For the Simple Star and Multiple Star topologies to be valid all the masters must be located at the centre of the stars. Depending on the topology selected the subsequent wizard pages will vary.

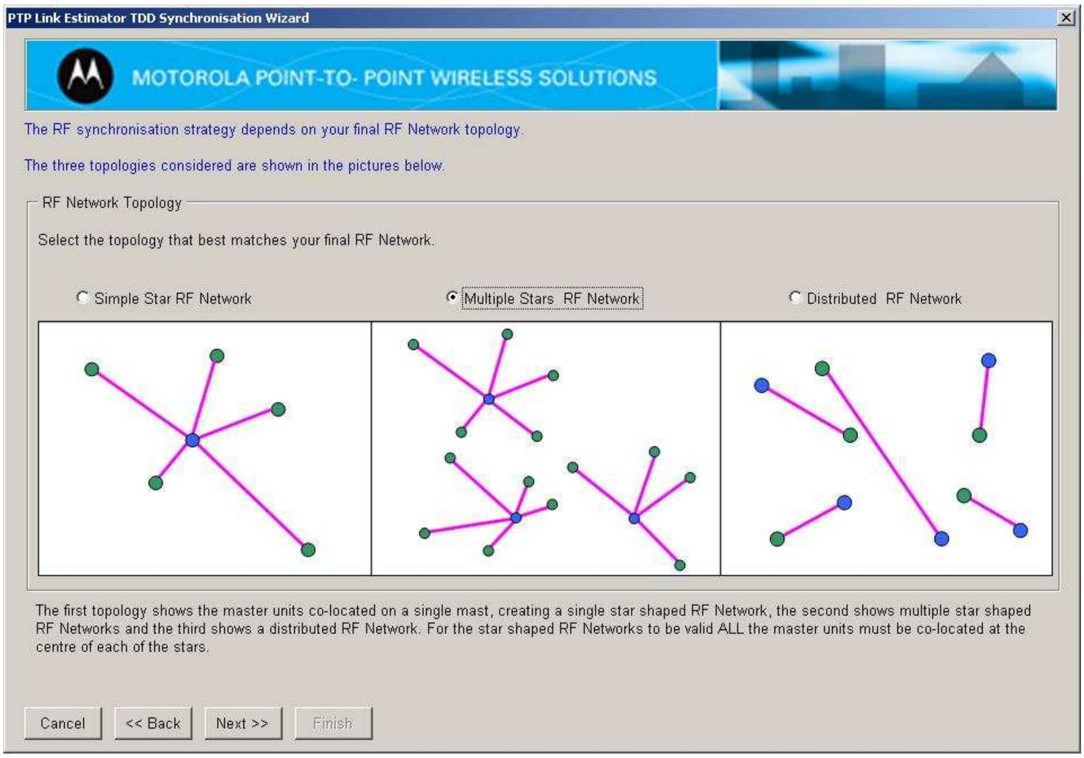

Figure 21 – TDD Synchronisation Wizard - Page 2 - Topology

6.3.3 TDD Wizard Page 3 – Channel Bandwidths

This page will load with the channel bandwidth selected in the Link Wizard. You are asked to identify what other channel widths exist in the RF Network. The combinations of channel bandwidths that can be synchronised are limited and those combinations are given on this page. If channel widths exist outside these combinations the RF network cannot be synchronised.

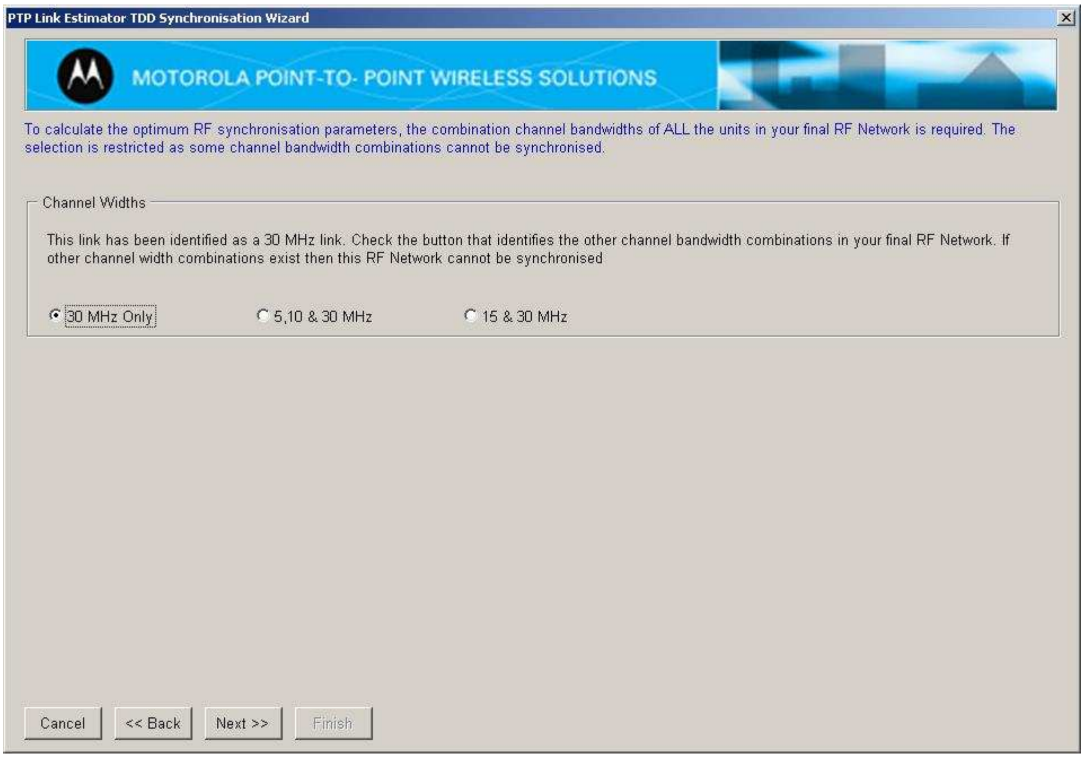

Figure 22 – TDD Synchronisation Wizard - Page 3 – Channel Widths

6.3.4 TDD Wizard Page 4 – Maximum Range Link

This is the length of the longest link in the RF Network. The length of this link and the distance units are automatically imported from the Link Wizard. If this is not the longest link in the RF Network then select "No" and enter the length of the longest link

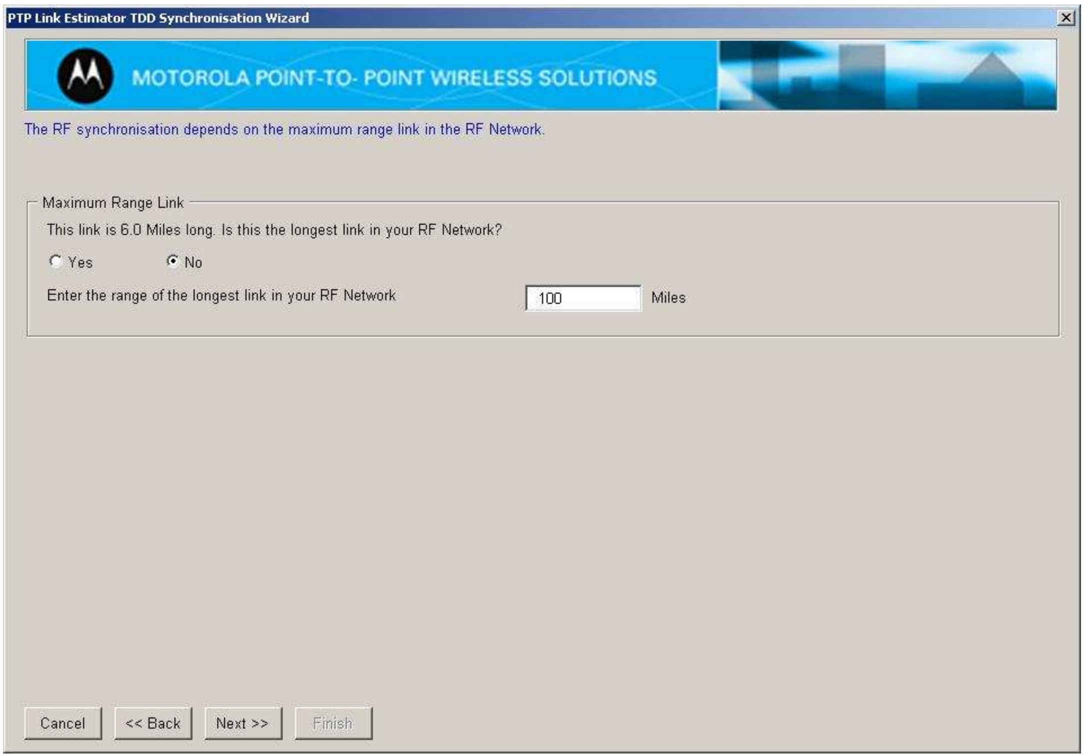

Figure 23 – TDD Synchronisation Wizard - Page 4 – Maximum Range Link

6.3.5 TDD Wizard Page 5 – Slave to Slave Interference

This page is used to enter information about slave units that are able to interfere with one another. In many cases the slave units will not interfere because of obstructions such as hills or buildings, or because they are not in the beam width of the antenna. The pictures on this page give some examples where interference is and is not possible. Where interference is possible, the longest distance between interfering units should be entered.

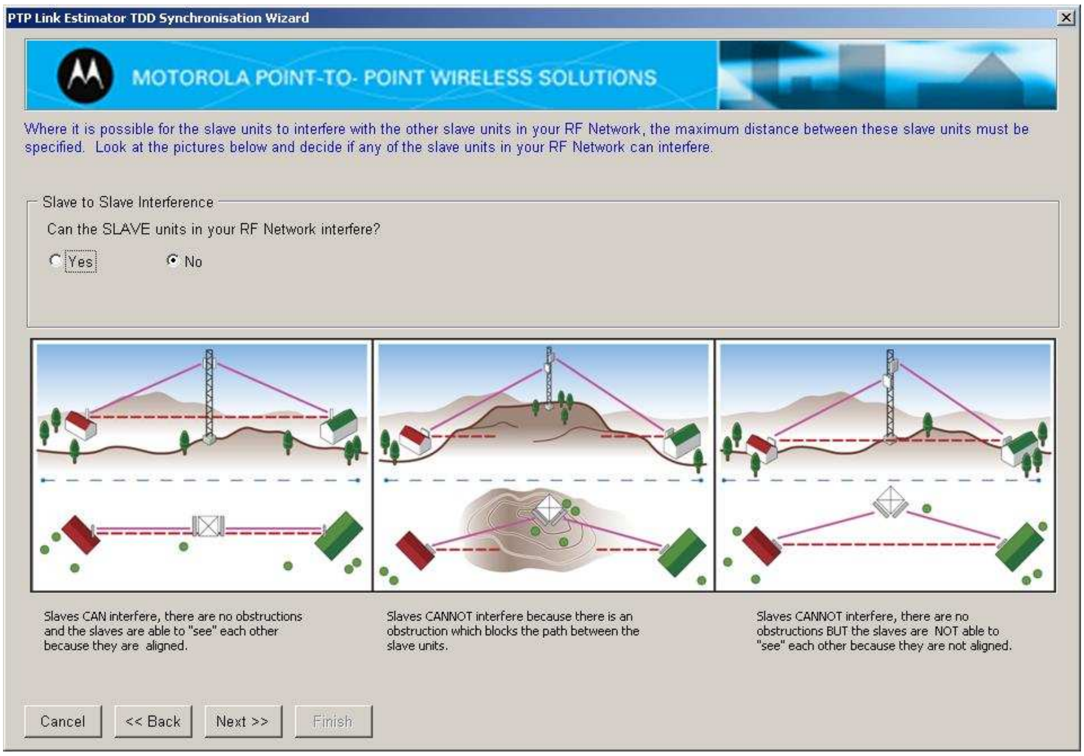

Figure 24 – TDD Synchronisation Wizard - Page 5 – Slaves Interfere

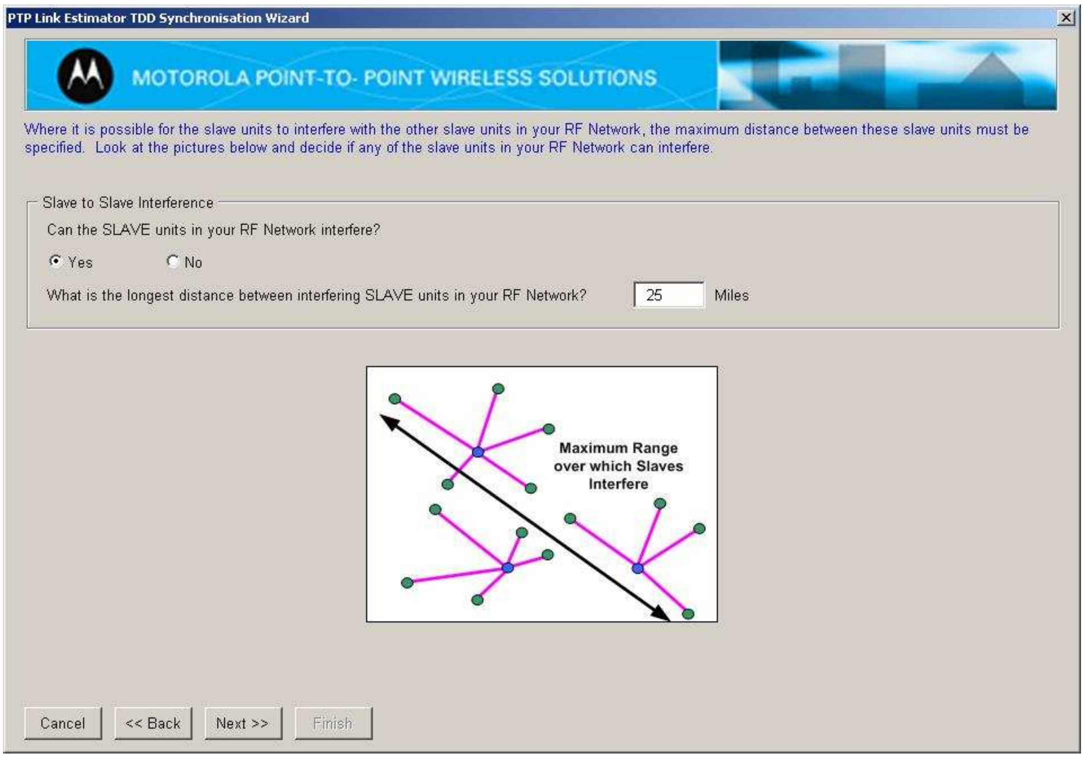

Figure 25 – TDD Synchronisation Wizard - Page 5 – Slave Range entry

6.3.6 TDD Wizard Page 6 – Master to Master Interference

This is only relevant for the Multiple Star and Distributed RF Network topologies.

This page is used to enter information about master units that are able to interfere with one another. In many cases the master units will not interfere because of obstructions such as hills or buildings, or because they are not beam width of the antenna. The pictures on this page give some examples where interference is and is not possible. Where interference is possible, the longest distance between interfering units should be entered.

