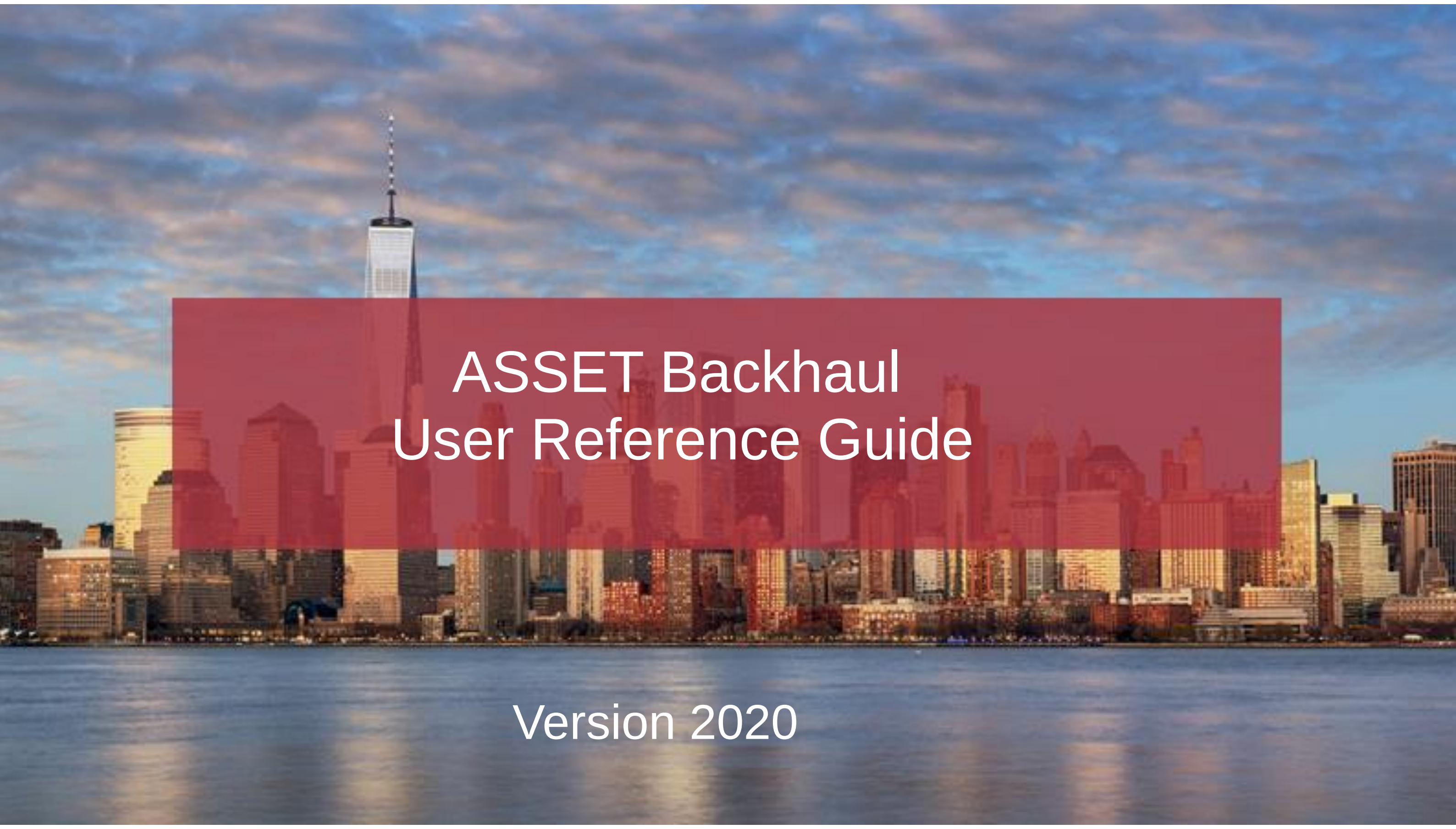
ASSET Backhaul
User Reference Guide



Version 2020

Your feedback is important to us: The TEOCO Documentation team takes many measures in order to ensure that our work is of the highest quality.

If you find errors or feel that information is missing, please send your Documentation-related feedback to Documentation@teoco.com

Thank you,

The TEOCO Documentation team

Change History

This table shows the change history of this guide:

Edition	Date	Reason
1	20 January 2020	First edition.

Table of Contents

1 Introduction

ASSET Backhaul is TEOCO's microwave link planning tool. It enables you to design and evaluate microwave networks across a variety of architectures, for example branch connections, multiple hops, loops or point to multi-point. It merges powerful link engineering capabilities with a graphical map view to fulfill all microwave transmission planning requirements. You can:

- View and report on performance calculations for individual or groups of links, in order to assess link reliability
- Use comprehensive wizards to analyze line of sight, link quality and interference
- Perform automatic link planning
- Store link capacity and equipment costs across the network

ASSET Backhaul supports all of the latest international (ITU) specifications for multi-path propagation and rain attenuation predictions. For information on purchasing these documents, see the International Telecommunications Union website at http://www.itu.int/.

ASSET Backhaul can be integrated with other ENTERPRISE tools and a (shared) Oracle database, providing an efficient and superior microwave link planning platform for voice and data networks.

Using ASSET Backhaul, you can consider two key aspects of transmission network design:

Item	Description
Physical Links and Topology	You can define the radio equipment, antennas and feeders to be used at the link ends. You can specify the frequencies to be used on the microwave links, and can perform a full interference analysis (in accordance with ITU recommendations). You can use the Height Profiler and the Map View to assess line of sight, using chosen resolutions.
Logical Routing	You can automatically or manually choose primary and secondary routes in the network and define the PS/CS traffic.

About the ASSET Backhaul Products

ASSET Backhaul is available as three different products, described in the following table:

Product Name	Description
ASSET Backhaul Lite	Used for designing transmission, microwave link and the backhaul network (point to point, point to multi-point and so on). Key features are multi-user capability, transmission and microwave link planning, TDD, FDD, Reports, TDM, Ethernet/IP, Equipment, Site and Link Database, and ITU/Vigants support.
ASSET Backhaul Standard	Contains all of the features of ASSET Backhaul Lite, with additional capability for frequency and interference planning, Line of Sight analysis, and High-Low conflict analysis.
ASSET Backhaul Professional	Contains all of the features of ASSET Backhaul Standard, with additional capability for backhaul capacity and route planning, and unified (2g, 3g and LTE) carried traffic analysis.

Important: Unless you have ASSET Backhaul Professional, some of the functionality described in this User Reference Guide will not be available. However, if you do not have all of the functionality that you require, a number of features are available as productivity packs:

- Interference analysis and frequency planning
- Line of sight link analysis and design
- High-Low conflict analysis and reporting
- Backhaul capacity and route planning

Using ASSET Backhaul with Other ENTERPRISE Tools

ASSET Backhaul is built around the use of an Oracle database to store link and site information. Where other modules of the ENTERPRISE suite have been installed, the ASSET Backhaul link/site data is automatically available for users of these other modules. There is also a reciprocal sharing of data, passing from the other modules to ASSET Backhaul.

For example, a cell planner using ASSET to create a UMTS cell plan adds Node Bs and other logical site elements to the shared database. The link planner using ASSET Backhaul can almost instantaneously see changes to site co-ordinates, heights and so on made by the cell planner without the need for synchronization scripts.

2 The ASSET Backhaul User Interface

As part of the ENTERPRISE suite, ASSET Backhaul retains the common look and feel of all the tools. For detailed descriptions of the user interface and functionality which it shares with other ENTERPRISE tools (especially the main toolbar, Map View window and Site Database), see the *ENTERPRISE User Reference Guide*. This is a useful introduction to any of the tools in the suite because it includes information on:

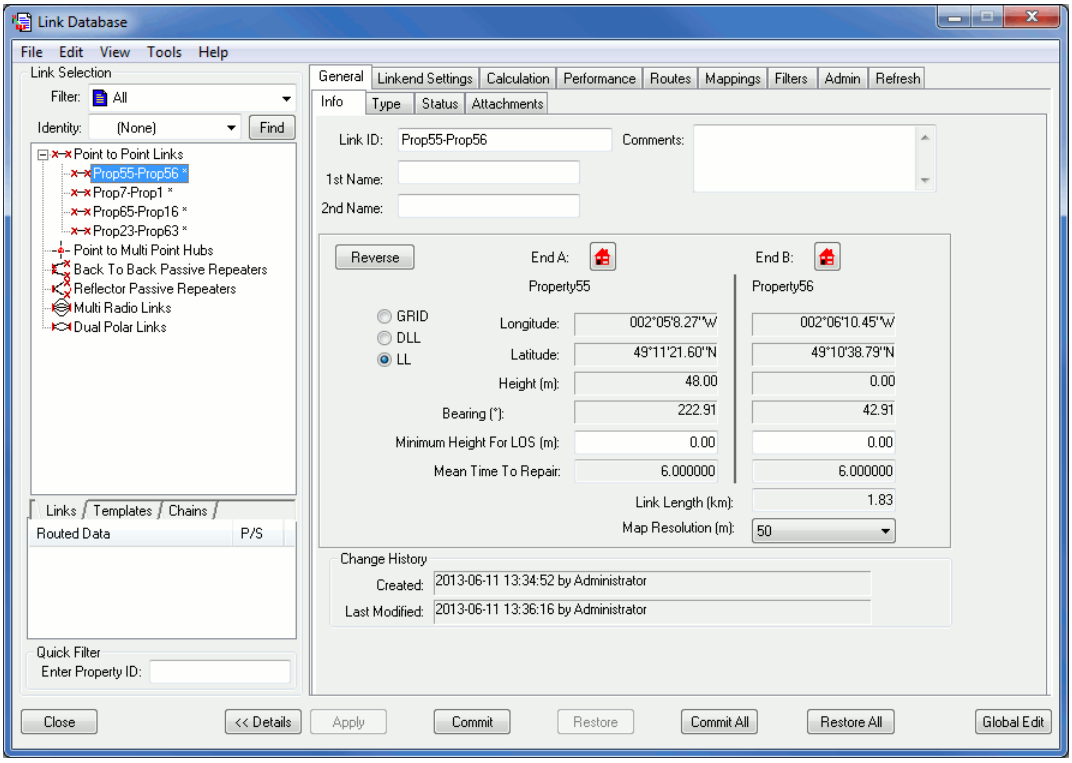
- Adding and storing equipment details
- Viewing and controlling the display of data in the Map View window
- Adding and editing data in the Map View window and in the Site Database window
- Using filters, fields and vectors
- Importing and exporting data
- Using Workspaces

Therefore it is recommended that the *ASSET Backhaul User Reference Guide* and *ENTERPRISE User Reference Guide* are used in conjunction.

About the Link Database Window

ASSET Backhaul has a **Link Database**, in which you can view and edit the attributes of all your links within the ENTERPRISE database.

This picture shows an example:



Link Database Window

Note: If you log in to a **Sandbox**, the effect of the **Commit** and **Restore** buttons differs from the normal behavior. For more information, see the *ENTERPRISE User Reference Guide*.

The following table describes what is displayed on each tab:

On this tab	You can view
Links	Links and hubs.
Templates	Templates for links and hubs.
Chains	Chains (cascades of multiple links).

The Link Database automatically updates when you create new links, hubs, templates or chains.

You can use this database to:

- Change the link/hub names, and all the physical properties of a link/hub including the link type, line of sight status, diversity, geographical information, calculation method, and so on.
- Create hub and/or link templates, and edit the physical properties of these.
- Add, edit and delete chains (and the links of which they are comprised).
- Locate links and hubs in the **Map View** window.

The Link Database stores:

- All linkend settings such as antenna, power, feeder information.
- The calculations you want to use across the link.
- The results of calculations for Link Budget, Fade Margin, Outage, Reliability, Adaptive Modulation and Objectives under the **Performance** tab. This performance data is based on the information you have entered.
- Routes information. When this is entered, the **Routed Data** box in the left pane displays any sites that are routed through the selected link.
- Mappings – how the link is set up and its timeslots.
- The filters that the link is associated with.

Sorting Data in the Link Database

To sort link, hub, template or chain information:

1. From the **Database** menu, click **Links**.

   – or –

   From the main toolbar, click  .

2. Ensure you are in the required view (**Links**, **Templates** or **Chains**).
3. From the **View** menu, point to either **Sort by Name** or **Sort by Creation**, and then click the appropriate option:
   - **Ascending** : in alphabetical order, or with earliest created shown first
   - **Descending** : in reverse alphabetical order, or with last created shown first

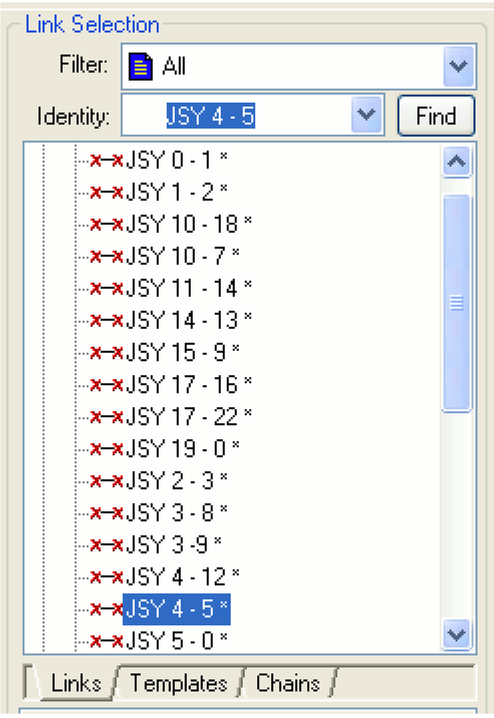
   The network elements are rearranged accordingly.

Searching for a Link

To search for the name of a link among those shown in the Link Database:

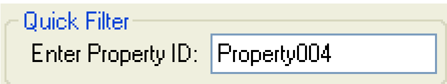
1. In the **Identity** box, type the name of the link, hub, sector or carrier.
2. Click the **Find** button.

   If any item matches your search, is it highlighted in the tree:



To search for all references to a Property:

Type the Property name in the **Enter Property ID** box:

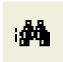


Tip: Clear this box after you have found what you want, to ensure that all the links are once again displayed.

Locating ASSET Backhaul Equipment, Links and Network Elements

You can use the **Search** dialog box to quickly locate ASSET Backhaul-specific equipment and network elements.

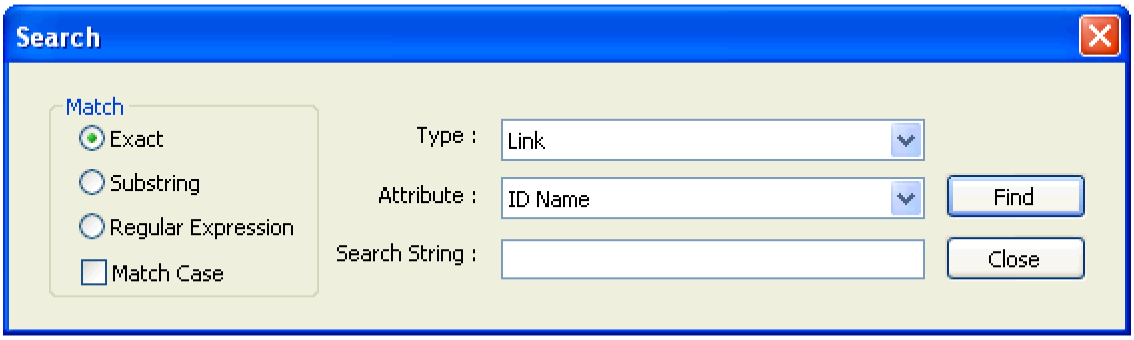
To do this:

1. On the main toolbar, click the **Search** button  .

   - or -

   From the **Options** menu, click **Search**.

   The **Search** dialog box appears:

2. From the **Type** drop-down list, select the type of network element for which you want to search.

3. From the **Attribute** drop-down list, select the attribute for the selected network element type on which you want to search.

4. In the **Search String** pane, type the string you want to search on based on the chosen attribute. For example, if you chose to search based on ID Name, type the search string for the ID Name that you want to search for.

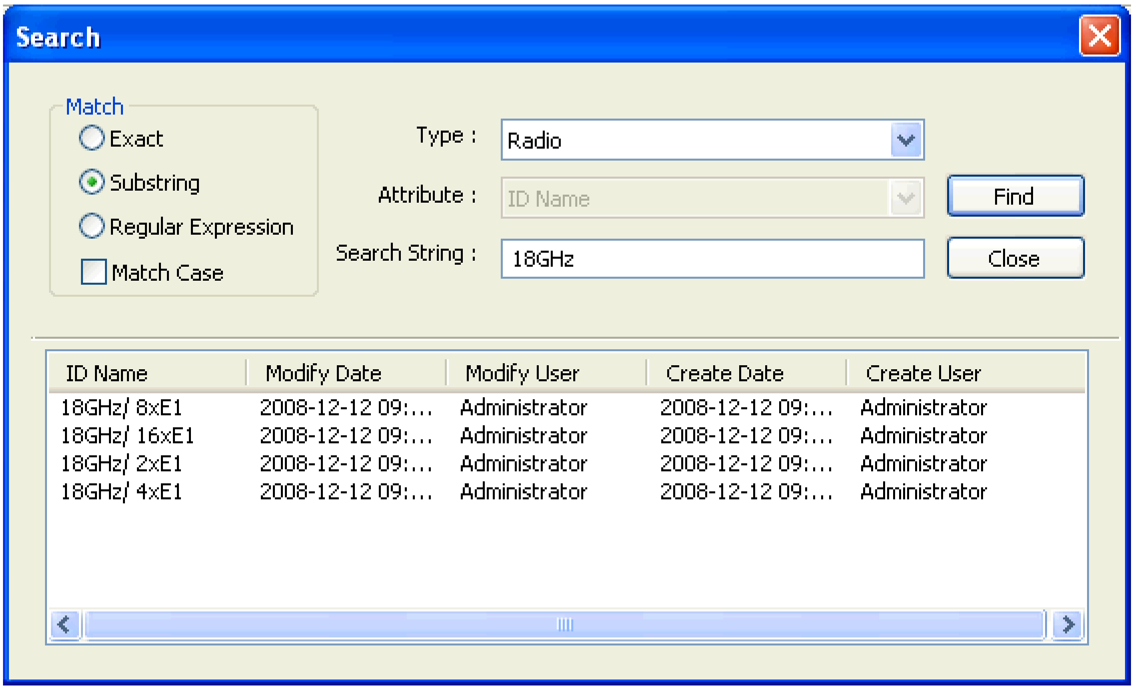
   You can search based on exact string (for example, Link_42A), substring (Link_) or regular expression. For information on searching by regular expression, see Examples of Using Regular Expressions in ASSET Backhaul on page 17.

   Tip: You can also search for exact names by selecting the **Match Case** checkbox.

5. Click **Find**.

   A list of the items matching your search is displayed, with some information for each item - who created it, when it was created, and so on.

This picture shows an example:



6. To locate one of the found items in the **Link Database** (for links, hubs, sectors, carriers or templates), **Equipment** dialog box (MW antennas, radios, feeders, link terminals, cabins or masts) or **Site Database** (Properties), double-click it.

   The selected item is highlighted in the appropriate window or dialog box.

Examples of Using Regular Expressions in ASSET Backhaul

For its regular expressions, ASSET Backhaul uses the Perl engine. Perl is widely documented on the internet. For example, you can read more about Perl regular expressions at this location:

http://search.cpan.org/dist/perl/pod/perlre.pod

This table shows some examples of regular expressions that you might use in ASSET Backhaul:

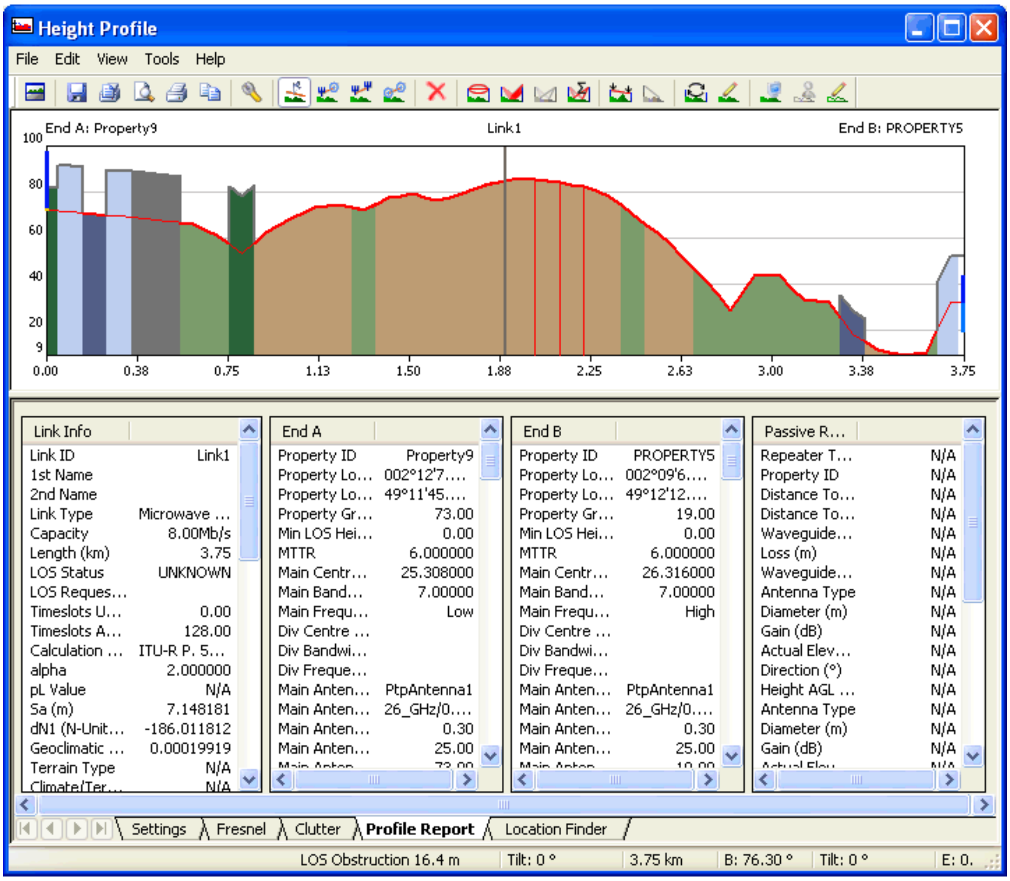
Enter	To Find
.*	Everything
^Link*	All links beginning with Link.
^Link*.+A$ or ^Link*.*A$	All links beginning with Link and ending with the letter A.
^Radio83(89|98)$	Radio8389 and Radio8398.
^Radio\d\d\.*A$	All elements beginning with Radio followed by two digits and an A.
.*[A-F]$	Elements with names ending in a,b,c,d,e,f or A,B,C,D,E,F unless you have selected the Match Case checkbox, in which case it only returns elements with names ending in A,B,C,D,E,F.
^(Cabin|Mast)_[0-9]{4}[a-fA-F]{0,1}	Cabin or Mast followed by an underscore, followed by exactly 4 digits, optionally followed by one letter. For example, this matches Cabin_3671 and Mast_3671C, but does not match Cabin_031A or Mast_0001TEST.

About the Height Profile Window

In ASSET Backhaul, you can use the **Height Profile** window to see a two dimensional cross-section of the terrain between two points on the map. The plot shows:

- Line of sight (LOS) between the two points
- Clearance, or height of an obstruction
- The distance between the two points
- The bearing from due north of the end point from the start point
- The angle of the elevation of the end point from the start point (a positive value means a downward tilt, a negative value means an upward tilt)
- Any resultant signal loss
- Any obstructions, shown as vertical red lines

This picture shows an example:



Height Profile window

The Height Profile window shares functionality with other tools in the ENTERPRISE Suite. For general information, see the *ENTERPRISE User Reference Guide*. For more detailed information on the ASSET Backhaul-specific functionality, see Using Height Profiles on page 89.

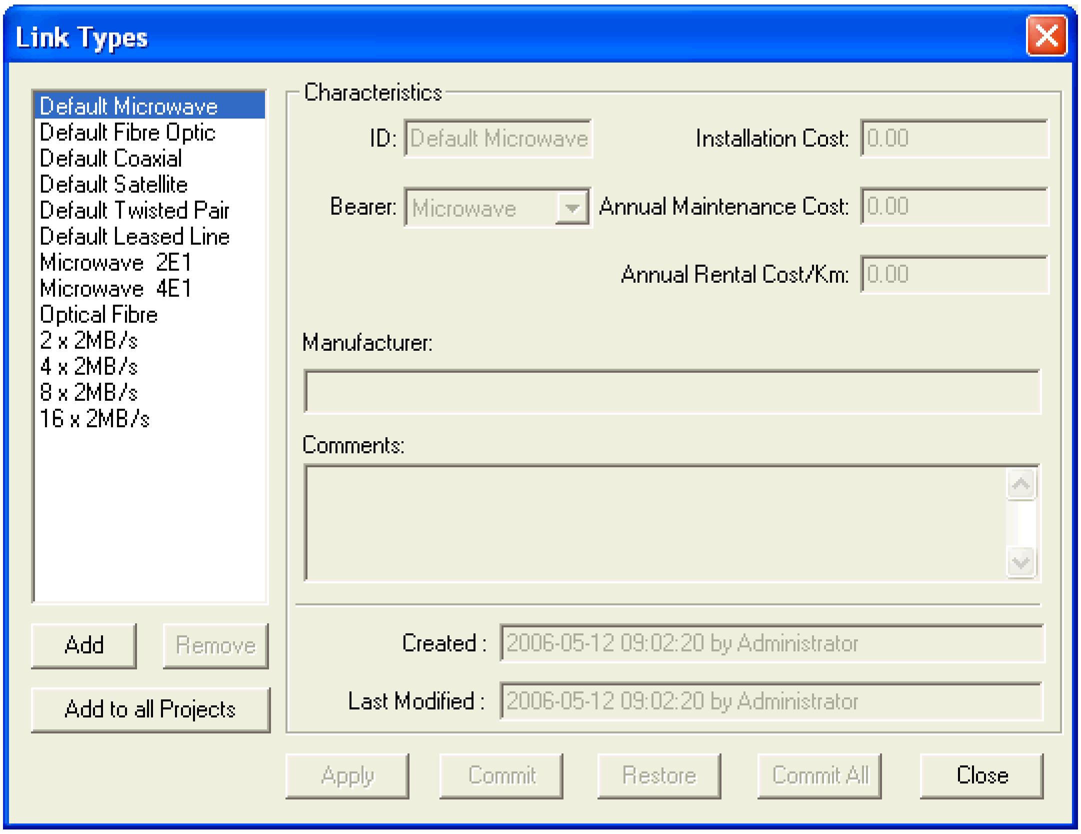
About the Link Types Dialog Box

ASSET Backhaul contains a **Link Types** dialog box where you can specify your link types, including the chosen media, type of bearer and manufacturer.

Six default link types are set up but you can also add your own types.

You can also set cost parameters (optional) here.

This picture shows an example:

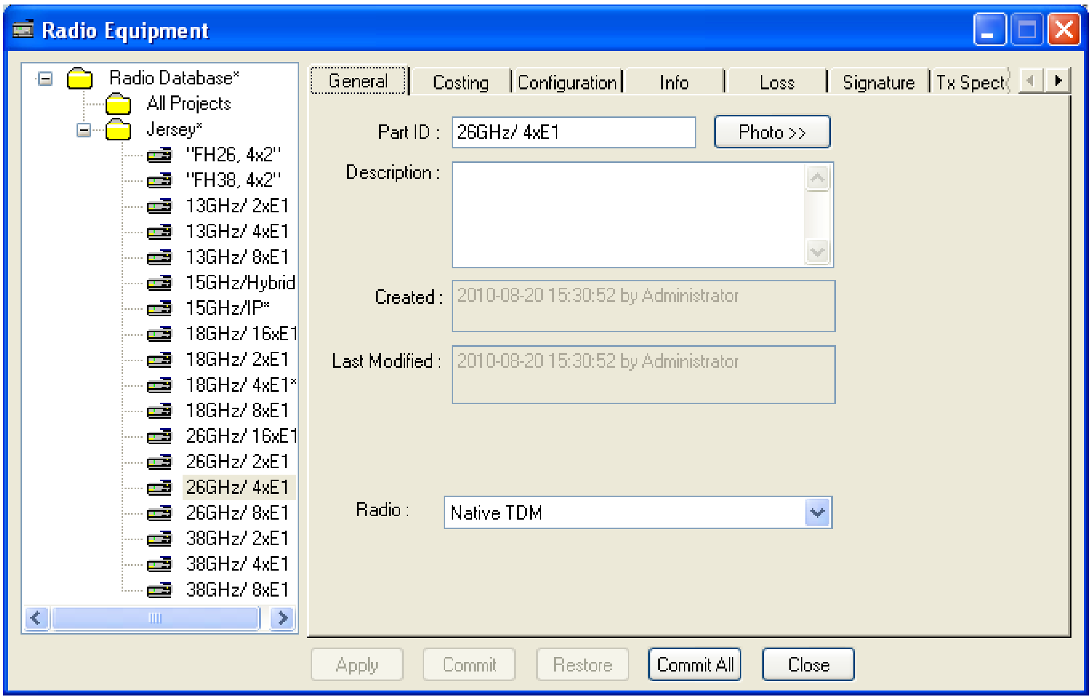


Link Types dialog box

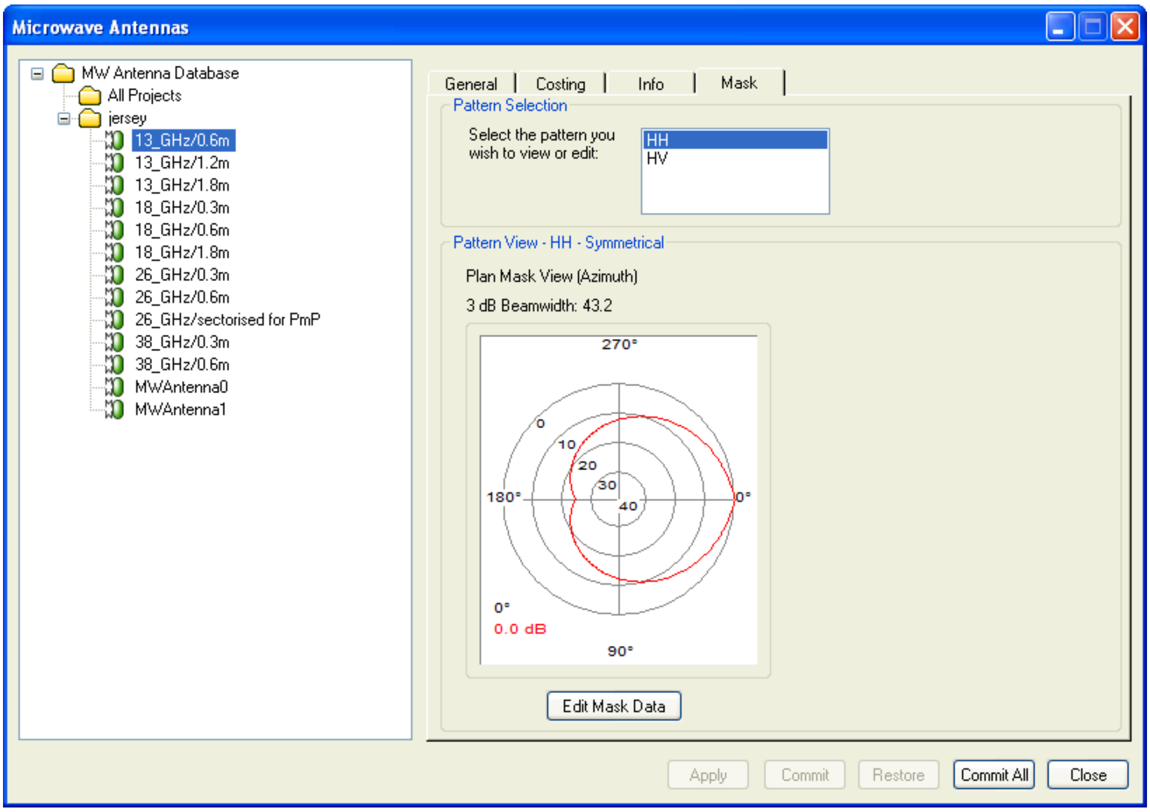
About the Equipment Dialog Boxes

In all ENTERPRISE tools, you can store libraries of information in the equipment dialog boxes. For ASSET Backhaul, these relate to:

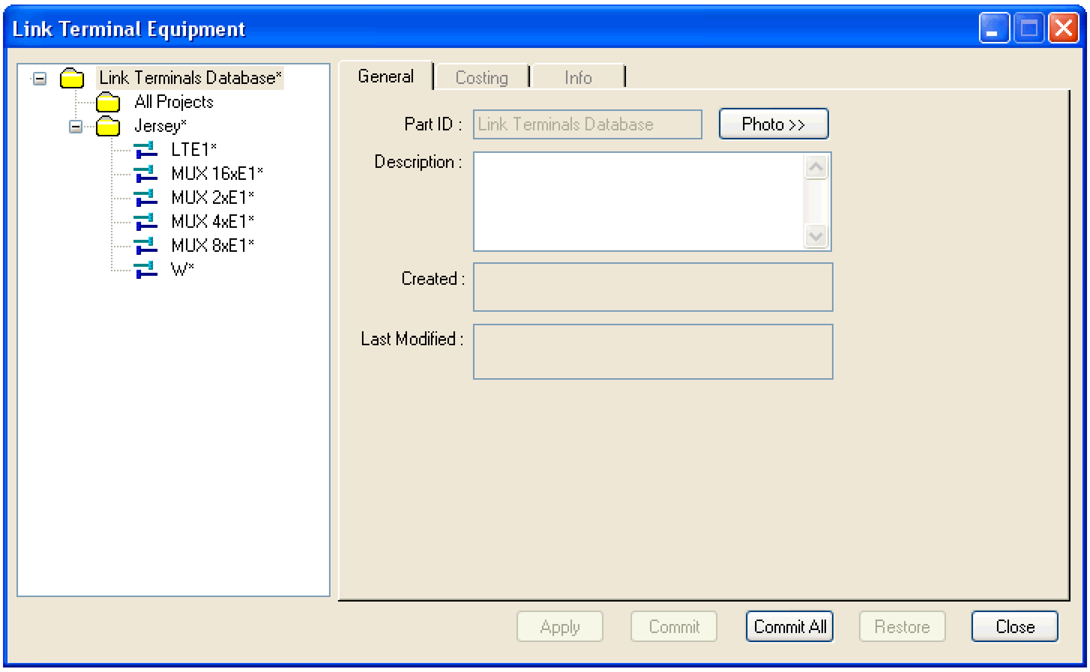
- Parameters for radio equipment:



- Information for microwave antennas, including frequency band, front to back ratio, operating frequency and so on:



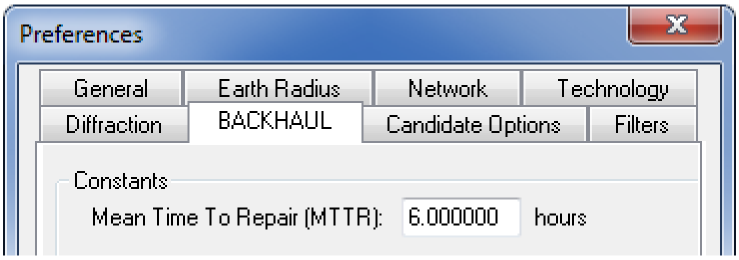
- Information for link terminal equipment, such as input and output type and cost:



Tip: When setting equipment parameters, include as much information as possible to get the most accurate result.

About the Preferences Dialog Box

Setting the preferences is the very first step when starting to plan your network. This is done in the **Preferences** dialog box:



Example Preferences dialog box

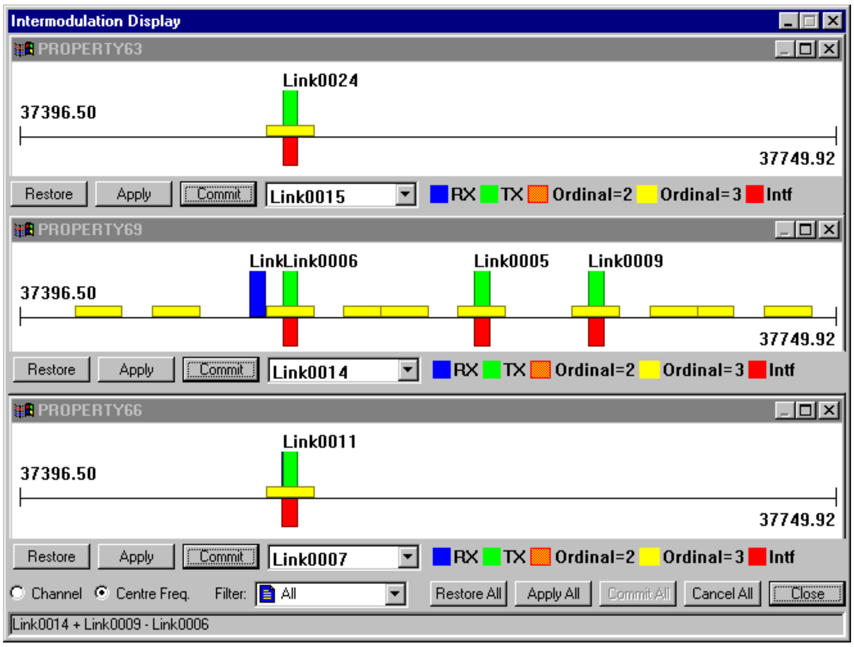
You can set the key parameters and settings for ASSET Backhaul on a number of tabs. The product-specific settings are on the **BACKHAUL** tab, but there are other relevant tabs such as the **Earth Radius** tab and the **Diffraction** tab.

For more information, see Setting Your Preferences on page 23.

About the Intermodulation Display Window

The **Intermodulation Display** window displays intermodulation data graphically, so that you can analyze all linkends at the same site and see where any new interfering frequencies have been generated within the receiver itself. You can then change this information in the window and apply and commit your changes to the database.

This picture shows an example window:



Example Intermodulation Display window

You can use the Intermodulation Display window to:

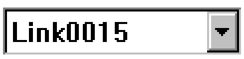
- Edit link frequency
- Change link properties
- View intermodulation calculations

You can view the display by channel or by center frequency, by selecting the appropriate option. You can also show restricted data by selecting any filter you have created, in the **Filter** menu.

In this window, the black horizontal line represents the radio spectrum. The following table shows the color coding which is used for blocks along this line:

This Block	Represents
Green block	Transmitting link.
Blue block	Receiving link.
Half height orange block	Second order intermodulation.
Quarter height yellow block	Third order intermodulation.
Red block below frequency spectrum line	Collision between transmitting and receiving frequency.

Any multiple links of the same frequency are displayed on top of each other. However, you can display a particular link at the top by selecting the required link in the list:



Link List

3 Before Starting Planning

This chapter describes information that you need before you start planning a network using ASSET Backhaul.

Before starting transmission planning in ASSET Backhaul, you must:

- Produce a network diagram that follows nominal transmission planning constraints
- Decide on the type of network connections (links) and initial data capacities that ASSET Backhaul requires to model the network
- Use ASSET to set up a plan

  – or –

  Define a plan solely in ASSET Backhaul

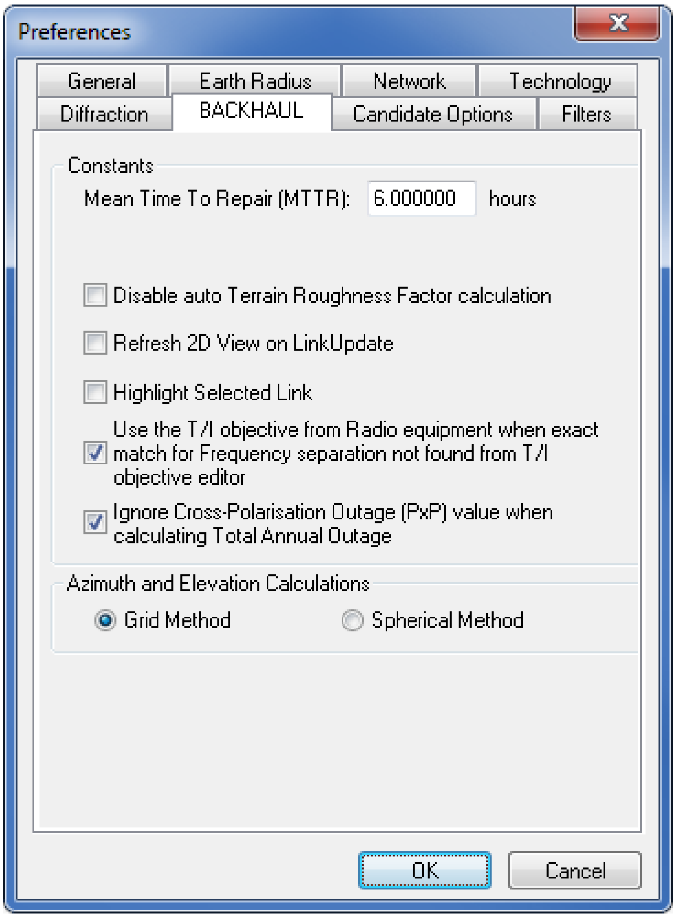
Setting Your Preferences

Before starting to plan a network, always make sure that you have set your preferences properly, for example, earth radius, k value and network type. Also, decide on which of the three calculation methods you want to use, and optionally, the default Kn values.

To open the Preferences dialog box:

1. From the **File** menu, click **Preferences**.

   The **Preferences** dialog box appears:



2. Click the appropriate tab, depending on the preferences that you want to set. The following sections describe what you can set on the various tabs.

Note: For information on the core Preferences dialog box, see the *ENTERPRISE User Reference Guide*.

Setting Preferences on the BACKHAUL Tab

On the **BACKHAUL** tab of the Preferences dialog box you can:

- Define a **Mean Time To Repair (MTTR)**, that is, a value in hours that represents the average time taken to fix equipment. This default value can be changed per link in the Link Database. MTTR is used in reliability and availability calculations in the Link Database.

  Tip: If you want equipment repair time to have no impact on the link calculations, set the MTTR to 0.

- Disable the **auto Terrain Roughness Factor calculation**. If you disable this, you can considerably reduce the time taken to create point to multi-point links.

  Warning: This value is used in the propagation prediction calculation (530-12 calculation method), so care should be taken when disabling it.

- Set ASSET Backhaul to:
  - Highlight links in the Map View window when you select it in the Link Database or choose to locate it in the Map View window.
  - Automatically refresh the Map View when you Apply a change to a link in the Link Database.
  - Use the **T/I objective** set on the radio equipment if an exact match for the frequency separation cannot be found in the T/I Objectives Editor.
  - Ignore **Cross-Polarization Outage (PxP)** value when calculating Total Annual Outage.

    Note: If you select this option, a warning is displayed on the Outage subtab of the Performance tab.
- Select how the Earth will be represented when performing azimuth and elevation calculations, based on either:
  - **Grid Method** - which treats the Earth as a flat plane

    \- or -
  - **Spherical Method** - which accounts for the curve of the Earth, and will produce bearings closer to those used in mapping software such as Google Earth

  For more information on these calculations, see Azimuth and Elevation Equations (the Spherical Method) on page 285.

Setting Earth Radius Preferences

On the **Earth Radius** tab of the **Preferences** dialog box, you can set the effective earth radius. Most of the calculations used in ASSET Backhaul (obstruction loss, minimum antenna height, Line of Sight Wizard, and so on) use this value and therefore it is very important to make sure that the correct *k* value is used before you begin planning the network.

To set the effective earth radius:

1. Type the actual earth radius in the **True earth radius** box.
2. Type the *k* value (or *k* factor) in the **K factor value** box. The *k* factor describes the bending of rays due to their refraction in the atmosphere.

   Tip: Usually *k* is 4/3, that is, 1.33333.

   ASSET Backhaul multiplies the two figures to give the effective earth radius.

If you want to analyze abnormal conditions in the whole network area, you can temporarily change the *k* value, and then look at the calculation results (for example, the result of interference analyses). If you do this, remember to change the value back again.

Tip: Analyzing one hop over terrain in abnormal conditions can be done on the **Fresnel** tab of the **Height Profile**, by changing the *k* value. For more information, see Displaying Fresnel Clearance Criteria on page 93.

Setting Diffraction Preferences

On the **Diffraction** tab of the Preferences dialog box, you can define the calculation method that will be used for obstruction loss calculations (in case of diffraction). The obstruction loss is dependent on frequency, clearance, obstacle shape and size. Therefore it is important to make sure that the correct calculation method is used when obstruction takes place.

Tips:

- In most cases, the **Terrain Averaging** method will provide accurate results, so you may wish to begin with this method until you encounter a knife edge for a particular link.
- When calculating obstruction loss for a single hop, it might be useful to change the diffraction calculation method here temporarily, to get a more exact value for the obstruction loss. If you wish to do this, you will need to select the **User Defined** checkbox and type the value that you have just calculated before changing the diffraction calculation method back to the original one in the **Preferences** dialog box. This will prevent the wrong diffraction loss calculation method being used later on in the project.

For information about the diffraction methods, see the *ENTERPRISE Technical Reference Guide*.

Setting Network Preferences

On the **Network** tab of the **Preferences** dialog box:

- **2G Parenting**

  If you want to activate automatic parenting when adding 2G network elements to the Map View, select **'Parent 2G network elements in logical hierarchy'**.

  If you activate this automatic parenting, any BSCs you add on the Map View will be parented to the nearest MSC, and any BTSs you add on the Map View will be parented according to your choice:

  - The nearest BSC
  - The BSC of the nearest Distribution Node

  Note: For all technologies in ENTERPRISE, network hierarchies are optional.

- **2G Automatic Reparenting**

  If you use ASSET Backhaul, whenever you make or break a link on the Map View, you may want the BTS-BSC parenting in the Site Database to be automatically updated to match any changed linking relationships in the Link Database. If you do, select **'Check all BTS-BSC parenting after making or breaking links, and reparent in Site Database if necessary'**.

  Important: It is generally recommended that you do *not* activate this option, so that you can maintain user control of the BTS-to-BSC parenting within the Site Database.

- **Network Element Creation (Logical Links View)**

  If you want to be prompted for which Property to choose (existing or new) when you create a network element in the Site Database, select **'When adding an element, prompt for a new property'**.

  If you do this, each time you add a new element, you will see a Property Information dialog box where you can choose to locate the element on any existing Property, or on a new Property for which you can specify the coordinates.

  This option is only relevant when:

  - The Site Database View mode is 'Logical Links'.
  - You are adding an element under a parent hierarchy (for example, adding a Site under an existing BSC, or adding a NodeB under an existing RNC. (If you add an element by right-clicking directly on the PLMN, this option is not relevant, because the Property Information dialog box is mandatory in that case.)

Defining and Storing Equipment Details

In ASSET Backhaul, you can store equipment details for radio equipment, antennas and so on separately to your site and link details.

To access the equipment details:

From the **Equipment** menu, click the appropriate equipment type.

Warning: If you do not include all the information required for link planning, ASSET Backhaul will warn you. For example, if the linkend settings are not complete or incompatible for any link, a warning will appear on the link performance calculations in the Link Database.

The following topics describe the details for ASSET Backhaul-specific equipment types. For information on storing details for masts, BTS equipment, cabins and cell equipment, see the *ENTERPRISE User Reference Guide*.

Important: Ensure that all changes and updates are applied and committed to the database before exiting ASSET Backhaul.

Managing Equipment Folders

You can manage equipment in two main types of folder:

- All projects - the equipment will be available in all projects within the current database
- The current project - the equipment will only be available in the project that is currently open

For information on how to add equipment to either type of folder, see the appropriate topic for the equipment type - for example, Defining Radio Equipment on page 29.

To add subfolders to these two main folders, to organize your equipment in a more structured way:

1. Select the main folder, either **All Projects** or the current project as required.
2. Right-click, and from the menu that appears, click **New folder**.

   A new folder is added to the list, which you should name as appropriate.

   Tip: If required, you can also add subfolders to subfolders.

To move subfolders and equipment within folders:

1. Select the equipment/subfolder that you want to move.
2. Right-click, and from the menu that appears, click **Cut**.
3. Select the folder/subfolder into which you want to move the equipment/subfolder.
4. Right-click, and from the menu that appears, click **Paste**.

To rename equipment or subfolders:

1. Select the required equipment or subfolder.
2. Right-click, and from the menu that appears, click **Rename**.
3. Type the new name as required, and then press **Enter**.

To delete equipment or subfolders:

1. Select the required equipment or subfolder.
2. Right-click, and from the menu that appears, click **Delete**.

   The selected equipment or subfolder is removed.

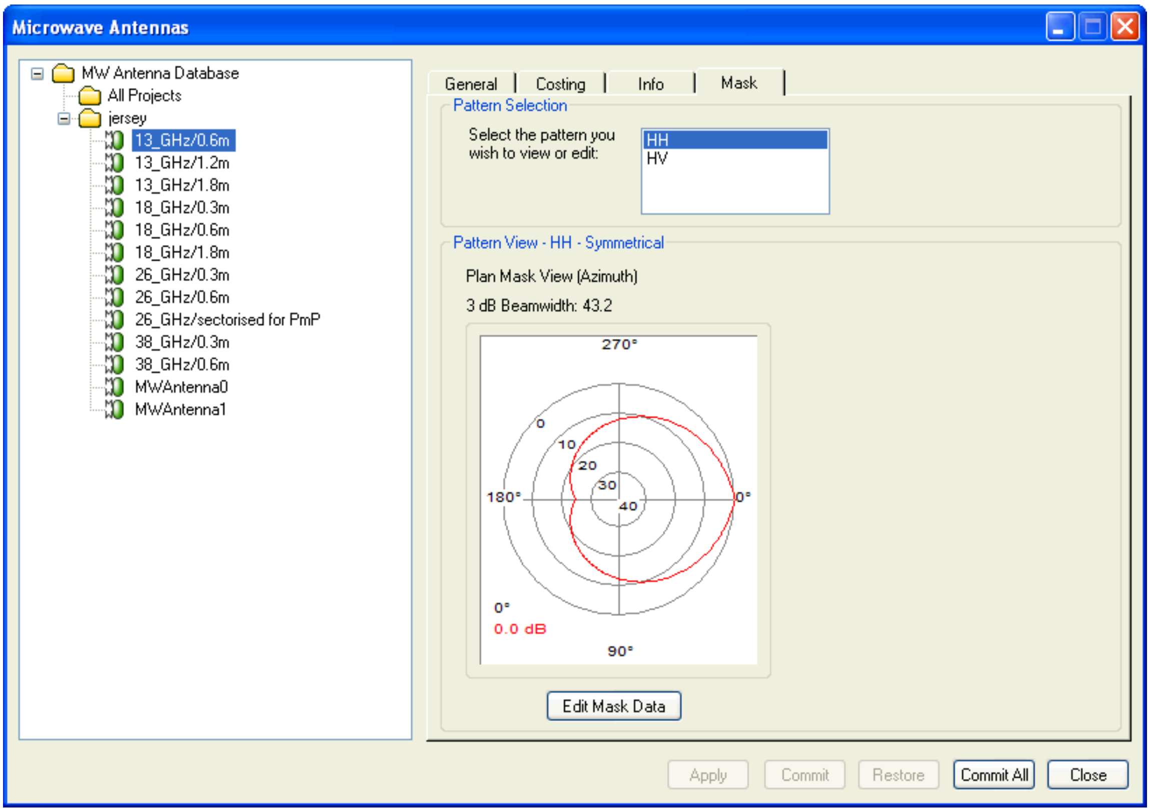
Defining Microwave Antenna Parameters

As antennas are important elements of a network, many parameters can be held against each antenna including supported polarizations (vertical/horizontal/dual), manufacturer name and a photograph of the antenna.

Depending on the supported polarizations, up to four radiation patterns (with 1 or 2 masks each) can be defined for each antenna, based on the losses for different values of antenna azimuth and inclination. The losses represent the reduction in MW antenna gain from the MW antenna pattern's point of maximum gain. The patterns can be viewed graphically, and edited accordingly.

ASSET Backhaul supports both point to multi-point and point to point antennas, and you can define the appropriate mask style accordingly - either symmetrical (for PtP antennas) or non-symmetrical (for PmP antennas).

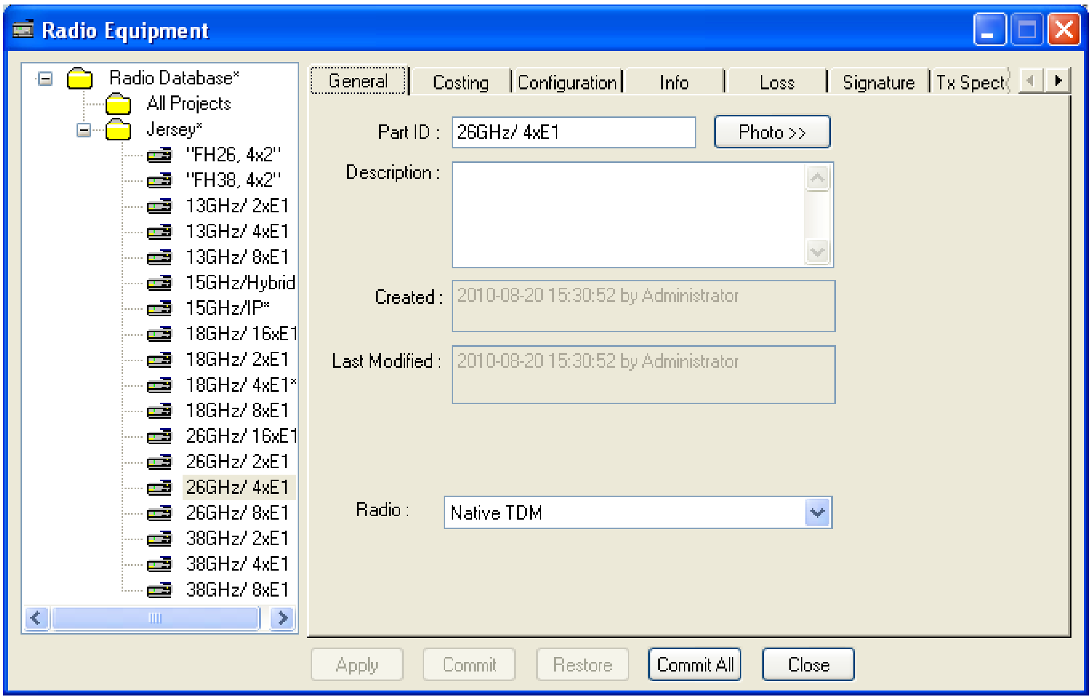
This picture shows an example antenna:



Example antenna in the Microwave Antennas dialog box

Defining Radio Equipment

Radio equipment parameters are defined in the Radio Equipment dialog box:



Example Radio Equipment dialog box

The parameters for radio equipment can usually be found in the manufacturer's datasheets.

To add a radio:

1. Select the folder to which you want to add the radio - either **All Projects** or just the current project.
2. Right-click, and from the menu that appears, click **New Radio**.
3. In the **Part ID** name type the name of the radio equipment.

Tip: When defining a Part ID name, include the radio equipment name, carrier frequency and capacity, such as DMC 7, 16x2 (representing a 7 GHz radio that has capacity of 16 x 2 Mbit/s) so you can see all this information at a glance in the Link Database.

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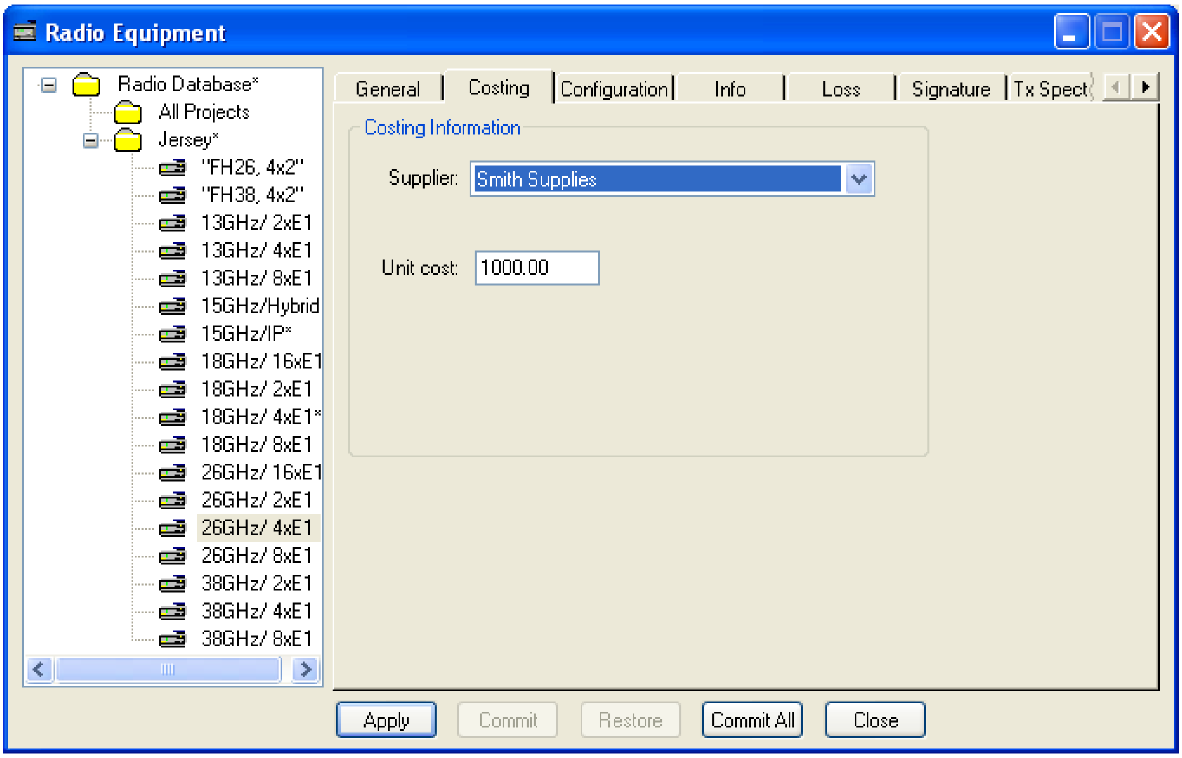
4. If required, add a description of the radio equipment.
5. From the **Radio** drop-down list, select the radio type, which indicates the type of traffic that the radio can support - Native TDM traffic only, Native IP traffic only, or a Hybrid of TDM and IP traffic.

   You can define the rest of the radio parameters on the other tabs in this dialog box.

Defining the Costs for Radio Equipment

When defining radio equipment, you can define the cost of a radio on the **Costing** tab of the **Radio Equipment** dialog box. This data can then be used along with other costs to evaluate the total cost of a site. You can select the name of the supplier from a list (defined in the **Equipment Supplier properties** dialog box) and the cost of the radio equipment.

This picture shows an example:

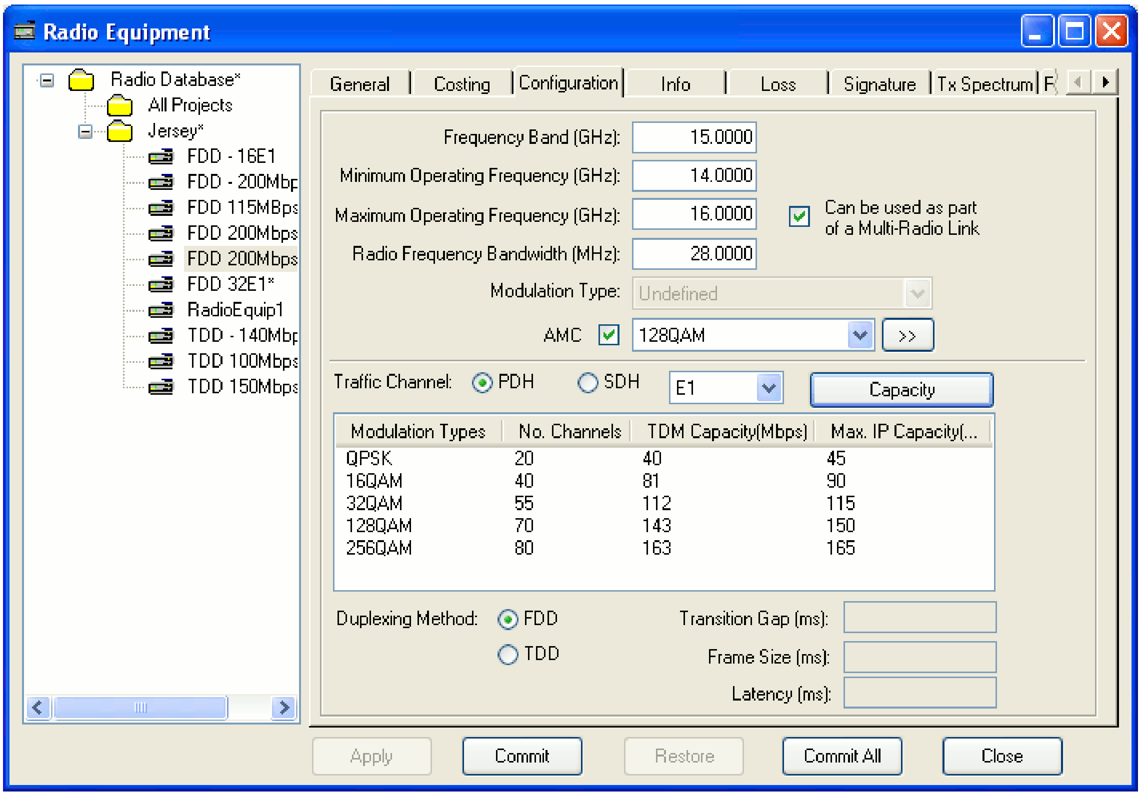


Costing tab for Radio Equipment

Defining the Frequency and Capacity of Radio Equipment

When defining radio equipment, you can provide frequency and capacity information on the **Configuration** tab of the **Radio Equipment** dialog box.

This picture shows an example:



Radio Equipment Configuration tab

To define the frequency and capacity information, specify the following parameters:

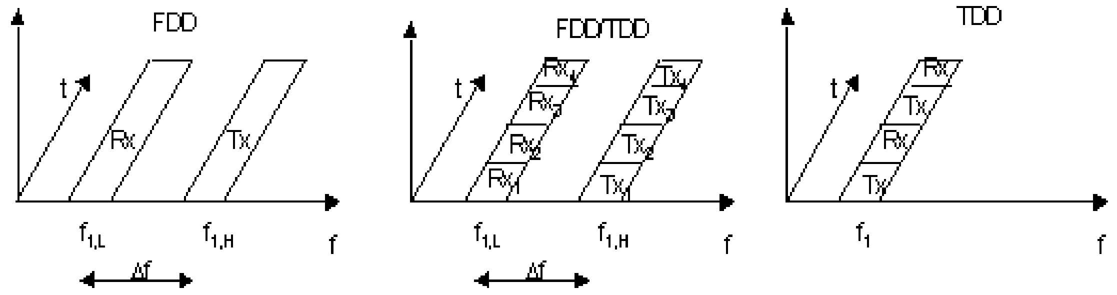
Item	Description
Frequency Band (GHz), Minimum Operating Frequency (GHz). Maximum Operating Frequency (GHz)	The frequency band and minimum/maximum operating frequencies in GHz are usually supplied by the manufacturer. **Important:** Ensure you set the correct values, as frequency band is an important value for the interference calculation. If you use this radio in these calculations and its frequency is not appropriate, ASSET Backhaul will warn you.
Radio Frequency Bandwidth (MHz)	This is the transmitted signal bandwidth and, along with the modulation scheme, is an important factor in determining the radio capacity. The higher the modulation scheme, the lower the bandwidth requirement for a particular capacity. This should also be supplied by the manufacturer.

Item	Description
Modulation Type	You can assign a modulation type to the radio equipment, which will determine how transmitted signals are modulated to achieve the required capacity demands. In ASSET Backhaul, you can use modulation types in two different ways: • Static : You select a fixed modulation type that can only be changed manually, regardless of the throughput requirements. • Dynamic : Using Adaptive Modulation Coding (AMC), you define a range of modulation types that can be used on this radio. ASSET Backhaul can then select the most appropriate one depending on the throughput requirements at that time. **Note:** You cannot assign a dynamic modulation type to Native TDM radios. To assign a static modulation type, from the Modulation Type drop-down list, select the required modulation type. - or - To assign a dynamic modulation type: • Select the AMC checkbox. • Click the AMC Schemes button >> . • In the dialog box that appears, select all of the modulation types that you want to make available for this radio. To select or deselect all modulation types, right-click in the list, and from the menu that appears, click either Select All or Clear All as required. **Note:** If AMC is enabled on a link using this radio, then the best available modulation type based on the throughput requirements will be assigned to the radio. For more information, see Defining the Required Throughput and Modulation Type for Linkends on page 137. • Click OK. By default, the highest available modulation scheme is selected for the radio, but you can select an alternative if required. The default modulation scheme is used if AMC is not enabled on the link. For more information, see Defining the Required Throughput and Modulation Type for Linkends on page 137.
Can be used as part of a Multi-Radio Link	Select this option if you want to be able to use this radio equipment on a multi-radio link.

Item	Description
Radio Capacity - No. Channels, TDM Capacity (Mbps) Max IP Capacity (Mbps)	To define the radio capacity that will be used for any microwave link with this radio equipment set on the linkend, click the Capacity button. If you are using AMC, you can define the capacity separately for each modulation type available on the radio. If you are not using AMC, then you will only be able to define the parameters for the static modulation type. For Native TDM Radios, define the traffic channel-based radio capacity by. • Choose either the PDH or SDH option. • Select the required capacity type - E1, J2, STM0, STS24 and so on. • Click the Capacity button. • Specify the number of channels. • Click OK. The total capacity that this configuration generates is calculated and displayed as the TDM Capacity (Mbps). For example, you could define a 4 x E1 capacity (for PDH), giving a total capacity of 8 Mbps (8,192 Kbps), or 8 x STM16 (for SDH), giving a total capacity of 19,906 Mbps (19,906,560 Kbps). For Native IP Radios: • Click the Capacity button. • Type the maximum IP capacity that this radio supports for each modulation. If you have imported radio equipment from previous versions of ASSET Backhaul, this value corresponds to the previous IP Interface Capacity value, which was a defined value rather than a calculated one. If the value does not exist, then the calculated one will be used. **Important:** Each radio has a maximum capacity, based on multiplying the number bits per modulation order symbol by the bandwidth. If you have not defined the modulation set correctly, it is assumed to have zero bits per modulation symbol. When you define the radio capacity, it should not exceed the maximum capacity per modulation. **Note:** If you are defining a TDD radio, the traffic capacity is aggregated for both directions, and will be based additionally on the defined frame size, transition gap and latency. For more information, see How the Maximum Capacity is Calculated for TDD Radios on page 328. For Hybrid IP and TDM Radios: • Click the Capacity button. • Define the traffic channel-based radio capacity (as described for a Native TDM radio). • Define the maximum IP capacity (as described for a Native IP radio).
Duplexing Method	Select the appropriate duplexing method, either Frequency Division Duplex (FDD) or Time Division Duplex (TDD). For more information, see About Duplexing Methods on page 34.
Frame Size (ms), Transition Gap (ms), Latency (ms)	If you have selected TDD , then you should define the following parameters: • Frame Size (ms) - The duration of the each timeslot in the TDD link. • Transition Gap (ms) - The time required for the radio to move from transmission to reception mode, or vice versa. • Latency (ms) - The total time delay, during which the TDD link can be regarded as unavailable. This value typically depends on the transition gap and the propagation delay, but you can also set a value here to keep it at a constant level.

About Duplexing Methods

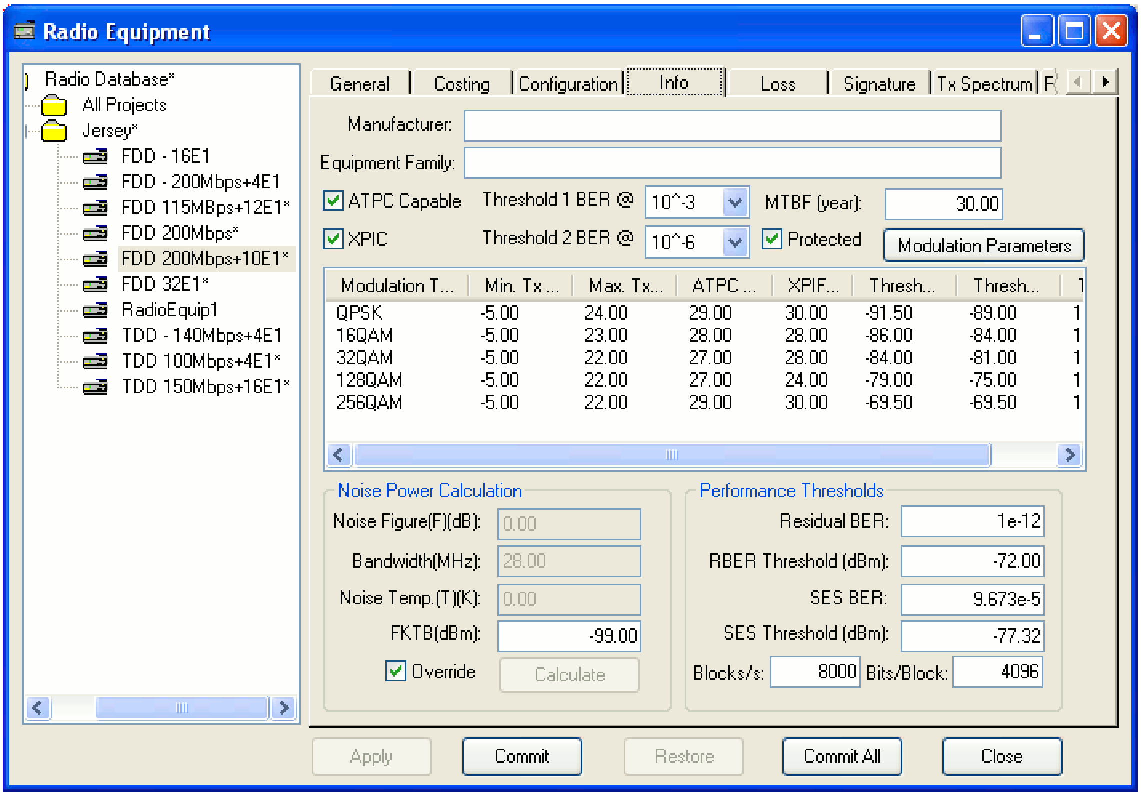
Digital systems can use either Frequency Division Duplex (FDD) or Time Division Duplex (TDD). The main differences between duplexing methods are shown in this picture:



In the TDD duplexing method the radio will transmit and receive on the same channel (frequency), whereas with the FDD duplexing method the radio will transmit and receive at different frequencies. FDD/TDD is a combination of both methods.

Defining the Parameters of Radio Equipment

When defining radio equipment, you can specify the equipment specifications on the **Info** tab of the **Radio Equipment** dialog box. This picture shows an example of the Info tab:



Radio Equipment Info tab

This table describes the general parameters for radio equipment:

Item	Description
Manufacturer	The name of the manufacturer of the radio equipment.
Equipment Family	The name of the equipment family that the radio equipment belongs to.
ATPC Capable	Indicates whether or not the radio equipment is able to use Automatic Transmit Power Control (ATPC). ATPC enables radio equipment to change its transmit power in order to offset the reduction in the received power caused by the Fade Margin.
Threshold 1 BER @ Threshold 2 BER @	The receiver threshold is the minimum signal level that the radio is able to discriminate a signal from the noise floor for a particular signal quality (or Bit Error Rate), usually 10^{-3} or 10^{-6}. This level is typically around the –80dBm level. For TDM or Hybrid IP and TDM radios, these values are used to calculate the Performance Thresholds. For more information, see Calculating Actual ESR, SESR and BBER for Links on page 291. In ASSET Backhaul, the receiver thresholds are set in two stages: • The signal quality/BER for each threshold is specified per radio, using these two drop-down lists • The signal level is specified per modulation type **Note:** If you are defining a Hybrid IP and TDM radio, and have enabled AMC on this radio, the threshold values for the default modulation type are used.
MTBF	The mean time between failures in the link. The manufacturer may provide this to show how reliable the component is. A nominal outdoor example would be one failure every 40 years. This value is used to calculate unavailability caused by equipment. **Note:** The MTBF value should be valid for an outdoor unit + indoor unit and since the same outdoor unit can operate with several different indoor units, this value varies significantly. That is, the actual MTBF value is dependent on: • The outdoor unit type (FlexiHopper, MetroHopper, DynaHopper, DMR, and so on) • The indoor unit type (FIU 19, RRIC, W, CE, and so on) • Used capacity (2x2 Mbit/s, 4x2 Mbit/s, 8x2 Mbit/s and so on) • Protection used
XPIC	Select the checkbox to enable a cross polar interference canceler on this radio equipment.
Protected	Indicates whether or not the radio equipment is protected.

Item	Description
Manufacturer	The name of the manufacturer of the radio equipment.
Noise Power Calculation	This pane contains the values that are used to calculate the FKTB value, which is the threshold for thermal noise at the receiver. The following values are used: F = Receiver Front-end Noise Figure (can be supplied by the equipment vendor) K = Boltzmann's constant $(1.38 \times 10^{-23}\,\mathrm{J/K})$ T = Thermal Noise Temperature (taken to be 290 Kelvin) B = Bandwidth of the receiver (MHz) If you are creating new radio equipment, you can enter the F, T and B values yourself, and then click Calculate to generate the FKTB value. - or - If you want to set a specific FKTB value yourself, select the Override option and type your own value in. **Note:** If you have imported your radio equipment, some of the values may already be present.
Performance Thresholds (for TDM or Hybrid IP and TDM Radios only)	This pane contains the values that will be used when ASSET Backhaul calculates the objectives performance targets. For more information on how these values are used in the calculations, see Objectives Equations on page 287. The required values are: • Residual BER and its corresponding threshold • The BER value that causes a severe error second and its corresponding threshold • The number of blocks per second • The number of bits per block Unless you have imported the values from a radio equipment file, these values (apart from Residual BER, which uses a default value) are approximated. These are calculated when the radio is initially selected in the Radio Equipment dialog box or the Link Database. This is done based on the threshold values and capacity, using the calculations described in Approximation Method for Calculating ESR, SESR and BBER on page 292. You can overwrite these values, but ASSET Backhaul will not recalculate the other values based on this. **Note:** You cannot Apply changes of less than 0.005 dBm to the RBER threshold or the SES threshold.

You can also define a number of parameters separately for each modulation type available on the radio:

Note: If you are not using AMC, then you will only be able to define the parameters for the static modulation type.

Item	Description
Min TX Power and Max TX Power	The lowest and highest power that the radio can transmit (before the antenna).
ATPC Range (dB)	If you have made the radio equipment ATPC capable, you can specify an acceptable range value, which can be added to the Min Tx Power or subtracted from the Max Tx Power as required.
XPIF (dB)	If you have enabled an XPIC on this radio equipment, you can type your own cross polarization improvement factor, which will be used in the link interference calculations.
Threshold 1 and 2 (dBm)	The minimum signal levels that correspond to the two signal quality/BER thresholds set for the radio.
T/I Objective (dB)	The T/I Objective for an interferer with the same bandwidth and same frequency (in other words, with a frequency separation of 0). This value is used to determine any significant interferers if no T/I objectives tables or Transmit Spectrum Density/Rx Selectivity masks are available.

To edit these parameters:

1. Click the **Modulation Parameters** and modify these parameters for each modulation type as required.

   Tip: You can use a set of default threshold values that are calculated based on the bandwidth and operating frequency requirements defined on the **Configuration** tab. To do this, click the **Default Values** button.

   For more information, see About the Default Transmit Power Values for Modulation Types on page 377 and About the Default Receiver Threshold Values for Modulation Types on page 378.

2. When you are satisfied with the defined values, click **OK**.

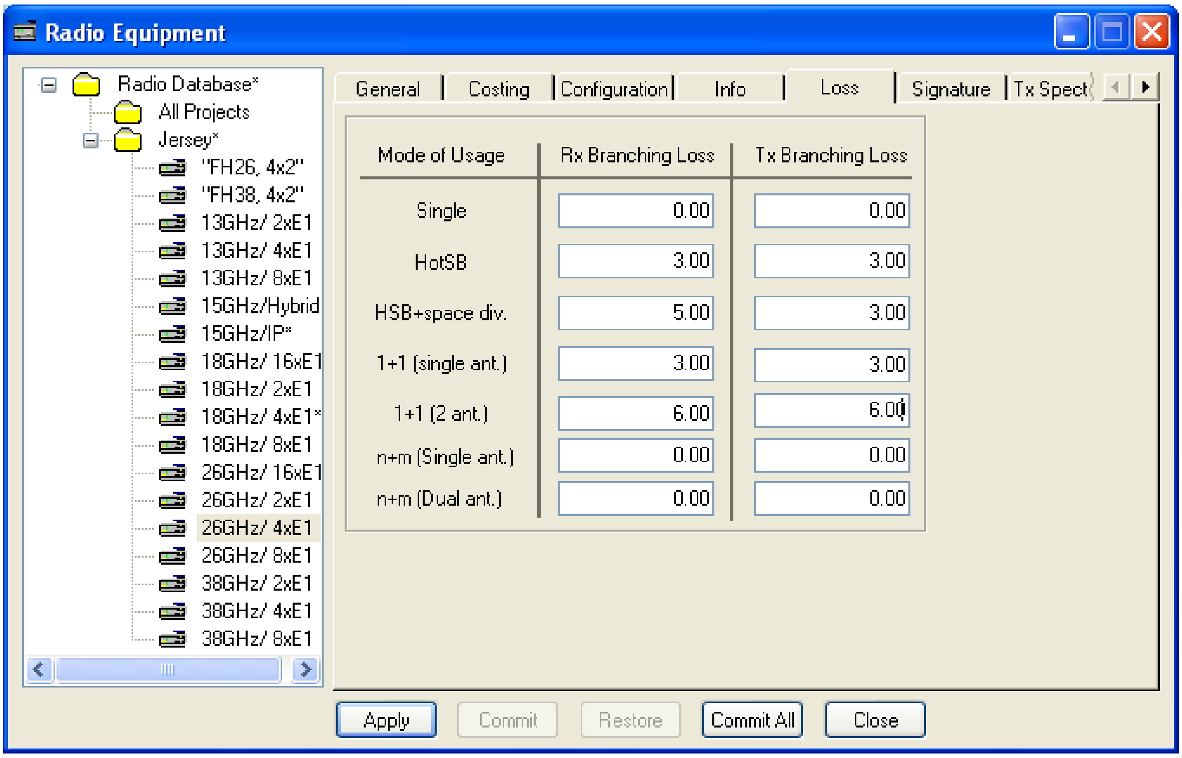
   Important: If you change the operating bandwidth after you have defined the AMC thresholds, you must open the **Modulation Parameters** dialog box and correct the values accordingly.

Tip: You can usually get values for most of these parameters from the manufacturer's datasheets.

Defining the Losses for Radio Equipment

When defining radio equipment, you can define the branching losses for different modes of usage on the **Loss** tab of the Radio Equipment dialog box. For more information on protecting links in the Link Database, see Using Diversity in the Link Database on page 111.

This picture shows an example Loss tab:



Loss tab for Radio Equipment

When defining radio equipment parameters, follow these steps for information on what to add to the Loss tab:

1. Ensure you view the manufacturer's datasheets for accurate branching loss values.

2. On the Loss tab, set all losses (filters, circulators and so on) in dB summed as a single Rx branching loss and a single Tx branching loss for these modes of usage:

Mode	Description
Single	An unprotected system (losses here are commonly the result of filters and circulators).
HotSB	In the Hot Standby configuration, there is a complete set of equipment. If a failure occurs in the primary radio, switching allows the second radio to transmit, usually on the same microwave antenna and feeder.
HSB+space div.	This is a combination of HotSB and space diversity.
1+1(single ant.)	An inband frequency diversity, where two links are set up over the same hop route to allow for constant link stability, with a single antenna.
1+1(2 ant.)	As 1+1(single antenna) but with 2 antennas.
n + m (Single ant.)	In this configuration, multiple radios are used on the same link.
n + m (Dual ant.)	As n + m (single antenna) but with 2 antennas.

The values defined here are used in link budget calculations.

Defining Fading Signature Parameters for Radio Equipment

When defining radio equipment, you can include information related to ITU-regulated selective fading on the **Signature** tab of the **Radio Equipment** dialog box.

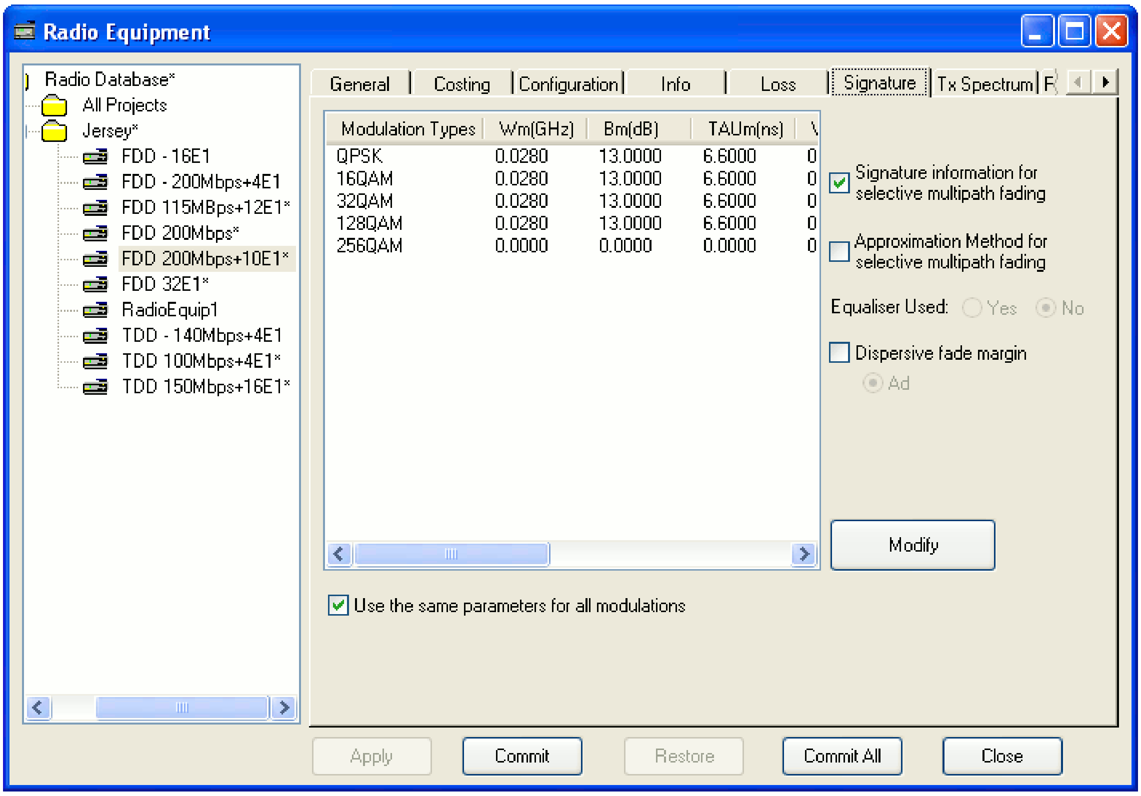
You can define the fading signature parameters separately for each modulation type that is available for the radio, or use the same values for all modulation types.

Important:

- The multi-path outage calculation results will be based on these parameters and are only valid for the specific error rate corresponding to these values. If the results of these calculations are required at a different error rate, you must include the signature data for this new error rate.
- Selective fading is only relevant when hop length is really long, used capacity is large and low frequencies are used.
- If you are not using AMC, then you will only be able to define the parameters for the static modulation type.

For information on the methods that you can use, see Selective Fading Outage Equations on page 299.

This picture shows an example Signature tab:



Example Signature tab

If you want to use the same values for every modulation type available to the radio (based on the modulation type specified on the Configuration tab of the Radio Equipment dialog box), ensure that the 'Use the same parameters for all modulations' option is selected. If you choose this option, when a change is made for one modulation type the other modulation types will be updated to reflect the change as well.

To define the signature information for selective multipath fading:

1. Select the **'Signature information'** checkbox.
2. Click the **Modify** button.
3. In the dialog box that appears, define the following values for each modulation type as required:

Item	Description
Wm (GHz) / Wnm (GHz)	Minimum Signature Width in Minimum/Non-Minimum Phase Conditions.
Bm (dB) / Bnm (dB)	Frequency Notch Attenuation in Minimum/Non-Minimum Phase Conditions.
TAUm (ns) / TAUnm (ns)	Frequency Delay in Minimum/Non-Minimum Phase Conditions.

Note: Of the three methods, the Signature method is generally regarded as the most accurate. It is also the method most commonly supported by equipment manufacturers.

To define the approximation method for selective multipath fading:

1. Select the **'Approximation Method'** checkbox.
2. Select whether or not an equalizer is used.
3. Click the **Modify** button.
4. In the dialog box that appears, define the following values for each modulation type as required:

Item	Description
Kn	The normalized system parameter. For more information, see ITU-R. F.1093-2.
Reduced Ratio	If you have specified that an equalizer is used, then this value is used as a multiplier for the Kn value to improve performance.

To define the dispersive fade margin:

1. Select the **'Dispersive fade margin'** checkbox.
2. Click the **Modify** button, and in the dialog box that appears, set the **Ad** value.

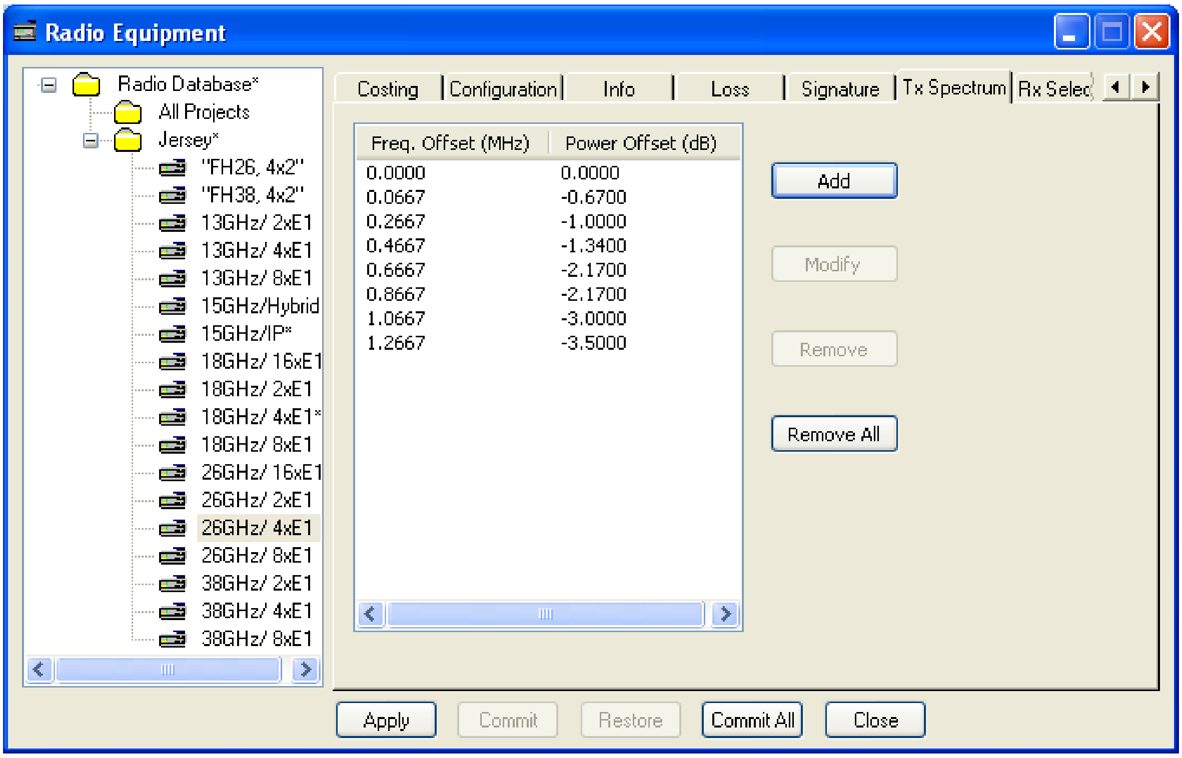
   This value represents a single non-calculated fade margin value. For more information, see Dispersive Fade Margin Method on page 300.

Defining Transmit Spectrum Density Masks for Radio Equipment

When defining radio equipment, you can define the transmit spectrum density mask on the **Tx Spectrum** tab of the **Radio Equipment** dialog box.

Vendors now commonly supply transmit spectrum density mask and receive selectivity mask information. These values can then be used to calculate interference in a more efficient and straightforward way than by using T/I objectives tables.

This picture shows an example:



Tx Spectrum tab for Radio Equipment

The transmit spectrum density mask and the receive selectivity mask are used to calculate interference.

For more information on the interference calculations, see Interference Equations on page 301.

To define the transmit spectrum density mask:

1. Click the **Add** button.
2. In the dialog box that appears, type your required frequency offset (in MHz) and associated power offset (in dB).

Tip: The offsets can be positive or negative.

---

3. Click **OK**.
4. Repeat steps 1 to 3, until you have defined all of the offset values for the mask.

Tip: A complete mask consists of a curve of both negative and positive offset values. If you define just the positive set of values, ASSET Backhaul automatically 'mirrors' these values on the negative side to create the full mask.

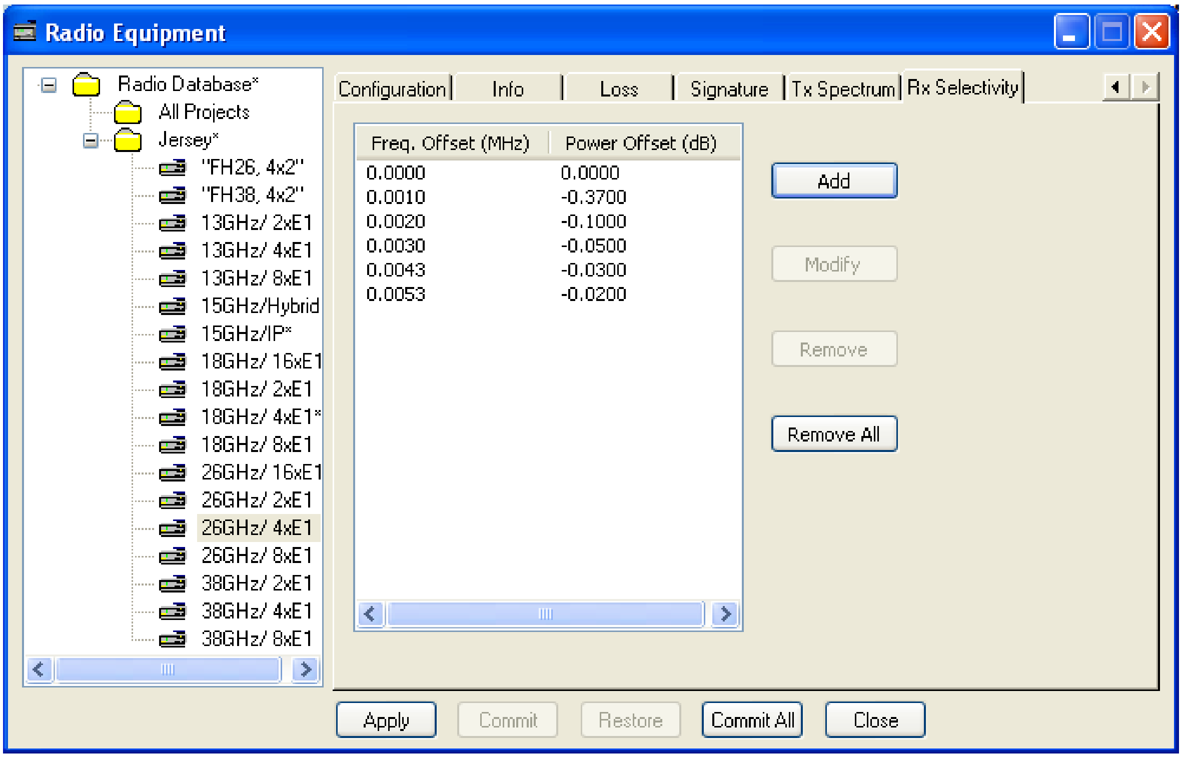
---

5. Click **Apply**.

Defining Receive Selectivity Masks for Radio Equipment

When defining radio equipment, you can define the receive selectivity mask on the **Rx Selectivity** tab of the **Radio Equipment** dialog box.

This picture shows an example:



Rx Selectivity tab for Radio Equipment

The receive selectivity mask, and transmit spectrum density mask, are used to calculate interference.

For more information on the interference calculations, see Interference Equations on page 301.

To define the receive selectivity mask:

1. Click the **Add** button.
2. In the dialog box that appears, type your required frequency offset (in MHz) and associated power offset (in dB).

   Tip: The offsets can be positive or negative.

3. Click **OK**.
4. Repeat steps 1 to 3, until you have defined all of the offset values for the mask.

   Tip: A complete mask consists of a curve of both negative and positive offset values. If you define just the positive set of values, ASSET Backhaul automatically 'mirrors' these values on the negative side to create the full mask.

5. Click **Apply**.

Defining Link Terminal Equipment

It is recommended that you include the necessary terminal equipment that you intend to use in your project, for example multiplexers, indoor units and so on, before you start planning.

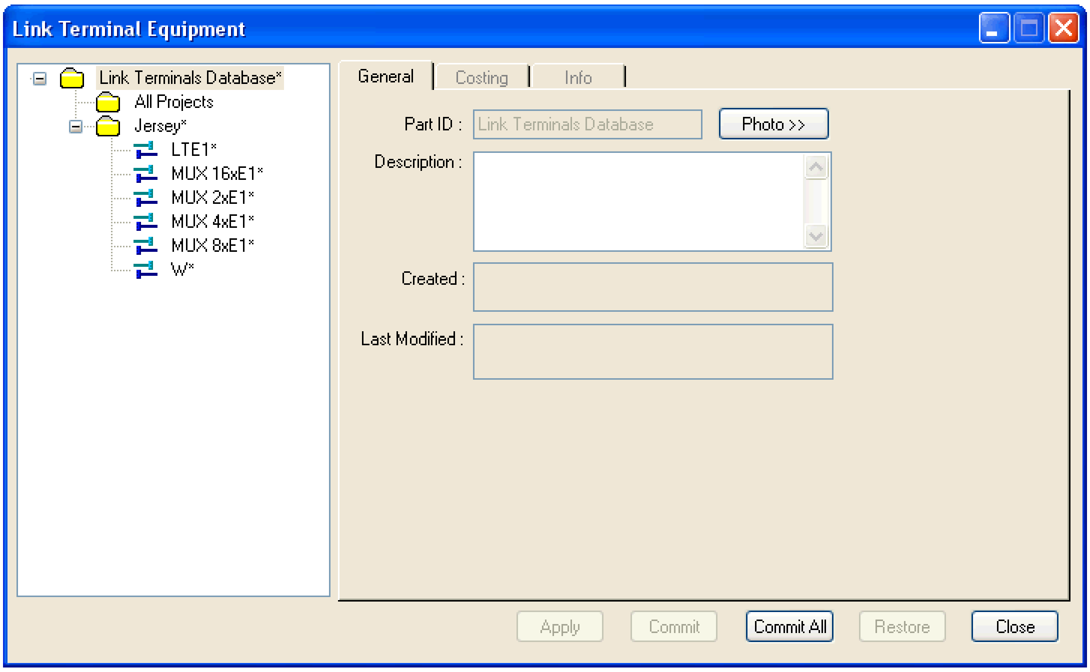
This information is important for costing your network.

To define link terminal equipment:

1. From the **Equipment** menu, click **Link Terminals**.

   The **Link Terminal Equipment** dialog box displays the link terminals available to the current project - which includes those specific to this project and those available to all projects.

   This picture shows an example:



2. Select the folder to which you want to add the link terminal, either the current project or **All Projects**.

3. Right-click, and from the menu that appears, click **New Link Terminal**.

   A link terminal with a default name appears in the list.

4. Select the new link terminal and add the required data on the tabs:

On this tab	Do this
General	Type a description which should include any information that you might find useful when planning a network, such as the model of indoor unit, type of cross connector and so on. Click Photo to display a photograph of the component or to search for and assign a photograph.
Costing	Select the supplier (from those you have set in the Equipment Suppliers dialog box) and type a unit cost. This cost parameter gives a weighting of suitability to a particular link terminal type.
Info	Type the manufacturer's name, and Input and Output types.

Tip: You can move, delete and rename link terminal equipment. For more information, see Managing Equipment Folders on page 27.

Defining Feeders

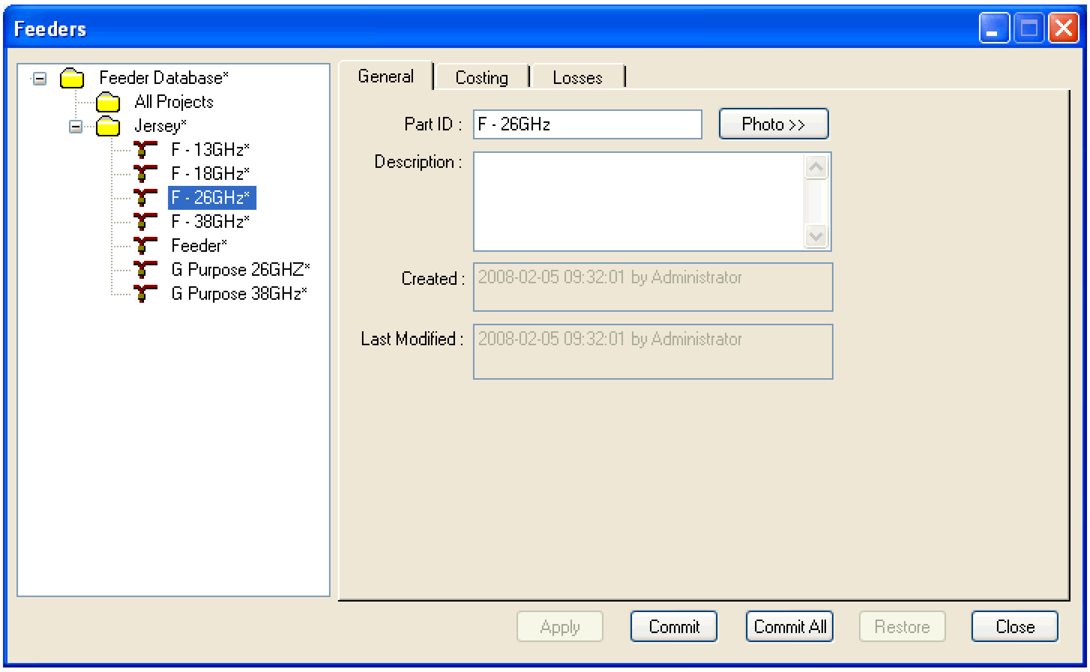
A microwave station includes 'plumbing', which typically consists of lengths of waveguides and connectors used to connect the transmitter and receiver to the antenna. It is important to define your feeders as accurately as possible, because they incur losses which will affect the performance of your network.

To define feeders in ASSET Backhaul:

1. From the **Equipment** menu, click **Feeders**.

   The **Feeders** dialog box displays the feeders available, to all projects and just the current project as well.

   This picture shows an example:



2. Select the folder to which you want to add the feeder, either the current project or **All Projects**.

3. Right-click, and from the menu that appears, click **New Feeder**.

   A feeder with a default name appears in the list.

4. Select the new feeder and add the required data on the tabs:

On this tab	Do this
General	In the Part ID box, type the user-defined name of the selected feeder to a maximum length of 18 characters. Click Photo to display a photograph of the component or to search for and assign a photograph.
Costing	Select one of the manufacturers from the list of suppliers that you have defined. Add a unit cost for the feeder.

On this tab	Do this
Losses	Specify the frequency band that the feeder is valid for. Specify the feeder loss on a per meter basis (not dB/100 m). The total loss of all connectors (around 0.5-1 dB per station) should also be included. Specify the feeder weight, in kg per meter.

Feeder parameters are important to realistically model losses incurred in microwave link equipment. This is especially important because losses incurred at SHF are usually greater than those experienced at UHF.

These losses are used in the link budget calculations and can be viewed on the **Link Budget** subtab of the **Performance** tab of the **Link Database**. For more information, see Viewing Link Budget Performance Results on page 158.

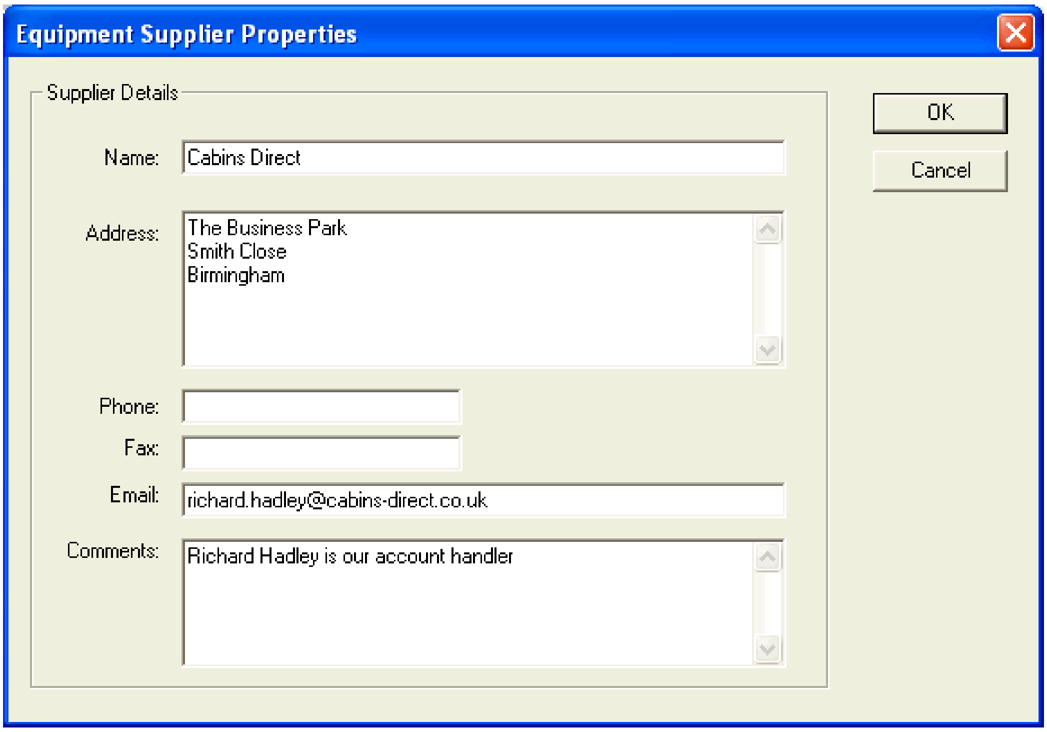
Tip: You can move, delete and rename feeders. For more information, see Managing Equipment Folders on page 27.

Adding Equipment Suppliers' Details

To store key equipment suppliers' details, and assist you in defining your equipment:

1. From the **Equipment** menu, click **Suppliers**.
2. In the dialog box that appears, click **Add**.
3. In the **Equipment Supplier Properties** dialog box, type the required supplier details, such as **Name**, **Address** and **E-mail**.

   This picture shows an example:



Adding Microwave Antennas

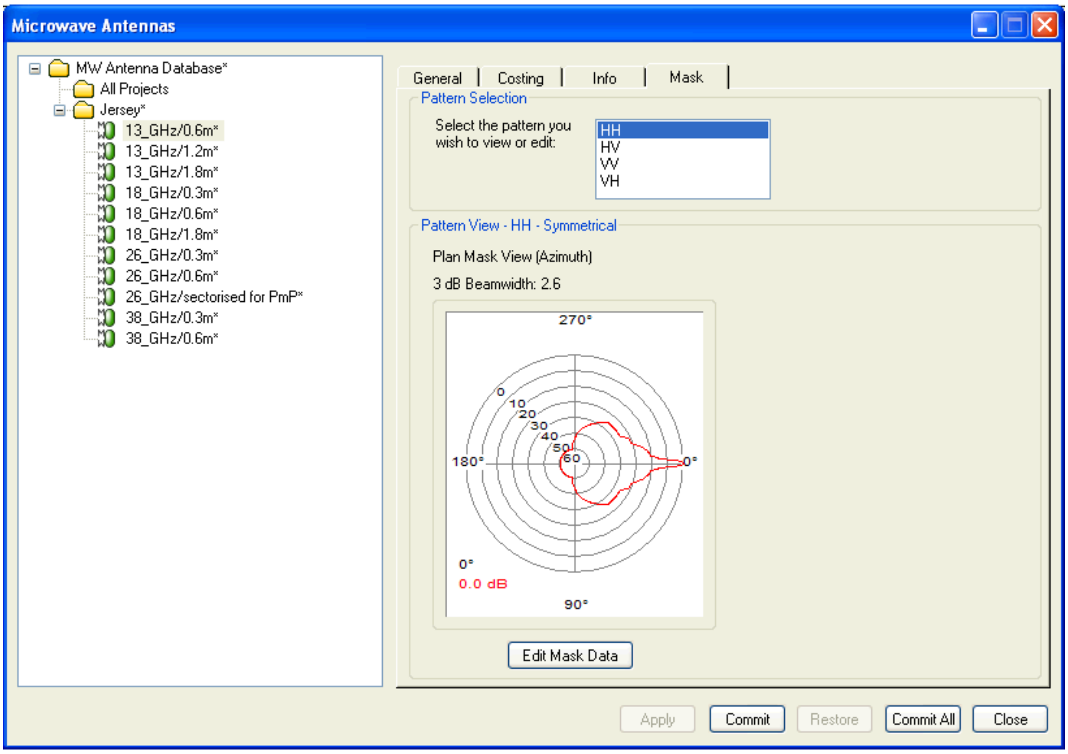
You can add microwave antennas to the antenna inventory in a number of ways:

- If you have the required microwave antennas stored in a file that uses one of the supported formats, you can import them. For more information, see 'Importing Microwave Antennas' in the *ASSET Backhaul User Reference Guide*.
- If you have the manufacturer's datasheets, or know the parameters (dimensions, masks and so on) that the antennas should have, you can add them manually.

To add an antenna manually:

1. Ensure you have write permissions for equipment.
2. From the **Equipment** menu, click **MW Antennas**.

   The **Microwave Antennas** dialog box appears:



3. Select the project folder in which you want to store the new antenna(s). You need the correct privileges to add antennas to the **All Projects** folder.
4. Right-click and from the menu that appears, select **New MWAntenna**.
5. Add the required information on the tabs including:

On This Tab	Do This
General	In the Part ID box, type the user-defined name of the selected antenna device to a maximum length of 31 characters. In the Description box, type in a description for your antenna device. Click Photo to display a photograph of the component or to search for and assign a photograph. ENTERPRISE automatically writes the Created and Modified boxes when a new antenna is created or modified.

On This Tab	Do This
Costing	Select one of the manufacturers from the list of suppliers that you have entered. Add a unit cost for the antenna.
Info	Define the gain for the selected beam pattern, referenced to either an isotropic (dBi) or a dipole (dBd) antenna. Specify the physical dimensions of the antenna - its diameter and weight. Specify the frequency band of the beam pattern, the minimum and maximum operating frequencies and the front to back ratio. Type the manufacturer's name in the appropriate box. Specify which type of polarization is used in this beam pattern - either single polarization (which can be horizontal, vertical or both (crosspolar)) or dual polarization. **Tip:** If you want the antenna to be used in dual polar links, select dual polarization. The polarization type that you choose will affect the number of masks you have to define on the Mask tab. Select the required mask style, depending on your link type: • If you are defining an antenna for a PtP link, a symmetrical mask is appropriate. In a symmetrical mask, the horizontal and vertical planes share the same mask. • If you are defining an antenna for a PmP link, a non-symmetrical mask is appropriate. In a non-symmetrical mask, different masks are used for the horizontal and vertical planes. If you are using NSMA format antennas, define: • The FCC/ETSI ID - the ID number issued by the Common Carrier Branch of the FCC. For services that do not issue ID numbers, insert NONE to ensure the antenna can be exported correctly. • The Pattern ID - The reverse pattern FCC ID number. The reverse pattern is generally obtained by inserting the feed in an opposite manner in order to reverse the pattern. • The Half Power Beam Width - This is the included angle centered on the main beam of the antenna and defines the angle where the antenna response falls below -3dB.
Mask	Select the pattern that you want to view. The number of patterns available will be based on the polarization type selected on the Info tab. For more information on the available types, see About the Microwave Antenna Patterns on page 47. A graphical illustration of the chosen pattern is displayed, along with the 3dB beamwidth. You can edit the mask data to show losses for different values of antenna azimuth (or elevation). For more information on how to do this, see Editing the Mask Data for Microwave Antennas on page 48. **Note:** Symmetrical patterns are indicated by an asterisk (*) next to the angle.

About the Microwave Antenna Patterns

On the **Mask** tab for a microwave antenna, the patterns are listed using abbreviations:

- V stands for vertical and H for horizontal
- The first letter shows the polarization that the antenna transmits
- The second letter shows the polarization of the signal being received

For example, a VH pattern transmits on the vertical plane and receives on the horizontal plane.

Depending on the polarization type you have selected on the **Info** tab, you should define the following patterns:

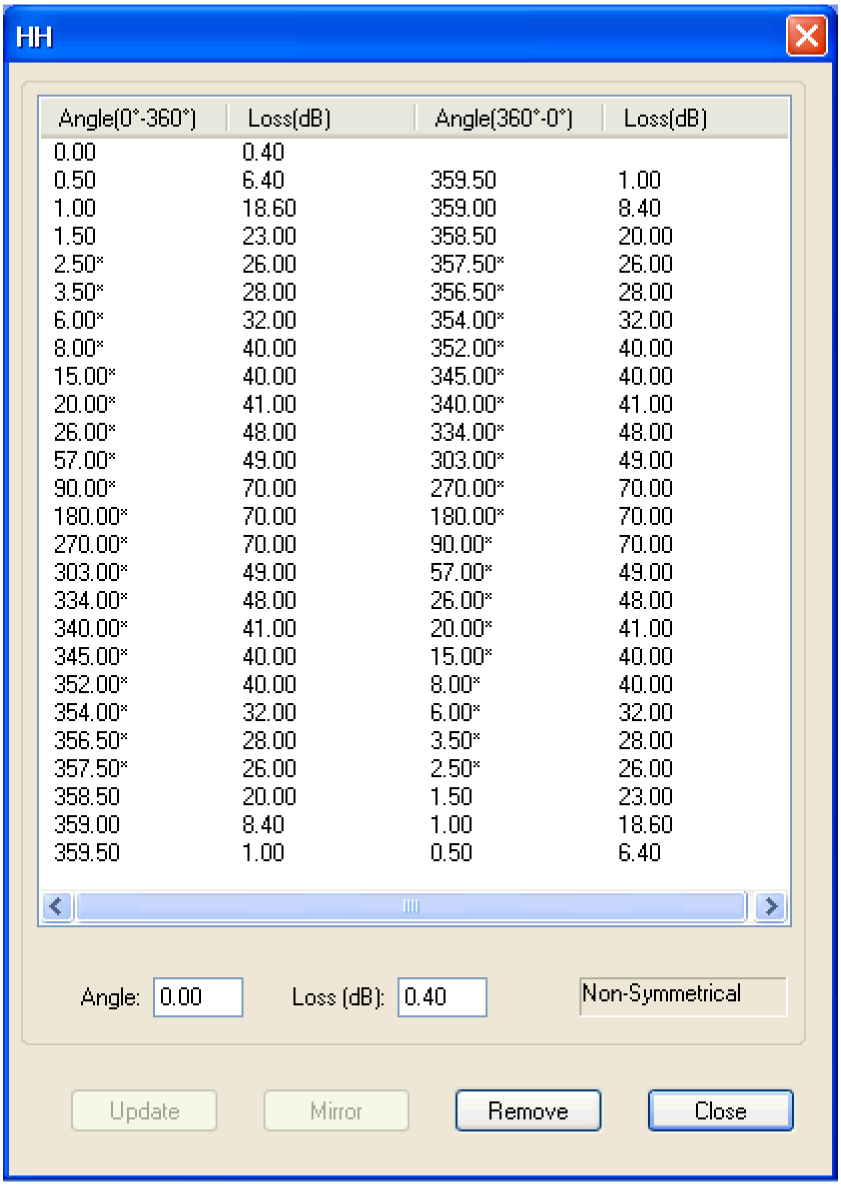
Polarization Type	Masks Required
Single Horizontal	HH HV
Single Vertical	VV VH
Single Horizontal and Vertical - or - Dual	HH HV VV VH

Note: Symmetrical patterns are indicated by an asterisk (*) next to the angle.

Editing the Mask Data for Microwave Antennas

On the **Mask** tab for a microwave antenna, you can click **Edit Mask Data** to see a table listing losses for different values of antenna azimuth (or elevation). These losses are the reduction in MW antenna gain from the MW antenna pattern's point of maximum gain.

This picture shows an example:



Example mask data for an antenna

You can add and change data in the table and this is then shown in the illustration on the **Mask** tab.

For the angle, you can enter values to 2 decimal places.

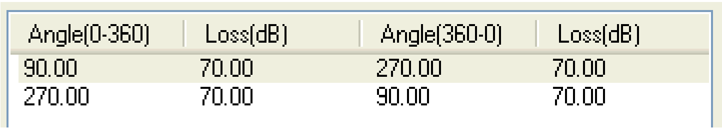
Tip: The mask that you want to add may be symmetrical - that is, have matching loss values for both sides of the mask (from 0° to 360° and from 360° to 0°, but not including 0° and 180°).

To quickly add a symmetrical mask:

1. Add one side of the mask (either the angle from 0 to 360 degrees, or the angle from 360 to 0 degrees) and the accompanying loss, and then click **Add**.

2. Click the **Mirror** button.

   The other side of the mask, and its corresponding row, are created automatically. If you subsequently update one of the rows, this is reflected in the corresponding row.



Angle(0-360)	Loss(dB)	Angle(360-0)	Loss(dB)
90.00	70.00	270.00	70.00
270.00	70.00	90.00	70.00

   Symmetrical masks are indicated by the word 'Symmetrical', and an asterisk (*) next to the angle in the list.

Important: Make sure that you have entered all the required antenna radiation patterns (VV, VH, HV and HH). Lacking one antenna radiation pattern might affect interference calculation results.

Editing, Moving and Deleting Microwave Antennas

Provided that you have write access to the **Microwave Antennas** dialog box, you can edit, move or delete MW antennas.

To edit an existing MW antenna:

1. From the **Equipment** menu, click MW Antennas.
2. In the Microwave Antennas dialog box, click on the antenna you wish to edit.
3. Edit the required information on the tabs.
4. When finished, click **Apply** and, if required, **Commit**.

To move an existing antenna to a different folder in the Microwave Antennas dialog box:

1. In the Microwave Antennas dialog box, select the antenna you want to move.
2. Drag and drop it to the appropriate folder.

Tip: Alternatively, you can use the **Cut** and **Paste** options from the right-click menu.

Warning: If you move antennas between projects, you cannot restore them to their original project by clicking the **Restore** button.

To delete a single antenna or antenna beam pattern:

1. In the Microwave Antennas dialog box, right-click the antenna that you want to delete.
2. From the menu that appears, click **Delete**.

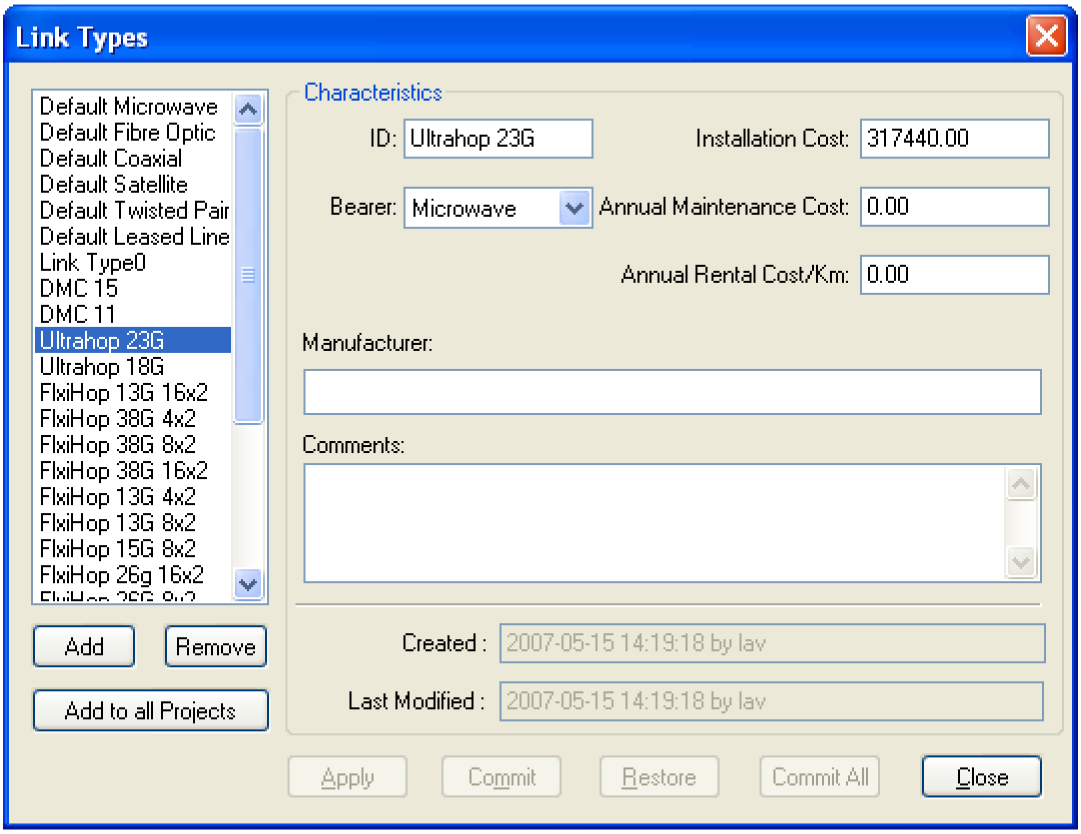
Note: You cannot delete antennas that are currently assigned to links in the Link Database, nor when the project has been opened in Partial Load or Region Load.

Tip: You can restore antennas by selecting them from the **Wastebasket**.

Defining Link Types

Within your network, you may use a variety of different link types to connect your network elements, depending on your cost and bearer requirements.

In ASSET Backhaul, there are six default types ready for you to use, but you can also add your own types in the **Link Types dialog box**. This picture shows an example:



Link Types dialog box

To add a link type:

1. From the **Options** menu, click **Link Types**.
2. Click **Add**.
3. Select the new link type, and define the following details:

Item	Description
ID	The name of the link type.
Bearer	The transmission method used by the link (microwave, fiber optic cable, coaxial cable, satellite, twisted pair or leased line).
Installation Cost	The cost of installing the link.
Annual Maintenance Cost	The cost of maintaining the link, per year.
Annual Rental Cost/km	The annual cost paid to lease the link per km (leased line only).
Manufacturer	The name of the manufacturer of the link.
Comments	Any additional planning comments you may wish to include.

Note: You cannot set the capacity for a link type; instead it is defined per link in the Link Database, or in a link template.

For microwave links using radio equipment on linkend A you can also set a total capacity in the Radio Equipment database. For information on how to do this, see Defining Radio Equipment on page 29.

Defining Modulation Types

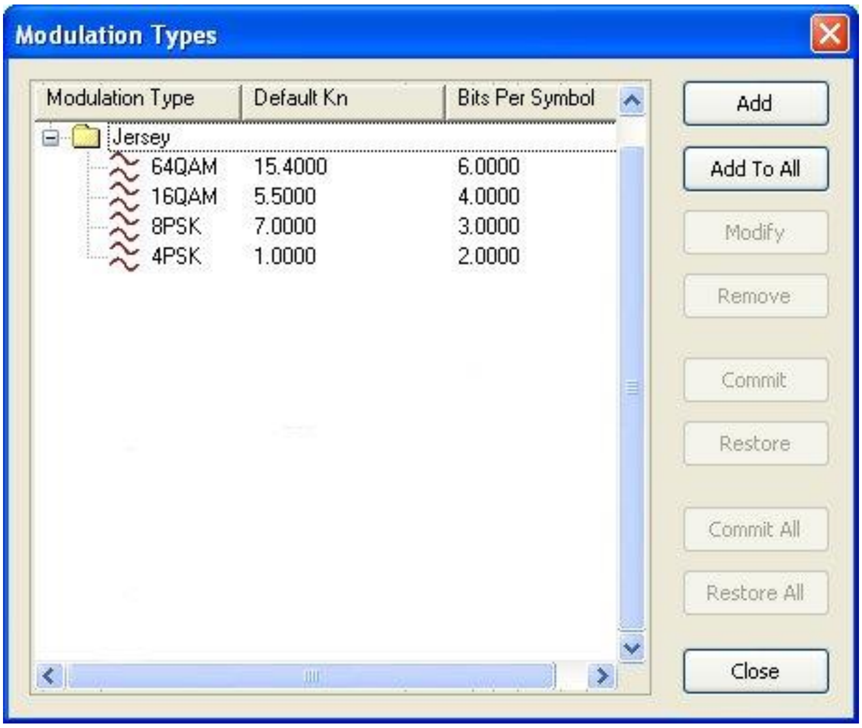
Transmitted signals are modulated using methods that also dictates their capacity. This means that for the same bandwidth, higher modulated signals will have a higher transmitted capacity than lower modulated signals.

In the Modulation Types dialog box, a number of standard modulation types are defined, which you can use in your network. However, you can define your own modulation types if required.

To define a modulation type:

1. From the **Options** menu, click **Modulation Types**.

   The **Modulation Types** dialog box appears:

2. If you want to make the modulation type available to a specific project only, click **Add**.

   - or -

   If you want to make the modulation type available to all projects, click **Add To All**.

3. In the dialog box that appears, type the:
   - Name of the modulation type
   - Default Kn value
   - Bits per symbol

   This table shows default Kn values for modulation types (normalised signature outage) figures as set out by the ITU:

Modulation Method	Kn
64QAM	15.4
16QAM	5.5
8PSK	7
4PSK	1

For detailed information regarding signature data, see the recommendation in ITU-R F. 1093-2.

4. Click **Add**.

   The new modulation type is added to the Modulation Types dialog box.

To edit an existing modulation type:

1. Select the modulation type that you want to edit, and click **Modify**.

   \- or -

   Double-click the modulation type that you want to edit.

2. In the dialog box that appears, make the required changes.

3. Click **Update**.

4. Click **Commit** to save your changes.

   The modulation type is updated in the Modulation Types dialog box, and if it is assigned to any radio that is used on a link, then the appropriate linkend modulation values on that link are updated as well.

To delete an existing modulation type:

1. Select the modulation type that you want to delete.

   Important: You cannot delete a modulation type that is assigned to any radio that is used on a link.

2. Click **Remove**.

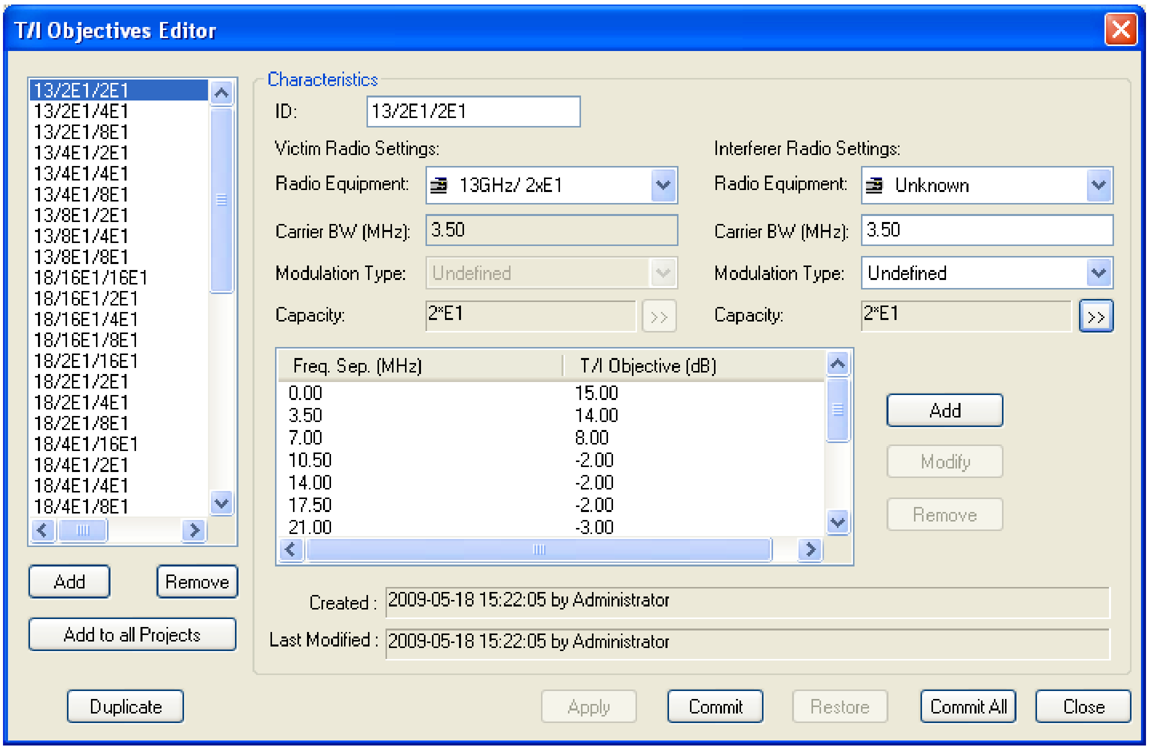
3. In the dialog box that appears, click **Yes**.

   The modulation type is removed.

Defining T/I Objectives

Threshold to Interference (T/I) objectives are needed in ASSET Backhaul when interference analyses are to be used, and are used to estimate the impact of an interfering signal (with a set bandwidth) on a particular piece of radio equipment.

The **T/I Objectives Editor** dialog box contains ratios that are used by ASSET Backhaul to estimate the impact on a specific piece of radio equipment of an interfering signal with a set bandwidth. This picture shows an example T/I Objectives Editor dialog box:



Example T/I Objectives Editor dialog box

Every piece of radio equipment must have a table of T/I objectives corresponding to each possible interferer bandwidth. T/I objectives are normally available from equipment vendors. This enables you to model the possible interference overlap between the wanted/unwanted signals and corresponding bandwidth associations. For example, if Radio A (7MHz bandwidth) is interfering with Radio B (3.5MHz bandwidth), ASSET Backhaul looks in the T/I table for Radio B and takes the T/I objective for an interfering bandwidth of 7MHz.

When you run an interference analysis, the T/I values obtained are compared to the T/I objectives of the equipment, which helps to analyze the impact of the interference on the links. For more information on how the T/I objectives tables are used, see How the T/I Objectives Radio Settings are Used on page 55.

T/I objectives are dependent upon the type of modulation process used and the quality of the radio equipment, therefore they have to be defined for each radio separately. (Modulation types are defined in their own dialog box, with specified default Kn values and bits per symbol.)

ASSET Backhaul is expecting to get all capacity combinations within the band (all the capacity combinations needed during interference analysis). If some of the tables are missing, it gives a warning when interference analysis is used. If there is a missing T/I objective then it will use the user-defined T/I value, so define this default T/I value before you run interference analysis.

Defining the Radio Settings for T/I Objectives

When you are defining T/I objectives in the T/I Objectives Editor, you can define the radio settings, with different values for victim and interferer radios.

This table describes the options available:

Item	Description
Radio Equipment	You can select the radio equipment for this T/I objective, based on the radios defined in the Radio Equipment dialog box. The list contains all radios defined for the current project and all projects. **Note:** You can set the interferer radio equipment as Unknown, in which case provided that you have set the bandwidth, modulation type and capacity, the Interference Wizard will find the appropriate T/I table.
Carrier BW (MHz)	This is the carrier bandwidth, taken from the radio equipment that you have selected.
Modulation Type	You can select the modulation type for this T/I objective, based on the modulation types defined in the Modulation Types dialog box. **Note:** You can set the modulation type as Undefined, in which case provided that you have set the radio equipment, bandwidth and capacity, the Interference Wizard will find the appropriate T/I table.
Capacity	The capacity of the radio equipment that you have selected, which is displayed as number of channels multiplied by the hierarchical bit rate (SDH/PDH) or a single value in Kbps. For example, if there are 2 SDH channels and a bit rate of 64kbit/s (E1), then the capacity is shown as 2E1. If the radio equipment is set to Unknown, then you can define your own capacity, otherwise it is read-only. To define the radio capacity when the equipment is Unknown: • Click the right arrow button >> . • Select the required option - for a channel-based capacity, either SDH or PDH, or for a single value capacity, the IP Interface Capacity option. • For a channel-based capacity, choose the required number of channels and the hierarchical bit rate. • For a single value capacity, type the value in Kbps.

For more information, see How the T/I Objectives Radio Settings are Used on page 55.

How the T/I Objectives Radio Settings are Used

When performing the interference analysis, ASSET Backhaul uses the radio settings that have been defined in the **T/I Objectives Editor** in the following way.

- If the victim radio equipment is **Unknown**, then no table is used.
- If both the victim and interfering radio equipment are matched, then the matching T/I objective table is used.
- If the victim radio equipment is matched and the interfering radio equipment is Unknown, then ASSET Backhaul looks for the closest table based upon the interfering modulation type, capacity and bandwidth value, in the following order:
    - Modulation type, capacity and bandwidth
    - Modulation type and capacity
    - Modulation type and bandwidth
    - Capacity matched with modulation type undefined in the T/I table
    - Bandwidth matched with modulation type undefined in the T/I table

- If there is no match, then ASSET Backhaul looks for the T/I table (with matching victim radio) using the interfering capacity value to chose the table. This selection is done randomly.
- If still no table is found, then ASSET Backhaul uses the bandwidth value to chose the T/I table (with matching victim radio). This selection is also done randomly.

Note: Whenever ASSET Backhaul matches a table, it looks for the frequency separation value and uses the corresponding T/I objective entry. If an exact match for frequency separation is not found, it uses the interpolation between two closest frequency separation values, and then uses the corresponding T/I objective entry.

Alternatively, in the **Preferences** dialog box, you can choose to automatically use the T/I objective set on the radio equipment if an exact match for the frequency separation cannot be found in the T/I Objectives Editor.

Defining Link Status Values

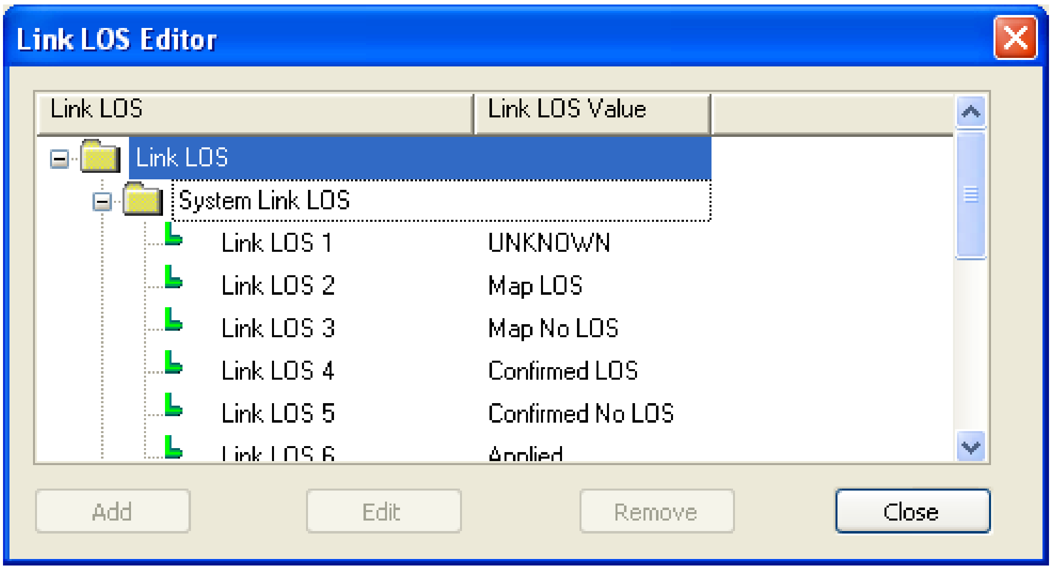
In ASSET Backhaul, when you are defining the general properties for links, you can specify the status of the link - for example, Commissioned, Planned, Temporary and so on.

By default, ASSET Backhaul has a number of predefined (system) link status values that can be used, but you may want to create your own in the Link LOS Editor.

To define the link status:

1. In the **Link Database**, from the **Tools** menu, click **Link LOS Editor**.

   The **Link LOS Editor** appears:



2. To add a status value, select the **User Link LOS** folder, and then click the **Add** button.
3. In the **Link LOS Status Details** pane that appears, type the name of the status and then click **Commit**.

To edit or remove any user link status values:

1. Select the link status that you want to remove.
2. Click **Edit** or **Remove**, as required.
3. If you chose **Edit**, the **Link LOS Status Details** pane appears.

   Modify the details as required, and then click **Commit**.

   - or -

   If you chose **Remove**, click **Yes** to confirm the deletion.

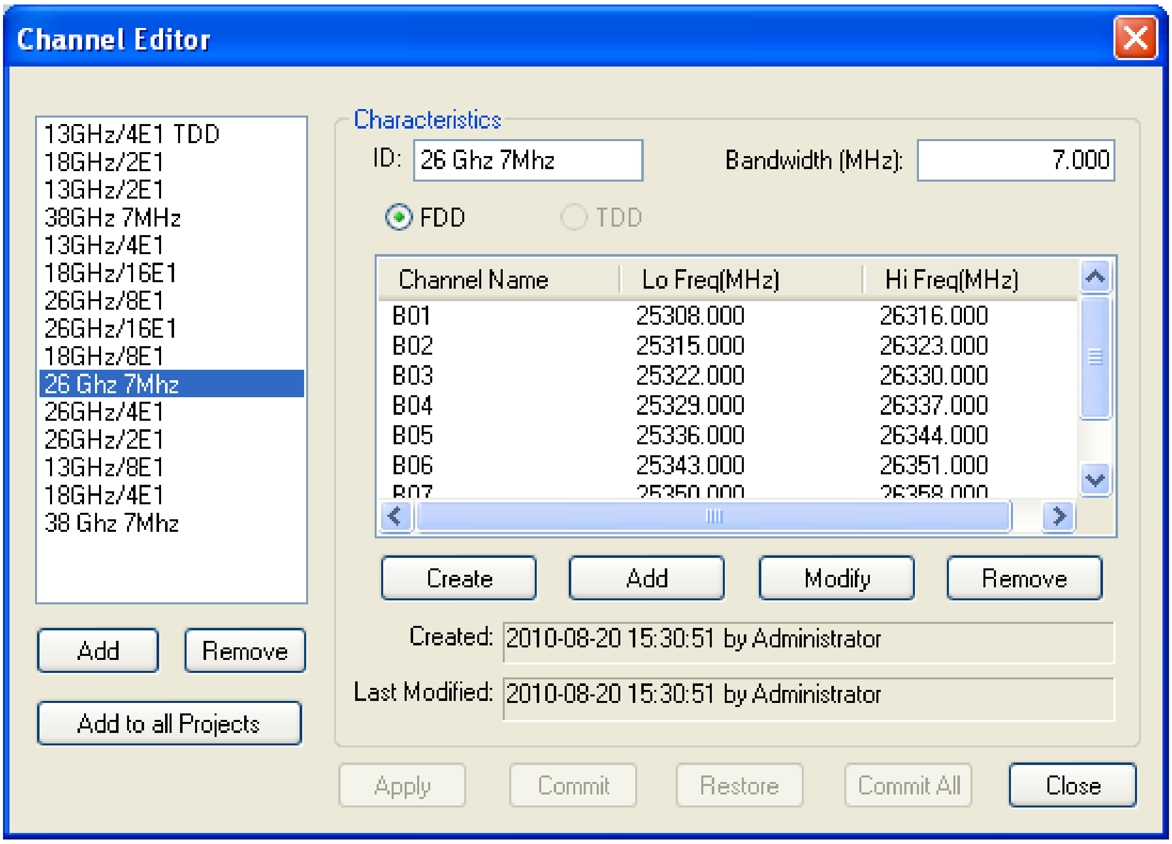
   The status is deleted from the list.

Defining Bands and Channel Information

To speed up and facilitate transmission network planning, you can define bands and channel names for easily identifying the channels, rather than having to remember the channel center frequencies. This will make frequency planning easier.

Tip: Before you start link planning, define all licensed frequencies in the database to simplify the process and avoid typing errors.

You can create bands and channels (FDD or TDD) in the **Channel Editor**, either manually or automatically. This picture shows an example:



Example Channel Editor

Creating Bands and Channels

To create a band:

1. From the **Options** menu, click **Bands Channels**.

   The **Channel Editor** appears.

2. In the left-hand pane, click **Add**.

3. In the **ID** box, name the new band.

   Tip: Band names should reflect the radio model, the band used (for example, 38, for the channels incorporating radios at the 38GHz band) and the capacity.

4. In the **Bandwidth** box, set the bandwidth.

5. Select the duplexing type, either **FDD** (Frequency Division Duplexing) or **TDD** (Time Division Duplexing).

   Warning: You should ensure that you select the correct type, as you cannot change this after the band has been Applied.

   You can now create channels for this band, either automatically or manually.

To create channels automatically:

1. In the **Characteristics** pane, click **Create**.

   In the dialog box that appears, specify the following channel details:

Item	Description
Channel Name Prefix	Up to 20 characters, which will be placed at the start of the channel name. This will be followed by the channel number. For example, if you specify a channel name prefix of 'Ch', the generated channels could be called Ch1, Ch2, Ch3 and so on.
First Channel Number	The number you want to give to the first channel. Subsequent channels will be numbered sequentially from this starting point.
Number of Channels to Create	Indicates how many channels will be generated, based on the details you have set.
Channel Spacing (MHz)	This always matches the defined bandwidth, and cannot be edited directly.
Start Frequency (MHz) (TDD bands only)	The frequency that you want to give to the first channel. Subsequent channels will be based on this starting point and the channel spacing value.
Start Low Frequency (MHz) (FDD bands only)	The low frequency that you want to give to the first channel. Subsequent channels will be based on this starting point and the channel spacing value.
Start High Frequency (MHz) (FDD bands only)	The high frequency that you want to give to the first channel. Subsequent channels will be based on this starting point and the channel spacing value.

   For more information, see Examples of Creating Channels Automatically on page 59.

2. Click **Create**.

   The required channels are created, and appear in the Channel Editor dialog box.

To create a channel manually:

1. Click **Add** in the right-hand pane.
2. Add all the relevant information for a channel (the unique channel name and the frequency information). This makes it easier to allocate channels when setting up the link frequency bands in the Link Database.
3. Continue until you have set all the available channels in this table.

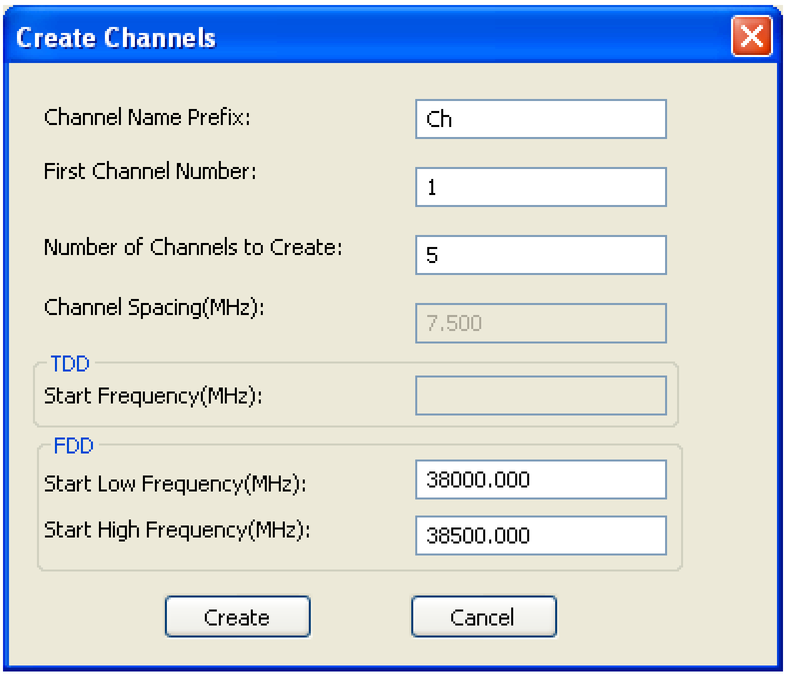
To edit a channel:

1. Select the required channel.
2. Click the **Modify** button.
3. In the dialog box that appears, modify the required details. You can edit the channel name and frequency (or frequencies).

Examples of Creating Channels Automatically

If you are creating channels automatically, the list of channels created is based on the parameters that you define.

For example, if you define the following parameters:

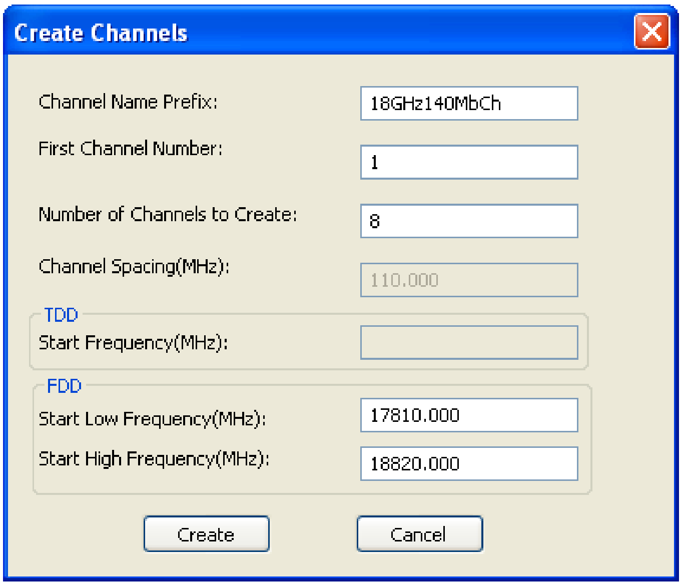


Creating Channels - Example 1

Then the following list of channels is created:

Channel Name	Low Frequency (MHz)	High Frequency (MHz)
Ch1	38000.00	38500.00
Ch2	38007.50	38507.50
Ch3	38015.00	38515.00
Ch4	38022.50	38522.50
Ch5	38030.00	38530.00

In another example, if you define these parameters:

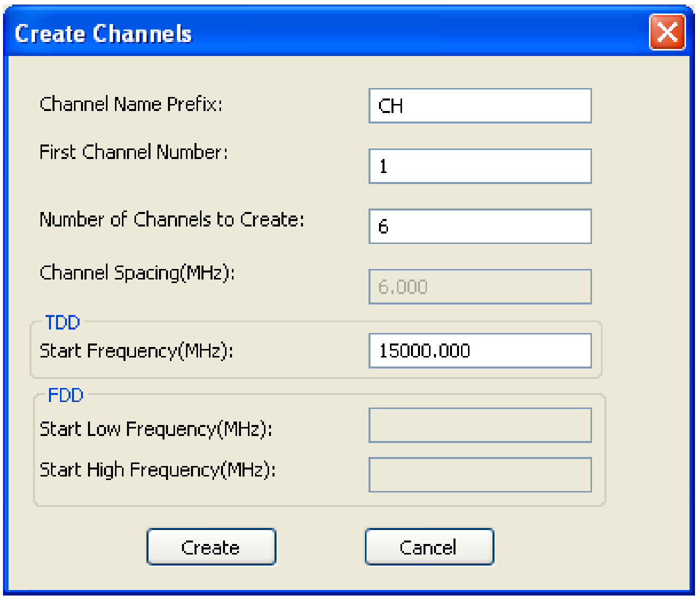


Creating Channels - Example 2

Then this list of channels is created:

Channel Name	Low Frequency (MHz)	High Frequency (MHz)
18GHz140MbCh1	17810.00	18820.00
18GHz140MbCh2	17920.00	18930.00
18GHz140MbCh3	18030.00	19040.00
18GHz140MbCh4	18140.00	19150.00
18GHz140MbCh5	18250.00	19260.00
18GHz140MbCh6	18360.00	19370.00
18GHz140MbCh7	18470.00	19480.00
18GHz140MbCh8	18580.00	19590.00

In an example for a TDD band, if you define these parameters:



Creating Channels - Example 3

Then this list of channels is created:

Channel Name	Frequency (MHz)
CH1	15000.00
CH2	15006.00
CH3	15012.00
CH4	15018.00
CH5	15024.00
CH6	15030.00

Which Frequencies Should I Use?

Certain frequencies, because of their propagation properties, are more suited to specific usage. Factors such as hop distance, frequency band used, climatic conditions, rainfall and terrain all affect the frequency that the network will use. Different frequency bands react differently to climatic and atmospheric conditions. Therefore you should consult ITU documents as appropriate. For information on purchasing ITU documents, see the International Telecommunications Union website at http://www.itu.int.

When planning frequency bands, you must take note of the current radio band usage in the appropriate World Region. For more information, see the ITU documents. You should also consult the radio allocation agency for the respective country. This section describes some allocation within the UK, and further information can be found at http://www.itu.int.

This table shows UK band allocations for point to point microwave transmission:

Frequency	Capacity Available	Hop Distance	Fading
7GHz	Med-High	>30km	Multi-path
10GHz	Low-Med-High	15-30km	Multi-path
13GHz	Low-Med-High	15-30km	Multi-path
18GHz	Low-Med-High	15-30km	Rain and Multi-path
23GHz	All	5-15km	Rain
38GHz	All, within short ranges	Up to 5km	Rain

Importing and Exporting Equipment and Link Details

To save time when you are setting up your microwave network, you can import equipment from other projects or sources. If you want to import from another ENTERPRISE project, you will have to export this equipment first.

You can do this for a number of equipment and link details in ASSET Backhaul, including:

- Microwave antennas
- Radio equipment
- Feeders
- Link types
- T/I objectives
- Bands/channels

You can import and export in a number of ways:

- Using ENTERPRISE's XML import/export.

  Note: For more information on this process, see the *ENTERPRISE User Reference Guide*.

- As part of exporting an entire ENTERPRISE project.

  Note: For more information on this process, see the *ENTERPRISE User Reference Guide*. For more information on what files to include, see What Files are Relevant to Transmission Planning? on page 62.

- Using one of a number of microwave antenna formats. For more information, see Importing Microwave Antennas on page 63.
- Using the Ericsson radio import, available for *.raf files. For more information, see Importing Radio Equipment on page 63.
- Export links to MapInfo format. For more information, see Exporting Links on page 64.

Tip: It is recommended that you commit all equipment immediately after you have imported it, so that all users of the project can use it.

What Files are Relevant to Transmission Planning?

If you are exporting an entire ENTERPRISE project, this table describes the information relevant to ASSET Backhaul projects and the file type used:

This information	Is Contained in This File
Radio equipment	radioequip.aid
Link terminal	linktermequip.aid
Feeder/waveguide	feeder.aid
MW antenna	mwantennatype.aid mwmask.aid
Cabin	cabin.aid
Filters	filter.aid
Fields	flags.aid
T/I objectives	tiobj.aid tiobjentry.aid
Channel	channel.aid band.aid
Link type	linktype.aid
MSC	msc.aid
BSC	bsc.aid
BTS	bts.aid
Equipment vs. site	interconnect.aid
Bearing vs. other link	linkend.aid
Property	siteaddress.aid
Mast	tower.aid

Importing Microwave Antennas

You can import microwave antennas in a number of formats, described in this table:

Format	Description
*.mwa	Imported using the MW Antennas option.
*.nsm	This is the standard data format for commercial antennas, provided by the National Spectrum Managers Association (NSMA).
*.txt	This is an option in the Import All Equipment dialog box.
*.xml	Imported using the standard ENTERPRISE XML import.

For more information on how to import microwave antennas using the *.txt and *.xml formats, see the *ENTERPRISE User Reference Guide*.

To import microwave antennas using *.mwa or *.nsm files:

1. From the **File** menu, point to **Import**, **Equipment**, **MW Antennas** and then click either **MW** (.mwa) format or **NSMA** (.nsm) format as required.
2. In the dialog box that appears, select the file(s) that you require.
3. Click **Open**.

   The microwave antennas in the selected files are imported.

   For information on the microwave antenna file format, see Microwave Antenna File Formats on page 249.

Importing Radio Equipment

You can import radio equipment in several formats:

- The standard ENTERPRISE XML format.
- The equipment (*.txt) format.

  Note: For information on import (or export) using either of these formats, see the *ENTERPRISE User Reference Guide*.

- The Ericsson radio (*.raf) format.

To import Ericsson radio equipment:

1. From the **File** menu, point to **Import**, **Equipment**, **Radio** and then click **Ericsson**.
2. In the dialog box that appears, select the *.raf file(s) that you require.
3. Click **Open**.

   The Ericsson radio equipment in the selected files is imported.

   Important:

   - If the MODEL field is missing from the *.raf file, then the file will not be imported.
   - If the modulation scheme is missing from the '*.raf' file or does not exist in the ENTERPRISE database, then this will be reported in the **Message Log**, the modulation scheme will be set as "Undefined" and the Kn value will be set to '1'.
   - If the radio capacity is missing from the '*.raf' file then this will be reported in the Message Log, and the file will not be imported.

- ASSET Backhaul will automatically generate a default T/I objective ID for each T/I objective table in the *.raf file.
- If either the modulation scheme or the radio capacity is missing for a T/I objective table, then this will be reported in the Message Log and the T/I objective will not be imported.

For more information on the Ericsson radio equipment file format, see Ericsson Radio Equipment File Format on page 274.

Exporting Links

You can export links (and the Properties connected by these links) from an ENTERPRISE project to MapInfo format (*.mif and *.mid) files. These are text files used by MapInfo software to generate displays.

To export your links to MapInfo format files:

Note: Ensure you have MapInfo software installed, unless you want to use non-earth projections.

1. From the **File** menu, point to **Export**, **Project Data** and then click **MapInfo Links**.
2. Click **Next**.
3. Choose the way in which you want to select the links (and if required, their associated Properties), either by selecting a catchment area on the Map View window, or by selecting a filter:
    - If you opt to choose by filter, select the appropriate filter here
    - If you opt to choose by view, you can choose the view on the next page of the wizard
4. Specify the name(s) of the file(s) that you want to export the data to, by either typing the name in the appropriate box or browsing to the correct file.

    You can export a number of different types of network element separately: point to point (PtP) links, point to multi-point (PmP) links, passive repeater (PR) links and Properties. This is because the different link types can have different fields associated with them.
5. If you have opted to choose by filter, click **Finish**. The links (and, if required, their Properties) contained in this filter are exported to the file in the specified location.

    – or –

    If you have opted to choose by view, click **Next**.
6. If you have multiple Map Views, select the one that you wish to use by clicking the **Select View** button, and then clicking the **Map View window** containing the links (and Properties) that you want to export.
7. Click **Next**.
8. If you do not have MapInfo® software installed then you will be prompted to browse for a file called MAPINFOW.PRJ.

    If you do not have this file, then in the **Open** dialog box, click **Cancel**. Non-earth projections will be used.
9. Select the co-ordinate system to be used for the MapInfo-based data that is to be exported. This should match the co-ordinate system used in the settings of the project that you want to export to.
10. Click **Finish**.

The links (and Properties) contained in this view are exported to the file in the specified location.

Note: When you select either the **View** or **Filter** option, the report will include the Properties at either end of a link whose link center lies within the view or filter.

For information on the file formats used to export links and Properties to a MapInfo format *.mif and *.mid file, see ASSET Backhaul File Formats and Examples on page 249.

Creating Microwave Link Fields

You can use fields to record and identify the progression of your network and its elements from initial design through to rollout, and even beyond this. A link field, for example, can indicate whether the link is proposed, under development or operational.

Important: It is strongly recommended that you create fields as early in the project as possible.

Tip: Fields can be used to record other information, for example, the region that the link is in or the planner in charge of maintaining the link.

You create fields using ENTERPRISE Administrator. For details on how to define microwave link fields, see the *ENTERPRISE Installation and Administration Guide*.

Examples of Microwave Link Fields

Examples of microwave link fields might include the following:

Group	Fields
Media	- Microwave Fiber Leased line Copper
Hop length	- < 1km 1-7km 7-13km > 13km
Link LOS Status	Unknown Temporary Map No LOS Map LOS Confirmed No LOS Confirmed LOS Applied Installed Commissioned OK
Antenna Diameter	- 0.3m 0.6m 1.2m 1.8m 2.4m
Packet	1, 2, 3, 4, 5, 6, 7, 8

Group	Fields
Band	2 GHz 7 GHz 10 GHz 13 GHz 15 GHz

Defining Link Templates

It is always good practice to set up the link (and) hub templates in the Link Database, with the most appropriate equipment and parameters, before creating any new links. For example, you can use templates to:

- Model the most common configuration and use this as the default for any new links subsequently created
- Simulate different variations and alternative scenarios that you want to investigate

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Note: After the links have been created, the default parameters can be modified at any stage.

Important: Ensure that you select the appropriate template before adding any links. Each template has a radio button, and these are mutually exclusive.

In ASSET Backhaul, you can use two types of link template, depending on how you want to plan your links:

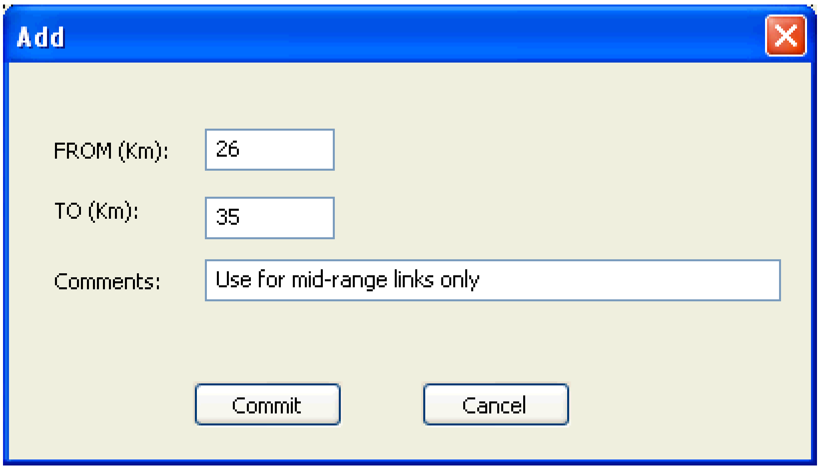
- Single Link Templates - A single link template can be assigned to a link when you create it.

  - or -

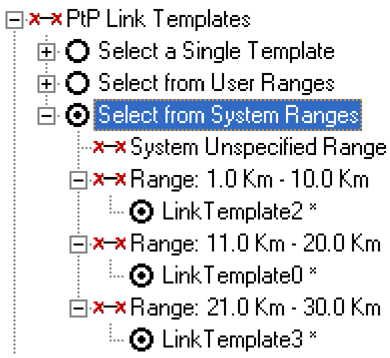
- Range Link Templates - A particular link template is assigned automatically, depending on the length of the link. There are two types of ranges, system ranges (for all users in a project) or user ranges (for a single user).

  You can add multiple range settings, and then select which link template corresponds to which range.

  This picture shows an example of adding a range:



This picture shows some example link templates that correspond to specific ranges:



You can create a completely new link template, or one based on an existing link that you have created.

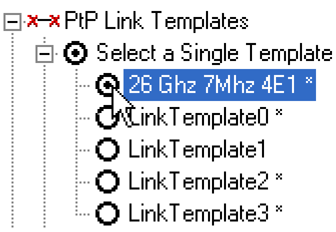
Tips on Setting Up Link Templates

When setting up your link template, use the following table to help you define the key settings in the **Link Database**.

You can set templates for both main and diversity information, by selecting the appropriate option at the top of the **Linkend Settings** subtabs.

Tab/subtab	Field(s)
General/Info	Link Range. This means that the correct template will be used, based on the link length.
General/Type	Link Type. LOS status: keep this as Unknown unless another status has been verified.
General/Status	As required.
Linkend Settings/Radio	Radio equipment. Threshold value.
Linkend Settings/Frequency	Band and channel. Polarization. Propagation model.
Linkend Settings/Antenna	As required.
Linkend Settings/Other subtabs	As required.
Calculation	As required.

When you have entered all of the template details, if you want to make this template the default that will be used, ensure that the template's default radio button is selected:



Now when you add a new link, the default information for that link is taken from the template you have set up.

Creating Link Templates

To create a new link template:

Tip: You can also create a link template based on a link that you have already created. For more information, see Creating a Link Template Based on an Existing Link on page 68.

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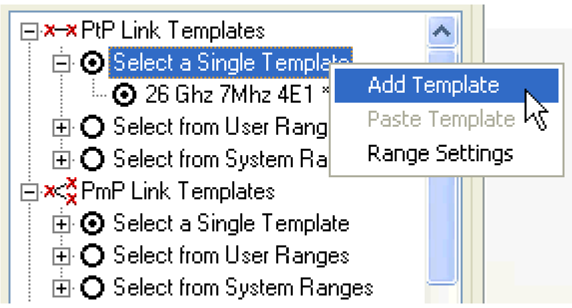
1. From the **Database** menu, click **Links**.
2. Click the **Templates** tab.

   – or –

   From the **View** menu, click **Templates**.
3. In the **Link Selection** pane, select the type of link template you want to create.

   If you are creating a PtP, PmP, Multi-radio or Dual Polar link template, you can also choose to create either a single template or range template. For more information, see Defining Single Link and Range Templates on page 69.
4. Right-click, and from the menu that appears, click **Add Template**:

5. Ensure that the **Details** pane is visible; if not, click the Details >> button.
6. Define the settings that you require, for example, by setting radio equipment, antennas and so on. See Configuring the Links on page 124 for more information on doing this.
7. Click **Apply** to save the template locally, and additionally **Commit** if you are saving a system range template.

Important: If you have Committed a system range template, another user with the same permissions can edit this. To protect the integrity of a template, create it with user ranges.

Creating a Link Template Based on an Existing Link

If you have created a link and think that its attributes would be useful to save and re-use, you can save it as a link template.

Note: It will still operate as a link in its own right, only its values will be copied for use as a template.

To define a link as a template in the Link Database:

1. From the **Database** menu, click **Links**.
2. Ensure that the **Links View** is selected.
3. Right-click the required link, and from the menu that appears, click **Set As Template**.
4. In the dialog box that appears, type a name for the template and choose whether or not to set it as the default template.
5. Click **OK**.

To define a link as a template in the Map View window:

1. Right-click the required link, and from the menu that appears, point to **Make Template From** and click the name of the link.
2. In the dialog box that appears, type a name for the template and choose whether or not to set it as the default template.
3. Click **OK**.

Tip: If you do not want to be prompted to set a template as default, from the **File** menu, click **Preferences**, and on the **General** tab ensure that the **Prompt For New Template ID** checkbox is not selected.

Defining Single Link and Range Templates

You set how to use link templates in the **Link Database**, on the **Templates** tab.

To set up ASSET Backhaul to use a single link template:

1. Ensure that the required link type is expanded. If not, click the plus sign.
2. Right-click **Select a Single Template**, and from the menu that appears, click **Add Template**.
3. Create a template in the usual way.

To set a template to be a range template:

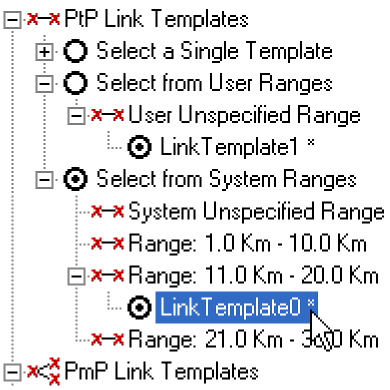
1. Create a template in the usual way.
2. Ensure the required set of ranges is available. For information on how to do this, see Setting Distance Ranges for Link Templates on page 70.

3. On the **Info** subtab of the **General** tab, from the **Link Range** drop-down list, select the required link range. You can select from the following options:

Choose This Link Range Option	To Store the Template in this Location
None	Select from Single Template list.
User Unspecified Ranges	Select from User Ranges/User Unspecified Range list.
System Unspecified Ranges	Select from System Ranges/System Unspecified Range list.
User Range: *(range in km)*	Select from User Ranges/Range *(range in km)* list.
System Range: *(range in km)*	Select from System Ranges/Range *(range in km)* list.

4. Click **Apply**.

   The selected template is now listed under the range templates:



Setting Distance Ranges for Link Templates

Before you can set a link template for a specific distance range, you must ensure that the different distance ranges that you need have been set up.

There are two types of distance range:

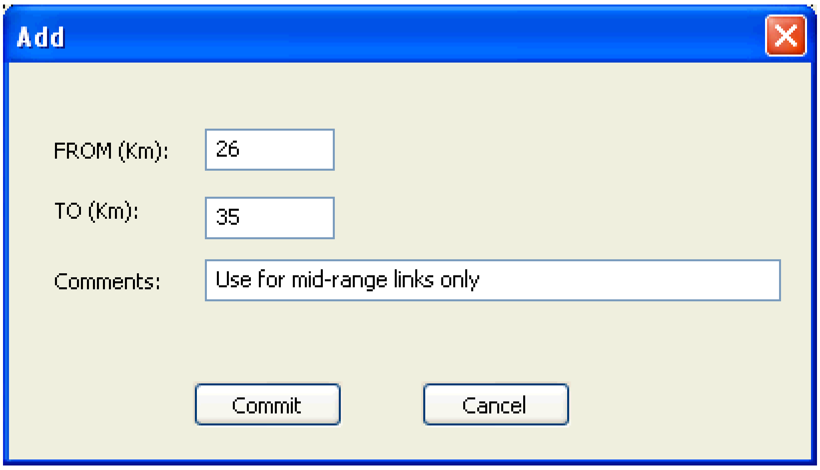
- System Ranges - These ranges are available to all users in a specific project, and are typically defined by the administrator or another user with the correct permissions.
- User Ranges - These ranges are only available to a specific user, and are a personal series of ranges that only that user wants to use.

To create a distance range:

1. If you want to create system ranges, ensure that you have the **Edit System Ranges** functional privilege. For more information, see your administrator.
2. In the **Link Database**, from the **Tools** menu, click **Range Settings**.
3. In the dialog box that appears, click the appropriate tab for the required link type.
4. Select the required folder, depending on the type of range you want to create.
5. Click the **Add** button.
6. In the dialog box that appears, type in the starting and ending distance (in km) for the range in the **FROM** and **TO** boxes, and add any additional comments.

Note: ASSET Backhaul automatically assigns a number to each range.

This picture shows an example range:



7. Click **Commit**.

   ASSET Backhaul updates the ranges in the database - for System Ranges, all project users will be able to see the change, whereas for user ranges, only you will see this change.

   The range appears in the **Range Settings** dialog box, and is now ready to be Applied to a link.

8. Click **Close**.

If you have the correct permissions, to edit or remove a range:

1. Select the required range.
2. Click **Edit** or **Remove**, as required.
3. If you chose **Edit**, in the dialog box that appears, make your changes and click **Commit**.

   - or -

   If you chose **Remove**, click **Yes**. The range is removed.

Defining a Hub Template

You can set up a template to use as a basis for your hubs so you do not have to define similar information again.

Important: In ASSET Backhaul, the hub template information always relates to linkend A. This means that each time a point to multi-point link is created, the linkend A information is non-writable, and you can only set parameters for linkend B.

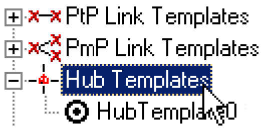
To define a hub template:

1. From the **Database** menu, click **Links**.
2. Click the **Templates** tab.

   – or –

   From the **Views** menu, click **Templates**.

3. In the **Link Selection** pane, select **Hub Templates**.



4. Right-click, and from the menu that appears, click **Add Template**.

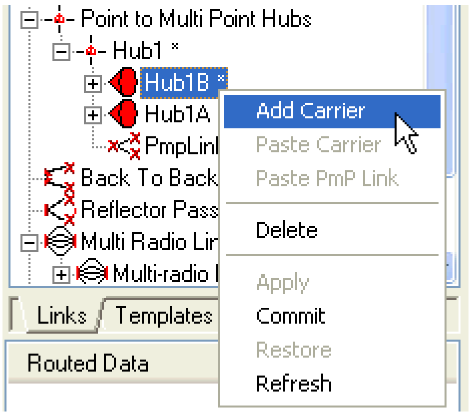
5. Define the name that will be used as the default when you add a new hub.