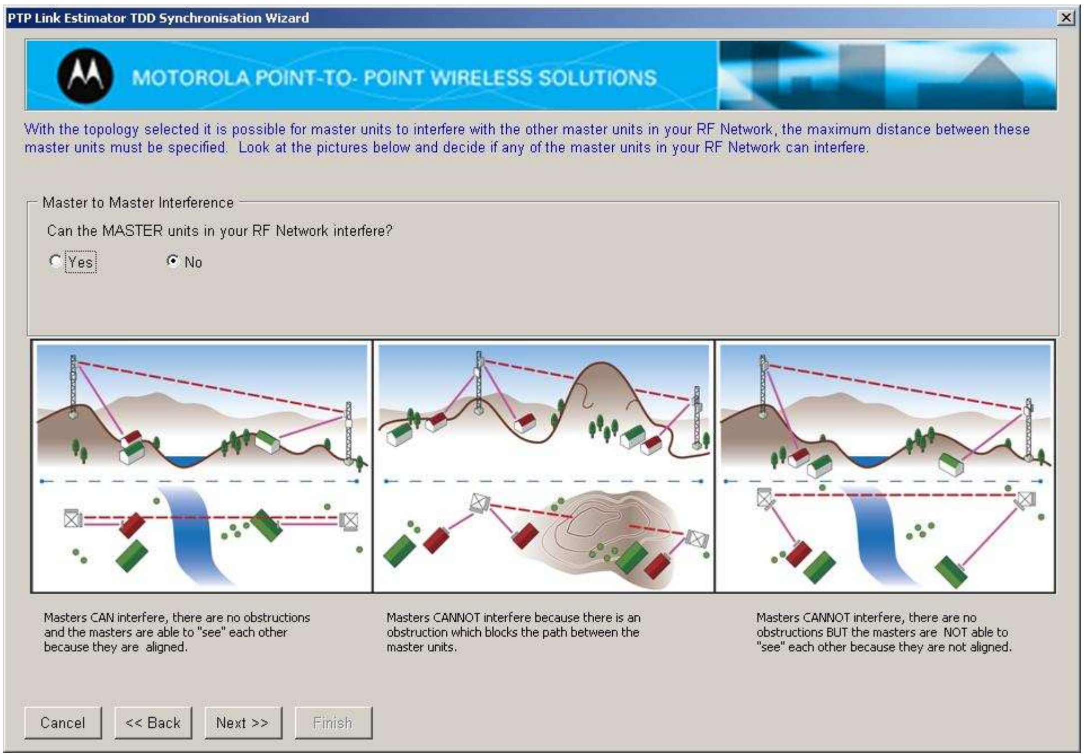

Figure 26 – TDD Synchronisation Wizard - Page 6 – Masters Interfere

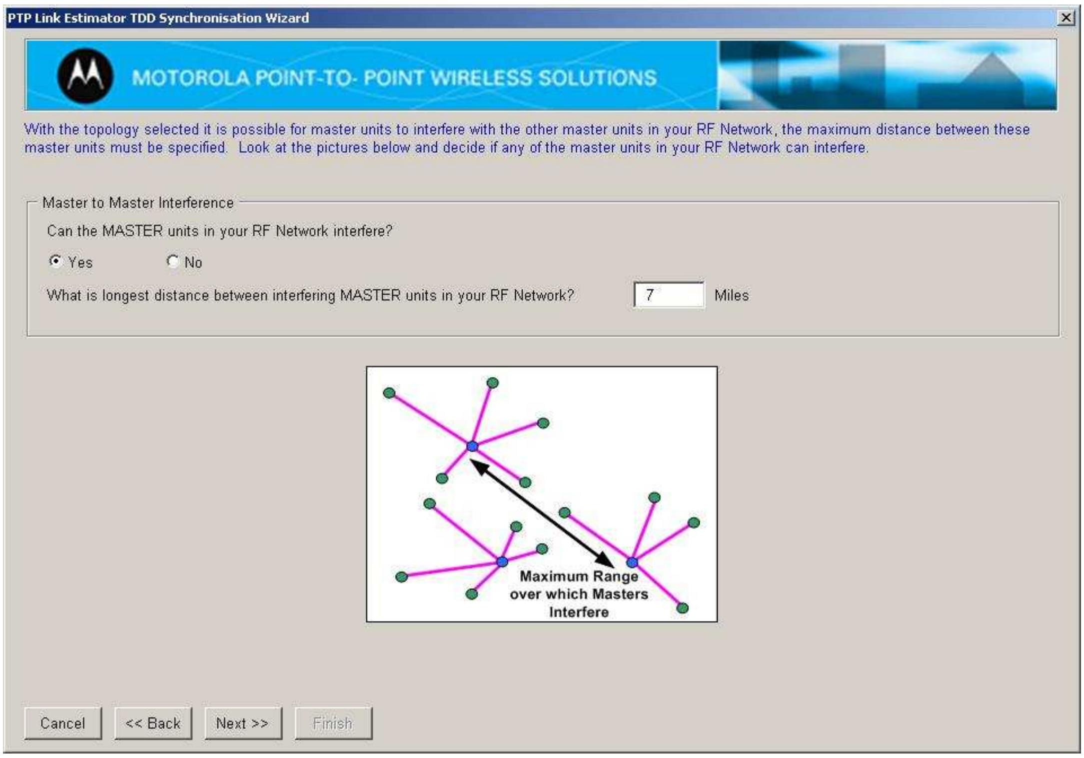

Figure 27 – TDD Synchronisation Wizard - Page 6 – Master Range entry

6.3.7 TDD Wizard Page 7 – Manual Range Entry

This is only relevant for the Multiple Star and Distributed RF Network topologies.

If you are willing to enter the range of every link in the RF Network during each individual installation, then further optimisations are possible.

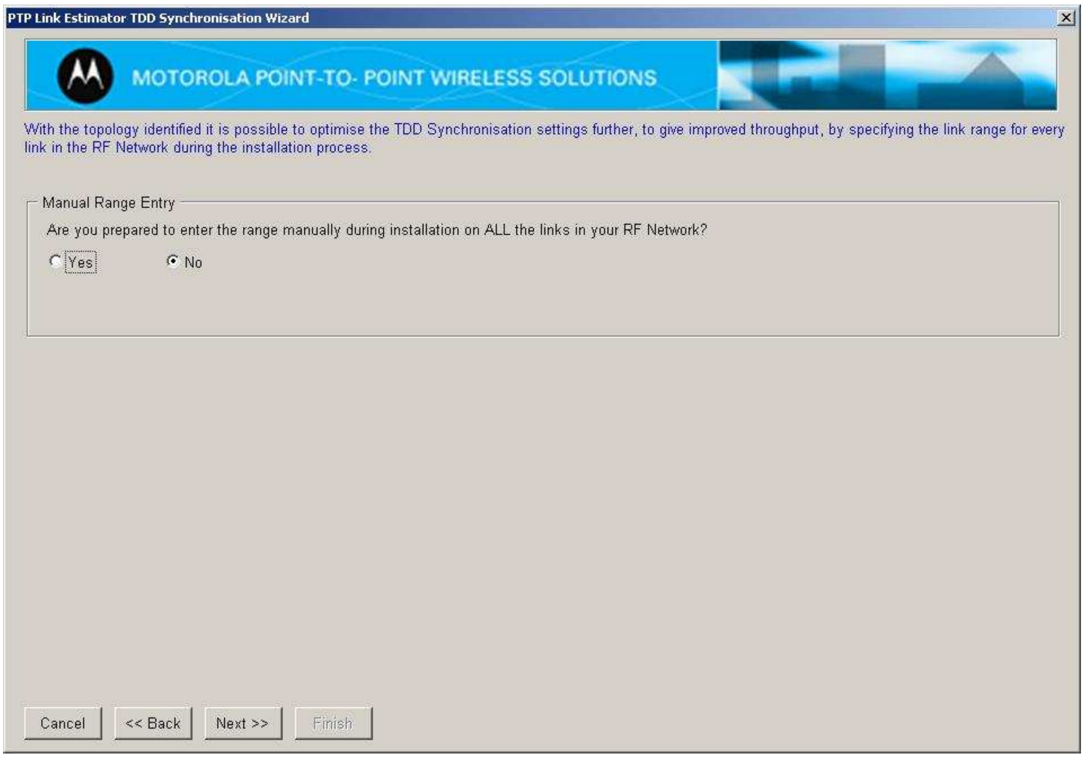

Figure 28 – TDD Synchronisation Wizard - Page 7 – Manual Range Entry

6.3.8 TDD Wizard Page 8 – Summary

This page gives a summary of the information entered and the resultant TDD parameters. Enabling TDD synchronisation reduces the data rate available on the radio link. Where TDM (E1/T1) channels have been selected in the Link Wizard, this reduction in data rate is checked to make sure the TDM channels can still be supported.

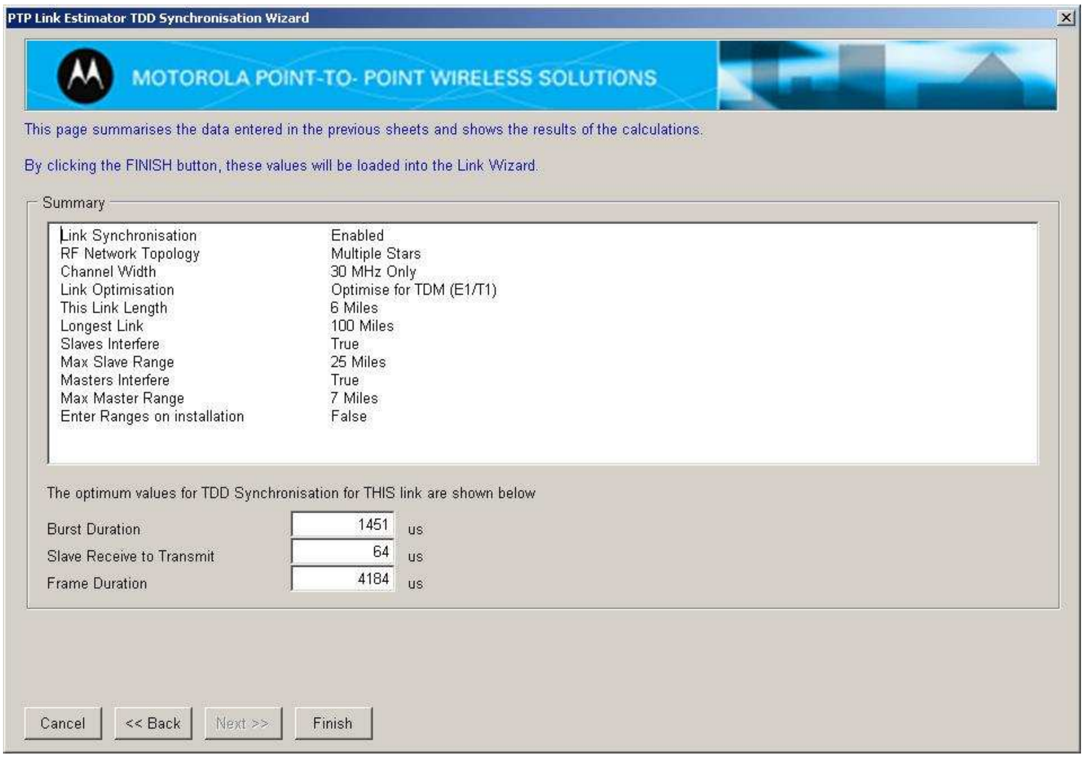

Figure 29 – TDD Synchronisation Wizard - Page 8 - Summary

6.3.9 TDD Synchronisation Example

Figure 30 shows an example RF Network topology with six links arranged as multiple stars. It is possible for the master units to interfere so it is desirable to synchronise this RF Network. The range will be entered into each link at installation.

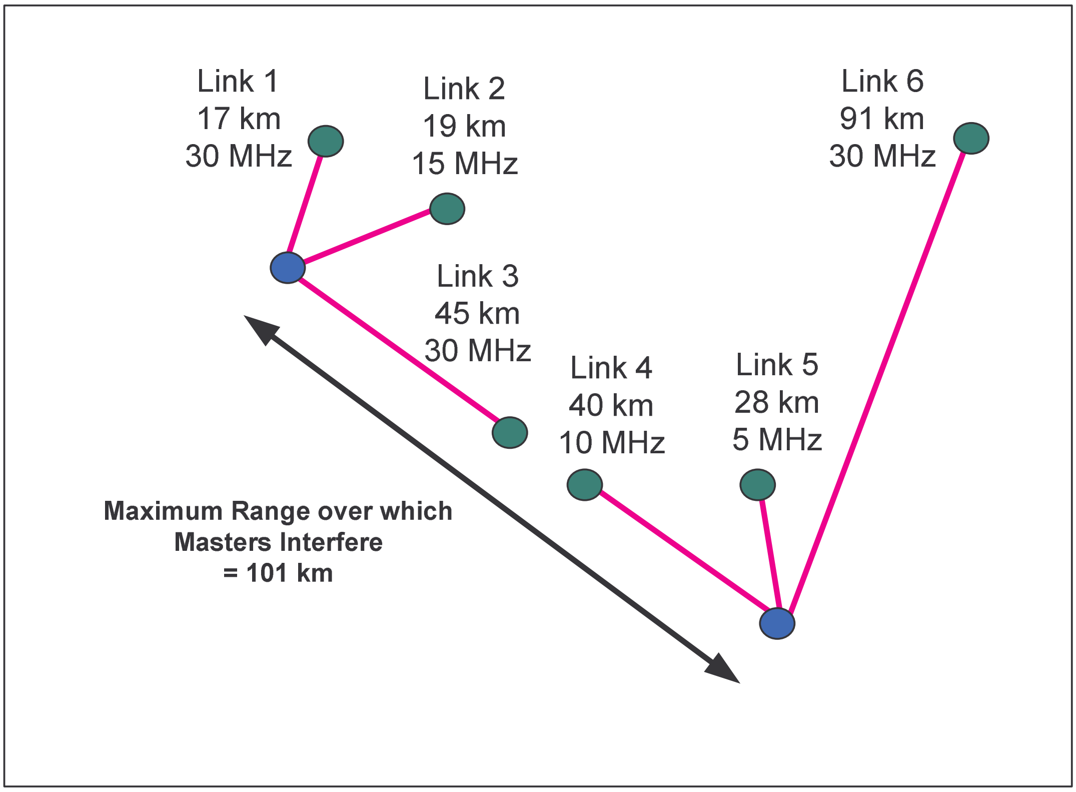

Figure 30 – TDD Synchronisation Wizard Example RF Network

Each individual link needs to be planned to arrive at the correct TDD Synchronisation parameters.

- Start the Link Wizard and enter the path length (17km) and channel width (30MHz) for Link 1.
- On the TDD Synchronisation page, enable TDD Synchronisation and start the TDD Synchronisation wizard.
- On the first page answer “Yes”, press “Next”.
- Select the topology. In this case the topology is Multiple Stars. Press “Next”.
- The network has links with three different channel width, 30MHz, 10MHz & 5MHz. Select the middle radio button and press “Next”.

- This page automatically loads the length of this link. This is not the longest link in the RF Network, so select “No” and enter the maximum link length which is 91 km. Press “Next”.
- In this topology the slaves do not interfere so press “Next”.
- In this topology the masters do interfere. Select “Yes” and enter the range over which the masters interfere, 101km. Press “Next”.
- The installer has indicated that the range will be entered manually on every link in the RF Network so select “Yes” and press “Next”.

The summary sheet should be displayed as shown in Figure 31. Repeat this process for each link in turn. The results of the fully planned RF Network are shown in Table 4.