6. If you want to add a sector to the hub template, right-click the hub template and from the menu that appears, click **Add Sector**.

7. You can configure various settings for the hub template sector:

On this Tab	You Can
General	Specify the Range (m), and view the Main Antenna Horizontal BW (degrees) and view or override the Sector BW (degrees). For more information, see Adding Point to Multi-point Sector Information on the General Tab on page 116.
Antenna	Add and configure the sector antenna(s). You can click the Add button to add a new antenna button, and then you can edit its settings. For more information, see Defining Antennas for Linkends on page 139.

8. If you want to add a carrier to a sector, right-click the required hub template sector, and from the menu that appears, click **Add Carrier**:



9. You can define various settings for the hub template carrier:

On This Tab	You Can
General	Edit the Carrier ID, Names and Comments. For more information, see Defining the General Properties of Carriers on page 117
Type	Include link type and carrier overhead information for the main and diversity equipment. For more information, see Defining the Link Type and Overhead for Carriers on page 117.
Radio	Include radio equipment and frequency information for the main and diversity equipment. For more information, see Defining the Radio Parameters of Carriers on page 119.
Modulation/Capacity	Include modulation and capacity information for the main and diversity equipment. For more information, see Defining the Required Throughput and Modulation Type for Carriers on page 120.
Feeders	Include feeder information for the main and diversity equipment. For more information, see Defining the Feeders for Carriers on page 123.

Setting up a Template Based on an Existing Hub

If you have created a hub and think that its attributes would be useful as a template for re-use, you can use it as a hub template.

To define a hub as a template in the Link Database:

1. From the **Database** menu, click **Links**.
2. Ensure that the **Links View** is selected.
3. Right-click the hub that you want to use as a template, and from the menu that appears, click **Set As Template**.
4. In the dialog box that appears, type a name for the template and choose whether or not to set it as the default template.
5. Click **OK**.

To define a hub as a template in the Map View window:

1. Right-click the required hub, and from the menu that appears, point to **Make Template From** and click the name of the hub.
2. In the dialog box that appears, type a name for the template and choose whether or not to set it as the default template.
3. Click **OK**.

Tip: If you do not want to be prompted to set a template as default, from the **File** menu, click **Preferences**, and on the **General** tab ensure that the **Prompt For New Template ID** check box is not selected.

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4 Designing the Physical Network

You can add and edit your network elements using the **Map View** window, the **Site Database** window or the **Link Database** window. Because this functionality is common to more than one product, basic information on designing your network can be found in the *ENTERPRISE User Reference Guide*.

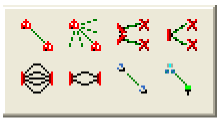
In addition to this shared basic functionality, ASSET Backhaul enables you to create, modify, and delete links and data related to links. This chapter describes the steps involved in designing links for microwave networks.

Adding and Editing Links

You can create a number of different sorts of link in the Map View window:

Link Type	Description
Point to point links	A link between a pair of Properties.
Point to multi-point links	A number of links from one hub Property to a number of other Properties. You use the same equipment (radio, antenna and so on) at the hub for all of the links, which reduces both costs and interference.
Passive repeater links	A pair of links used to deflect the microwave beam around an obstacle, using either back-to-back antennas or a reflector.
Multi-radio links	A link between a pair of Properties that contains a number of radios carrying different frequencies. This enables you to model configurations such as 7+1, where you have 7 STM-1 channels each with its own radio, plus 1 (STM-1) protection channel, without having to use 8 separate links.
Dual polar links	A link between a pair of Properties that contains a pair of radios, with each on a different polarization (1 vertical, 1 horizontal).

You can add links in the Map View window quickly and easily, using the dedicated toolbar buttons:



Make Link toolbox

The basic procedure for creating the different link types is as follows:

Link Type	Process
Point to point (PtP)	In the Map View window: • Choose the End A Property • Choose the End B Property In the Link Database, configure the linkends.

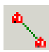
Link Type	Process
Point to multi-point (PmP)	In the Map View window: • Choose the Property on which the PmP hub will be located, or create a new Property for this purpose • Select the hub (transmitter) Property • Choose multiple receiver Properties In the Link Database, configure the hub, sector and linkends.
Passive repeater (back to back or reflector)	In the Map View window: • Choose the End A Property • Choose the Property on which the repeater (reflector or back-to-back antenna) will be located • Choose the End B Property In the Link Database, configure the linkends, including the passive repeater functionality.
Multi radio link	In the Map View window: • Choose the End A Property • Choose the End B Property In the Link Database, add the required number of radio sublinks. Configure the linkends, for the main link, and each sub-link.
Dual polar link	In the Map View window: • Choose the End A Property • Choose the End B Property In the Link Database, configure the linkends.

Adding and Editing Point to Point, Multi-radio and Dual Polar Links

If you want to link one Property to another single Property in the Map View window, you can use a regular point to point link, or for more advanced scenarios, you could use one of the following:

Link Type	Description
Multi-radio link	A link between a pair of Properties that contains a number of radios carrying different frequencies.
Dual polar link	A link between a pair of Properties that contains a pair of radios, with each on a different polarization.

To add a point to point, multi-radio or dual polar link:

1. In the **Map View window**, click the down arrow on the **Make Link** toolbox, and then click the appropriate button, for example, the **Make Point to Point Link** button  .
2. Click the two Properties.
3. If the link does not appear on the map, click the  button.
4. In the **Layer Control** dialog box, click the **Data Types** tab.
5. In the list of data types, under the **Filters** category, ensure that the relevant heading is selected.

6. To confirm that the link has been created, from the **Database** menu, click **Links** and ensure the new link ID is shown.

7. If you are creating a multi-radio link, add the required number of radio links by right-clicking the multi-radio link group and selecting **Add Radio Link**.

Note: The number of radio links that you can add depends on the **N** value defined on the **Info** subtab of the **General** tab in the **Link Database**. For more information, see Defining the General Properties for Links on page 124.

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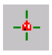
8. To edit a link, in the **Link Database**, change the properties required.

Adding and Editing Point to Multi-point Links

If you want to link one point to a number of other points in the **Map View window**, you can use a point to multi-point link.

To add a point to multi-point link:

1. Click the **Add Point to Multi-Point Hub**  button.

2. Click the Property on which you want to create the point to multi-point (PmP) Hub.

   – or –

   Click the required location in the Map View window. A Property is automatically generated.

3. Configure your hub with carriers and sectors as required. For more information on how to do this, see Configuring Network Elements on page 114.

4. Click the **down arrow** on the **Make Link** toolbox, and then click the **Create Point to Multi-Point Link** button  .

5. Click the hub that you want to use for this PmP link, and then click all of the Properties that you want to connect with this link. The linkend at the hub end is designated as linkend A, and the other linkend is linkend B.

   If you have configured the carriers and sectors for your hub, the link is added to the **Link Database** according to the following criteria:

   - If the new link matches all of the criteria for a carrier, the link is added to that carrier
   - If it does not match all of the criteria for any of the carriers, but matches all of the criteria for a sector, it is added to the sector
   - If it does not match all of the criteria for any of the sectors, it will be added to the hub

   For more information, see Adding Links to Sectors Automatically on page 78.

Note: You cannot create a link to the same Property that the hub is on, but you can have more than one link to the same Property.

To edit a PmP link:

1. In the **Link Database**, edit the parameters of the appropriate linkend Bs.

2. To edit linkend As, in the **Link Database**, click the relevant carrier for the hub and edit the properties.

3. To change the Property to which a PmP hub is attached, click the **Move PmP Hub** button  , then click the new Property. All of the links connected to the hub will be updated automatically.

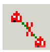
Adding Links to Sectors Automatically

ASSET Backhaul can automatically put a PmP link in the appropriate sector within a hub on a Property. For ASSET Backhaul to do this, the PmP link must match the following criteria:

Criteria	Description
Within the sector range	If the PmP link falls within the range of a sector, as defined on the General tab for a PmP sector, it can be added to that sector.
Within the sector arc	If a PmP link falls within a sector's arc (calculated based on the direction and beamwidth of its antenna) it can be added to the sector. For example, if the direction is 100 degrees and the antenna beamwidth is 60 degrees, the arc is 70 degrees to 130 degrees. If a PmP link falls within the range of two sectors' arcs, then ASSET Backhaul chooses the sector with the closest main antenna direction/boresight. For example, Sector 0A has a direction of 120 degrees and a width of 60 degrees and Sector 0B has a direction of 100 degrees and a width of 80 degrees. If a PmP link is created at an angle to the hub of 130 degrees, even though it falls within the arcs of both sectors it will be added to Sector 0A because it is closer to its main antenna direction.
Within the capacity limits of the carrier(s) on the sector	If the capacity of the PmP link does not exceed the capacity of the carrier(s) on the sector, it can be added to that sector.
Within the frequency limits of the carrier(s) on the sector	If the frequency of the PmP link does not exceed the frequency of the carrier(s) on the sector, it can be added to that sector.

Deleting Point to Multi-point Links

To delete a point to multi-point (PmP) link in the Map View window:

1. Click the down arrow on the **Break Link** toolbox, and then click the **Break Connection** button  .
2. Click the required link. (You do not have to click the sites).

   The link is moved to the Wastebasket.

To delete a PmP hub and all connected links, click the **Delete PmP Hub** button, and then click the required PmP hub.

Tip: To change the Property to which a PmP hub is attached, click the **Move PmP Hub** button and then click the Property you want to move the PmP hub to. All of the links connected to the hub will be updated automatically.

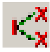
Adding Passive Repeater Links

When you are planning your network, and line of sight is not possible between two sites, you can use passive repeater links to deflect the microwave beam around the obstacle. To see an example of using a passive repeater link, see About Passive Repeater Links on page 80.

ASSET Backhaul supports two types of passive repeater:

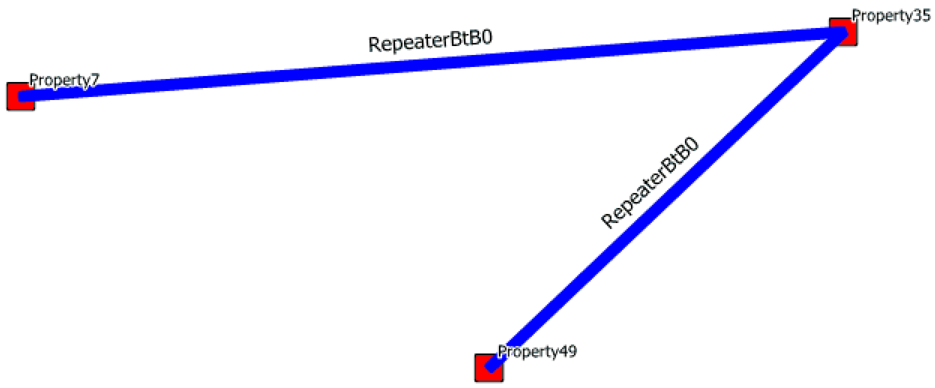
Passive Repeater Type	Description
Back to Back Antennas	Two antennas are placed on or around the obstacle so that line of sight can be obtained directly between two sites. The antennas face each end of the link and are connected via a short waveguide.
Reflector	A large reflective object is placed to one side of the obstacle, to enable the microwave beam to be deflected off the passive repeater between the two sites.

To add a passive repeater link in the Map View:

1. Ensure that you have least three Properties in the required positions.
2. In the **Map View window**, click the down arrow on the **Make Link** toolbox and then click the required **Add Passive Repeater Link** button, either **Back To Back Passive Repeater**  or **Reflector Passive Repeater**  .
3. On the map, click the three Properties that you want to use for the passive repeater link, in the following order:
    - End A Property
    - Repeater Property
    - End B Property

Tip: To cancel a passive repeater link you are creating, press the **Esc** key.

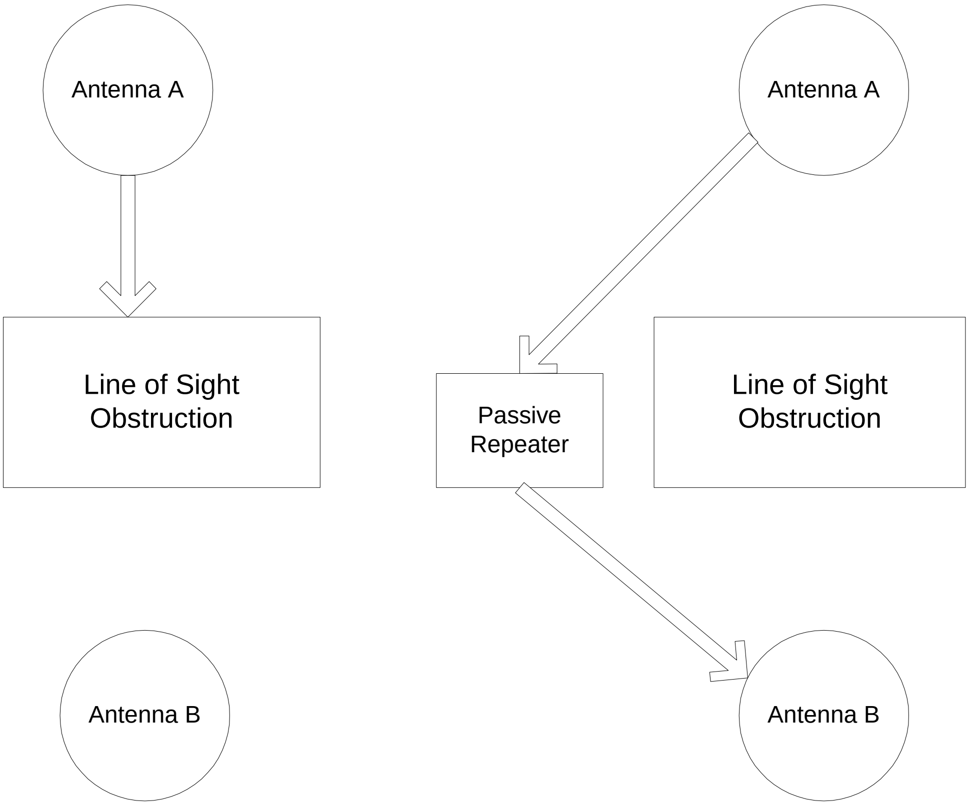
This picture shows an example of a passive repeater link (RepeaterBtB0); the End A Property is Property49, the repeater Property is Property35 and the End B Property is Property7:



A passive repeater link on the Map View

About Passive Repeater Links

This diagram shows an example of using a passive repeater link:

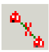


Using a Passive Repeater to avoid a Line of Sight Obstruction

In the diagram on the left, the line of sight obstruction is preventing the microwave beam from traveling from a transmitter at Site A to a receiver at Site B. However, in the diagram on the right a passive repeater site has been added to the left of the line of sight obstruction and the microwave beam is able to pass through it and onto its destination, Site B.

Deleting Passive Repeater Links

To delete a passive repeater link:

1. In the **Map View window**, click the **down** arrow on the **Break Link** toolbox and then click the **Break Connection** button  .
2. Click either half of the passive repeater link.

   The passive repeater link is removed to the Wastebasket.

– or –

1. In the **Link Database** window, click the passive repeater link.
2. Right-click, and from the menu that appears, click **Delete**.

   The link is moved to the Wastebasket.

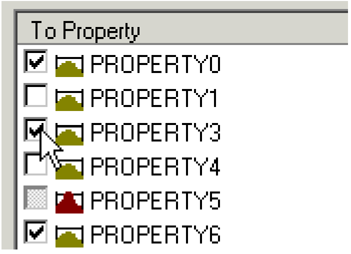
Adding Links Based on Line Of Sight Reports

After you have produced a line of sight report, you can use the results as the basis for creating new links. This means that you can create links that already have line of sight established.

To create new links in this way:

1. In the **LOS Results** dialog box, select the transmitter Property in the **From Property ID** box.

2. In the results pane, select the Properties that you want to create links to:



Note: You can only select Properties that have LOS clearance.

If you chose to produce a line of sight report based on a PmP hub, the links created will be PmP links, rather than PtP. These PmP links may be added to configured sectors automatically, providing they meet the criteria. For more information, see Adding Links to Sectors Automatically on page 78.

Tip: To select all receiver Properties with line of sight to the transmitter Property, click **Select All**. To undo this, click **Clear All**.

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3. Click **Create Links**.

4. In the dialog box that appears, choose the required option:

   - Create links based on a single default template. For more information on defining which link is the default, see Tips on Setting Up Link Templates on page 67.
   - Create links based on any range templates that you have created. For more information on creating templates based on ranges, see Defining Single Link and Range Templates on page 69.

5. Click **Next**.

   A summary of the links to be created (and the templates they are based on) appears.

6. If required, change the template for a particular link by double-clicking the **Link Template to be Used** column, and selecting the required template.

7. Click **Finish**.

   The required links are created.

Setting Link Identifiers

You can set the default identifier for a link, so that its ID is based upon a specified string.

To set a link identifier:

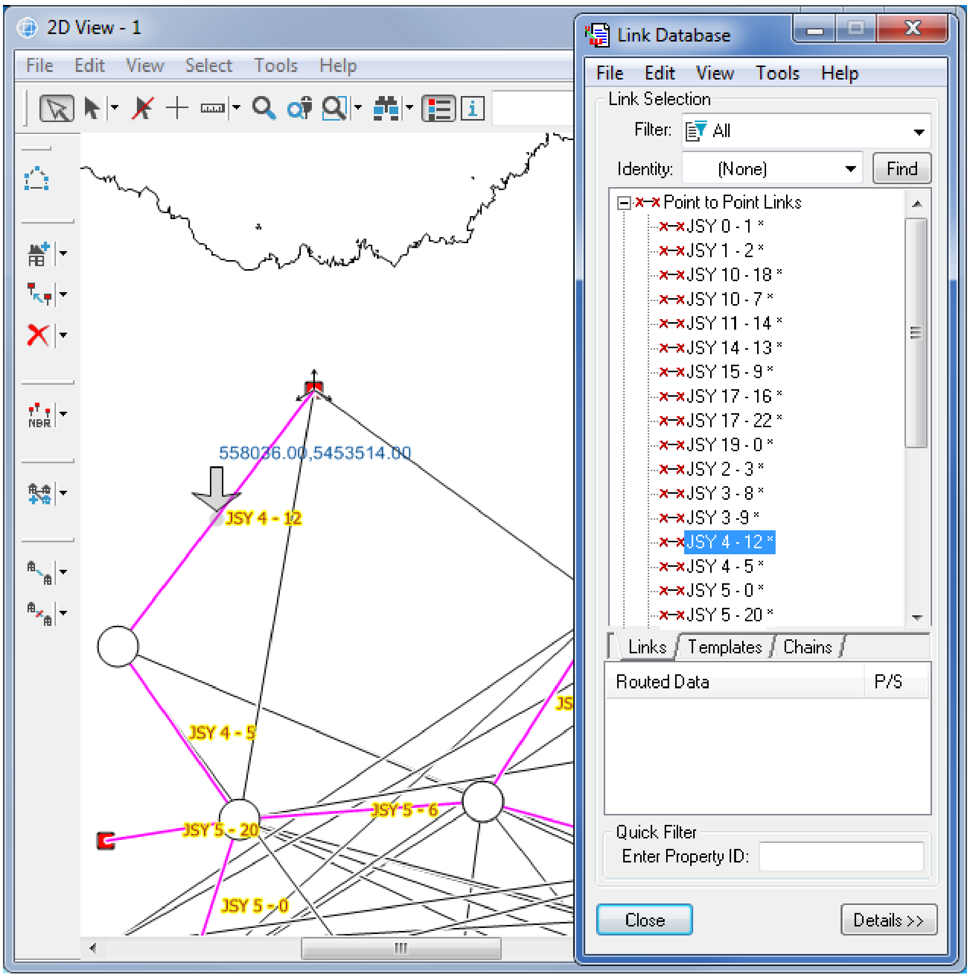
1. From the **Database** menu, click **Identifier Creation**.
2. In the left hand list, select the link type for which you want to set the identifier.
3. In the right hand pane, specify the base strings you want for the link (and if appropriate, the antenna).
4. If you want to use padding (with three digits), select the **Use Padding Min Length** checkbox.

   Padding can be used to ensure that the identifier is a particular character length.
5. Click **OK**.

Highlighting Links

After you have added a link, you can choose to highlight it in both the **Map View window** and the **Link Database**.

This picture shows an example of a highlighted link, shown in the Map View window and Link Database.



A highlighted link, shown in the Link Database and the Map View window

To highlight a link:

1. In the **Preferences** dialog box, on the **BACKHAUL** tab, select the **Highlight Selected Link** option.
2. Select the required link in the Link Database, right-click and from the menu that appears, click **Locate in 2D View**.

   The link will be centered, and highlighted in the **Map View Window**.

Moving Links

After you have added a link in the Map View window or Link Database, you can change its physical location by moving one or both of the linkends to another Property in the Link Database.

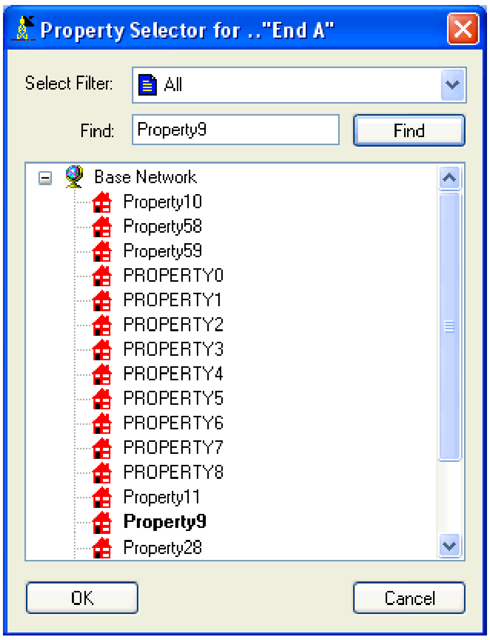
To move a link:

1. From the **Database** menu, click **Links**.

   The **Link Database** appears.
2. In the left-hand pane, select the link that you want to move.
3. On the **General** tab, click the **Info** subtab.
4. For the linkend that you want to change (End A or End B), click the **Change Linkend Property** button  .
5. In the dialog box that appears, select the Property that you want to use for the linkend.

   Tip: Use the **Filter** and **Find** options to help you to locate the required Property. Using the Find option, you can search on substring, where ASSET Backhaul will locate the first Property matching that substring.

   This picture shows an example:



6. Click **OK**.

   The linkend is moved to the selected Property, and inherits all of the parameter settings for that Property.

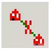
As well as moving the linkends from one Property to another, you can also reverse the two linkends for a particular link, switching the Properties. You can do this in two ways:

- For more information on how to do this in the Height Profile window, see Displaying Height Profiles Based on Map Data
- For more information on how to do this in the Link Database, see Defining the General Properties for Links on page 124

Note: You can not reverse the Properties for sub-links of dual polar links.

Deleting Links

To delete links in the Map View window:

1. Click the **down** arrow on the **Break Link** toolbox, and then click the **Break Connection** button  .
2. Click the required link. (You do not have to click the Properties).

   The link is moved to the Wastebasket.

– or –

1. In the **Link Database** window, select the link.
2. Right-click, and from the menu that appears, click **Delete**.

   The link is moved to the Wastebasket.

   Important: When you delete a link, any associated User Defined Profile is also moved to the Wastebasket as a separate item. It must be restored separately, after the link has been restored.

Changing Many Links Simultaneously

To change many links simultaneously and give them the same attributes, use the Global Link Editor:

Important: For antennas, only the transmitting antenna can be Applied in the Global Link Editor.

---

1. From the **Database** menu, click **Links**.
2. In the **Links Database** dialog box, click the **Global Edit** button.
3. Select the filter you require. For information on defining filters, see the *ENTERPRISE User Reference Guide*.
4. Click the tab that you want to edit. **Frequency**, **Antenna** and **Radio** tabs are available for:
   - Point to point links
   - Point to multi-point linkends
   - Point to multi-point carriers

   You can also edit **Connection**, **Status** and **Admin** details on the corresponding tabs.
5. Select to edit either main or diversity information.

Note: Frequency diversity is not applicable for multi-radio links.

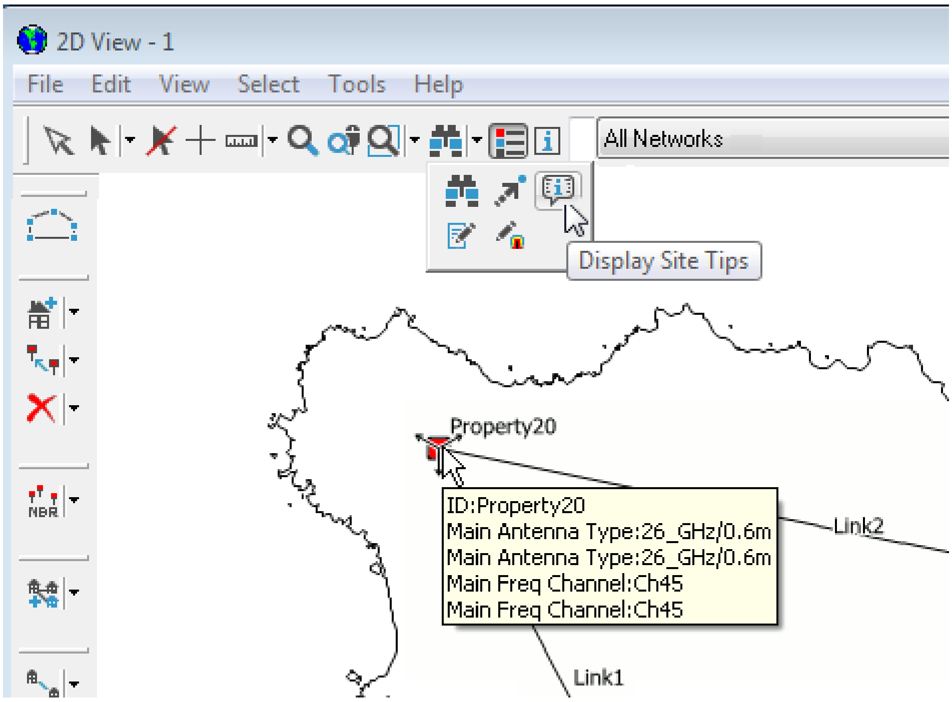
6. Select the checkbox for the attribute that you want to change, for example, antenna height (m).
7. Specify the required value.
8. Click **Apply**.

   Now all the links you selected have the attribute value that you set.

Viewing Linkend Attribute Data as Screentips

In ASSET Backhaul, you can display linkend attribute data in the Map View window as screentips, which appear as you hover over cells/repeaters in your network.

This picture shows an example, where the Main Antenna Type and Main Frequency Channel are displayed as site tips for the closest cell:

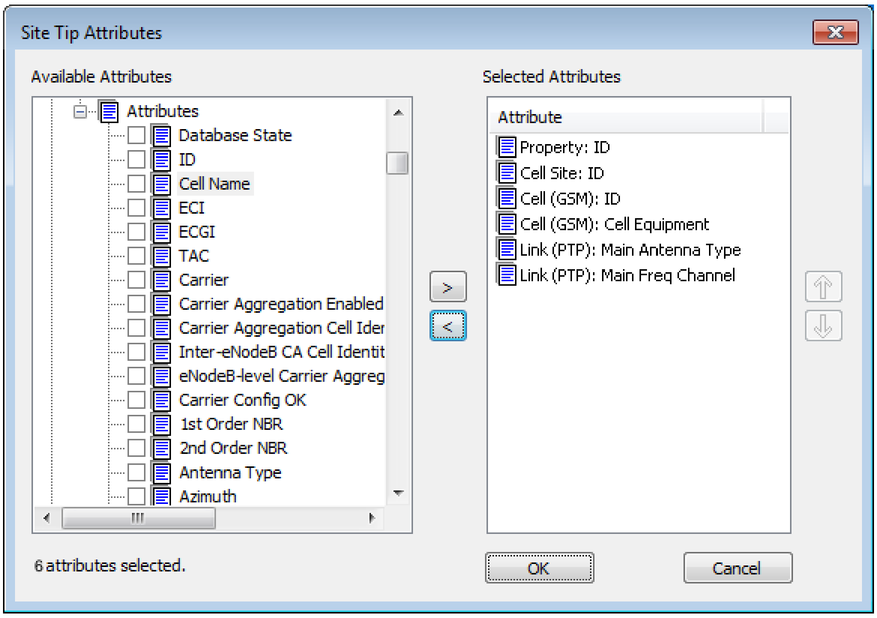


Viewing Linkend attribute data as screentips

To display screentips:

1. On the **Map View** toolbar, click the **Display Site Tips** button .

   The **Site Tips Attributes** dialog box appears:



2. In the **Available Attributes** pane, expand the required network element, and either:

   - Click the name of the attribute that you want to display on the Map View, and click the **right arrow** button

     - or -

   - Select the checkboxes of the attribute(s) that you want to display on the Map View

   The attributes are added to the **Selected Attributes** pane.

Tips:

- If you want to remove an attribute from the Selected Attributes pane, select the required attribute and click the left arrow button .
- If you want to re-order the way that the attributes will be displayed, click the **up** and **down** arrow buttons to change the position. The attribute at the top of the list is displayed first and the attribute at the end of the list is displayed last.

---

3. When you have selected all of the required attributes, click **OK**.

   The chosen attributes are available as screentips.

To stop displaying site tips:

1. Click the **Display Site Tips** button again.
2. In the **Site Tip Attributes** dialog box, click **Cancel**.

   Site tips are no longer displayed when you hover over network elements.

Adding and Editing Objects in the Link Database Window

You can use the **Link Database** window to add and delete network elements. In this way, you can add multiple sectors to a hub and multiple carriers to a sector.

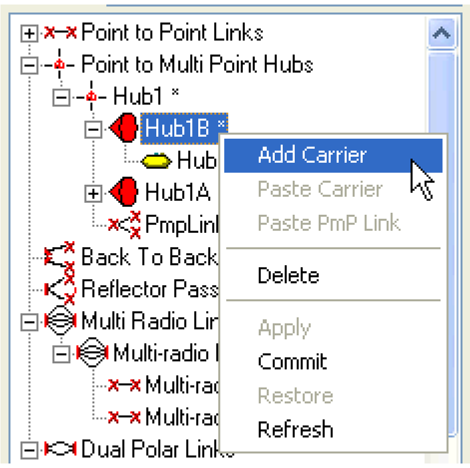
Adding network elements always follows the network hierarchy. For point to multi-point links you cannot add a carrier until you have added a sector.

To add a network element:

1. In the left pane of the **Link Database**, right-click the element above the one you wish to add.

   For example, to add a sector, right-click the relevant hub; to add a carrier, right-click a sector and so on.

2. From the menu that appears, click the appropriate **Add** option, for example, **Add Carrier**.



The selected network element is added.

To delete a network element:

In the left pane, right-click the element you wish to delete and from the menu that appears, click **Delete**.

The deleted item is sent to the Wastebasket from where it can be restored or deleted from the master database.

Warning: Deleting a network element also deletes everything attached to it, for example, deleting a sector will delete all of the carriers attached to it.

You can add and delete sectors and carriers in this way. You can also cut and paste point to multi-point links attached to sectors or carriers, but only within the same hub grouping.

Updating Objects in the Link Database Window

If you are one of several people simultaneously using the same database, you may want to update your project to include any Committed changes that other users have made.

To see whether an individual object has Committed changes on it:

In the **Link Database**, select the object and on the **Refresh** tab, click **Check for Changes**.

To update an individual object:

In the **Link Database**, right-click the required object and from the menu that appears, click **Refresh**.

– or –

In the **Link Database**, select the required object and on the **Refresh** tab, click **Refresh**.

If other people are logged into the same database as you, it is possible that they have Committed changes to objects that are now trying to Commit. If this happens, you are prompted either to cancel the Commit or to continue, merging their Committed data with your own changes.

To update all objects in the Link Database:

1. In the **Link Database**, in a blank area of the left hand pane, right-click and from the menu that appears, click **Refresh All**.

   - or -

   From the **Database** menu, click **Refresh All**.

2. If you are sharing your project, select to view changes between:
   - This project and the master project
   - All projects that are shared with your master project
3. In the dialog box that appears, view the changes to objects that have been Committed by users since you started using the project.
4. Click **Refresh All** to refresh your project with the other people's Committed changes and merge in your own, or **Cancel**.

Tip: You can also access this dialog box from the **Link Database Edit** menu by clicking **Refresh All**.

Using the Grid Data Loader with ASSET Backhaul

You can add and update links in the Link Database using the Grid Data Loader. For more information, see the chapter entitled About the Grid Data Loader in the *ENTERPRISE User Reference Guide*.

Refreshing the Display of Objects in the Link Database Window

To refresh the information shown in the tree pane of the **Link Database** window:

1. In the **Link Database** window, ensure you are displaying the correct view for the objects you wish to reconstruct.
2. In a blank area of the left hand pane, right-click and from the menu that appears, click **Reconstruct Tree**.

   – or –

   From the **Link Database View** menu, click **Refresh Tree**.

Using Height Profiles

The Height/Link Profile can be used to:

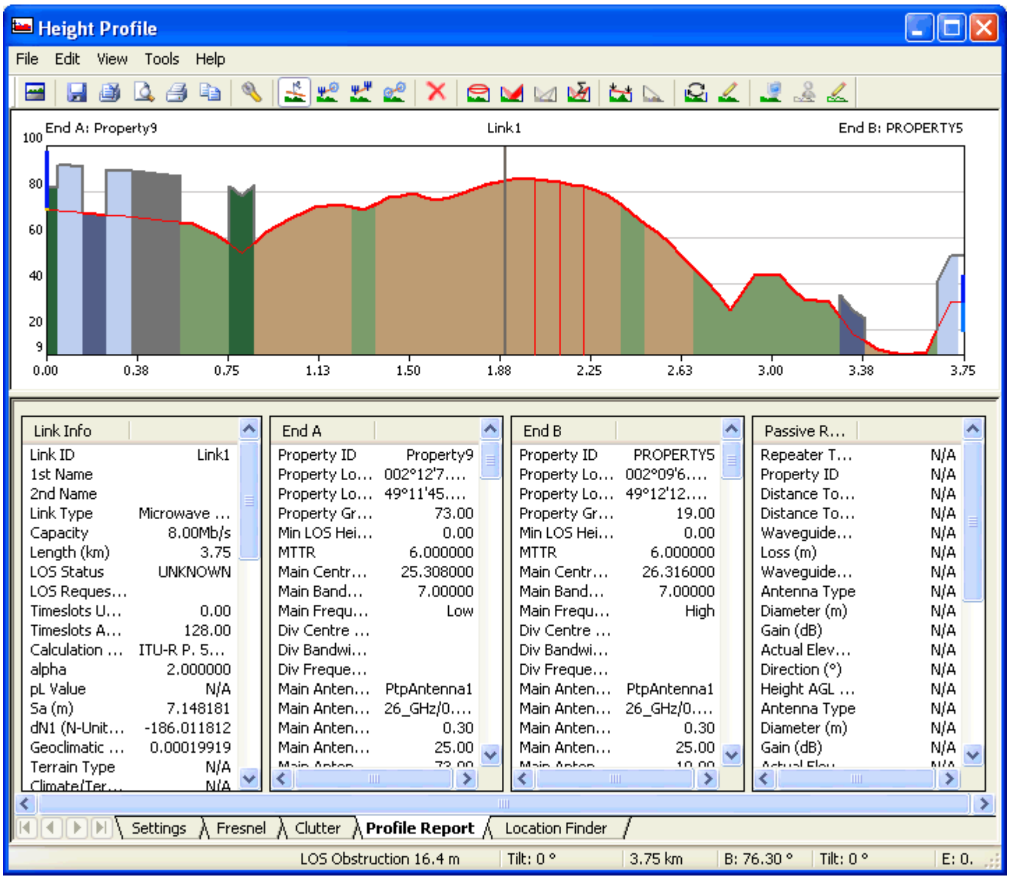
- Display the terrain profile along an existing link profile.
- Determine the profile for a new link between two Properties or two points on the Map View, taking into account antenna heights, clearance over obstructing terrain and objects, and the effects of terrain reflections.

  The Height Profile can be set to display the LOS and Fresnel zone clearance between the link and the DTM, clutter and buildings.
- Add and edit DTM, building and clutter data through the Location Finder function.
- Display link settings and performance values below the profile plot, for reporting purposes.
- Define your own profile with the User Defined Profile editor.

This table describes what can be displayed for each type of height profile:

Height Profile	Display Parameters
Map Data	DTM, Clutter, Building Vector, Building Raster
User-defined Data	DTM, Clutter, Obstruction

This picture shows an example height profile report:



Example height profile report

Displaying Height Profiles Based on Map Data

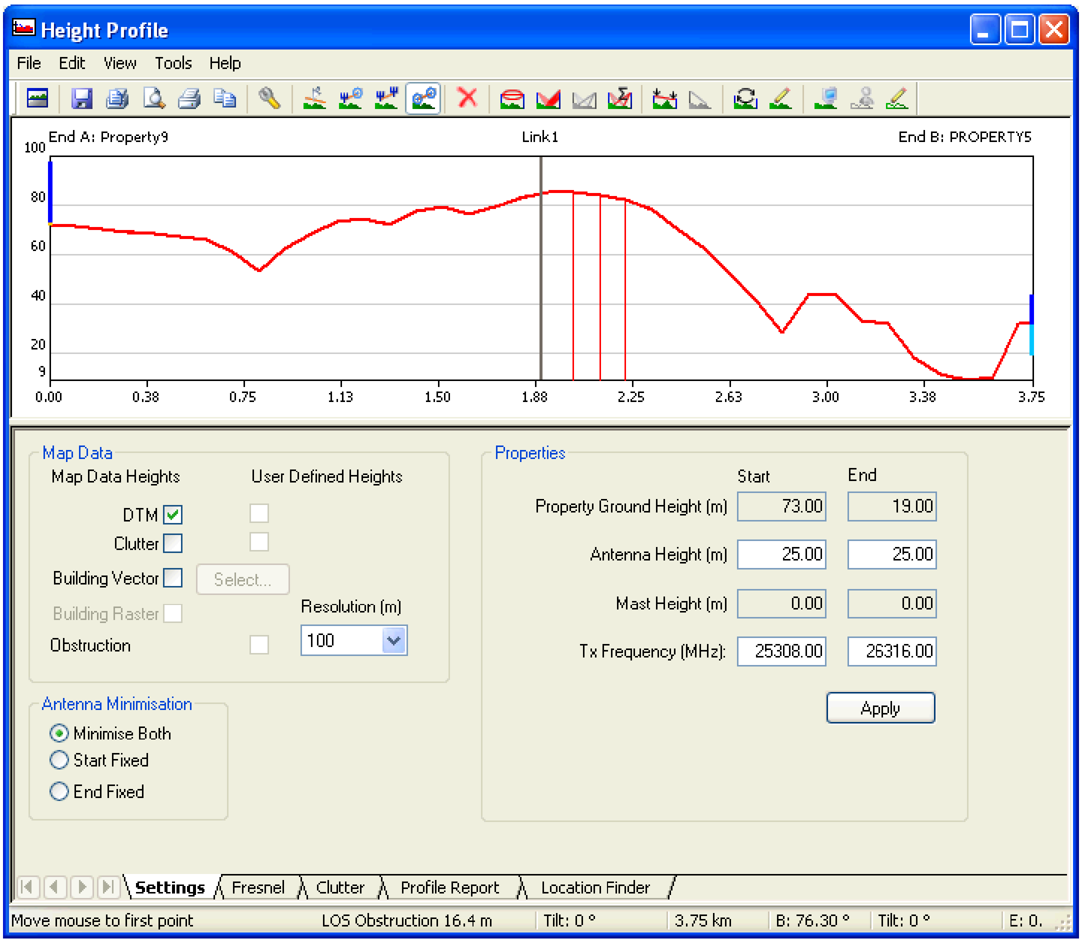
To display the height profile for a link based on map data:

1. In the **Map View** window, ensure you have links displayed.
2. From the **View** menu, click **Height Profile**.
3. Create a profile for a link. To do this, either:
   - Select the required link in the **Link Database**, right-click and from the menu that appears click **Profile**.

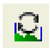
     \- or -

   - Click the **Select Link** button  in the **Height Profile** window, and then in the **Map View** window, click the required link.

The height profile for that link is displayed. This picture shows an example:



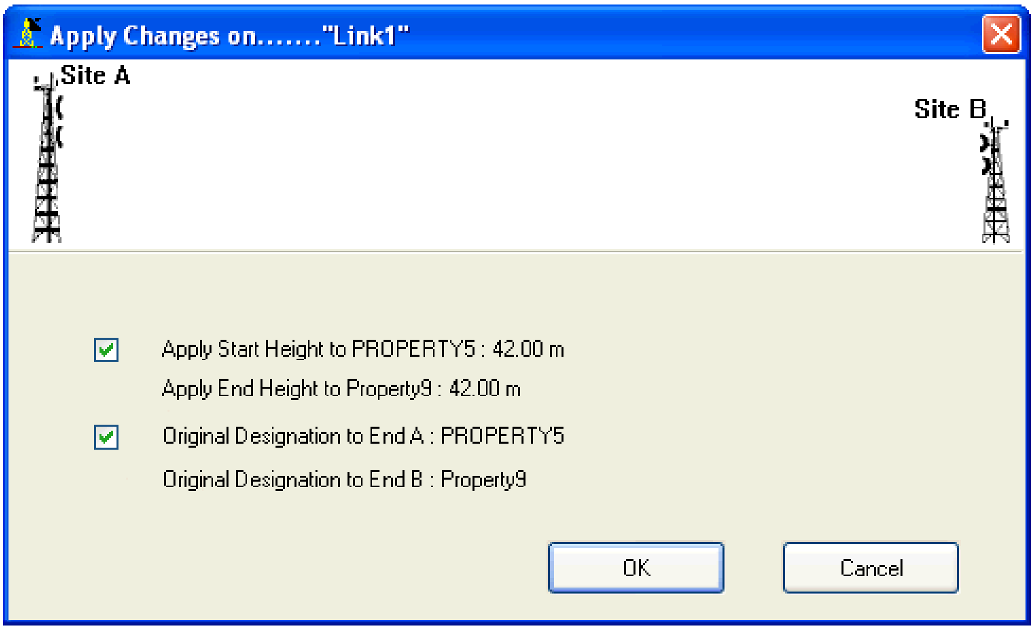
4. If you want to reverse the linkends, changing the Property on linkend A to the Property on linkend B and vice versa:

   - Click the **Reverse Profile**  button. On the **Settings** tab, the start and end Property ground heights change.

     Note: You cannot reverse the Properties for sub-links of dual polar links.

   - Click **Apply**.

The **Apply Changes** dialog box appears, detailing the changes that you are about to make. This picture shows an example:



Ensure that the required options are selected (in particular that the Properties at end A and B are the required ones) and then click **OK** to save your changes.

Tip: When creating height profiles you should consider the following guidelines:

- Construct your profile to take into account the curvature of the Earth.
- Try to avoid reflections, because reflection of the microwave signal by the terrain along the path is particularly troublesome for digital microwave systems.
- Select antenna heights to ensure sufficient clearance over obstructions at every point along the microwave path. The high cost of providing large antenna support structures (such as towers) means that you may have to consider several site locations rather than face the cost of providing the required clearance.

After you have displayed a height profile based on map data, you can additionally define and view:

- Fresnel clearance criteria
- Multi-path reflections
- Clutter heights
- Minimum antenna heights
- A height profile based on user-defined height data

Displaying Fresnel Clearance Criteria

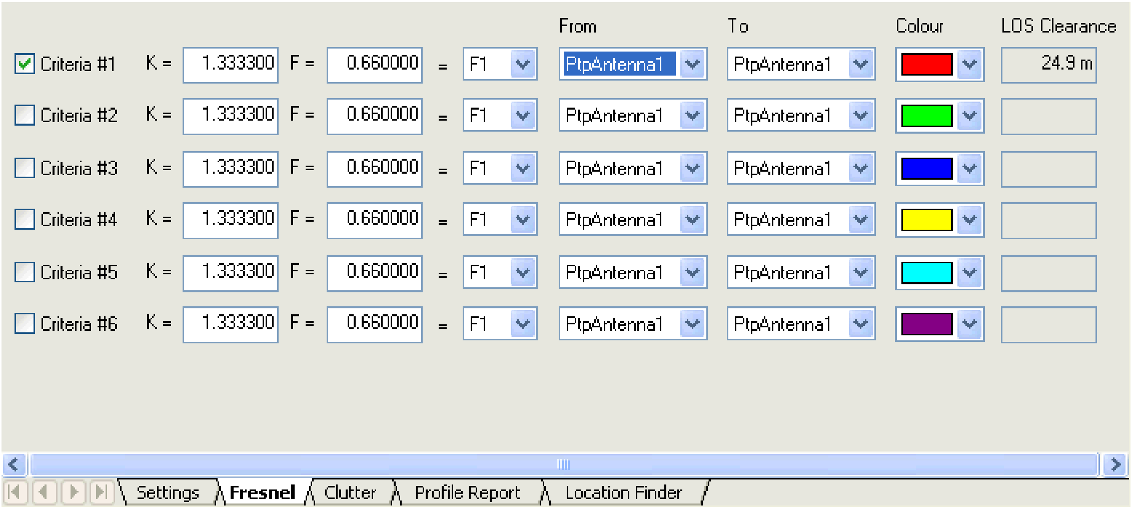
After you have displayed a height profile, you can additionally display Fresnel clearance criteria.

The amount of clearance required depends on the path length, the position of any obstruction along a path and the frequency being used. Fresnel clearance criteria take all these factors into account.

In ASSET Backhaul, you can define up to 6 Fresnel clearance criteria. For each one, you can specify the following:

Item	Description
K	The *k* factor – The factor by which the Earth's radius is multiplied to reflect the effective Earth bulge.
F	The Fresnel factor – This is the amount of clearance that should be afforded in a particular location, based on ITU-R recommendations. For example, for k=1.33, the clearance should be 1.0 F1. However, if k=minimum exceeded for 99.9% of the time, the clearance should be 0.3 F1 for a rounded obstacle, or 0 F1 for a single sharp obstacle.
#	The number of the Fresnel zone – F1 is the first Fresnel zone, F2 is the second Fresnel zone and so on.
From and To antennas	The two antennas that connect the link. The height of the antennas will be considered in the Fresnel zone calculations.
Color	The display color that you will use to visually identify the Fresnel zone.

For example:



You can also view line of sight (LOS) clearance:

- If no criteria are selected, the LOS clearance is calculated based on the global default *k* factor
- If one criterion is selected, the LOS clearance is calculated based on the *k* factor defined for that criterion
- If more than one criterion is selected, the LOS clearance is calculated based on the *k* factor defined for the first criterion selected

To display a clearance criterion that you have defined:

Select its checkbox. You can display multiple pairs on the same profile.

Displaying Multi-path Reflections

After you have displayed a height profile, you can additionally display the multi-path reflections from transmitter to receiver over the profile. For more information on what multi-path reflections are, see About Multi-path Reflections on page 95.

Important: For reflections to be possible, the start antenna height must be greater than zero.

To display basic reflection points:

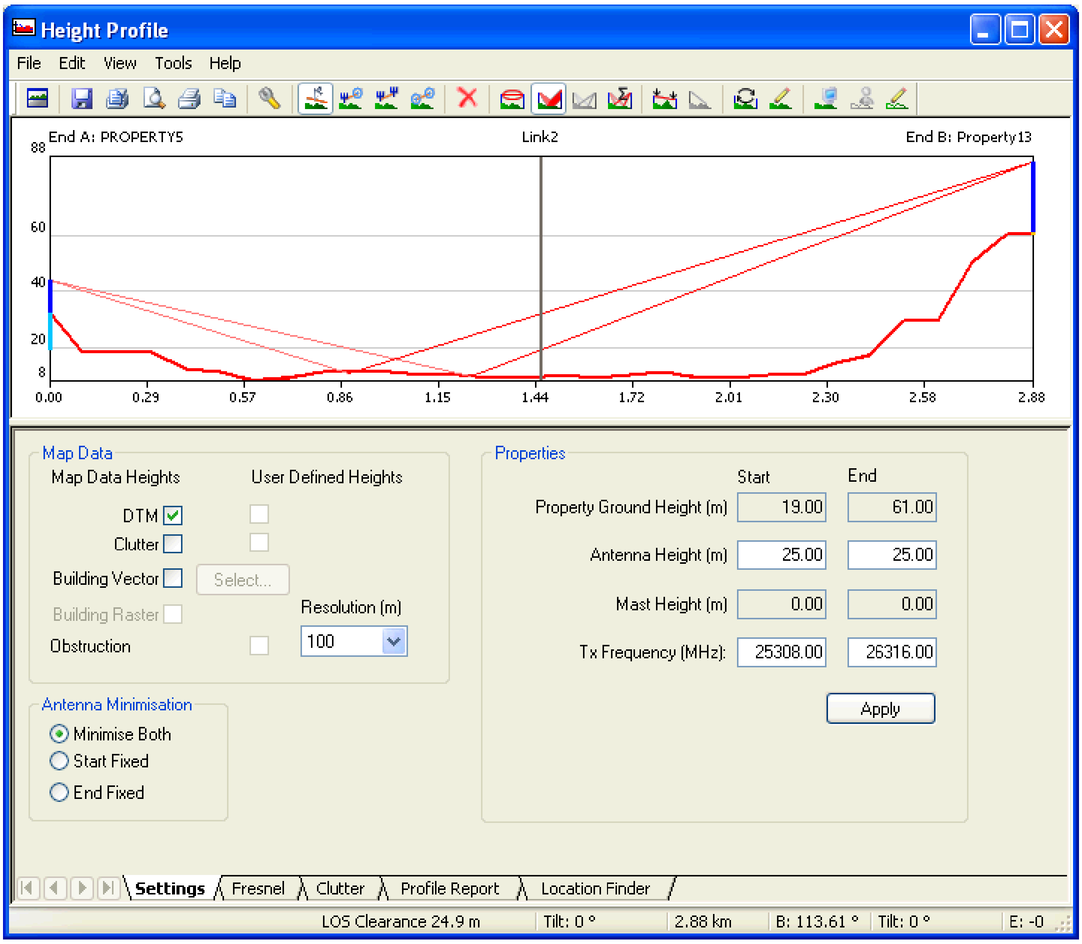
1. Display a height profile.
2. Ensure that you have defined your reflection settings correctly. For more information, see Defining Reflection Settings on page 95.
3. Click the **Toggle Basic Reflections** button  .

   - or -

   From the **Tools** menu, point to **Reflections** and click **Show Basic Reflections**.

   The reflections for this profile are displayed, based on the reflection settings.
4. To stop displaying reflections, click the button again.

   This picture shows an example of reflections. Any harmful reflections will be shown in blue.



As well as displaying basic reflection points, you can also perform a full reflection analysis. For more information on how to do this, see Analyzing Reflections on page 96.

About Multi-path Reflections

The Earth's surface can influence transmission quality by reflecting signals. If the phase difference between the reflected and non-reflected signals is near 180 degrees, the resulting received signal level may be severely reduced.

The reflection loss is described in the reflection coefficient, which is the ratio between the field strength before and after reflection. The reflection coefficient depends on the angle of incidence and the polarization of the radio wave. The angle of incidence is usually the angle between the direction of propagation and the reflecting surface, but if the reflecting surface is not flat, the angle of incidence is between the direction of propagation and a tangent to the surface.

The most reflective hops are:

- Water surfaces
- Damp, flat, open terrain (such as large marshes, fields and rice fields)

This is because most of the reflecting surfaces are relatively rough as compared to the wavelength, and signals arriving from multiple reflection points are non-coherent, leading to a lower power in the total reflected signal. However, problems may arise due to reflections from metal roofs or from calm water surfaces.

The significant area of reflective surface is proportional to the Fresnel zone, and reduces as frequency increases. This means that surfaces whose dimensions are only 5m (or even 10m) may, in unfavorable circumstances, cause noticeable reflections.

You can reduce the effect of possible reflections by:

- Designing the hop to have only the minimum required clearance (keeping only the first Fresnel zone clear)
- Appropriately selecting your antenna heights so that terrain obstacles or buildings shadow the reflected ray when seen from either or both of the antennas
- Increasing the arrival angle of a reflection and using the antenna pattern to reduce the level

Defining Reflection Settings

If you are performing basic and/or specular reflection analysis, you can set the area of the receiver antenna that will be used in reflection calculations. This is particularly useful if you want to, for example, see reflections that impact within the dish's radius, or within the area of the effective antenna size.

To define this setting:

1. In the **Height Profile** dialog box, from the **Tools** menu, point to **Options** and click **Reflection Settings**.
2. In the dialog box that appears, select one of these options:
   - Consider reflections within the effective antenna diameter, which is defined as the actual antenna diameter plus the width of the 1st Fresnel zone at a point one antenna diameter's distance away from the receiver.
   - Consider reflections within the actual antenna diameter.
   - Consider reflections within a specified distance (in meters).

     Note: If you are performing a specular reflection analysis, the specified distance is ignored, and the effective antenna diameter is used instead.
3. If you choose to consider reflections within a specified distance, type the distance in meters in the first box.

   In the second box, you should type the interval value used across that distance. This will determine how many reflections will be calculated and (if appropriate) displayed across the chosen distance. For example, if you chose a distance of 10m in intervals of 1m, then up to 10 reflections will be calculated and displayed.

4. Click **OK**.

Analyzing Reflections

In ASSET Backhaul, you can identify the reflections that will affect the links in your network by performing a reflection analysis.

The reflection analysis method used by ASSET Backhaul is based on a two-ray model, where the first ray is the direct (main) signal and the second ray is the ground-reflected interfering signal.

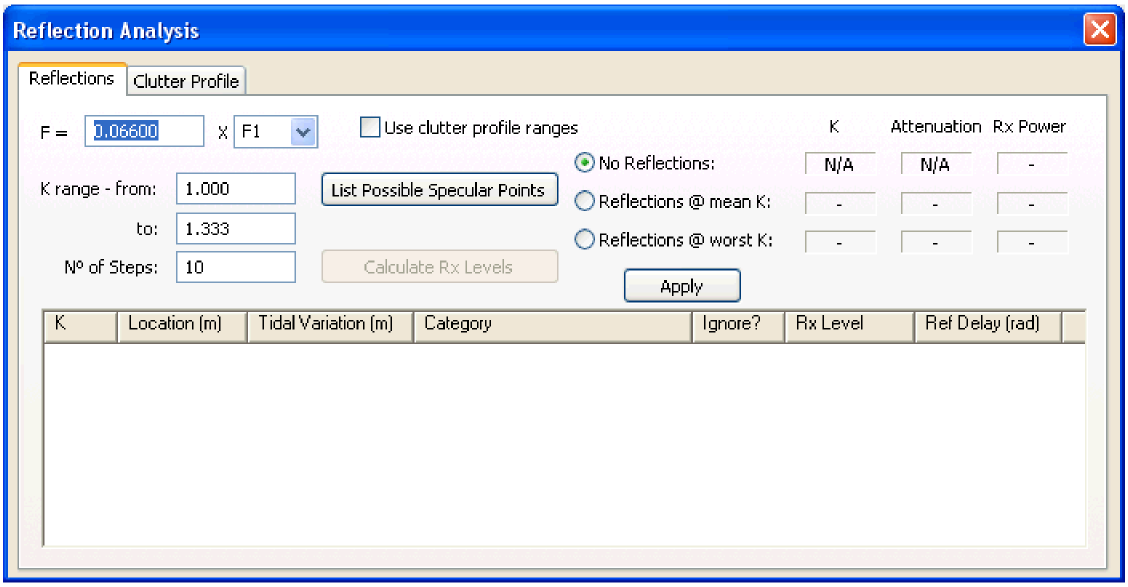
To analyze reflections:

1. Click the **Reflection Analysis** button  .

   - or -

   From the **Tools** menu, point to **Reflections** and click **Reflection Analysis**.

   The **Reflection Analysis** dialog box appears:

2. On the **Reflections** tab, set the Fresnel, K values and other parameters that will be used in the reflection analysis. For more information, see Configuring the Reflection Analysis on page 99.

3. Click the **List Possible Specular Reflection Points** button. The link is analyzed, and the calculated points are displayed in the **Reflection Analysis** dialog box. For more information on the results that are displayed, see About the Reflection Analysis Results on page 100.

4. After the list of reflection points has been created, you can calculate the Rx level for these points. To do this, click the **Calculate Rx Levels** button.

5. To view the specular reflections on the height profile:

   Click the **Toggle Display of Specular Reflections** button  .

   - or -

   From the **Tools** menu, point to **Reflections** and click **Show Specular Reflections**.

Tip: By default, the current clutter values are used, but on the **Clutter Profile** tab, you can define the characteristics of each clutter type that will be used to calculate the specular properties of each reflection point. For more information, see Defining the Clutter Profile for Reflection Analysis on page 97.

Defining the Clutter Profile for Reflection Analysis

On the **Clutter Profile** tab of the **Reflection Analysis** dialog box, you can define the characteristics of each clutter type that will be used to calculate the specular properties of each reflection point.

You can do this in two different ways:

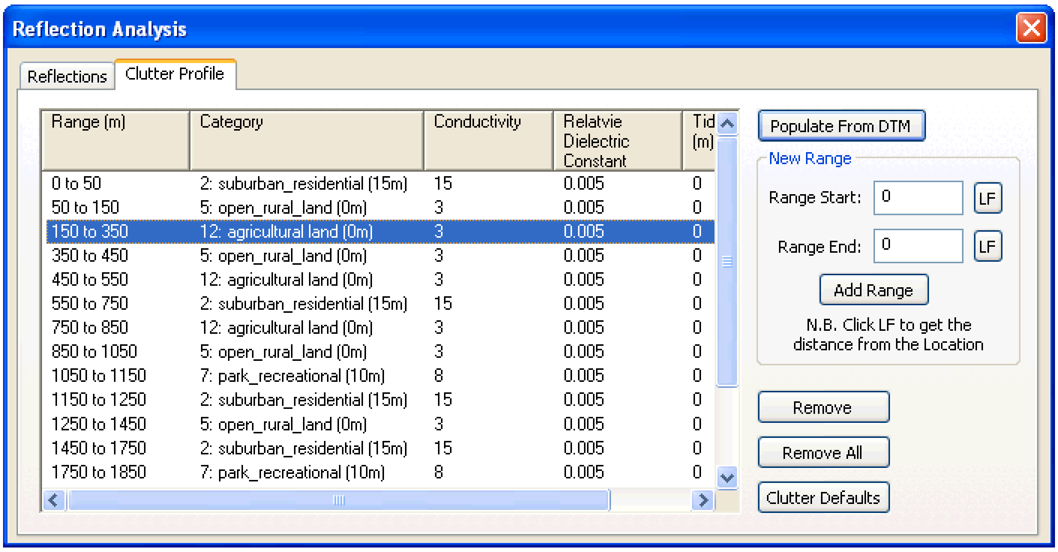
- Set the clutter ranges and associated clutter types automatically, based on the current DTM values
- Create your own clutter ranges and associate the clutter types manually

To set the clutter ranges and types automatically:

Click the **Populate from DTM** button.

ASSET Backhaul assesses the height profile and identifies the clutter ranges and associated types. These are displayed on the **Clutter Profile** tab.

This picture shows an example:



To set the clutter ranges and types manually:

1. In the **Range Start** box, type the starting point (in m) of the range, which is defined as the distance between antenna A and the start of the clutter type.

Tip: Click the **LF** button to get the value from the position of the Location Finder on the Height Profile. You can also use this to define the end point of the range.

---

2. In the **Range End** box, type the end point (in m) of the range, which is defined as the distance between antenna A and the end of the clutter type.
3. Click **Add Range**.

The new range appears in the list, with its associated values taken from the **Clutter Defaults** dialog box. This table describes the values:

Item	Description
Category	The clutter type associated with this range.
Conductivity	This is taken from ITU-R P.527, and is based on the frequency and ground type.
Reflective Dielectric Constant	This is taken from ITU-R P.527, and is based on the frequency and ground type.
Tidal Variation (in m)	This is a positive or negative number, and indicates how the water will rise/fall above/below the height given by the mapping data.

All of these values are initially taken from the Clutter Defaults. To view the Clutter Defaults dialog box, click the **Clutter Defaults** button.

For information on how to edit the Clutter Defaults, see Defining the Clutter Defaults on page 98.

4. If required, edit the values by double-clicking the required value and type the new value, or in the case of clutter category, select the required clutter type from the drop-down list.

5. If required, delete a range by selecting it and clicking **Remove**. To delete all of the ranges displayed, click **Remove All**.

6. To use the clutter profile that you have defined, on the **Reflections** tab, select the **Use clutter profile ranges** option.

Defining the Clutter Defaults

In the **Clutter Defaults** dialog box, you can set the default parameter values for each clutter category. These will be used on the **Clutter Profile** tab when you are analyzing reflections.

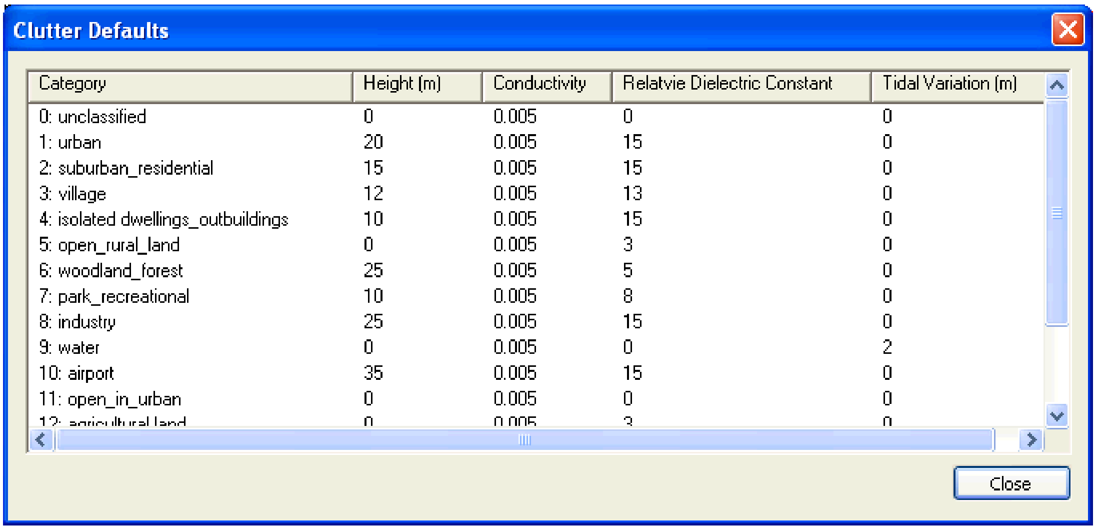
Tip: The conductivity and relative dielectric constant values will vary according to the frequency band that you use, so the clutter defaults should be updated if you change frequency band that you are planning on.

To define the clutter defaults:

1. In the **Reflection Analysis** dialog box, click the **Clutter Defaults** button.

2. In the dialog box that appears, you can edit the parameter values for each clutter category defined in the map data.

   This picture shows an example:



Category	Height (m)	Conductivity	Relatvie Dielectric Constant	Tidal Variation (m)
0: unclassified	0	0.005	0	0
1: urban	20	0.005	15	0
2: suburban_residential	15	0.005	15	0
3: village	12	0.005	13	0
4: isolated dwellings_outbuildings	10	0.005	15	0
5: open_rural_land	0	0.005	3	0
6: woodland_forest	25	0.005	5	0
7: park_recreational	10	0.005	8	0
8: industry	25	0.005	15	0
9: water	0	0.005	0	2
10: airport	35	0.005	15	0
11: open_in_urban	0	0.005	0	0
12: agricultural_land	0	0.005	3	0

You can edit the following values:

- Conductivity
- Relative Dielectric Constant
- Tidal Variation

Note: You cannot edit the height; this is taken from **Clutter** tab of the **Height Profile** dialog box.

---

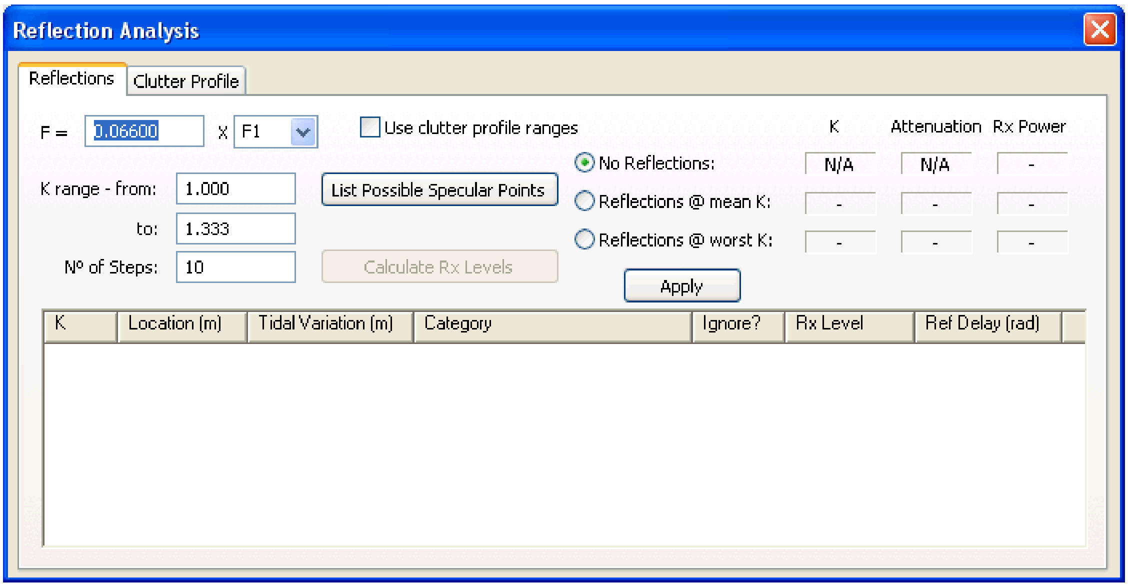
3. When you have finished defining the clutter defaults, click **Close**.

Configuring the Reflection Analysis

On the **Reflections** tab of the **Reflection Analysis** dialog box, to set the Fresnel, K values and other parameters that will be used in the reflection analysis:

1. Click the **Reflections** tab.

   This picture shows an example:



2. Select the proportion of the Fresnel zone that will be considered in the reflection analysis. This is defined as a decimal - for example, 0.1 is 10%, 0.66 is 66% and so on.

3. Choose which Fresnel zone will be considered, from F1 to F6.

4. If you want to use the clutter profile ranges that you have defined on the **Clutter Profile** tab, select this option.

   If you do not select this option, the clutter defaults will be used.

5. Specify the K range (from and to) in the appropriate boxes. This range is used by the reflection analysis calculations to determine the start and end reflection points.

6. You can now analyze reflections.

About the Reflection Analysis Results

After you have performed a reflection analysis, you can view the analysis results on the **Reflections** tab of the **Reflection Analysis** dialog box.

You can view the **K** value, **Attenuation** (in dB) and **Rx Power** (in dBm) under the following assumptions:

Item	Description
No reflections	ASSET Backhaul calculates the attenuation and Rx power levels after free space loss, antenna gain and the feeder loss. This is the default, before the analysis has been performed, and is taken from the Link Budget subtab of the Performance tab in the Link Database.
The reflections at the mean K value	ASSET Backhaul calculates the attenuation and Rx power levels after free space loss, antenna gain, feeder loss and reflected loss when K is at its mean value.
The reflections at the worst K value	ASSET Backhaul calculates the attenuation and Rx power levels after free space loss, antenna gain, feeder loss and worst reflected loss.

To Apply one of these calculated Rx Power values to the Link Database, select the appropriate radio button and click **Apply**.

Warning: This overrides the current value on the **Link Budget** subtab of the **Performance** tab of the **Link Database**.

You can also view the details of the individual reflections, as described in the following table:

Item	Description
K	The K value for each reflection point.
Location (m)	The distance of the reflection point along the height profile path, from Linkend A.
Tidal Variation (m)	The tidal variation value at the reflection point.
Category	The clutter type at the reflection point.
Ignore?	Indicates whether or not the reflection point will be ignored when calculating the Rx Power values.
Rx level	The received power level for each reflection ray.
Reflection delay	The number of wavelengths, in radiants.

Defining Clutter Heights Over a Profile

After you have displayed a height profile, you can define your own clutter heights to be Applied. These height values are used in the antenna minimisation calculation and can be used in the obstruction loss calculations (displayed on the **Link Budget** subtab of the **Performance** tab in the **ASSET Backhaul Link Database**).

To define the clutter heights over a height profile:

1. In the **Height Profile** window, ensure that you are displaying the full view. If not, click the **Toggle View** button  .
2. Click the **Settings** tab, and in the **Map Data** pane, ensure the correct **Clutter** checkbox is selected (either **Map Data Heights** or **User Defined Heights**).

3. Click the **Clutter** tab.
4. To change the height of a clutter type:
   - Select it from the list and click the **Edit Height** button
   - In the **Clutter Height Editor**, type the required height and click **OK**

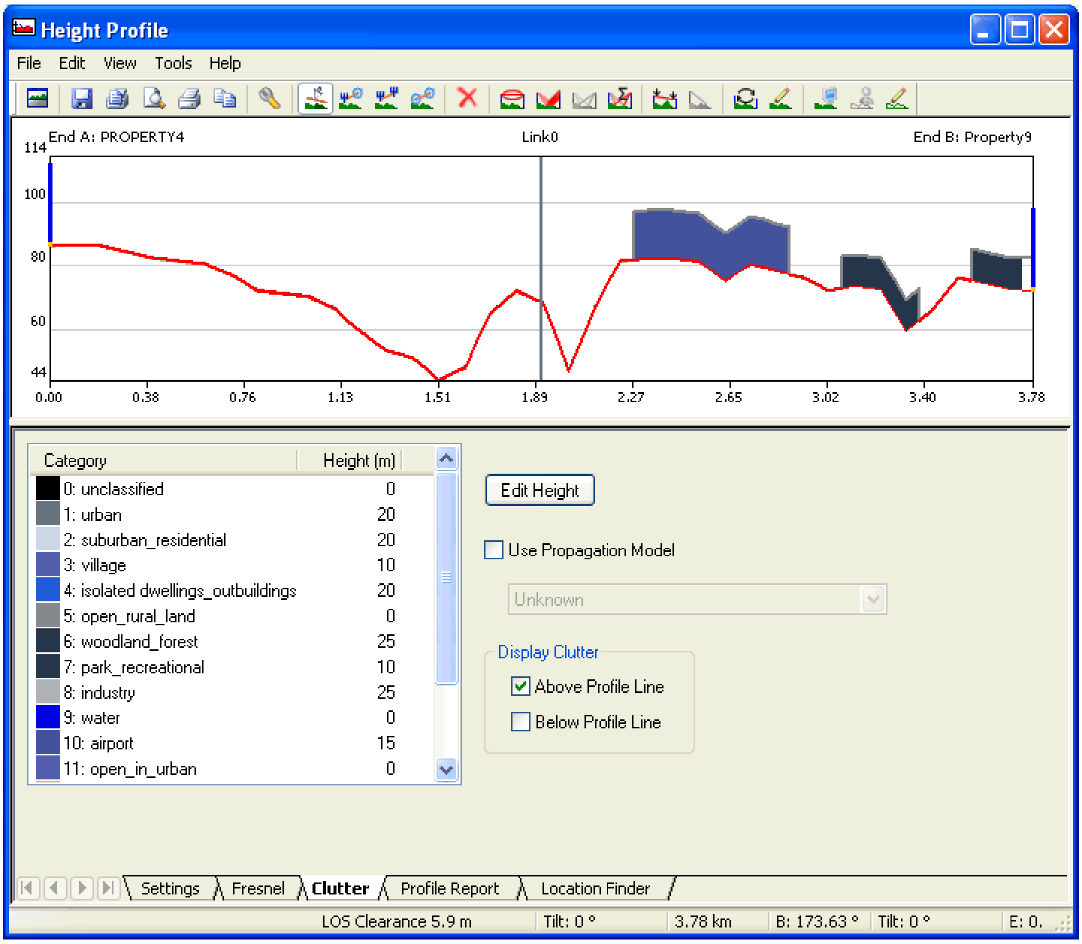
Tip: You can also open the Clutter Height Editor by double clicking on the clutter type.

5. If any propagation models have been defined, you can select the **Use Propagation Model** checkbox to choose a height model.

   For more information on defining propagation models, see the *ENTERPRISE User Reference Guide*.

6. Select the required checkboxes to display clutter above and/or below the height profile line.

   This picture shows an example of clutter heights displayed above the line:



Calculating the Minimum Antenna Height

After you have displayed a height profile, you can calculate the lowest antenna height required for a link between two Properties.

Important: When using minimum antenna heights you should take into account k-fading. For more information on this, see About Diffraction (k-) Fading on page 111.

To calculate the minimum antenna height required for a link:

1. From the **View** menu, click **Height Profile**.

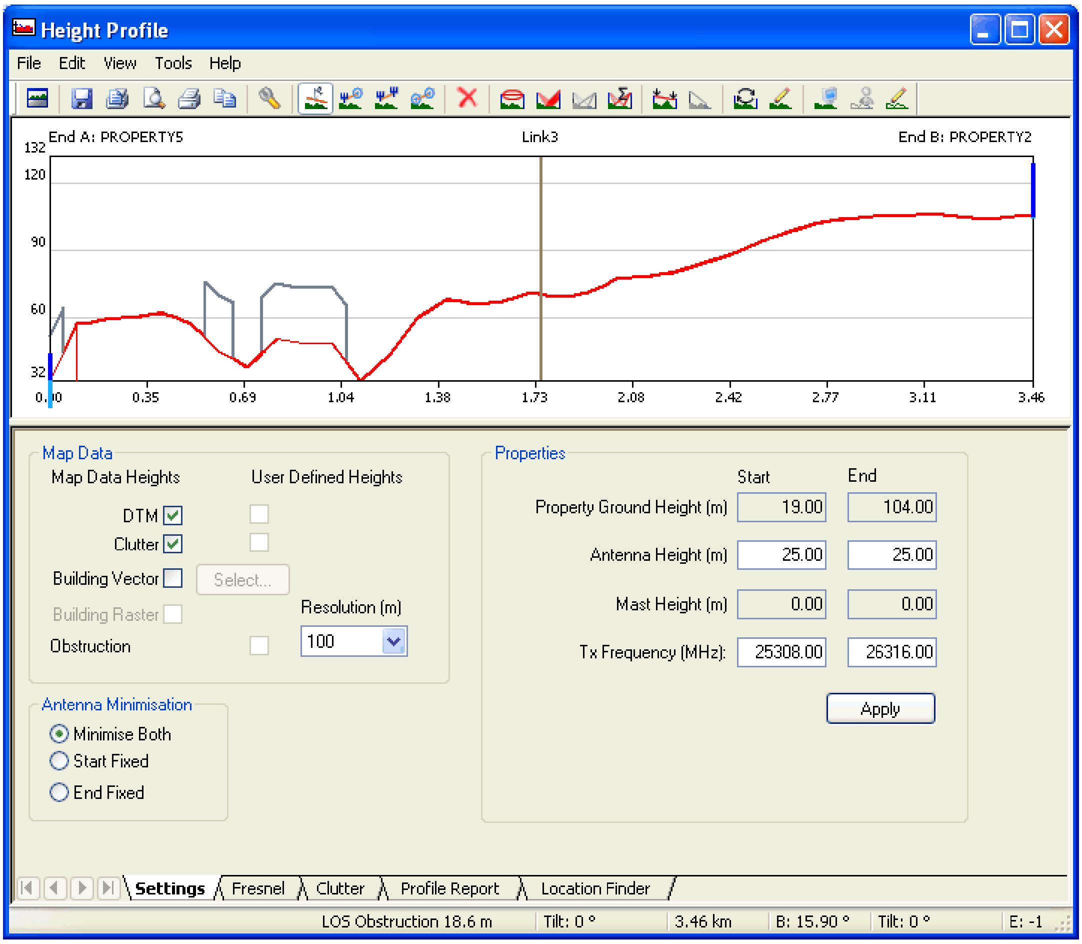
2. Create a profile for a link. To do this, either:

   ○ Select the required link in the **Link Database**, right-click and from the menu that appears click **Profile**

   - or -

   ○ Click the **Select Link** button  in the **Height Profile** window, and then in the **Map View** window, click the required link

   The height profile appears in the Height Profile window, for example:



3. Ensure that the **Height Profile** tabs are displayed; if they are not, click the **Toggle View** button  .

4. On the **Fresnel** tab, ensure the correct clearance criteria are used. For more information, see Displaying Fresnel Clearance Criteria on page 93.

5. On the **Settings** tab, in the **Antenna Minimization** pane, define which algorithm is to be used to calculate the minimum antenna height. This table shows which algorithm to select:

If	Then
Both Properties are new	In the Antenna Minimization pane, select Minimize Both.
The start Property has an existing mast	1. In the Properties pane, type the height of the antenna. 2. In the Antenna Minimization pane, select Start Fixed. The minimum antenna height at the end site will be calculated.
The end Property has an existing mast	1. In the Properties pane, type the height. 2. In the Antenna Minimization pane, select End Fixed. The minimum antenna height at the start site will be calculated.

6. Click the **Antenna Minimization** button  .

   A dialog box appears showing you the minimum required antenna heights, based on the specified criteria:

   - If no criteria are selected, the antenna heights are minimized based on the global default K factor
   - If one criterion is selected, the antenna heights are minimized based on the K factor defined for that criterion
   - If more than one criterion is selected, the antenna heights are minimized based on the K factor defined for the first criterion selected

7. If you are satisfied that the antenna heights are achievable in terms of resources (cost, installation time and so on), click **Apply** to Apply the suggested antenna heights to the database.

Creating User-Defined Height Profiles

After you have displayed a height profile, you can create a user-defined height profile in order to view selected data and base it on your own height data values.

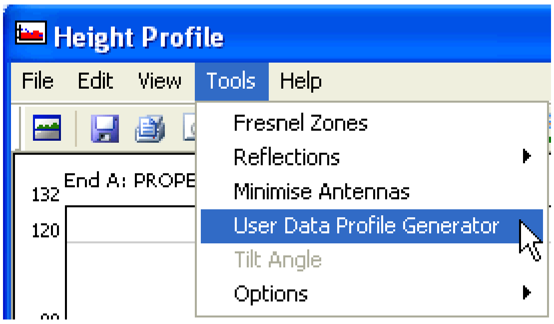
To create a height profile:

1. Ensure that you have displayed a height profile along a link.

2. Click the **User Data Profile Generator** button  .

   - or -

   From the **Tools** menu of the **Height Profile** window, click **User Data Profile Generator**.



3. In the dialog box that appears, you can create a user-defined height profile based on either:

   - Points generated automatically, using a default interval. For more information, see Generating Height Profile Points Automatically on page 105.

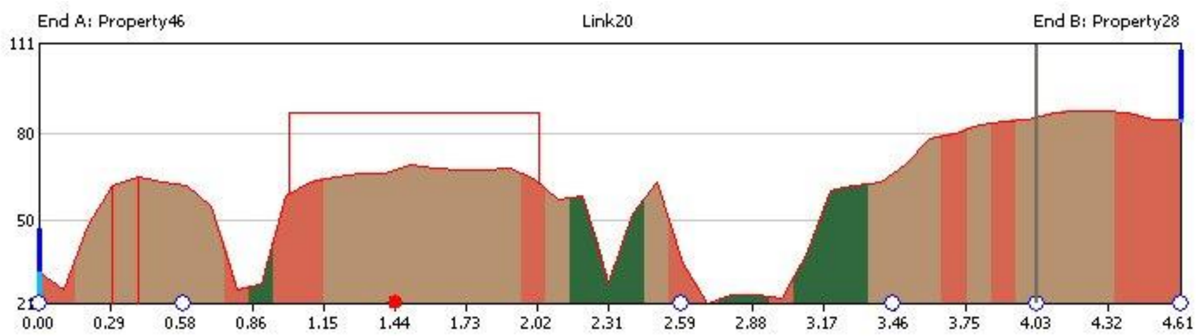
   - or -

   - Points generated manually. For more information, see Generating Profile Points Manually on page 106.

4. To highlight a point in the Height Profile window, click the required point (but not the checkbox) in the **Points** column of the **User Defined Profile** table:

Points	Distance(m)	DTM(m)	User DT...	Clutter(m)	User Clutter(m)	Building V...	Building R...	User Obst.
1	0.00	32.00	32.00	5.open_rural_land (...	5.open_rural_land (...	0.00	0.00	0.
2	581.58	63.00	63.00	12.agricultural land ...	12.agricultural land...	0.00	0.00	0.
3	1443.45	66.00	66.00	12.agricultural land ...	12.agricultural land...	0.00	0.00	20.
4	2599.61	35.00	35.00	5.open_rural_land (...	5.open_rural_land (...	0.00	0.00	0.
5	3447.45	69.00	69.00	12.agricultural land ...	12.agricultural land...	0.00	0.00	0.
6	4029.04	87.00	87.00	12.agricultural land ...	12.agricultural land...	0.00	0.00	0.
7	4610.62	85.00	85.00	5.open_rural_land (...	5.open_rural_land (...	0.00	0.00	0.

The chosen point will be highlighted in red in the Height Profile window:



5. If you want to edit the user-defined data:
    - Click **Show User Defined Heights**
    - Double-click the required value (for example, **User Clutter**)

      Tip: The columns that you can edit are marked in yellow
    - If you are editing clutter, select the required clutter category (and its corresponding height) from the drop-down list

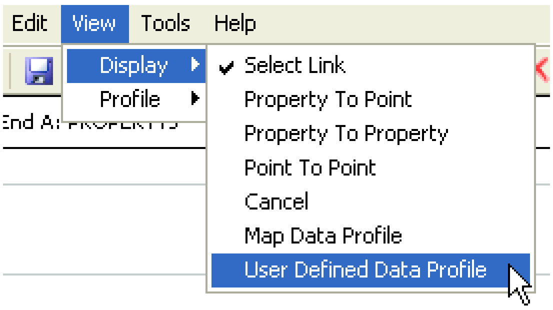
      - or -
    - If you are editing user DTM height or user obstruction data, type in the required value and press **Enter**
6. Click **Apply** to save any changes locally, or **Commit** to make any changes available to other users.

Warning: This only Applies/Commits the user-defined height profile. The associated link is unaffected. However, if you delete the associated link, the user-defined height profile is deleted also, as a separate item.

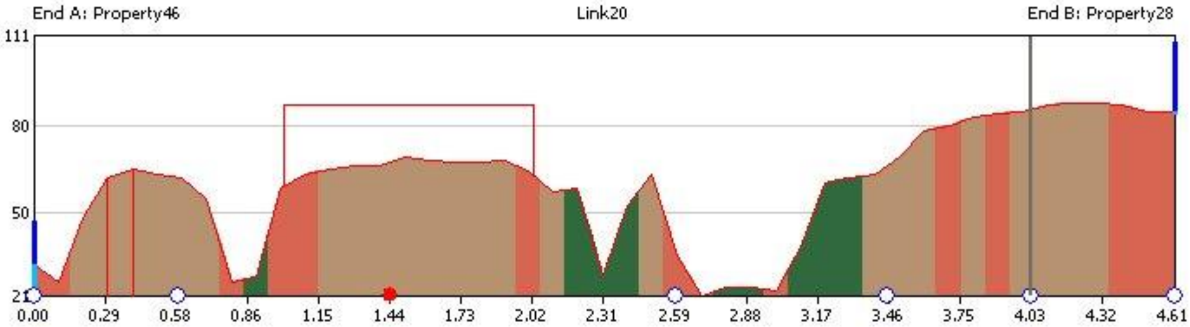
---

7. If you have edited the height data, to view the edited profile based on this height data:
    - Click the **UDP (User Defined Profile)** button 

    - or -
    - From the **View** menu of the **Height Profile**, point to **Display** and click **User Defined Data Profile**



In this example, the map data DTM and clutter has been used, but the user also has defined an obstruction at point 3:



8. After you have defined the points in your profile, you can generate a report. For more information on how to do this, see Producing User-Defined Profile Reports on page 248.

Generating Height Profile Points Automatically

When you are creating a user-defined height profile, you can generate the height profile points automatically.

To do this:

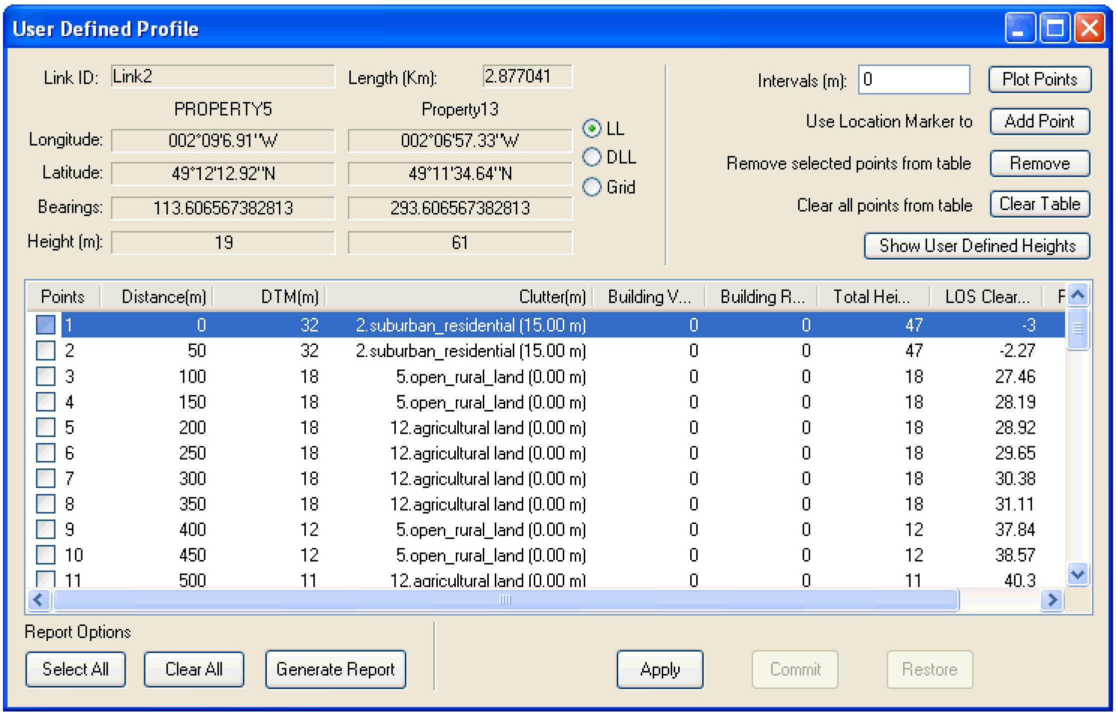
1. In the **Intervals** pane of the **User Defined Profile** dialog box, type the required interval between points (in meters).

2. Click **Plot Points**.

   Data is added to the user-defined profile, based on points along the Height Profile set at the specified interval.

   For more information on what is displayed in the User Defined Profile dialog box, see Viewing and Editing the User-Defined Profile Information on page 106.

   In this example, an interval of 50m has been set:



Generating Profile Points Manually

When you are creating a user-defined height profile, you can generate the height profile points manually:

To do this:

1. In the **Height Profile** window, on the **Location Finder** tab, select the **Show Marker** option.
2. Move the marker line along the Height Profile to the first point that you require, by either:
   - Clicking on the marker line, and dragging it left and right as required

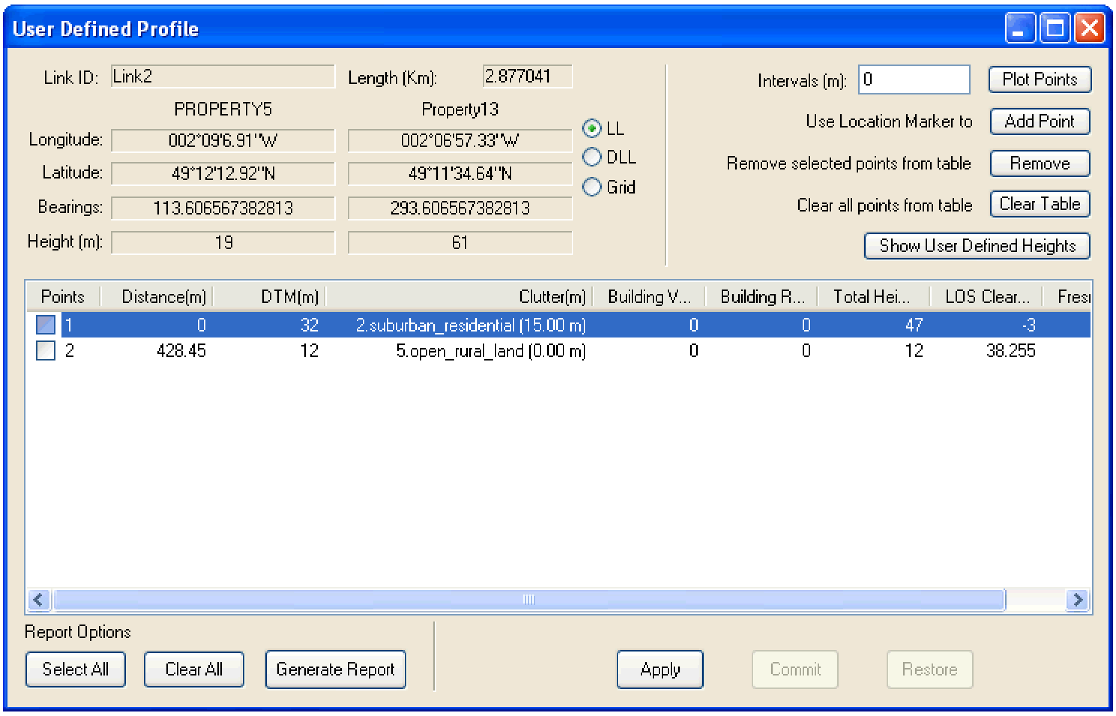
   \- or -

   - Clicking the **Fine Tune** left and right arrow buttons, for a more accurate location of a point on a pixel by pixel basis
3. In the **User Defined Profile** dialog box, click **Add Point**.

   Data is added to the user-defined profile for the particular point you have chosen.

   For more information on what is displayed in the User Defined Profile dialog box, see Viewing and Editing the User-Defined Profile Information on page 106.

   This picture shows an example:



4. Repeat steps 2-3 until you have added all of the points that you would like to view information for.

Note: You have to plot a minimum of 3 points to generate a user defined profile.

Viewing and Editing the User-Defined Profile Information

After you have created a user-defined profile, you can view and edit the profile information in the **User Defined Profile** dialog box.

To view the user-defined profile information, click **Show User Defined Heights**.

This table describes the data that you can view and edit:

Item	Description
Link ID	The name of the link on the Height Profile.
Link Length (km)	The end-to-end length of the link.
Property - Longitude, Latitude, Bearings, Height (m)	The co-ordinates of the two linkend Properties, and the antenna height at each linkend.
Distance (m)	The distance of the point from linkend A.
DTM (m)	The DTM height at the point, based on the map data.
User DTM (m)	The DTM height at the point, which you can edit.
Clutter (m)	The clutter category and height at the point, based on the map data.
User Clutter (m)	The clutter category and height at the point, which you can edit.
Building Vector (m)	The building vector height at the point, based on the map data.
Building Raster (m)	The building raster height at the point, based on the map data.
User Obstruction (m)	The obstruction height at the point, which you can edit. This will be either the building vector or building raster height, whichever is greater.
Total Height (m)	The sum of the DTM and clutter or DTM and building height, whichever is greater.
LOS Clearance (m)	The line of sight clearance at the point.
Fresnel Clearance (m)	The Fresnel zone clearance at the point, if applicable.

5 Planning Microwave Links

Before you plan your microwave links and calculate the link power budget, ensure that you have:

- Added all licensed frequencies to the database. For more information, see Defining Bands and Channel Information on page 57.
- Configured your equipment correctly. For more information, see Defining and Storing Equipment Details on page 27.

Warning: If you do not configure feeders, you cannot perform link performance or interference calculations.

For information on acquiring the ITU recommendation documents, see the International Telecommunications Union website at http://www.itu.int/.

How ASSET Backhaul Calculates the Link Budget

The steps needed to calculate the microwave link power budget are described in this chapter including:

- Setting up a link template if required
- Configuring the links and associated network elements
- Checking for High Low conflicts
- Choosing the calculation method
- Defining geographical data
- Viewing calculation results

ASSET Backhaul uses these statistical methods to predict the reliability (or availability) of a microwave link. A link is unavailable when either:

- The receiver carrier-to-noise ratio falls to or below a level such that the BER degradation is unacceptable

  \- or -

- The degree of inter-symbol interference present at the receiver results in an unacceptable degradation in BER

The carrier-to-noise ratio may be degraded either by the received signal strength falling or the noise level rising. A rise in noise level may be caused by interference.

The received signal level is subjected to fading as a result of the mechanisms described in the following sections.

Inter-symbol interference is caused by multi-path activity.

For information about purchasing the ITU documents, see the International Telecommunications Union website at http:\\www.itu.int.

Apportioning Availability and Error Performance

When calculating availability and error performance, ASSET Backhaul takes into account the following assumptions:

- Unavailability means more than ten consecutively errored seconds
- Error performance parameters are measured during available time
- Availability is related to annual objectives, whereas error performance is related to worst month objectives
- Hardware and equipment failures are apportioned to unavailability because they last more than ten consecutively errored seconds

The outage due to clear-air effects, such as non-selective multi-path, selective multi-path and multi-path XPD outage, is mostly apportioned to performance. Outage due to precipitation (rain and XPD rain outage) is mostly apportioned to availability.

About Multi-path Fading

Multi-path fading is a phenomenon whereby a received signal has a varying amplitude, because it is the total of all the signals propagating over multiple paths. Multi-path fading can cause the signal to noise ratio to fall below the threshold, resulting in an outage.

Multi-path propagation, where there are multiple paths through the atmosphere, with differing lengths and delays, is caused by:

- Bubbles of different density and relative humidity throughout the troposphere, which cause variable and localized changes in the refractive index
- Variations in the rate of change of refractive index with altitude at different altitudes, caused by weather fronts
- Differential solar heating of the troposphere at different altitudes just after sunset and prior to sunrise

The degree of multi-path activity depends on:

- Frequency of operation
- Path length
- Climate (average water vapor content of the troposphere)
- Nature of the terrain over which the signal is being propagated

Although aggregating signals with different phases causes a frequency dependent affect, the fading can be regarded as flat over narrow bandwidths. As the bandwidth of interest at the receiver widens with increased capacity, so the frequency selective nature of the fading becomes important. The effect of frequency selective fading is described by the receiver signature.

Multi-path fading is the most important influencing factor on the performance of radio links below about 10GHz. It also affects links above 17GHz, but the impact reduces with shortening hop lengths at increasing frequencies, and finally vanishes above 26GHz.

For more information on calculating multi-path fading in ASSET Backhaul, refer to ITU documents ITU-R P.530-7, 530-12, 530-15 or Vigants.

You can reduce the effects of multi-path activity by:

- Increasing the fade margin
- Employing diversity
- Using adaptive equalization

Note: Increasing the fade margin does not reduce the effects described by the receiver signature.

About Diffraction (k-) Fading

k-fading occurs when changes in the clearance above the surface result in changes in the amount of Fresnel clearance.

Refraction of a microwave signal within the troposphere is described above.

As the signal bends around the earth, the radio horizon tends to move further away than the geometric horizon, effectively increasing the earth's radius. The effective earth radius value is obtained by multiplying the actual earth radius by the radio climatic factor. The radio climatic factor can be calculated from relative humidity measurements taken by a weather balloon, but is generally considered to have a value somewhere between 2/3 and 4/3.

k is variable according to the rate of change of refractive index with altitude, and when *k* changes, the clearance of a microwave path above the earth’s surface changes also. This causes *k*-fading.

Note: *k*-fading is flat, that is, not frequency selective.

You should closely observe *k*-fading and try to achieve a constant line of sight between link ends, and roughly plan your links for the desired clearance at k=2/3 and k=4/3. For long links, you may need to use vertically spaced diversity antennas.

About Rainfall Fading

Rainfall also causes attenuation with the amount of rain attenuation depending on the frequency of the radio signal, polarization, rain rate and drop size. The fact that the properties of rain vary considerably over space and time makes the calculation of rain attenuation complicated.

See Rainfall Fading Equations on page 310 for further information on:

- The relationship between specific attenuation and rainfall
- The polarization effect on propagation
- Predicting specific attenuation due to rain
- Attenuation due to cloud and fog

Using Diversity in the Link Database

Sometimes changes in your network conditions (an increase in bandwidth, the operating frequency or the path length) means that a link may fail to meet the unavailability requirement. In such cases, basic remedial action is possible – for example, you can increase the antenna size or the transmit power.

But sometimes this is not sufficient, and you may need to use diversity to improve the performance of your links. ASSET Backhaul provides a number of diversity options, which are described in this table:

Diversity Type	Description
Frequency	Uses 2 different frequencies on 1 or 2 antennas. Frequency diversity can be either: • Channel-based - 2 different channels are used • User-defined frequency-based - 2 different frequency ranges are defined
Space2	Uses 1 receiver at each linkend, with 2 antennas at 1 linkend and 1 antenna at the other.
Space4	Uses 1 receiver and 2 antennas at each linkend.
Space2Frequency	A hybrid of Space 2 and frequency diversity.
Space4Frequency	A hybrid of Space 4 and frequency diversity.
Angle	Uses 2 antennas close together, with 1 given a slight tilt.

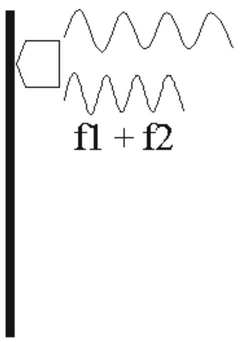
For more information on the principles of different diversity types and a brief description of how they can be used in ASSET Backhaul, see the sections below.

For more detailed information on how to configure the different types of diversity on links, see Configuring the Links on page 124.

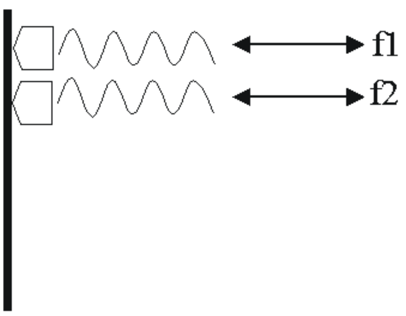
Note: You cannot use frequency diversity on multi-radio links.

Frequency Diversity

When the same antenna uses two different frequencies or where two antennas and two frequencies are used, this is called frequency diversity. Examples are shown here:



Frequency diversity based on two frequencies on the same antenna



Frequency diversity based on two frequencies on two antennas

A frequency diversity system requires cross-band diversity to remove all correlation between fades on the two frequencies.

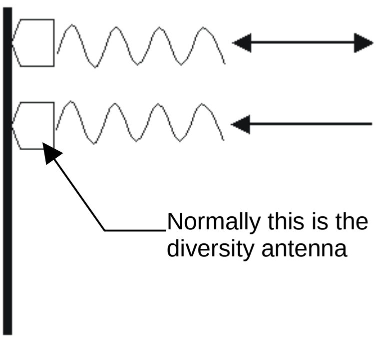
To use frequency diversity in ASSET Backhaul, select the **Frequency Diversity** option appropriate to the link type you are using:

For this link type	The Frequency Diversity option is located on
Point to point, passive repeater, multi-radio, dual polar	The Radio, Frequency and Feeder subtabs of the Linkend Settings tab
Point to multi-point	The Radio and Feeder tabs of the (Hub) Carrier

You can set up frequency diversity in link templates and on individual links.

Space Diversity

Space diversity is where two vertically spaced receiver antennas are used at either end of the link, as shown here:



Space Diversity

The spacing is set so that the delta 1 path length (from the transmitting antenna to the main receiver antenna) and the delta 2 path length (from the transmitting antenna to the diversity antenna) differ by half a wavelength, where delta is the path difference between the direct and reflected path.

It is usually sufficient to provide two receivers with hitless baseband switching to eliminate the effects of the reflection. RF combing with eye detector and IF level driven phase shifters in one leg is generally used. Adaptive equalizers are also quite cheap, with baseband transversal equalizers being the cheapest to implement. Hitless switching is used for protection against equipment failure.

For more information on the calculations used, see Space2 Diversity Improvement Factor Calculation on page 350.

You can set up space diversity in ASSET Backhaul, on link templates and on individual links. To do this:

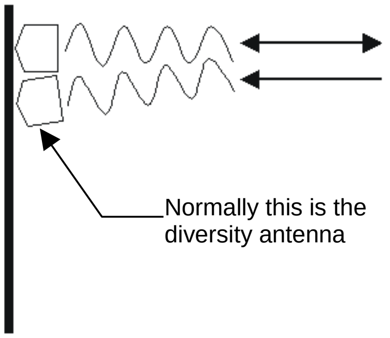
1. On the **Antenna** subtabs of the **Linkend Settings** tab, define at least two antennas at one linkend (for Space2Diversity) or at both linkends (Space4Diversity).

2. On the **Feeders** subtab, ensure that you make at least two of the defined antennas available at one linkend (for Space2Diversity) or at both linkends (Space4Diversity).

To calculate the space diversity improvement that this will produce, ASSET Backhaul searches for a second connected antenna at a different height at each linkend and then follows the ITU-R procedures for predicting the improvement.

Angle Diversity

Angle diversity is where two antennas are used close together, and one is given a slight tilt, as shown here:



Angle Diversity

It is, however, much more likely that a single parabolic reflector will have two offset feeds to achieve the same end. This is cheaper and saves space when this method is used in place of space diversity where there is not room for two antennas.

To use angle diversity in ASSET Backhaul, you can alter the elevation and/or height of the antenna on the **Antenna** tab for the link in the **Link Database**.

Configuring Network Elements

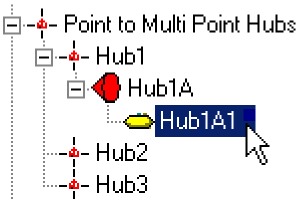
Use the **Link Database** to set up the physical properties of the elements contained in your network, including the links and point to multi-point (PmP) hubs.

Tip: You can create a template containing the most likely settings you will require and then use this for the basis of all new point to point links. This will save you time when configuring individual links. See Defining Link Templates on page 66 for more information.

You can also create templates for point to multi-point hubs. See Defining a Hub Template on page 71 for more information.

To define information for a network element:

1. From the **Database** menu, click **Links**.
2. To select the network element, in the **Link Database**, click the required element:



Tip: You can also click the network element in the **Map View** window and the Link Database automatically updates to show that link.

You can configure the following network elements in this way:

- PmP sectors
- PmP carriers
- Links

Viewing and Editing Point to Multi-point Hub Information

You can view the physical properties of point to multi-point (PmP) hubs in the Link Database.

To view and edit the information for a hub:

1. From the **Database** menu, click **Links**.
2. To select a hub, in the **Link Database**, click the **Hub ID**.
3. Ensure that the Link Database is expanded.

   This table shows the hub properties shown on the **General** tab:

Item	Description
Hub ID	The ID code of the hub, as it appears in the Map View window and in the Link Database.
1st and 2nd Names	Further names you may wish to add for descriptive purposes – for example, a building address or location.
Comments	Any supplementary notes about the hub that you may want to note.
Property ID	The ID code of the Property that the hub is attached to.
Property Location	The geographical position of the Property – choose to express it as Latitude/Longitude, Digital Latitude/Longitude or a Grid position.
Ground Height	The height of the Property – either the value provided in the map data, or a user-defined value taken from the Site Database.
Change History	The history of the hub – the date when it was created, and the date when it was last modified.

   Tip: You can also click the hub in the **Map View** window and the Link Database automatically updates to show that hub.

4. Click the **Filters** tab. You can add a hub to a static filter, or remove it from a static filter:
   - To add the hub to a filter, click **Add**, select the filter from the dialog box that appears, and click **OK**.
   - To remove the hub from a filter, select the filter from the list and click **Remove**.
5. Click the **Update** button to save this change to the filter.

   Important: This does not save any changes made to the hub.

You can also view a report on the traffic data for a hub. For more information on how to do this, see Producing Hub Reports on page 245.

Configuring Point to Multi-point Sectors

In the Link Database, you can configure the physical properties of PmP sectors that you have.

To view information for a sector:

1. From the **Database** menu, click **Links**.
2. To select a sector, in the **Link Database**, click the **Sector ID**.

> **Tip:** You can also click the sector in the **Map View** window and the Link Database automatically updates to show that sector.

Adding Point to Multi-point Sector Information on the General Tab

You can set the general properties of sectors on the **General** tab of the **Link Database**. This table shows the sector properties shown on the General tab:

Item	Description
Sector ID	The ID code of the sector, as displayed in Link Database.
1st and 2nd Name	Further names you may wish to add for descriptive purposes – for example, a building address or location.
Comments	Any supplementary notes about the sector that you may want to include.
Sector Layout	The actual location of the sector, used for the sector display in the Map View window: • Range (m) - If a microwave link falls within this radius range, and also falls within the arc and capacity limits of the carrier(s) on this sector, it will be added to this sector automatically. For more information, see Adding Links to Sectors Automatically on page 78. • Main Antenna Horizontal BW (degrees) - This is the horizontal beamwidth value on the Mask tab in the MW Antennas dialog box for the antenna on associated hub. If there is no antenna on the hub, the beamwidth is 0. • Sector BW (degrees) - By default, this is the same value as the main antenna horizontal beamwidth, but you can edit this by selecting the Override option and typing the new value.
Change History	The date when the sector was created, and the date when it was last modified.

Adding Point to Multi-point Sector Information on the Antennas Tab

To edit the antennas that can be used in a sector.

1. Select the **Sector ID** in the **Link Database**.
2. Click the **Antennas** tab and then click **Add**.
3. Select the antenna model (**ID** and **Type**) used in the sector and ensure there is no conflict between this and your selected radio equipment.

   The gain, diameter and frequency band are taken from the microwave antenna defined in the **Microwave Antennas** dialog box.
4. Set the actual antenna height that should be the value from ground level or building rooftop. Ensure that this value is correct because path inclination (used in the multi-path calculations) will be based on this figure.

5. Type values for the tilt and direction of the antenna.
6. In the **Dry Radome Loss** box, set any loss caused by having a dry antenna cover on. This will affect the fade margins.
7. In the **Wet Radome Loss** box, set any loss associated with an antenna cover that is wet due to ice, snow and so on. This will affect the availability caused by rain calculations.
8. If necessary, specify the antenna location, which you can view as **Longitude/Latitude**, **Digital Longitude/Latitude** or as a **Grid** reference.

Tip: You can switch between an **Absolute** or **Relative** antenna location by clicking the **Toggle** button in the **Antenna Location** pane.

Important: The **Absolute/Relative** setting has a highly significant impact in the event of changing the location of the Property. For important information about the behavior of antenna locations when a Property is moved, see 'Moving Network Elements' in the *ENTERPRISE User Reference Guide*.

Configuring the Point to Multi-point Carriers

You can configure the physical properties of point to multi-point (PmP) carriers in the **Link Database**.

To view information for a carrier:

1. From the **Database** menu, click **Links**.
2. To select a carrier, in the **Link Database**, click the **Carrier ID**.

You can view the traffic for a carrier in a report. For more information, see Producing Traffic Reports on page 247.

Defining the General Properties of Carriers

You can set the general properties of carriers on the **General** tab of the **Link Database**. This table shows the carrier information shown on the General tab:

Item	Description
Carrier ID	The ID code of the carrier, as displayed in Links Database and the Map View window.
1st and 2nd Name	Further names you may wish to add for descriptive purposes – for example, a building address or location.
Comments	Any supplementary notes about the carrier that you may want to note.
Change History	The history of the carrier – the date when it was created, and the date when it was last modified.

Defining the Link Type and Overhead for Carriers

When defining a carrier, to specify and/or view the carrier capacity and load details on the Type tab:

1. Select the duplexing method that will be used on this link, either **FDD** or **TDD**.

   Note: Only radios matching the chosen duplexing method will be available for the carrier.

2. If the link duplexing method is TDD, you can define the symmetry ratio for the link, which specifies the ratio of frames carrying uplink traffic to frames carrying downlink traffic.

   You can specify either value (up to a maximum of 100), and the other value will be calculated automatically. For example, if you set the first (A->B) value to 65, then the second (B->A value) will be set at 35 automatically.

   Note: For Native TDM radios, the ratio is a read-only value of 50/50 - that is, frames are divided equally between uplink and downlink traffic.

3. If the carrier is using TDD and you want to use asynchronous frame transmission, then specify a delay in ms. The initial frame is sent from End A to End B after the number of milliseconds calculated using the Delay value that is specified (in ms).

   If you want to use synchronization from End A (the carrier linkend), then do not specify a delay. In this case, the initial frame is sent from End A to End B at 0 seconds.

4. If the radio on this link is **Native IP** or **Hybrid IP** and **TDM**, define:
   - The packet type, either IPv4, IPv6 or a user-defined frame size.
   - The packet size, in bytes.
   - For user-defined frames, the header size of the Ethernet frame, in bytes. This cannot be greater than the packet size.

   Note: The packet type and size will have an impact on link capacity and performance. Smaller packets have a smaller available capacity, because they have a higher ratio of overhead to payload; larger packets have a higher error rate, and therefore a lower performance.

   The link capacity values are calculated as follows:

Item	Description
Radio Capacity	For a Native TDM radio link, this is expressed as the number of channels x the TDM traffic channel type. For example, 2 x E1. For a Native IP radio link, this is expressed as the total value in kbps, and stored in the Ethernet/IP box. For a Hybrid IP and TDM radio link, both of these values are shown; the Ethernet/IP value will be the Total Capacity minus the native TDM radio capacity. These values are taken from the Configuration tab of the radio equipment selected for this link on the Radio A and B subtabs.
Total Capacity (kbps)	For a Native TDM radio link, this is the same as the TDM Capacity. For a Native IP or Hybrid radio link, this is the Max IP Capacity of the Radio.

Item	Description
Control Overhead (kbps)	This is calculated based on traffic type and throughput: • For a Native TDM radio link, this is calculated as Number of Channels x Control Overhead for that Traffic Channel Type. For example, 16 x E1 has a control overhead of 2048 kbps (16 x 128). For more information, see About the Control Overheads for TDM Traffic Channels on page 129. • For a Native IP radio link, this is calculated as Header Size x Ethernet/IP value / Packet Size. **Important:** This means that if the Header Size is 0, then the Control Overhead will also be 0. • For a Hybrid IP and TDM radio link, this is calculated as the combined value of the control overheads for the IP radio and the TDM radio.
Routed Traffic (kbps)	This is the total amount of traffic routed through the carrier, which is the sum of the End A to End B Routed Traffic values for all of the multi-point links that this carrier serves. For more information, see Planning Routes on page 217.
Available Capacity (kbps)	This is calculated as Total Capacity minus Control Overhead minus Routed Traffic.
Link Occupancy (%)	This is calculated as 100*Routed Traffic/(Total Capacity - Control Overhead), and is calculated based on any routed logical/cellular connections that use the link. For more information, see 'Viewing and Editing Logical/Cellular Connections' in the *ENTERPRISE User Reference Guide*.
Capacity Status	Indicates whether or not the capacity on the carrier is sufficient to meet its traffic demands (if any). For more information on the criteria used to determine the capacity status, see How the Capacity Status is Calculated on page 130.

5. You can also view the following calculated carrier load values:

Item	Description
Number of PmP Links	The total number of links connected to this carrier.
Total Capacity of Links	The combined maximum achievable throughput for all links connected to the radio of this carrier's hub. The maximum achievable throughput for each individual multi-point link is defined on the Radio B subtab of the Linkend Settings tab.
Carrier Remaining Capacity	This is the same as Available Capacity.
Percentage Load	This is the same as Link Occupancy.

6. In the **Route Traffic** pane, you can specify any additional traffic that you would like to route through the carrier. You can use this to replicate any future traffic demands that may come from extra sites, nodes and so on, without having to create and route these extra elements.

Note: This value is also used as the EndA -> EndB **Additional Link Traffic** value on the **Routes** tab of the associated multi-point links for this carrier.

Defining the Radio Parameters of Carriers

Having added information on the General tab, click the **Radio** tab and then follow these steps to set up your carriers:

1. Select to edit either main information, or information related to diversity.

Important: If you do not select the **Frequency Diversity** option on this tab, you cannot use diversity or edit diversity information.

---

2. Select the required propagation model, which will also be used across all PmP links for the carrier.

Note:

- The list of available models is taken from the **Propagation Models** dialog box. For more information, see the *ENTERPRISE User Reference Guide*.
- If you want to use any model with a defined frequency, ensure that this frequency is within the link's radio frequency range. Free space loss models are valid for all frequencies because they inherit the frequency from the associated link.

---

3. Select the **Channel Based** checkbox, and then select the band and channel for the link frequency, using the two boxes. See Defining Bands and Channel Information on page 57 for information on how to specify bands and channels.
4. Designate the link as either **High** or **Low** band.

Important: Whichever designation you select, linkend B's designation (on the **Frequency** subtab of the **Linkend Settings** tab for the PmP link) will be automatically set to the polar opposite. You cannot edit the frequency designation on linkend B.

---

5. Select the polarization for the sector, either vertical or horizontal.
6. Select the radio equipment from the available list.

   All equipment defined in the database is available. When you have made a choice, the associated equipment parameters automatically appear, and you can change these settings manually.

   For more information on these parameters, see Defining the Frequency for Linkends on page 130.

Note: The parameters set on the **Radio** tab for the carrier are also used on the **Radio A** subtab of the **Linkend Settings** tab for each of the multipoint links, where they are read-only.

Defining the Required Throughput and Modulation Type for Carriers

When defining a carrier you can define the required throughput and modulation type on the **Modulation/Capacity** tab.

Important: To use this tab, you must ensure that the radio for the carrier has been configured with AMC capability.

Initially, the modulation type and maximum achievable throughput based on the radio configuration for the carrier (defined on the **Radio** tab) are displayed.

Notes:

- If you are defining a point to multi-point link and you want to use AMC, the AMC settings for End A are taken from the carrier, and for End B they are defined on the other PmP linkend.
- The maximum achievable throughput is calculated per modulation type as:

  The radio capacity minus the control overhead

  However, by using AMC, you can specify the actual throughput that you require, and allow ASSET Backhaul to automatically select the best modulation type for you. If you disagree with the choice, you can disable AMC by overriding the chosen modulation type with a different one.
- You can define different modulation types for both ends of a point to multi-point link.

To define the required throughput and modulation type:

1. Select to edit either main information or information related to diversity.
2. If you want to use adaptive modulation coding, select the **Enable Carrier AMC** option.
3. In the **Carrier Required Throughput** pane, type the throughput that you require.

   Notes:

   - You can also type this if you are using a static modulation type.
   - If you have routed traffic over this carrier, then the default required throughput will be the Routed Traffic defined on the **Routes** tab. If required, you can edit this value. For more information, see Planning Routes on page 217.

   ---

4. In the **Required Availability** pane, type the availability threshold for the required throughput.

   Notes:

   - If you have any sensitive data (such as voice) within your required throughput, you can designate this as **High Priority Throughput**. Type the required value (which must not be greater than the overall **Required Throughput**) in the **High Priority Throughput** pane. You can also specify the required availability for this high priority throughput, which must be greater than the **Required Availability** (the default is 99.99%).
   - If you have routed traffic over this carrier, then the default high priority throughput will be the **Total CS traffic** (in Mbps). You can edit this, but the value must be between the calculated value and the overall **Required Throughput**.

   ---

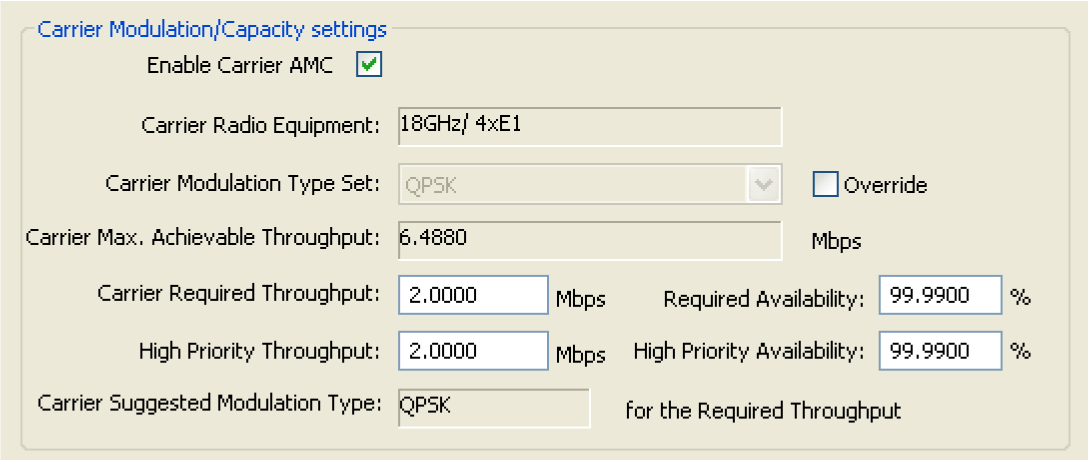
5. Click **Apply**.

If you are using AMC, ASSET Backhaul compares the required throughput with the maximum achievable throughput for each of the modulation types that are available for the radio assigned to the carrier, and selects the best modulation type.

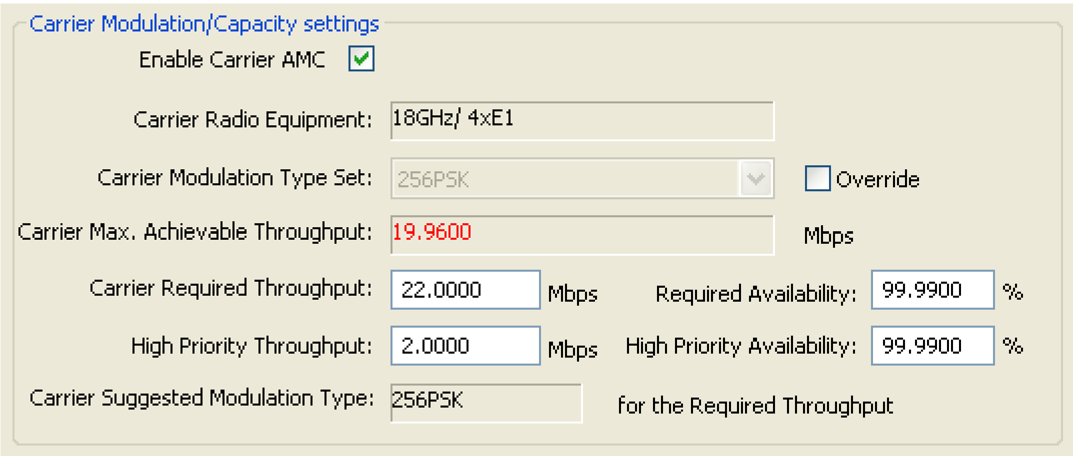
This is defined as the lowest of the available modulation types that satisfy the required throughput criteria. For example, if the bandwidth is 7MHz, the throughputs for the three available modulation types QPSK, 16-QAM and 64-QAM are 14, 28 and 42 Mbps respectively. Therefore, if the required throughput is 16 Mbps, then the suggested modulation type would be 16-QAM.

Note: If the required throughput is 0, then the suggested modulation type is the default modulation order.

This is displayed in the **Carrier Suggested Modulation Type** for the **Required Throughput** pane and the **Carrier Modulation Type Set** pane:



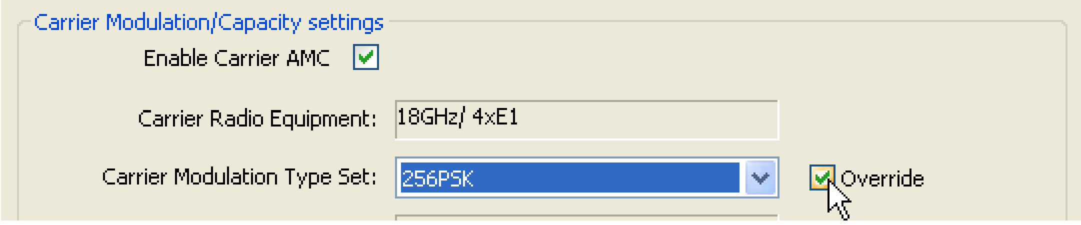
Important: If the maximum achievable throughput on all of the available modulation types is less than the required throughput, ASSET Backhaul selects the one which is the closest value, and highlights the maximum achievable throughput in red:



To resolve this problem, you must reduce the required throughput, choose a higher bandwidth, or make more modulation types available for the radio selected on the carrier.

---

6. If you want to choose a modulation type different to the one recommended:
   - Select the **Override** checkbox:



   - From the **Carrier Modulation Type Set** drop-down list, select the required modulation type.

Important:

- If the **Modulation Type Set** is overridden, then the new type will become the **Operating Modulation Type** on the **Radio** tab. If AMC is disabled, then the Operating Modulation Type will become the default modulation schema.
- If you have routed traffic over this carrier, you should ensure that any change to the modulation type does not result in the capacity status becoming Insufficient. However, it is possible to change the modulation type if it results in Insufficient TDM Throughput or Insufficient IP Throughput, because one traffic type can be mapped over the other. For more information, see How the Capacity Status is Calculated on page 130.

---

7. Click **Apply**. Based on the new modulation type, the maximum achievable throughput is recalculated.
8. If the **Required Throughput** does not exceed the **Maximum Achievable Throughput**, and you are satisfied with the chosen modulation scheme, click the **Feeders** tab to continue defining your carriers.

Defining the Feeders for Carriers

When defining a carrier, to configure the antennas and feeders that you want to use on this carrier:

1. On the **Feeders** tab, select to edit either main information or information related to diversity.

Note: If you do not select the **Frequency Diversity** option on the **Radio** tab, you cannot edit diversity information.

---

2. Select the antenna(s) that will be used for the carrier.

Note: The available antennas are defined on the **Antennas** tab of the sector.

---

3. Select which antenna will be the Tx antenna. The rest of the available antennas will be used for diversity.

Note: When you select an antenna, an associated feeder is created for it.

---

4. In the **Feeder settings** pane, you can set the feeder properties – feeder type, feeder length. To edit the total feeder loss, select the **Override** checkbox and type the required value.

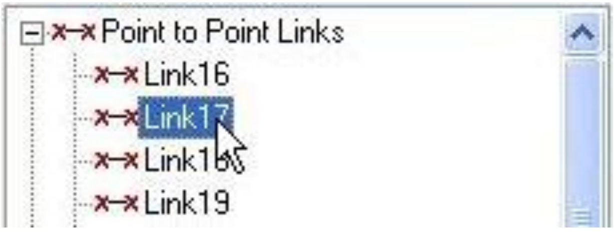
Configuring the Links

You can use the **Link Database** to set up the physical properties of links including the link type and line-of-sight status.

Tip: You can set up a template containing the most common settings you will require and then use this for the basis of all new links. This will save you time when configuring individual links.

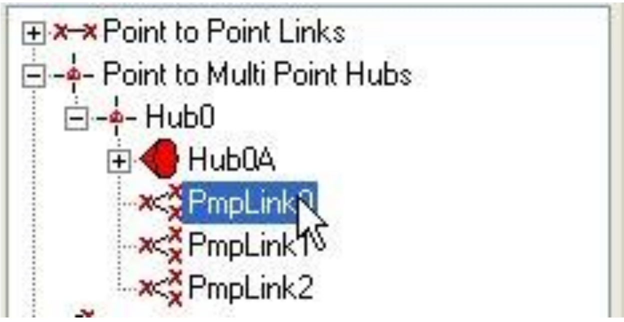
To configure a link:

1. From the **Database** menu, click **Links**.
2. To select a point to point, multi-radio or dual polar link, in the Link Database, click the **Link ID**:



– or –

For a point to multi-point link, click the **+** sign on the **Hub ID** and then click the **Link ID** from the list that appears:



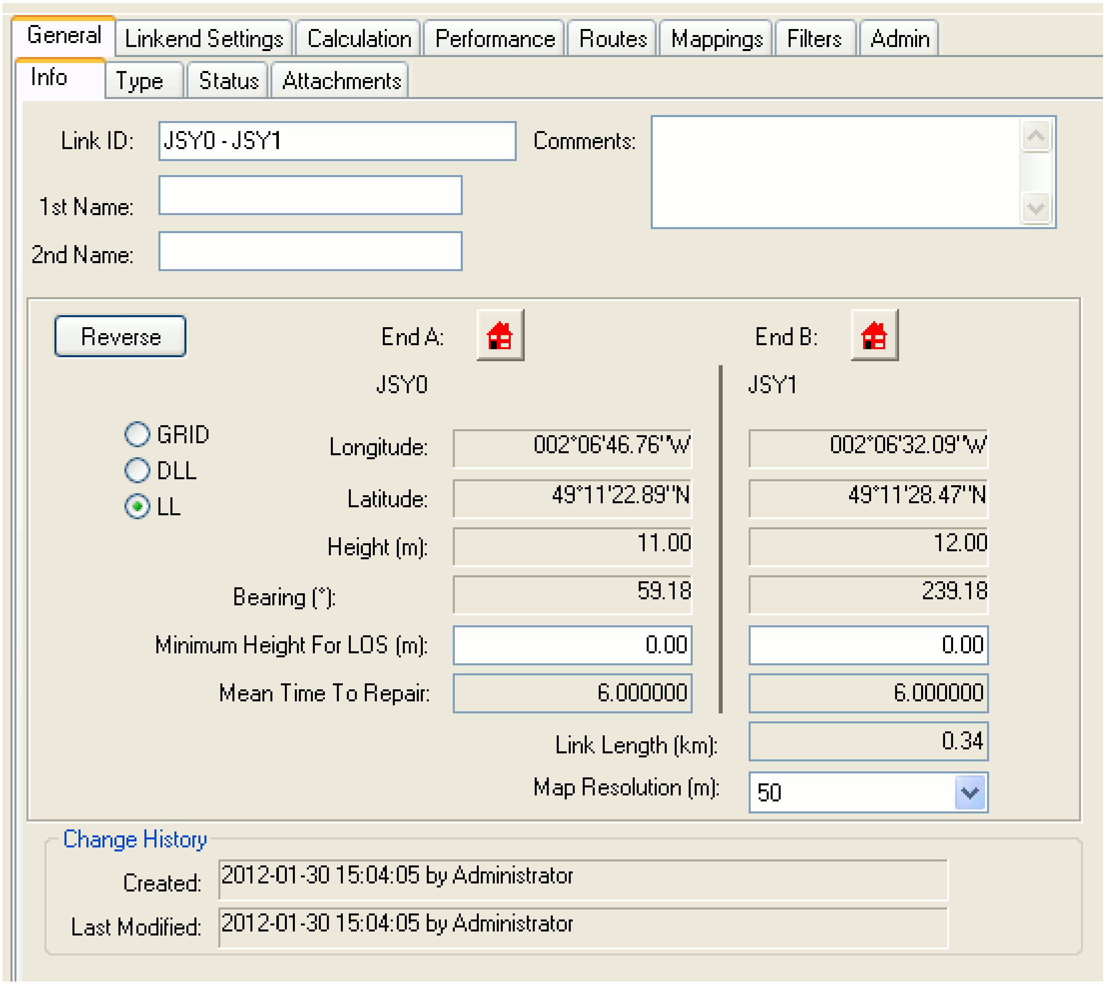
If the link is attached to a sector or carrier, you must click the + sign on these to display the list of links.

Tip: If you click the link in the **Map View** window, the Link Database automatically updates to show that link.

Defining the General Properties for Links

The general properties of links are defined on the **General** tab of the **Link Database**, on a number of subtabs. When you have selected a link, click the **General** tab and follow these steps:

1. Click the **Info** subtab. This picture shows an example:



2. If required, specify a 2nd and 3rd name in addition to the main link ID.

Note: If you are creating a multi-radio link or dual polar link, each sublink will be named based on the Identifier options, which by default includes the main link ID as the prefix. For more information on how to change this, see the *ENTERPRISE User Reference Guide*.

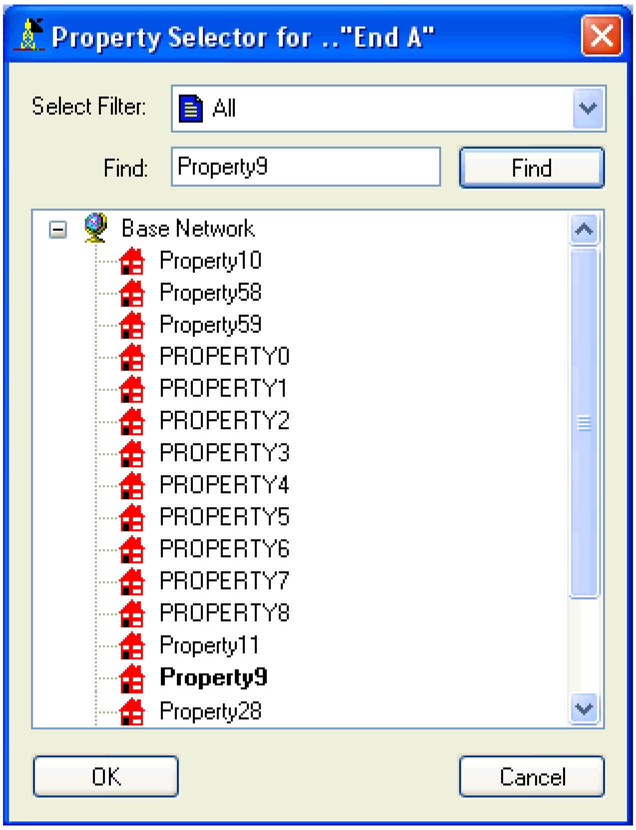
3. Ensure that the link connects the two required Properties. If it does not:

   a. For the linkend that you want to change (End A or End B), click the **Change Linkend Property** button  .

   b. In the dialog box that appears, select the Property that you want to use for the linkend.

   Tip: Use the **Filter** and **Find** options to help you to locate the required Property. Using the Find option, you can search on substring, where ASSET Backhaul will locate the first Property matching that substring.

This picture shows an example:



c. Click **OK**.

The linkend is moved to the selected Property, and inherits all of the parameter settings for that Property.

\- or -

In the **Link Database**, on the **Info** subtab, click the **Reverse** button to swap over the Properties for linkends A and B. You can also do this in the **Height Profile** window, see Displaying Height Profiles Based on Map Data for more information.

Important: You can only reverse the Properties for point to point links and links with single polarization.

---

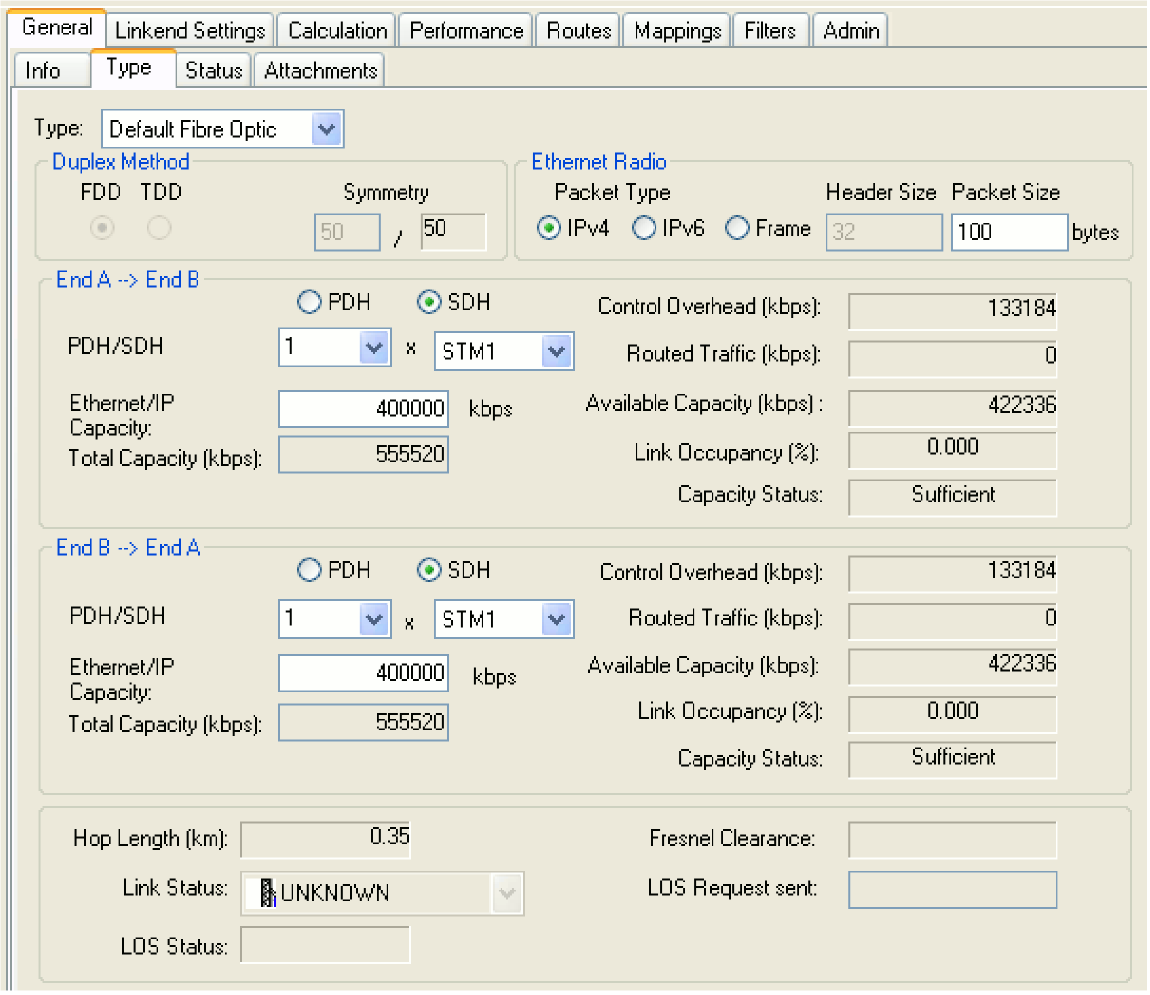
4. For each Property, choose the minimum height required for line of sight, based on the results given by the **Height Profile**.

   Some information displayed on this tab is taken from the Property data, for example, co-ordinates and height.

5. If you are defining a multi-radio link, specify the radio configuration that you want to use:

   - **N** is the total number of traffic links that can be supported (in other words, the total that you can create within the multi-radio link).
   - **M** indicates whether one of the traffic links will be reserved for protection (1) or not (0). The option that you choose will determine the operating modes available on the Radio A subtab of the Linkend Settings tab.

6. Click the **Type** subtab. This picture shows an example:



7. Select the type of link that you require, for example, **Default Microwave**.

   For more information how to create your own link types, see Defining Link Types on page 51.

8. Select the duplexing method that will be used on this link, either **FDD** or **TDD**.

Note: Only radios matching the chosen duplexing method will be available for this link.

---

9. If the link duplexing method is TDD, you can define the symmetry for the link, which specifies the ratio of frames carrying uplink traffic to frames carrying downlink traffic.

   You can specify either value (up to a maximum of 100), and the other value will be calculated automatically. For example, if you set the first (A->B) value to 65, then the second (B->A value) will be set at 35 automatically.

Note: For Native TDM radios, the ratio is a read-only value of 50/50 - that is, frames are divided equally between uplink and downlink traffic.

---

10. If the radio on this link is **Native IP** or **Hybrid IP and TDM**, define:

    - The packet type - IPv4, IPv6 or a user-defined frame size.
    - The packet size, in bytes.
    - For user-defined frames, the header size of the Ethernet frame, in bytes. This cannot be greater than the packet size.

Notes:

- The packet type and size will have an impact on link capacity and performance. Smaller packets have a smaller available capacity, because they have a higher ratio of overhead to payload; larger packets have a higher error rate, and therefore a lower performance.
- If this is a multi-point link, the packet type and packet size are based on those defined on the carrier, and cannot be edited here.
- If the vendors provide the payload capacity, then you should define the frame with a header size of 0, because the **Control Overhead** has already been subtracted.

11. The link capacity values are calculated as follows, and displayed separately for each traffic direction (End A to End B and End B to End A). If you are configuring a multi-point link, then the End A -> End B values are taken from the carrier. For more information, see Defining the Link Type and Overhead for Carriers on page 117.

Item	Description
Radio Capacity	For a Native TDM radio link, this is calculated as the number of channels x the TDM traffic channel type. For example, 2 x E1. For a Native IP radio link, this is expressed as the total value in kbps, and stored in the Ethernet/IP Capacity box. For a Hybrid IP and TDM radio link, both of these values are shown; the Ethernet/IP value will be the Total Capacity minus the native TDM radio capacity. These values are taken from the Configuration tab of the radio equipment selected for this link on the Radio A and B subtabs. You can modify them here, but you cannot exceed the values defined on the radio equipment for the respective modulation type.
Total Capacity (kbps)	The total capacity that the linkend radio supports. For a Native TDM radio link, this is the same as the TDM Capacity. For a Native IP or Hybrid radio link, this is the Max IP Capacity of the radio.
Control Overhead (kbps)	This is calculated based on traffic type and throughput: • For a Native TDM radio link, this is calculated as Number of Channels x Control Overhead for that Traffic Channel Type. For example, 16 x E1 has a control overhead of 2048 kbps (16 x 128). For more information, see About the Control Overheads for TDM Traffic Channels on page 129. • For a Native IP radio link, this is calculated as Header Size x Ethernet/IP value / Packet Size. **Warning:** This means that if the Header Size is 0, then the Control Overhead will also be 0. • For a Hybrid IP and TDM radio link, this is calculated as the combined value of the control overheads for the IP radio and the TDM radio.
Routed Traffic (kbps)	If you have routed traffic, then this is taken from the Routes tab for the link, and is calculated as Total CS Traffic plus Total PS Traffic plus Additional Link Traffic. For more information, see Viewing the Traffic Routed on a Link on page 222.
Available Capacity (kbps)	If you have routed traffic, then this is taken from the Routes tab for the link, and is calculated as Total Capacity minus Control Overhead minus Routed Traffic. For more information, see Viewing the Traffic Routed on a Link on page 222. If you have not routed traffic, then this is calculated as Total Capacity minus Control Overhead.
Link Occupancy (%)	This is calculated as 100*Routed Traffic/(Total Capacity - Control Overhead), and is calculated based on any routed logical/cellular connections that use the link. For more information, see 'Viewing and Editing Logical/Cellular Connections' in the *ENTERPRISE User Reference Guide*.

Item	Description
Capacity Status	Indicates whether or not the capacity on the link is sufficient to meet its traffic demands (if any). For more information on the criteria used to determine the capacity status, see How the Capacity Status is Calculated on page 130.

12. Specify the **Link** status. You can choose from a number of standard, system-defined values, or you can define your own. For more information, see Defining Link Status Values on page 56.

    You can also define whether a LOS Request was sent.

    Note: In this pane, you can also view the hop length (km), the Fresnel clearance (if any) and whether or not there is line of sight. These values are calculated automatically by ASSET Backhaul.

    ---

13. On the **Status** subtab, set the status of any fields that you have defined. For information on defining fields, see Creating Microwave Link Fields on page 65.

14. On the **Attachments** tab, attach any relevant files required.

    Now define information on the **Linkend Settings** tab, starting with the frequency. For more information, see Defining the Frequency for Linkends on page 130.

About the Control Overheads for TDM Traffic Channels

When you are calculating the link capacity values for a Native TDM radio link, the following values are used to represent the control overhead per channel for the different TDM traffic channels:

Traffic Channel	Control Overhead (kbps)
E0	0
E1	128
E2	768
E3	3,648
E4	16,384
E5	73,628
T1	8
T2	168
T3	1,728
T4	16,128
J1	8
J2	168
J3	1,344
J4	5,568
J5	73,628
STS-1/STM-0	1,728
STS-3/STM-1	5,184
STS-12/STM-4	20,736
STS-9	15,552
STS-18	31,104

Traffic Channel	Control Overhead (kbps)
STS-24	41,472
STS-36	62,208
STS-48/STM-16	82,944
STS-192/STM-64	331,776
STS-768/STM-256	1,327,104

How the Capacity Status is Calculated

On the **Type** subtab of the **General** tab for a link (or on the **Type** tab for a carrier) in the **Link Database**, you can define the general properties as well as view traffic demands and capacity details for that link.

This subtab also indicates the capacity status for the link, which is determined as described in the following table:

Note: For Hybrid radios, the criteria for both Native TDM and Native IP radio types apply.

Capacity Status	Radio Type	Description
Sufficient	Native TDM or Native IP	Available capacity is greater than 0.
	Hybrid IP and TDM	Radio capacity is equal to or greater than Total CS traffic AND Ethernet/IP capacity is equal to or greater than Total PS traffic.
Insufficient	Native TDM	Available capacity is less than 0.
	Native IP	
	Hybrid IP and TDM	
Insufficient TDM Throughput	Hybrid IP and TDM	Radio capacity is less than Total CS traffic, but Ethernet/IP capacity is equal to or greater than Total PS traffic.
Insufficient IP Throughput	Hybrid IP and TDM	Ethernet/IP capacity is less than Total PS traffic, but Radio capacity is equal to or greater than Total CS traffic.

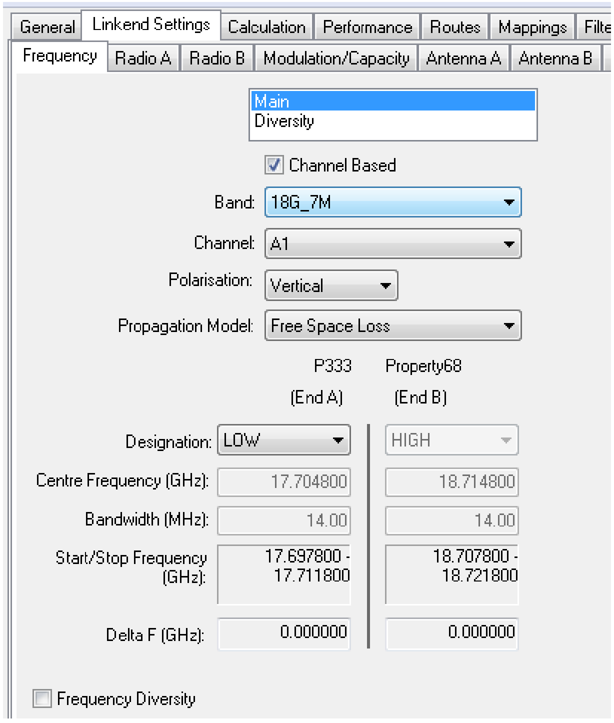
Defining the Frequency for Linkends

After you have defined the general properties for a link on the General tab, to set up your linkends:

Warning: When configuring the linkends, ensure that you do not mismatch your settings, as this can cause the performance calculation results to be invalid. For more information, see About the Linkend Settings Mismatch Conditions on page 133.

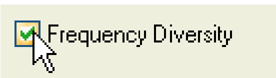
---

1. Click the **Linkend Settings** tab.
2. Click the **Frequency** subtab. This picture shows an example:



3. Select whether to define main information or information related to diversity.

   If you want to define frequency diversity information, you must ensure that the **Frequency Diversity** option is selected:

   Note: This option is not available for multi-radio links.

   ---

4. To specify the frequencies for the link:
   - If you want the frequency to be channel based, select the relevant checkbox, and then select the band and channel from the two drop-down lists. For more information, see Defining Bands and Channel Information on page 57.

     Note: The available bands and channels will be based on the link duplexing type, as defined on the **Type** subtab of the **General** tab.

     \- or -
   - Specify the required center frequency (in GHz) and bandwidth (in MHz). For FDD links, you must define a frequency pair, whereas for TDD links, you only need to define a single frequency.

5. Select the polarization of the antenna, either horizontal or vertical.

   If you are creating a dual polar link, radios A and B are automatically set to be vertical and horizontal respectively.

   If you are creating a back-to-back antenna passive repeater, you can set a different polarization for each section of the link information (A to B and B to C).

6. If you are defining an FDD link, if you are configuring a point to point link, and have selected to make the frequency channel-based, then designate one end of the link as either High or Low band. The other end updates accordingly.

   Tip: To ensure there are no linkends on the same Property that are on the same band but on alternate (High or Low) channels, you can use the **High Low Conflicts Wizard**. For more information on how to do this, see Checking High Low Conflicts on page 146.

   Note: The frequency designation for a point to multi-point link is automatically set, and is opposite to the designation set for the hub carrier.

   The rest of the information shown should be correct, otherwise you can update it accordingly.

7. If you are defining a TDD link, then you can choose whether or not to synchronize the radio stations, and if so, how to synchronize them.

   This table describes the options:

Item	Description
Synchronized at End A	The initial frame is sent from End A to End B, at 0 ms - the time of reference for all radio stations.
Synchronized at End B	The initial frame is sent from End B to End A, at 0 ms.
Asynchronized	The initial frame is sent from End A to End B after the number of milliseconds calculated using the Delay value that is specified (in ms). For more information on how the actual delay is calculated, see Calculating the Actual Delay for Asynchronized Transmission on a TDD Link on page 331.

   Note: If you are using frequency diversity, the synchronization option that you have chosen for the main link will also be used for the diversity link.

8. If you are defining microwave links, select the required propagation model.

   Notes:

   - The list of available models is taken from the **Propagation Models** dialog box. For more information, see the *ENTERPRISE User Reference Guide*.
   - If you want to use any model with a defined frequency, ensure that this frequency is within the link's radio frequency range. Free space loss models are valid for all frequencies because they inherit the frequency from the associated link.
   - The propagation model for a point to multi-point link is automatically set, based on what has been defined on the carrier.

9. You should now define the radio equipment that will be used on this link. For more information, see Defining the Radio Equipment on Linkends on page 134.

About the Linkend Settings Mismatch Conditions

If the linkend settings for a link are mismatched, the calculation results that are displayed on the **Performance** tab may be invalid. The following mismatches are possible:

- The radio equipment at each linkend is different
- The radio's frequency is different to that of the selected antenna and/or the frequency settings
- The frequency settings are different to those on the selected radio and/or the selected antenna
- The antenna's frequency is different to that of the selected radio and/or the frequency settings

If there is a mismatch, a warning appears at the top of each Performance subtab and in the message log.

Note: Only antennas that are connected to a radio using a feeder are checked for mismatches.

Using Powers on Linkends

In the **Link Database**, on the **Radio** subtabs of the **Linkend Settings** tab, you can define a number of different powers that can be used by the radio equipment at the linkend.

You can set:

- The Minimum Power (or Pmin) - used in non-fade conditions to reduce power consumption and limit interference
- The Maximum Power (or Pmax) - used in fade conditions
- The Nominal Power (or Pnom) - provided to the regulatory body

The methods for using these powers are described in the following table:

To Use This Method	Do This
Static ATPC	Ensure that the selected radio equipment is ATPC capable. Select the Enable ATPC option. Set either the Pmin or Pmax, by typing the required power in the Pmin or Pmax box as appropriate. Click Apply to update the other power value, based on the ATPC range. For example, if the ATPC range is 4dB, and you set a Pmin of 4dB, then the Pmax is automatically calculated as 8dB. Alternatively, if you set a Pmax of 7dB, then the Pmin is automatically calculated as 3dB.
Flexible ATPC	Ensure that the selected radio equipment is ATPC capable. Select the Enable ATPC option. Set a Pnom value, by selecting the Override Pnom option and typing the required power in the Pnom box. **Note:** Pnom must be equal to or greater than Pmin, but less than Pmax. This is the power level provided to the regulatory body, and is regarded by them as the accepted minimum power. However, the flexibility of ATPC enables the power to go lower than Pnom as far as Pmin, and higher than Pnom as far as Pmax. The Pmin is automatically calculated by subtracting the ATPC range from the Pmax.

To Use This Method	Do This
Non-ATPC	If you have not chosen to enable ATPC on the radio equipment, or if ATPC is not available for the selected radio equipment, you can only set Pmax, which is used as the fixed power for this linkend. To set Pmax, type the required power in the Pmax column.

Note: The Pmin cannot be less than the Min Tx-Power and the Pmax cannot be more than the Max Tx-Power set in the **Radio Equipment** dialog box.

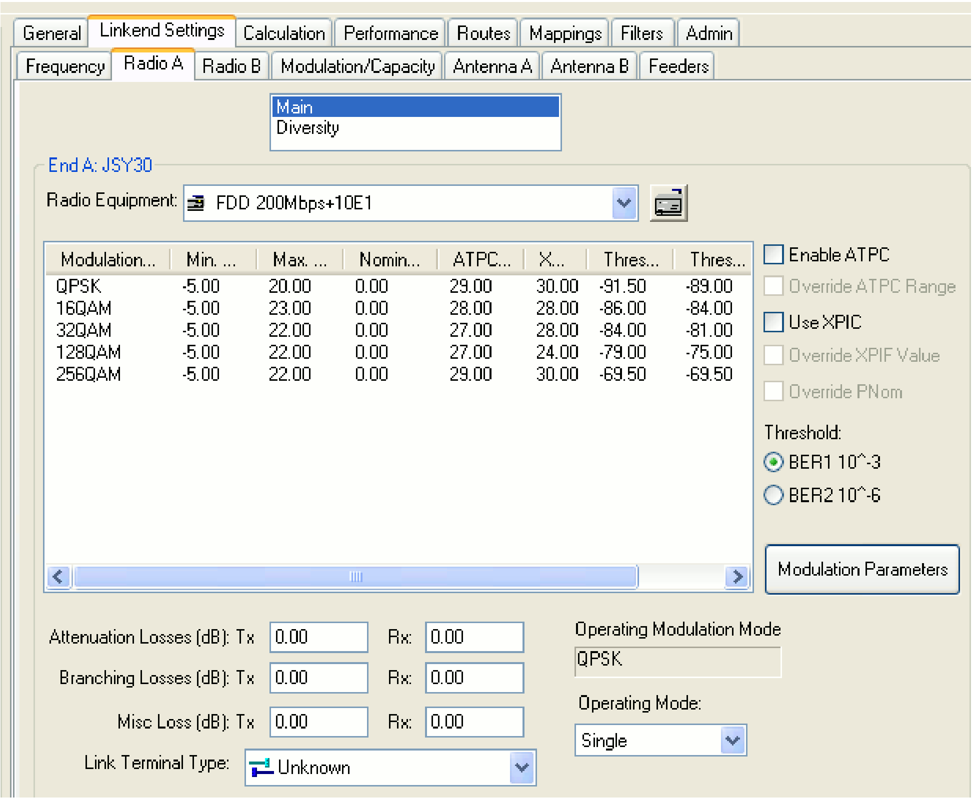
Defining the Radio Equipment on Linkends

When defining a link on the **Linkend Settings** tab in the **Link Database** (or a template for a link), after you have defined the frequency, you can define the radio equipment that is used.

Warning: When configuring the linkends, ensure that you do not mismatch your settings, as this can cause the performance calculation results to be invalid. For more information, see About the Linkend Settings Mismatch Conditions on page 133.

To define the equipment:

1. Click the **Radio A** subtab to define the radio at linkend A. This picture shows an example:



Note: If you are defining a point to multi-point link, then these values are read-only, because linkend A is the carrier linkend. You can configure this on the **Radio** tab for the carrier - for more information, see Defining the Radio Parameters of Carriers on page 119.

2. Choose whether to edit either main information, or information related to frequency diversity.

3. Select the radio equipment from the available list for each linkend.

   The list contains all radios in the current project and all projects that match the frequency defined on the **Frequency** tab. If you have not specified a frequency and used the default instead, then all of the radios are available.

   Tip: To check the details of a selected radio in the **Radio Equipment** dialog box, click the  button.

   When you have made a choice, the associated equipment parameters automatically appear, and you can change these settings manually.

   Important: All radios used on the traffic links for a point to multi-point, multi-radio or dual polar link should be the same. Also, radios that are used on multi-radio links should be compatible for this use. For more information on how to make a radio available for multi-radio links, see Defining the Frequency and Capacity of Radio Equipment on page 31.

   ---

4. This table describes the general parameters for the selected radio:

Item	Description
Enable ATPC	Select whether or not to enable ATPC on the linkend (if the radio equipment has this capability). For more information on ATPC, see Defining the Parameters of Radio Equipment on page 34. **Warning:** If you have enabled ATPC, you cannot override the calculated Max EiRP on the Antenna tab. Similarly, if you have overridden the calculated Max EiRP, you cannot enable ATPC on the linkend.
Override ATPC Range	If you have enabled ATPC, you can select to override the default range with your own value.
Use XPIC	Choose whether or not to use a cross-polar interference canceler (XPIC), if the radio equipment has one.
Override XPIF Value	If you have selected to use an XPIC, you can also choose to override the default cross-polarization improvement factor (XPIF) with your own value.
Override PNom	Choose whether or not to use Nominal Power (Pnom). This option is only available if ATPC is enabled. If you select this option, you can set a value per modulation type. For more information on setting the different power values, see Using Powers on Linkends on page 133.
Attenuation Losses (dB), Branching Losses (dB), Misc Loss (dB)	Define the losses associated with this radio equipment (attenuation, branching and miscellaneous) for both the transmitter and the receiver.
Link Terminal Type	Select the link terminal type (indoor unit) - this can only be defined for main (non-diverse) links. **Note:** The list of available link terminals is created based on the same rules as for radios - that is, it is project-based and frequency-based.
Operating Mode	Select the required operating mode. The options available will depend on the radio configuration for the link. For example, if you are creating a multi-radio link, and have specified that one of the links is reserved for protection, then you can select one of the n + m operating modes.
Threshold	Choose which threshold value will be used throughout the project.

5. You can also define a number of parameters separately for each modulation type available on the selected radio:

   Important: If you are not using AMC, then you will only be able to define the parameters for the static modulation type on the selected radio.

Item	Description
Min TX Power, Max TX Power. Nominal Power	Specify the Minimum and Maximum Tx Powers (Pmin and Pmax respectively), and - if the Override PNom option has been selected - Nominal Power (Pnom). To edit these values, click the Modulation Parameters button. If required, you can modify the Min and/or Max Tx Power values, provided that you keep the values within the range originally set on the selected radio equipment. However, you cannot modify the Modulation Type or the Rx Thresholds. **Notes:** • If you modify either the Min or Max Tx Power, the other value is updated based on the ATPC range, if the radio is ATPC-capable and ATPC is enabled. Otherwise, you can only modify the Max Tx Power. • The radio must be ATPC-enabled for you to define Pmin. • The Pmin cannot be less than the Min Tx-Power and the Pmax cannot be more than the Max Tx-Power set in the Radio Equipment dialog box.
ATPC Range (dB)	If you have made the radio equipment ATPC capable, you can specify an acceptable range value, which can be added to the Min Tx Power or subtracted from the Max Tx Power as required.
XPIF (dB)	If you have enabled an XPIC on this radio equipment, you can type your own cross polarization improvement factor, which will be used in the link interference calculations.
Threshold 1 and 2 (dBm)	The minimum signal levels that correspond to the two signal quality/BER thresholds set for the radio. **Note:** These are read-only values.
Maximum Achievable Throughput (Mbps)	This is calculated per modulation type, and is a read-only value.

   Note: On the **Radio A** and **B** subtabs, you can also view the **Operating Modulation Type**. This is the default modulation type set on the radio. However, if you have enabled AMC on the radio, the Operating Modulation Type is the **Modulation Type Set** that has been defined on the **Modulation/Capacity** tab. For more information, see Defining the Required Throughput and Modulation Type for Linkends on page 137.

   These values are based on the configuration of the selected radio, and cannot be modified directly. For more information, see Defining Radio Equipment on page 29.

When you have finished defining Radio A, click the **Radio B** subtab, and repeat these steps to define the radio at linkend B.

Defining the Required Throughput and Modulation Type for Linkends

When defining a link (or the template for a link), on the **Modulation/Capacity** subtab, you can define the required throughput and modulation type.

Important: To use this subtab, you must ensure that the radios for each linkend have been configured with AMC capability.

Initially, the modulation type and maximum achievable throughput based on the radio configuration for the linkend (defined on the **Radio A** and **Radio B** subtabs) are displayed.

Note: The maximum achievable throughput is calculated per modulation type as:

The radio capacity minus the control overhead

However, by using AMC, you can specify the actual throughput that you require, and allow ASSET Backhaul to automatically select the best modulation type for you. Alternatively, if you disagree with the choice, you can override the chosen modulation type with a different one.

You can do this for both ends of the link using the End A and End B panes, and both ends can have different modulation types.

Important: If you are defining a point to multi-point link and you want to use AMC, the AMC settings for End A are taken from the carrier, and for End B they are defined on the other PmP linkend.

To define the required throughput and modulation type:

1. Select to edit either main information or information related to diversity.
2. If you want to use adaptive modulation coding, select the **Enable AMC** option.

   The **Operating Modulation Type** defined on the **Radio A** and **B** subtabs is defined as the **Modulation Type Set**.
3. In the **Required Throughput** pane, type the actual throughput that you require.

   Notes:

   - You can also type this if you are using a static modulation type.
   - If you have routed traffic over this link, then the default required throughput will be the **Routed Traffic** defined on the **Routes** tab. If required, you can edit this value. For more information, see Planning Routes on page 217.

   ---
4. In the **Required Availability** pane, type the availability threshold for the required throughput.

   Tip: If you have any sensitive data (such as voice) within your required throughout, you can designate this as **High Priority Throughput**. Type the required value (which must not be greater than the overall **Required Throughput**) in the **High Priority Throughput** pane. You can also specify the required availability for this high priority throughput, which must be greater than the **Required Availability** (the default is 99.99%).

   Note: If you have routed traffic over this carrier, then the default high priority throughput will be the **Total CS traffic** (in Mbps). You can edit this, but the value must be between the calculated value and the overall **Required Throughput**.

   ---

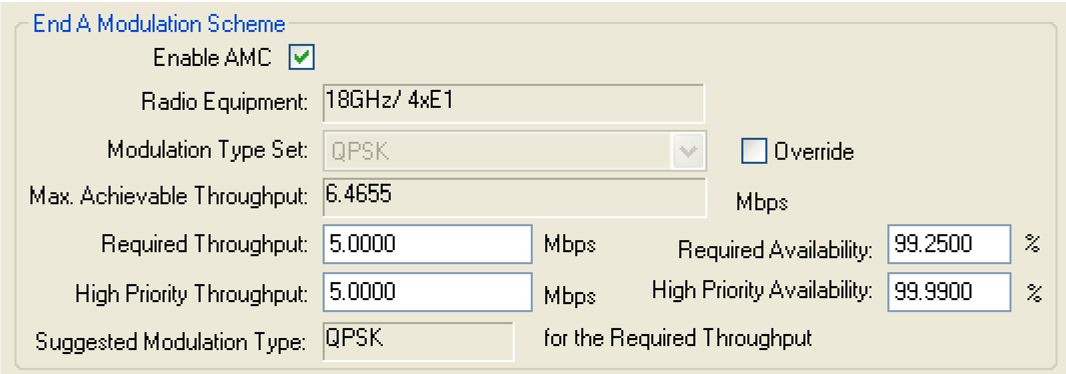
5. Click **Apply**.

6. If you are using AMC, ASSET Backhaul compares the required throughput with the maximum achievable throughput for each of the modulation types that are available for the radio assigned to the linkend, and selects the best modulation type.

   This is defined as the lowest of the available modulation types that satisfy the required throughput criteria. For example, if the bandwidth is 7MHz, the throughputs for the three available modulation types QPSK, 16-QAM and 64-QAM are 14, 28 and 42 Mbps respectively. Therefore, if the required throughput is 16 Mbps, then the suggested modulation type would be 16-QAM.

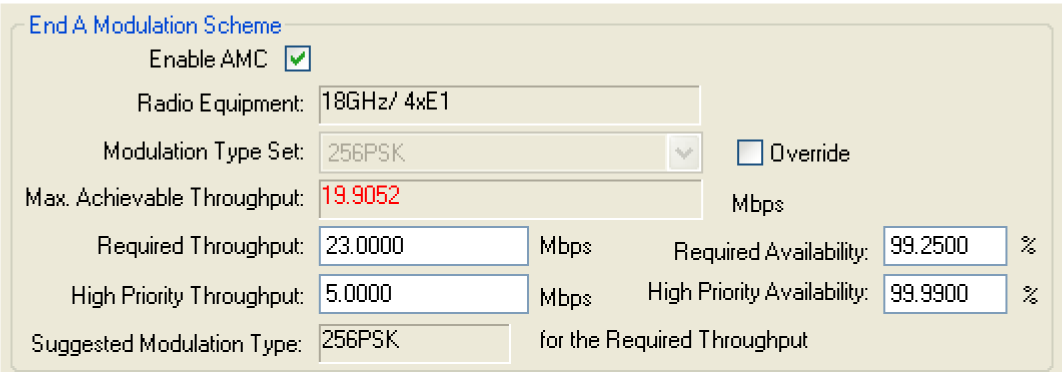
   Note: If the required throughput is 0, then the suggested modulation type is the default modulation order.

   This is displayed in the **Suggested Modulation Type for the Required Throughput** pane, and the **Modulation Type Set** pane:



   The maximum achievable throughput for this modulation type is also shown.

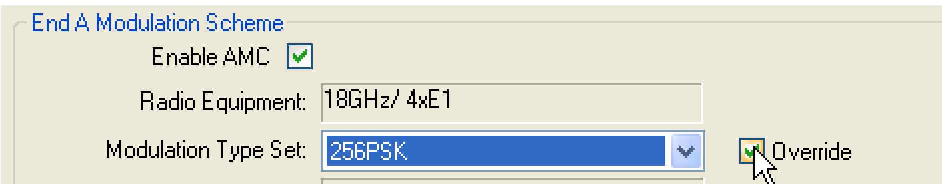
   Important: If the maximum achievable throughput on all of the available modulation types is less than the required throughput, ASSET Backhaul selects the one which is the closest value, and highlights the maximum achievable throughput in red:



   To resolve this problem, you must reduce the required throughput, choose a higher bandwidth, or make more modulation types available for the radio selected on the linkend.

7. If you want to choose a modulation type different to the one recommended:

   - Select the **Override** checkbox:



   - From the **Modulation Type Set** drop-down list, select the required modulation type.

Note: If the **Modulation Type Set** is overridden, then the new type will become the **Operating Modulation Type** on the radio subtabs. If AMC is disabled, then the Operating Modulation Type will become the default modulation schema.

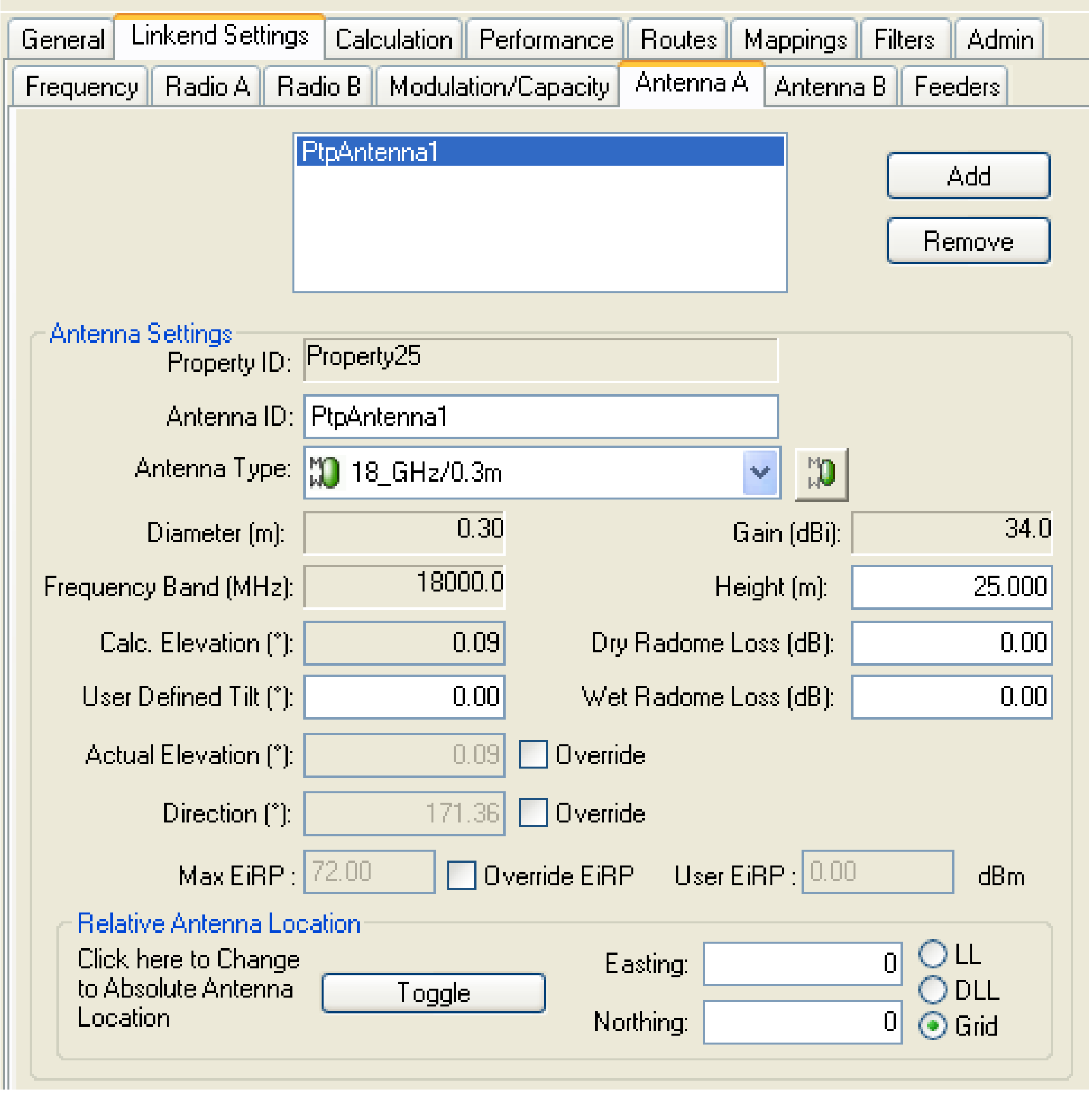
Important: If you have routed traffic over this link, you should ensure that any change to the modulation type does not result in the capacity status becoming Insufficient. However, it is possible to change the modulation type if it results in **Insufficient TDM Throughput** or **Insufficient IP Throughput**, because one traffic type can be mapped over the other. For more information, see How the Capacity Status is Calculated on page 130.