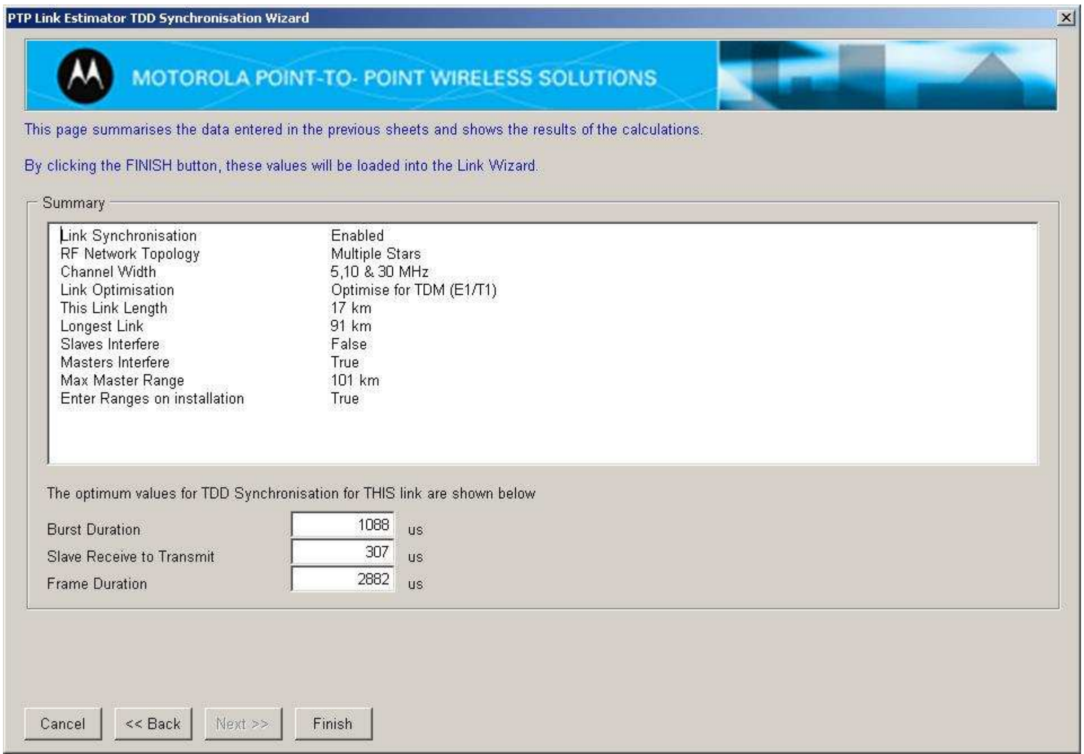

Figure 31 – TDD Synchronisation Wizard Example Summary

Link	Burst Duration (us)	Slave Gap (us)	Frame Duration (us)
1	1088	307	2882
2	1088	300	2882
3	1088	213	2882
4	1088	230	2882
5	1088	270	2882
6	1088	60	2882

Table 4 – TDD Synchronisation Example Parameter Results

6.4 Main Screen (Data Entry)

Figure 32 shows the main PTP Link Estimator screen. The main screen supports an advanced display mode as shown in Figure 33 - Main Screen (Advanced Mode), available from the Utilities menu. A description of each section of the screen follows.

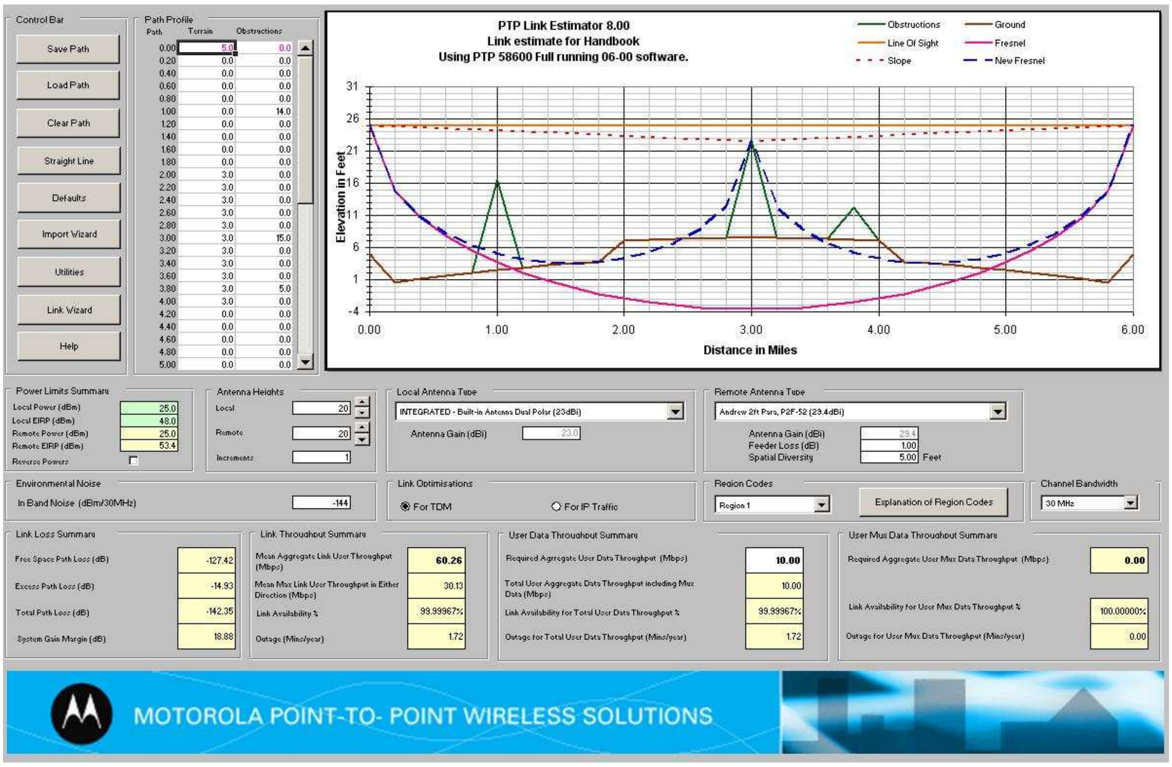

Figure 32 - Main Screen

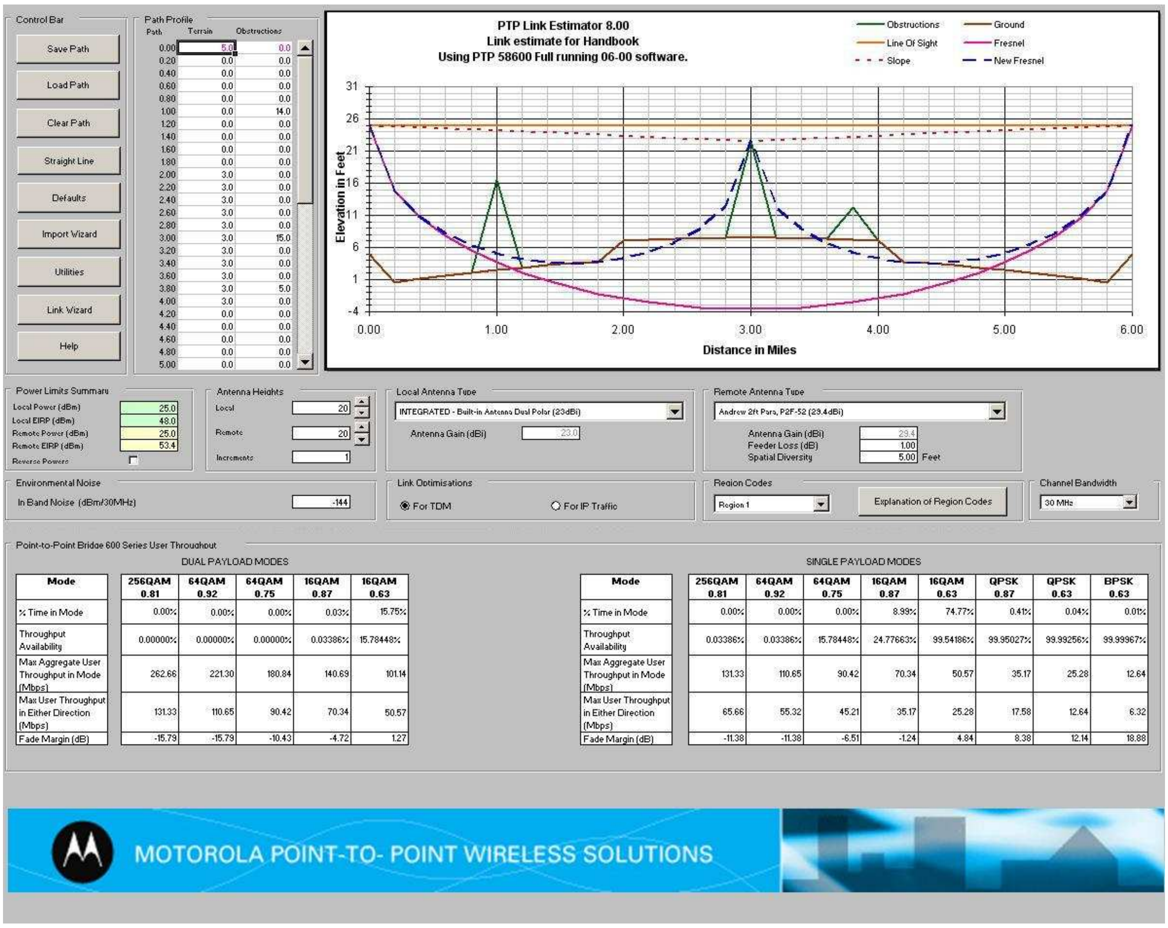

Figure 33 - Main Screen (Advanced Mode)

6.5 Path Visualization

The “Path Visualization” (Figure 34) shows a path of length 6 miles (9.6 km). The largest obstruction is shown at 3 miles (4.8 km) and the smaller obstructions are shown at 1 and 3.8 miles (1.6 and 6.1 km). The terrain is shown in brown and the obstructions are in green. The orange solid line shows the line of sight between antennas. The red dashed line (called slope) shows the line of sight to the largest obstruction. The pink solid line shows the lower Fresnel Zone (n = 0.5) for the main path and the blue dashed lines show the sub paths. As can be seen by the curvature of the brown line 4/3 Earth has been taken account. The display also shows the name of the path, the height units and the distance units.

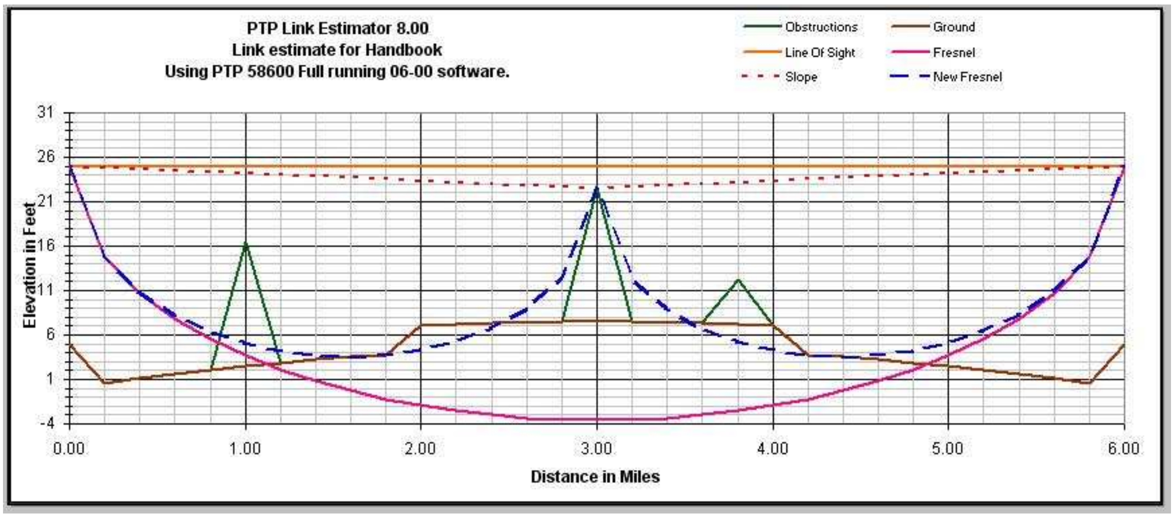

Figure 34 - Path Visualization

The tool uses the methods of ITU P-526-7 (Deygout method) to calculate the excess path loss. This procedure searches for the major obstruction at 3 miles (4.8 km) which obscures the link by the largest amount, i.e. the greatest percentage of Fresnel zone. It then takes the link in two parts and finds the greatest obstructions from one end to the major obstruction and from the major obstruction to the other end. As can be seen in Figure 35 this particular link gives an excess path loss of 14.93 dB

The main obstruction obscures nearly 50% of the Fresnel zone. The two secondary obstructions obscure about 25% of the secondary Fresnel zones. If there are no objects obscuring more of the primary or secondary zones then sufficient modelling has been achieved.

The tool is unlikely to give very accurate results due to the difficulty of obtaining accurate data. Even with accurate data the losses over certain objects depends upon the curvature of the top of those objects. Nevertheless the tool gives a good idea of the performance to be expected, and doing what/if analysis gives an inexperienced person a good feel for what Motorola means by non-line-of-sight.

A further use of the tool is in predicting the fade margin required. Do not use these figures for other equipment which do not have fade mitigation techniques built in.

Simple adjustment of the antenna heights enables an assessment of the height required at each end of the link.

6.6 Link Loss Summary

This summary (Figure 35) highlights the Free Space Path Loss component and the Excess Path Loss based upon the diffraction loss over the obstacles that cut the Fresnel zone number 0.5. The Total Path Loss and System Gain Margin is also given.

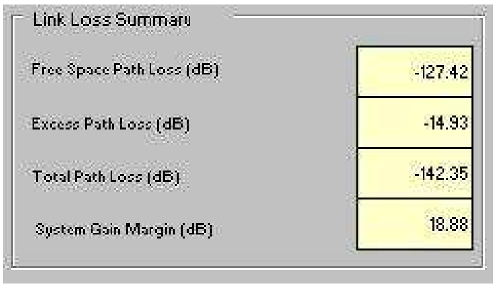

Figure 35 - Link Loss Summary Information

The link losses displayed here take into account "Worst Case Analysis" as described in section 6.14.

6.7 Link Throughput Summary

This summary (Figure 36) shows the mean aggregate link throughput that should be achieved, the radio availability for the most robust modulation mode and the corresponding outage in minutes per year.

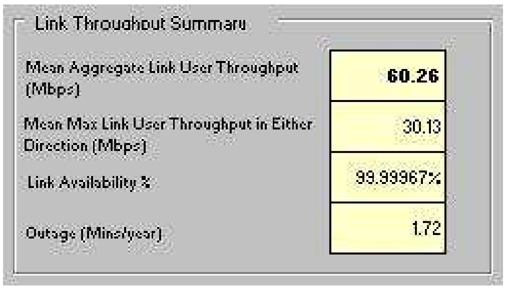

Figure 36 - Link Throughput Summary Information

6.8 User Mux Throughput Summary

This summary is used to give an indication of the link availability for the amount of data reserved for TDM traffic. In this case 7.34Mbits/s of data has been reserved for E1/T1 traffic and this has an availability of 99.99990% which equates to an outage of 0.54 minutes per year. For this calculation, TDM traffic is always assumed to be higher priority than user IP traffic. The TDM traffic allocation can only be changed via the Link Wizard.