8. Click **Apply**. Based on the new modulation type, the maximum achievable throughput is re-calculated.

9. If the **Required Throughput** does not exceed the **Maximum Achievable Throughput**, and you are satisfied with the chosen modulation scheme, click the **Antenna A** subtab to continue defining your linkends.

Defining Antennas for Linkends

When defining a link on the **Linkend Settings** tab in the **Link Database** (or a template for a link), you can configure the antennas at both ends of a link, using the two **Antenna** subtabs for End A and End B. This picture shows an example:



Antenna Subtab of the Link Database

Note: For a PmP link, the Hub linkend is always End A.

To define the antennas:

1. Add or remove any antennas you require.

   Note: If you want to use Space2 diversity, you should add two antennas to one of the linkends; if you want to use Space4 diversity, you should add two antennas to both linkends.

2. Select the antenna model (ID and Type) used in the link and ensure there is no conflict between this and your selected radio equipment.

   Tip: To check the details of a selected antenna in the **Microwave Antennas** dialog box, click the  button.

   Note: If you are defining a dual polar link, you can only choose from antennas that have dual polarization enabled on the **Info** tab. For more information, see Adding Microwave Antennas on page 46.

3. Set the actual antenna height which should be the value from ground level or building rooftop. Ensure that this value is correct because path inclination (used in the multi-path calculations) will be based on this figure.

   Note: If you calculate antenna heights in the **Height Profile** window using **Select Links** mode, you can then **Apply** the suggested value directly to this tab in the **Link Database**. See Calculating the Minimum Antenna Height on page 101 for information on doing this.

4. Define a value for tilt, that is, for antenna mechanical misalignment. If you cannot, because the box is grayed out, ensure that the **Override Actual Elevation** checkbox is not selected.

5. If you select the **Override Actual Elevation** checkbox, you can set an elevation in the **Actual Elevation** box. If you do not select this, Actual Elevation will equal the Calculated Elevation + Tilt.

   Note: For PmP links, the elevation value of the hub antenna is used.

6. If you want to edit the antenna bearing, select the **Override Direction** checkbox and type your own value.

   Note: For PmP links, the direction value of the hub antenna is used.

7. In the **Dry Radome Loss** box, define any loss associated with an antenna cover that is dry. This will affect the fade margins.

8. In the **Wet Radome Loss** box, define any loss associated with an antenna cover that is wet due to ice, snow and so on. This will affect the availability caused by rain calculations.

9. If you want to set a maximum EiRP for the main antenna on the linkend, select the **User Limit** option and in the **User EiRP** box type the required value. This value will be used for any diversity antennas as well.

Note: The **Max EiRP** value will always be 1dBm less than the defined **User EiRP** value.

Important:

- Any defined EiRP value will have an identical effect on the Tx Power of the radio. For example, if EiRP increases by 2, then the Tx Power will also increase by 2, or if EiRP decreases by 4, then the Tx Power will also decrease by 4.
- If you have overridden the calculated Max EiRP, you cannot enable ATPC on the linkend. Similarly, if you have enabled ATPC, you cannot override the calculated Max EiRP on the **Antenna** tab.
- EiRP cannot be calculated for dual polar or multi-radio links, because they have multiple radio links, and therefore multiple Tx powers.
- You can only define the **User EiRP** for PtP, PmP and passive repeater (back-to-back antenna and reflector) links.

10. If necessary, specify the antenna location, which you can view as **Longitude/Latitude**, **Digital Longitude/Latitude** or as a **Grid** reference.

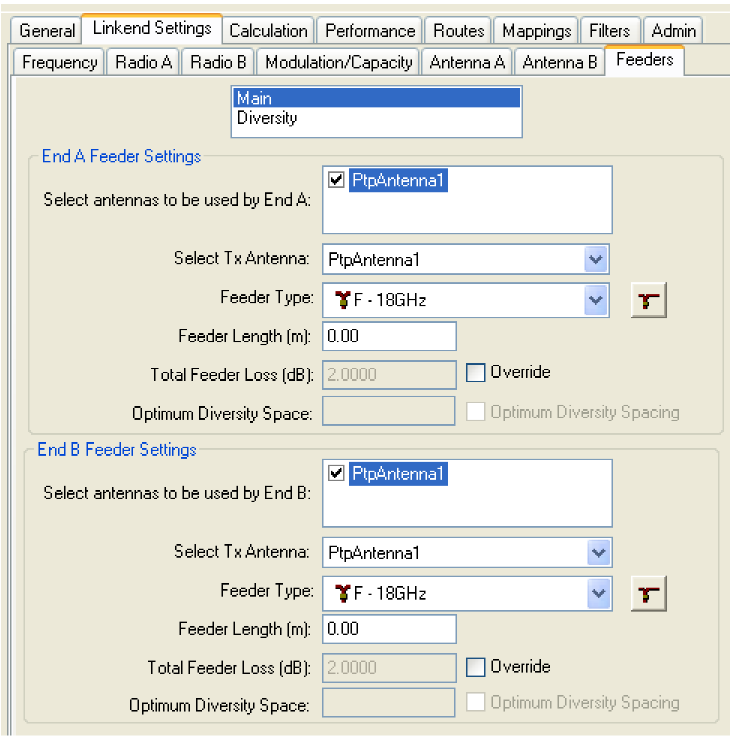
Tip: You can switch between an **Absolute** or **Relative** antenna location by clicking the **Toggle** button in the **Antenna Location** pane.

Warning: The **Absolute/Relative** setting has a highly significant impact in the event of changing the location of the Property. For important information about the behavior of antenna locations when a Property is moved, see 'Moving Network Elements' in the *ENTERPRISE User Reference Guide*.

11. Now click the **Feeders** subtab.

Defining Feeders for Linkends

When defining a link (or a template for a link), on the **Feeders** subtab of the **Linkend Settings** tab in the **Link Database**, you must configure the feeders that you want to use with this link. This picture shows an example:



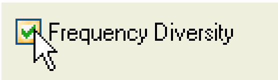
Feeders subtab of the Link Database

Important: A feeder is required when you have selected an antenna to use on a link. You must configure feeders in order to be able to perform link performance and interference calculations.

To configure the feeder:

1. Select to edit either main information or information related to diversity.

   Note: If you want to define frequency diversity information, you must ensure that the **Frequency Diversity** option is selected on the **Frequency** tab:

2. For each linkend, select the antenna(s) which may be used on this linkend.
3. Choose one of the antennas to be the transmitter (Tx) antenna. If you selected more than one antenna to be used on this linkend (in Step 2), the rest of the antennas will be used for space diversity.
4. Set the feeder properties - the feeder type and feeder length. To edit the total feeder loss, select the **Override** checkbox and type the required value.

   The list of feeder types contains all feeders:

   - Defined for the current project and all projects.

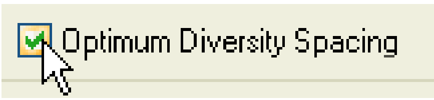
     - and -

   - Which match the frequency defined on the **Frequency** tab.

     Note: If you have not specified a frequency and used the default instead, then all of the feeders are available.

   Tip: To check the details of a selected feeder in the **Feeders** dialog box, click the  button.

5. If you are using space diversity, and want to set the optimum spacing between the diverse and main antenna, select the **Optimum Diversity Spacing** option:

   This will modify the height of the diverse antenna (on the **Antenna** tab) according to the optimum spacing calculation, and makes this value read-only. You can still edit the main antenna height.

   Important:

   - If you remove the **Optimum Diversity Spacing** option later on, the change to the height of the diverse antenna is not undone, but you can then edit it to be the required height.
   - You can only choose the optimum diversity spacing option on PtP, PmP and passive repeater (back-to-back antenna and reflector) links.
   - If you select this option, the optimum spacing calculation will be performed each time you change the position and/or the height of the main antenna and/or the operating frequency and then click **Apply**.

6. If you are configuring a passive repeater link, now click the **Passive Repeater** tab. Otherwise, click **Apply**.

Defining Passive Repeaters on Linkends

When defining a link (or a template for a link), on the **Passive Repeater** subtab of the **Linkend Settings** tab in the **Link Database**, you can define the passive repeater parameters that you want to use with this link.

In summary, you can define the following key parameters for passive repeaters:

- For back-to-back antenna passive repeaters
  - Antenna type, diameter, gain, height, elevation, direction
  - Waveguide length, loss/m, loss
- For reflector passive repeaters - width, height, passive center height, area, effective area, passive angle, reflector angles, passive gain

Defining Back-to-Back Antenna Passive Repeaters

If you have created a back-to-back antenna passive repeater, you can define and/or view the following parameters:

Item	Description	Editable?
Property ID	The identity of the property containing the passive repeater.	N
Dist. To Property A (km)	The distance from the antenna to the property containing the transmitter.	N
Dist. To Property B (km)	The distance from the antenna to the property containing the receiver.	N
Longitude and Latitude/Easting and Northing	The co-ordinate location of the Property containing the passive repeater, in LL, DLL or GRID format.	N
Antenna Type	The type of antenna used on the passive repeater.	Y
Antenna Location	The co-ordinate location of each antenna on the repeater, in LL, DLL or GRID format. **Tip:** You can switch between an Absolute or Relative antenna location by clicking the Toggle button in the Antenna Location pane. **Warning:** The Absolute/Relative setting has a highly significant impact in the event of changing the location of the Property. For important information about the behavior of antenna locations when a Property is moved, see 'Moving Network Elements' in the *ENTERPRISE User Reference Guide*.	Y
Diameter (m)	The antenna diameter.	N
Gain (dB)	The antenna gain.	N
Height (m)	The height of the antenna used on the passive repeater.	Y
Elevation (degrees)	The angular elevation of the antenna.	N
Direction (degrees)	The angular direction of the antenna.	N
Waveguide Length (m)	This is the length of the microwave waveguide that connects the two back to back antennas. A waveguide is a metallic tube that guides the microwave signal.	Y
Waveguide Loss/m (dB)	The power losses per meter (in dB) that the waveguide will cause to the signal while transmitting from one antenna to the other.	Y

Item	Description	Editable?
Loss (dB)	The waveguide loss.	N

Defining Reflector Passive Repeaters

If you have created a reflector passive repeater, you can define and/or view the following parameters:

Item	Description	Editable?
Property ID	The identity of the property containing the passive repeater.	N
Dist. To Property A (km)	The distance from the reflector to the property containing the transmitter.	N
Dist. To Property B (km)	The distance from the reflector to the property containing the receiver.	N
Longitude and Latitude/Easting and Northing	The co-ordinate location of the Property containing the passive repeater, in LL, DLL or GRID format.	N
Antenna Location	The co-ordinate location of the antenna on the repeater, in LL, DLL or GRID format. **Tip:** You can switch between an Absolute or Relative antenna location by clicking the Toggle button in the Antenna Location pane. **Warning:** The Absolute/Relative setting has a highly significant impact in the event of changing the location of the Property. For important information about the behavior of antenna locations when a Property is moved, see 'Moving Network Elements' in the *ENTERPRISE User Reference Guide*.	Y
Width (m)	The width of the reflector.	Y
Height (m)	The height of the reflector.	Y
Passive Centre Height (m)	The height of the center point of the reflector (above ground level).	Y
Area (m^2)	The area of the reflector.	N
Effective area (m^2)	The area of the reflector that is available to the antenna, based on the angle of the reflector.	N
Passive Angle	The angle between the transmitter and receiver via the passive repeater.	N
Reflector Angles	The Azimuth angle is the bearing or direction of the plane of the reflector from the north. For more information, see Calculating Passive Reflector Angles on page 373. The Pointing angle indicates the direction of the perpendicular from the plane of the reflector.	N
Gain Calculations	The Passive Gain of the repeater (dB).	N

Producing Passive Repeater Graphs

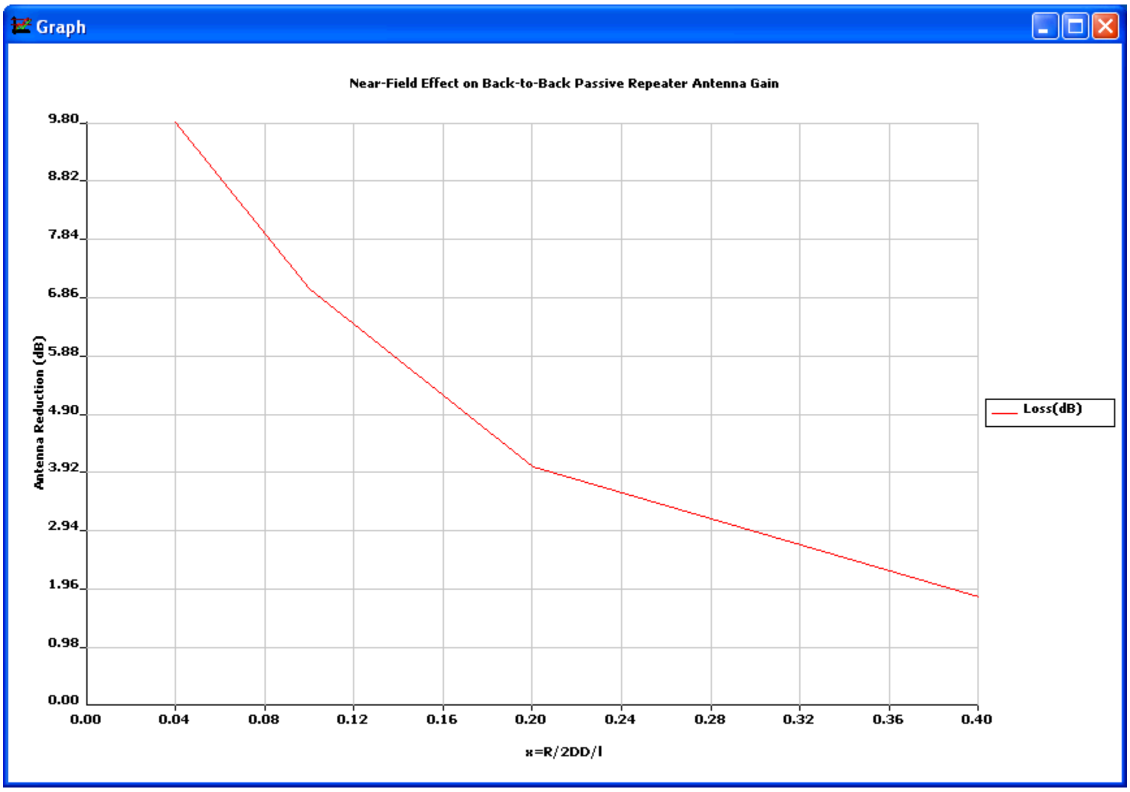
In the **Link Database**, on the **Passive Repeater** subtab of the **Linkend Settings** tab for a link, you can create graphs displaying passive repeater information. You can create the following graphs:

For this type of repeater:	You can create this graph:
Back-to-back antenna	Near-field loss values
Reflector	Additional attenuation

Viewing Near-Field Loss Values Graphically

For back-to-back antenna passive repeaters, you can view a graph of the near-field effect on the antenna gain (when the passive repeater is too close to either the transmitter or receiver). This figure is important, since it affects the received signal value shown on the Link Budget tab. **To view this graph:**

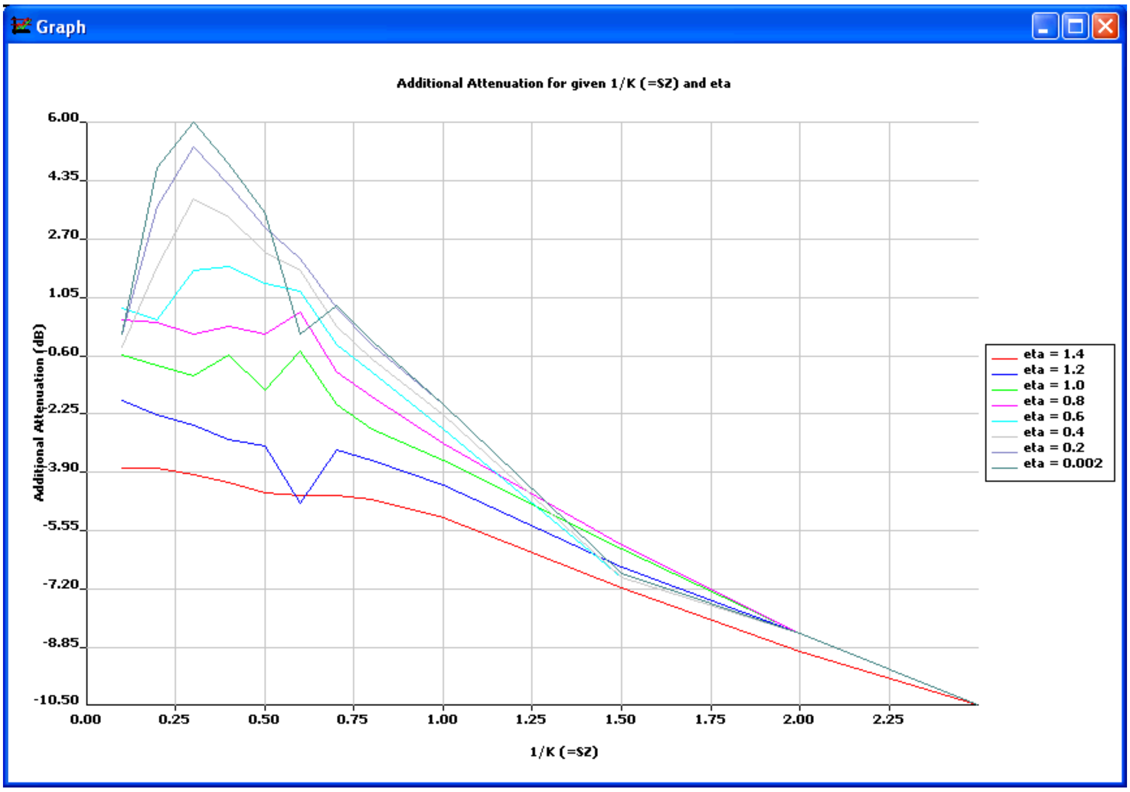
1. Click the **Graph** button.
2. In the dialog box that appears, create a table of the attenuation values. You can either use automatically calculated values by clicking the **Set to Defaults** button, or type your own values directly into the table.
3. Click the **Show Graph** button to display a graph based on these values. This picture shows an example:



Viewing Additional Attenuation Graphically

For reflector passive repeaters, you can view a graph of additional attenuation, which affects the antenna gain. This figure is important, since it affects the received signal value on the Link Budget tab. **To view this graph:**

1. Click the **Graph** button.
2. In the dialog box that appears, create a table of attenuation values. You can either use automatically calculated values by clicking the **Set to Defaults** button, or type your own values directly into the table.
3. Click the **Show Graph** button to display a graph based on these values. This picture shows an example:



Checking High Low Conflicts

When configuring your linkends, it is important to ensure that no two linkends on the same Property are using the same bands/channels but are on alternate (High/Low) channels. To check this, use the **High Low Conflict Wizard** which enables you to:

- Produce a report containing details of any conflicting linkends
- Display conflicting linkends in the **Map View** window

You can then automatically locate the conflicting linkend in the **Link Database**, use the information to resolve the conflict and then re-run the High Low Conflict Wizard to check that the conflict has been resolved.

Running the High Low Conflict Wizard

To run the High Low Conflict wizard to check for High/Low conflicts:

1. From the **Tools** menu, point to **High Low Conflict Wizard** and then click **High Low Conflict Wizard**.

2. Click **Next**.

3. You can either:

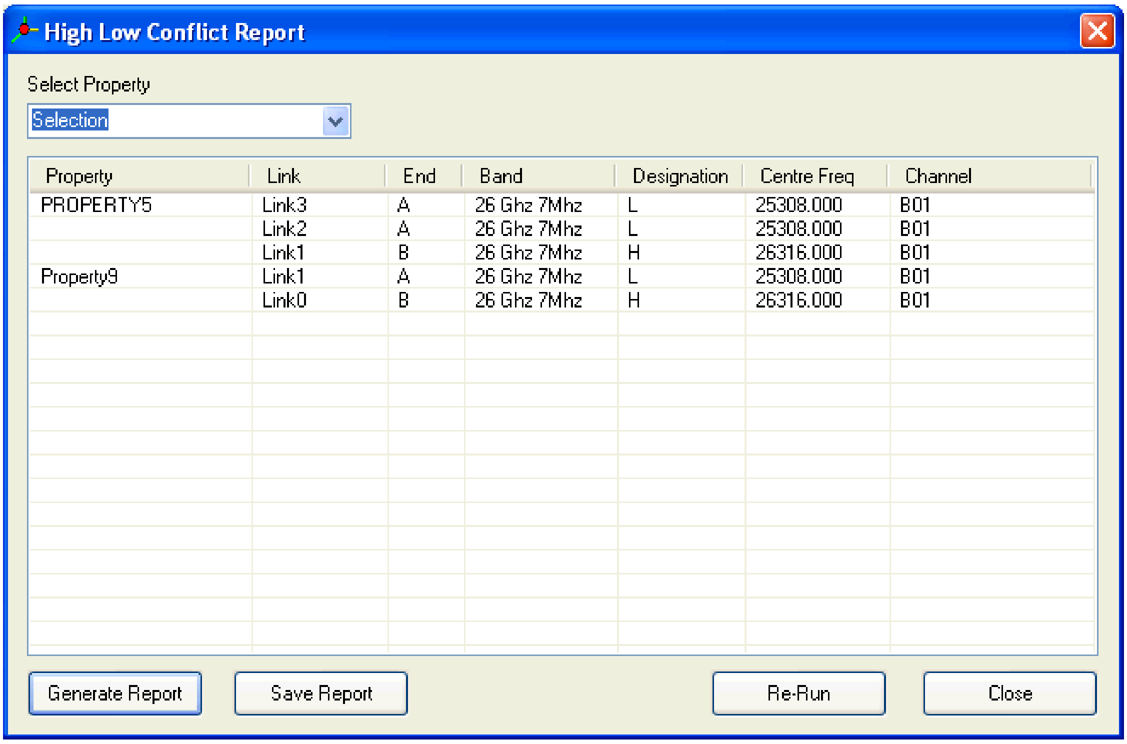
   - Select a specific area in which to check for High/Low conflicts by choosing the **Select a View** option and then clicking **Next**.
   - Select a specific set of linkends contained in a filter by choosing the **Select a Filter** option, choosing the filter from the list and clicking **Next**.
   - Select a linkend on a specific Property, by choosing the **Select a Property** option, clicking the required Property in the **2D Map View** window and then clicking **Next**.

   If you have chosen to select a view, either type the co-ordinates of the required area, or select from a **Map View** window, then click **Next**.

4. Type any additional planning comments that you would like to add to a generated report. Only one line of comments is saved.

5. Click **Finish**.

   A list of conflicts is produced, as shown in this example:



Property	Link	End	Band	Designation	Centre Freq	Channel
PROPERTY5	Link3	A	26 Ghz 7Mhz	L	25308.000	B01
	Link2	A	26 Ghz 7Mhz	L	25308.000	B01
	Link1	B	26 Ghz 7Mhz	H	26316.000	B01
Property9	Link1	A	26 Ghz 7Mhz	L	25308.000	B01
	Link0	B	26 Ghz 7Mhz	H	26316.000	B01

   The report displays information related to any High/Low conflicts found. If you selected View or Filter option, the report includes the Properties at either end of a link whose link center lies within the view or filter. For more information on this, see About the Information Shown in the High Low Conflicts Report on page 237.

6. To publish this report, click the **Generate Report** button. For more information on what this does, see Producing High Low Conflict Reports on page 236.

7. You can display the reported High/Low conflicts on the **Map View**. For more information on how to do this, see Viewing High/Low Conflicts on the Map View on page 148.

8. To view a conflicting link in more detail:
    - Ensure that the **Link Database** is open, and displaying the filter containing the conflicting link.
    - Right-click the required link and from the menu that appears, click **Select Link**.

      The **Link Database** locates and highlights the link.

      Tip: If you have the **Map View** window open, the link is also highlighted in the Map View window.
9. Make the required changes to the link, and if required, view and change any other links that have a High/Low conflict.
10. Click the **Re-Run** button to re-run the **High Low Conflict Wizard** using the same parameters.

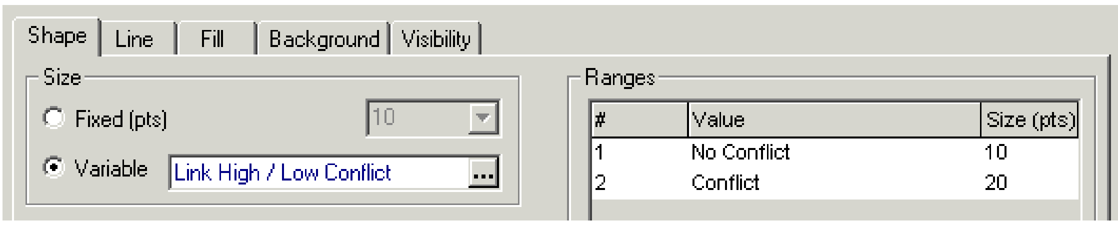
    Any resolved conflicts are removed from the results.

Viewing High/Low Conflicts on the Map View

As well as producing a report of High/Low conflicts, to view the High/Low conflicts on the Map View window:

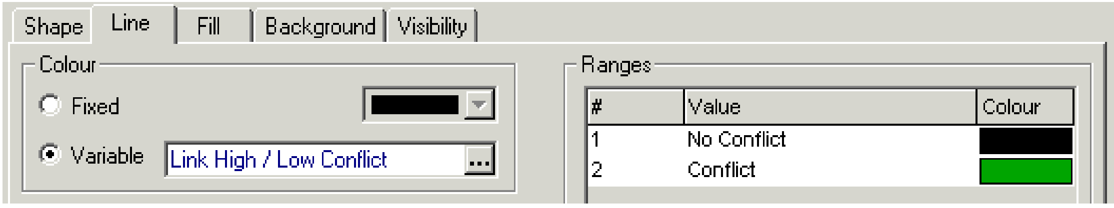
1. On the Map View toolbar, click the  button.
2. In the **Layer Control** dialog box, click the **Data Types** tab.
3. In the list of data types that appears, expand **Filters** and double-click the **All** filter.

   In the **Filter Display Properties** dialog box, expand **Property** and click **Symbol**.
4. Click the **Shape** tab, and in the **Size** pane, choose **Variable**.
5. Click the **Browse** button  to browse for an attribute.
6. From the list of Property Attributes, select **Link High/Low Conflict** and click **OK**.
7. In the **Ranges** pane, you can type the size (in points) that you want the Property to appear as, depending on whether or not it has a High/Low conflict. In this example, the Property size doubles if it has a High/Low conflict:



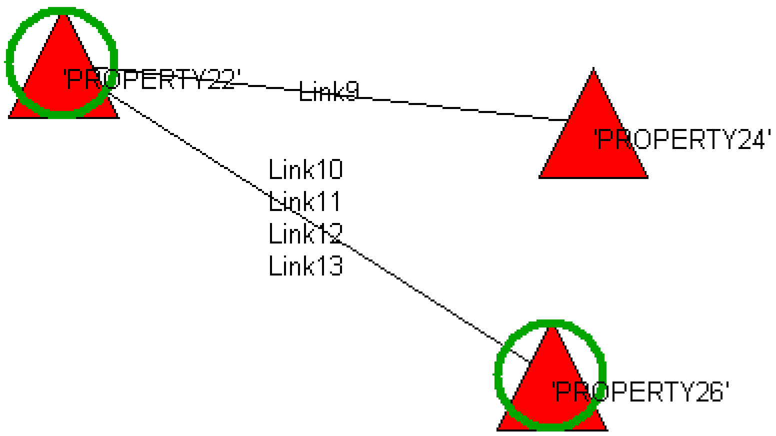
8. Click the **Line** tab, and in the **Color** pane choose **Variable**.
9. Click the **Browse** button  to browse for an attribute, and from the list of Property Attributes select **Link High/Low Conflict** and click **OK**.

10. In the **Ranges** pane, you can select the color that you want to the Property to appear as, depending on whether or not it has a High/Low conflict. In this example, Properties with a High/Low conflict are displayed in green:



11. When you are satisfied with the size and color choices, click **OK**.

This picture shows Properties containing linkends with conflicting High/Low orientations (marked in green):



Defining Link Calculation Parameters

When you have configured your links on the **General** tab and **Linkend Settings** tab, click the **Calculation** tab and add information on:

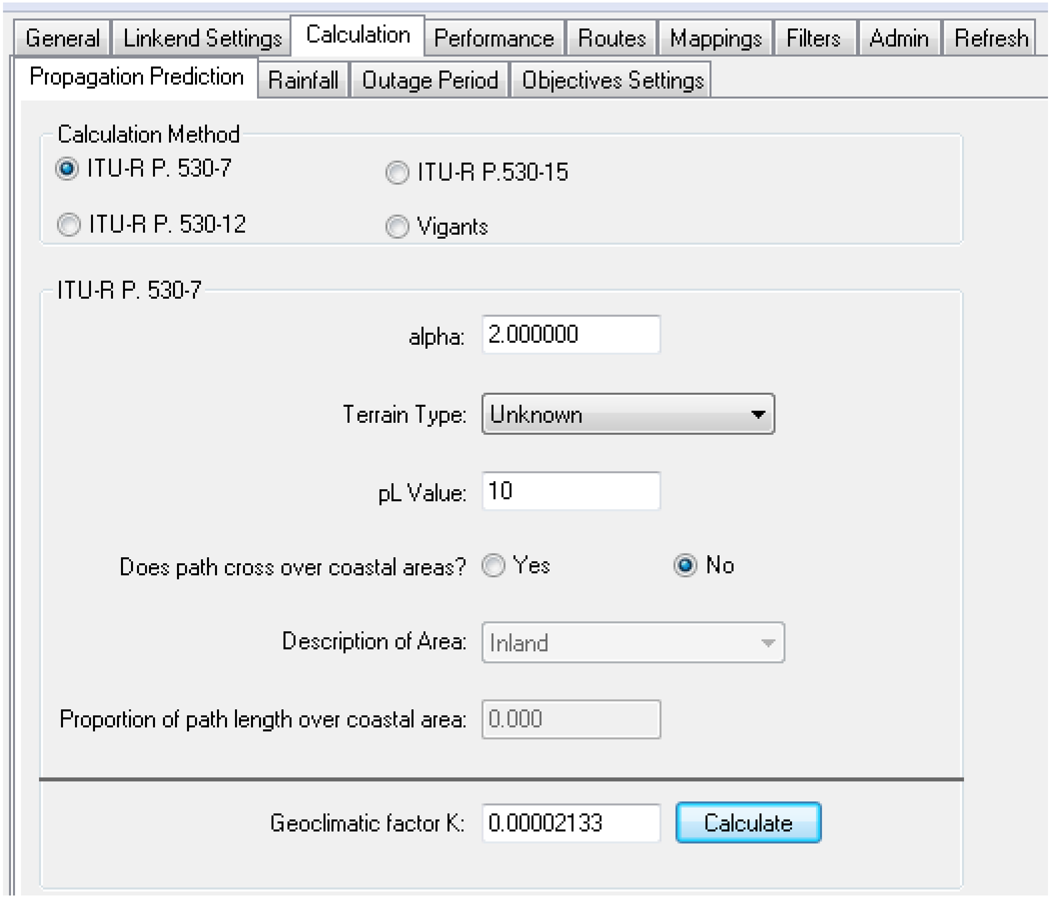
- The **Propagation Prediction** tab. This is where you choose the calculation method that you will use for calculating the availability of the link. The information that you need to complete here will change based on the method you choose, so select one of these options:
  - ITU-R 530-7
  - ITU-R 530-12
  - ITU-R 530-15
  - Vigants
- The **Rainfall** tab
- The **Outage Period** tab
- The **Objectives Settings** tab

Defining Link Propagation Prediction Information for ITU-R P.530-7

This table describes the information you need to define if you have chosen a calculation method of ITU-R P.530-7 on the **Propagation Prediction** tab in the **Link Database**.

Item	Description
Alpha	Alpha is a constant (weighting factor) that can have a value of between 1.5 and 2. The default value (2) is the safe value for most cases. More information relating to this value can be found in the ITU-R F. 1093 recommendation, Effects of Multi-path Propagation on the Design and Operation of Line Of Sight Digital Radio-Relay Systems.
Terrain type	Choose 'Unknown', 'Plains', 'Hills' or 'Mountains' depending on which terrain the path mostly crosses over.
pL value	This value depends on the location where the hop is planned. More about this value can be found in the ITU-R P.453 recommendation.
Does the path cross over coastal areas?	If the path crosses over an area that is covered with water, select Yes.
Description of area	Select the area type that best fits the terrain type.
Proportion of path length over coastal area	The proportion of the path that crosses over an area that is covered with water.
Geoclimatic factor	Geoclimatic factor is the result of the terrain type and pL value. Click Calculate each time you change the terrain type or pL value.

This picture shows an example **Calculation** tab, where the ITU-R P.530-7 calculation method has been chosen:



Example calculation tab (530-7 method)

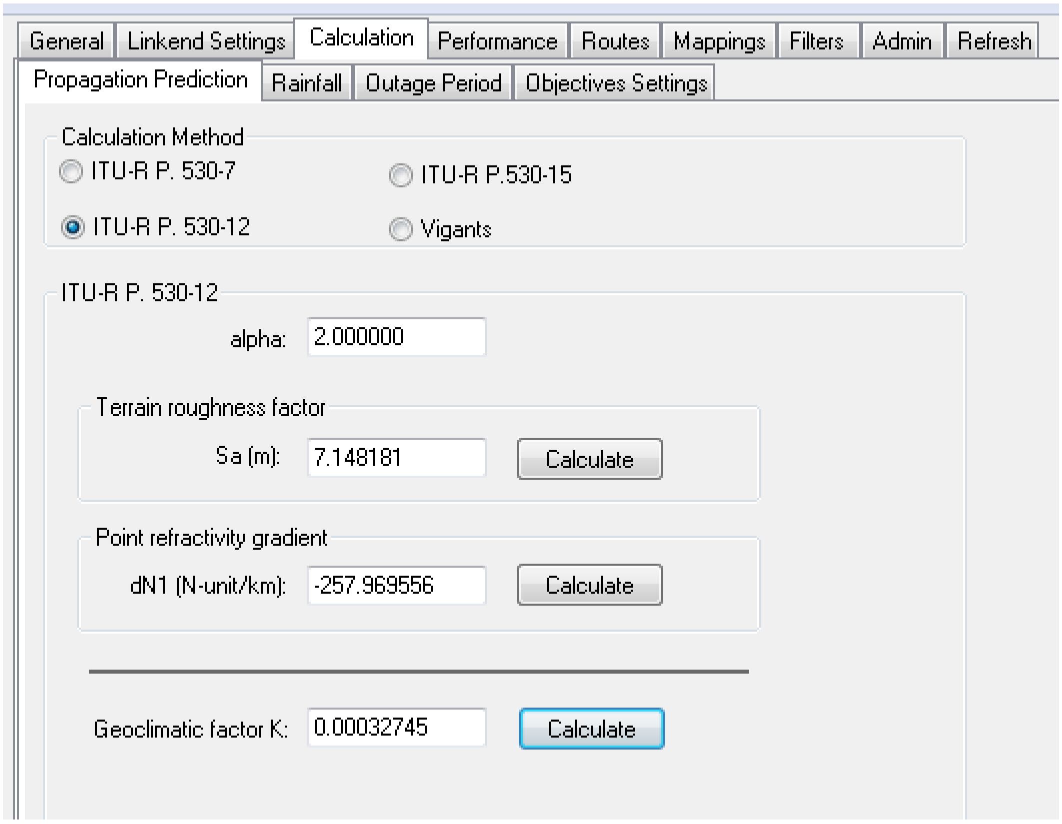
For further information, see the ITU-R P.530-7 recommendation, Propagation data and prediction methods required for the design of terrestrial line of sight systems, 1997.

Defining Link Propagation Prediction Information for ITU-R P.530-12

This table describes the information you need to define if you have chosen a calculation method of ITU-R P.530-12 on the **Propagation Prediction** tab in the **Link Database**.

Item	Description
Alpha	Alpha is a constant (weighting factor) that can have a value of between 1.5 and 2. The default value (2) is the safe value for most cases. More information relating to this value can be found in the ITU-R F.1093 recommendation, Effects of Multi-path Propagation on the Design and Operation of Line Of Sight Digital Radio-Relay Systems.
Terrain roughness factor (s_a)	The area terrain roughness, defined as the standard deviation of terrain heights (m) in a 110km x 110km area with a 30m resolution.
Point refractivity gradient (dN1)	The point refractivity gradient is defined in the lowest 65m of the atmosphere not exceeded for 1% of an average year. Point refractivity gradient (dN1) is provided on a 1.5° grid in latitude and longitude in Recommendation ITU-R P.453.
Geoclimatic factor K	Geoclimatic factor is the result of the terrain factor and the refractive gradient. Click Calculate each time you change the terrain factor or refractive gradient.

This picture shows an example **Calculation** tab, where the ITU-R.P 530-12 calculation method has been chosen:



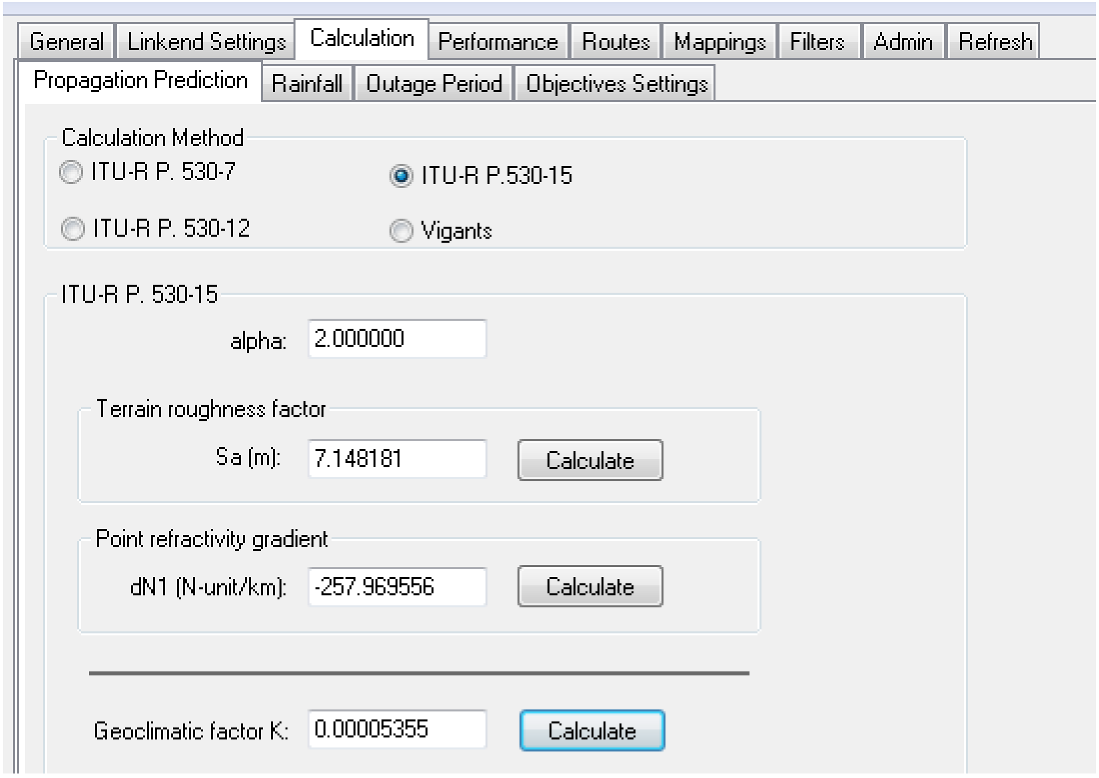
Example calculation tab (530-12 method)

Defining Link Propagation Prediction Information for ITU-R P.530-15

This table describes the information you need to define if you have chosen a calculation method of ITU-R P.530-15 on the **Propagation Prediction** tab in the **Link Database**.

Item	Description
Alpha	Alpha is a constant (weighting factor) that can have a value of between 1.5 and 2. The default value (2) is the safe value for most cases. More information relating to this value can be found in the ITU-R F. 1093 recommendation, Effects of Multi-path Propagation on the Design and Operation of Line Of Sight Digital Radio-Relay Systems.
Terrain roughness factor (s_a)	The area terrain roughness, defined as the standard deviation of terrain heights (m) in a 110km x 110km area with a 30m resolution.
Point refractivity gradient (dN1)	The point refractivity gradient is defined in the lowest 65m of the atmosphere not exceeded for 1% of an average year. Point refractivity gradient (dN1) is provided on a 1.5° grid in latitude and longitude in Recommendation ITU-R P.453.
Geoclimatic factor K	Geoclimatic factor is the result of the terrain factor and the refractive gradient. Click Calculate each time you change the terrain factor or refractive gradient.

This picture shows an example **Calculation** tab, where the ITU-R.P 530-15 calculation method has been chosen:



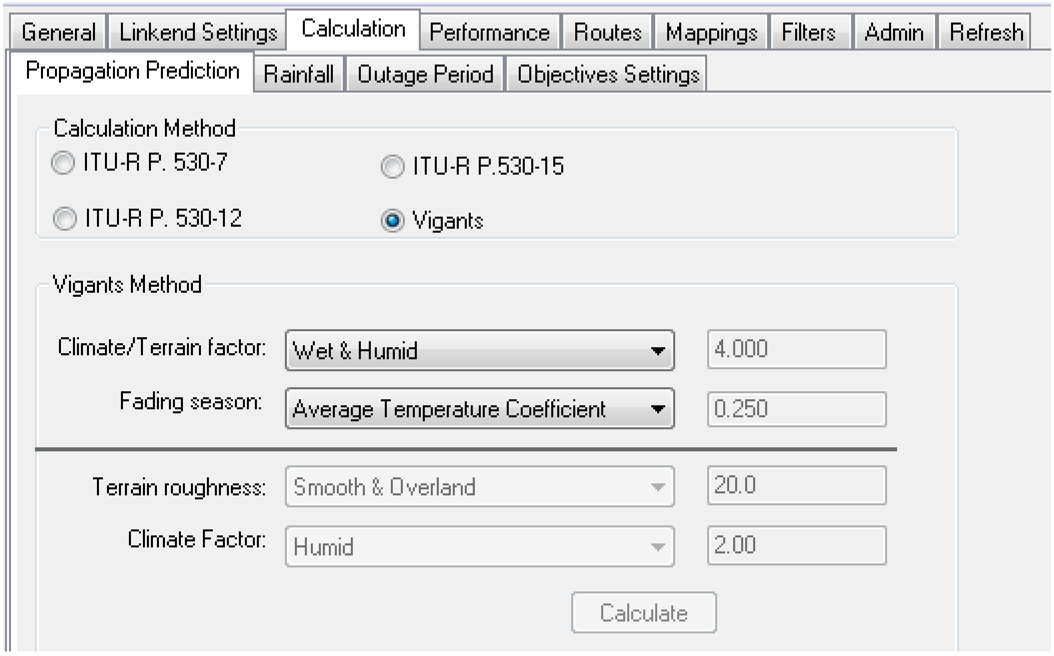
Example calculation tab (530-15 method)

Defining Link Propagation Prediction Information for Vigants

These steps describe the information you need to define if you have chosen a calculation method of **Vigants** on the **Propagation Prediction** tab in the **Link Database**.

1. In the **Climate/Terrain factor** box, select the appropriate conditions.
2. If you choose **User Define Terrain & Climate**, type the value required.
3. If you choose **Terrain & Climate Factor**:
   a. In the **Terrain Roughness** box, you can then select a type from **Smooth & Overland**, **Average**, **Mountain & Rough**, **User Defined Roughness**.
   b. In the **Climate Factor** box, select a type of **Humid**, **Average Dry** or **User Defined Climate**.
   c. Click **Calculate** to calculate the climate/terrain factor.

This picture shows an example **Calculation** tab, where the Vigants calculation method has been chosen:



Example calculation tab (Vigants method)

Defining Rainfall Information for Link Calculations

Because microwave links behave differently in different rainfall regions, you can:

- Define geographically dependent parameters
- Design specific rainfall thresholds

Rain rate is used to calculate the level of attenuation absorption. The loss is due to scattering, both spatial and scattering in to the orthogonal polarization that occurs. Like a car's headlights in fog, they do not fade out with distance; instead the beam is defocused or scattered. Because most outages caused by rain attenuation will last for more than 10 consecutive seconds, it is mainly attributed to unavailable time. Given the rain rate and the average annual percentage of time this rate is exceeded, ASSET Backhaul can calculate the probability of outage (availability).

To define the rainfall information:

1. From the **Database** menu, click **Links**.
2. In the **Link Database**, on the **Links** tab, select the link for which you want to define rainfall information.
3. On the **Calculation** tab, click the **Rainfall** subtab.
4. In the **Calculation Method** pane, select the required model - **ITU-R P.530-12**, **ITU-R P.530-15** or **Crane**.

   For information on the algorithms used, see Rainfall Fading Equations on page 310.
5. In the **Percentage of Time Rainfall** box, type a value. This will be used in calculations for required fade margin against rain.
6. Do one of the following:
   - Select the **Rate for 0.01%** and select the **Auto Calculate** checkbox to have ASSET Backhaul calculate the rainfall rate automatically. ASSET Backhaul looks up the co-ordinates of the link and using the ITU map showing rainfall regions, gives the rain rate automatically for the link. Where a link passes through two rainfall regions, the mean is used. (ITU-R models only).
   - Select the **Rate for 0.01%** and give the correct value for rainfall rate that exceeds 0.01% of time, that is, a rain rate that you are prepared to accept as making the link unavailable for 0.01% of the time, for example, 8mm per hour. (ITU-R models only).
   - Select **Use Rainzone** and choose from the pre-defined rainzone values. To check which rainzone is required, click the button for the required geographical area.

   If you are using one of the ITU-R models and angle diversity, you can also view the average angle for refractivity for both linkends. This is a variable used for calculating outage after diversity (if you are using angle diversity) for the ITU-R.530-7, 530-12 and 530-15 set of calculations.

Defining Link Outage Period Information

On the **Outage Period** subtab on the **Calculation** tab in the **Link Database**, the availability and reliability of the link can be determined for a specific short worst period of time ranging from one hour to one month. You can also indicate the terrain to be used.

These calculation factors are used on the **Reliability** subtab of the **Performance** tab.

To define this link outage period information:

1. In the **region and propagation effects** pane, select the appropriate region and propagation effect for the link.

   Based on this, a **β** and a **Q1** value are generated, which are used in the reliability period calculations.
2. In the left-hand box of the **Outage Period** pane, type the unit to be used (6 for 6 hours, 2 for 2 weeks and so on).
3. In the central box, select the time period you want to use. The choices available are hours, days, weeks, and month.

   Warning: You can only specify a period between 1 hour and 1 month long.
4. In the right-hand box, select the terrain to be used.

Defining Link Performance Objectives

On the **Objectives Settings** subtab on the **Calculation** tab in the **Link Database**, you can set the performance objectives that the radio link must meet. Then, on the **Link Objectives Performance Results** tab, you can check if the link meets the objective set.

To set the link performance objectives:

1. Set the calculation method that will be used to check the objectives of the link:
   - For a **Native TDM** radio link, you can choose either ITU-R F.1668-1 (for links of 2Mbps capacity or greater) or ITU-T G.821 (for links of less than 2Mbps capacity).
   - For a **Native IP** radio link, the ITU-T Y.1541 method is automatically selected, as this corresponds to the network performance objectives for packet switched networks.
   - For a **Hybrid IP and TDM** radio link, you can select either of the calculation methods available for a TDM radio link, and the ITU-T Y.1541 method is automatically selected as well.

   Note: Recommendation ITU-R. F.1668-1 defines error performance objectives for real digital fixed wireless links used in 27,500km hypothetical reference paths and connections, and supersedes recommendations ITU-R F.1397 and ITU-R F.1491. Performance events and objectives for connections using equipment designed prior to the approval of ITU-T Recommendation G.826 (December 2002) are given in ITU-T Recommendation G.821 and Recommendations ITU-R. F.634, ITU-R. F.696 and ITU-R. F.697.

2. Click **Apply**.
3. Set the objectives for the link, as described in this table:

Item	Description
Link grade	Links of less than 2Mbps capacity can have a link grade of High, Medium or Local. Links of 2Mbps or more capacity can only have a link grade of Access, Long Haul or Short Haul. The specification for the selected grade is described in the dialog box, beneath the Link Length box.
Link Class (for Medium grade links only)	Medium grade links can be of classes 1 to 4. Classes 1 and 2 represent links of 280km and Classes 3 and 4 represent links of 50km. For more information on link classes and their properties, refer to ITU-R F.696.
A1, B or C Parameter	If your link has a capacity of 2Mbps or more, you must define an A1, B or C parameter value, depending on which link grade you have set. The ranges of values you can enter are described to the right of the Parameter text box. These parameter values are used in the Objectives Equations.

   Note: There are no properties to define for the ITU-T Y.1541 method.

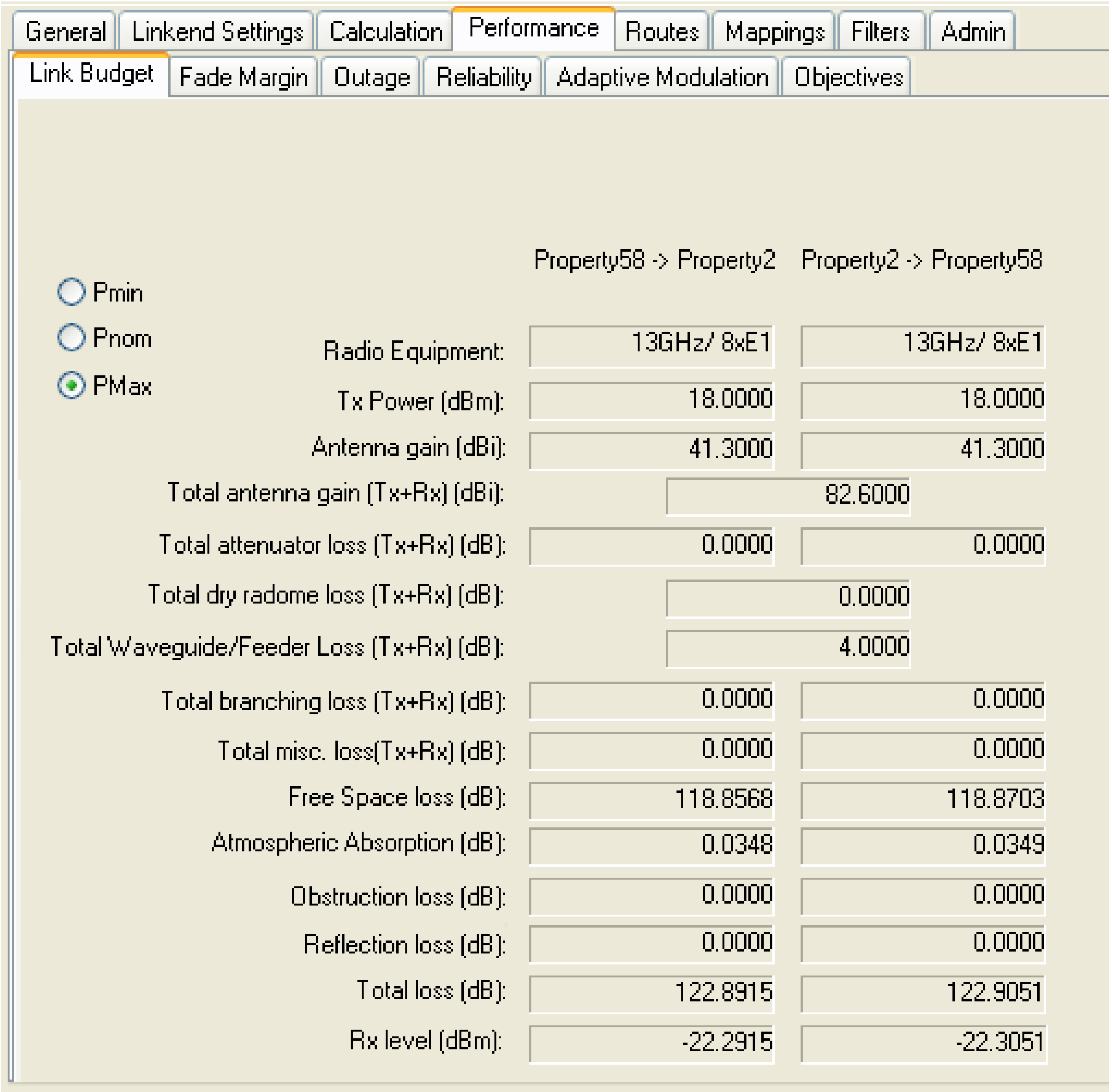
4. Based on these values, the objectives are calculated and displayed on the **Objectives** subtab of the **Performance** tab.

   For more details on the algorithms used, see Objectives Equations on page 287.

Assessing Link Performance

When you have created a link and configured it with valid equipment and frequency information, ASSET Backhaul automatically calculates various link performance indicators, which are displayed on the **Performance** tab.

This picture shows an example:



Link Budget indicators in the Link Database

Each tab displays a different group of indicators, which are described in this table:

Indicator	Description
Link Budget	Shows transmitter and receiver power, antenna gains, path loss, atmospheric absorption and other losses. Different values for receiver power are shown for Pmax, Pmin and Pnom in cases when ATPC is applied.
Fade Margin	Shows the receiver threshold, flat and other fade margins, interference threshold degradation and the required fade margin for the specified rain rate.

Indicator	Description
Outage	Shows the predicted flat (non-selective) outage, selective outage, cross-polarization outage, total worst month and annual outages. Diversity improvements are also shown here, if applicable. **Note:** These values can be viewed in a number of different ways - as a percentage, in terms of seconds/year, or in terms of minutes/year.
Reliability	Shows the rain and equipment availabilities and, together with the outages, predicts the total worst month and annual reliability. **Note:** These values can be viewed in a number of different ways - as a percentage, in terms of seconds/year, or in terms of minutes per year.
Adaptive Modulation	If the link's radio has been AMC-enabled, this tab shows the performance results for each modulation type that is available for the link, and indicates how the throughput requirements can be met.
Objectives	Specifies the error performance objectives (ESR, SESR and so on) that the link should meet.

All of these indicators, with the exception of Objectives, are available for both main and diversity links.

Note: The performance results shown on the **Link Budget** and **Fade Margin** tabs are based on the values for the **Operating Modulation Mode** for the radio selected on the link.

For more information, see Defining the Radio Equipment on Linkends on page 134.

Viewing Link Budget Calculation Results

In order to perform effective transmission planning using ASSET Backhaul, it is important to understand the link performance results, because you can then redesign the link in order to satisfy the required criteria.

To view calculation results for the microwave link power budget:

1. From the **Database** menu, click **Links**.
2. Select the required link, and ensure you have defined all the required information.
3. Click the **Performance** tab. You can view the link's performance on the different subtabs, to see whether it has worked to your satisfaction.

   Depending on the operator's exact requirements, you will probably need to achieve a compromise between performance and cost.

   You can view link performance data for all types of link.
4. If you are using diversity, to view the performance data for a diversity link, on the required subtab (**Link Budget**, **Fade Margin** or **Outage**), from the drop-down menu, select the required link.

   For information on how main/diversity links are named, see Viewing Main and Diversity Link Budget Information on page 158.

Warning: If the linkend settings are mismatched, the calculation results that are displayed may be invalid. You are warned that there is a mismatch at the top of each **Performance** subtab and in the message log. For more information on the possible mismatches that will cause this, see About the Linkend Settings Mismatch Conditions on page 133.

Viewing Main and Diversity Link Budget Information

If you are using diversity on any links, you can view separate link budget information for main and diversity links. Depending on the type of diversity used, the links will be named differently. This table describes the naming convention used:

Diversity Type	Naming Used
Channel Based Frequency Diversity	Main Link (Channel 1, Ptp Antenna 1 <-> Ptp Antenna 1) Fq. Diversity Link (Channel 2, Ptp Antenna 1 <-> Ptp Antenna 1)
User-defined Frequency Diversity	Main Link (Main frequency, Ptp Antenna 1 <-> Ptp Antenna 1) Fq. Diversity Link (Diversity frequency, Ptp Antenna 1 <-> Antenna 1)
Space Diversity (at one linkend)	Main Link (Channel 1/Main frequency, Ptp Antenna 1 <-> Ptp Antenna 1) Sp. Diversity Link (Channel 1/Main frequency, Ptp Antenna 1 <-> Ptp Antenna 2)
Space Diversity (at both linkends)	Main Link (Channel 1/Main frequency, Ptp Antenna 1 <-> Ptp Antenna 1) Sp. Diversity Link (Channel 1/Main frequency, Ptp Antenna 1 <-> Ptp Antenna 2) Sp. Diversity Link (Channel 1/Main frequency, Ptp Antenna 2 <-> Ptp Antenna 1) Sp. Diversity Link (Channel 1/Main frequency, Ptp Antenna 2 <-> Ptp Antenna 2)
Space Diversity (at both linkends) and Frequency Diversity	Main Link (Channel 1/Main frequency, Ptp Antenna 1 <-> Ptp Antenna 1) Sp. Diversity Link (Channel 1/Main frequency, Ptp Antenna 1 <-> Ptp Antenna 2) Sp. Diversity Link (Channel 1/Main frequency, Ptp Antenna 2 <-> Ptp Antenna 1) Sp. Diversity Link (Channel 1/Main frequency, Ptp Antenna 2 <-> Ptp Antenna 2) Fq. Diversity Link (Channel 2/Diverse frequency, Ptp Antenna 1 <-> Ptp Antenna 1) Fq. Diversity Link (Channel 2/Diverse frequency, Ptp Antenna 1 <-> Ptp Antenna 2) Fq. Diversity Link (Channel 2/Diverse frequency, Ptp Antenna 2 <-> Ptp Antenna 1) Fq. Diversity Link (Channel 2/Diverse frequency, Ptp Antenna 2 <-> Ptp Antenna 2)

Note: Frequency diversity is not available for multi-radio links.

Viewing Link Budget Performance Results

The **Link Budget** subtab of the **Performance** tab in the **ASSET Backhaul Link Database** is a summary showing the gains and losses at a glance. The values are automatically produced, based on other values that you have defined in the Link Database, and the link configuration. This table describes some of the key factors affecting what is displayed on the Link Budget subtab:

Factor	Description
Diversity	If you are using diversity, you can view the link budget performance data for any of the diversity links, as well as for the main link. From the drop-down menu, select the required link. For information on how main/diversity links are named, see Viewing Main and Diversity Link Budget Information on page 158.
ATPC	If you have enabled ATPC for the linkend, you can choose to view link budget performance results based on either Minimum Power (Pmin) or Maximum Power (Pmax). In addition, if you have selected to use the Nominal Power on the linkend, you can view results based on this (Pnom). For more information on these powers, see Using Powers on Linkends on page 133.
AMC	If you are using AMC, then the calculations are performed for all of the available modulation schemas. However, the results that are displayed are for the Operating Modulation Type set on the Radio A and B subtabs.
Propagation model	The link budget calculations will vary according to the propagation model that you have selected on the linkend or carrier: • If you use a free space loss model, the calculations use the antenna height at the linkend rather than the model's antenna height. • If you use a model other than a free space loss model, then the free space loss, atmospheric absorption, obstruction and reflection losses are not individually calculated; only a final Total Loss value is given. • If the propagation model is 'Unknown', then no performance calculations can be performed.

Notes:

- Free space loss, atmospheric absorption and obstruction loss are all calculated using the center frequency of the linkend, as defined on **Frequency** subtab of the **Linkend Settings** tab.
- If the link is using TDD, then the free space loss, atmospheric absorption, obstruction loss and reflection loss are the same for both linkends.

As well as the radio equipment and the Tx power, these values are shown:

Value	Description
Antenna gain	The gain of the antenna after it has left the mask, calculated as the dBi gain minus the mask reduction.
Total antenna gain	The combined antenna gain for both linkends.
Total attenuator loss	The sum of Tx and Rx attenuator loss.
Total dry radome loss	Total amount of energy that is absorbed by the radome in dry weather.
Total waveguide/feeder loss	Total loss caused by the feeder at each end of the link.
Total branching loss	Losses caused by the selected operating mode.

Value	Description
Total miscellaneous loss	Any additional losses to be accounted for.
Free space loss	The value of attenuation in ideal conditions. **Note:** This is only calculated as a separate value if the link uses a free space loss propagation model.
Atmospheric absorption	The value of absorption due to water vapor and atmospheric gases. The effect at frequencies below 10GHz is very small, and is generally ignored, but at higher frequencies, atmospheric absorption becomes significant on longer paths and at specific frequencies. **Note:** This is only calculated as a separate value if the link uses a free space loss propagation model.
Obstruction loss	The interference along the path is calculated based on the propagation model selected for the link, comparing the selected values at each point and choosing the largest obstruction. The obstruction loss value is recalculated based on this. **Note:** This is only calculated as a separate value if the link uses a free space loss propagation model.
Reflection loss	The attenuation caused by reflections. **Note:** This is only calculated as a separate value if: • The link uses a free space loss propagation model • The Calculate Reflection Loss option has been selected on the propagation model
Total loss	The total path loss (in dB) including total miscellaneous loss, but excluding the antenna gains and the transmit powers.
Rx level	The signal strength at the receiving antenna, including the Tx power and total antenna gain for each linkend. **Note:** If the linkends/carriers are using the Free Space Loss propagation model, the Rx levels will be different for each linkend. If any other propagation model is used, the Rx levels will be the same.

For a more detailed explanation of the algorithms used, see Link Budget Equations on page 320.

Viewing Link Fade Margin Performance Results

The values on the **Fade Margin** subtab of the **Performance** tab in the **ASSET Backhaul Link Database** are automatically produced, based on other values you have defined in the Link Database, such as the Pmax value set on the linkend. This table describes some of the key factors affecting what is displayed on the Fade Margin subtab:

Factor	Description
Diversity	If you are using diversity, you can view the fade margin performance data for any of the diversity links, as well as for the main link. From the drop-down menu, select the required link. For information on how main/diversity links are named, see Viewing Main and Diversity Link Budget Information on page 158.
AMC	If you are using AMC, then the calculations are performed for all of the available modulation schemas. However, the results that are displayed are for the Operating Modulation Type set on the Radio A and B subtabs.

This table describes the values shown on this subtab:

Value	Description
RX Level	The Rx level in dBm.
Threshold value	The weakest power level at which the radio can work using certain qualifying (BER) criteria.
Flat fade margin	The flat fade margin of a radio link hop, calculated by subtracting the threshold value from the Rx level.
Interference margin	The margin between the calculated T/I and T/I objectives set.
Threshold degradation	How much the cumulative interference will reduce the radio's sensitivity.
Flat fade margin after interference	A recalculation of the flat fade margin to account for interference.
Dispersive fade margin	This is taken from the radio equipment database, and is used to calculate selective fading.
Composite fade margin	The sum of the flat fade margin after interference and the dispersive fade margin.
Required fade margin against rain	The fade margin required to offset the effect of rainfall.

For a more detailed explanation of the algorithms used, see Fade Margin Equations on page 326.

Warning: If the Flat Fade margin or Interference margin value is negative, the link will fail. When this happens, the value appears in red.

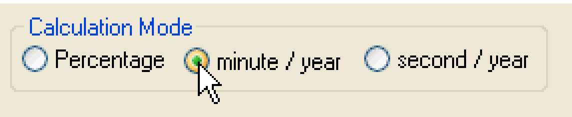
For a more detailed explanation of these algorithms, see TDD Equations on page 328.

Viewing Link Outage Performance Results

Fading (outage) causes a link to be unavailable. The more a link is unavailable, the less efficient it will be. If you are to model noise effectively in your network, you need to account for outage and configure the equipment to lessen any fading.

The **Outage** subtab of the **Performance** tab in the **ASSET Backhaul Link Database** shows various availability information depending on the calculation method selected. The values on this subtab are automatically produced, based on other values in the Link Database, such as the Pmax value set on the linkend.

Note: These values can be viewed in a number of different ways - as a percentage, in terms of minutes/year or seconds/year. You can select the required option in the **Calculation Mode** pane:



If you are using diversity, to view the performance data for a diversity link, from the drop-down menu, select the required link. For information on how main/diversity links are named, see Viewing Main and Diversity Link Budget Information on page 158.

The following values are displayed on the **Outage** subtab:

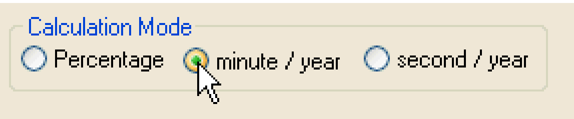
Value	Description
Calculation method	The method you have selected on the link.
Coefficient	The weighting or alpha value for apportioning the relative values of P_{ns} and P_s. Alpha lies between 1.5 and 2, based on the algorithm defined in ITU-R F.1093-1: $$P=\left(P_s^{\frac{\alpha}{2}}+P_{ns}^{\frac{\alpha}{2}}\right)^{\frac{2}{\alpha}}$$ so for $\alpha=2$, $$P=P_s+P_{ns}$$
Flat outage (Pns)	The value of outage caused by flat fading.
Selective outage (Ps)	The value of outage caused by selective fading.
Cross-polarization outage (clear-air) (PxP)	The value of outage caused by clear-air cross-polarization. **Note:** You can choose to ignore this value when calculating the Total Outage. See Setting Preferences on the BACKHAUL Tab on page 24.
Total worst (x) period outage (Pt w/o div)	The total value of outage without diversity in the worst period.
Total annual outage (Pt, w/o div)	The sum of outage caused by flat fading, outage caused by selective fading and the reduction of cross-polar discrimination, calculated for the year.
Outage after diversity (Pd)	The value of outage recalculated to account for diversity.
Improvement factor (I)	The space or frequency diversity improvement factor.
Total worst (x) period outage (Pt)	The total value of outage with diversity in the worst period.
Total annual outage	The sum of outage, taking into account diversity, calculated for the year.

The symbols in parentheses are used in the outage algorithms. For a more detailed explanation of the algorithms used, see Outage Equations on page 335.

Viewing Link Reliability Performance Results

The **Reliability** subtab of the **Performance** tab in the **ASSET Backhaul Link Database** displays availability and reliability data based on radio and equipment unavailability, and other values in the Link Database, such as the Pmax value set on the linkend.

Tip: These values can be viewed in a number of different ways - as a percentage, in terms of minutes per year or seconds/year. You can select the required option in the **Calculation Mode** pane:



If you are using diversity on this link, this protection will be indicated on the tab, and the values will include diversity improvement.

The following values are displayed on the Reliability subtab:

Value	Description
Rain	The amount of unavailability that is caused by rain.
Equipment	The amount of unavailability caused by equipment failures, based on time taken to repair and time between failures.
Annual unavailability	The amount of unavailability annually.
Annual availability	The amount of availability annually.
Worst month unavailability	The amount of unavailability for the month that has the most rainfall.
Worst month availability	The amount of availability for the month that has the most rainfall.
Total annual unreliability	This is the sum of unavailability caused by rain and equipment, for a period of one year.
Total annual reliability	This is the sum of availability caused by rain and equipment, for a period of one year.
Total worst month reliability	This is the value of reliability for the month that has the most rainfall.
Total worst month unreliability	This is the value of unreliability for the month that has the most rainfall.

Note: The availability calculations are the same for both FDD and TDD links.

For a more detailed explanation of the algorithms used, see Reliability Equations on page 353.

Viewing Link Adaptive Modulation Performance Results

The **Adaptive Modulation** subtab of the **Performance** tab for a link in the **Link Database** displays the performance results for each modulation type that is available for the link.

Notes:

- If AMC has not been enabled for this link,then this subtab is not used.
- If you are viewing the results for a series of point to multi-point links, although the AMC parameters are configured with the same values for each multi-point link from End A to End B (because these values are defined on the carrier), the calculated availabilities and fade margins will differ for each multi-point link. This is because the received signal levels and corresponding fade margins will be different.

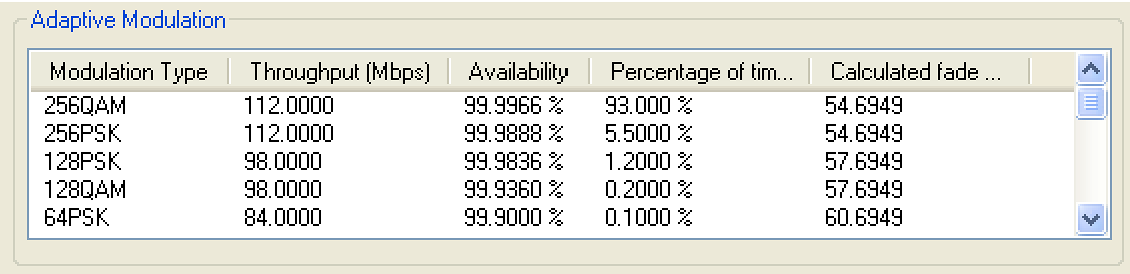
To view the results for the required link direction, select either the **End A -> End B** or the **End B -> End A** option.

In the **Adaptive Modulation** pane, you can view results related to each modulation type available for the link, sorted by throughput.

This table describes the information that you can view:

Item	Description
Throughput (Mbps)	The provided throughput for the modulation type.
Availability	The calculated availability for the modulation type. The calculation is the same as for a link on which AMC is not enabled - it is assumed that the modulation type is fixed on the link. In other words, if three modulation types are available for the link, the availability calculations are performed as if for three separate links.
Percentage in time of mode	The percentage of time that the radio uses the modulation type. This is calculated by subtracting each availability from the succeeding one. For example, 128-QAM has an availability of 99.935%, 64-QAM has an availability of 99.987%, and QPSK has an availability of 99.999%. Therefore, the percentage of time in mode for 128-QAM is 99.935% (99.935-0), the percentage of time in mode for 64-QAM is 0.052% (99.987-99.935), and the percentage of time in mode for QPSK is 0.012% (99.999-99.987).
Calculated fade margin (dB)	The calculated fade margin, after any interference effects have been taken into consideration.

This picture shows an example:


Adaptive Modulation

Modulation Type	Throughput (Mbps)	Availability	Percentage of tim...	Calculated fade ...
256QAM	112.0000	99.9966 %	93.000 %	54.6949
256PSK	112.0000	99.9888 %	5.5000 %	54.6949
128PSK	98.0000	99.9836 %	1.2000 %	57.6949
128QAM	98.0000	99.9360 %	0.2000 %	57.6949
64PSK	84.0000	99.9000 %	0.1000 %	60.6949

Adaptive Modulation pane

In the **Throughput Requirements** pane, you can view the results for the throughputs that you have defined on the - both the **Required Throughput** and the **High Priority Throughput** (if this has been defined).

This table describes the information that you can view:

Item	Description
Required Throughput (Mbps) or High Priority Throughput (Mbps)	The level of throughput that must be delivered - defined on the Modulation/Capacity subtab of the Linkend Settings tab as either the Required Throughput or in the case of sensitive data, High Priority Throughput.
Required Availability (%)	The percentage of time for which the Required Throughput (or High Priority Throughput) must be delivered, as defined on the Modulation/Capacity subtab of the Linkend Settings tab.
Minimum Modulation Order	The lowest modulation order that satisfies the required throughput. This should be used to avoid wasting resources by selecting an unnecessarily high modulation type.
Required Fade Margin (dB)	If the demands for throughput and availability cannot be met by the minimum modulation order, then this is the additional fade margin that is required. This will be either the multipath or rain fading value, whichever is the greater.

This picture shows an example:

Throughput Requirements pane

Viewing Link Objectives Performance Results

The **Objectives** subtab of the **Performance** tab in the **ASSET Backhaul Link Database** displays information on the performance objectives set for the link, according to ITU-R recommendations. The calculated objectives are based on the values defined on the **Objectives Settings** subtab.

If you are using diversity on this link, the objectives for the main and diverse link will be the same.

The following values are displayed on the Objectives subtab:

Tip: You can switch between the performance results for each direction by selecting the **End A -> End B** and **End B -> End A** radio buttons as required. If you are viewing the results for a point to multi-point link, then the calculations for End A -> End B are based on the settings defined for the PmP carrier and the calculations for End B -> End A are based on the settings defined for the multi-point link.

Pane	Value	Description
Error Performance Objectives	Calculation Method	The method(s) used to calculate the objectives for this link. For more information, see Defining Link Performance Objectives on page 155.
	Link Length (km)	The length of the link.
	Radio	Indicates the type of the radio specified on the Radio subtab on this link. The radio type is defined on the General tab for the corresponding radio.
	Available Link Capacity	The maximum available capacity for the link, as defined on the Type subtab of the General tab.
PDH/SDH (Not used for Native IP radio links)	Link Grade	Links of less than 2Mbps capacity can have a link grade of High, Medium or Local. Links of 2Mbps or more capacity can only have a link grade of Access, Long Haul or Short Haul. This is defined on the Objectives Settings subtab on the Calculation tab in the Link Database.

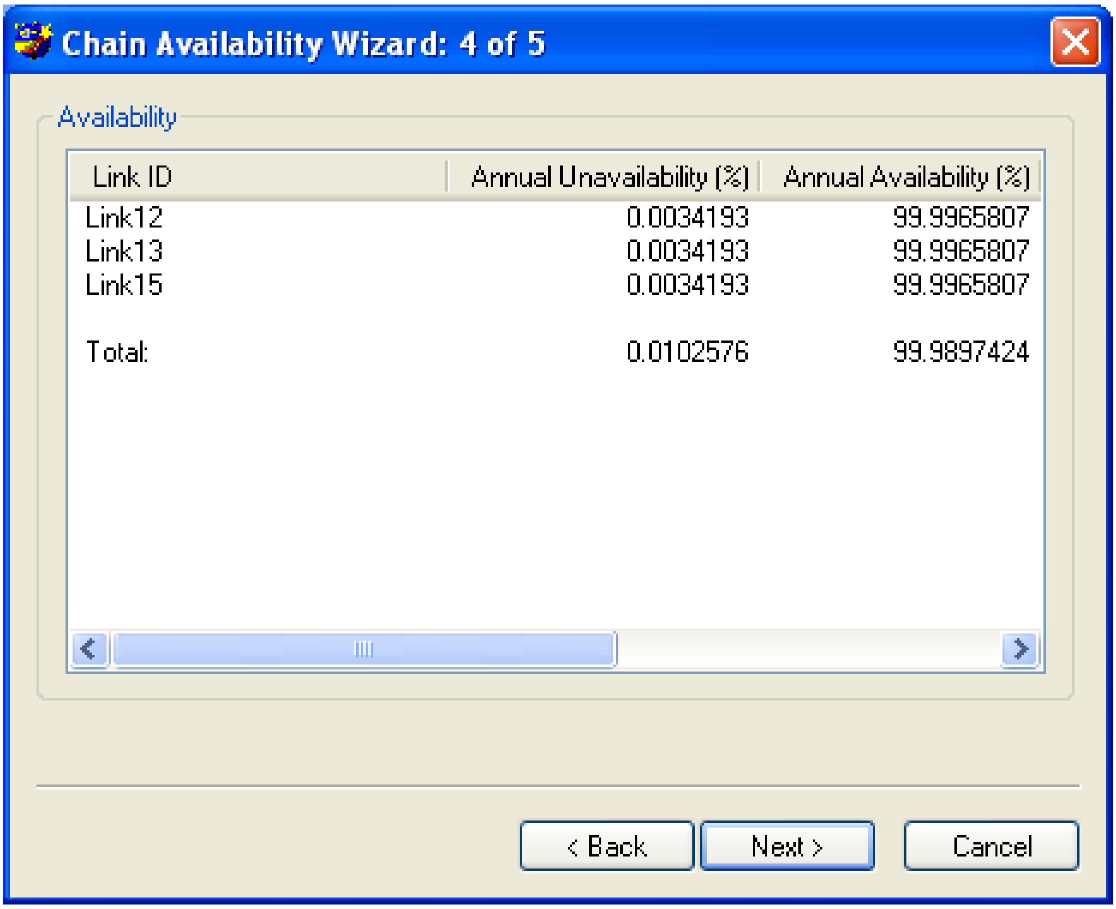
Pane	Value	Description
	Link Class (for Medium grade links only)	Medium grade links can be of classes 1 to 4. Classes 1 and 2 represent links of 280km and Classes 3 and 4 represent links of 50km. For more information on link classes and their properties, refer to ITU-R F.696. This is defined on the Objectives Settings subtab on the Calculation tab in the Link Database.
	Link Class Period (for Medium grade links only)	The reference link distance for the link class. For link classes 1 and 2, the reference link distance is 280km. For link class 3 and 4, the reference link distance is 50km. This is defined on the Objectives Settings subtab on the Calculation tab in the Link Database.
	Parameter	Indicates which parameter - A1, B or C - is being used. This is based on the link grade. This is defined on the Objectives Settings subtab on the Calculation tab in the Link Database.
	Map Ethernet/IP Traffic	Select this option if you want to map Ethernet/IP traffic over the Native TDM link.
	Packet Size (bytes) and Packet Type	If you have chosen to map Ethernet/IP traffic over the Native TDM radio link, define a packet size and type for the mapped Ethernet/IP packets.
	Ethernet/IP Throughput (Mbps)	If you have chosen to map Ethernet/IP traffic over the Native TDM radio link, this is the available capacity that the mapped Ethernet/IP can achieve, based on the available capacity, IP packet size and packet type.
	ESR (Objectives, Link)	The number of errored seconds per month, during which the link will be unavailable. An errored second is one in which one or more bits are in error. The Objectives pane shows the required number, the Link pane shows the actual number on this link. **Note:** If you are using the ITU-T G.821 calculation method, then only the objective will be calculated, not the actual link value.
	SESR (Objectives, Link)	The number of severely errored seconds per month, during which the link will be unavailable. A severely errored second is one which has a bit error ratio of $\geq 10^{-3}$. The Objectives pane shows the required number, the Link pane shows the actual number on this link. **Note:** If you are using the ITU-T G.821 calculation method, then only the objective will be calculated, not the actual link value.

Pane	Value	Description
	BBER (Objectives, Link)	The number of seconds during which the link will be unavailable based on the background block error ratio, which is the ratio of errored blocks to total blocks during a month, excluding all blocks during short errored seconds and unavailable time. The Objectives pane shows the required number, the Link pane shows the actual number on this link.
	Recommended Block Size	The recommended block size, based on the link capacity and whether the link is SDH or PDH.
Ethernet/IP (Not used for Native TDM radio links)	Packet Type and Packet Size (bytes)	The type and size of the IP packets, defined on the Type subtab of the General tab for the IP radio link.
	Map TDM Traffic	Select this option if you want to map TDM traffic over the Native IP radio link.
	TDM Channel	If you have chosen to map TDM traffic over the Native IP radio link, select the TDM channel type that you want to map.
	TDM Throughput (Mbps)	If you have chosen to map TDM traffic over the Native IP radio link, this is the total TDM traffic that can be delivered using this link, as well as the number of TDM channels. If the required TDM traffic cannot be mapped on the IP link due to insufficient resources (if you want to map an E3 TDM channel (line rate of 34,368 kps), but your Ethernet capacity is 30,000 kps), then the result would be expressed as 0 TDM channels.
	PER	The Packet Error Rate, which is the number of incorrectly transferred data packets divided by the number of transferred packets. A packet is assumed to be incorrect if at least one bit is incorrect. The Objectives pane shows the required maximum value (0.001 for all types of classes), the Link pane shows the actual value on this link, which is calculated based on the received power level and the packet size in bits.
	Optimum Packet Size (bytes) and Optimum Available Capacity (Mbps)	The optimum packet size and optimum available capacity are calculated based on the required PER.

For a more detailed description of the algorithms used, see Objectives Equations on page 287.

Calculating Information for Multiple Links

In order to calculate the overall availability of a series of links, you can nominally connect multiple links together in a chain. This picture shows an example chain:



Chain Availability Wizard

You can create chains using the **Chain Availability Wizard**, and store them in the **Link Database**, where you can edit them.

Creating Link Chains

You can nominally connect multiple links together in a chain using the **Chain Availability Wizard**. To do this:

1. If you want to use the **Map View** window to help you make your chain, ensure you have a Map View window open.
2. From the **Tools** menu, click **Chain Availability Wizard**.
3. Click **Next**.
4. Choose whether you want to select the links for the chains from:
   - The **Map View** window
   - The **Link Database**
   - The **Site Database** in the **Physical Links** view

If you select the Site Database method, select how far down a chain of connectivity you want to display. For example, a depth value of 2 will show up to 2 connected Properties (one link), 5 will show up to 5 connected Properties (four links), and so on.

5. Click **Next**.
6. Depending on the method you have chosen, your options will be different. The following table describes the next step for each method:

For This Method	Do This
Map View Window	Hold down the Shift key and click each link that you want to add. They are all automatically added to the chain. **Note:** You can also add individual links by clicking the link and clicking the Add button.
Site Database	1. Open the Site Database, and ensure it is displaying the Physical Links view. 2. In the Site Database, select the first Property in the chain, and then the Property it is linked to. 3. In the Chain Availability Wizard, click the Add button. 4. To add another link to the chain, click the start Property of the link, and then click the Property that it is linked to. **Note:** To add multiple links to the chain without using the Add button, hold down the Shift key while you are clicking the Properties. You must click the start and end Property of each link separately. 5. Click Next.
Link Database	1. From the Database menu, click Links to open the Link Database, and then select the first link that you want to add. 2. In the Chain Availability Wizard, click the Add button. 3. Repeat steps 1 and 2 until you have selected all of the links for the chain. 4. Click Next.

Note: If your network contains multi-radio or dual polar links, you can choose to include their sublinks in the chain. They are treated like regular point to point links.

7. The next page displays the total unavailability/availability for the link chain you are creating. You can view either annual or worst month statistics.
8. Click **Next**, and type a name for the chain, and check the summary of links included.
9. If you are satisfied, click **Apply** and then click **Finish** to close the wizard.

   – or –

   If you need to edit the chain, click **Back** and edit the details accordingly.

Viewing and Editing Link Chains

If you have created a link chain, you can view, edit and delete the details in the **Link Database**.

To view a chain:

1. From the **Database** menu, click **Links**.
2. Ensure that the **Details** pane is visible; if not, click the **Details** button.
3. In the **Link Selection** pane, click the **Chains** tab.

4. In the list of chains, select the link chain that you want to view.

   The chain details are displayed.

To edit a chain:

1. Click **Edit Chain Details**.
2. The **Chain Availability Wizard** opens, and you can edit your chain on the tabs.

To delete a chain:

1. Right-click the required chain, and from the menu that appears, click **Delete**.
2. Click **Yes**.

   The chain is removed from the Link Database.

How is Unavailability Calculated for Link Chains?

When you are calculating information for multiple links using a link chain, ASSET Backhaul takes into account your system configuration. This table describes how different configurations will affect the calculations:

For These Configurations	ASSET Backhaul Will Consider
1+1, HotSB	Propagation unavailability only.
1+0, Single	Propagation and equipment unavailability.

The following tables describe practical examples of the unavailability calculated for a chain, where:

- MTTR is 4 hours
- MTBF is 80 years

Example Chain 1

Link in Chain	Link0143	Link0149	Link0142	Unavailability Chain (%)	Unavailability Chain (sec/yr)
Capacity (Mb/s)	2x2	4x2	16x2		
Configuration	1+1	1+1	1+1		
Length (km)	1.14	1.59	2.93		
Propagation Unavailability (%)	0.000018	0.00012	0.00025	0.000388	122
Equipment Unavailability (%)	0.00094	0.00094	0.00094	0.003137	989
			Total	0.000388	122

Example Chain 2

Link in Chain	Link0143	Link0149	Link0142		
Capacity (Mb/s)	2x2	4x2	16x2		
Configuration	1+0	1+1	1+1	Unavailability Chain (%)	Unavailability Chain (sec/yr)
Length (km)	1.14	1.59	2.93		
Propagation Unavailability (%)	0.000018	0.00012	0.00025	0.000388	122
Equipment Unavailability (%)	0.00188	0.00094	0.00094	0.00188	591
			Total	0.0023	714

Example Chain 3

Link in Chain	Link0143	Link0149	Link0142		
Capacity (Mb/s)	2x2	4x2	16x2		
Configuration	1+0	1+0	1+1	Unavailability Chain (%)	Unavailability Chain (sec/yr)
Length (km)	1.14	1.59	2.93		
Propagation Unavailability (%)	0.000018	0.00012	0.00025	0.000388	122
Equipment Unavailability (%)	0.00188	0.00188	0.00094	0.00375	1183
			Total	0.0041	1305

Example Chain 4

Link in Chain	Link0143	Link0149	Link0142		
Capacity (Mb/s)	2x2	4x2	16x2		
Configuration	1+0	1+0	1+0	Unavailability Chain (%)	Unavailability Chain (sec/yr)
Length (km)	1.14	1.59	2.93		
Propagation Unavailability (%)	0.000018	0.00012	0.00025	0.000388	122
Equipment Unavailability (%)	0.00188	0.00188	0.00188	0.0062	1954
			Total	0.0066	2077

Analyzing Interference

A radio link system is rarely situated in an isolated environment. More often, as well as the wanted signal, one or more interference signals are received which cause deterioration in the receiver performance. Usually, this is transformed into an equivalent degradation in the receiver threshold power.

The interference problem generally decreases as the frequency gets higher and the directivity of the antennas increases. Also the increasing attenuation of the atmosphere helps to attenuate interference from distant sources, particularly at frequencies above 54GHz.

Even well designed links and networks are of no use if there are possible interference conflicts with existing links in the environment.

You can use ASSET Backhaul to assess levels of both co-channel and adjacent interference. It will alert you to those levels of interference that do not meet your defined threshold to interference ratio (T/I) or threshold degradation objectives. You can analyze links as 'interferer' links (those that may be causing interference) and 'victim' links (those that suffer from interference), as well as specify the channel(s) on a link that you want to analyze.

You can switch between the channels available for a link and assess the effect of interference on each channel and at different polarizations. Based on your assessments, you can make changes to the channel and polarization and apply these directly to the link.

Note: If your network contains multi-radio and/or dual polar links, for the purpose of analyzing interference, the individual sub-links are considered as regular point to point links.

Analyzing Links for Interference

To analyze a link, or groups of links, for interference:

1. If you want to select the link(s) for analysis by using the Map View window, ensure you have a **Map View** window open showing the required link.

   - or -

   If you want to analyze links from a filter, ensure you have created the link filter you require, using the **Filter Wizard** as described in the *ENTERPRISE User Reference Guide*.

2. From the **Tools** menu, point to **Interference Analysis** and click **Interference Wizard**. The **Interference Wizard** dialog box appears.

3. Click **Next**.

4. Select the link(s) that you want to analyze for interference (the 'victim' links), using one of the following methods:

To	Do This
Select a set of links using the Map View window	Choose the Select a view option, and click Next. If the Map View window shown is not the correct one, click Select View and click the required Map View window.
Select the link(s) using a filter	Choose the Select a filter option, and from the list pick the filter containing the link.
Select a single link in the Map View window	Choose the Select a link option, and in the Map View window, click the required link.

Note: Whichever option you choose, this is selected by default when you have to select interferer links, but it can be changed.

5. If required, you can refine the analysis to:
   - Check all channels in the subband. The link(s) will be analyzed on all channels in the links' subband. If you are analyzing a single link, you can choose a subset of channels to analyze, rather than all of them. For information on how to do this, see Selecting Channels for Link Interference Analysis on page 175.

     Warning: If you are selecting links using the **Map View** window or a filter and you choose the **'Check all channels in sub-band'** option, then the analysis will take longer to run.

     Note: If you do not select the 'Check all channels in sub-band' option, the analysis will use the single channel assigned to each victim link being analyzed.
   - Allow polarization changes. The link(s) will be analyzed with both horizontal and vertical polarization.
6. Click **Next**.
7. Select the link(s) that you want to consider as possible interferers (the 'interferer' links) to the 'victim' links that you have selected.

   The possible methods that you can use are the same as for the 'victim' links.
8. Define a guard band. This will depend on the bandwidth, for example, for 7MHz, a guard band of 28MHz would consider interference up to 4 channels away.
9. Set the distance to consider. This will account for the effect that an interferer has on a given transmission path for a given radius. For example, the default value of 100km is acceptable as it is the maximum hop distance considered in a standard microwave network.

   Tip: If the hop distances are all less than 100km, limit the distance considered to the highest hop distance in the plan to speed up the analysis.
10. If you want to calculate interference based on the ATPC settings on the linkends, select the **'Consider ATPC settings on the Link'** option.

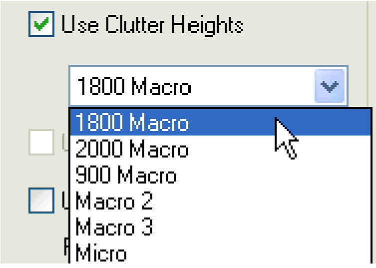
    If you select this option, the Pmin or Pnom value for the Operating Modulation Mode on the link will be used as the link's power.

    Otherwise, ensure that the **'Ignore the ATPC settings on the Link'** option is selected.

    For more information on ATPC settings, see Defining the Parameters of Radio Equipment on page 34 and Defining the Frequency for Linkends on page 130.
11. If you have defined the spectrum density and receive selectivity masks on the radio equipment, and no T/I objectives tables exist, then you must specify the threshold degradation objectives:
    - The accepted level of interference per interferer (dB)
    - The accepted total interference (dB)

    Note: If there are T/I objective tables available, both criteria should be met. The default T/I objective on the radio equipment is only used if neither T/I objective tables nor threshold degradation objectives exist.
12. In the **Height Data** pane, select which height data you want to use when calculating interference, and the resolution that you want to use:

If you select the **Use Clutter Heights** option, select a propagation model from the list.



Note: If you specify an unknown propagation model, the values defined in the Height Profile are used.

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13. If any of the links that you are analyzing for interference use TDD, then you can specify the frame overlap (in ms), which represents the acceptance tolerance of overlapping frames, beyond which they are considered to be interfering.

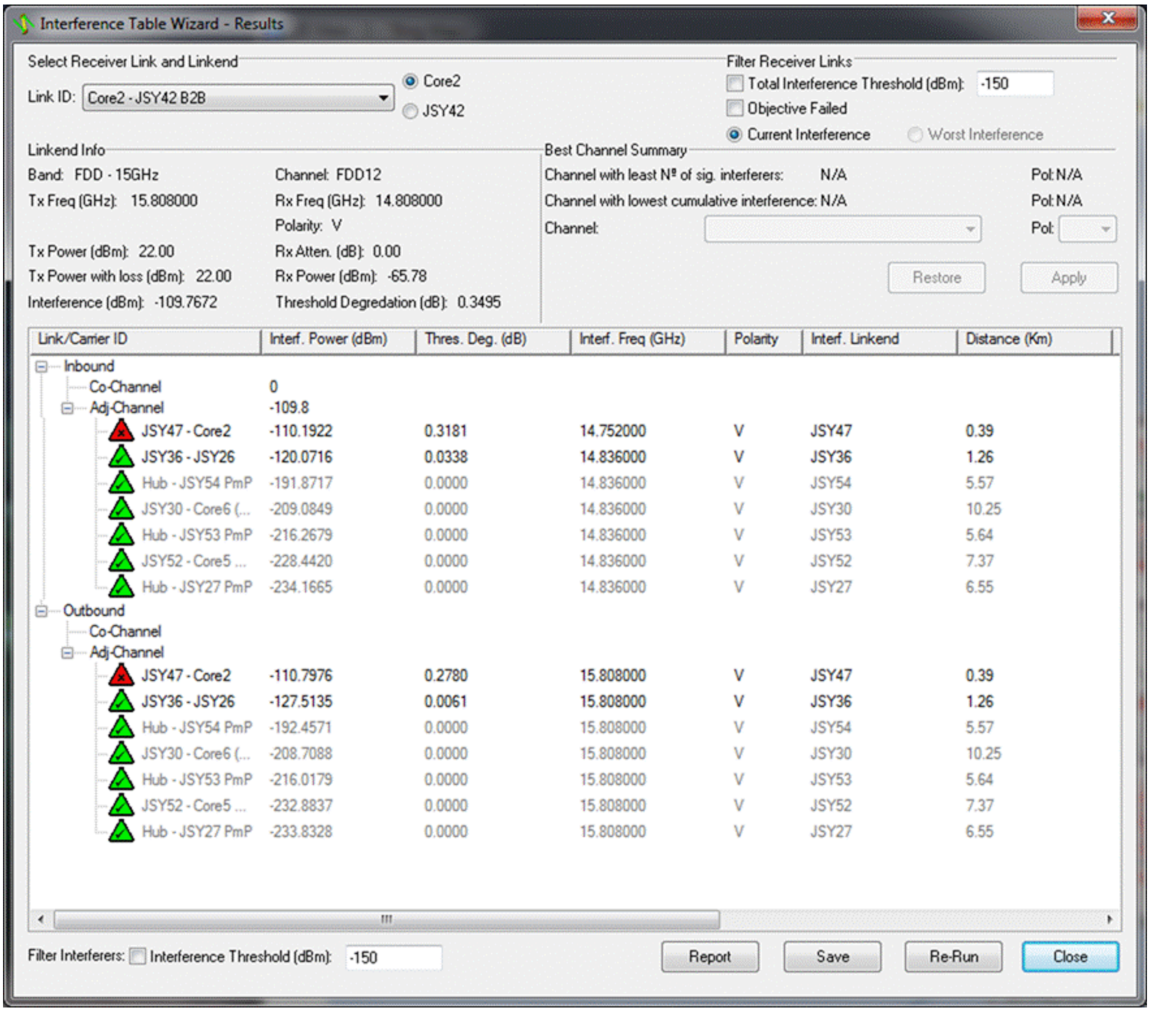
14. Click **Next**.

15. If you want the interference analysis to consider correlated fading, select the **Enable Correlated Fading** checkbox, and then specify the following maximum border conditions:

Value	Description	Minimum	Maximum	Default
Maximum Angle Separation (degrees)	The maximum angle separation between the victim link and the interfering linkend.	0	45	10
Maximum Distance Separation (km)	The maximum distance separation between the victim link and the interfering linkend.	0	30	5
Maximum Correlated Fading (dB)	The maximum amount that the interfering linkend will fade when the victim link is faded.	20	150	60

16. Click **Finish**.

Any interference is displayed in the **Interference Table Results** dialog box. This picture shows an example:



For more information on what is displayed, see About the Data Shown in the Interference Table Results Dialog Box on page 178.

17. If you make any changes in the Link Database while you have the Interference Table Results dialog box open, you can update the interference results by clicking the **Re-Run** button.

Note: It is recommended that the interference is analyzed each time a new link is added, since the new link may cause interference to existing links (outbound interference) or suffer interference from existing links (inbound interference).

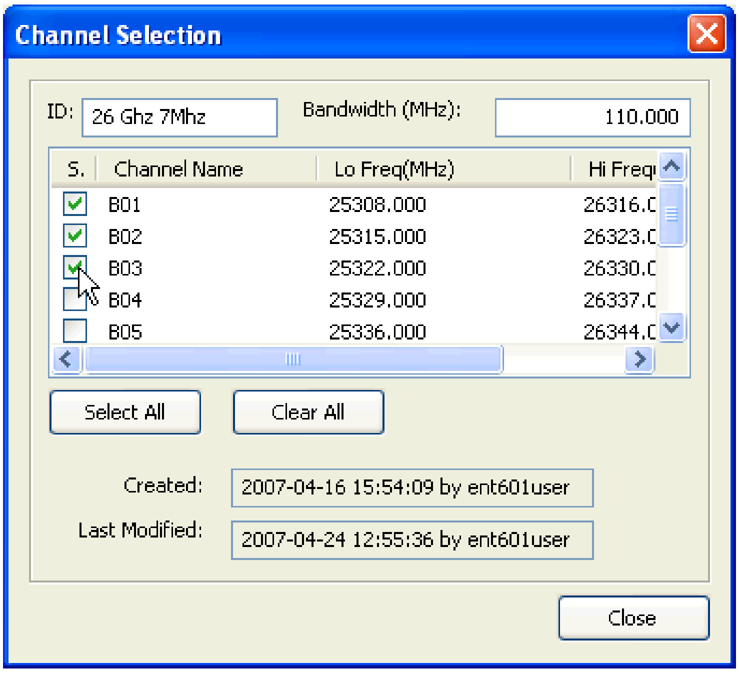
Selecting Channels for Link Interference Analysis

When you are configuring a link interference analysis, to restrict the analysis to particular channels on the link:

1. In the **Interference Wizard**, ensure you have chosen the **Select a link** option, which enables you to choose a particular link to be considered as the 'victim' link.

2. After you have chosen the link, click the **Channel Selection** button.

3. In the dialog box that appears, select the required channels:



Tips:

- To select all of the channels, click **Select All**.
- To deselect any chosen channels, click **Clear All**.

4. Click **Close**.

   The selected channels will be used for calculating interference.

Viewing Link Information in the Interference Table Results Dialog Box

After you have run the **Interference Wizard**, you can view information for each link in the **Interference Table Results** dialog box.

To do this:

1. In the **Link ID** box, select the link you require.

Tip: You can restrict the list of links displayed by selecting one of the **Filter Receiver Links** options:

- To those links on which one or both linkends has a total interference greater than the specified interference threshold
- To those links on which one or both linkends has failed to meet the objectives

2. Select one of the **Link End** option buttons.

> **Note:** If you are analyzing point to multi-point links on a PmP hub, the linkend will be listed by its sector, with the Hub ID in brackets.

3. In the **Best Channel Summary** pane, the channel with the least number of significant interferers and the channel with the lowest cumulative interference are indicated. You can also look at other information in this pane:
   - If you selected to check channels in the subband in the Interference Wizard, select the channel for which you want to view information
   - If you selected to allow polarization changes in the Interference Wizard, select the polarization for which you want to view information

   See About the Data Shown in the Interference Table Results Dialog Box on page 178 to see a list of values displayed for the receiver and transmitter.

   > **Tip:** You can restrict the list of interfering links displayed by selecting the Filter Interferers option and typing a minimum total interference power in the **Interference Threshold** box.

4. When you find the optimum channel and/or polarization, you can click **Apply** to save the changes to the link.

   > **Important:**
   > - Any changes to the channel and/or polarization that you Apply may have a detrimental effect on the other linkends.
   > - If you click **Restore**, this will restore all other changed values, not merely the channel and/or polarization.

5. To save any Applied interference analysis results to be loaded and viewed later, click **Save**.

   – or –

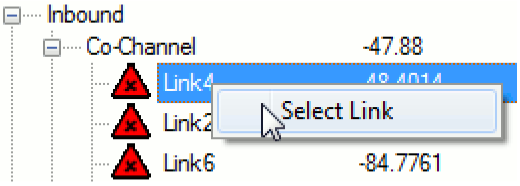
   From the **Tools** menu, point to **Interference Analysis** and click **Save Interference Data**.

   Choose a location and filename (*.txt) and click **Save**.

6. You can produce a report of interference that appears in Microsoft Excel® (or a text editor), for either the currently displayed link or all affected links. For information on how to do this, see Producing Interference Reports on page 235.

7. If you make any changes in the Link Database while you have the Interference Table Results dialog box open, you can update the interference results by clicking **Re-Run**.

Tip: To locate a link shown in the interference results in the Link Database, right-click the link name in the Interference Results dialog box and then click **Select Link**:



Selecting Links in the Link Database using the Interference Results

About the Data Shown in the Interference Table Results Dialog Box

The following tables show the information that you can view after you have performed an interference analysis.

This information is available for:

- Current Interference - based on the current Operating Modulation Mode set on the interfering linkend radio
- Worst Interference - corresponds to the worst possible case (in other words, the maximum interference) based on considering all of the available modulation types for the interfering linkend radio

For the analyzed link:

Item	Description
Link ID	The name of the link analyzed.
Band	The operating band of the link.
Channel	The channel on the operating band.
Tx Frequency (GHz)	The transmitted frequency.
Rx Frequency (GHz)	The received frequency.
Polarity	The polarity of the link.
Tx Power (dBm)	The transmitted power level.
Rx Atten. (dB)	The amount of received attenuation.
Tx Power with Loss (dBm)	The transmitted power when losses have been subtracted.
Rx Power (dBm)	The received power level.
Interference (dBm)	The interference at this link.
Threshold Degradation (dB)	The amount by which cumulative interference will reduce the radio's sensitivity. For more information, see Calculating Threshold Degradation on page 304.
Best Channel Summary	The channel with the least number of significant interferers and the channel with the lowest cumulative interference, plus their respective polarizations.

For each associated link:

Item	Description
Link	The name of the link, divided into: • Inbound interference (links that interfere with the analyzed link) or outbound interference (links that suffer interference from the analyzed link) • Co-channel and Adjacent Channel interference **Note:** If the interference analysis has found an interfering link on a PmP hub, the ID of the carrier containing the link is displayed here. The links are color-coded as follows: • A tick in a green triangle  indicates that the calculations are valid and the level of calculated interference is not regarded as significant. • An exclamation mark in a yellow triangle  indicates that the calculations are valid and the level of calculated interference could be regarded as significant. • A cross in a red triangle  indicates that the calculations are valid and the level of calculated interference is significant. **Tip:** For more information on the interference calculated for a particular link, hover the cursor over it. For more information on how interference is calculated, see Interference Equations on page 301. **Warning:** If Tx/Rx masks are being used and no T/I objective tables have been defined, the interference margin is not considered when evaluating whether the interferer is significant or not.
Interference Power (dBm)	The power at the interfering transmitter.
Threshold Degradation (dB)	The amount by which cumulative interference will reduce the radio's sensitivity.
Interference Frequency (GHz)	The frequency of the interfering transmitter.
Polarity	The polarity of the interfering link.
Interfering Linkend	The Property containing the interfering transmitter. **Note:** If the interference analysis has found an interfering link on a PmP hub, the name of the sector and the hub ID are displayed here.
Distance	The distance between the analyzed link and the interfering link.
T/I Objective	The T/I objective taken from the T/I objectives tables. If T/I objectives tables are unavailable, this is defined on the radio equipment.
Calc T/I	The calculated T/I value.
Interference Margin	The interference margin. For more information, see Calculating the Interference Margin on page 304.

The interfering transmitters are displayed in order of decreasing interference.

There are also additional fields displayed in the **Interference Report**. For more information see About the Additional Fields Shown in the Interference Report on page 180.

About the Additional Fields Shown in the Interference Report

When you generate an **Interference Report**, in addition to the fields shown in the **Interference Table Results** dialog box, you can also view the following fields:

Item	Description
Interference Before T/I	Interference before T/I ratio is taken into account.
Band Name	The operating band of the interfering link.
Channel Name	The channel on the operating band of the interfering link.
Tx Power (dBm)	The transmitting power of the interfering link.
Tx Power with Loss (dBm)	The transmitting power of the interfering link after loss has been subtracted.
Departure Angle	The direction from which the interference is transmitted.
Arrival Angle	The direction from which the interference is received.

Viewing Interference in the Map View Window

You can display on the map:

- Receiver interference
- Co-channel interference
- Adjacent interference

To display interference on a map:

1. Ensure you have performed an interference analysis.
2. On the Map View toolbar, click the  button.
3. In the **Layer Control** dialog box, click the **Data Types** tab.
4. In the Data Types list, under **Filters**, double-click the required filter.
5. In the dialog box that appears, expand the required link category, and click **Line 1** or **2**.
6. To change colors for interference, click the **Line** tab.
7. In the **Color** pane, select the **Variable** option, select the **Show Interferers** attribute, and then click **OK**.
8. Change a color by clicking the old color in the **Ranges** pane, selecting the new color and then clicking **OK**.
9. Click **OK**.
10. Right-click on the map and from the menu that appears, click **Redraw**.

    Interference at any receiver can now be viewed by clicking on the appropriate linkend.

Loading Interference Data

You can load interference data that you have previously saved.

Warning: If sites have been moved, added, deleted or changed since the interference data was saved, then do not load the stored analysis. Instead perform a new analysis. This is because analysis is only 100% valid for the sites and the positions that they were calculated for.

To view the results of a previously stored interference analysis:

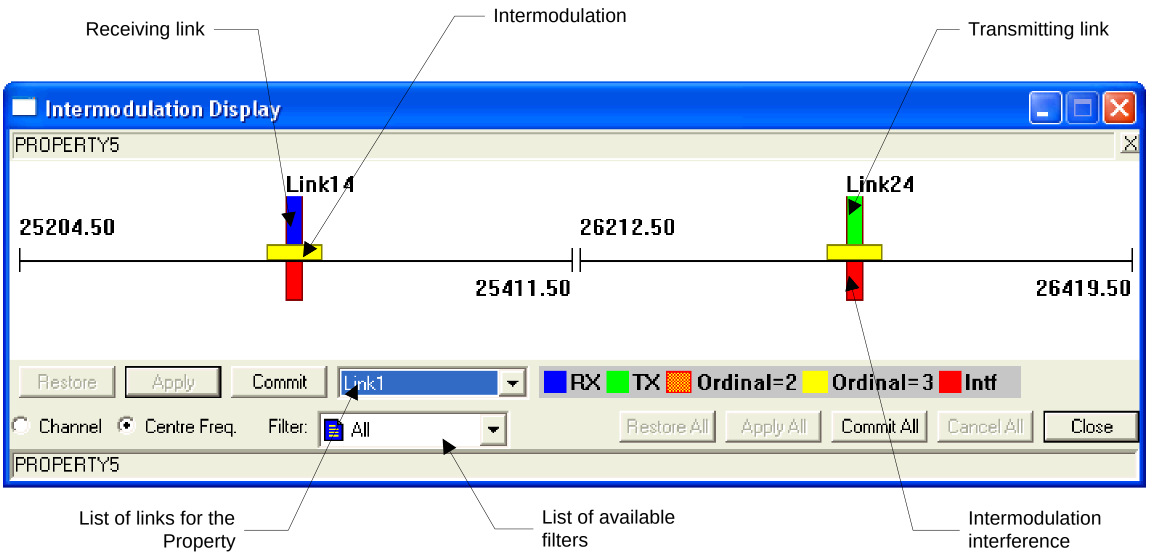
1. From the **Tools** menu, point to **Interference Analysis** and click **Load Interference Data**.
2. Select the *.txt file that contains the data and click **Open**.

Viewing and Editing Intermodulation Data

You can display intermodulation data in a report and also graphically.

You can view where the transmit frequencies are, where the receive signals are, and where the intermodulation products are situated on the frequency spectrum. This means you can change the allocated transmit or receive frequencies to solve any problems caused by intermodulation. You can view multiple Properties simultaneously, which enables you to see how changes to a link on one particular Property may affect links on other Properties.

This picture shows an example of displayed intermodulation data:



Example Intermodulation Display

Note: If you have multi-radio links and/or dual polar links, these will be treated as regular point to point links.

Displaying Intermodulation Data Graphically

To display a graph of intermodulation data:

1. From the **Reports** menu, click **Intermodulation Reporter**.

   Important: This option is not available to you if you have opened the project with only a subset of the project data.

2. In the **Intermodulation** window that appears, right-click a Property that you want to display graphically.
3. From the menu that appears, click **View Intermodulation**.

   Tip: Repeat steps 2 and 3 if you want to display multiple Properties up to a total of four.

4. The **Intermodulation Display** window appears, showing intermodulation characteristics for each selected Property in its own window. If you want to use a particular filter on the display (for example, one that only contains specific links attached to a Property), select it from the list of available filters.
5. If you have a number of links for a Property close together, and want to show a particular one on top, select it from the list of links for the Property.

   Tip: You can also display this graph from the **Link Database**, **Site Database** or **Map View** window, right-clicking the required link or site and from the menu that appears, clicking **View Intermodulation**. This is particularly useful for viewing intermodulation for items that do not appear in reports.

You can use this graph to:

- Edit link frequency
- Change link properties

For information on producing intermodulation reports, see Producing Intermodulation Reports on page 243.

Viewing Intermodulation Calculations

In the **Intermodulation Display** window, the data shown is calculated using specific algorithms.

To view the algorithm for a particular link:

Move the cursor over a link.

The algorithm for this link is displayed in the **Status Bar** at the bottom of the graph.

For a detailed explanation of the algorithms used, see Intermodulation Equations on page 356.

Editing Link Frequency

In the **Intermodulation Display** window you can edit the frequency of a link to reduce the effect of intermodulation by moving it to another channel or by moving it along the frequency spectrum.

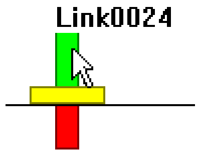
To do this:

1. Select the option by which you want to change the link – either by **Channel** or by **Center Freq**.
2. Click and drag the link you wish to move to the required channel or frequency.

Changing the Properties of a Link

To edit a link's properties from the Intermodulation Display window:

1. In the Intermodulation Display window, right-click the required link (the top vertical bar).



2. In the **Link** dialog box that appears, change the band, channel, link type and center frequency as required.
3. Click **OK**.

6 Automatically Planning Your Links

In ASSET Backhaul, you can use the **Automatic Link Planner** to help to improve the performance of your network. You can run the planner in two different modes, depending on what you want to achieve:

- You can run **Site Backhaul Ranking**:

  This enables you to assess the backhaul viability of existing or candidate small cells.

  If required, you can choose to run Automatic Link Planning and Optimization directly after running Site Backhaul Ranking. There is a special option to activate this within the wizard.

  This mode is described in About Site Backhaul Ranking on page 185.

- You can run **Automatic Link Planning and Optimization**:

  This enables you to optimize your existing network based on:

  - Increased availability
  - Reduced interference degradation
  - Maximized capacity

  You can also choose to automatically create and configure new links.

  This mode is described in Automatic Link Planning and Optimization on page 193.

If you are running the Automatic Link Planning and Optimization on its own, and you want to create and configure new links, this requires an input file that contains information about the linkends and the connection types. However, if you are running it as a follow-on from the Site Backhaul Ranking, this information is captured automatically.

Important: To use this planner, you must have the Automatic Link Planner license.

About Site Backhaul Ranking

Small cells are now increasingly relevant in today's networks, as one of the solutions to the ever-increasing demands for capacity.

ENTERPRISE enables you to set up small cells in the Site Database and perform coverage analysis for them, in exactly the same way as for macrocells.

In a real network, the location and implementation of small cells requires careful planning, to minimize equipment costs and site rentals. This planning should ensure that they are only set up in locations where they serve a real purpose (to provide extra coverage and capacity) and also where they have connectivity with the backhaul network.

There is a wide variety of connectivity options, such as microwave (MW) point-to-point links, millimeter wave (mmW) point-to-point links, line-of-sight or near/no line of sight (LoS or N*LoS), point-to-multipoint, optical fiber and coaxial cable (typically, the mmW links would interconnect small cells in star, tree or mesh configurations). Moreover, where the small cells supplement the macrocell network, the macrocell sites can act as aggregation points.

Site Backhaul Ranking Mode

ASSET Backhaul provides a Site Backhaul Ranking mode (one of the modes in the Automatic Link Planner). This assesses the backhaul viability of existing cells and/or candidate small cells. By evaluating the feasibility of backhaul connectivity and capacity in a cost-effective way, it aims to produce the near-optimum solution.

Important:

- For more detailed information on using Site Backhaul Ranking, you can request an Application Note from Product Support. This includes how the information generated may be useful when performing automatic cell planning.
- The Site Backhaul Ranking mode does not perform sophisticated planning; such an exercise would require detailed channel information and extensive interference analysis.

Preparing for Site Backhaul Ranking

Before you can use the Site Backhaul Ranking mode, you need to have set up the small cells in the Site Database. The configuration of small cells is the same in principle as for macrocells.

There may be different network scenarios: it may involve a mix of 'existing' small cells and 'candidate' small cells, or it may only involve one or the other.

For this purpose, the definitions are as follows:

- Existing small cells: cells that are already (or planned to be) 'live' in your network
- Candidate small cells: cells that are proposed, or on trial

You will need to prepare your filters appropriate to your scenario (see 'Required Inputs' below).

Point-of-Presence (PoP) Locations

Point-of-Presence Locations are points with optical fibre hubs. You can use point vectors to define these locations (for information on this, see 'Creating Your Own Vector File Features' in the *ENTERPRISE User Reference Guide*). The Site Backhaul Ranking planner allows you to specify which Point-of-Presence Locations you want to include.

Required Inputs

The Site Backhaul Ranking mode allows for different planning scenarios. The input is flexible according to your requirements, but the *minimum* inputs are as follows:

- ONE or BOTH of the following must be true:
  - The 'Macrocells' filter contains valid cells
  - The 'Point-of-Presence Locations' option is selected

  \- AND -
- ONE or BOTH of the following must be true:
  - The 'Existing Small Cells' filter contains valid sites/nodes or cells
  - The 'Candidate Small Cells' filter contains valid sites/nodes or cells

  Note: If sites/nodes are used in the filters, rather than cells, the default height above ground is assumed to be 4 metres.

If the above minimum inputs are not provided, the Site Backhaul Ranking mode will not run.

Ability to run Automatic Link Planning directly after running Site Backhaul Ranking

You can choose to:

- Run the Site Backhaul Ranking on its own, and then look at the recommendations in the generated report.
- Run the Site Backhaul Ranking, and then directly afterwards run the Automatic Link Planning and Optimization using the output files generated by the Site Backhaul Ranking. This will automatically create and configure the new links, based on the recommendations and configured according to the connection types. There is an option to activate this within the wizard.

It is recommended that you decide this before launching the Automatic Link Planner from the menu.

Running the Site Backhaul Ranking

To run the Site Backhaul Ranking:

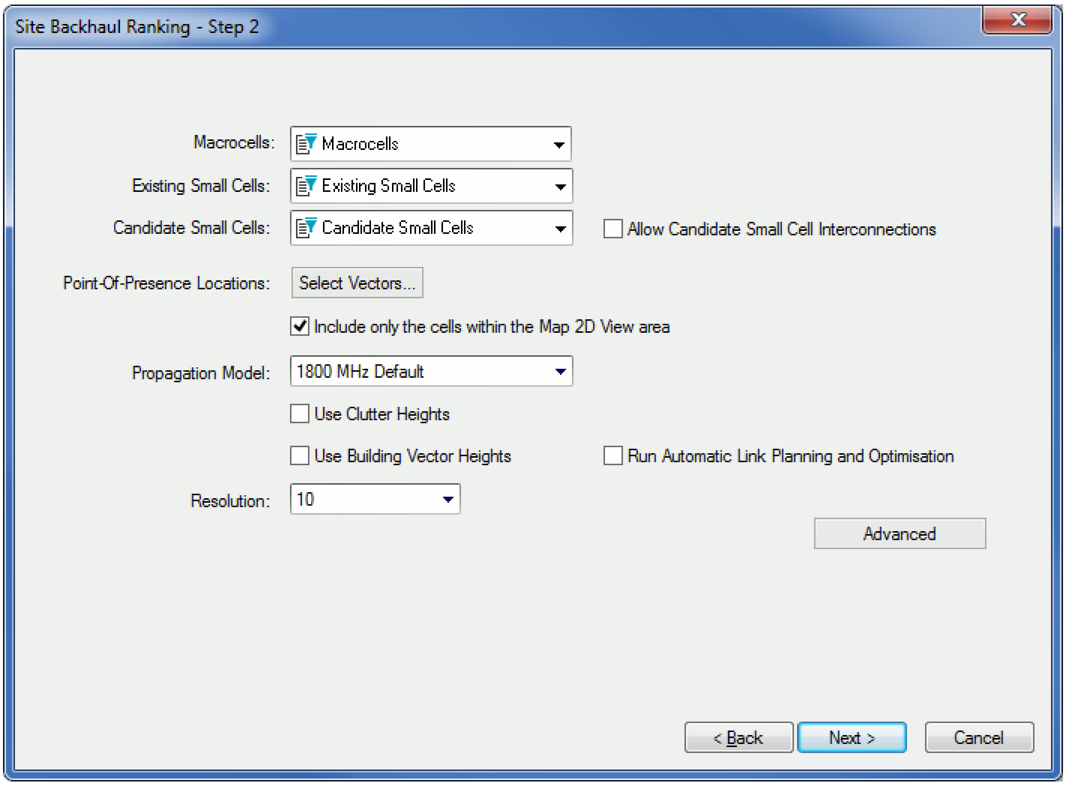
1. Ensure that you have read the prerequisites in the previous topic.
2. Open the Map View window, showing the area of interest.
3. From the **Tools** menu, click **Automatic Link Planner**.

   The Automatic Link Planner appears. Click **Next**.
4. Select the **Site Backhaul Ranking** option, and then click **Next**.

   The area shown in the wizard corresponds to the Map View window that you have opened. You will have the option later to confine the cell selection to the Map View region, or to ignore it.

   Click **Next**.

   You need to set the planning parameters, as in this example:



This table describes the settings and parameters:

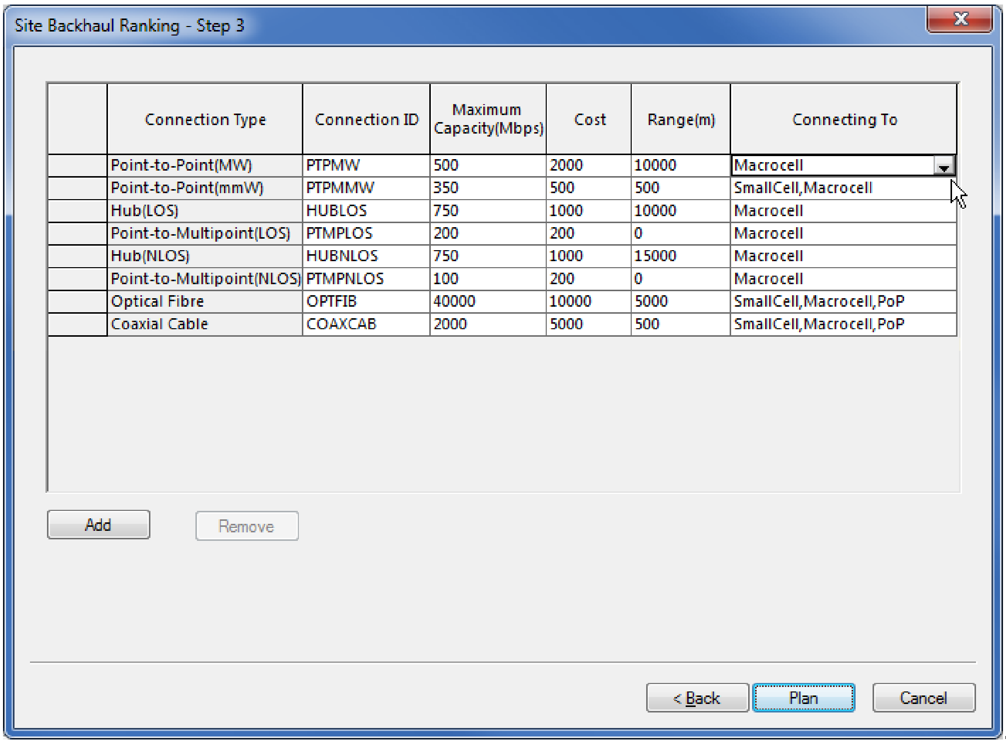
Setting or Parameter	Description
Filters for: • Macrocells • Existing Small Cells • Candidate Small Cells	Select the filters to be included in the plan, using the drop-down lists. You must select at least one of the Small Cells filters. (If you want to exclude one of the Small Cells filters, choose the <Select Filter> option from the drop-down list.) **Important**: If a cell belongs to more than one filter, the priority order for its parent filter is (i) Macrocells, (ii) Existing Small Cells, (iii) Candidate Small Cells. For that reason, you must NOT select the 'All' filter from the Macrocells drop-down list, otherwise all the cells in all three filters will be considered as Macrocells. **Note**: In the Small Cells filters, you can include the sites/nodes rather than the cells, but where there is no cell information, the default height above ground is assumed to be 4 metres.
Allow Candidate Small Cells Interconnections	Select this checkbox if you want the plan to assume that candidate small cells can interconnect with each other.
Point-of-Presence locations	If you want to include Point-of-Presence locations, click the **Select Vectors** button, then select the required vector(s), and click **OK**.
Include only the cells within the Map 2D View area	If you want to only include cells within the Map View area, select this checkbox. Otherwise, all filtered cells will be included, regardless of the Map View.
Propagation Model	Select the Propagation Model you want to use in the plan.
Use Clutter Heights Use Building Vector Heights	Select one or both of these checkboxes if required.
Resolution	Select the resolution of the map data that you want to use in the plan.
Run Automatic Link Planning and Optimization	If you also want to perform automatic link planning and optimization directly afterwards, select this checkbox. For more information, see Preparing for Site Backhaul Ranking on page 186.

If you want to view or edit the configuration parameters, click the **Advanced** button. For information on this, see About the Advanced Configuration Parameters on page 190.

Click **Next**.

5. For each of the appropriate Connection Types in your network, specify the maximum capacity, the cost, the range, and which network elements they can connect to. These factors are used by the planning algorithm.

6. This picture shows an example:



Important: The costs you specify for the connection types are relative costs. They are integral to the planning algorithm.

This table shows the options under the 'Connecting To' column for each Connection Type (in addition to 'None'):

Connection Type	Connectivity Options (Connecting To)
Point-to-Point (MW)	Macrocell and Small Cell
Point-to-Point (mmW)	Macrocell and Small Cell
Hub (LoS)	Macrocell
Point-to-Multipoint (LoS)	Macrocell
Hub (NLoS)	Macrocell
Point-to-Multipoint (NLoS)	Macrocell
Optical Fibre	Macrocell, PoP and Small Cell
Coaxial Cable	Macrocell, PoP and Small Cell

Notes:

- If you want to specify any of the Connection Types as not available, select 'None' in the 'Connecting To' column.
- The wizard will not run unless at least one Connection Type is specified to connect to Macrocell or to PoP.
- 'Range' for the Point-to-Multipoint types is not required, as this is done through the respective hubs.
- If required, you can edit the Connection ID strings.
- If required, you can use the 'Add' button to set up other wired connection types.

7. If you are running the Site Backhaul Ranking on its own (that is, you did not select the 'Run Automatic Link Planning and Optimization' checkbox), click **Plan**.

   The Site Backhaul Ranking planner calculates the results, and generates a report. See Viewing the Progress of the Site Backhaul Ranking on page 191.

   - or -

   If in the previous step you selected the 'Run Automatic Link Planning and Optimization' checkbox, click **Next**, and then follow the instructions in Running the Automatic Link Planning and Optimization on page 194 (from the instruction step 5 onwards).

About the Advanced Configuration Parameters

The scope of the Site Backhaul Ranking algorithm is to provide a cost value for every Small Cell with respect to its backhaul connectivity.

The calculations are dependent on a set of configuration parameters:

- Microwave Link Prediction Parameters
- Hub Connection Capabilities
- Traffic Parameters

If you wish to view or edit them, click the **Advanced** button on the second step of the wizard.

The default values are as follows:

MW Link Prediction Parameters	Default	Minimum	Maximum
Frequency (GHz)	7.00	2.50	100
Tx Power (dBm)	5.00	-15.00	45
Tx Antenna Gain (dB)	30.00	0.00	50.00
Rx Antenna Gain (dB)	30.00	0.00	50.00
Received Power (dBm)	-60.00	-120.00	0.00

Hub Connection Capabilities	Default	Minimum	Maximum
Max LoS Hub Connections	10	1	50
Max NLoS Hub Connections	5	1	50

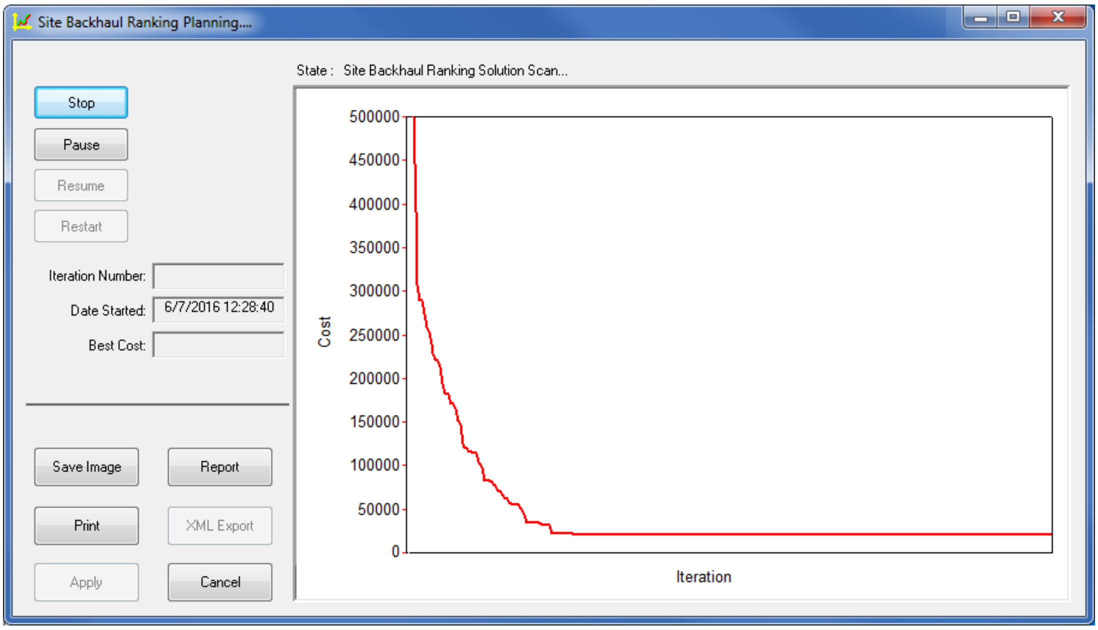
Traffic Parameters	Default	Minimum	Maximum
Peak Traffic (Mbps)	187.50	0.00	9999.99
Average Traffic (Mbps)	40.00	0.00	9999.99

If required, you can edit these parameters. After you have run the planner, the values will be saved for subsequent runs.

In "daisy chain" configurations, the total load of each hop will consider the traffic of the preceding small cells. The total traffic requirement in each hop will be calculated as Aggregate Traffic = max (peak, N × average), where peak is the peak traffic of a small cell, average is its average traffic and N is the number of small cells that this hop serves.

Viewing the Progress of the Site Backhaul Ranking

After you click the **Plan** button in the planning wizard, the planning begins and a progress graph appears:



Example of Site Backhaul Ranking Progress Chart

Tip: ASSET Backhaul adds the above dialog box to the taskbar, so that you can view it at any time.

The state at the top of dialog box indicates which state the planner is currently in:

State	Description
Solution Scan	This is the initial state, after you have started the planner. At this point, the algorithm is calculating a number of parameters that will be used when searching for a solution. The solution scan runs for a number of iterations equal to the number of considered links × 2.
Running	The planner is currently processing, and searching for appropriate solutions.
Idle	The planner has been stopped, and can be restarted based on the initial solution.
Paused	The planner has been temporarily stopped, and can be resumed from the point at which it was paused.

Statistical data is displayed on the left-hand side, indicating the iteration number that is currently running, the date and time at which the planner was started, the best cost that has been found so far and if applicable the date and time at which the planner was stopped.

The graph on the right-hand side shows a visual representation of the planner results, plotting the energy cost per iteration.

The planner will continue to run until either:

- It finds a solution that has an energy value equal to or less than 0.1 × the energy of the initial solution
- The solution temperature has dropped to 0.1 × the initial value

As soon as either of these things happen, the planner will stop.

However, using the buttons on the left-hand side, you can:

- Stop the planner
- Restart the planner from the initial solution
- Pause the planner temporarily, perhaps to release processing resources for other tasks
- Resume the planner from the iteration at which was paused

Note: Due to the nature of the algorithm, it will only find an improved solution based on the parameters that have been specified. This is not necessarily the best solution. However, the same scenario can be run a number of times to find different solutions.

You can also use the results in a number of ways, such as saving the graph as an image file or exporting the results to an Excel report. For more information, see Using the Site Backhaul Ranking Results on page 192.

Using the Site Backhaul Ranking Results

When the Site Backhaul Ranking has finished running, you can use the results in a number of different ways. You can:

- Generate a Microsoft Excel report detailing the best solution from the results
- Save the graph as a graphics image (*.bmp or *.jpg)
- Print the graph displaying the results
- Save the results in the form of XML files

Generating Excel Reports

To generate an Excel report:

Click the **Report** button.

The report lists the cells ranked by their cost value (lowest to highest). Here is an example:

Sheet1

	A	B	C	D	E	F
1	Property A	Cell A	Property B	Cell B	Connection Type	Connection Cost
8	JSY16	ESC10	JSY4	Macrocell4	PTMPLOS	200.00
9	JSY17	ESC11	JSY4	Macrocell4	PTMPLOS	200.00
10	JSY18	ESC12	JSY0	Macrocell0	PTMPLOS	200.00
11	JSY8	ESC2	JSY4	Macrocell4	PTMPLOS	220.00
12	JSY9	ESC3	JSY3	Macrocell3	PTMPLOS	225.00
13	JSY10	ESC4	JSY74	Macrocell6	PTMPLOS	230.00
14	JSY11	ESC5	JSY74	Macrocell6	PTMPLOS	240.00
15	JSY12	ESC6	JSY4	Macrocell4	PTMPLOS	260.00
16	JSY13	ESC7	JSY0	Macrocell0	PTMPLOS	300.00

Saving Graphs as Images

To save the current graph as a graphic image (either *.jpg or *bmp):

1. Click the **Save Image** button.
2. In the dialog box that appears, select the location where you want to create the file, and the required format.
3. Click **Save**.

Printing Graphs

To print the current graph:

1. Click the **Print** button.
2. In the dialog box that appears, define the required page setup (positioning, margins and graph size).
3. Click **OK**.
4. In the dialog box that appears, select the required printer and print properties.
5. Click **OK**.

   The graph is printed.

Automatic Link Planning and Optimization

The **Automatic Link Planning and Optimization** mode enables you to optimize the performance of your network based on:

- Increased availability
- Reduced interference degradation
- Maximized capacity

It also enables you to automatically create and configure new links.

This mode uses a metaheuristic search algorithm to find a solution to meet the requirements that you set, using the following parameter values:

- The available frequency channels
- Frequency designation
- Polarization
- Power
- Modulation

Tip: If required, you can choose to run Automatic Link Planning and Optimization directly after you run Site Backhaul Ranking. For more information, see Preparing for Site Backhaul Ranking on page 186.

Preparing for Automatic Link Planning and Optimization

You can use the Automatic Link Planning and Optimization mode to either:

- Plan and optimize your existing network

  - or -
- Automatically create, configure and optimize new links

  - or -
- Perform both of the above actions

It is recommended that you decide what you wish to do before launching the Automatic Link Planner from the menu.

If you are running it on its own (without first running the Site Backhaul Ranking), and you want to create and configure new links, you will need to prepare an input file (text or CSV) that contains information about the linkends and the connection types. Here is a simple example:

	A	B	C	D
1	Property A	Property B	Connection Type	
2	UMTS_NodeBCSC13	MobileWiMAX_NodeESC0	PTPMW	
3	GSM_SITECSC2	LTE_CSC27	PTPMMW	
4	LTE_CSC29	MobileWiMAX_NodeESC5	HUBLOS	
5	LTE_CSC30	GSM_SITECSC0	PTMPLOS	
6	Wi-Fi_NodeCSC40	LTE_Macrocell2	HUBNLOS	
7	JSY16	JSY1	PTMPNLOS	
8	JSY17	JSY2	OPTFIB	
9	JSY18	JSY3	COAXCAB	
10				

Example of file for link creation

However, if you are running it as a follow-on from the Site Backhaul Ranking, this information is automatically captured, and so you will not need to prepare any external files.

Running the Automatic Link Planning and Optimization

To run the Automatic Link Planning and Optimization:

1. Ensure that you have read the prerequisites in the previous topic.
2. If you are intending to optimize your network, and you want to select the links using the Map View (instead of filters), open the Map View window showing the area of interest.
3. From the **Tools** menu, click **Automatic Link Planner**.

   The Automatic Link Planner appears. Click **Next**.
4. Select the **Automatic Link Planning and Optimization** option, and then click **Next**.

5. You now have a choice of one or both actions, as described here:

If You Want the Automatic Link Planner to	Do This
Create, configure and optimize new links	In the **Optimization with Link Creation and Configuration** pane: • Click the Browse button. • Navigate to the file (.txt or .csv) that contains details of the linkends (A and B) and the connection type (ID). For a description, see the prerequisites in the previous topic. • Click Open. This displays all valid link types from the file in the data grid. • For each connection type (ID), select the required template(s) from the Template Name drop-down list. You cannot proceed unless all connection types have at least one template selected. **Note**: If you are running the Automatic Link Planning and Optimization as a follow-on from the Site Backhaul Ranking mode, the connection types (IDs) are specified automatically, so the Browse button is inactive. **Important**: If you do not also want existing links to be considered for optimization: • In the **Optimization for Existing Network** pane, click 'Select links from this filter' and choose the <Select Filter> option from the drop-down list (this will deactivate this option).
Optimize your existing network	In the **Optimization for Existing Network** pane: Select the existing link(s) that you want to consider by using one of these options: • Click 'Select links from the 2D View'. - or - • Click 'Select links from this filter' and then select the filter from the drop-down list.

6. Click **Next**.
7. If you chose to select a view, it appears in this step so that you can check it. Click **Next**.
8. Define the basic parameters for your link planning scenario:

Parameter	Description
Guard Band	Define a guard band, which is the maximum frequency separation between victim and interferer links. This will depend on the bandwidth, for example, for 7MHz, a guard band of 28MHz would consider interference up to 4 channels away.
Distance to consider	Set this as the maximum distance separation in km between victim and interferer. This will account for the effect that an interferer has on a given transmission path for a given radius. For example, the default value of 100km is acceptable as it is the maximum hop distance considered in a standard microwave network. **Tip**: If the hop distances are all less than 100km, you can speed up the search for a better solution by limiting the distance considered to match the highest hop distance in the plan.

<table>
<tr><th>Parameter</th><th>Description</th></tr>
<tr><td>Threshold Degradation Objectives

Use T/I Objectives tables</td><td>If you have defined the spectrum density and receive selectivity masks on the radio equipment, you must specify the acceptable levels for the threshold degradation objectives, which act as 'hard' constraints on the search.

For more information on 'hard' and 'soft' constraints, see Overview of the Concepts used by the Search Algorithm on page 204.

Note: If there are T/I objective tables available, both criteria should be met. The default T/I objective on the radio equipment is only used if neither T/I objective tables nor threshold degradation objectives exist.</td></tr>
<tr><td>Resolution</td><td>Specify the resolution of the map data that you want to use. The default is the minimum available map resolution.</td></tr>
<tr><td>TDD Interference - Frame Overlap</td><td>If any of the links that you are using for automatic planning use TDD, then you can specify the frame overlap (in ms), which represents the acceptance tolerance of overlapping frames. Where this overlap is exceeded, they are considered to be interfering.</td></tr>
<tr><td>Include power in the optimal solution search - Power Step</td><td>If you want to include power values in the search for a better solution, select the 'Include power …' option and specify the required Power Step.

Tip: If you have a wide range of power values, a small power step will increase the number of values considered in the search.</td></tr>
<tr><td>Allow Designation Changes (Hi-Low)</td><td>Select this if you want to allow the frequency designation to change between high and low during the search.</td></tr>
<tr><td>Allow Polarisation Changes</td><td>Select this if you want to allow the polarisation to change during the search.</td></tr>
<tr><td>Target Availability</td><td>Specify the minimum required availability for the links (this is another 'hard' constraint on the search).</td></tr>
<tr><td>Enable Correlated Fading</td><td>Select this if you want the automatic planner to consider correlated fading, and then specify the following criteria:
Maximum Angle Separation (between victim link and interfering linkend)
Maximum Distance Separation (between victim link and interfering linkend)
Maximum Correlated Fading (amount that the interfering linkend will fade when the victim link is faded)</td></tr>
</table>

If you want to define advanced parameters for your link planning scenario, click the **Advanced Configuration** button.

(This button is inactive if you have chosen to only create and configure links.)

For information on this, see About the Advanced Configuration Parameters on page 197.

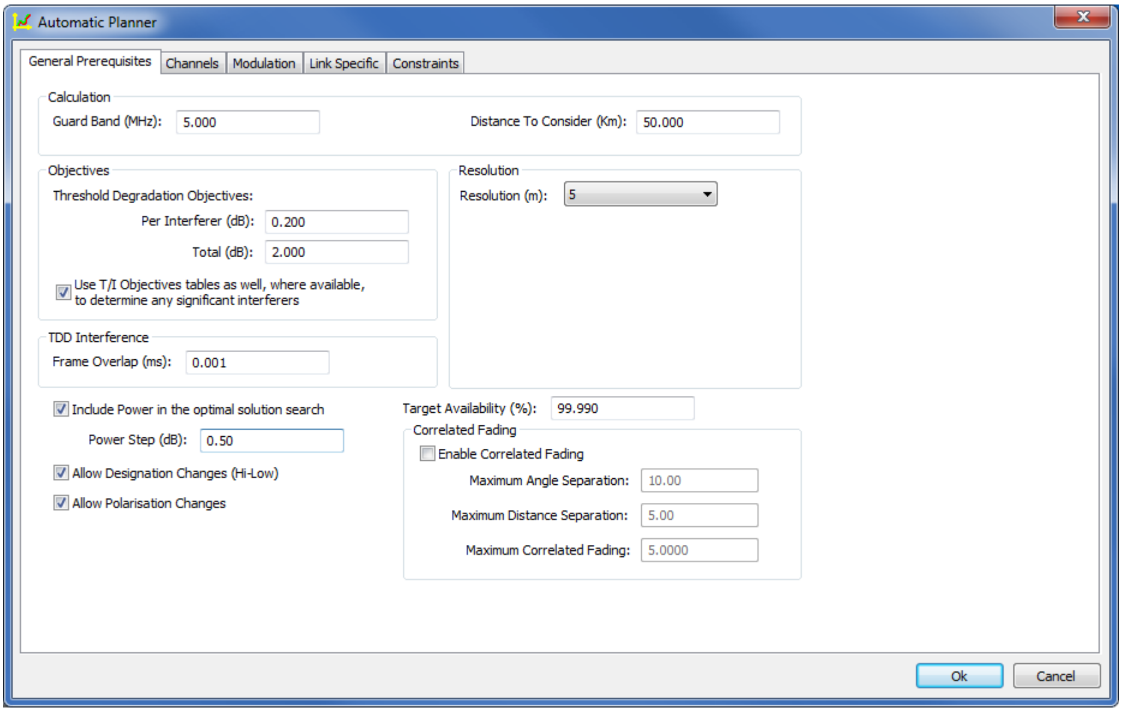
9. When you are satisfied with the link planning scenario that you have defined, click **Plan**.

Note: The parameter values that you define in the Automatic Link Planner are saved, and will also be the default values the next time you run it.

For more information on what happens when the planning algorithm is run, see Viewing the Progress of the Automatic Link Planning and Optimization on page 203.

About the Advanced Configuration Parameters

The Advanced Configuration parameters for the Automatic Link Planning and Optimization option are presented on five tabs:



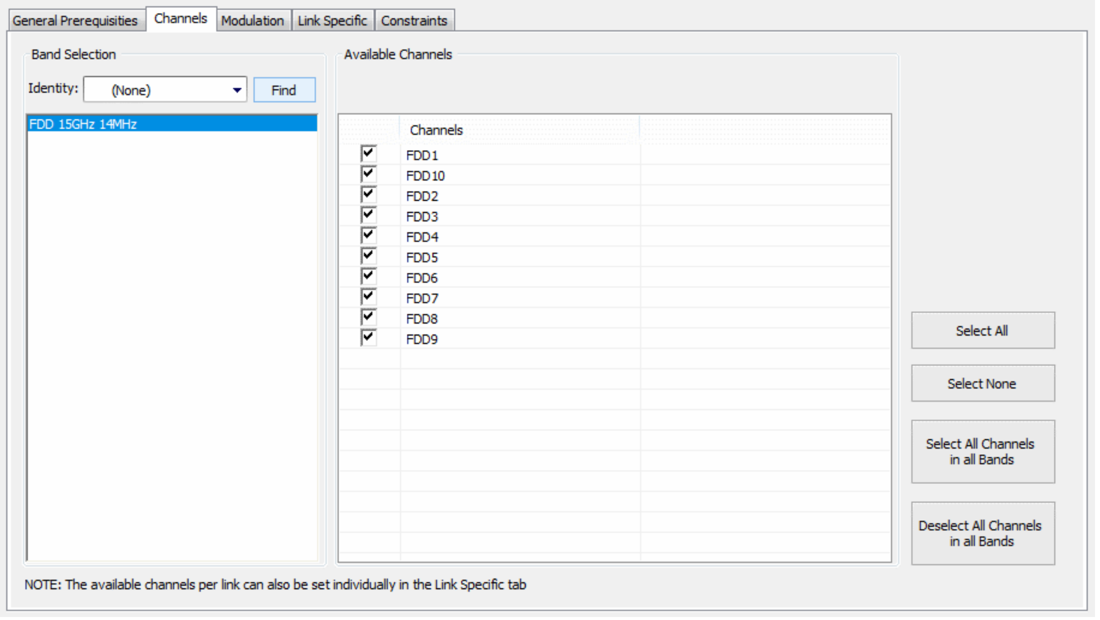
Automatic Planner Advanced Configuration Parameters

- **General Prerequisites**: These are the same as the basic parameters already described in Running the Automatic Link Planning and Optimization on page 194. They are repeated in this dialog box for your convenience.
- **Channels**: See Defining Parameters on the Channels Tab on page 198.
- **Modulation**: See Defining Parameters on the Modulation Tab on page 199.
- **Link Specific**: See Defining Parameters on the Link Specific Tab on page 200.
- **Constraints**: See Defining Parameters on the Constraints Tab on page 202.

After you have defined all or as many of these parameters as you require, click **OK** to return to the Automatic Link Planner.

Defining Parameters on the Channels Tab

On the **Channels** tab of the Automatic Planner, you can define which channels will be considered during the link planning and network optimization.



Automatic Planner - Channels tab

The **Band Selection** pane displays all of the available bands used on the links and/or associated with the templates selected in the Running the Automatic Link Planning and Optimization on page 194.

To define the channels to be considered:

1. To select all of the channels for all of the bands in the Band Selection pane, click the **Select All Channels in All Bands** button.

   \- or -

   To select the required channels from specific bands:

   - In the Band Selection pane, select the required band.

     The list of available channels for that particular band are displayed in the **Available Channels** pane.

     Tip: To locate a particular band, in the Identity field, type the name (or part of the name) of the band containing the channels that you want to consider, and then click the **Find** button. The matching (or nearest matching) band is highlighted in the list.

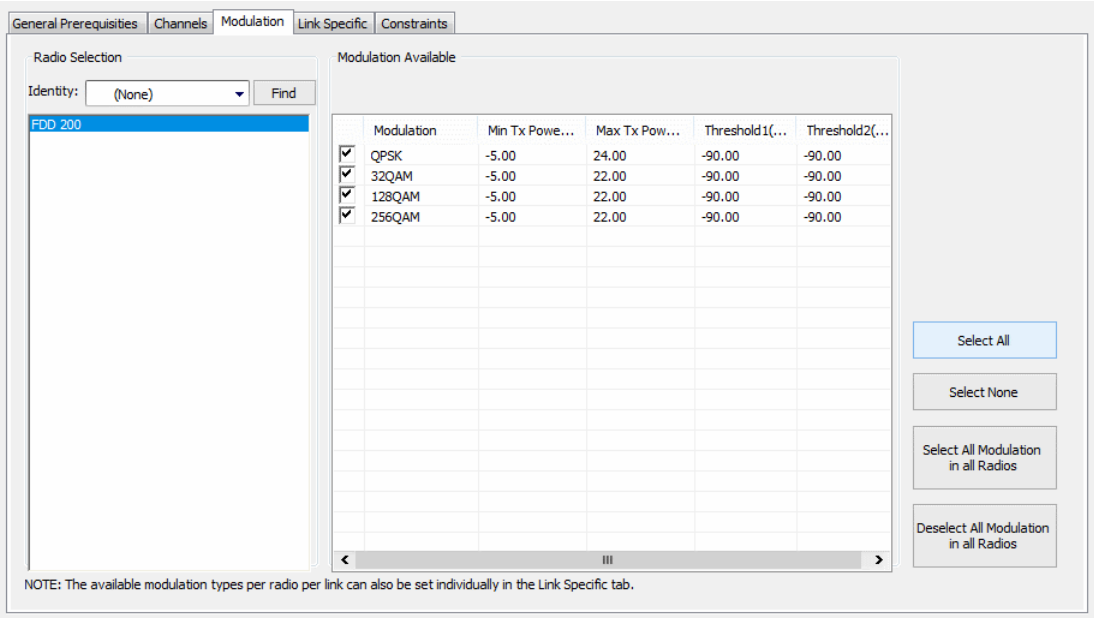
   - In the Available Channels pane, all of the channels for that band are selected by default to be considered. But if required, you can deselect any channels that you want to ignore.

   Note: On the **Link-Specific** tab, you can also specify individual channels for each link.

2. Click **OK** to return to the Automatic Link Planner Wizard, or click another tab to continue defining the planning criteria.

Defining Parameters on the Modulation Tab

On the **Modulation** tab of the Automatic Planner, you can define which modulation schemes will be considered during the link planning and network optimization.



Automatic Planner - Modulation tab

The **Radio Selection** pane displays all of the available radios (including Native TDM radios) used on the links and/or associated with the templates selected in the Running the Automatic Link Planning and Optimization on page 194.

To define the modulation schemes to be considered:

1. To select all of the modulation schemes for all of the radios in the Radio Selection pane, click the **Select All Modulation in all Radios** button.

   - or -

   To select the required modulation schemes from specific radios:

   - In the **Radio Selection** pane, select the required radio.

     The list of available modulation schemes for that particular radio are displayed in the **Modulation Available** pane.

     Tip: To locate a particular radio, in the **Identity** field, type the name (or part of the name) of the radio containing the modulation schemes that you want to consider, and then click the **Find** button. The matching (or nearest matching) radio is highlighted in the list.

   - In the Modulation Available pane, all of the modulation schemes for that radio are selected by default to be considered. But if required, you can deselect any schemes that you want to ignore.

   Note: On the **Link-Specific** tab, you can also specify individual modulation schemes for each link.

   ---

2. If required, you can modify the minimum and maximum power supported by the modulation scheme (but not the received threshold).

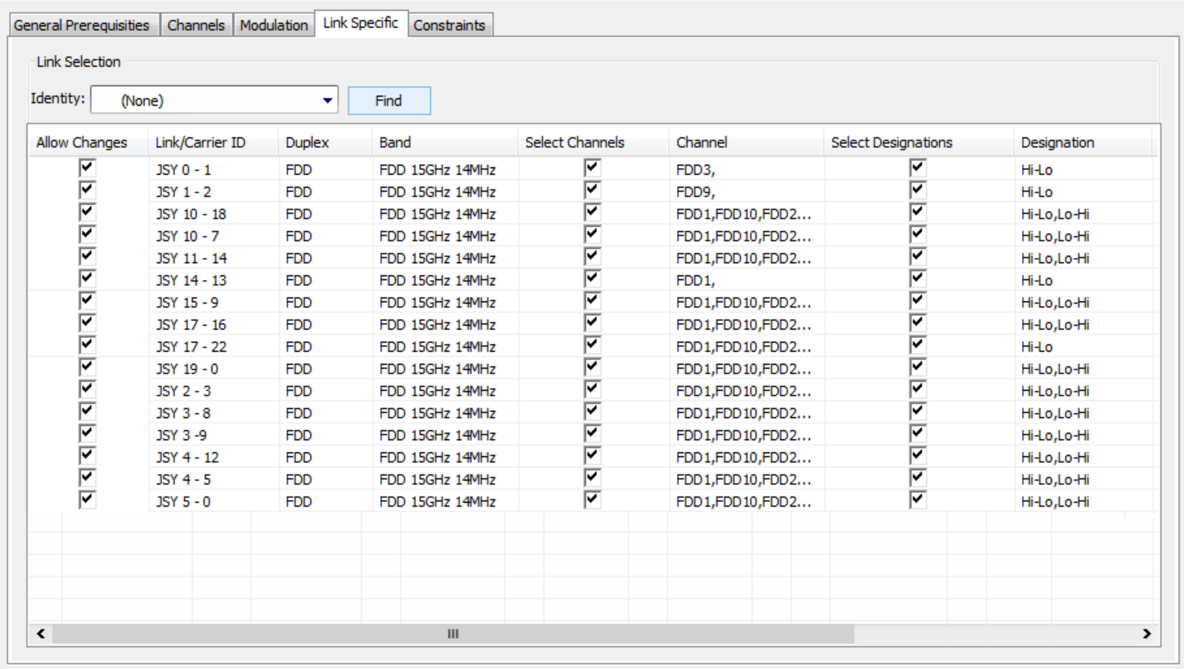
Note: You cannot set this below the minimum or above the maximum power defined in the AMC thresholds on the linkend radio. You can view these values in the **Radio Equipment** dialog box, on the Info tab. For more information, see Defining the Parameters of Radio Equipment on page 34.

---

3. Click **OK** to return to the Automatic Link Planner Wizard, or click another tab to continue defining the planning criteria.

Defining Parameters on the Link Specific Tab

On the **Link Specific** tab of the Automatic Planner, you can decide which specific links you want to be considered for changes, and define the range of values that will be available for each parameter on those links during the planning and optimization process.



Allow Changes	Link/Carrier ID	Duplex	Band	Select Channels	Channel	Select Designations	Designation
☑	JSY 0 - 1	FDD	FDD 15GHz 14MHz	☑	FDD3,	☑	Hi-Lo
☑	JSY 1 - 2	FDD	FDD 15GHz 14MHz	☑	FDD9,	☑	Hi-Lo
☑	JSY 10 - 18	FDD	FDD 15GHz 14MHz	☑	FDD1,FDD10,FDD2...	☑	Hi-Lo,Lo-Hi
☑	JSY 10 - 7	FDD	FDD 15GHz 14MHz	☑	FDD1,FDD10,FDD2...	☑	Hi-Lo,Lo-Hi
☑	JSY 11 - 14	FDD	FDD 15GHz 14MHz	☑	FDD1,FDD10,FDD2...	☑	Hi-Lo,Lo-Hi
☑	JSY 14 - 13	FDD	FDD 15GHz 14MHz	☑	FDD1,	☑	Hi-Lo
☑	JSY 15 - 9	FDD	FDD 15GHz 14MHz	☑	FDD1,FDD10,FDD2...	☑	Hi-Lo,Lo-Hi
☑	JSY 17 - 16	FDD	FDD 15GHz 14MHz	☑	FDD1,FDD10,FDD2...	☑	Hi-Lo,Lo-Hi
☑	JSY 17 - 22	FDD	FDD 15GHz 14MHz	☑	FDD1,FDD10,FDD2...	☑	Hi-Lo
☑	JSY 19 - 0	FDD	FDD 15GHz 14MHz	☑	FDD1,FDD10,FDD2...	☑	Hi-Lo,Lo-Hi
☑	JSY 2 - 3	FDD	FDD 15GHz 14MHz	☑	FDD1,FDD10,FDD2...	☑	Hi-Lo,Lo-Hi
☑	JSY 3 - 8	FDD	FDD 15GHz 14MHz	☑	FDD1,FDD10,FDD2...	☑	Hi-Lo,Lo-Hi
☑	JSY 3 -9	FDD	FDD 15GHz 14MHz	☑	FDD1,FDD10,FDD2...	☑	Hi-Lo,Lo-Hi
☑	JSY 4 - 12	FDD	FDD 15GHz 14MHz	☑	FDD1,FDD10,FDD2...	☑	Hi-Lo,Lo-Hi
☑	JSY 4 - 5	FDD	FDD 15GHz 14MHz	☑	FDD1,FDD10,FDD2...	☑	Hi-Lo,Lo-Hi
☑	JSY 5 - 0	FDD	FDD 15GHz 14MHz	☑	FDD1,FDD10,FDD2...	☑	Hi-Lo,Lo-Hi

Automatic Planner - Link Specific tab

The **Link Selection** pane displays all of the links selected in the Running the Automatic Link Planning and Optimization on page 194.

Tips:

- To locate a specific link, in the **Identity** field, type the name (or part of the name) of the link and then click the **Find** button. The matching (or nearest matching) link is highlighted in the list.
- The dialog box is re-sizable, which enables you to view all the columns more easily.

To determine whether any changes can be made on each link:

1. Decide which specific links you want to be considered for changes.
2. In the **Allow Changes** column, select or deselect the checkboxes as appropriate.

   Tip: If you right-click, you can access short-cut functions such as Select All and Clear All.

To set the value ranges for the parameters:

For each individual link that has its **Allow Changes** column selected, you can set values for any of its parameters, such as **Channels**, **Designations**, **Polarizations**, **ATPC**, **Modulations** and **Power**.

Most of them consist of a checkbox and associated value. Here are two examples:

- **To modify the available channels for a link:**
    a. Ensure that the **Select Channels** checkbox for that link is selected.
    b. In the **Channel** column, double-click the current list of available channels.
    c. In the dialog box that appears, select the channels that you want to be considered. Click **OK**.
- **To override one of the power values for a link:**
    a. Ensure that the **Set Power A** checkbox for that link is selected.
    b. In the **Power A (dBm)** column, click and edit the current value. Click **OK**.

Editing most of the other parameters follows the same principle.

Note:

- The Designation and Polarization parameters will not be considered in the plan unless the corresponding checkboxes have been selected on the General Prerequisites tab.
- For dual polar links, the Channel and Designation parameters are subject to restrictions. When each sub-link is on a different band, a change to either of these parameters would cause an invalid configuration. If this occurs, an appropriate message is shown in the Message Log. The other parameters are not affected by this.

Enabling ATPC

The ATPC checkboxes are only active if the radio equipment supports ATPC.

If you want any linkend to be considered as ATPC-enabled, select the **Enable ATPC End A** and/or **B** checkbox(es) as appropriate.

If you are optimising capacity as well as frequency, and want to modify the available modulation schemes at linkend A or B (where AMC is supported):

1. Select the corresponding **Select Modulations** checkbox.

   Warning: If you deselect the checkbox, the selected modulation reverts back to the original value.

2. In the **End A Modulation** or **End B Modulation** column (as appropriate), double-click the list of current modulation schemes.

3. In the dialog box that appears, select the modulation schemes that you want to be considered.

   You can also edit the minimum and maximum powers for any of the selected modulation schemes. However, you cannot go below the minimum or above the maximum power defined in the AMC thresholds on the linkend radio. You can view these values in the **Link Database**, on the **Radio** subtabs of the **Linkend Settings** tab. For more information, see Defining the Radio Equipment on Linkends on page 134.

   Note: If the link is ATPC-enabled, then the minimum power is equal to the minimum power defined in the AMC thresholds on the linkend radio plus the link's ATPC range (defined on the **Info** tab of the **Radio Equipment** dialog box).

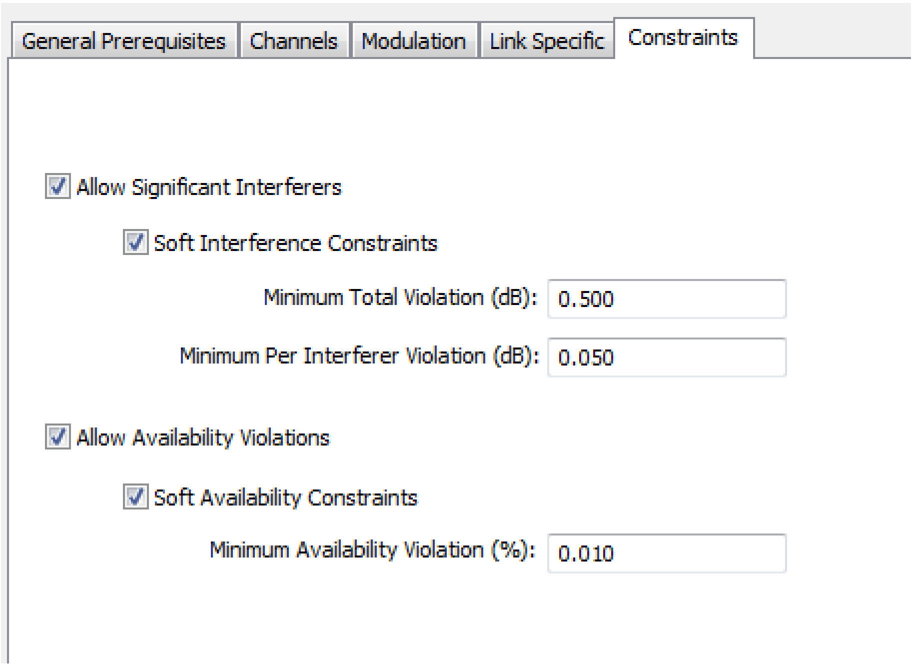
4. Click **OK**.

When you have finished, click another tab to continue defining the planning criteria, or click **OK** to return to the Automatic Link Planner Wizard.

Defining Parameters on the Constraints Tab

On the **Constraints** tab of the Automatic Planner, you can specify any further constraints that should be considered during the link planning and network optimization.

Note: By default, there are no constraints set on the Planner, which means that significant interferers and availability violations are allowed. These will override any interference constraints specified on the General Prerequisites tab.



Automatic Planner - Constraints tab

To specify the required constraints:

1. Select the appropriate soft constraints checkbox(es) and set the violation values.

   These values are penalty weightings that will increase the solution energy, and therefore determine how much or how little leniency you will give any solutions that violate the interference/availability constraints (if any) specified on the General Prerequisites tab.

   The higher these values are, the more leniency you are giving the planner when considering constraints.

   Note: If the solution energy is still the best found after the weighting, the solution will still be accepted.

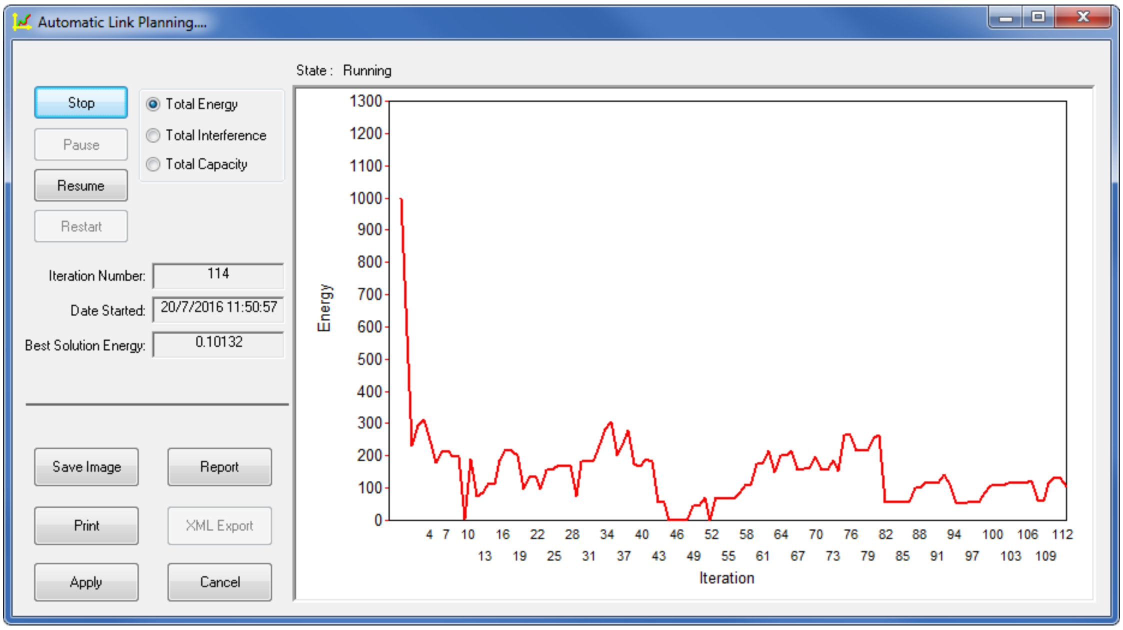
   For more information on 'hard' and 'soft' constraints, see the Overview of the Concepts used by the Search Algorithm on page 204.

2. Click **OK** to return to the Automatic Link Planner Wizard, or click another tab to continue defining the planning criteria.

Important: If you do not select any options on this tab, then the planner will use the 'hard' interference and availability constraints (if any) specified on the General Prerequisites tab.

Viewing the Progress of the Automatic Link Planning and Optimization

After you click the **Plan** button in the planning wizard, the search algorithm is started and a progress graph appears:



Example of Automatic Link Planning and Optimization Progress Chart

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Tip: ASSET Backhaul adds this dialog box to the taskbar, so that you can view it at any time.

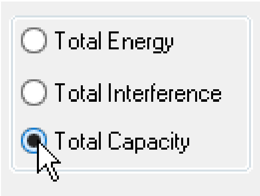
The state at the top of dialog box indicates which state the planner is currently in:

State	Description
Solution Scan	This is the initial state, after you have started the planner. It will assign the lowest channel available at each link, the lowest modulation and the maximum power for that modulation, thus Vmax int = sum (threshold degradation per each linkend) The capacity term can be easily calculated through the min and max capacity values of each linkend.
Running	The planner is currently processing, and searching for appropriate solutions.
Idle	The planner has been stopped, and can be restarted based on the initial solution.
Paused	The planner has been temporarily stopped, and can be resumed from the point at which it was paused.

Note: For additional information about the key components of the search algorithm, such as the solution energy and the number of iterations, see Overview of the Concepts used by the Search Algorithm on page 204.

Statistical data is displayed on the left-hand side, indicating the iteration number that is currently running, the date and time at which the planner was started and the best solution energy that has been found so far.

The graph on the right-hand side shows a visual representation of the planner results, plotting the total energy, worst interference (in dB) or total capacity (Mbps) per iteration. You can select which of these data categories is shown using the radio buttons on the right-hand side:



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Selecting what data category is displayed

The planner will continue to run until either:

- The total number of iterations is reached. The maximum number of iterations is (160 × L) where L is the number of linkends.
- The number of consecutive iterations without generating a better solution is reached. This is represented by: ($L_{repeated}$ = 6 × L) where $L_{repeated}$ increments whenever the algorithm discards consecutive solutions.

As soon as either of these things happen, the planner will stop.

However, using the buttons on the left-hand side, you can:

- Stop the planner
- Restart the planner from the initial solution
- Pause the planner temporarily, perhaps to release processing resources for other tasks
- Resume the planner from the iteration at which was paused

Note: Due to the nature of the algorithm, it will only find an improved solution based on the parameters that have been specified. This is not necessarily the best solution. However, the same scenario can be run a number of times to find different solutions.