Figure 37 – User TDM Data Throughput

6.9 User Data Throughput Summary

This summary can be used to confirm the probability that a link will support a target IP data throughput. In this case, the availability of 10Mbits/s of IP data traffic is calculated as 99.99990% with a corresponding outage of 0.54 minutes per year. The IP traffic allocation can be entered directly and allows the user to get a good idea of the real data performance of the link. For this calculation, TDM traffic is always assumed to be higher priority than user IP traffic.

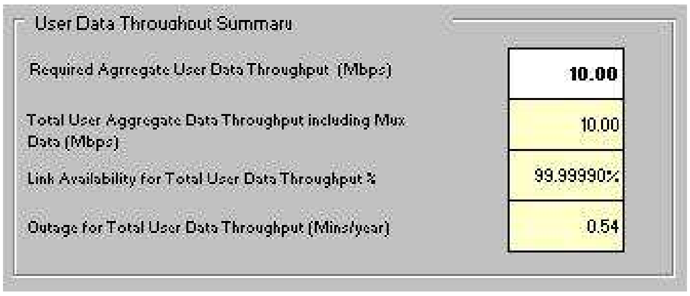

Figure 38 - User IP Data Throughput

6.10 User Throughput Rates (Advanced Mode only)

This area of the screen shows the user data throughput rate for each mode, the time as a percentage spent in each mode, the throughput reliability for each mode and the link margin for that mode. In detail these are:

- ‘Mode’ stated as a modulation,
- ‘% Time in Mode’ is the percentage of time spent in that mode and not in any other mode,
- ‘Throughput Availability’ is the percentage of time that the data throughput rates shown for each will be available
- ‘Max Aggregate User Throughput in Mode (Mbps)’. These are the user data rates and give the maximum aggregate throughput achievable (sum of both directions). They are automatically adjusted for the range of the link being studied.
- ‘Max User Throughput in Either Direction (Mbps)’. Applies to PTP600 Series bridges only. These give the maximum user throughput achievable in a single direction.
- ‘Fade Margin (dB)’ is the margin available for that mode.

The appearance of these tables is different for PTP400 and PTP600 Series systems.

6.10.1 User Throughput Display for PTP600 Series Links

Point-to-Point Bridge 600 Series User Throughput

DUAL PAYLOAD MODES

Mode	256QAM 0.81	64QAM 0.92	64QAM 0.75	16QAM 0.87	16QAM 0.63
% Time in Mode	0.00%	0.00%	0.00%	0.28%	23.05%
Throughput Availability	0.00000%	0.00000%	0.00000%	0.27908%	23.32521%
Max Aggregate User Throughput in Mode (Mbps)	262.66	221.30	180.84	140.69	101.14
Max User Throughput in Either Direction (Mbps)	131.33	110.65	90.42	70.34	50.57
Fade Margin (dB)	-16.45	-13.55	-8.85	-3.65	3.55

SINGLE PAYLOAD MODES

Mode	256QAM 0.81	64QAM 0.92	64QAM 0.75	16QAM 0.87	16QAM 0.63	QPSK 0.87	QPSK 0.63	BPSK 0.63
% Time in Mode	0.00%	0.00%	0.00%	34.56%	41.98%	0.11%	0.02%	0.00%
Throughput Availability	0.27908%	0.27908%	23.32944%	57.88716%	99.86480%	99.97818%	99.99750%	99.99990%
Max Aggregate User Throughput in Mode (Mbps)	131.33	110.65	90.42	70.34	50.57	35.17	25.28	12.64
Max User Throughput in Either Direction (Mbps)	65.66	55.32	45.21	35.17	25.28	17.58	12.64	6.32
Fade Margin (dB)	-12.05	-9.85	-4.45	0.45	6.65	9.95	14.45	21.45

Figure 39 - PTP600 Series Link User Throughput Information

The display is split into two blocks, the right block giving the throughputs in single payload modes and the left block giving the throughput in dual payload modes. The adaptive modulation scheme in a PTP600 link will always select the mode which gives the maximum data rate.

6.10.2 User Throughput Display for PTP400 Series Links

The format of the display for a PTP400 link will depend on the setting of “Link Symmetry”. When the “Link Symmetry” is set to symmetrical (Section 6.13 “Link Symmetry”) the data rates are as shown in Figure 40, whereas when the “Link Symmetry” is set to asymmetrical the data rates shown for each direction as shown in Figure 41.

Point-to-Point Bridge 400 Series User Throughput

SINGLE PAYLOAD MODES

Mode	64QAM 7/8	64QAM 3/4	64QAM 2/3	16QAM 3/4	16QAM 1/2	QPSK 2/3	QPSK 1/2	BPSK 1/2
% Time in Mode	19.11%	70.63%	9.71%	0.53%	0.01%	0.00%	0.00%	0.00%
Throughput Availability	19.11090%	89.74468%	99.45949%	99.98538%	99.99673%	99.99983%	99.99990%	99.99999%
Max Aggregate User Throughput in Mode (Mbps)	34.68	29.73	26.42	19.82	13.21	8.81	6.61	2.94
Fade Margin (dB)	-0.57	2.24	4.62	10.75	13.88	20.33	21.65	30.79

Figure 40 - PTP400 Series Link User Throughput Information Symmetric Operation

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Point-to-Point Bridge 400 Series User Throughput

SINGLE PAYLOAD MODES

Mode	64QAM 7/8	64QAM 3/4	64QAM 2/3	16QAM 3/4	16QAM 1/2	QPSK 2/3	QPSK 1/2	BPSK 1/2
% Time in Mode	19.11%	70.63%	9.71%	0.53%	0.01%	0.00%	0.00%	0.00%
Throughput Availability	19.11090%	89.74468%	99.45949%	99.98538%	99.99673%	99.99983%	99.99990%	99.99999%
Max Aggregate User Throughput in Mode(Mbps)	37.74	32.35	28.75	21.56	14.38	9.58	7.19	3.19
User Throughput in Mode Local to Remote(Mbps)	25.16	21.56	19.16	14.37	9.59	6.39	4.79	2.13
User Throughput in Mode Remote to Local(Mbps)	12.58	10.79	9.59	7.19	4.79	3.19	2.40	1.06
Fade Margin (dB)	-0.57	2.24	4.62	10.75	13.88	20.33	21.65	30.79

Figure 41 - PTP400 Series Link User Throughput Information Asymmetric Operation

6.11 Control Bar

The control bar contains the main data management buttons (Figure 42).

Figure 42 - Control Bar

The following Shortcut keys are supported:

- F1 Help
- CTRL-Q Straight Line
- CTRL-W Link Wizard
- CTRL-S Save Path Profile
- CTRL-I Import Wizard
- CTRL-D Default
- CTRL-R Clear Path Data
- CTRL-U Utilities
- CTRL-O Run Report

6.11.1 Save Path and Load Path

The “Save Path” and “Load Path” buttons are used to Save and Load path data to disk. After pressing one of these buttons you will be presented with your operating systems standard folder/file navigation tool.

6.11.2 Clear Path

The “Clear Path” button will clear your path data. All other data will stay intact.

6.11.3 Straight Line

When entering a long path, needing many points, the straight line feature can be useful. If a group of terrain cells are selected pressing the “Straight Line” button will adjust the points between to form a straight line. You will need to select at least three points on the path to draw a straight line (Figure 43).

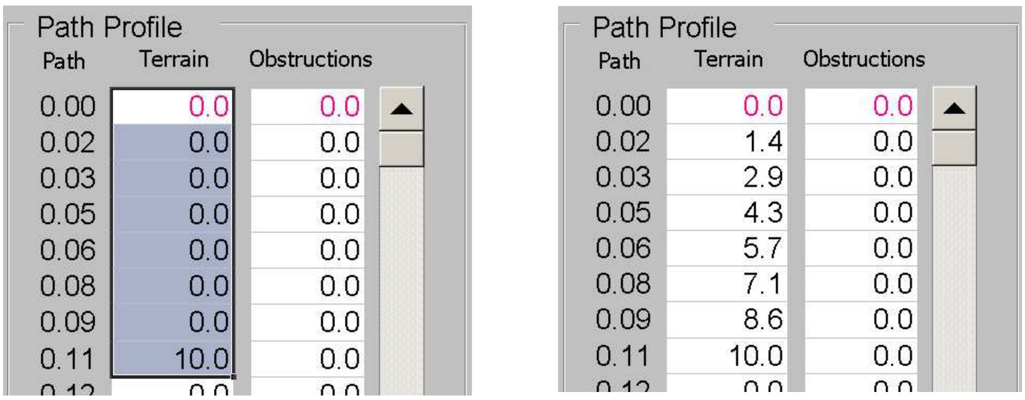

Figure 43 - Straight Line Drawing Example

6.11.4 Defaults

The “Defaults” button will return the PTP Link Estimator to the factory defaults state (i.e. the state when the PTP Link Estimator is first opened).

6.11.5 Import Wizard

The “Import Wizard” (Figure 44) provides a facility to import path profiles produced by other tools or in Motorola format.

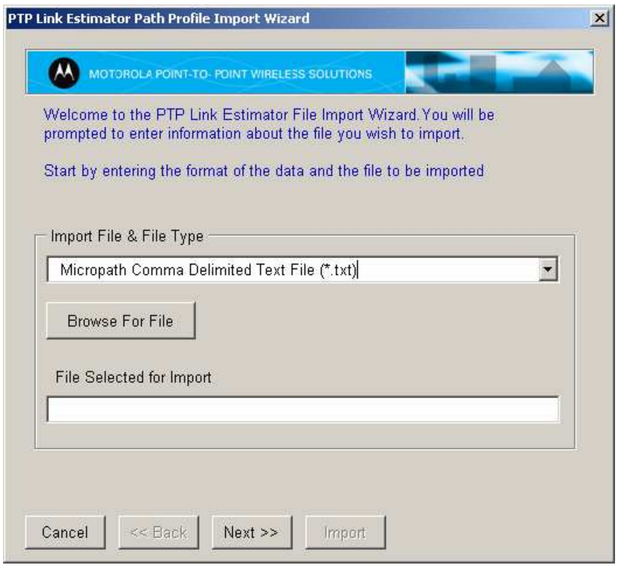

Figure 44 - Path Import Wizard - Page 1

The following file formats are supported:

- Motorola Hydra Path File (*.pth)
- Micropath Comma Delimited File (*.txt)
- Comma Delimited File (Length Height Obstruction) (*.csv)
- ATDI ICS Telecom Comma Delimited Text File (*.txt)
- Softwright TAP 4.3 (*.txt)
- Radio Mobile for Windows (*.txt)
- Pathloss Export (*.txt)

Example files are provided as part of the PTP Link Estimator package. The formats of these files are shown in section 8 ”Import File Formats”. The import wizard has three pages for format and file selection (Figure 44), unit entry (Figure 45) and link name (Figure 46).

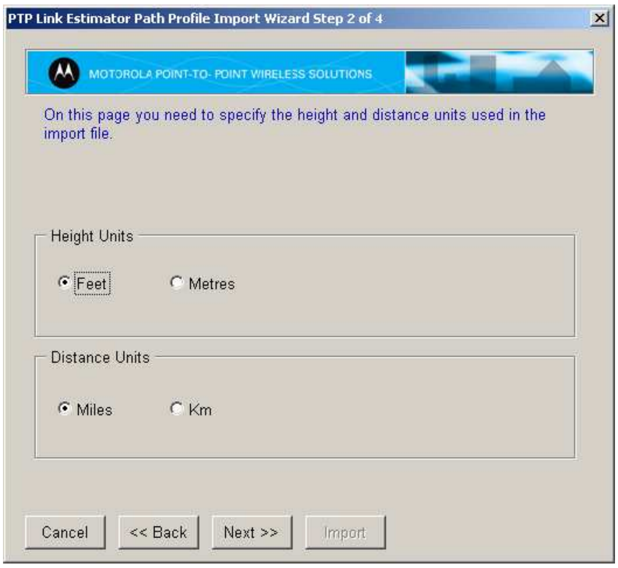

Figure 45 - Path Import Wizard - Page 2

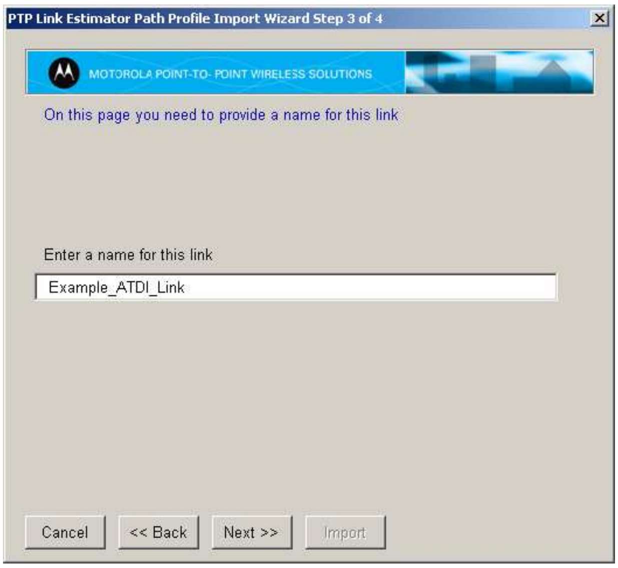

Figure 46 - Path Import Wizard - Page 3

The final page (Figure 47) has a summary of the selections made and data is imported by pressing the import button. All previous path information will be lost once import starts.

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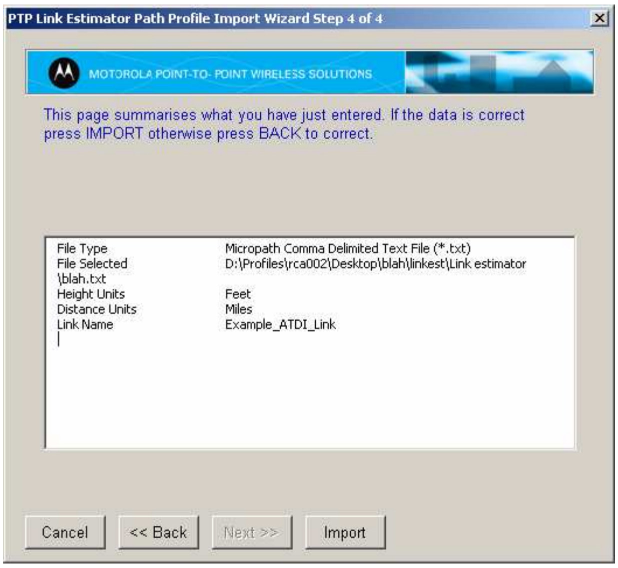


Figure 47 - Path Import Wizard - Page 4

6.11.6 Utilities

Pressing the "Utilities" button brings up the utilities button box (Figure 48).

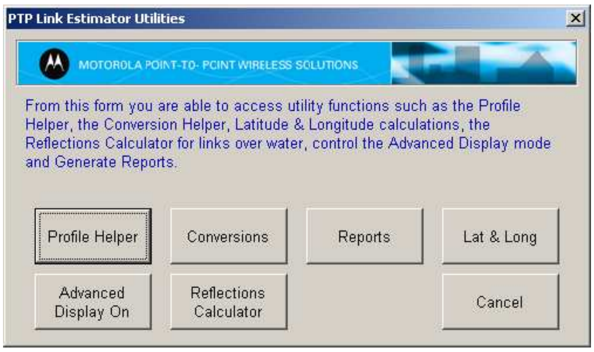


Figure 48 - Utilities Button Box

6.11.6.1 Profile Helper

Pressing the "Profile Helper" button will take you to the "Profile Helper" tab described in section 6.12.2 "Path Profile Helper".