You can also use the results in a number of ways, such as saving the graph as an image file or exporting the results to an Excel report. For more information, see Using the Automatic Link Planning and Optimization Results on page 205.

For more information on the calculations used, see Automatic Link Planner Equations on page 357.

Overview of the Concepts used by the Search Algorithm

This section introduces the basic concepts which are used in the search algorithm.

These will provide an overview of how the algorithm works, and help you to understand what the planner is doing while it runs. However, for a more detailed explanation, see Automatic Link Planner Equations on page 357.

This table describes the functions and terminology used in the algorithm:

Concept	Description
Initial Function	Initial solution represents the existing configuration in the Link Database.
Energy Function	The objective function that needs to be minimized. The value of the Energy function indicates the energy of the system for the respective solution, and also includes the hard and soft constraints that have been set for the problem. The constraints are parameter values that are either entirely forbidden or penalized, and are used to guide the solution to a more acceptable value. **Important:** The Energy function and the Neighbor function are core elements of the algorithm, and their careful definition can greatly reduce the running time of the planner.
Temperature Function	Calculates the temperature at the current stage. Can be used as a termination criterion in the Stop function.
Stop Function	Defines when the algorithm will stop searching for a solution. The criteria used to stop the algorithm are: • Maximum number of iterations • Temperature For more information, see Viewing the Progress of the Automatic Link Planning and Optimization on page 203.
Neighbour Function	Generates a new solution based on the latest one - either the initial solution or the solution that was last generated. This function also helps to produce solutions that do not violate any constraint and/or move the solution towards a very costly value.
Constraints	The Automatic Link Planner uses two types of constraint - 'hard' and 'soft' - which will have different effects on a solution found by the planner: • If a solution violates a 'hard' constraint, it will be rejected by the planner. 'Hard' constraints are defined as part of the Running the Automatic Link Planning and Optimization on page 194, and include significant interferers. • If the solution violates a 'soft' constraint, its energy will be artificially increased based on the magnitude of the violation. This weighting is added in order to make it a less favorable solution. 'Soft' constraints are defined on the Constraints tab of the Automatic Planner and include the minimum acceptable availability violation (%) and the minimum total interference violation (dB).

Using the Automatic Link Planning and Optimization Results

When the Automatic Planner has finished running, you can use the results in a number of different ways. You can:

- Generate a Microsoft Excel report detailing the best solution from the results
- Save the graph as a graphics image (*.bmp or *.jpg)
- Print the graph displaying the results
- Apply the best solution to the Link Database (this can include optimized existing links and/or newly created links, as appropriate to the plan)
- Save the results as XML files

Generating Excel Reports

To generate an Excel report of the best solution that the planner has found:

Click the **Report** button.

Microsoft Excel opens, and displays the best solution in a single worksheet. This picture shows part of an example report:

	A	B	C	D	E	F
1	ALP Solution Results					
2	Generated on:	Wed Jul 20 11:51:41 2016				
3						
4						
5	Link ID	Duplex	Band ID	Channel ID Best	Channel ID Current	Designation Best
6	JSY 0 - 1	FDD	FDD 15GHz 14MHz	FDD3	FDD3	Lo-Hi
7	JSY 1 - 2	FDD	FDD 15GHz 14MHz	FDD9	FDD9	Hi-Lo
8	JSY 10 - 18	FDD	FDD 15GHz 14MHz	FDD2	FDD5	Lo-Hi
9	JSY 10 - 7	FDD	FDD 15GHz 14MHz	FDD3	FDD3	Lo-Hi
10	JSY 11 - 14	FDD	FDD 15GHz 14MHz	FDD1	FDD10	Hi-Lo
11	JSY 14 - 13	FDD	FDD 15GHz 14MHz	FDD5	FDD1	Hi-Lo
12	JSY 15 - 9	FDD	FDD 15GHz 14MHz	FDD2	FDD2	Hi-Lo
13	JSY 17 - 16	FDD	FDD 15GHz 14MHz	FDD1	FDD1	Lo-Hi
14	JSY 17 - 22	FDD	FDD 15GHz 14MHz	FDD6	FDD6	Hi-Lo

For each link and for each category (Channel, Designation, and so on) the report displays the initial ('Current') values, alongside the optimized ('Best') value produced by the plan.

Note: The above example shows results for optimized existing links. If the plan included link creation, the newly created links would have no 'Current' values, because they would not yet exist in the database. Newly created links would appear as 'EndA_EndB_XX' in the Link ID column, where XX is a unique number.

Saving Graphs as Images

To save the current graph as a graphic image (either *.jpg or *bmp):

1. Click the **Save Image** button.
2. In the dialog box that appears, select the location where you want to create the file, and the required format.
3. Click **Save**.

Printing Graphs

To print the current graph:

1. Click the **Print** button.
2. In the dialog box that appears, define the required page setup (positioning, margins and graph size).
3. Click **OK**.
4. In the dialog box that appears, select the required printer and print properties.
5. Click **OK**.

   The graph is printed.

Applying Solutions to the Link Database

To Apply the 'best solution' that has been found by the plan:

1. When the planner is in an 'Idle' state, click the **Apply** button.
2. In the dialog box that appears, click **Yes** to confirm that you want to Apply the 'best solution' to the Link Database.

   The values for the best solution are Applied.

   This can include optimized links and/or newly created links, depending on the input to the plan.

   After this has been done, if you run the Interference Analysis in ASSET Backhaul, you should find that the results match those in the report.

Notes:

- For links that are AMC-enabled, the initial modulation scheme will be overridden by that of the best solution, along with the corresponding power.
- For links that are ATPC-enabled, the initial Pnom will be overridden by that of the best solution. The min and max power for each link should fall inside the power range of the radio on that linkend.

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7 Performing Coverage Analysis

ASSET Backhaul enables you to perform microwave coverage analysis.

Important: The Coverage Analysis options are only available for ASSET Backhaul users with a Coverage Predictions license.

This provides the capability to plan the microwave network more efficiently by quickly identifying problem areas, decreasing planning time and increasing network performance.

The microwave coverage analysis is useful when planning the connections of candidate remote backhaul modules (RBMs) or customer premises equipment (CPEs) to existing point to multi-point hubs. The analysis can calculate and display arrays showing the predicted coverage area from the carriers of these hubs.

In addition, you can include any other type of microwave node (such as point to point links, multi-radio links, repeaters) in the coverage analysis if you want to calculate interference arrays.

You can:

- Generate coverage predictions
- Calculate interference arrays
- Create and display arrays
- Analyze the results

The resulting arrays enable you to analyze information such as received power, received field strength, fade margin and interference from each transmitter. You can then perform a number of actions, such as adding microwave points, CPEs and RBMs in positions that provide improvements to the network.

Small Cells

The coverage analysis can also help to plan the deployment of Small Cells.

Given that Small Cells will be mainly implemented in urban areas, it is expected that their main implementation will be Non-Line-of-Sight Point-to-Multipoint links or Near-Line-of-Sight Point-to-Point or Point-to-Multipoint links. This means that building information needs to be taken into account, as well as the ability to define specific propagation models that would capture the signal transmission in this environment.

In summary, the new functionality enables you to:

- Use the Propagation Models dialog box to create, edit and store one or more customized instances of a Free Space Loss model
- In the model parameters, you can optionally define settings for clutter heights, building vectors, diffraction loss, reflection loss and so on, allowing these to be considered when performing the coverage analysis
- Access all the other default models available in the Propagation Models dialog box, and define your own models
- Optionally assign any propagation model to a Point-to-Multipoint link or Point-to-Multipoint link in the Link Database

About Arrays

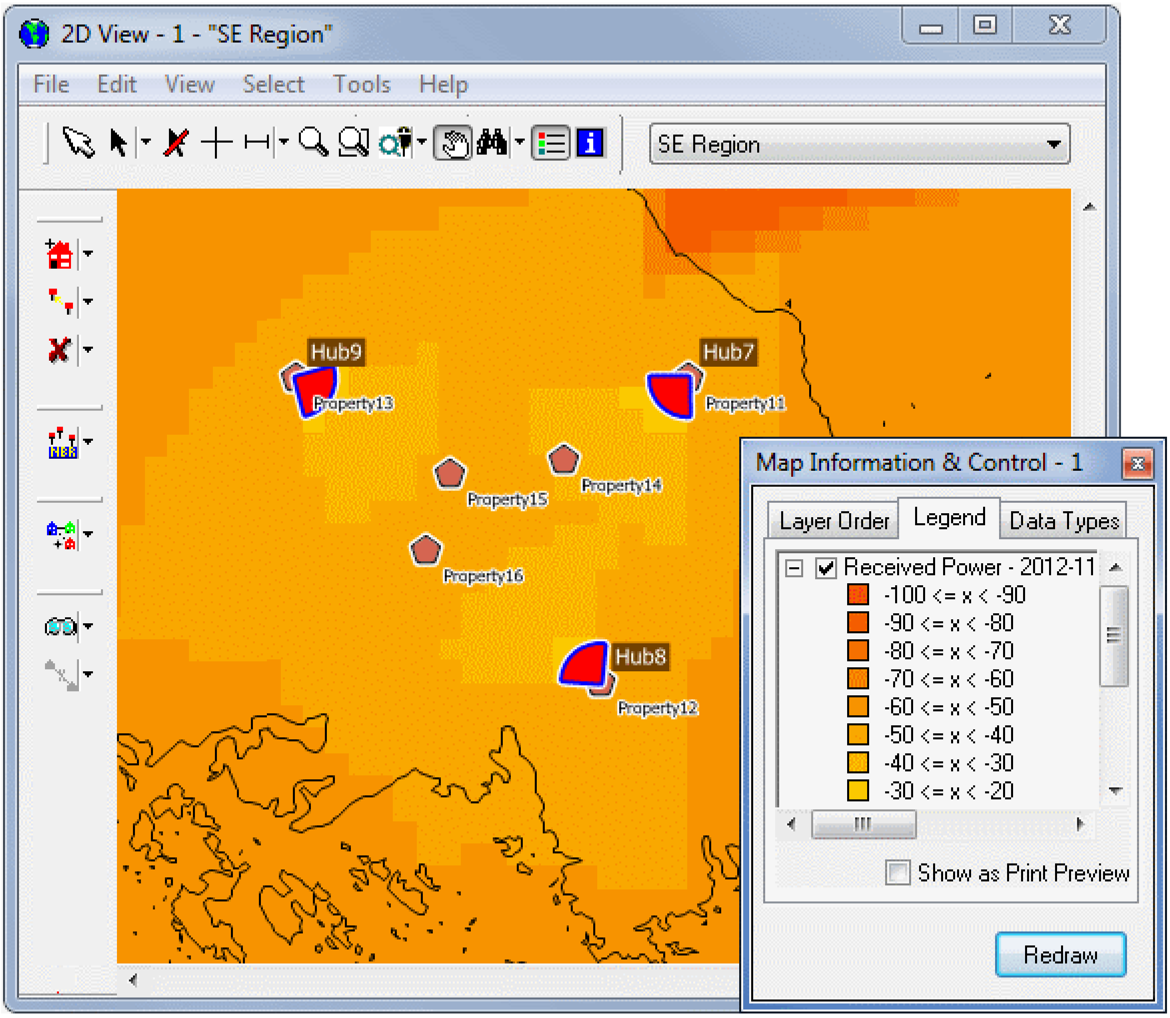
An array is a pixel-by-pixel look at the predicted performance of a network in terms of coverage or interference. An array helps to validate the suitability of your network design.

When an array is created, every pixel in the Map View is analyzed, therefore the size of the array is directly proportional to the area you want to study. If you have various map data pixel resolutions, it can be beneficial to produce overview studies of large areas using lower resolution map data, and then study smaller areas using higher resolution map data.

The arrays that you can create in ASSET Backhaul include:

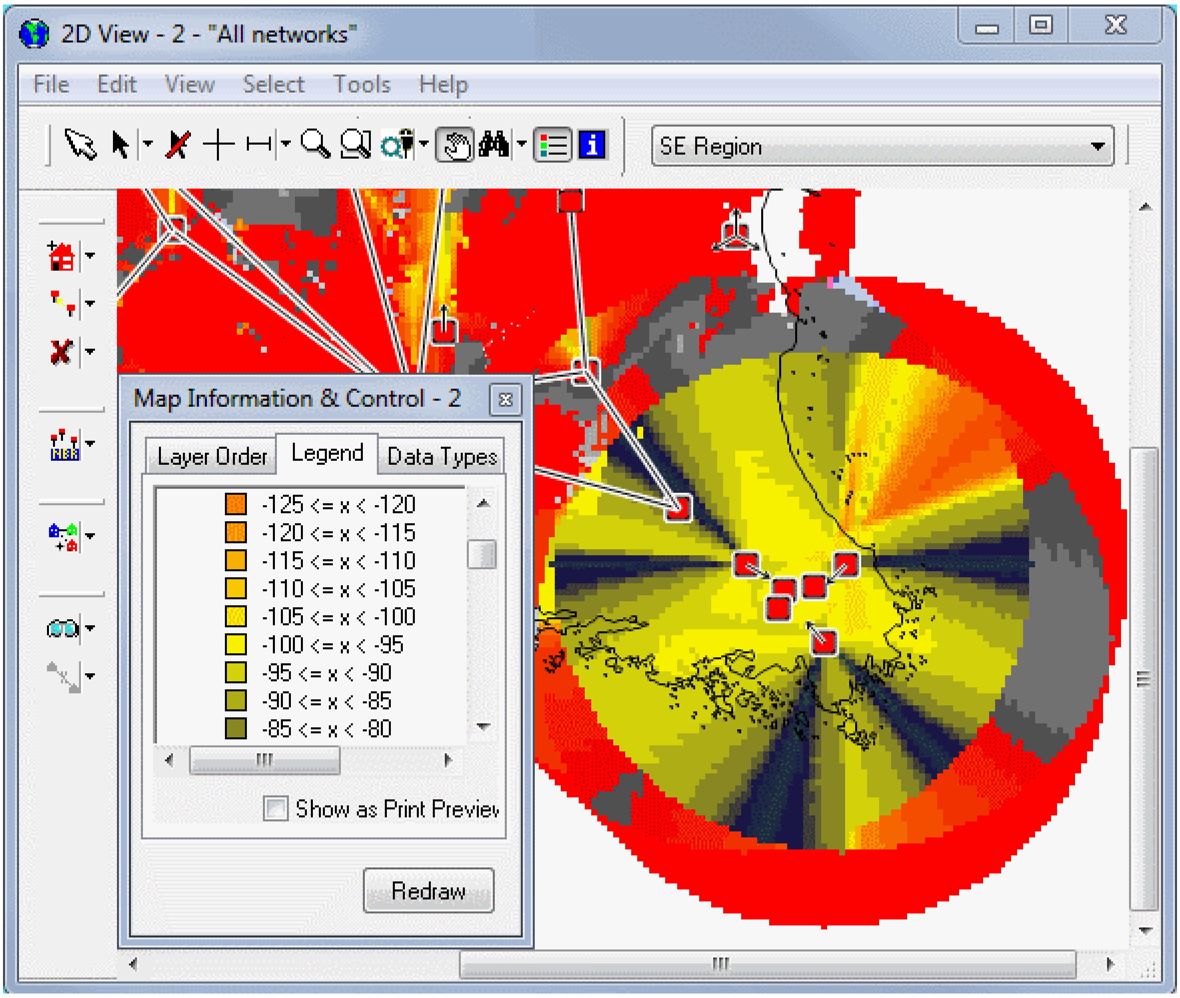
- Received Power, and its Best Server and Nth Best Server
- Received Field Strength, and its Best Server and Nth Best Server
- Fade Margin, and its Best Server
- Interference, Threshold Degradation Due to Interference, Fade Margin after Interference

This picture shows an example of a Received Power array:



Example of Received Power array

This picture shows an example of an Interference array:



Example of Interference array

Tip: For brief descriptions of the different types of output arrays, see Array Descriptions on page 381.

Note: ASSET Backhaul also provides extensive array-related functionality. For more information, see Managing, Displaying and Analyzing Arrays on page 211.

Managing, Displaying and Analyzing Arrays

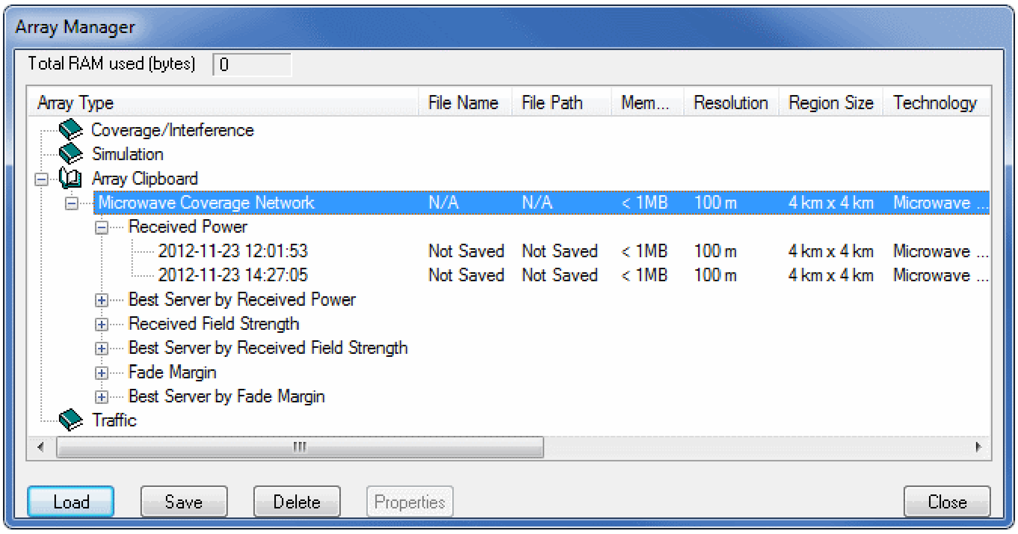
ASSET Backhaul provides extensive array-related functionality. You can:

- Use the **Array Manager** to list, load, save or delete arrays
- Display arrays in the **Map View**
- Customize the colors and ranges of the arrays
- Use the **Pixel Analyzer** to view and analyze pixel-specific network information from the arrays
- Generate statistical reports from the arrays

For full information on the above options, please see the chapter named 'Managing, Displaying and Analyzing Arrays' in the *ENTERPRISE User Reference Guide*.

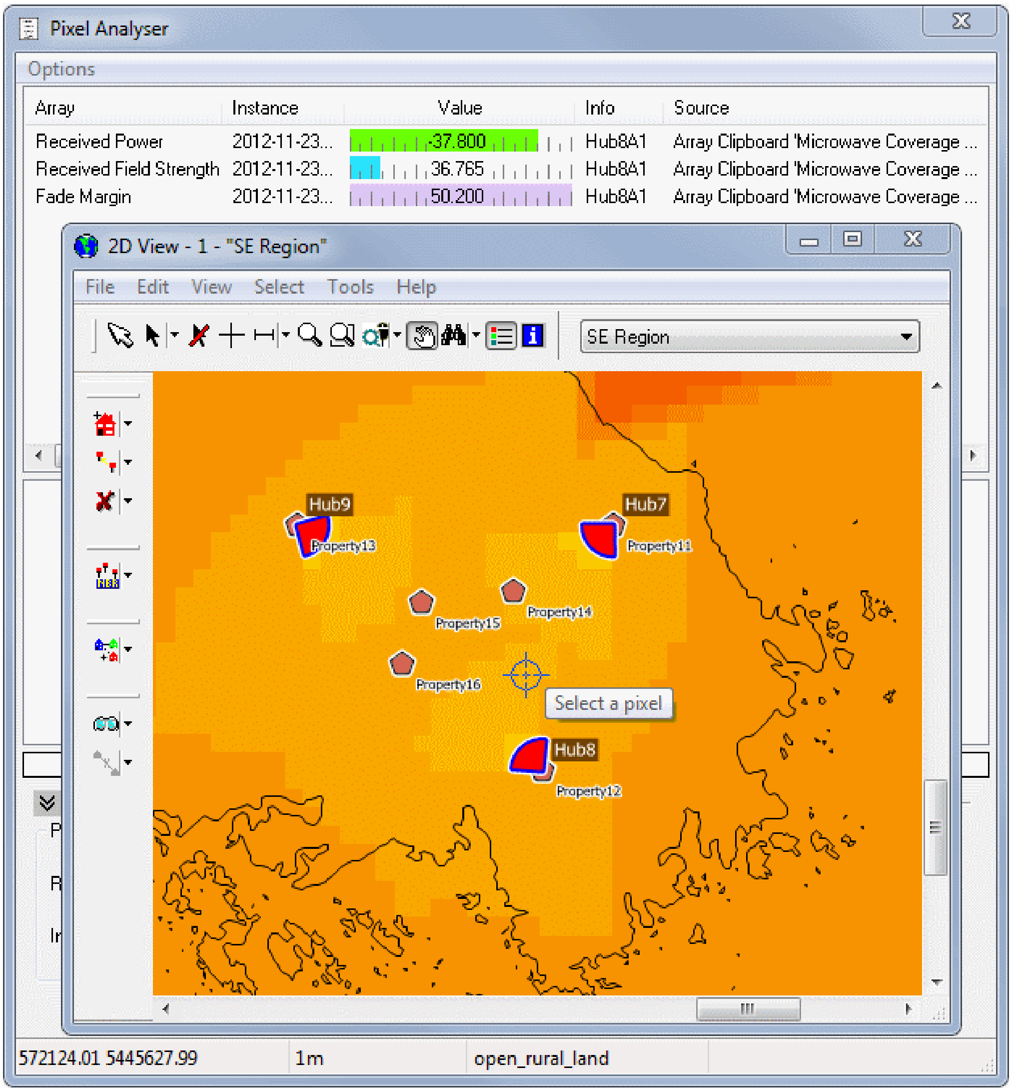
The two pictures below may help to illustrate some of this array-related functionality.

This picture shows an example of the Array Manager dialog box:



Example of Array Manager dialog box

This picture shows an example of the Pixel Analyzer (interacting with the Map View):



Example of Pixel Analyzer interacting with Map View

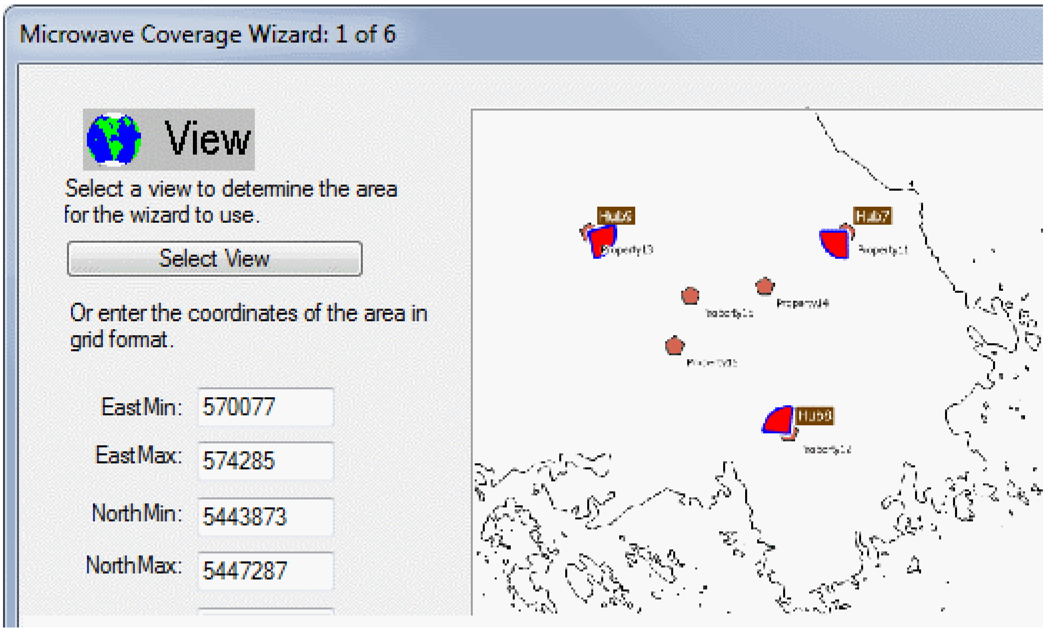
Using the Microwave Coverage Wizard

For a summary of the purpose of the **Microwave Coverage Wizard**, see Performing Coverage Analysis on page 209.

Note: The microwave coverage arrays are generated as *.3ga files which are individual Clipboard arrays. Therefore, within one session, you can run the Microwave Coverage Wizard repeatedly without overwriting previously created arrays. The arrays will be listed in the Array Manager dialog box, and can optionally be saved. If they are not saved, you will not be able to load them (to have them in memory) when you start a new session.

To create a coverage array:

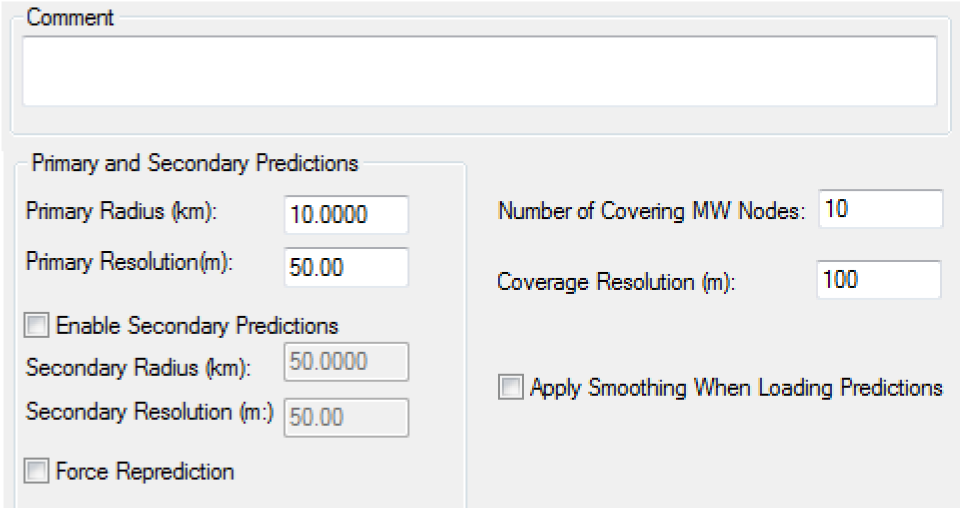
1. Open a **Map View** window that shows the region of interest.
2. From the **Arrays** menu, click **Microwave Coverage Wizard**. This picture shows an example:



3. Check that the region for the coverage array is correct. If necessary, you can modify the region by entering precise co-ordinates.

   Click **Next**.

The parameters for the wizard appear:



You can set the parameters as follows:

- Optionally, type a descriptive comment which will appear in the **Array Manager** dialog box.
- Specify the required primary radius (km) and resolution (m) for the predictions.
- If required, select the **'Enable Secondary Predictions'** checkbox and define the secondary radius and resolution. See About Primary and Secondary Predictions on page 215.
- If necessary, choose to force repredictions. Normally, due to the recognition capabilities of the prediction system, this is unnecessary. However, there may occasionally be unusual circumstances, for example where changes have been made to the underlying map data used by the project.
- Specify the number of covering microwave nodes. This is the maximum number of covering nodes that will be considered for each pixel.

  Warning: The greater the number of pixels, the larger the array and therefore the larger the amount of memory required.
- Set the required coverage resolution (m) for the arrays.
- If you want the prediction system to perform bilinear smoothing on the prediction data (using interpolation between pixels), choose to **Apply Smoothing When Loading Predictions.** This can be useful when creating arrays at a different resolution to the prediction data, and helps to minimize any edge effects between a primary and secondary prediction. For example, you may be creating an array at a 15m resolution, where the prediction data for some transmitters is at 5m, and for others is at 30m.

Click **Next**.

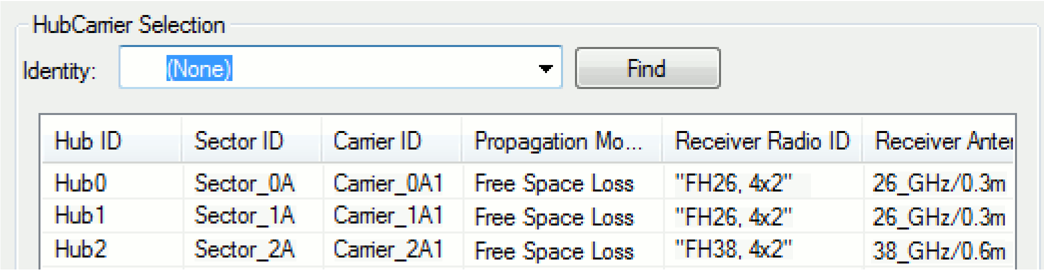
4. Specify the filter(s) you want to include in the coverage by selecting one of the two options. You can either:

   - **'Use selected filters from 2D View'**: This uses all filters currently selected in the Data Types list of the chosen 2D View.
   - **'Use filters selected below'**: This requires you to select the filter(s) from the tree list under the Filter Database heading.

   By default, only nodes that are located within the region specified on the first page of the wizard will be included. However, if you also want to consider the effect of overlapping predictions from microwave nodes located outside the specified region, you can select the **'Consider nodes with prediction area within specified region'** checkbox.

   Click **Next**.

5. The point to multi-point hubs/carriers that you have included in your chosen filter(s) will be listed. Here is an example:



Notes:

- If the propagation model for a particular hub/carrier has been set to 'Unknown', it will not be included in the list.
- The antenna height displayed here is taken from the specified propagation model.

Tip: You can use the Find option to search for a Hub ID in the list.

Click **Next**.

6. Select the arrays that you want to output from the wizard.

Tip: You can speed up the process if you omit arrays that you do not need.

Click **Next**.

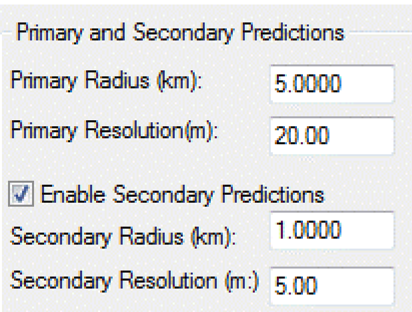
7. If you are satisfied with the summary of the parameters, click **Finish**.

Important: For information on displaying, analyzing and managing arrays and generating statistics, see the cross-references in About Arrays on page 210.

About Primary and Secondary Predictions

When you run the Microwave Coverage Wizard, the coverage predictions are created or loaded for the microwave transmitters in your network. If required, you can use a 'dual prediction', enabling you to specify a 'primary' resolution and radius, and, optionally, a 'secondary' resolution and radius. This results in a multi-resolution array.

This can be useful if, for example, you want to create/load a low-resolution prediction (say 50m) in the radial area further from the transmitter, but a high-resolution prediction (say 10m) in the radial area closer to the transmitter. This picture shows an example of how you might do this when setting up the wizard:



Example of Primary and Secondary Prediction settings on Step 2 of the Microwave Coverage Wizard

Important: Secondary predictions, if enabled, act as an 'overlay' which overrides the primary predictions in the area bound by the secondary radius. For that reason, the secondary radius should always be less than the primary radius.

8 Planning Routes

You can route data in several ways:

- Automatically, using the **Unified Route Planner**.

  Important: To use the Unified Route Planner, you must have the correct license. For more information, contact Product Support.

- Manually, using the **Logical/Cellular Connection Database**.

  For more information on how to do this, see the *ENTERPRISE User Reference Guide*.

You can route:

- GSM traffic through the logical hierarchy of MSCs, BSCs and Sites
- UMTS traffic across the cellular connections between WMSCs/SGSNs and RNCs, and between RNCs and NodeBs
- CDMA traffic across the cellular connections between CDMA MSCs, BSCs and BSs
- LTE packet-switched traffic across the logical connections between eNodeBs, and between eNodeBs and eNodeBs that have been nominated as S-GWs

Before you attempt to route your data, you should ensure that the following prerequisites are in place:

1. The logical/cellular connections between your network elements have been defined correctly:
   - For GSM networks, this is done automatically, using the hierarchy structure of the **Site Database**.

     You can view this hierarchy information in the **Logical/Cellular Connections Database**. For more information, see 'Viewing and Editing Logical/Cellular Connections' in the *ENTERPRISE User Reference Guide*.

     You can also view this hierarchy in the Site Database, and edit it by cutting and pasting nodes. For more information, see 'Reparenting Network Elements' in the *ENTERPRISE User Reference Guide*.
   - For UMTS or CDMA networks, you must create cellular connections between network elements.

     For more information, see 'Adding Logical and Cellular Connections' in the *ENTERPRISE User Reference Guide*.
   - For LTE networks, you must create logical connections between eNodeBs.

     For more information, see 'Adding Logical and Cellular Connections' in the *ENTERPRISE User Reference Guide*.
2. The traffic demands on your network elements have been created.

   You can do this in two ways:
   - Generating traffic automatically using the **ASSET Simulator**, and then importing this traffic into the Site Database.

     For more information, see 'Writing Carried Traffic Data to the Site Database' in the *ASSET User Reference Guide*.
   - Adding traffic manually to the network elements on the **Carried Traffic** tab of the Site Database.

     For more information, see 'About the Carried Traffic Tab' in the *ASSET User Reference Guide*.

Automatically Creating Routes to Carry Traffic Across your Network

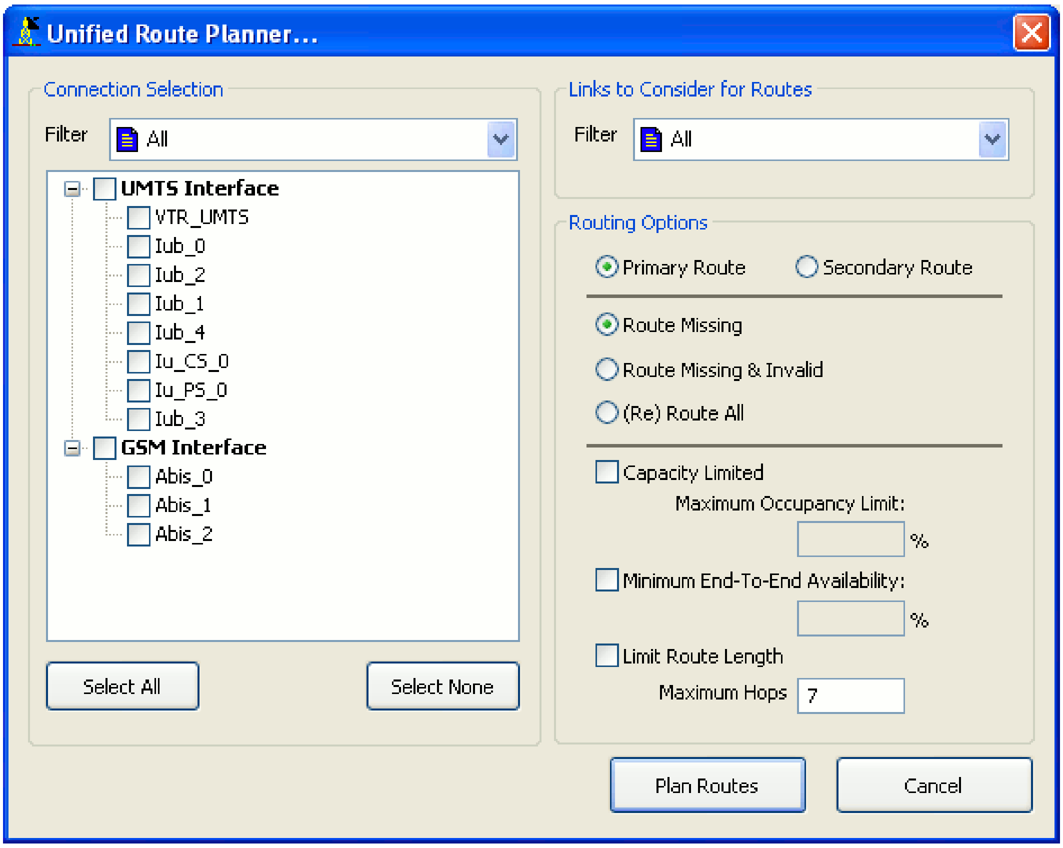
You can use the **Unified Route Planner** to create routes (primary and secondary) to carry traffic across your network.

Important: To use the Unified Route Planner, you must have the correct license. For more information, contact Product Support.

To do this:

1. Ensure that you have configured your network according to the prerequisites described in Planning Routes on page 217.
2. From the **Tools** menu, click **Unified Route Planner**.

   The Unified Route Planner appears:

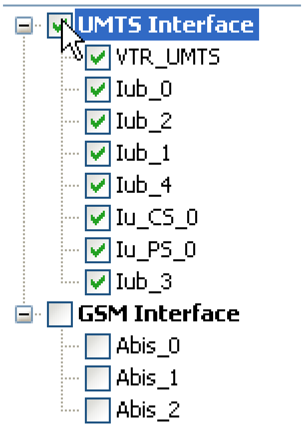
   The **Connection Selection** pane displays the connections (or interfaces) for all technologies that are available for routing:

   - The UMTS/CDMA interfaces are based on the cellular connections that you have defined
   - The GSM interfaces are based on the hierarchy that you have defined in the **Site Database**
   - The LTE interfaces are based on the logical connections that you have defined
   - The Logical Interfaces are based on any other non-LTE logical connections that you have defined

3. In this pane, select all of the connections that you want to route across, for all of the required technologies. You can select a filter to limit the connections that are displayed.

Tips:

- In the **Preferences** dialog box, you can specify which filters are displayed by default in the **Connection Selection** and the **Links to Consider for Routes** panes when you open the Unified Route Planner. For more information, see the *ENTERPRISE User Reference Guide*.
- To select all of the connections for a particular group (for example, UMTS traffic), select the checkbox for the technology:



- To select all of the connections, click the **Select All** button. To de-select all of the connections, click the **Select None** button.
- To expand or collapse the list of connections for a particular group (for example, GSM traffic), click the name of the group.

4. If required, you can limit the physical paths that are considered for routing by selecting a filter in the **'Links to Consider for Routes'** pane.

5. In the **Routing Options** pane select the type of route that you want to plan, either primary (which is the route that the traffic will try to use first) or secondary (the route that the traffic will try to use if the primary route is unavailable).

Note: If you later apply a secondary route for a logical/cellular connection that does not have a primary route, then the secondary route will become the primary route.

6. Select one of the options for calculating the routes:

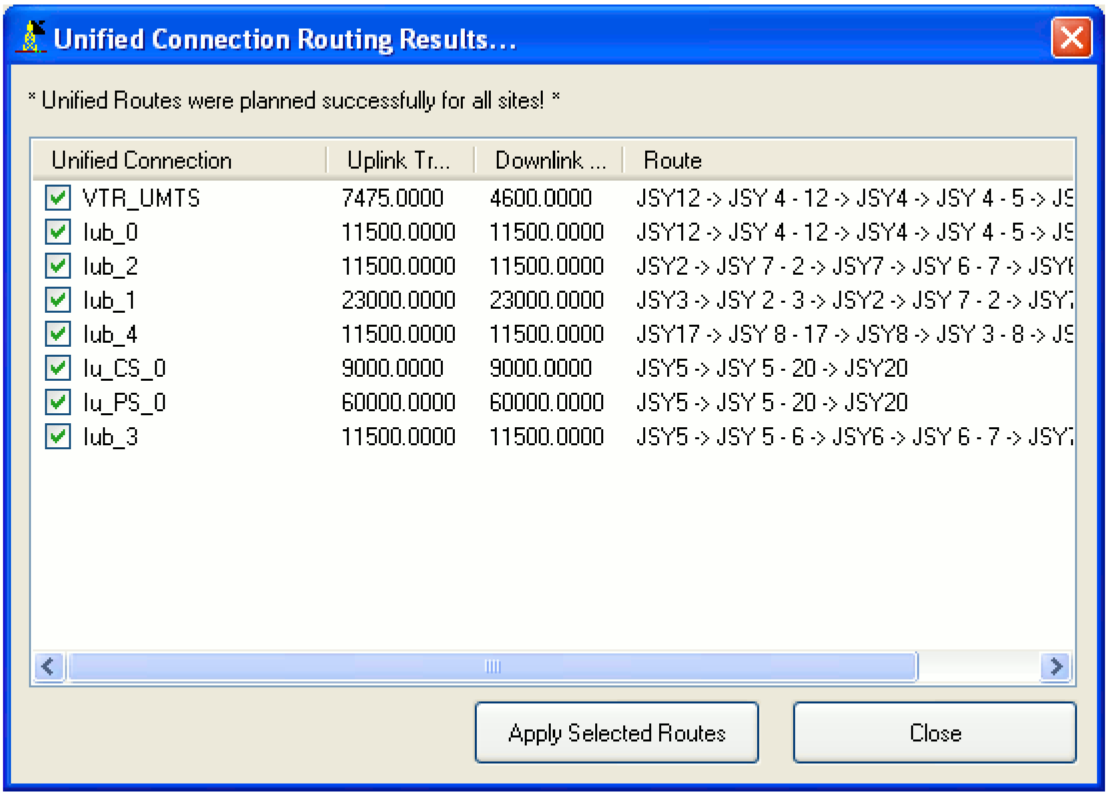
Option	Description
Route Missing	Routes the connections that have not previously been routed.
Route Missing and Invalid	Routes the connections that have not previously been routed and the connections that were previously routed but have since been made invalid.
(Re) Route All	Routes all of the connections, including those previously routed. **Warning:** If you try to reroute an existing connection, the existing route will not be retained, even if a new one cannot be found.

7. By default, ASSET Backhaul will route using the shortest possible path, but you can set other criteria for selecting routes. This table describes the available options:

Option	Description
Capacity Limited	Selects a route that does not exceed link capacities. If it cannot find a route that does not overload at least one link, it will not create a route and an error will appear in the message log. If required, you can fine-tune this by specifying a maximum occupancy limit (%) for the hops. If the traffic on a particular hop exceeds this threshold, then the hop is not accepted. **Tip:** You can set occupancy to be greater than 100%.
Minimum End-to-End Availability (%)	Selects a route that matches or exceeds a minimum required end-to-end (chain) availability. **Note:** For non-microwave links, availability can be assumed to be 100%.
Limit Route Length	Selects the route with the shortest physical length.

Note: When planning secondary routes, the Unified Route Planner will try to find routes with the fewest number of links that overlap with the primary routes (while also taking into account the selected routing options).

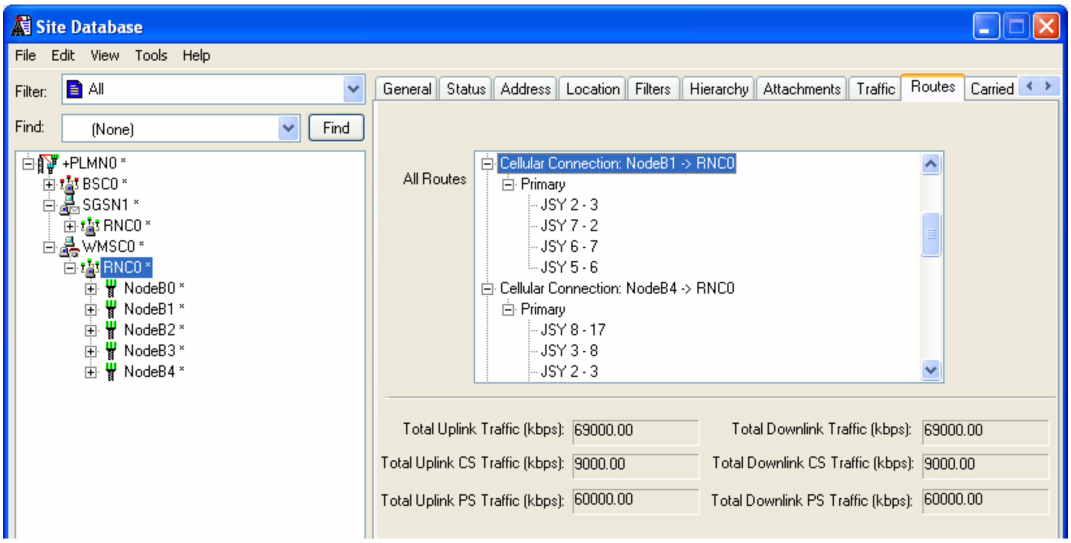
8. If required, specify a maximum number of route hops for the route.
9. Click the **Plan Routes** button.
10. In the **Routing Results** dialog box that appears, the planned primary routes for the selected connections are displayed, along with the amount of traffic carried by the route (taken from the **Traffic** tab of the **Logical/Cellular Connections Database**):



Tip: If a connection cannot be routed, the **Message Log** provides more information on why it has failed.

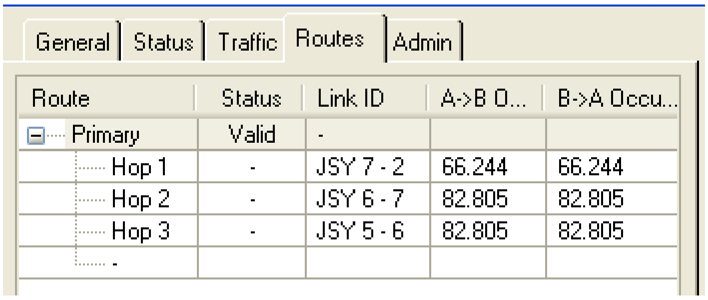
11. Select any of the calculated routes that you want to Apply, and then click **Apply Selected Routes**. When you do this:

   - The Applied routes for all technologies appear on the **Routes** tab for the respective network element:



   For more information, see Viewing Routed Traffic for Network Elements on page 222.

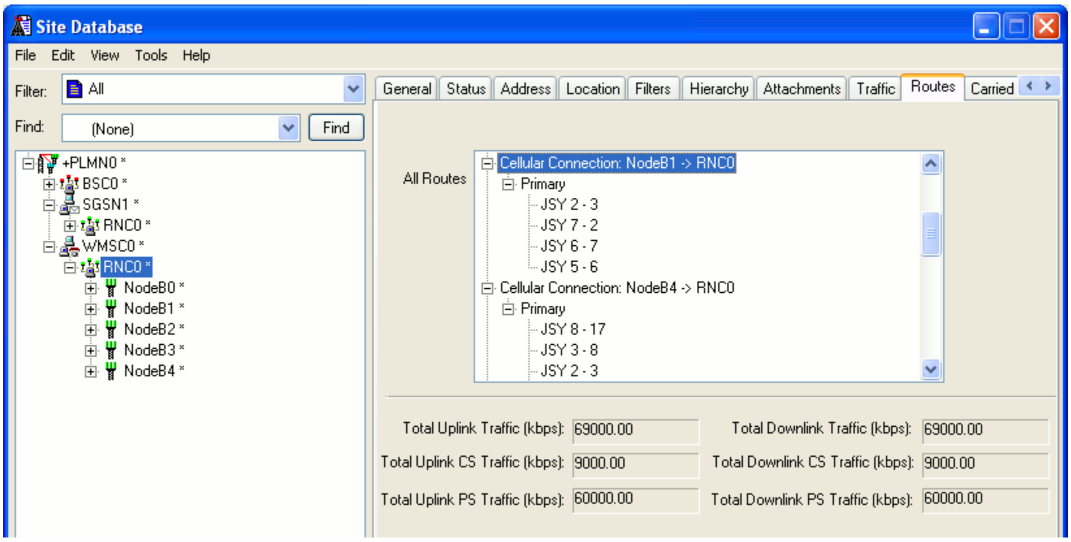
   - The Applied routes also appear on the Routes tab in the Logical/Cellular Connections database, from where you can edit them. For more information, see the *ENTERPRISE User Reference Guide*.



Note: If you later Apply a secondary route for a logical/cellular connection that does not have a primary route, then the secondary route will become the primary route.

Viewing Routed Traffic for Network Elements

On the **Routes** tab for a network element, you can view the traffic routed between network elements. This picture shows an example:



Routes and traffic displayed for a site

For the route, ASSET Backhaul displays the nodes at either end of the route and each hop in between. In this example, NodeB0 is associated with two primary routes. The first route is as follows:

Route	Start Node	Hop 1	Hop 2	Hop 3	Hop 4	End Node
1	NodeB1	Link JSY 2-3	Link JSY 7-2	Link JSY 6-7	Link JSY 5-6	RNC0

In addition, this tab also shows a number of calculated traffic values, which are taken from the **Traffic** tab for the network element.

Note: If you want to edit these values, you can only do this on the **Carried Traffic** tab. For more information, see the *ASSET User Reference Guide*.

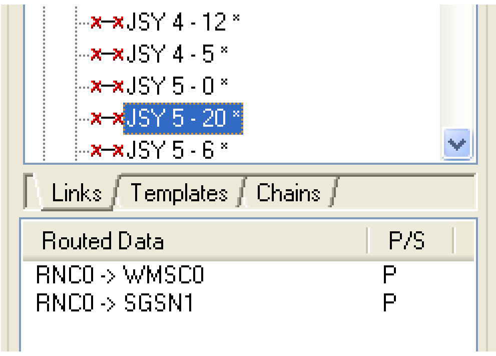
Viewing the Traffic Routed on a Link

On the **Routes** tab for a link in the **Link Database**, you can view all of the traffic demands on the physical links, based on the network elements that use the link for routing.

Important: To view the Routes tab and the **Routed Data** pane, you must have the correct license. For more information, contact Product Support.

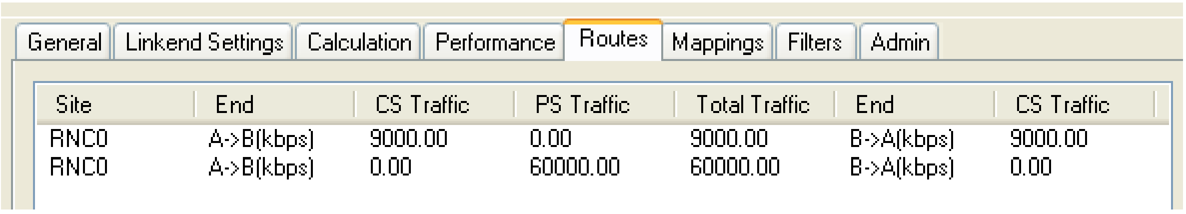
Tip: You can also view the total routed traffic for each direction on the **Type** subtab of the **General** tab for a link in the Link Database. For more information, see Defining the General Properties for Links on page 124 or Defining the Link Type and Overhead for Carriers on page 117 (for point to multi-point links).

Details are shown for each of the routes that use the link, listed in the **Routed Data** pane:



Routes using the link

For each of these routes, details of the hop that use this link are shown in the traffic pane. This picture shows an example:



Routes tab, showing the hops that use the link

Note: For point to multi-point links, End A to End B represents the traffic from the carrier to the multi-point link, while End B to End A represents the traffic from the multi-point link to the carrier.

For each hop, it displays the total traffic demand on the link for each direction, and shows how it is divided between CS and PS. It also indicates whether the route is the Primary (P) or Secondary (S) route.

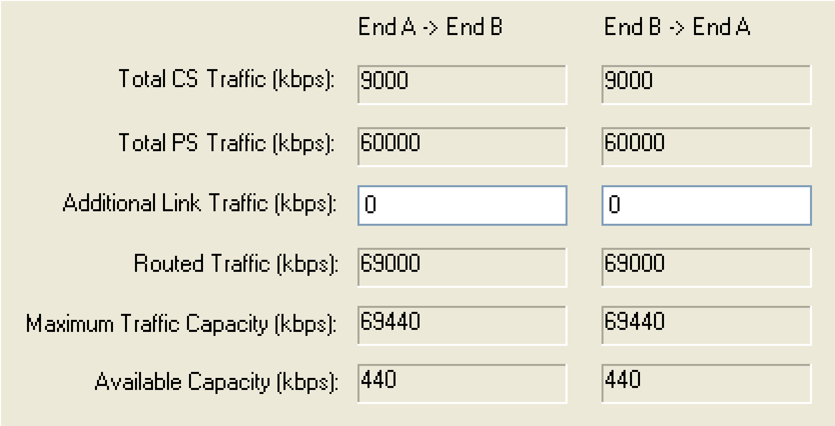
In the example above, Link JSY 4-12 is used in two routes:

- The primary route from RNC0 to WMSC0, in which this hop carries 9000kbps CS traffic and no PS traffic from EndA to EndB of this link, and 9000kbps CS traffic from EndB to EndA
- The primary route from RNC0 to SGSN1, in which this hop carries no CS traffic and 60000kbps PS traffic from EndA to End B of this link, and no CS traffic from EndB to EndA

The CS Traffic, PS Traffic and Total Traffic values are taken from the Traffic tab from the respective site.

Tip: These values can be overridden on the **Routes** tab of the **Logical/Cellular Connections Database**. For more information, see the *ENTERPRISE User Reference Guide*.

In addition, a number of aggregated results are displayed for the respective link direction. This picture shows an example:



Traffic grid, showing the aggregated traffic demands on the link

These values are as follows, for the respective direction:

Value	Description
Total CS Traffic	The sum of all CS Traffic taken from all of the hops using this link.
Total PS Traffic	The sum of all PS Traffic taken from all of the hops using this link.
Additional Link Traffic	If required, you can add some additional traffic, to replicate any future traffic demands that may come from extra sites, nodes and so on, without having to create and route these extra elements. **Note:** For point to multi-point links, this value is read-only on Linkend A, and taken from the Additional Carrier Traffic value on the Routes tab for the carrier associated with this multi-point link
Routed Traffic	The sum of Total CS Traffic, Total PS Traffic and Additional Link Traffic.
Maximum Traffic Capacity	The sum of Total Capacity minus Control Overhead (taken from the Type subtab of the General tab for the link).
Available Capacity	The sum of Maximum Traffic Capacity minus Routed Traffic.

Note: The **Routed Traffic** and **Available Capacity** values are also displayed on the **Type** subtab of the **General** tab for the link.

About Timeslot Mappings

A digital link is divided into a number of channels or timeslots to allow:

- Data from and to different sources/destinations
- Multiple users to share a common transmission medium

You can set up each link on a network to contain a certain number of timeslots, and allocate them as appropriate.

For example, for a BTS to BSC link, the more cell carriers on the BTS, the more telephone traffic it can handle, the more capacity, and hence timeslots, the link will require.

The allocation of these slots is known as the logical routing.

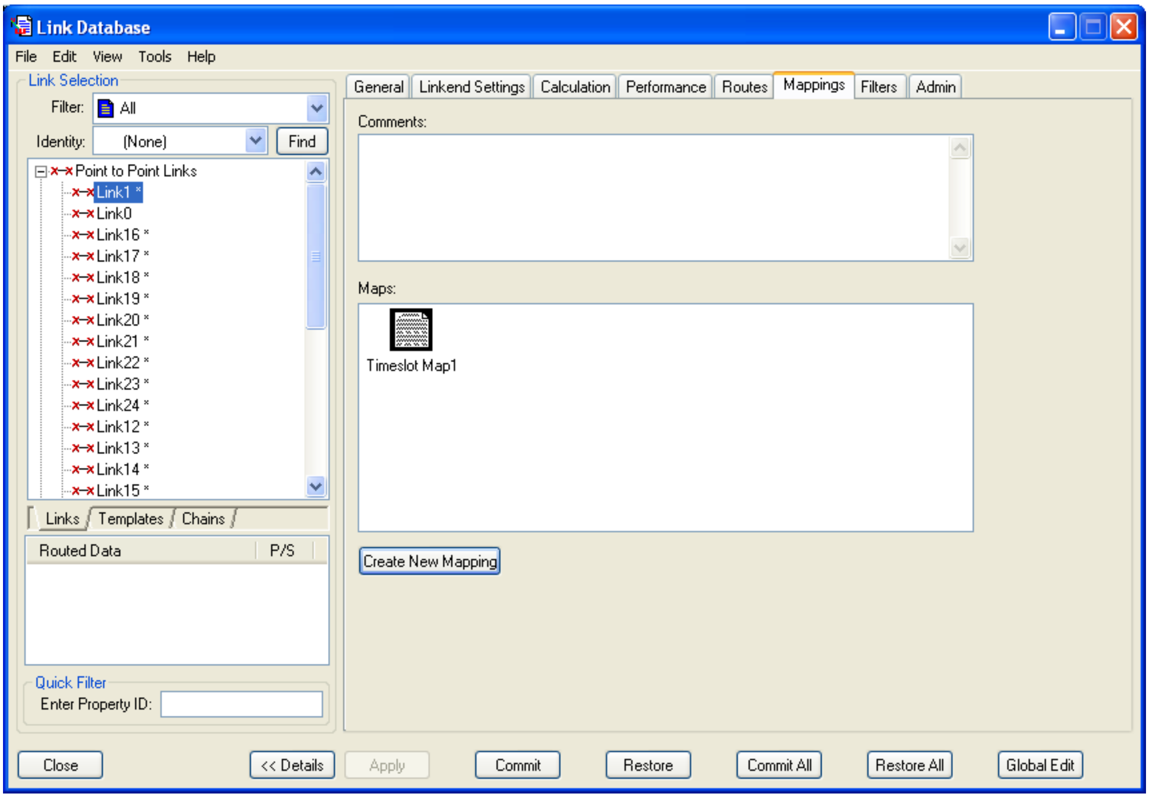
Creating and Editing Timeslot Mappings

You can create and modify timeslot mappings.

To do this:

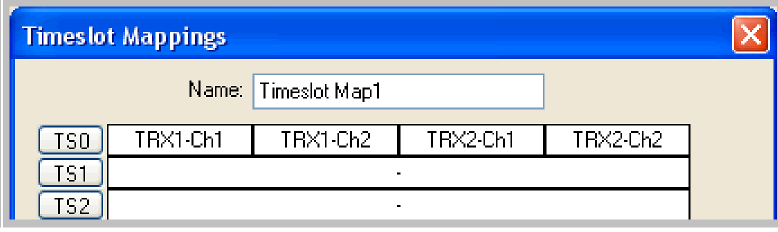
1. From the **Database** menu, click **Links**.
2. Ensure the window is expanded.
3. In the left pane, select the required link.
4. Scroll through the tabs and click the **Mappings** tab.

   For example:



5. Any timeslot maps associated with the selected link are displayed in the **Maps** pane.
6. To add a new map, click **Create New Mapping**.
7. To edit an existing timeslot map, double-click the timeslot map icon.
8. In the **Timeslot Mappings** dialog box you can change the name of the map and edit the actual maps themselves.

9. You can add an entry for each timeslot 0 to 31. This table shows what you can do:

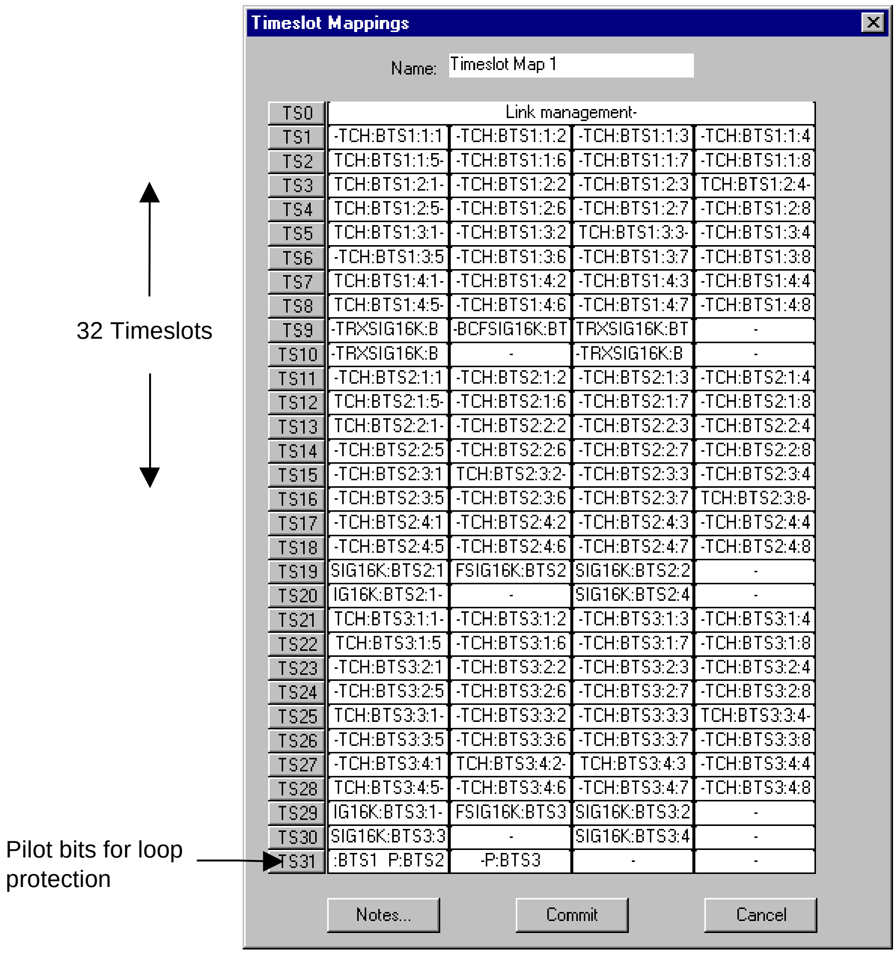
Add	By
Any text (to represent 64kbs of capacity)	Clicking in the timeslot box, and typing an entry. For example, to show timeslot 0 is used for signaling, type Signaling.
Four separate text values, each representing 16kbs of capacity)	Clicking on the Timeslot Number to divide the timeslot into four columns: for example: 

10. Click **Notes** to define information about the map and about the equipment at each end of the link.

11. To save the details of the map, click **Commit** or to cancel the changes, click **Cancel**.

Example of Timeslot Mapping

This example shows how a timeslot map can be used to describe the traffic mappings on a 2Mb E1 link:



TS0	Link management-			
TS1	-TCH:BTS1:1:1	-TCH:BTS1:1:2	-TCH:BTS1:1:3	-TCH:BTS1:1:4
TS2	TCH:BTS1:1:5-	-TCH:BTS1:1:6	-TCH:BTS1:1:7	-TCH:BTS1:1:8
TS3	TCH:BTS1:2:1-	-TCH:BTS1:2:2	-TCH:BTS1:2:3	TCH:BTS1:2:4-
TS4	TCH:BTS1:2:5-	-TCH:BTS1:2:6	-TCH:BTS1:2:7	-TCH:BTS1:2:8
TS5	TCH:BTS1:3:1-	-TCH:BTS1:3:2	TCH:BTS1:3:3-	-TCH:BTS1:3:4
TS6	-TCH:BTS1:3:5	-TCH:BTS1:3:6	-TCH:BTS1:3:7	-TCH:BTS1:3:8
TS7	TCH:BTS1:4:1-	-TCH:BTS1:4:2	-TCH:BTS1:4:3	-TCH:BTS1:4:4
TS8	TCH:BTS1:4:5-	-TCH:BTS1:4:6	-TCH:BTS1:4:7	-TCH:BTS1:4:8
TS9	-TRXSIG16K:B	-BCFSIG16K:BT	TRXSIG16K:BT	-
TS10	-TRXSIG16K:B	-	-TRXSIG16K:B	-
TS11	-TCH:BTS2:1:1	-TCH:BTS2:1:2	-TCH:BTS2:1:3	-TCH:BTS2:1:4
TS12	TCH:BTS2:1:5-	-TCH:BTS2:1:6	-TCH:BTS2:1:7	-TCH:BTS2:1:8
TS13	TCH:BTS2:2:1-	-TCH:BTS2:2:2	-TCH:BTS2:2:3	-TCH:BTS2:2:4
TS14	-TCH:BTS2:2:5	-TCH:BTS2:2:6	-TCH:BTS2:2:7	-TCH:BTS2:2:8
TS15	-TCH:BTS2:3:1	TCH:BTS2:3:2-	-TCH:BTS2:3:3	-TCH:BTS2:3:4
TS16	-TCH:BTS2:3:5	-TCH:BTS2:3:6	-TCH:BTS2:3:7	TCH:BTS2:3:8-
TS17	-TCH:BTS2:4:1	-TCH:BTS2:4:2	-TCH:BTS2:4:3	-TCH:BTS2:4:4
TS18	-TCH:BTS2:4:5	-TCH:BTS2:4:6	-TCH:BTS2:4:7	-TCH:BTS2:4:8
TS19	SIG16K:BTS2:1	FSIG16K:BTS2	SIG16K:BTS2:2	-
TS20	IG16K:BTS2:1-	-	SIG16K:BTS2:4	-
TS21	TCH:BTS3:1:1-	-TCH:BTS3:1:2	-TCH:BTS3:1:3	-TCH:BTS3:1:4
TS22	TCH:BTS3:1:5	-TCH:BTS3:1:6	-TCH:BTS3:1:7	-TCH:BTS3:1:8
TS23	-TCH:BTS3:2:1	-TCH:BTS3:2:2	-TCH:BTS3:2:3	-TCH:BTS3:2:4
TS24	-TCH:BTS3:2:5	-TCH:BTS3:2:6	-TCH:BTS3:2:7	-TCH:BTS3:2:8
TS25	TCH:BTS3:3:1-	-TCH:BTS3:3:2	-TCH:BTS3:3:3	TCH:BTS3:3:4-
TS26	-TCH:BTS3:3:5	-TCH:BTS3:3:6	-TCH:BTS3:3:7	-TCH:BTS3:3:8
TS27	-TCH:BTS3:4:1	TCH:BTS3:4:2-	TCH:BTS3:4:3	-TCH:BTS3:4:4
TS28	TCH:BTS3:4:5-	-TCH:BTS3:4:6	-TCH:BTS3:4:7	-TCH:BTS3:4:8
TS29	IG16K:BTS3:1-	FSIG16K:BTS3	SIG16K:BTS3:2	-
TS30	SIG16K:BTS3:3	-	SIG16K:BTS3:4	-
TS31	:BTS1 P:BTS2	-P:BTS3	-	-

Example timeslot map

Each timeslot on a 2Mb E1 link has a bit rate of 64Kbs. However, they are generally divided into 4 to accommodate the 16Kbs channels usually used on the A-bis interface between the BTS and BSC.

In this example, the link is being shared by 3 BTSs, each BTS has 4 TRXs, which in turn have the standard 8 channels. TS0 is used for link management and then TS1 to TS30 are used to carry the BTS traffic.

The traffic is divided into user traffic and signaling traffic. For each BTS there are 32 traffic channels (4 TRX x 8 channels) and 5 signaling channels (1 for the BTS equipment and 1 for each TRX).

The final timeslot is used for loop protection, 1 Pilot-Bit is required for each BTS.

9 Producing Reports

You can use ASSET Backhaul to generate detailed reports displaying information about your network. You can report on:

- The results of the wizards in ASSET Backhaul - line of sight, interference and High/Low conflicts
- The link budget data contained in the Height Profile (including user-defined profiles)
- Intermodulation data
- A number of network/project elements:

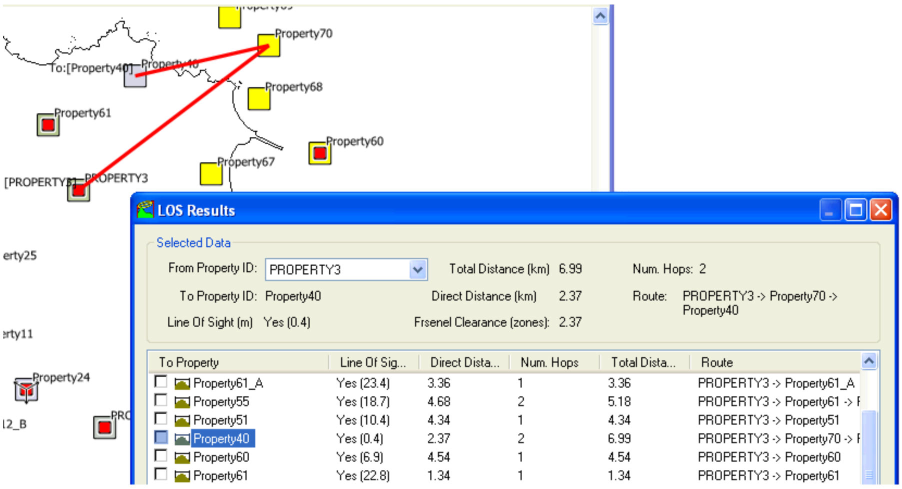
Report Type	Description
Link Reporter	Shows the link settings, including default parameters and prediction models, linkend settings and performance values. In the Link Report Generator you can choose which fields to display/hide in the report. Link reports can be generated for a single link, all links or sub-set of links within a filter. **Tip:** You could customize the report further using a macro or VBA for Microsoft Excel to produce commissioning or license application documentation.
Node Reporter	Shows information such as ground heights, coordinates, addresses and so on for all nodes (sites and Properties) in the network.
Hub Reporter	A special type of node report, which just shows information for PmP hub sites.
Cost Reporter	Provides a capital and operational expenditure breakdown for the link equipment used in the network.
Traffic Reporter	You can generate traffic reports in ASSET Backhaul that detail the uplink/downlink traffic and number of subscribers on a per hub/sector basis.

Producing Line of Sight Reports

You can use the **LOS Wizard** to suggest routes between Properties based on:

- LOS/Fresnel clearance
- Maximum number of hops allowed
- Antenna heights

After you have produced a report for the suggested routes, you can view them in the **Map View** window. This picture shows an example of the **LOS Results** dialog box, with one of the routes between two Properties displayed on the Map View:



LOS Wizard Results

Creating a Line of Sight Report

To produce a report that provides line of sight information:

1. Ensure that you have the **Map View** window open, displaying the relevant network area.
2. From the **Tools** menu, point to **LOS Wizard** and click **LOS Wizard**.

   Page 1 of the LOS Wizard appears, explaining the line of sight calculation process.
3. Click **Next**.
4. Select the group of Properties that you want to check for line of sight, using one of the following methods:

To	Do This
Select the Property or Properties using the Map View window	Choose the Select a View option and click Next. If the Map View window shown is not the correct one, click Select View and click the required Map View window.
Select the Property or Properties using a filter	Choose the Select a Filter option, and from the list pick the filter that contains the Properties.

5. Further specify the Property or Properties you want to check, using one of the following methods:

To	Do This
Select all Properties	Choose the From all Properties option.
Select a specific Property	Choose the From a Property option. In the Map View window, click the Property.
Select the Property for a particular PmP hub	Choose the From a PmP Hub option. In the Map View window, click the Property containing the PmP hub and from the menu that appears, click the required PmP hub.

6. Click **Next**.

7. This table describes the information you should define:

Define	Description
Default TX Antenna Height	The default antenna height at the transmitter that will be used in the LOS calculations. You can additionally choose to include the Available Mast Height (defined on the General tab for the Property) in the overall antenna height. **Note:** If you have selected a specific Property or PmP hub, then the TX height will be used for the Property/hub site.
Default RX Antenna Height	The default antenna height at the receiver that will be used in the LOS calculations. You can additionally choose to include the Available Mast Height (defined on the General tab for the Property) in the overall antenna height. **Note:** If you have selected a specific Property or PmP hub, then the RX height will be used for all other Properties. If you have selected all Properties, the RX Antenna Height will be the same as the TX Antenna Height.
Hop Distance (Minimum and Maximum)	The minimum and maximum considered distance between a link end A and B.
Maximum Number of Hops	This is the maximum number of Properties to consider when selecting a suitable route back to the BSC.
K Factor	This geoclimatic factor is used to calculate the effective earth radius. **Tip:** The usual geoclimatic factor is 1.3333333.
Clearance Calculation Type	Select whether you want to use the regular LOS calculation, or include Fresnel clearance in the calculations as well.
Default Frequency (Fresnel Clearance only)	By typing a frequency value, you can assess LOS for a specific frequency or frequency band. To do this, you would have to: • Prepare a filter based where frequencies have been separated into their respective frequency bands • Select this filter on the opening page of the LOS Wizard
Fresnel Zone (Fresnel Clearance only)	This is the maximum number of Fresnel zones to consider when calculating the Fresnel clearance.
Fresnel Zone Factor (Fresnel Clearance only)	Valid values are real numbers between 0.0 and 1.0. It is generally recommended to use a default value of 0.6, but for frequencies greater than 3 GHz, you should use 1.0.

8. Click **Next**.

9. Select which heights you want to include in the line of sight calculation that is used for the report:

   - **Clutter Heights** (and the propagation model containing them)
   - **Building Raster Heights**
   - **Building Vector Heights**

   If you do not select one or more height options, the ground height data is used as default.

   Note: If you select to use building vector heights, their position is calculated based upon the position at which the vector line intersects the profile.

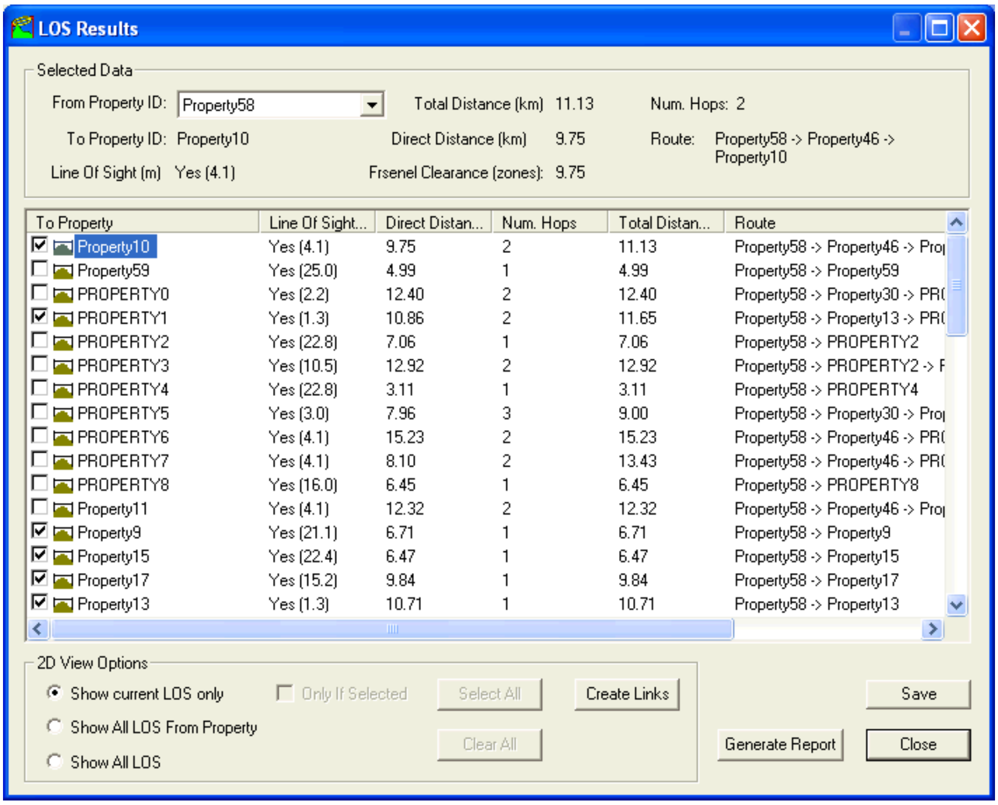
10. Click **Finish**.

    The line of sight data is displayed. For more information, see Viewing Line of Sight Information on page 232.

If you are satisfied with the results of the line of sight report, you can use them as the basis for creating new links. For information on how to do this, see Adding Links Based on Line Of Sight Reports on page 81.

Viewing Line of Sight Information

When you produce a line of sight report using the LOS wizard, the line of sight data is displayed in the **LOS Results** dialog box:



An example LOS Results dialog box

To save the data in an LOS Data file (*.los):

1. Click **Save**.
2. In the dialog box that appears, browse to the location you want to store the file, type a name for the file and then click **Save**.

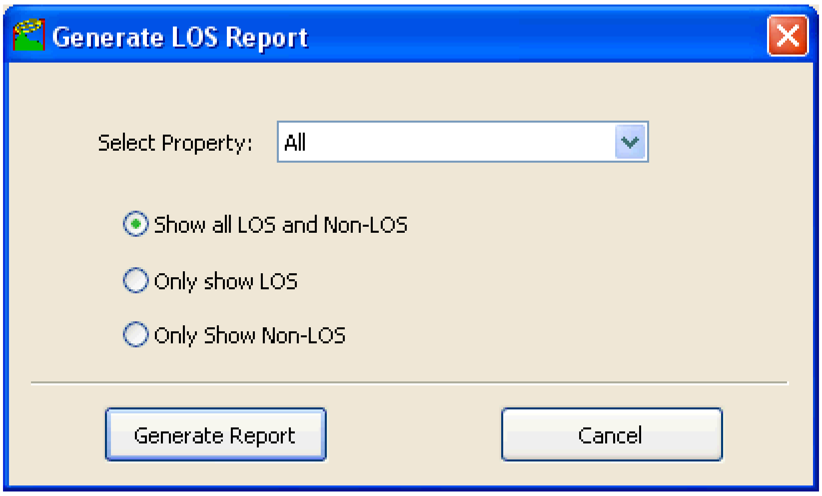
To display the report data in an Excel file:

Note: If you do not have Excel installed, the report is generated as a tab-separated text file.

---

1. Click **Generate Report**.
2. In the dialog box that appears, select the Property whose LOS data you want to report on, or select **All** to report on all Properties.

3. In the dialog box that appears, choose which LOS information you want to report for the selected Property (or Properties):



This table describes the options:

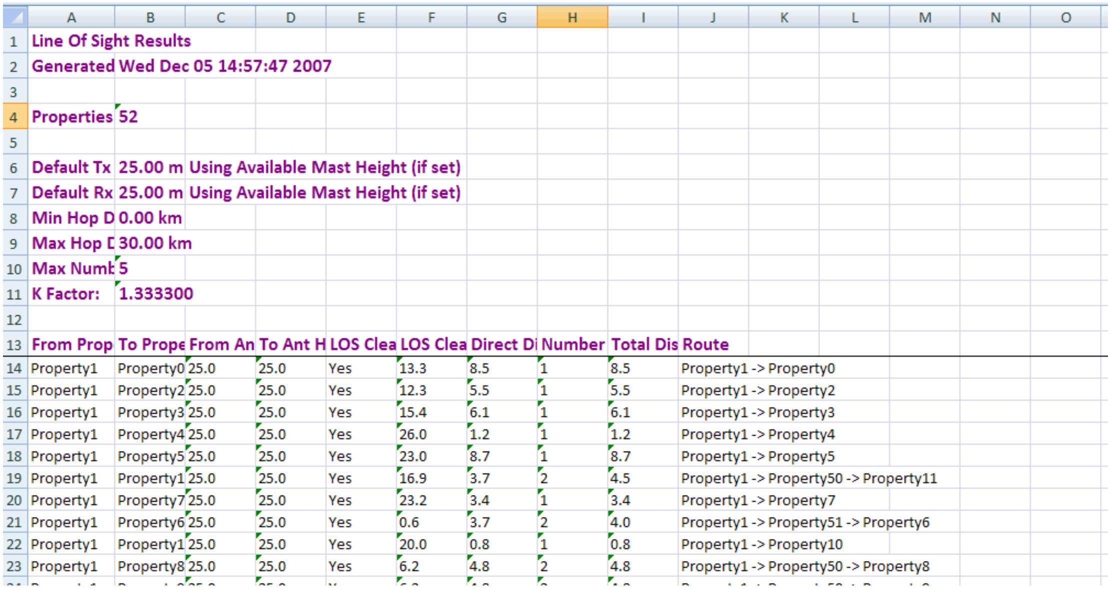
Item	Description
Show All LOS and Non-LOS	Show all information for the Property, whether there is line of sight or not.
Only Show LOS	Only show information for the Properties which have line of sight with the chosen Property.
Only Show Non-LOS	Only show information for the Properties which do not have line of sight with the chosen Property.

The report is generated and opens automatically. To see an example report, see Example Line of Sight Report on page 234.

Tip: When you have created a line of sight report, you can view the LOS data directly on the Map View window. For information on how to do this, see Displaying Line of Sight Data in the Map View Window on page 234.

Example Line of Sight Report

This picture shows an example line of sight report, where the Only Show LOS option has been chosen for Property1:



	A	B	C	D	E	F	G	H	I	J
1	Line Of Sight Results									
2	Generated	Wed Dec 05 14:57:47 2007								
3										
4	Properties	52								
5										
6	Default Tx	25.00 m	Using Available Mast Height (if set)							
7	Default Rx	25.00 m	Using Available Mast Height (if set)							
8	Min Hop D	0.00 km								
9	Max Hop D	30.00 km								
10	Max Numb	5								
11	K Factor:	1.333300								
12										
13	From Prop	To Prope	From An	To Ant H	LOS Clea	LOS Clea	Direct Di	Number	Total Dis	Route
14	Property1	Property0	25.0	25.0	Yes	13.3	8.5	1	8.5	Property1 -> Property0
15	Property1	Property2	25.0	25.0	Yes	12.3	5.5	1	5.5	Property1 -> Property2
16	Property1	Property3	25.0	25.0	Yes	15.4	6.1	1	6.1	Property1 -> Property3
17	Property1	Property4	25.0	25.0	Yes	26.0	1.2	1	1.2	Property1 -> Property4
18	Property1	Property5	25.0	25.0	Yes	23.0	8.7	1	8.7	Property1 -> Property5
19	Property1	Property1	25.0	25.0	Yes	16.9	3.7	2	4.5	Property1 -> Property50 -> Property11
20	Property1	Property7	25.0	25.0	Yes	23.2	3.4	1	3.4	Property1 -> Property7
21	Property1	Property6	25.0	25.0	Yes	0.6	3.7	2	4.0	Property1 -> Property51 -> Property6
22	Property1	Property1	25.0	25.0	Yes	20.0	0.8	1	0.8	Property1 -> Property10
23	Property1	Property8	25.0	25.0	Yes	6.2	4.8	2	4.8	Property1 -> Property50 -> Property8

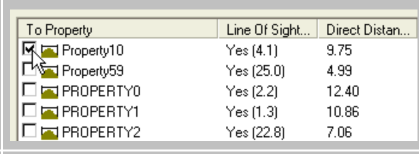
For example, the report indicates that there is LOS clearance of 13.3m between Property 1 and Property 0, which both have an antenna height of 25m.

Displaying Line of Sight Data in the Map View Window

After you have produced a line of sight report, you can view the data in a report or in the Map View window.