6.11.6.2 Conversions

Pressing the "Conversions" button will pop up a conversion screen (Figure 49) giving you utilities to convert availability/outage, distance, height and power.

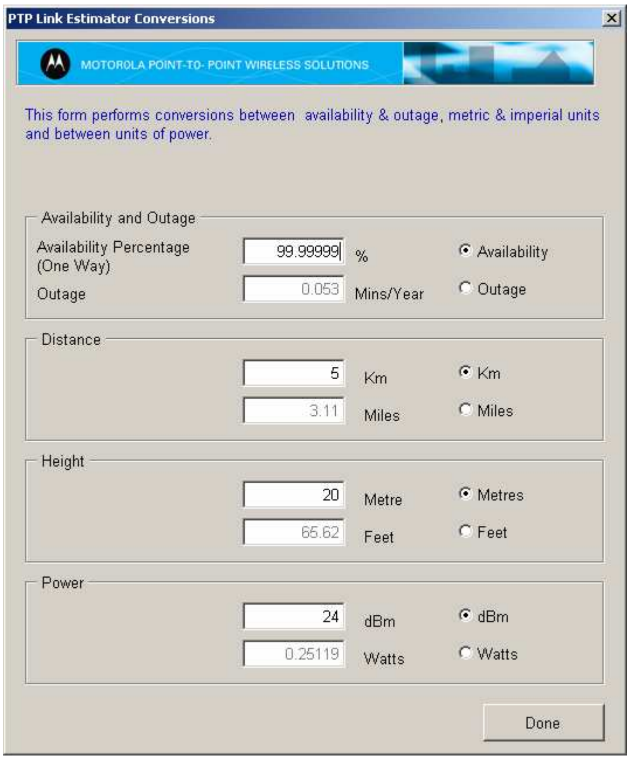


Figure 49 - Conversion Screen

6.11.6.3 Reports

Pressing the “Report” button starts the report generator screen (Figure 50). The report generator is used to produce reports in HTML format. An example HTML report is shown in section 9 “Example HTML Report”.

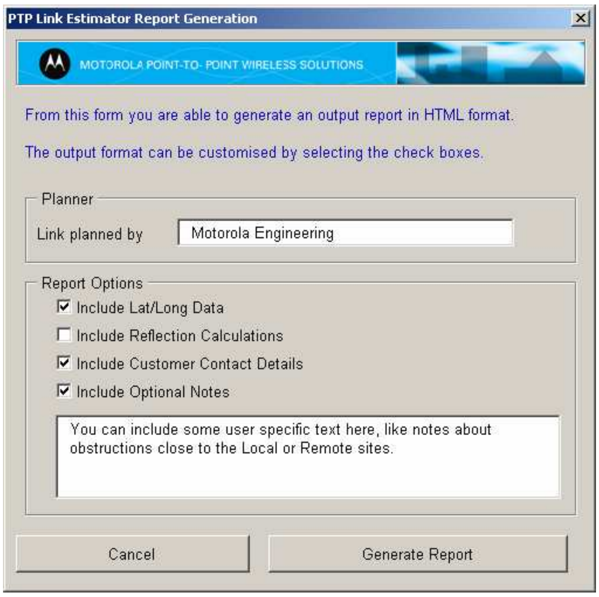


Figure 50 - Report Generator Screen

6.11.6.4 Lat and Long

Assistance with installation and survey can be achieved by using the 'Lat & Long' button. This screen enables input of the latitude and longitude of the two locations and it returns the range and direction for each end of the link. The Latitude and Longitude may be entered in a number of common methods.

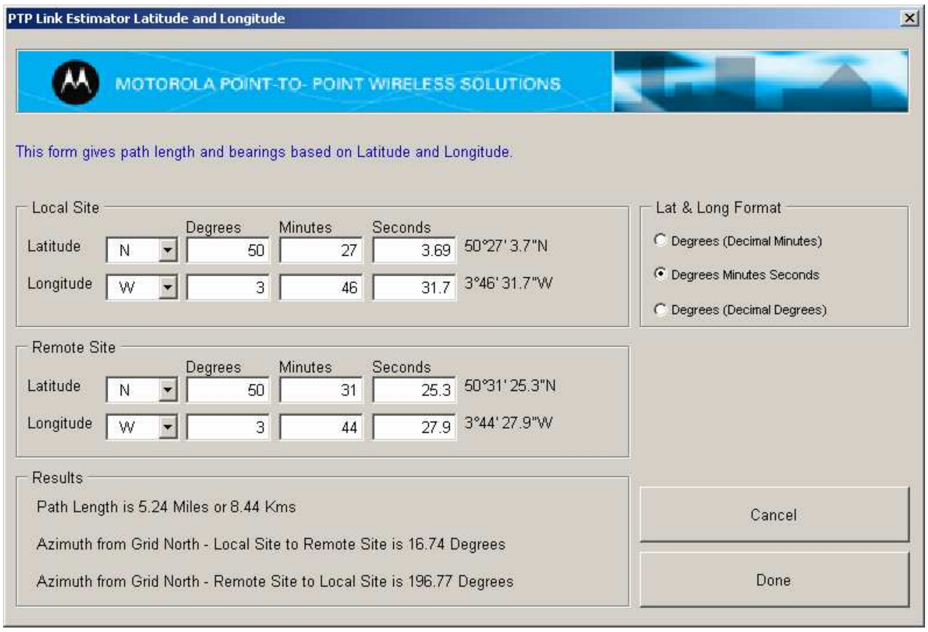
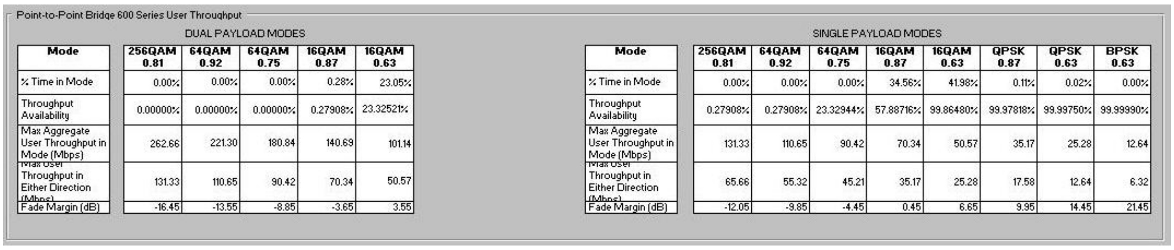


Figure 51 - Latitude and Longitude Conversion Page

6.11.6.5 Advanced Display On

The advanced display on button causes the main screen to insert an additional pane at the bottom of the main screen. The pane gives a detailed breakdown of the link performance is a combination of single, dual payload and modulation mode depth. See Figure 52. Advanced display also enables the Worst Case analysis controls.



Point-to-Point Bridge 600 Series User Throughput

DUAL PAYLOAD MODES

Mode	256QAM 0.81	64QAM 0.92	64QAM 0.75	16QAM 0.87	16QAM 0.63
% Time in Mode	0.00%	0.00%	0.00%	0.28%	23.05%
Throughput Availability	0.00000%	0.00000%	0.00000%	0.27908%	23.32521%
Max Aggregate User Throughput in Mode (Mbps)	262.66	221.30	180.84	140.69	101.14
Max User Throughput in Either Direction (Mbps)	131.33	110.65	90.42	70.34	50.57
Fade Margin (dB)	-16.45	-13.55	-8.85	-3.65	3.55

SINGLE PAYLOAD MODES

Mode	256QAM 0.81	64QAM 0.92	64QAM 0.75	16QAM 0.87	16QAM 0.63	QPSK 0.87	QPSK 0.63	BPSK 0.63
% Time in Mode	0.00%	0.00%	0.00%	34.56%	41.98%	0.11%	0.02%	0.00%
Throughput Availability	0.27908%	0.27908%	23.32944%	57.88716%	99.86480%	99.97818%	99.99750%	99.99990%
Max Aggregate User Throughput in Mode (Mbps)	131.33	110.65	90.42	70.34	50.57	35.17	25.28	12.64
Max User Throughput in Either Direction (Mbps)	65.66	55.32	45.21	35.17	25.28	17.58	12.64	6.32
Fade Margin (dB)	-12.05	-9.85	-4.45	0.45	6.65	9.95	14.45	21.45

Figure 52 - Detailed User Throughput

6.11.6.6 Reflections Calculator

This button will start the Reflections Calculator, which can be used to determine how much vertical antenna spacing is required to overcome fading associated with reflective terrains such as water. For more details refer to section 6.18.

6.11.7 Link Wizard

Pressing the “Link Wizard” button will start the link set-up wizard described in section 6.2 “Link Wizard”.

6.11.8 Help

Pressing the “Help” button will display this document in PDF form.

6.11.9 Environmental Noise

The environmental noise is the amount of in-band site noise in the 30 MHz channel bandwidth for a PTP600 Series bridge and 10 MHz channel bandwidth for a PTP400 Series bridge, expected at the antenna connector. This noise is assumed to be a constant power added to the thermal noise of the front end of the wireless.

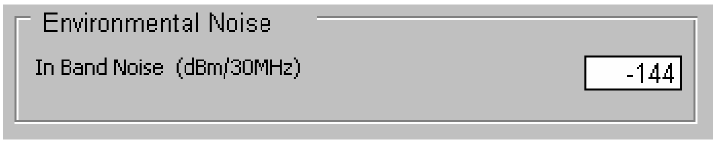


Figure 53 - Environmental Noise

6.11.10 Link Optimizations

This feature is operates differently for PTP400 Series and PTP600 Series links.

The PTP600 Series optimizations allow the user to select between the TDM (E1/T1) mode in which the traffic is always symmetrical or the IP (Ethernet) mode, where the traffic symmetry varies according to load.

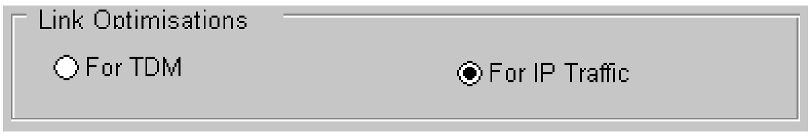


Figure 54 - Link Optimization for PTP600

The PTP400 Series optimizations allow the user to select between the low latency mode or high throughput modes. PTP400 Series systems allow the user to trade off Packet Latency[5] against Ethernet throughput.

[5] It should be noted that low latency mode is only supported on symmetric wireless links.

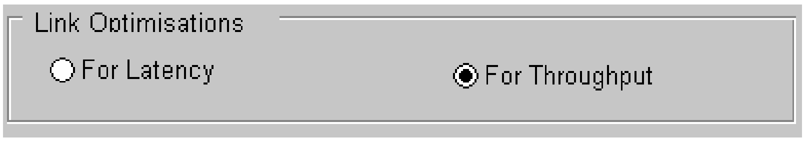


Figure 55 - Link Optimization for PTP400

6.12 Path Profile

6.12.1 Path Profile Main Screen

In this area (Figure 56) the detailed path characteristics are entered. Changes can be seen on the path visualization, where the terrain is identified in brown and obstructions are identified in green. If the scroll bar is present then it enables movement to a different area of the profile.

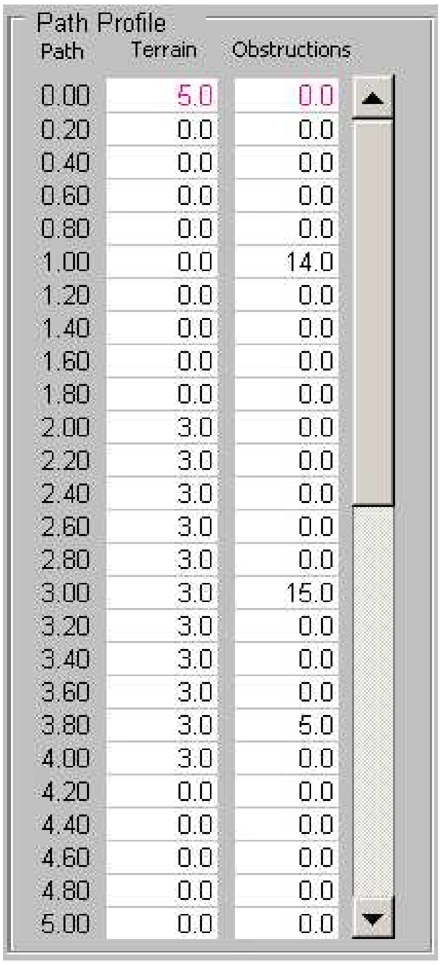


Figure 56 - Path Profile Entry

6.12.2 Path Profile Helper

The "Profile Helper" (Figure 57) is intended to be an aid for the generation of profiles when a list of data is available, particularly if it can be pasted from a text file.

The “Profile Helper” is particularly useful when managing the data from very long paths.

The “Profile Helper” is accessed by selecting the appropriate tab at the bottom of the screen or by pressing the “Profile Helper” button on the “Utilities” page.

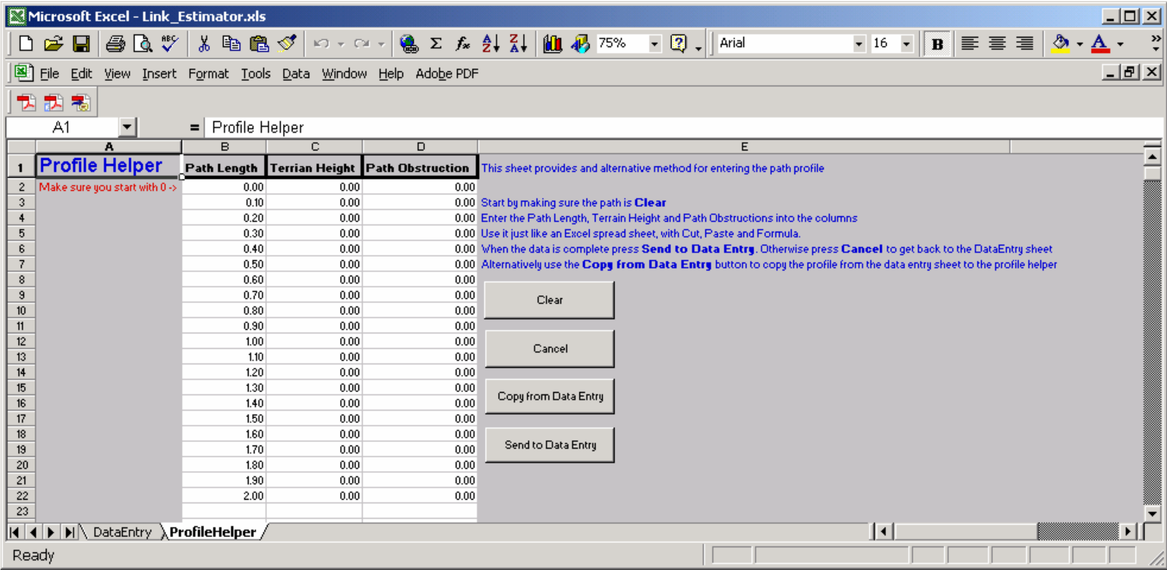


Figure 57 - Path Profile Helper

This worksheet has four buttons:

- “Clear” this causes all data in the profile helper to be cleared.
- “Cancel” that takes you back to the “Data Entry” sheet.
- “Copy from Data Entry” which transfers the profile from the “Data Entry” sheet to the Profile Helper.
- “Send to Data Entry” sends the current path “Data Entry” sheet to the “Profile Helper”.

To use the helper, paste or type a path profile into the three columns for Path Position, Terrain Height and Path Obstruction, remembering to start the path at a path position of 0. The important features of the path profile are the high points; however ensure that if you only insert the high points accurately there are some appropriate low points between the high points. The path position does not need to increment linearly but may give an odd looking picture on the path visualization.

6.13 Link Symmetry

In this area the link can be selected as 1:1 or 2:1, this represents the data throughput in each direction.

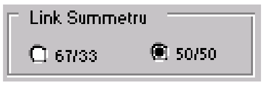


Figure 58 - Link Symmetry Selection

This mode is only available for PTP400 Series links. Symmetry selection for PTP600 Series links is automatic when in IP mode.

6.14 Worst Case Analysis (Advanced Mode only)

In this area the Worst Month results can be selected for display. In the ITU-R P.530-10 standard the propagation reliability varies dependent upon the time of the year. Many operators will want to design the link for the worst month rather than the year. When “Worst Month” is selected the “Data Rate Summary” (Figure 58) displays the availability and outage for the Worst Month. This is highlighted by a change in cell color and a change of legend to Mins/month.

Variations in atmospheric refractive conditions cause changes in the effective Earth’s radius from its median value of approximately 4/3 for a standard atmosphere (see Recommendation ITU-R P.310). When the atmosphere is sufficiently sub-refractive, the radio path will be bent in such a way that the Earth appears to obstruct the direct path between transmitter and receiver, giving rise to the kind of fading called diffraction fading. This fading is the factor that determines the antenna heights. By selecting “Worst Earth” the link estimator will change the value of the earths curvature to a value that occurs 0.1% of the time. The value used for the earths curvature varies with range. It is not necessary to check this on short links but with long links it can become critical. On long links “Worst Earth” should be selected to ensure that the 0.1% value of the earth’s curvature does not completely block the link. When “Worst Earth” is selected the summary reliability numbers in the “Data Rate Summary” area are blanked as they are not relevant for 0.1% of the time.

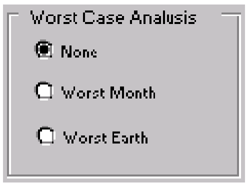


Figure 59 - Worst Case Analysis Selection

6.15 Power Limits Summary

The “Power Limits Summary” (Figure 60) gives the selected power outputs and EIRP for each end of the link. By default the local site power is used to determine the data rate and reliability of the link where the local and remote powers are the same. The power and EIRP setting cannot be adjusted here and can only be changed using the ‘Link Wizard’. If the antenna gains are different and the regulatory regime is for a maximum EIRP (hence different Tx powers) then it will be necessary to know the data rate and reliability of the link in each direction. This can be done by checking the ‘Reverse Powers’ check box which changes the direction being analysed. The direction is shown highlighted in green. (If the Local and Remote Power are the same, changing this will have no effect.)

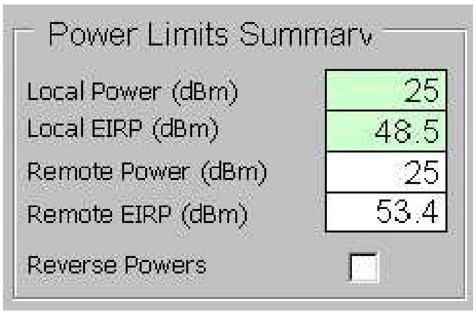


Figure 60 - Power Limit Summary Information

Note: Link estimates are made on the lower of the calculated power or 25 dBm. For example if the user enters an EIRP limit in the “Link Wizard” of 53dBm (New Zealand), using integrated antennas. This equates to a unit output power of 29.5dBm. In this case the “Power Limit Summary” will display a unit power level of 29.5 dBm and EIRP level of 53 dBm. However the PTP Link Estimator will use 25 dBm (this is indicated in the report output). If the user then selects an Andrew 6ft Parabolic, P6F-52 (37.6dBi) antenna, the power output from the unit drops to 16.4dBm, and in this case the estimates are made at 16.4dBm.

6.16 Antenna Heights

The antenna height can be adjusted at each end of the link to see the effect upon the average data rate, minimum data rate and outage. The values can be adjusted using the up and down arrows or by entering a value (Figure 61). The step size for the up and down arrows can be adjusted by entering a value in the height increments boxes.

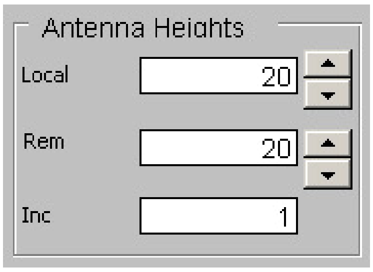


Figure 61- Antenna Height Adjustment

6.17 Local and Remote Antenna Type

This provides a facility to evaluate different antennas for each end of the link (Figure 62). From the drop down boxes, different antennas may be selected for the local and remote sites from an approved list[6]. If an external antenna is selected, the Feeder Loss is displayed; if the external antenna is single polar then Spatial Diversity is displayed. The feeder loss can be adjusted directly on the Data Entry sheet, or alternatively it can be adjusted using the 'Link Wizard', where the feeder type and length can be entered for automatic calculation of the loss, see figure 10. The Spatial Diversity can be entered as a value or zero (no space diversity), the estimator implements ITU-R P.530-10 for the improvement in reliability obtained.

Figure 62 - Antenna Type Selection

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[6] For countries that follow FCC approval.

The ability to investigate the antenna gain required is enabled as well as making a selection of an antenna from the approved list. The feeder type and length can also be entered. This must be done using the “Link Wizard” described in section 6.2 ”Link Wizard”.

6.18 Reflections Calculator

6.18.1 Techniques for Alleviating the Effects of Multipath Propagation

In Line-of-Sight links, reflections from water or very flat pieces of land can be a problem. This is because the reflection can be of the same magnitude as the direct signal and sometimes arrive in inverse phase to the direct signal such that when the two add together, they sum to zero.

At first sight, in a fixed location, one would imagine the reflection would be fixed in phase relative to the direct signal. Unfortunately on long links this is not the case. There are two methods of mitigating the problem;

1. Using an obstacle to ensure that the reflection is not seen, or
2. Using the diversity built into the PTP400 and PTP600 Series Bridges to ensure that the signal never decreases significantly from this cause.

It is obviously important to know when mitigation is required, the following is a guide;

1. If most of the path is over water and the antenna at each end of the link can see the water and the angle of incidence to the water is less than 5 degrees, or
2. If the link is over very flat land with no obstructions, desert regions sometimes exhibit this property.

It is important to inspect the geometry bearing in mind the size of the Fresnel zone and the amplification of the vertical scale using the path visualisation.

6.18.2 Shielding of the Reflection Point (Reproduced from ITU-R P.530)

One technique is to use the advantage of hills, mountains or buildings along the path to shield the antennas from the more specularly-reflective[7] surfaces along the path (e.g. water surfaces, plains, smooth hilltops not covered by trees, building tops) as shown in Figure 63. Ideally, hills or mountains should be covered in vegetation to further reduce the level of the field diffracted over them. Of course, shielding of reflective surfaces is more readily possible when path clearance is reduced.

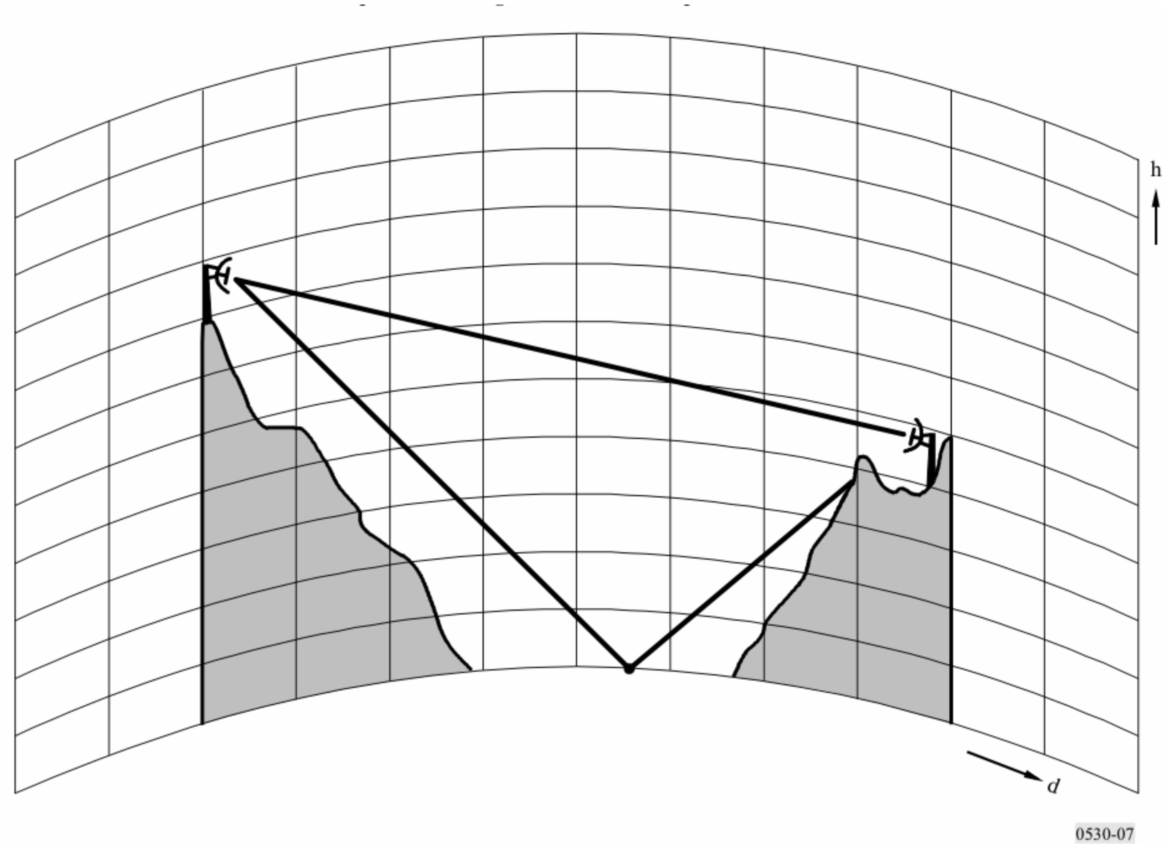

Figure 63 - Example of Shielding of Antenna from Specular Reflection

Ray-tracing analysis to find a suitable shielding obstacle should be carried out for a range of effective k factors varying from ke (99.9%) (or some other minimum value) to infinity. Care must be taken to ensure that the surface reflection is blocked, or at least partially shielded, for large effective k values, as well as the median value. Clearly the advantage of obstacle

[7] Specular – having the properties of a mirror

shielding is lost to some extent if one or more surface reflected waves are super-refracted over the obstacles, since surface multipath fading and distortion are more likely to occur during such conditions. Care must also be taken to ensure that the direct wave is not diffracted more than acceptable within the path clearance criteria at the low effective k values occurring in sub-refractive conditions.

6.18.3 Using the Diversity Built into the PTP400 and PTP600 Series Bridges

The PTP400 and PTP600 Series Bridges employ transmit and receive diversity which enables space diversity for each direction to be employed with only three physical antennas; a dual polar at one end of the link and two single polar antennas at the other end of the link. The link estimator helps you to design the configuration of these antennas using the Reflection Calculator, which is accessible from the Utilities page. The Reflections Calculator is shown in Figure 64.

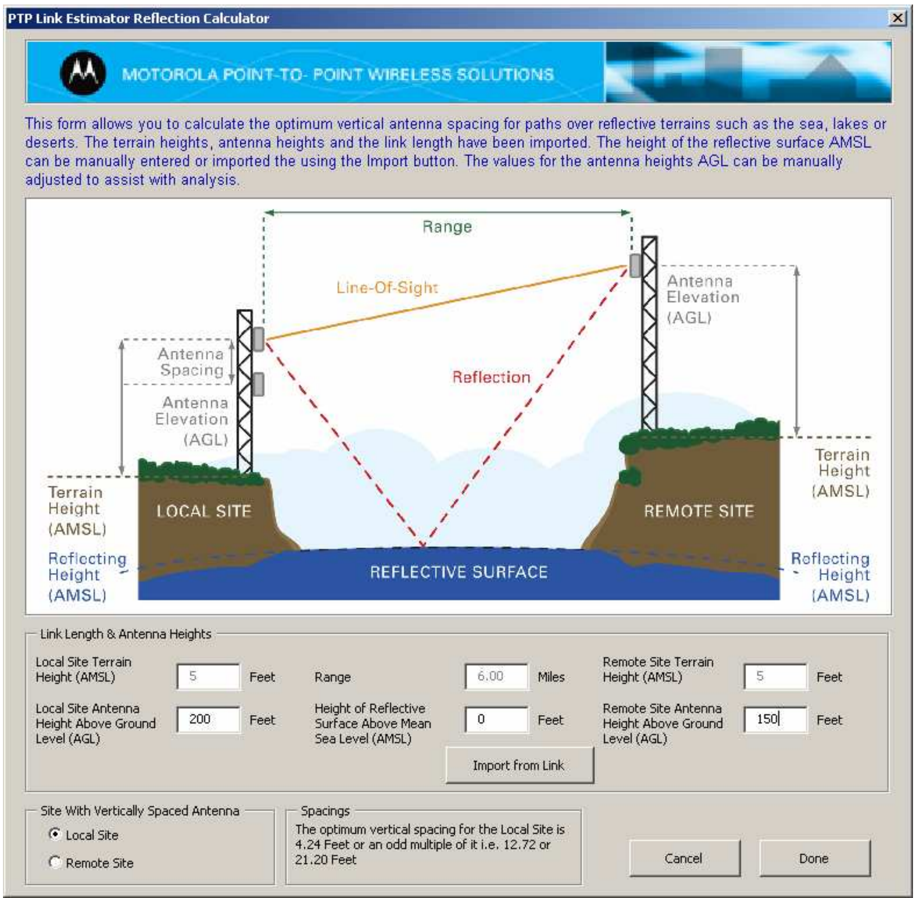

Figure 64 - Reflections Calculator

The Reflections Calculator enables calculation of the optimum vertical spacing for the antennas given the link design on the Data Entry page. When the calculator is opened, the antenna and terrains heights are automatically imported but the height of the reflective surface is not. This can either be entered manually, or imported from the link data. However, the value that is imported is assumed to be lowest point on the path but this may not always be correct as shown in Figure 65 where, in this example, the reflective surface is the lake and not the low point on path. It is important to note that the value entered for reflecting surface height is the height above mean sea level (AMSL).

The calculator will determine the optimum vertical separation of the antenna. Two alternative values are given which correspond to 3 and 5 times the nominal value. In principle, any odd multiple of the nominal value can be used, however as the multiple gets large so the accuracy of the technique reduces.

The height of the antennas above ground level (AGL) at either end of the link can be adjusted to show how the separation changes with height. It is also possible to select which end of the link has the spaced antennas using the Local or Remote Site radio buttons.

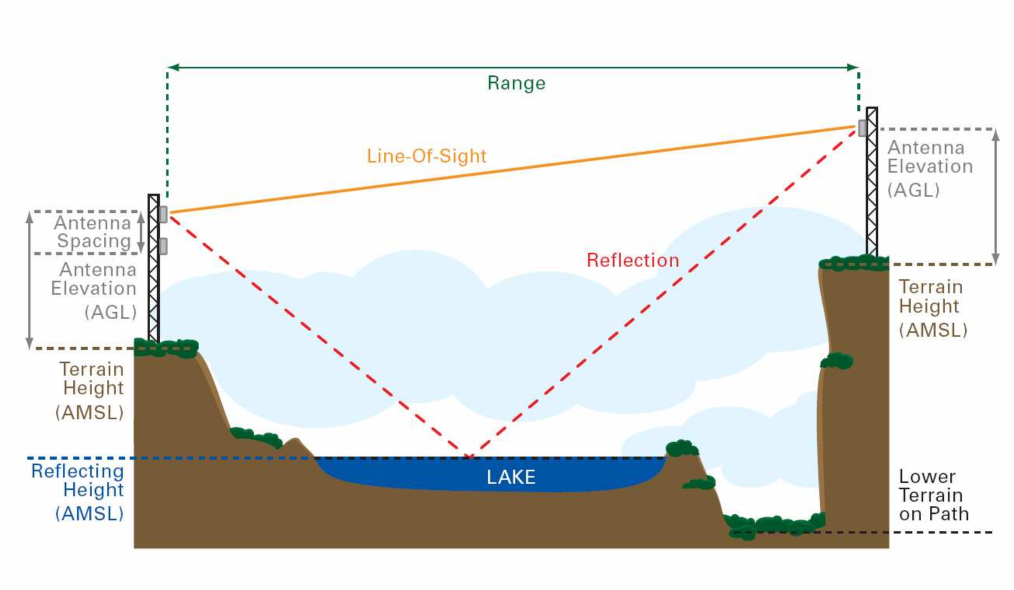

Figure 65 - How to Determine the Reflective Surface

7 Path Profiles

In order to obtain an accurate link estimate where the path impinges on the Fresnel zone an accurate height profile of the path is required. In some parts of the world this path profile can be obtained from other propagation prediction packages such as MicroPath, PathLoss, ATDI ICS Telecom, Softwright TAP and Radio Mobile. Also, Motorola has produced a web based utility (Figure 66) that creates path profiles, which can be directly imported into the Link Estimator.[8]

The web address can be found at the following address:

http://www.motorola.com/ptp/secure/pathprofile.html

(requires username and password)

Prior to use it will be necessary to have:

- User name and password which is obtained through your sales director
- The latitude and longitude of the local and remote ends of the wireless link in decimal format to WGS 84
- An email address to which an email containing the path profile files can be delivered.
- The heights above ground level of the local and remote ends of the link.
- A filename that is used to name the path profile files that are returned via email.
- Contact information including name, company and telephone number.

Location can now be entered in a number of new formats in addition to the decimal format. These are:-

- 'ddd:mm:ss.sP' eg. 50:33:20.6N,
- 'ddd:mm.mmmP' eg. 50:33.33.9N, and
- 'ddd.dddddP' eg 50.55345N.

The Web site requires input of Height and Range units. These are used for the link estimator's use of this path. The Antenna Heights are referenced to ground level, they are

[8] This is a complete file in the sense that it includes the Latitude and Longitude. Most of the imports from other software do not address this problem and thus it is important to correct the Latitude and Longitude in the link estimator for translated files.

adjustable in the link estimator. The number of points divided by the range of the link gives the resolution along the path of the link. The link name is displayed on the graphical display of the link estimator. The Filename gets '.dat' appended to it. The Contact Name enables Motorola to know who is requesting path profiles. The Company Name and Phone is for similar purposes. The Email address is the place where the path profile will be delivered usually in a few minutes after pressing 'Send Form'.

Checks that should be made on loading the path profile are:-

- Is the ground height at each end of the link what is given by the tool?
- Are any over water segments of the path accurate? Inaccuracies in these are caused by the method of survey, which is radar on board a satellite. The ground return is dispersive in angle ensuring that some power goes back to the satellite. A water return in calm conditions can be reflected in one direction away from the satellite, which introduces errors. Sometimes very large.

There are three data sources used in these profiles. The lowest resolution is global and is in 30 arc second steps (900 meters) using 1 meter vertical resolution. The middle resolution covers most of the land area between 61 degrees North and 61 degrees South, it has 3 arc second resolution steps (90 meters) using 1 meter vertical resolution. The highest resolution is for the United States only, it has 1 arc second resolution steps and also has 1 meter vertical resolution.

The vertical accuracy is claimed by NASA to be 10 meters RMS, it is noticeable that the middle resolution is has less noise than the highest resolution and yet it comes from the same radar scans (February 2000 Shuttle Radar Topography Mission SRTM). This is because each data point is an average of 9 points from the highest resolution. The low resolution data was obtained from many different sources.

See Section 10 for a technical guide to SRTM which acknowledges NASA and the University of Maryland's work.

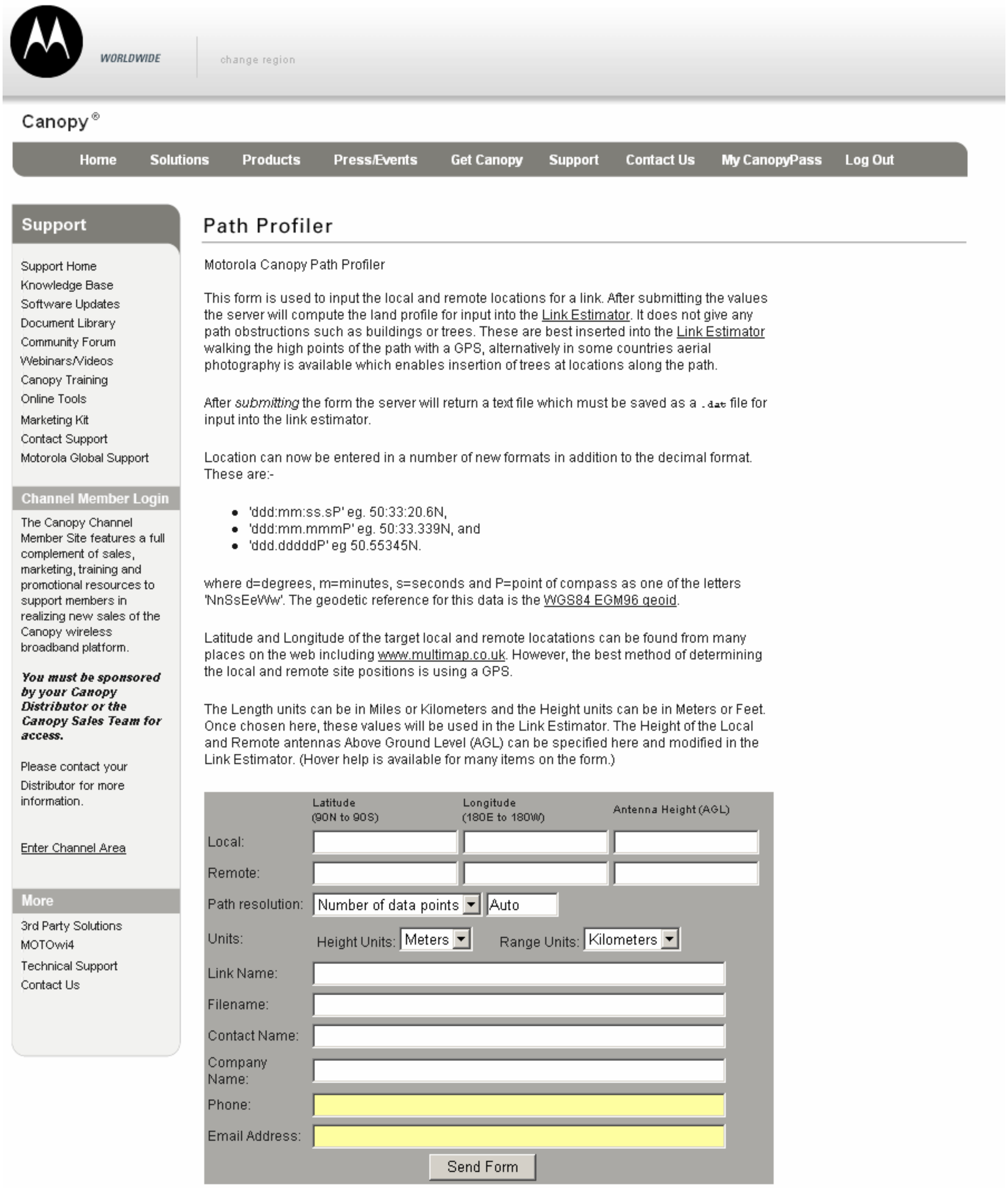

Figure 66 - Path Profile Web Page

7.1 Path Profile E-mail

After submitting the link parameters to the path profiler server, the server generates detailed path profile data. The data is returned via an email. The email has three files attached:

7.1.1 DAT file

The DAT file is a Motorola proprietary format file suitable for loading into the PTP Link Estimator.

7.1.2 PDF file

This file is a graphical representation of the link profile, useful for a quick visualization of the path.

7.1.3 GPX

The file enables checking the path using a GPS, Expert GPS or Terrabrowser software.

7.1.4 KML

KML, or Keyhole Markup Language, is an XML grammar and file format for modeling and storing geographic features such as points, lines, images, and polygons for display in Google Earth.

Using the KML data along with Google Earth allows the position of the Local and Remote points to be checked as well as the terrain.

With Google Earth installed, clicking on the KML open Google Earth at the link location. The link will be displayed by a white line indicating the LOS path and a purple line showing the path across the ground. The highest points (HP1 to HP3) along the path are also displayed so that they can be checked. The display of these features can be controlled from the temporary places menu.

8 Import File Formats

The PTP Link Estimator can import profile data files in a number of common formats. The supported formats are detailed in the subsections below.

8.1 Motorola Hydra No Site Names(*.pth)

Hydra export format

```
40.047845833333334 -75.175095277777771
40.042207222222224 -75.168060277777784
50 TxHt(Meters)
8 RxHt(Meters)
5734 Freq(Mhz)
0
0 95 0 0
0.76553904027639119 95 0 15
1.5310780805527824 95 0 15
2.2966171208291732 95 0 150.60,1712.7,,0.00
```

8.2 Motorola Hydra with Site Names(*.pth)

Hydra export format

```
SiteNames
Big House
Garage
40.047845833333334 -75.175095277777771
40.042207222222224 -75.168060277777784
50 TxHt(Meters)
8 RxHt(Meters)
5734 Freq(Mhz)
0
0 95 0 0
0.76553904027639119 95 0 15
1.5310780805527824 95 0 15
2.2966171208291732 95 0 15
```

8.3 Micropath Comma Delimited File (*.txt)

Micropath export format

```
0.00,1719.2,,0.00
0.20,1722.5,,0.00
0.40,1722.5,Tree,75.00
0.60,1712.7,,0.00
0.80,1709.4,Tree,75.00
```

Where the data is columns with column 1 giving the path increments, the second giving terrain height, the third giving obstruction labels and the fourth giving the obstruction height. Where there is no obstruction label the column has no entry but is still comma separated.

8.4 Comma Delimited File (Length Height Obstruction) (*.csv)

Motorola CSV (comma separated variables) — can be created by the user using Excel or a text editor;

```
0,1719.2,0
0.2,1722.5,0
0.4,1722.5,75
0.6,1712.7,0
0.8,1709.4,75
0.99,1712.7,0
1.19,1702.8,75
```

Where the data is columns with column 1 giving the path increments, the second giving terrain height and the third giving obstructions.

8.5 ATDI ICS Telecom Comma Delimited Text File (*.txt)

ATDI export — created with ICS Telecom

```
LONGITUDE or X,LATITUDE or Y,ALTITUDE,DTM STEP,DISTANCE (m),DIST
RAY/GROUND (m),ELLIPSOID (m),DIST
ELLIP./GROUND (m),EARTH DELTA (m)
274100,62350,182,50,0.00,7,0.00,7.00,0
274100,62300,182,50,50.00,7,1.61,5.39,0
274100,62250,178,50,100.00,11,2.27,8.73,0
274100,62200,172,50,150.00,17,2.78,14.22,0
274100,62150,164,50,200.00,25,3.20,21.80,0
```

Where the data is columns with column 1 giving the longitude, the second giving latitude, the third giving terrain height, the fourth the path increments, fifth giving distance of ray to ground, sixth giving the ellipsoid, seventh giving distance ellipsoid to ground and the eighth giving the earth delta. The first row is expected to contain the headings and is ignored during the import.

8.6 Softwright TAP 4.3 (*.txt)

Softwright TAP export format

```
Elevation Data Points
 Test Link
  42 40 22.10 N  84 32 14.90 W NAD 27
 Path from Point A to Point B

Azimuth 177.8538°
Max Distance 18.6304 mi

DIST(mi)    ELEV(ft)     AZIMUTH
   0.0000    867.4512   177.8538°    0000001
   0.1000    873.7765   177.8538°    0000001
   0.2000    864.6915   177.8538°    0000001
   0.3000    864.4267   177.8538°    0000001
   0.4000    853.7549   177.8538°    0000001
```

```
0.5000    868.6268   177.8538°    0000001
0.6000    869.2807   177.8538°    0000001
0.7000    863.2444   177.8538°    0000001
0.8000    873.6597   177.8538°    0000001
0.9000    880.0432   177.8538°    0000001
1.0000    874.2274   177.8538°    0000001
```

8.7 Radio Mobile for Windows (*.txt)

```
Radio Mobile for Windows
Version 6.0
** Left site data **
 Name
 Antenna height (m)
** Right site data **
 Name
 Antenna height (m)
** Link data **
 Frequency (GHz)
 Earth curvature factor
** Path Profile **
 Records:    Distance(km)    Elevation(m)    Color(0-15)    Height(m)
PathLoss(dB)     [     Latitude(°)     Longitude(°)     Xmap     Ymap
RadioBeamElevation(m) Clearance(m) FirstFresnel(m) Ratio ]
Start
Locsite
 10
Remsite
 40
 5.75
 1.33331675899808
0000.000    0886.0      0      0      000.0
0000.068    0886.0      0      0      000.0
0000.137    0885.0      0      0      088.6
0000.205    0886.0      0      0      098.4
0000.274    0885.0      0      0      094.6
0000.342    0884.0      0      0      096.7
0000.410    0883.0      0      0      098.3
```

8.8 Pathloss Export (*.txt)

Terrain Data Pathloss Example

	Local	Remote
Latitude	50 01 20.80 N	50 59 40.60 N
Longitude	082 31 11.80 W	082 32 49.20 W
True azimuth (°)	220 47 27.55	040 46 41.82
Calculated Distance (mi)	2.531	
Profile Distance (mi)	2.531	
Datum	WGS 1984	
UTM zone	17N	17N
Easting (km)	350.576	347.877
Northing (km)	3100.620	3097.570

Elevation (ft)	29.53	13.12

Distance (mi)	Elevation (ft)	GroundStructure (ft)
0.000	29.53	AG
0.020	29.53	AG53.0 ft Tree - Start of Range
0.040	29.53	AG
0.068	29.53	AGEnd of Range
0.080	29.53	AG
0.100	29.53	AG
0.136	29.53	AG52.0 ft Tree
0.140	29.53	AG
0.160	29.53	AG
0.180	29.53	AG
0.200	29.53	AG25.0 ft Building
0.200	29.53	AG54.0 ft Tree
0.240	29.53	AG
0.260	29.53	AG
0.280	29.53	AG
0.300	29.53	AG30.0 ft Building
0.320	29.53	AG
0.340	29.53	AG
0.360	29.53	AG
0.380	29.53	AG
0.400	29.53	AG54.0 ft Tree
0.420	29.53	AG
0.440	29.53	AG
0.460	29.53	AG
0.480	29.53	AG

9 Example HTML Report

MOTOROLA POINT-TO- POINT WIRELESS SOLUTIONS

PTP Link Estimator Configuration Worksheet

29 February 2008

Summary	
Link Name	Handbook
Customer Name	Motorola Point To Point Wireless Solutions Group
Link Type	Near Line of Sight
Maximum Obstruction Height	0.00 Feet
Link Distance	6.00 Miles
Free Space Path Loss	-127.42 dB
Excess Path Loss	-14.93 dB
User Throughput Expectation	Aggregate 60.26 Mbps assuming PTP Bridge 600 Series running a 06-00 software load
RF Frequency Band	5.8 GHz (5.725 to 5.850 GHz)
RF Channel Bandwidth	30 MHz

Installation Notes	
Bearing to REMOTE from LOCAL	16.7° from True North
Bearing to LOCAL from REMOTE	196.8° from True North
Predicted Receive Power	-57.97 dBm to -76.93 dBm
Predicted Link Loss	-132.87 dB to -151.83 dB

Perform the following checks during the installation

1. Check with a GPS that you are installing at the correct location.

2. Check carefully the direction to the other end of the link. Either use a corrected compass or use the GPS waypoint feature about 300 meters from the installation location.

3. Keep directing the antenna until the correct Receive Power is achieved. This should ensure that you are not peaking on a sidelobe of the antenna.

4. An hour after disarming check that the mean value for the link loss is as predicted.

Local Site	
Site Name	The Name of Local
Hardware Platform	PTP Bridge 600 Series Integrated
Antenna Type	INTEGRATED - Built-in Antenna Dual Polar (23dBi)
Antenna Gain	23 dBi
Antenna Height	20 Feet AGL
Local Site Elevation	5.0 Feet AMSL
Feeder Cable	N/A
Feeder Length	N/A
Feeder Loss	N/A
Spatial Diversity	N/A
Local Site Location	50°27' 3.7" N 3°46' 31.7" W

Remote Site	
Site Name	The Name of Remote
Hardware Platform	PTP Bridge 600 Series Connectorised
Antenna Type	Andrew 2ft Para, P2F-52 (29.4dBi)
Antenna Gain	29.4 dBi
Antenna Height	20 Feet AGL
Remote Site Elevation	5.0 Feet AMSL
Feeder Cable	LMR600 7.3 dBm/100ft @ 5.8 GHz
Feeder Length	13.699 Feet
Feeder Loss	1 dB
Spatial Diversity	N/A
Remote Site Location	50°31' 25.3" N 3°44' 27.9" W

Link Throughput & Availability	
User Throughput Expectation	Aggregate 60.26 Mbps
User Effective Throughput Rate Upstream	30.13 Mbps
User Effective Throughput Rate Downstream	30.13 Mbps
Link Symmetry	50:50 Fixed
Availability	99.99967%
Outage	1.72 Minutes/Year
Worst Case Analysis	Not Selected
Link Optimisation	Optimised for TDM Traffic
TDD Synchronisation	Disabled

Required User Throughput	
Required User Mux Data Throughput (Mbps)	0.00
Link Availability for User Mux Data Throughput (%)	100.00000%
Outage for User Mux Data Throughput Minutes/Year	0.00
Required User Data Throughput (Mbps)	10.00
Total User Data Throughput including Mux Data (Mbps)	10.00
Link Availability for Total User Data Throughput (%)	99.99967%
Outage for Total User Data Throughput Minutes/Year	1.72

Modulation	User Aggregate Throughput(Mbps)	Fade Margin (dB)	%Time In Mode	Throughput Availability
256QAM 0.81 Dual	262.66	-15.79	0.00%	0.00000%
64QAM 0.92 Dual	221.30	-15.79	0.00%	0.00000%
64QAM 0.75 Dual	180.84	-10.43	0.00%	0.00000%
16QAM 0.87 Dual	140.69	-4.72	0.03%	0.03386%
256QAM 0.81 Single	131.33	-11.38	0.00%	0.03386%
64QAM 0.92 Single	110.65	-11.38	0.00%	0.03386%
16QAM 0.63 Dual	101.14	1.27	15.75%	15.78448%
64QAM 0.75 Single	90.42	-6.51	0.00%	15.78448%
16QAM 0.87 Single	70.34	-1.24	8.99%	24.77663%
16QAM 0.63 Single	50.57	4.84	74.77%	99.54186%
QPSK 0.87 Single	35.17	8.38	0.41%	99.95027%
QPSK 0.63 Single	25.28	12.14	0.04%	99.99256%
BPSK 0.63 Single	12.64	18.88	0.01%	99.99967%

Regulatory Conditions	
Region Code	Region 1
Max EIRP	48.0 dBm
Output Power	25.0 dBm
In Band Environmental Noise	-144 dBm/30 MHz

The calculations for this link estimate were made assuming an output power of 25 dBm in the lowest modulation mode

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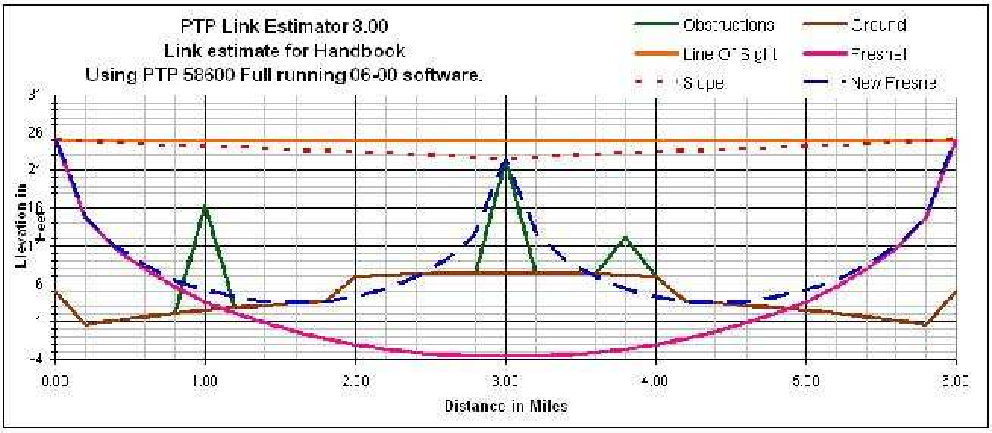
Terrain Profile



Reflection Calculations

There is insufficient antenna height to calculate an optimum vertical spacing - try increasing the antenna heights

Customer Contact Information	
Contact Name	Motorola Engineer
Company Name	Motorola Point To Point Wireless Solutions Group
Address 1	Linhay Business Park
Address 2	Ashburton
State/Province	Devon
Zip/Postal Code	TQ13 7UP
Country	UK
Phone	+44 1364 655500
Cell Phone	
E-Mail	

Other Notes

You can include some user specific text here, like notes about obstructions close to the Local or Remote sites.

This link estimator supports the recommendations in ITU-R P.530-10 and ITU-R P.526-9. This link was planned by Motorola Engineering on 29 February 2008 11:55:09 using the PTP Link Estimator.

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10 SRTM Technical Guide

Shuttle Radar Topography Mission (SRTM) Technical Guide

Global Land Cover Facility
University of Maryland Institute for Advanced Computer Studies
University of Maryland Department of Geography

Introduction
The Shuttle Radar Topography Mission (SRTM) obtained elevation data on a near-global scale to generate the most complete high-resolution digital topographic database of Earth. SRTM consisted of a specially modified radar system that flew onboard the Space Shuttle Endeavour during an 11-day mission in February of 2000. SRTM is an international project spearheaded by the National Geospatial-Intelligence Agency (NGA) and the National Aeronautics and Space Administration (NASA).

Data Set Overview
The Global Land Cover Facility provides SRTM data at three resolutions:

- 1 arc-second/30-meter DEM of the United States
- 3 arc-second/90-meter DEM of the world
- 30 arc-second/1km SRTM-GTOPO30 product corrected by GTOPO30 30 arc-second DEM

These comprise the initial edition of the SRTM data set, per the USGS standard. USGS plans to process the data to a higher level to account for missing land values and negative values in water bodies. This "finished" SRTM product is anticipated in Fall 2004, whereupon GLCF will update its holdings accordingly.

Processing Characteristics
The Global Land Cover Facility editions of SRTM data are available in six layers (Table 1). The processing for each of the editions is diagrammed in Figure 1.

Table 1: GLCF SRTM Editions

Resolution	Projection	Coverage
1 arc-second/ 30-meter	Geographic	**Native USGS Tiles**
	UTM	**WRS-2 Path/Row**
3 arc-second/ 90-meter	Geographic	**Native USGS Tiles**
	UTM	**WRS-2 Path/Row**
1 Kilometer	Geographic	**Native USGS Tiles**
	Geographic	**Global**

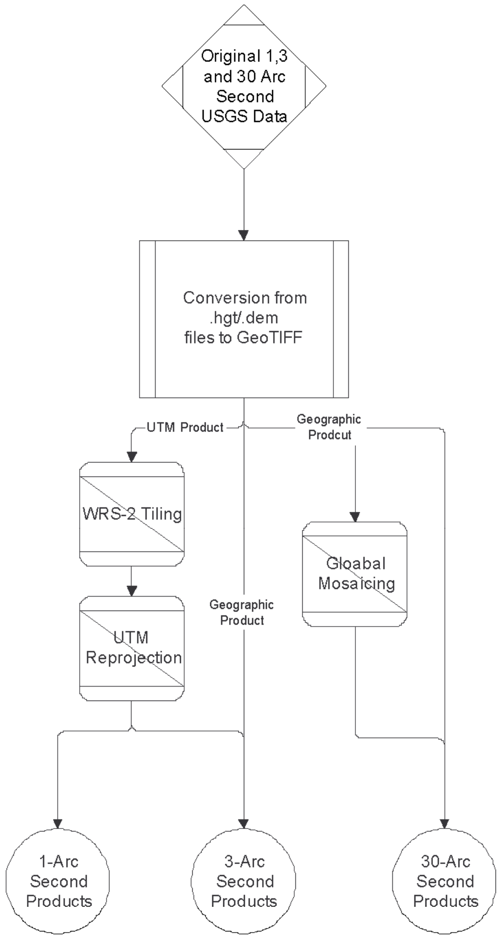

Figure 1: Processing Conducted for Each Edition of the GLCF SRTM Data Sets

Per Figure 1, all editions were initially converted to GeoTIFF. The 1 and 3 arc-second editions were then made available in their native USGS format and were also tiled to the Landsat WRS-2 reference schema (and reprojected to UTM). The global 30 arc-second product was the result of mosaicing the USGS native

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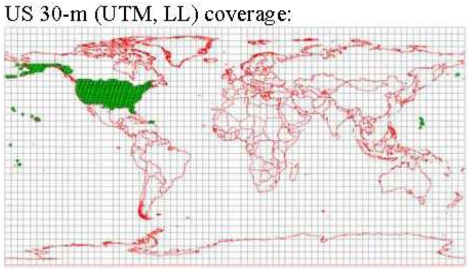
tiles, which are also available from GLCF. The last step in the processing will really occur in Fall 2004 when the same procedure is conducted with the "Finished" USGS product.

Data Properties (Geographic Coordinates):
All elevations are in meters referenced to the WGS84 EGM96 geoid and the horizontally georeferenced to the WGS84 ellipsoid using a geographic projection. The naming scheme is tied with the geographic coordinates of the data content. For example, the coordinates of the lower-left corner of tile N40W118.tif are 40 degrees north latitude and 118 degrees west longitude. The output GeoTIFF files for the 3 arc-second product are 1201*1201 in size, and those of the 1 arc-second product are 3601*3601 in size. All GeoTIFF files are 16-bit GeoTIFFs.

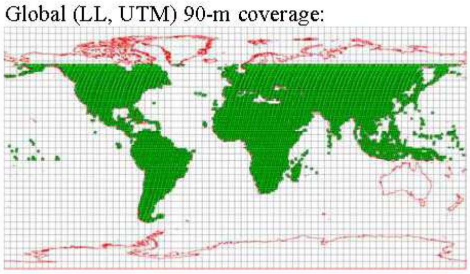
Data Properties (UTM Coordinates):
The elevation data of the UTM datasets are referenced to the WGS84 EGM96 geoid, and horizontally georeferenced to the WGS-84 ellipsoid using a UTM projection. The center longitude of each file decides which UTM zone it should be in. And the center latitude of each file decides the North/South UTM zoning. The naming scheme is tied with the WRS-2 system. For example, p15r33_utm.tif contains the data for Path 15, Row 33 of the WRS-2 system, which is the Washington-Baltimore region. This WRS-2 conversion for SRTM data is meant to support data synthesis with the Landsat GeoCover dataset also available from the GLCF website. The GeoCover dataset is also in the WRS-2 convention, however, due to satellite mechanics, the Landsat imagery actually taken may have a shift up to 5 kilometers. Therefore, GLCF SRTM-UTM dataset was generated with a 7.5-km data-buffer around the WRS2 tile.

Data Coverage
The respective coverages for each of the data products is outlined in the below three diagrams (Figures 1,2,3).

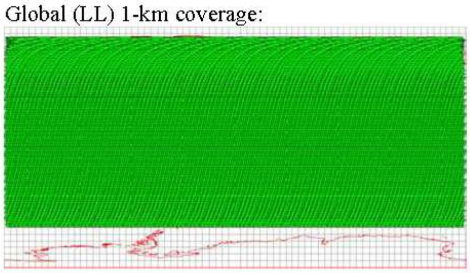
US 30-m (UTM, LL) coverage:



Global (LL, UTM) 90-m coverage:



Global (LL) 1-km coverage:



Figures 2,3,4: GLCF SRTM Product Coverages.

Please email glcf@umiacs.umd.edu with all questions concerning the derived SRTM products. All questions concerning the SRTM sensor itself should be directed to the NASA SRTM project (see the below link).

Primary Links

- National Aeronautics and Space Administration Jet Propulsion Laboratory SRTM Project: http://www2.jpl.nasa.gov/srtm/
- United States Geological Survey SRTM Project: http://srtm.usgs.gov/
- Landsat 7 WRS-2 Web Site: http://landsat.gsfc.nasa.gov/documentation/wrs.html

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11 Glossary

AGL	Above Ground Level
AMSL	Above Mean Sea Level
ATDI	Advanced Topographic Development & Images Ltd.
BPSK	Binary Phase Shift Keying
CD	Compact Disc
CSV	Comma Separated Variables
DFS	Dynamic Frequency Selection
EIRP	Equivalent Isotropic Radiated Power
ETSI	European Telecommunications Standards Institute
FCC	Federal Communications Commission
FEC	Forward Error Correction
ITU	International Telecommunications Union
KML	Keyhole Markup Language
LoS	Line-of-Sight
MIMO	Multiple-Input Multiple-Output
NLoS	non-Line-of-Sight
PTP	Point-To-Point
SRTM	Shuttle Radar Topography Mission
TDD	Time Division Duplex
TDM	Time Division Multiplexing

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