To display the LOS data in the Map View window:

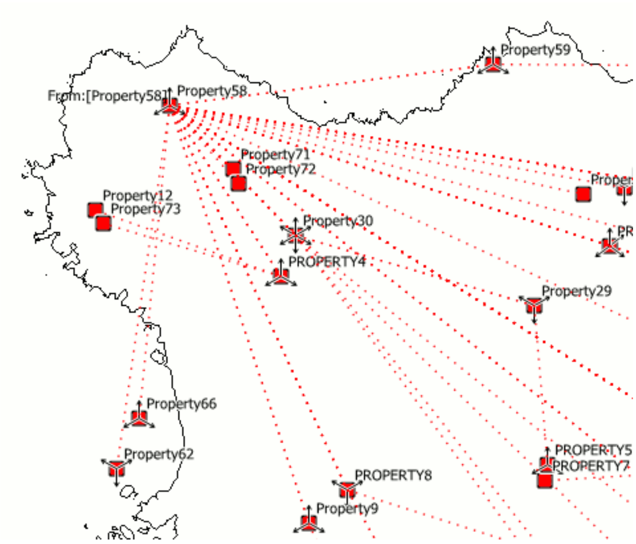
1. On the Map View toolbar, click the  button.
2. In the **Layer Control** dialog box, click the **Data Types** tab.
3. In the list of data types, select and expand the **LOS Info**, and then select **LOS Data**.
4. In the **LOS Results** dialog box, select the transmitter Property in the **From Property ID** box.
5. In the **2D View Options** pane, select one of the options described in this table:

Option	Description
Show Current LOS Only	Displays line of sight from the selected transmitter Property to the currently highlighted link in the results pane:  To Property | Line Of Sight... | Direct Distan... Property10 | Yes (4.1) | 9.75 Property59 | Yes (25.0) | 4.99 PROPERTY0 | Yes (2.2) | 12.40 PROPERTY1 | Yes (1.3) | 10.86 PROPERTY2 | Yes (22.8) | 7.06
Show All LOS From Property	Displays all of line of sight from the selected transmitter Property.
Show All LOS	Displays all of line of sight from all Properties.

6. If you want to further limit what is displayed by only Applying the **2D View Option** to Properties that you have selected, choose the **Only If Selected** checkbox.

Tip: To select all receiver Properties with line of sight to the transmitter Property, click **Select All**. To undo this, click **Clear All**.

This picture shows an example, where all the line of sight from Property 58 is displayed:



To change the LOS display properties:

1. On the Map View toolbar, click the  button.
2. In the **Layer Control** dialog box, click the **Data Types** tab.
3. In the list of data types, select and expand the **LOS Info**, and then select **LOS Data**.
4. Double-click **LOS Data**.
5. In the dialog box that appears, change the appearance of the:
   - **Route Line** (style, color, width)
   - **Label** (color, font, size)
   - **Label Background** (solid or halo, color)
6. Click **OK**.

Producing Interference Reports

After you have performed an interference analysis, you can produce a report of interference for either the currently displayed link or all affected links.

To do this:

1. Click the **Report** button.
2. In the dialog box that appears, select the **Current links** or **All links** option.
3. If you have chosen to report on all links, select how the report will be generated:
   - As a single page, with each link on a separate row

   \- or -

   - As multiple pages, with each link on a separate page

Note: If you are reporting on more than 35,000 links, you can only generate the report as a single page.

4. Click **Generate.**

   The report appears in Microsoft Excel® (or, if Microsoft Excel is not installed, a text editor).

This picture shows an example interference report:

Link Interference Data		
Generated on: 2006-06-14 11:45:30		
Rx Link:	Link15	
Co Channel Interf.:	-31.6330	
Adjacent Channel Interf.:	-94.6717	
Rx Property/Carrier:	Property3	
Rx Power (dBm):	-10.85	
Tx Power (dBm):	5.00	
Tx Power With Loss (dBm):	5.00	
Rx Attenuation Loss (dB):	0.00	
Rx Attenuator (dB):	0.00	
Tx Attenuator (dB):	0.00	
Band:	Band 15GHz, 16x2	
Channel:	G1	
Rx Frequency (GHz):	15.047000	
Tx Frequency (GHz):	14.627000	
Polarity:	V	
Threshold Degradation (dB):	65.3670	
FKTB (dB):	-97.0000	
Co-Channel Interferers:		
Tx Link	Interference before filter discrimination (C/I)(dBm)	Interference power
Link14	-45.29	-32.29
Link16	-53.14	-40.14
Link17	-79.87	-66.87
Link22	-93.99	-80.99
Link19	-95.16	-82.16
Adjacent Channel Interferers:		
Tx Link	Interference before filter discrimination (C/I)(dBm)	Interference power
Link26	-83.69	-94.69
Link24	-108.91	-119.91
Link25	-116.86	-127.86

Example Interference Report

Producing High Low Conflict Reports

When you are configuring linkends during link planning, you must ensure that there are no conflicting High/Low orientations on Properties that have linkends of the same band.

The **High Low Conflict** wizard produces a list of conflicts, which you can save as a spreadsheet or text editor.

To produce a report:

1. Run the **High Low Conflict** wizard, as described in Checking High Low Conflicts on page 146.

2. In the list that appears, select the Property on which you want to create a report (you can choose **All**).

3. Click the **Generate Report** button.

The results of the High Low Conflict wizard are displayed in a Microsoft Excel spreadsheet, or if you do not have Excel installed, a text editor. This picture shows an example:

High Low Conflict Report
Generated on: 02/06/03 - 10:28:17

Property ID	Link ID	Linkend	Band	Designation	Centre Freq(MHz)	Channel
PROPERTY5'	Link9	B	Band1	L	38000.004	Channel1
	Link5	A	Band1	H	39000.004	Channel2
PROPERTY6'	Link4	B	Band1	L	39501.004	Channel4
	Link3	A	Band1	H	40000.004	Channel4
	Link5	B	Band1	L	38501.004	Channel2
PROPERTY7'	Link10	A	Band2	H	41500.004	Channel3
	Link7	B	Band2	L	41501.004	Channel4
	Link6	B	Band2	L	40001.004	Channel1
PROPERTY9'	Link8	B	Band1	L	39501.004	Channel4
	Link3	B	Band1	L	39501.004	Channel4
	Link1	A	Band1	H	38500.004	Channel1

4. To save this report, click the **Save Report** button in the **High Low Conflicts** list dialog box. The report will be saved as an *.hlc file.

About the Information Shown in the High Low Conflicts Report

The following table details the information that is shown in a High Low Conflicts Report:

Item	Description
Property	The Property to which the link is connected.
Link	The ID code of the link.
End	The linkend of the link, either A or B.
Band	The frequency band of the link (in the case of a conflict these will be identical).
Designation	The designation of the channel of the link, either High (H) or Low (L) (in the case of a conflict these will be different).
Centre Frequency	The center frequency of the link.
Channel	The frequency channel of the link.

Loading High Low Conflicts

If you have previously saved a High Low Conflict report, to re-load it at a later date:

1. From the **Tools** menu, point to **High Low Conflicts** and then click **Load High Low Conflicts**.
2. In the dialog box that appears, type the name of the file (*.hlc) that you want to import, or locate the import file and double-click it to select it.
3. Click the **Open** button.

   The High Low Conflict report is loaded, and displayed.

Viewing High Low Conflicts

To view a High Low Conflict report at any time after you have closed the High Low Conflicts wizard:

1. From the **Tools** menu, point to **High Low Conflicts** and click **View High Low Conflicts**.
2. The report currently in memory (either the one most recently saved, or the one most recently loaded) is displayed.

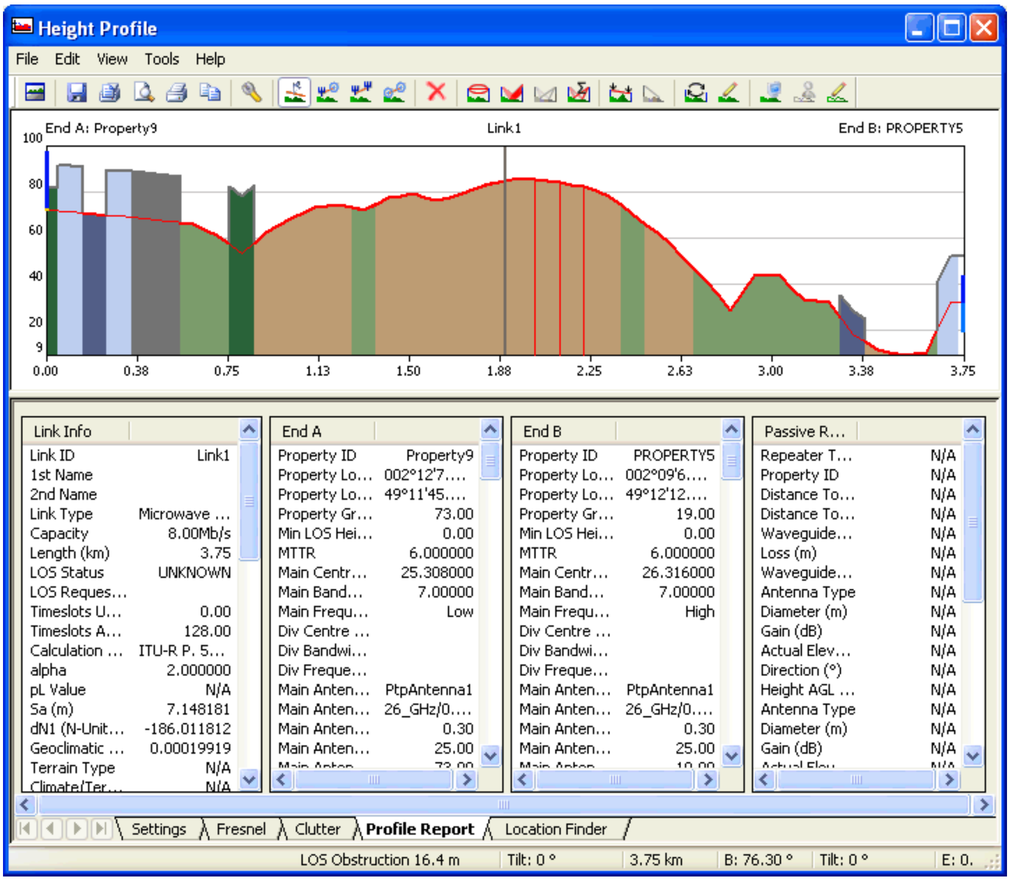
Producing Link Profile/Budget Reports

To produce a link profile/budget report:

1. In the **Map View** window, select a link on the map.
2. From the **Reports** menu, click **Link Profile/Budget Report**.

   A report is generated which shows the profile for the link with the Fresnel zone and various site/link details. The report is displayed as a tab (**Profile Report**) on the **Height Profile** window.

This picture shows an example link profile/budget report:



Link Profile/Budget Report

After you have generated your initial link profile/budget report, you can manipulate it in a number of ways:

- Select what is displayed in the report
- Print your report with an additional legend

To save the report:

1. Click the **Save** button.
2. Browse to the folder in which you want to save the report, type the filename for the report and click **Save**.

Tip: You can also copy the report and paste it into, for example, a Microsoft Word document. To do this, from the **Edit** menu, click **Copy**.

Editing What is Displayed in the Link Profile/Budget Report

When you generate a Link Profile/Budget report, by default it displays all of the available information about the selected main link.

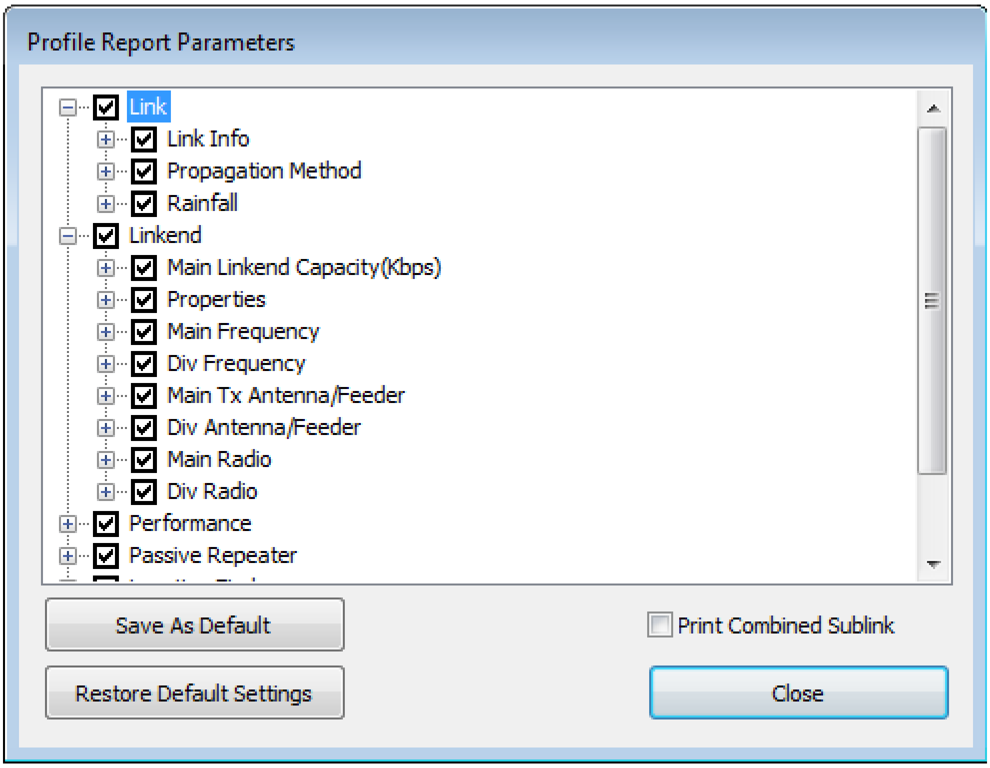
To edit what is displayed:

1. In the **Height Profile** window, from the **Tools** menu, point to **Options** and click **Profile Report Parameters**.

   – or –

   On the **Height Profile** window toolbar, click the **Select Link Profile Report Parameters** button  .

2. In the dialog box that appears, you can select the categories of information that you want to display. You can select subcategories of information, by expanding the category:

   See About the Information You Can Display in Link Profile/Budget Reports for more information on the information categories that you can choose to display.

   To return to the default (or previously saved) selection at any time, click the **Restore Default Settings** button.

3. If you are printing a report for a Dual Polar Link or a Multi-Radio Link and you want to include sublink details, select the Print Combined Sublink option:

   
.

4. When you have selected the required parameters, click the **Close** button. The **Link Profile/Budget** report is updated accordingly.

Tip: You can also set your selection as the default setting by clicking the **Save as Default** button before you click the **Close** button.

About the Information You Can Display in Link Profile/Budget Reports

In the **Profile Report Parameters** dialog box, you can choose to display a variety of information from a number of categories. This table describes the categories:

Note: Unless otherwise indicated, you can also report on these parameters in Producing Customized Link Reports on page 244.

Category – Subcategory	Information Displayed Includes
Link – Link Info	Link ID, 1st Name, 2nd Name, Link Type, Duplex Method, Header Size (bytes), Packet Size (bytes), Packet Type, Actual Latency (ms), Synchronization, Delay (ms), Length, LOS Status, LOS Request Sent, Timeslots Used, Timeslots Available **Link Report only :** Link Created Date, User Created, Link Modified Date, User Modified
Link – Propagation Method	Calculation Method, alpha, pL Value, Sa (m), dN1 (N-unit)/, Geoclimatic Factor K, Terrain Type, Climate/Terrain Factor
Link - Rainfall	ITU Climate Region/Rate, Crane Climate Region/Rate, Rain Model, % Time Rainfall
Link - Multi Radio Links (Link Report only)	Radio Config. N (how many sub-links can be added up to a maximum of 99), Radio Config. M (whether protection is in place (1) or not (0).
Linkend - Main Linkend Capacity (Kbps)	Main TDM Capacity (Kbps), Main Linkend Symmetry, Main Ethernet Capacity (Kbps), Main Total Capacity (Kbps), Main Control Overhead (Kbps), Main Available Capacity (Kbps), Capacity Status, Main Total CS Traffic, Main Total PS Traffic, Main Additional Link Traffic, Main Routed Traffic, Main Occupancy (%)
Linkend - Properties	Property ID, Location (LL, DLL or Grid), Property Height, Min LOS Height, MTTR
Linkend – Frequency (Main and Diverse)	Band, Band Duplex Method, Channel, Center Frequency, Bandwidth, Frequency Designation, Propagation Model **Link Report only :** Mast Name, Mast Type, Mast Height.
Linkend – Main Tx Antenna/Feeder, Div Antenna/Feeder	Antenna ID, Antenna Type, Antenna Size, Antenna Height, Antenna Ground Height (Link Profile/Budget Report only), Antenna Direction, Actual Elevation, Antenna Gain, EiRP (Main only), Dry Radome Loss, Wet Radome Loss, Polarization, Feeder Type, Feeder Length, Feeder Loss, Absolute Antenna Location (LL, DLL or Grid), Relative Antenna Location (LL, DLL or Grid)
Linkend - Radio (Main and Div)	Radio Type, Radio Operating Mode, Radio User Defined Latency (ms), Radio Frame Size (ms), Radio Transition Gap (ms), Min Tx Power, Max Tx Power, Tx Attenuator, Rx Attenuator, Operating Mode, Link Terminal Equipment, Threshold, Xpif Value, Tx Branching Loss, Rx Branching Loss, Tx Misc Loss, Rx Misc Loss, ATPC Value (Link Report only), Nominal Power (dB), AMC Enabled, Operating Modulation, Min Modulation, Max Modulation, Max Achievable Throughput, Required Throughput, High Priority Throughput, Required Availability, High Priority Availability, All AMC Threshold, Residual BER, RBER Threshold, SES BER, SES Threshold, Blocks Per Second, Bits Per Block
Performance – Link Budget	Total Antenna Gain, Total Antenna Loss, Total Dry Radome Loss, Total Feeder Loss, Total Branching Loss, Total Misc Loss, Freespace Loss, Atmospheric Absorption, Obstruction Loss, Total Loss, Rx Level, Linkend Antenna Gain

Category – Subcategory	Information Displayed Includes
Performance – Fade Margin	Threshold Value, Threshold Degradation, Composite Fade Margin, Flat Fade Margin, Flat Fade Margin After Interference, Req FM Against Rain, Interference Margin, Dispersive Fade Margin
Performance – Outage	Flat Outage (PnS), Selective Outage (Ps), Cross-polarization Outage (clear-air) (Pxp), Total Worst Month Outage (Pt, w/o Div) (%), Total Worst Month Outage (Pt, w/o Div) (s/yr), Total Annual Outage (Pt, w/o Div) (%), Total Annual Outage (Pt, w/o Div) (s/yr), Outage After Diversity (Pd), Improvement Factor, Total Worst Month Outage (Pt) (%), Total Worst Month Outage (Pt) (s/yr) Total Annual Outage (Pt) (%), Total Annual Outage (Pt) (s/yr)
Performance – Reliability	Rain (Pr) (%), Equipment (Pe) (%), Annual Unavailability (%), Annual Unavailability (s/yr), Annual Availability (%), Annual Availability (s/yr), Worst Month Unavailability (%), Worst Month Unavailability (s/yr), Worst Month Availability (%), Worst Month Availability (s/yr), Total Annual Unreliability (%), Total Annual Unreliability (s/yr), Total Annual Reliability (%), Total Annual Reliability (s/yr), Total Worst Month Unreliability (%), Total Worst Month Unreliability (s/yr), Total Worst Month Reliability (%), Total Worst Month Reliability (s/yr)
Performance - Adaptive Modulation	Throughput (Mbps), Availability (%), Percentage in Time of mode (%), Calculated fade margin, AMC Perf.
Performance – Objectives	Link PER, Optimum Packet Size (bytes), Optimum Available Capacity (Kbps), Objective Calculation Method, Link Grade, Link Class, Hop Length, Error Performance, ESR Objective, SESR Objective, BBER Objective, Link ESR, Link SESR, Link BBER, ES/Month, SES/Month, BBE/Month
Passive Repeater – Repeater Type	Repeater Type,
Passive Repeater – Property ID	Property ID
Passive Repeater - Repeater Mast Name (Link Report only)	Repeater Mast Name
Passive Repeater - Repeater Mast Type (Link Report only)	Repeater Mast Type
Passive Repeater - Repeater Mast Height (Link Report only)	Repeater Mast Height
Passive Repeater – Distance Calculations	Distance to Site A, Distance to Site B
Passive Repeater – Back To Back	Waveguide Length, Loss, Waveguide Loss, Link 1 Repeater (Antenna Type, Diameter, Gain, Absolute Antenna Location, Relative Antenna Location, Actual Elevation, Direction, Height AGL), Link 2 Repeater (Antenna Type, Diameter, Gain, Absolute Antenna Location, Relative Antenna Location, Actual Elevation, Direction, Height AGL)
Passive Repeater - Reflector	Width, Height, Area, Passive Center Height, Effective Area, Passive Angles (Included, Face), Reflector Angles (Azimuth, Pointing, Vertical), Gain Calculations (Passive Gain)
Location Finder - LOS (Link Profile/Budget Report only)	LOS Clearance To Ground (DTM), LOS Clearance To Clutter, LOS Clearance To Building Vectors, LOS Clearance To Building Rasters
Location Finder – Fresnel Clearance (Link Profile/Budget Report only)	Fresnel Clearance To Ground (DTM), Fresnel Clearance To Clutter, Fresnel Clearance To Building Vectors, Fresnel Clearance To Building Rasters
Location Finder – Grid Reference (Link Profile/Budget Report only)	LL, DLL, Grid
Fresnel Zone (Link Profile/Budget Report only)	Criterion #1 to Criterion #6

Category – Subcategory	Information Displayed Includes
Field Groups	Candidate Status. Select which link and linkend (Property) field values you want to display for the selected link.

Note: For passive repeater links, the antennas for the active ends of the links are displayed in accordance with the feeders selected in the Link Database.

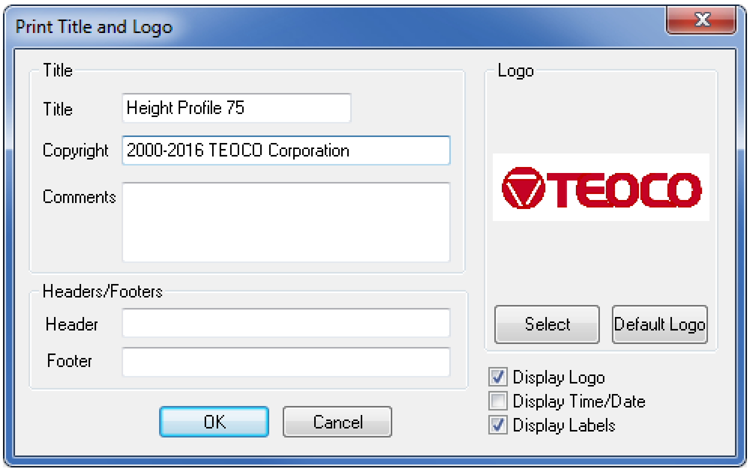
Printing Link Profile/Budget Reports

To print the contents of the Link Profile/Budget report:

1. On the **Height Profile** window toolbar, click the **Print Profile** button and specify page orientation, size, source and margins; change the printer, printer properties and number of copies. These settings default to those assigned as default by the Windows printer driver.

2. Click the **Print Title and Logo** button , and specify the following as required:
   - Title
   - Copyright
   - Comments
   - Headers/footers
   - Logos
   - Time/date
   - x/y axis labels

   This picture shows an example:



3. Click **OK**.

4. Click the **Print Preview** button before you print, so you can verify plots before sending them to the printer or plotter.

Producing Intermodulation Reports

You can generate intermodulation reports that detail:

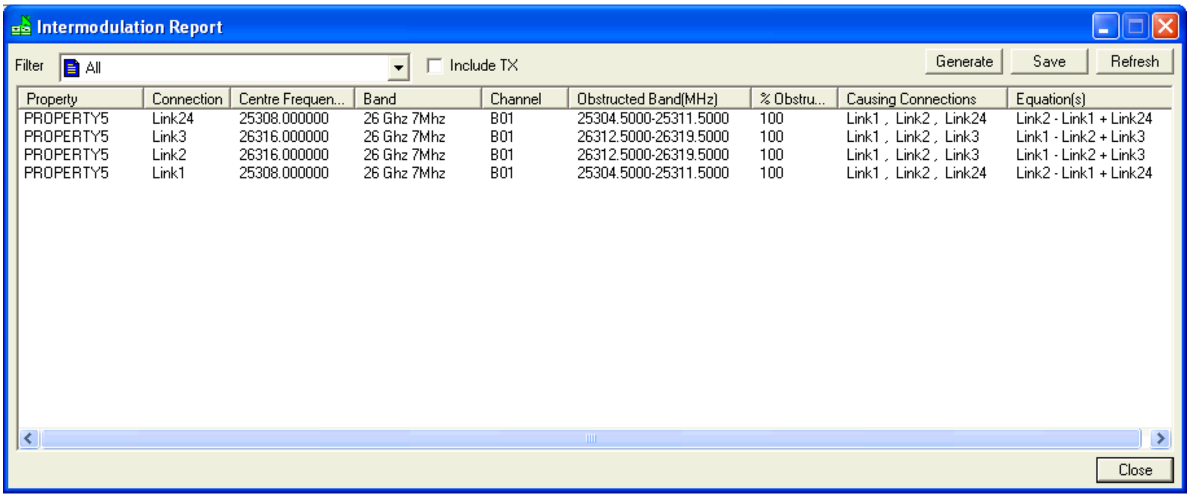
- Property ID
- Link ID for the link(s) causing intermodulation
- Center frequency
- Band ID
- Channel
- Obstructed bandwidth
- % of the bandwidth obstructed
- Causing links

By default, the table displays data for receiver obstructions only. However, you can display data for transmitter obstructions also. To do this, select the **Include Tx** checkbox.

To display a report of intermodulation data:

From the **Reports** menu, click **Intermodulation Reporter**.

This picture shows an example intermodulation report:



Example Intermodulation Report

If multiple combinations of frequencies cause a resonance within the threshold range of the link's frequency, multiple entries for each link are generated.

Saving Intermodulation Reports

To save intermodulation reports as text files (*.txt) or in Microsoft Excel (*.xls) format:

1. In the intermodulation report, click the **Save** button.
2. In the dialog box that appears, browse to the required folder, select the file type and enter a file name.
3. Click **Save**.

Filtering Data Shown in Intermodulation Reports

You can restrict the data that is displayed in an intermodulation report by using the filter boxes. There are two filters available, one for Properties and one for links.

Any filters that you have already defined are available in these boxes.

To use a filter:

Select one of the items in the appropriate filter box and click **Refresh**.

Only data included in that filter is now displayed.

Note: If you click **Abort** while the filter is processing, the data that has been filtered so far is shown.

Producing Customized Link Reports

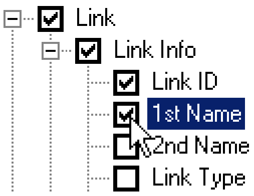
You can produce link reports containing information that you have specified (on links, linkends, link performance, passive repeaters and so on).

To do this:

1. From the **Reports** menu, click **Link Reporter**.
2. Select the filter containing the links that you want to report on.

   - or -

   To report on a particular link, select the **Select Link from 2D View** checkbox, and on the **Map View**, click the required link.
3. Specify the information you want in the report by selecting the checkboxes for the different categories as required:



Tip: The parameters available for customized link reports are very similar to those for Link Profile/Budget reports. For more information, see About the Information You Can Display in Link Profile/Budget Reports.

4. Select how the report will be generated. Choose one of these options:
    - As a single worksheet, with each linkend on a separate row
    - As a single worksheet, with both linkends for each link on the same row
    - As multiple worksheets, with each link on a separate worksheet

---

Notes:

- If you are reporting on more than 35,000 links, you can only generate the report as a single worksheet.
- If you are reporting on multi-radio and dual polar links, each sublink in the group is treated as a separate link and the report will show group ID, sub-link IDs and parameters.

---

5. Click **Generate**.

This picture shows an example link report:

Link Reporter			
Generated on: 2015-07-29 09:52:53			
Link			
Link ID		Link26	
1st Name			
2nd Name			
Link Type		Default Microwave	
Link Created Date		2006-06-13 10:59:41	
User Created		lav	
Link Modified Date		2006-06-13 11:01:33	
User Modified		lav	
Length (km)		3.16	
LOS Status		UNKNOWN	
LOS Request Sent			
Main Band		0.00	
Main Channel		512.00	
Calculation Method		ITU-R P. 530-12	
alpha		2.000000	
pL Value		N/A	
Sa(m)		7.072150	
dN1 (N-unit/km)		-185.462588	
Geoclimatic factor K		-9999.00000000	
Terrain Type		N/A	
Climate/Terrain factor		N/A	
ITU Climate Region/Rate		N	
Crane Climate Region/Rate			
Current RainModel		ITU_RAIN_MODEL	
% Time Rainfall		0.0100	
Linkend	**End A**		**End B**
Main Centre Frequency (GHz)	15.075000		14.655000
Main Bandwidth (MHz)	28.00000		28.00000
Main Frequency Designation	High		Low

Producing Hub Reports

You can generate hub reports that detail:

- Hub ID information
- Sector information, such as ID and sector layout
- Carrier information, such as ID, Tx antenna (type, height, polarization and so on), frequency (band, channel, bandwidth and so on) and radio (Tx power, threshold, Tx branching loss) information

To display a report of hub data:

1. From the **Reports** menu, click **Hub Reporter**.
2. Choose the hub you want to display a report for, either by:
   - Choosing a filter.

     – or –
   - Selecting the **Select hub from the 2D View** option, and clicking the required hub in the **Map View** window.
3. On the **Hubs & Sectors** tab, specify the hub and sector information you want in the report.
4. Click the **Carriers** tab, and specify the carrier information you want in the report.
5. Click **Generate**.

   If you have Microsoft Excel installed, the report appears in an Excel spreadsheet, otherwise it appears in a text editor.

Producing Customized Node Reports

To produce node reports containing information that you have specified.

1. From the **Reports** menu, click **Node Reporter**.
2. Select the filter containing the nodes that you want to report on.

   - or -

   To report on a particular site, select the **Select site from 2D View** checkbox, and on the **Map View**, click the required site.
3. Specify the Node, Link and LinkEnd information you want in the report then click **Generate**.

   If you have Microsoft Excel installed, the report appears in an Excel spreadsheet, otherwise it appears in a text editor. This picture shows an example:

Node Report

Generated on: 2008-12-15 14:41:52

Property	Latitude	Longitud	Link ID	Connecting	Link Type	Link Len	Radio Equi	Tx Powe	LT Equip	Antenna ID	Ant. Size	Ant. Ht.	Band
			Link3	Property33	Microwave 2E1	1.97	26GHz/ 2xE1	18.00	MUX 2xE1	PtpAntenna1	0.30	25.00	26GHz,
			Link4	Property15	Microwave 2E1	2.05	13GHz/ 2xE1	18.00	MUX 2xE1	PtpAntenna1	1.80	25.00	13GHz,
			Link3	Property2	Microwave 2E1	1.97	26GHz/ 2xE1	18.00	MUX 2xE1	PtpAntenna1	0.30	25.00	26GHz,
Property1	49°12'28.0	002°04'22.	Link0	Property41	Microwave 2E1	2.82	13GHz/ 2xE1	18.00	MUX 2xE1	PtpAntenna1	0.60	25.00	13GHz,
Property1	49°13'50.7	002°06'14.	Link2	Property20	Microwave 2E1	4.90	26GHz/ 4xE1	18.00	MUX 4xE1	PtpAntenna1	0.60	25.00	26GHz,
Property4	49°13'9.60	002°06'26.	Link1	Property20	Microwave 2E1	3.64	26GHz/ 4xE1	18.00	MUX 4xE1	PtpAntenna1	0.60	25.00	26GHz,
			Link0	Property12	Microwave 2E1	2.82	13GHz/ 2xE1	18.00	MUX 2xE1	PtpAntenna1	0.60	25.00	13GHz,
			Link4	Property31	Microwave 2E1	2.05	13GHz/ 2xE1	18.00	MUX 2xE1	PtpAntenna1	1.80	25.00	13GHz,
Property2	49°11'12.1	002°06'9.6	Link1	Property41	Microwave 2E1	3.64	26GHz/ 4xE1	18.00	MUX 4xE1	PtpAntenna1	0.60	25.00	26GHz,
			Link2	Property13	Microwave 2E1	4.90	26GHz/ 4xE1	18.00	MUX 4xE1	PtpAntenna1	0.60	25.00	26GHz,

Producing Cost Reports

To produce cost reports that contain information about the capital costs and annual operating costs of links:

1. From the **Reports** menu, click **Cost Reporter**.
2. This table shows what you can choose:

To Use	Do This
Links in a filter	1. Choose Select Filter. 2. Select the required filter. 3. Click Finish.
Links shown in an open Map View window	1. Choose Select View. 2. Click Next. 3. Click in the open Map View window. 4. Click Finish.

If you have Microsoft Excel installed, the report appears in an Excel spreadsheet, otherwise it appears in a text editor. This picture shows an example:

Cost Report

Generated on: 2008-12-15 14:24:53

Capital Costs

	Cost								
LinkID	**Installati**	**LinkTerm**	**RadioEq**	**Antenna**	**Feeder**	**Total**	**LinkType**	**Length (l**	**Capacity**
Link1	82.00	10.00	20.00	12.00	0.00	124.00	Microwav	3.64	8192
Link0	82.00	0.00	0.00	0.00	0.00	82.00	Microwav	2.82	4096
Link2	82.00	10.00	20.00	12.00	0.00	124.00	Microwav	4.90	8192
Link3	82.00	0.00	0.00	0.00	0.00	82.00	Microwav	1.97	1536
Link4	82.00	0.00	0.00	0.00	0.00	82.00	Microwav	2.05	4096
Totals:	3362.00	20.00	40.00	24.00	0.00	3446.00			

Annual Operating Costs

	Cost		
LinkID	**Mainten**	**Rental**	**Total**
Link1	25.00	728.70	753.70
Link0	25.00	563.50	588.50
Link2	25.00	979.95	1004.95
Link3	25.00	394.79	419.79
Link4	25.00	409.69	434.69

Producing Traffic Reports

You can generate traffic reports in ASSET Backhaul that detail:

- Hub ID
- Sector ID
- Number of Subscribers
- Traffic in Mbps

The traffic and the number of subscribers are taken from the logical connection.

To produce a report of traffic data:

1. From the **Reports** menu, click **Traffic Reporter**.
2. In the dialog box appears, either select a particular filter or choose to select a particular view.
3. If you have chosen to select a particular view, click **Next**, select the required view and then click **Finish**.

   - or -

   If you have selected a filter, click **Finish**.

This picture shows an example traffic report:

	A	B	C	D	E
1	Traffic Report				
2	Generated on: 09/06/01 - 14:54:35				
3	Hub ID	Sector ID	Traffic(Mbps) Uplink	Traffic(Mbps) Downlink	No. Subscribers
4	Hub1	Hub1A	250	250	50
5	Hub2	Hub2A	300	300	75
6	Hub3	Hub3A	250	250	85

Example Traffic Report

Producing User-Defined Profile Reports

After you have created a user-defined profile, you can generate a report based on its data.

To do this:

1. In the **Points** column, select the points that you want to include in the report:

Points	Distance(m)	DTM(m)	User DT...	Clutter(m)	User Clutter(m)	Building V...	Building R...	User Obst.
1	0.00	32.00	32.00	5.open_rural_land (...	5.open_rural_land (...	0.00	0.00	0.
2	581.58	63.00	63.00	12.agricultural land ...	12.agricultural land...	0.00	0.00	0.
3	1443.45	66.00	66.00	12.agricultural land ...	12.agricultural land...	0.00	0.00	20.
4	2599.61	35.00	35.00	5.open_rural_land (...	5.open_rural_land (...	0.00	0.00	0.
5	3447.45	69.00	69.00	12.agricultural land ...	12.agricultural land...	0.00	0.00	0.
6	4029.04	87.00	87.00	12.agricultural land ...	12.agricultural land...	0.00	0.00	0.
7	4610.62	85.00	85.00	5.open_rural_land (...	5.open_rural_land (...	0.00	0.00	0.

Tip: To select all of the points in the list, click Select All.

2. In the **User Defined Profile** dialog box, click **Generate Report**.
3. Browse to the required location, and type a filename for the report.
4. Click **Save**.

10 ASSET Backhaul File Formats and Examples

This chapter describes and gives examples of the file formats that are used to import and export network data to/from ASSET Backhaul.

Tip: If you have network data in a format that is not listed here, TEOCO may have a power tool that can convert this data into a compatible format. Please contact Product Support for more information.

Microwave Antenna File Formats

Microwave antennas can be imported in a number of different file formats, described in this section.

Microwave Antenna (*.txt) File Format

This table shows the microwave antenna *.txt file format that can be imported into ASSET Backhaul:

Field	Description
ID	The identification code for the antenna
Description	The brief description of the antenna
Photo File	The full filename of a photo file for the antenna
Filename	Not used
Unit Cost	The cost of the antenna
Supplier	The name of the antenna vendor
Manufacturer	The name of the antenna manufacturer
Frequency	The frequency of the antenna
Front to Back Ratio	The amount of signal emitted in the direction required compared to that in the opposite direction, providing an idea of the interference expected
Cross Polar Discrim.	Not used
Gain Type	Specifies whether the gain is referenced to an isotropic (0) or a dipole (1) antenna
Tilt Type	Specifies the type of tilt associated with the antenna, either mechanical (1) or electrical (0)
Polarization	The type of polarization associated with the antenna, horizontal (0), vertical (1) or cross-polar (2)
Gain	The actual value of the gain for the antenna
Min Op. Frequency	The minimum operating frequency of the antenna
Max Op. Frequency	The maximum operating frequency of the antenna
Diameter	The diameter of the antenna, in meters
Weight	The weight of the antenna, in kg

The text file can also contain mask data section:

Field	Description
MW Antenna ID	The identification code for the microwave antenna
Angle	The angle of the microwave antenna
VV	Indicates whether or not the antenna radiation pattern is VV – 1=Yes, 2=No
HH	Indicates whether or not the antenna radiation pattern is HH – 1=Yes, 2=No
VH	Indicates whether or not the antenna radiation pattern is VH – 1=Yes, 2=No
HV	Indicates whether or not the antenna radiation pattern is HV – 1=Yes, 2=No

Example Microwave Antenna *.txt File

This shows an extract from an example microwave antenna (*.txt) file:

```
[Name: "Antennas" FilterId: {d8369b51-5d64-11d4-80bc-00b0d0388bb2}]
ID       Description     Photo File      Filename        Unit Cost        Supplier        Manufacturer     Frequency
741324_DL_900                            0                        947.5   10       3      1        0       1        15.85
736347_DL_900                            0                        947.5   10       3      1        0       1        9
736350_DL_900                            0                        947.5   10       3      1        0       1        5.85
739619_DL_900                            0                        947.5   10       3      1        0       1        6.85
739620_DL_900                            0                        947.5   10       3      1        0       1        10.35
739630_DL_900                            0                        947.5   10       3      1        0       1        15.85
739650_DL_900                            0                        947.5   10       3      1        0       1        14.85
741320_DL_900                            0                        947.5   10       3      1        0       1        13.35
730380_DL_900                            0                        947.5   10       3      1        0       1        14.5

[Name: "Antenna Mask Data" FilterId: {d8369b52-5d64-11d4-80bc-00b0d0388bb2}]
Antenna ID      Angle   VV      HH
741324_DL_900   0       0       0
741324_DL_900   1       0.3     0
741324_DL_900   2       1       0
741324_DL_900   3       2.3     0
741324_DL_900   4       4.2     0.1
741324_DL_900   5       7       0.1
741324_DL_900   6       11.1    0.1
741324_DL_900   7       16.9    0.1
741324_DL_900   8       21.3    0.2
741324_DL_900   9       17.1    0.2
741324_DL_900   10      14.7    0.3
741324_DL_900   11      14      0.4
```

Example microwave antenna (.txt) file*

Microwave Antenna (*.mwa) File Format

This table shows the microwave antenna *.mwa file format that can be imported into ASSET Backhaul:

Field	Description
NAME	Antenna name
FREQUENCY	Frequency (MHz)
GAIN	Antenna Gain (dBi)
MIN_FREQ	Minimum operating frequency of the antenna
MAX_FREQ	Minimum operating frequency of the antenna
DIAMETER	Diameter of the antenna
COST	Cost of the antenna
COMMENTS	Additional comments
HH	Horizontal/ Horizontal Pattern (number of mapped points)

Field	Description
HV	Horizontal/ Vertical Pattern (number of mapped points)
VV	Vertical/ Vertical Pattern (number of mapped points)
VH	Vertical/Horizontal Pattern (number of mapped points)

Example Microwave Antenna *.mwa File

This shows an example microwave antenna (*.mwa) file:

```
NAME 23_GHz/0.6m

MAKE ANDREW CORPORATION

FREQUENCY 23000

GAIN 40.10 dBi

COMMENTS VHLP2-220, SINGLE POLARISATION

FRONT_TO_BACK 61

MIN_FREQ 21200

MAX_FREQ 23600

DIAMETER 0.6

POLARIZATION POL_X

COST 13000

HH      48

-180.0  -66.0

-100.0  -66.0

 -85.0  -57.0

 -61.5  -46.0

 -52.0  -42.0

 -30.0  -42.0

 -15.0  -35.0

 -10.0  -31.0

  -8.0  -28.0

  -6.0  -25.0

  -5.0  -25.0

  -4.3  -18.0

  -2.5  -10.0

  -1.3  -10.0

  -1.1   -8.0
```

```
 -1.0   -5.9
 -0.9   -4.5
 -0.8   -3.3
 -0.7   -2.5
 -0.6   -1.4
 -0.5   -0.9
 -0.3   -0.4
 -0.2   -0.1
 -0.1    0.0
  0.1    0.0
  0.2   -0.1
  0.3   -0.4
  0.5   -0.9
  0.6   -1.4
  0.7   -2.5
  0.8   -3.3
  0.9   -4.5
  1.0   -5.9
  1.1   -8.0
  1.3  -10.0
  2.5  -10.0
  4.3  -18.0
  5.0  -25.0
  6.0  -25.0
  8.0  -28.0
 10.0  -31.0
 15.0  -35.0
 30.0  -42.0
 52.0  -42.0
 61.5  -46.0
 85.0  -57.0
100.0  -66.0
180.0  -66.0
```

```
HV      0
VV      0
VH      21
-180.0  -71.0
 -85.0  -71.0
 -79.0  -66.0
 -57.0  -59.0
 -35.0  -59.0
 -25.0  -53.5
 -15.0  -51.0
  -8.0  -45.5
  -5.5  -45.5
  -2.0  -30.0
   0.0  -30.0
   2.0  -30.0
   5.5  -45.5
   8.0  -45.5
  15.0  -51.0
  25.0  -53.5
  35.0  -59.0
  57.0  -59.0
  79.0  -66.0
  85.0  -71.0
 180.0  -71.0
```

Microwave Antenna (*.nsm) File Format

The file format for *.nsm files (defined at http://www.fcc.gov/oet/info/software/nsma/nsma-intrp.html) is as follows.

Each file consists of data for one antenna at one or more frequencies:

- Each frequency consists of one or more pattern cuts
- Each pattern cut consists of a number of data points

Important: The antenna manufacturer should provide at least the required fields (described below) to ensure compliance to the standard.

File Naming

The filename is a case-insensitive, unique, 6-character ID code, which is assigned by the manufacturer with the file extension of '*.nsm', for example, '24032G.nsm'. This table describes what each part of the filename represents:

Part of Filename	Description	Valid Values
1st character	1-digit Frequency Code Number.	0-9
2nd-5th character	4-character alpha-numeric unique Manufacturer ID Number that is assigned by the manufacturer.	0000-ZZZZ
6th character	1-character Manufacturer Code that is registered with the NSMA	A, C, G, M
Extension	Standard file extension for v1 of the NSMA standard.	*.nsm

How the Required Fields are Mapped

The required fields are mapped using the following field descriptors:

Field Name	Field Descriptor	Database Column
Antenna Manufacturer	ANTMAN	Manufacturer
Antenna Model Number	MODNUM	Description
Comment	DESCR1 DESCR2	Description
FCC/ETSI ID Number	N/A	FCCID
Pattern ID Number	PATNUM	PATTERNID
Date of Data	DTDATA	Description
Manufacturer ID Number	See filename table above	Manufacturer
Frequency Range	LOWFRQ,HIGHFRQ	1st value = MinOpFreq 2nd value = MaxOpFreq **Note:** The average of these will be used as the Frequency Band for the MW antenna.
Mid-band Gain	MDGAIN	Gain
Half-power Beam Width	ELWIDT	Half-power Beam Width
Front to Back Ratio	FRTOBA	Fronttobackratio
Polarisation (char 7) + chr$(32) + datacount (char 7) + chr$(32)	POLARI	Polarization
Angle(1) (char 7) + chr$(32) + relative gain in dB(char7) + chr$(32)	NUPOIN/FSTLST	Mask Mask style

Note: For more information on the required fields, see About the Required Data Fields for NSMA Files on page 255.

The first two lines of the file will be two mandatory field descriptors:

- REVNUM - The revision number of the NSMA file format, for example, 'NSMA WG16.99.050'
- REVDATE - The revision date, in YYYYMMDD format, for example, '19990520'

The fields and values are separated by ':,' (colon comma).

How the File is Read if it does not have the Field Descriptors

If the file does not use the field descriptors for the required fields, the following constraints (according to the WG 16 recommendation) need to be considered:

- The 1st 10 lines must exist and end with both a carriage return and line feed
- Dates should be formatted as 12/31/[19]96, 31 DEC [19]96 or [19]96.12.31
- The mid-band gain should be in dBi (relative to an isotropic radiator)
- Frequency range should be in dBi (from 6525.0 - 6875.0)
- Place 'NONE' in any rows which would otherwise be blank
- All values should be left justified in their character fields
- Polarization should be formatted as [HH|HV|VV|VH|ELHH|ELHV|ELVV|ELVH] where:
    - [HH|HV|VV|VH] represents -180 degrees < Angle (x) < 180 degrees
    - [ELHH|ELHV|ELVV|ELVH] represents -90 degrees < Angle (x) < 90 degrees
    - Angle (1) < Angle (2) < ... < Angle (datacount)

  Note: [ELHH|ELHV|ELVV|ELVH] is described here for information purposes only. ASSET Backhaul does not import this value.

- Relative Gain in dB < ~0 including sign

  Note: Most values will be non-positive, though exceptions could include antennas (for example, some panel antennas) that have slightly depressed main lobes at 0 degrees. This value is relative to the mid-band gain.

About the Required Data Fields for NSMA Files

This table describes the required data fields for NSMA files:

Field Name	Format	Description
Antenna Manufacturer	30data	The name under which the data was filed with the FCC. This will not contain abbreviations.
Full Model Number	30data	The full model number used when the data was filed with the FCC. Modifiers to the model number (such as dashes or exceptions) can be included.
FCC ID Number	16data	The ID number issued by the Common Carrier Branch of the FCC. For services that do not issue ID numbers, insert 'NONE'.
Reverse Pattern ID Number	16data	The reverse pattern FCC ID number. The reserve pattern is generally obtained by inserting the feed in an opposite manner in order to reverse the pattern.
Date of Data	16data	The date referenced on the published pattern.

Field Name	Format	Description
Manufacturer ID Number	4data	The reference number assigned by the antenna manufacturer. This 4-character alpha-numeric should be included with all antenna models and should also be used to name the antenna pattern filename.
Frequency Range	16data	Identifies the full frequency range (in MHz) for which this pattern is valid, and agrees with the range specified in the printed pattern.
Mid-band Gain	16data	The gain (in dBi above an isotropic radiator) of the antenna at mid-band.
Half-power Beam Width	16data	The included angle centered on the main beam of the antenna. Defines the angle where the antenna response falls below -3dB.
Front to Back Ratio	10 data	Over the antennas operating bandwidth, this is the worst case power level in dBi between the main lobe peak and the peak of the antenna's back lobe. The back lobe peak does not necessarily point 180 degrees behind the main lobe.
Polarisation (data count)	7data,1space (7data, 1space)	The data is preceded by an indication of the polarization of the data. The commonly-accepted linear polarization designators are used: • HH - Horizontal polarized port response to a horizontally polarized signal in the horizontal direction. • HV - Horizontal polarized port response to a vertically polarized signal in the horizontal direction. • VV - Vertical polarized port response to a vertically polarized signal in the horizontal direction. • VH - Vertical polarized port response to a horizontally polarized signal in the horizontal direction. • ELHH - Horizontal polarized port response to a horizontally polarized signal in the vertical direction. • ELHV - Horizontal polarized port response to a vertically polarized signal in the vertical direction. • ELVV - Vertical polarized port response to a vertically polarized signal in the vertical direction. • ELVH - Vertical polarized port response to a horizontally polarized signal in the vertical direction. The data count is the number of data points to follow. **Important:** All 8 responses should be included. If different polarizations have identical responses, they should be duplicated. **Note:** [ELHH|ELHV|ELVV|ELVH] is described here for information purposes only. ASSET Backhaul does not import this value.

Field Name	Format	Description
Angle (response)	7data, 1space (7data, 1 space)	A full complement of data shows the antenna response in the horizontal direction for a 'horizontal cut' and in the vertical direction for a 'vertical cut'. The data is presented in 2 columns: • The angle of observation • The antenna response For the horizontal direction, the angle of observation starts at -180 degrees (the left side of the antenna), decreasing in angle to 0 degrees (the main beam) and then increasing to +180 degrees. The full data covers the 360 degrees of the antenna. For the vertical direction, the angle of observation starts from -5 (-90) degrees (the antenna response below the main beam), decreasing in angle to 0 degrees (the main beam) and then increasing to +5(+90) degrees. The full data covers the 10 (180) degrees centered about the main beam. The antenna response is listed in dB down from the main lobe response and is negative. As a minimum, the data points are the breakpoints, defining a change in the slope of the data or an adequate number of points to define a non-linear line. It is acceptable to include periodical points (for example, every 1 degree or more) between the breakpoints.

Note: This information can also be found at http://www.fcc.gov/oet/info/software/nsma/nsma-intrp.html.

NSMA File Structure for Microwave Antennas

The outline of the file structure for a *.nsm microwave antenna file is as follows (where CRLF represents Carriage Return Line Feed):

```
[Antenna Manufacturer] + CRLF

[Antenna Model Number] + CRLF

[Comment] + CRLF

[FCC ID Number] + CRLF

[Reverse Pattern ID Number] + CRLF

[Date of Data] + CRLF

[Manufacturer ID Number] + CRLF

[Frequency Range]

[Mid-band Gain]

[Half-power Beam Width]

[Front to Back Ratio]

[Polarisation (char 7) + chr$(32) + datacount (char 7) + chr$(32) + CRLF]
```

```
[Angle(1) (char 7) + chr$(32) + relative gain in dB (char 7) + chr$(32) +
CRLF]

.

.

.

[Angle(datacount) (char 7) + chr$(32) + relative gain in dB (char 7) +
chr$(32) + CRLF]

.

.

.

[Polarisation (char 7) + chr$(32) + datacount (char 7) + chr$(32) + CRLF]

[Angle(1) (char 7) + chr$(32) + relative gain in dB (char 7) + chr$(32) +
CRLF]

.

.

.

[Angle(datacount) (char 7) + chr$(32) + relative gain in dB (char 7) +
chr$(32) + CRLF]
```

Example Microwave Antenna *.nsm File with Field Descriptors

This shows an example microwave antenna (*.nsm) file with field descriptors:

REVNUM:,NSMA WG16.99.050

REVDAT:,19990520

ANTMAN:,ERICSSON

MODNUM:,ML 7/8/1 0.6m HP

PATNUM:,0621095sc11a

FEDORN:,NA

DESCR1:,UKY 210 95/SC11

DESCR2:,

DESCR3:,

DESCR4:,

DESCR5:,

DTDATA:,20060313

LOWFRQ:,7100

HGHFRQ:,8500

GUNITS:,DBI/DBR

LWGAIN:,31.0

MDGAIN:,32.0

HGGAIN:,32.7

AZWIDT:,4.2

ELWIDT:,4.2

ATVSWR:,1.29

FRTOBA:,57

ELTILT:,0

ANTWID:,0.6

PATTYP:,ENVELOPE

NOFREQ:,NA

PATFRE:,NA

NUMCUT:,4

PATCUT:,AZ

POLARI:,H/H

NUPOIN:,41

-180,-58,

-100,-57,

-70,-43,

-65,-39,

-52,-33,

-45,-33,

-35,-30,

-27,-30,

-20,-27,

-10,-19,

-5,-12,

-4.5,-12,

-4,-9.4,

-3.5,-7,

-3,-5.1,

-2.5,-3.5,

-2.1,-3,

-1.5,-1.3,

-1,-0.6,

-0.5,-0.2,

0,0,

0.5,-0.2,

1,-0.6,

1.5,-1.3,

2.1,-3,

2.5,-3.5,

3,-5.1,

3.5,-7,

4,-9.4,

4.5,-12,

5,-12,

10,-19,

20,-27,

27,-30,

35,-30,

45,-33,

52,-33,

65,-39,

70,-43,

100,-57,

180,-58,

PATCUT:,AZ

POLARI:,H/V

NUPOIN:,15

-180,-62,

-80,-62,

-70,-53,

-35,-44,

-20,-44,

-5,-34,

-1.5,-32,

0,-32,

1.5,-32,

5,-34,

20,-44,

35,-44,

70,-53,

80,-62,

180,-62,

PATCUT:,AZ

POLARI:,V/V

NUPOIN:,41

-180,-58,

-100,-57,

-70,-43,

-65,-39,

-52,-33,

-45,-33,

-35,-30,

-27,-30,

-20,-27,

-10,-19,

-5,-12,

-4.5,-12,

-4,-9.4,

-3.5,-7,

-3,-5.1,

-2.5,-3.5,

-2.1,-3,

-1.5,-1.3,

-1,-0.6,

-0.5,-0.2,

0,0,

0.5,-0.2,

1,-0.6,

1.5,-1.3,

2.1,-3,

2.5,-3.5,

3,-5.1,

3.5,-7,

4,-9.4,

4.5,-12,

5,-12,

10,-19,

20,-27,

27,-30,

35,-30,

45,-33,

52,-33,

65,-39,

70,-43,

100,-57,

180,-58,

PATCUT:,AZ

POLARI:,V/H

NUPOIN:,15

-180,-62,

-80,-62,

-70,-53,

-35,-44,

-20,-44,

-5,-34,

-1.5,-32,

0,-32,

1.5,-32,

5,-34,

20,-44,

35,-44,

70,-53,

80,-62,

180,-62,

ENDFIL:,EOF

Example Microwave Antenna *.nsm File without Field Descriptors

This shows an example microwave antenna (*.nsm) file without field descriptors:

RADIO FREQUENCY SYSTEMS

SPF 2 - 23A

2 ; PLANE POL STD PREF

21000C

N/A

2005-02-11

USA 050211

2300 - 2500 MHZ

20.5 dBi

13.8 Deg

HH 37

-180.0 -30.00

-109.0 -30.00

-61.0 -17.00

-39.0 -12.00

-14.0 -12.00

-13.0 -10.60

-12.0 -9.03

-11.0 -7.59

-10.0 -6.27

-9.0 -5.08

-8.0 -4.01

-7.0 -3.07

-6.0 -2.26

-5.0 -1.57

-4.0 -1.00

-3.0 -0.56

-2.0 -0.25

-1.0 -0.06

0.0 0.00

1.0 -0.06

2.0 -0.25

3.0 -0.56

4.0 -1.00

5.0 -1.57

6.0 -2.26

7.0 -3.07

8.0 -4.01

9.0 -5.08

10.0 -6.27

11.0 -7.59

12.0 -9.03

13.0 -10.60

14.0 -12.00

39.0 -12.00

61.0 -17.00

109.0 -30.00

180.0 -30.00

HV 7

-180.0 -31.00

-33.0 -31.00

-14.0 -25.00

0.0 -25.00

14.0 -25.00

33.0 -31.00

180.0 -31.00

VV 37

-180.0 -30.00

-109.0 -30.00

```
-61.0  -17.00
-39.0  -12.00
-14.0  -12.00
-13.0  -10.60
-12.0   -9.03
-11.0   -7.59
-10.0   -6.27
 -9.0   -5.08
 -8.0   -4.01
 -7.0   -3.07
 -6.0   -2.26
 -5.0   -1.57
 -4.0   -1.00
 -3.0   -0.56
 -2.0   -0.25
 -1.0   -0.06
  0.0    0.00
  1.0   -0.06
  2.0   -0.25
  3.0   -0.56
  4.0   -1.00
  5.0   -1.57
  6.0   -2.26
  7.0   -3.07
  8.0   -4.01
  9.0   -5.08
 10.0   -6.27
 11.0   -7.59
 12.0   -9.03
 13.0  -10.60
 14.0  -12.00
 39.0  -12.00
 61.0  -17.00
109.0  -30.00
```

180.0 -30.00

VH 7

-180.0 -31.00

-33.0 -31.00

-14.0 -25.00

0.0 -25.00

14.0 -25.00

33.0 -31.00

180.0 -31.00

PlaNet Link File Format

This section describes the file formats that are used when importing links into ASSET Backhaul using the PlaNet Link Import function. You can import three types of file.

PlaNet Microwave Database Files

The following tables provide more information on the file formats used by PlaNet to import the different link data files:

- Transmitter site (Site A)
- Receiver site (Site B)
- Link A to B
- Link X to Y / Link Y to X
- Link Y to X / Link X to Y

Transmitter Site (Site A) PlaNet File Format

This table shows the PlaNet file format used to import Transmitter Site Link data:

Identifier	Description	Type	Units
SITE_ID	Microwave site Identifier. Must not contain Tab or Space.	STRING	None
SITE_NAME	Microwave site name.	STRING	None
SITE_TYPE	Site type (for example, cell site, repeater or switch).	INT	None
LATITUDE	The latitude of the microwave site. Cannot be used at the same time as EASTING NORTHING co-ordinates.	STRING	See Lat-Long Co-ordinates
LONGITUDE	The longitude of the microwave site. Cannot be used at the same time as EASTING-NORTHING co-ordinates.	STRING	See Lat-Long Co-ordinates
NORTHING	The northing of the microwave site. Cannot be used at the same time as LATITUDE-LONGITUDE co-ordinates.	FLOAT	Grid co-ordinates

Identifier	Description	Type	Units
EASTING	The easting of the microwave site. Cannot be used at the same time as LATITUDE- LONGITUDE co-ordinates.	FLOAT	Grid co-ordinates
GND_HEIGHT	Height of the ground at the microwave site co-ordinates. If zero then DTM height is used.	STRING	None

Receiver Site (Site B) PlaNet File Format

This table shows the PlaNet file format used to import Receiver Site Link data:

Item	Description	Type	Units
SITE_ID	Microwave site identifier. Must not contain Tab or Space.	STRING	None
SITE_NAME	Microwave site name.	STRING	None
SITE_TYPE	Site type (for example, cell site, repeater or switch)	INT	None
CELL_SITE	Related cell site.	STRING	None
LATITUDE	The latitude of the microwave site. Cannot be used at the same time as EASTING-NORTHING co-ordinates.	STRING	See Lat-Long Co-ordinates
LONGITUDE	The longitude of the microwave site. Cannot be used at the same time as EASTING-NORTHING co-ordinates.	STRING	See Lat-Long Co-ordinates
NORTHING	The northing of the microwave site. Cannot be used at the same time as LATITUDE-LONGITUDE co-ordinates.	FLOAT	Grid Co-ordinates
EASTING	The easting of the microwave site. Cannot be used at the same time as LATITUDE-LONGITUDE co-ordinates.	FLOAT	Grid Co-ordinates
GND_HEIGHT	Height of the ground at the microwave site co-ordinates. If zero then DTM height is used.	FLOAT	None

Link A to B PlaNet File Format

This table shows the PlaNet file format used to import Transmitter Site Link data:

Identifier	Description	Type	Units
EQUIPMENT_A	Name of the item of equipment at the transmitter site (the first site on the link)	STRING	None
EQUIPMENT_B	Name of the item of equipment at the receiver site (the second site on the link)	STRING	None
ANTENNA_A	Name of the transmitting antenna at the transmitter site	STRING	None
ANTENNA_B	Name of the receiving antenna at the receiver site	STRING	None
ANT_HEIGHT_A	Height above ground of the transmitter antenna	FLOAT	Grid Co-ordinates
ANT_HEIGHT_B	Height above ground of the receiver antenna	FLOAT	Grid Co-ordinates

Identifier	Description	Type	Units
UPPER_ANT_HEIGHT_B	Height above ground of the upper receiver antenna	FLOAT	Grid Co-ordinates
FEEDER_A	Name of the feeder at the transmitter site	STRING	None
FEEDER_B	Name of the feeder at the receiver site	STRING	None
FEEDER_LENGTH_A	Length of the feeder at the transmitter site	FLOAT	Grid Co-ordinates
FEEDER_LENGTH_B	Length of the feeder at the receiver site	FLOAT	Grid Co-ordinates
TX_LOSS_A	Loss for the transmitter for the link A to B	FLOAT	dB
RX_LOSS_A	Loss for the receiver for the link B to A	FLOAT	dB
TX_LOSS_B	Loss for the transmitter for the link B to A	FLOAT	dB
RX_LOSS_B	Loss for the receiver for the link A to B	FLOAT	dB
CHANNEL	Channel of the links AB and BA	INT	Enumeration
HALF_BAND	Half-band (Low/Up) for the link A to B	INT	Enumeration
POLARIZATION	Polarization (Horizontal/Vertical) for the links A to B and B to A	INT	Enumeration
RAIN_INTENSITY	Rain rate exceeded for 0.01% of the time	FLOAT	mm/h
DFM	Dispersive fade margin	FLOAT	dB
STATUS_1	Status Field 1	STRING	Status Field
STATUS_2	Status Field 2	STRING	Status Field
STATUS_3	Status Field 3	STRING	Status Field
STATUS_4	Status Field 4	STRING	Status Field
STATUS_5	Status Field 5	STRING	Status Field
STATUS_6	Status Field 6	STRING	Status Field
STATUS_7	Status Field 7	STRING	Status Field
STATUS_8	Status Field 8	STRING	Status Field
STATUS_9	Status Field 9	STRING	Status Field
STATUS_10	Status Field 10	STRING	Status Field
CALL_SIGN	Microwave link call sign	STRING	None
LICENSEE	Microwave link licensee	STRING	None
OWNER	Microwave link owner	STRING	None
CONTACT_PERSON	Microwave link contact person	STRING	None
PHONE_NUMBER	Contact person’s telephone number	STRING	None
OPERATOR_NAME	Microwave link operator name	STRING	None
RADIO_MODEL	Name of the microwave radio model	STRING	None

For a duplex link X to Y, the microwave (link) database contains two links, X to Y and Y to X, but only one link is required to define the duplex link. The following displays the equality between the different fields.

Link X to Y / Link Y to X PlaNet File Format

This table shows the PlaNet file format used to import Transmitter Site Link data:

SITE A (SITE B)	=	SITE B (SITE A)
EQUIPMENT_A (EQUIPMENT_B)	=	EQUIPMENT_B (EQUIPMENT_A)
ANTENNA_A (ANTENNA_B)	=	ANTENNA_B (ANTENNA_A)
ANT_HEIGHT_A (ANT_HEIGHT_B)	=	ANT_HEIGHT_B (ANT_HEIGHT_A)

Link Y to X / Link X to Y PlaNet File Format

This table shows the PlaNet file format used to import Transmitter Site Link data:

FEEDER_A (FEEDER_B)	=	FEEDER_B (FEEDER_A)
FEEDER-LENGTH_A (FEEDER-L._B)	=	FEEDER-LENGTH_B (FEEDER-L._A)
TX_LOSS_A (TX_LOSS_B)	=	TX_LOSS_B (TX_LOSS_A)
RX_LOSS_A (RX_LOSS_B)	=	RX_LOSS_B (RX_LOSS_A)
HALF_BAND = Low (Up) HALF_BAND	=	Up (Low)
Other fields	=	Other fields

Note: Two different formats are supported for Lat-Long co-ordinates:

- DDD°MM'SS.S"X (Degrees, Minutes, Seconds, X = N/S/E/W)
  For example, 112°34'12.6"N or 56°23'13.2"S
- DD.DDDDDD (Decimal degrees)
  For example, 112.57 or -56.386944

Example Microwave Database PlaNet Format File

An example microwave database file is shown here:

```
mw01 0 446790.78125 5414224.00000 mw06 0 449863.15625

50.00000 60.00000 EW_23 EW_23 0.00000 0.00000 17.00000 0.00000

0.00000 0.00000 53 1 0 33 Yes 23 2*2 G Apple Sheffield O NULL

mw06 0 449863.15625 5414872.50000 mw01 446790.78125 5414224.00000

NORKA_2_23 NORKA_2_23 ValuLine ValuLine 50.00000 50.00000 60.00000

EW_23 EW_23 0.00000 0.00000 0.00000 0.00000 17.00000 0.00000 53 0

0 33 Yes 23 2*2 G Apple Sheffield O NULL

5414872.50000 NORKA_2_23 NORKA_2_23 ValuLine ValuLine 50.00000
```

The file uses the following fields (reading left to right):

SITE_ID	SITE_TYPE	NORTHING	EASTING
SITE_ID	SITE_TYPE	NORTHING	EASTING
EQUIPMENT_A	EQUIPMENT_B	ANTENNA_A	ANTENNA_B
ANT_HEIGHT_A	ANT_HEIGHT_B	UPPER_ANT_HEIGHT_B	FEEDER_A
FEEDER_B	FEEDER_LENGTH_A	FEEDER_LENGTH_B	TX_LOSS_A
RX_LOSS_A	TX_LOSS_B	RX_LOSS_B	CHANNEL

HALF_BAND	POLARIZATION	RAIN_INTENSITY	STATUS_1
STATUS_2	STATUS_3	STATUS_4	STATUS_5
STATUS_6	STATUS_7	PHONE_NUMBER	

Note: All fields are *Tab* separated. Words within the same field are *Space* separated.

PlaNet Status Files

The following table shows the PlaNet file format used to import Status File data. All fields are *Space* separated. If a group of words is to be read as one field then it must be enclosed in double quotation marks.

Line	Status	Database	Status	Database	Status	Database
1	"Update No"	No	"Update Yes"	Yes		
2	23GHz	23	38GHz	38		
3	2*2MBit/s	2*2	2*4MBit/s	2*4		
4	Green	G	Red	R	Blue	B
5	Apple	Apple	Pear	Pear	Apricot	Apricot
6	Sheffield	Sheffield	Norfolk	Norfolk	Bristol	Bristol
7	West	W	North	N	South	S

In the example table above, if *No* is read from the database for a STATUS_1 field then the first line of fields will be set to *Update No*. If *B* is read for a STATUS_4 field then the second line of fields will be set to *Blue*.

Example PlaNet Status File

This shows an example PlaNet file for importing Status File data:

```
"Update No" No "Update Yes" Yes

23GHz 23 38GHz 38

2*2MBit/s 2*2 2*4MBit/s 2*4

Green G Red R Blue B

Apple Apple Pear Pear Apricot Apricot

Sheffield Sheffield Norfolk Norfolk Bristol Bristol

West W North N South S
```

The format file for the database must contain the following lines:

```
[...]

STATUS_1

STATUS_2

STATUS_3

STATUS_4
```

```
STATUS_5

STATUS_6

STATUS_7

[...]
```

PlaNet Database Files

The following tables provide more information on the file formats used by PlaNet to import the different database data files:

- Equipment database
- Feeder database
- Frequency planning database

Equipment Database PlaNet File Format

The Equipment Database PlaNet file is an ASCII file containing a list of equipment. There is a separate line for each item of equipment and fields are *Space* separated. For example:

```
NORKA_2_23 17 -85 -99.8 23 3.5 FSK 4 1

NORKA_2_38 16 -83 -97.3 38 3.5 FSK 4 1

SAT1G_4_23 19 -85 -99 23 7 FSK 8 1

SAT1G_4_38 18 -81.5 -94 38 7 FSK 8 1

Urbi_23_A 17 -85 -96 23 3.5 4_FSK 4 1

Urbi_38_A 16 -82 -92 38 3.5 4_FSK 4 1

Urbi_38_C 16.5 -77 -92 38 14 4_FSK 8 1
```

The database fields are arranged as follows:

Field	Storage	Description
Name	STRING	Equipment name.
Transmitter Power (dBm)	FLOAT	Power at the transmitter.
Rx Threshold (dBm)	FLOAT	Outage level of the receiver.
Thermal Noise (dBm)	FLOAT	Thermal noise of the receiver.
Frequency Range (GHz)	INT	Frequency range of the equipment.
Channel Bandwidth (MHz)	FLOAT	Bandwidth of a channel.
Capacity (Mbit/s)	INT	Capacity of the equipment.
Modulation Type	STRING	Information purposes only.
Equipment Type	INT	Duplex (1) or simplex (0).

Feeder Database PlaNet File Format

The Feeder Database PlaNet file is an ASCII file containing a list of feeders. There is a separate line for each feeder and fields are *Space* separated. For example:

```
EW_23 23 0.2
EW_38 38 0.65
Sans_perte_23 23 0
Sans_perte_38 38 0
WR_23 23 0.4
WR_38 38 0.7
```

The database fields are arranged as follows:

Field	Storage	Description
Name	STRING	Name of the feeder.
Frequency Range (GHz)	INT	Frequency range of the feeder.
Feeder Loss (dB/m or dB/100ft)	FLOAT	Used to compute line loss.

Frequency Planning Database PlaNet File Format

The Frequency Planning Database PlaNet file is an ASCII file containing a list of frequency planning details. There is a separate line for each frequency plan and fields are Space separated. For example:

```
23_C 23 22001.000000 3.500000 139 53 57 1008.000000

23_D 23 21999.250000 7.000000 69 27 32 1008.000000

38_A 38 37014.250000 3.500000 25 9 10 1260.000000

38_B 38 37012.500000 7.000000 55 49 54 1260.000000

38_C 38 37009.000000 14.000000 60 25 27 1260.000000
```

The database fields are arranged as follows:

Field	Storage	Description
Name	STRING	Name of the frequency plan.
Frequency Range (GHz)	INT	Frequency range of the frequency.
Reference Frequency (MHz)	FLOAT	Reference frequency.
Channel Bandwidth	FLOAT	Channel bandwidth.
Number of Channels	INT	Maximum number of channels available.
Lower Channel	INT	First allowable channel.
Upper Channel	INT	Last allowable channel.
Duplex separation (MHz)	FLOAT	Duplex separation.

MapInfo Export File Formats

This section describes the file formats ENTERPRISE uses when a link (and its associated Property) is exported from an ENTERPRISE project to a MapInfo format *.mif file or MapInfo format *.mid file.

Map Info *.mif File for Links

The *.mif file begins as follows:

Version 300

Charset "WindowsLatin1"

Index 1

CoordSys Earth Projection 1,0

The next line is

Columns n

Where *n* is the number of field groups (actually the number of field groups minus 1, plus one for the LinkID). This also indicates how many tab separated fields that will appear in the *.mid file.

The next line is

ID Char (32)

Which is the mandatory entry for the ID. Then on the subsequent lines come the names of the field groups appended by *Char(32)*, for example:

x Char(32)

y Char(32)

etc.

The line after the last field group is

Data

Then the following two lines are used per link:

LINE *n n n n*

PEN (1, 0, 255)

When *n n n n* are the coordinate values of the two ends of the link

Map Info *.mid File for Links

The *.mid file lists the link names. Also for every field group specified in the *.mif file, the *.mid file contains its value for that link. For example:

Link1 FG1A FG2A FG3B

Link 2 FG1B FG2B FG3A

Where A and B are the two possible field values.

Note: All of the entries are tab-separated, with underscores in place of parentheses and white spaces.

Map Info *.mif File for Properties

The *.mif file begins as follows:

Version 300

Charset “WindowsLatin1”

Index 1

CoordSys Earth Projection 1,0

Columns 1

ID Char(50)

Data

Then the following two lines are used per Property:

POINT *n n*

SYMBOL (34, 2, 10)

When *n n* are the co-ordinate values of the Property.

Map Info *.mid File for Properties

The *.mid file lists the Property names.

Radio Equipment File Formats

In ASSET Backhaul, there are two types of radio equipment file format:

- *.raf format, used for importing Ericsson radio equipment
- *.txt format, used for importing and exporting radio equipment

Ericsson Radio Equipment File Format

The file format for Ericsson radio equipment (*.raf) files is described below. The first word on a line is the field name, which is then followed by a tab space, and then its value.

```
PLW40_RADIOSPEC   // This is the filename

MANUFACT    Ericsson

MODEL MLTN 7/2X 155_128-X

COMMENT_1   Output Power

COMMENT_2   Version            >>>Range<<<

COMMENT_3   Standard:   -5 to +26 dBm

COMMENT_4

COMMENT_5

EMDESIG     27M1D7W     //

RADIO_ID

MODULATION  128QAM

CAPACITY    STM1TN      //Traffic capacity
```

```
DATA_RATE   172.726     //(Mbit/s)
............................
............................
TXPOWER_DBM 26    //(dBm)
FREQ_LO_MHZ 7100  //    Depends on subband,
FREQ_HI_MHZ 7725  //    please see product catalogue...
ATPC_RANGE  31    //(dB)
USE_SIGNATURE     YES
............................
............................
BITS_BLOCK  102400
BLOCKS_SEC  1000
............................
............................
SIGNATURE_NONMINPH_10-3 22    //(dB)
SIGNATURE_DELAY_10-6    6.3   //(ns)
SIGNATURE_WIDTH_10-6    30    //(MHz)
SIGNATURE_MINPH_10-6    21    //(dB)
.............................
.............................
RXTHRESH_10-3     -78   //(dBm)
RXTHRESH_10-6     -77   //(dBm)
RESIDUAL_BER      1.0E-12     //
RXTHRESH_BER      -72   //(dBm)
SES_BER     4.00E-04    //
RXTHRESH_SES_BER  -77.9 //(dBm) Interpolation
............................
............................
<<Followed by T/I objectives tables>>
<<TX Emission values >>
```

T/I objectives tables use the following format:

```
Ttol_2E1-CQPSK    //Ttol_Capacity-ModulationsScheme
0     32
7     32
```

```
14    21
21    -12
28    -13
35    -19
42    -24
56    -24
```

Tx emissions (or transmitter spectrum limits) use the following format:

```
TX_EMISSION 8     // Transmitter spectrum limits
0     2     // Offset in MHz from carrier frequency / dBc
12    2
14.5  -10
15.5  -32   // EN 302 217-2-2 v1.1.13
17    -36   // 6, 7, 8 & 10 GHz, System B.3/Class 5B (ACCP/CCDP)
40    -45   // 128QAM / STM-1 / 28 MHz channel spacing
50    -55
70    -55
```

For more information on how these fields are mapped into ASSET Backhaul, see How Ericsson Radio Fields are Mapped into ASSET Backhaul on page 276.

How Ericsson Radio Fields are Mapped into ASSET Backhaul

When importing an Ericsson radio, ASSET Backhaul maps the fields in the *.raf file as follows:

Note: ASSET Backhaul only imports the fields listed below. Any other fields in the *.raf file are ignored.

This table shows the fields that are mapped to the RADIOEQUIP database table:

Ericsson File Field	Database Column
MANUFACT	MANUFACTURER
MODEL	IDNAME
COMMENT_1 to COMMENT_5	DESCRIPTION **Note:** Ericsson field values are concatenated with a space.
COMMENT_3	Min Value = MINPOWER Max Value = MAXPOWER
RADIO_ID	FAMILY
CAPACITY	CHANNELCAPACITYENUM
MODULATION	MODULATION

Ericsson File Field	Database Column
CHANNELBW_MHZ	FREQBW
TXPOWER_DBM	MAXPOWER
FREQ_LO_MHZ	MINOPFREQ
FREQ_HI_MHZ	MAXOPFREQ
ATPC_RANGE	ATPCRANGE
Ttol_COCHAN_LIKE	TIOBJECTIVES
USE_SIGNATURE	SELECTIVE
XPIF	XPIFVALUE
BITS_BLOCK	BITSPERBLOCK
BLOCKS_SEC	BLOCKSPERSECOND
SIGNATURE_DELAY_10-6	TAUM
SIGNATURE_DELAY_10-6	TAUNM
SIGNATURE_WIDTH_10-6	WM/1000 (as ASSET Backhaul takes GHz)
SIGNATURE_WIDTH_10-6	WNM/1000 (as ASSET Backhaul takes GHz)
SIGNATURE_MINPH_10-6	BM
SIGNATURE_NOMINPH_10-6	BNM
DIFPFM_10-3	AD
RXTHRESH_10-3	THRESH1DB / THRESH1BER
RXTHRESH_10-6	THRESH2DB / THRESH2BER
RESIDUAL_BER	RESIDUALBER
RXTHRESHOLD_BER	RBERTHRESHOLD
SES_BER	SBER
RXTHRESH_SES_BER	SESTHRESHOLD

Notes:

- If BITS_BLOCK and/or BLOCKS_SEC are 0 or less, then ASSET Backhaul replaces them with an approximated value
- If RESIDUAL_BER, SES_BER, RXTHRESHOLD_BER, RXTHRESH_SES_BER are not specified or 0, then ASSET Backhaul replaces them with an approximated value
- If any of the values RESIDUAL_BER, SES_BER, RXTHRESHOLD_BER, RXTHRESH_SES_BER, BITS_BLOCK and/or BLOCKS_SEC are missing, then the values which are present from this group are used to calculate the missing ones. For example, if BITS_BLOCK has been specified, then this is used to calculate BLOCKS_SEC and vice versa. For more information, see Approximation Method for Calculating ESR, SESR and BBER on page 292.

To map the T/I objectives, the table name is split into three components. If you take for example, the Ericsson field value Ttol_2E1-CQPSK, the 2E1 represents the number of channels multiplied by the hierarchical bit rate (SDH/PDH), in others words, 2 channels multiplied by the hierarchical bit rate of 64kbit/s for SDH.

This table shows how these fields would be mapped to the CIOBJ table.

Ericsson File Field	Database Column
2	INTFNOCHANNEL

E1	INTFCHANNELCAPACITYENUM
CQPSK	INTFMODTYPE

This table shows how each row of data for a T/I objective is mapped to the CIOBJENTRY table:

Ericsson File Field	Database Column
1st value (for example, 7)	FREQSEP
2nd value (for example, 32)	CIOBJECTIVE

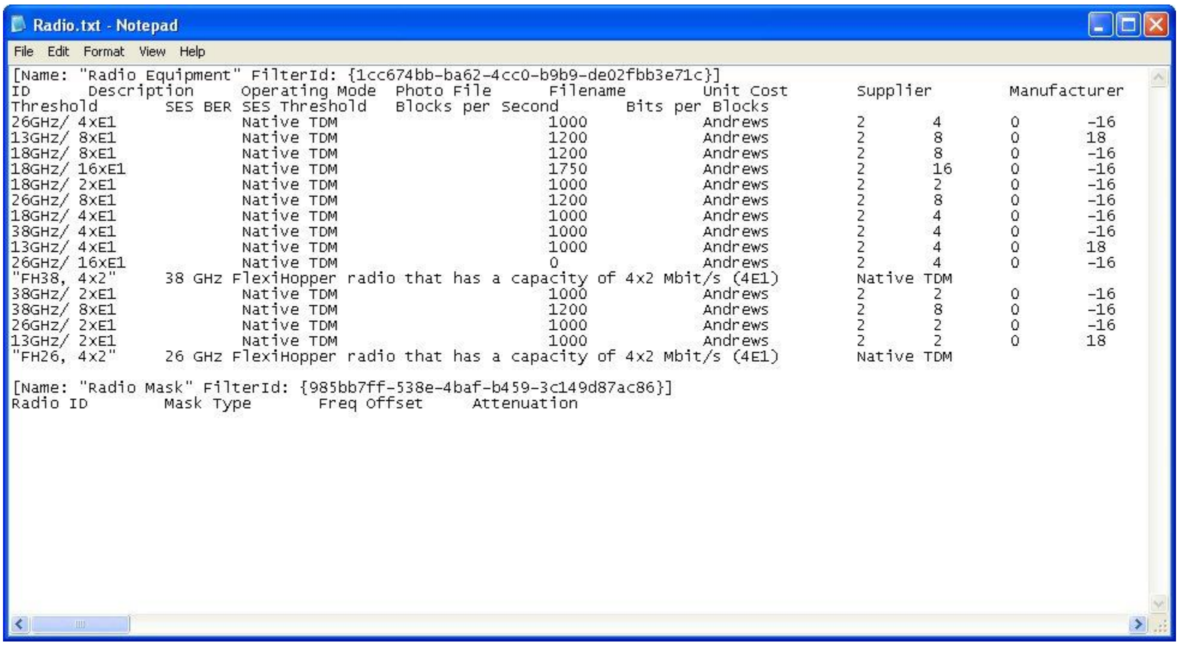
This table shows how each row of data for a Tx emission is mapped to the RADIOMASK table:

Ericsson File Field	Database Column
1st value (for example, 12)	OFFSETVALUE **Important:** In the Ericsson file field, this value is stored as MHz, so must be multiplied by 1 million to map to the existing functionality.
2nd value (for example, 2)	ATTENVALUE

Note: In the RADIOMASK table, the MASKTYPE value will always be 0 (representing 'transmit') for a Tx emission.

Radio Equipment Export File Format

This picture shows an example radio equipment (*.txt) file:



```
Radio.txt - Notepad
File  Edit  Format  View  Help
[Name: "Radio Equipment" FilterId: {1cc674bb-ba62-4cc0-b9b9-de02fbb3e71c}]
ID      Description      Operating Mode  Photo File      Filename        Unit Cost       Supplier        Manufacturer
Threshold       SES BER SES Threshold   Blocks per Second       Bits per Blocks
26GHz/ 4xE1             Native TDM                      1000            Andrews         2       4       0       -16
13GHz/ 8xE1             Native TDM                      1200            Andrews         2       8       0       18
18GHz/ 8xE1             Native TDM                      1200            Andrews         2       8       0       -16
18GHz/ 16xE1            Native TDM                      1750            Andrews         2       16      0       -16
18GHz/ 2xE1             Native TDM                      1000            Andrews         2       2       0       -16
26GHz/ 8xE1             Native TDM                      1200            Andrews         2       8       0       -16
18GHz/ 4xE1             Native TDM                      1000            Andrews         2       4       0       -16
38GHz/ 4xE1             Native TDM                      1000            Andrews         2       4       0       -16
13GHz/ 4xE1             Native TDM                      1000            Andrews         2       4       0       18
26GHz/ 16xE1            Native TDM                      0               Andrews         2       4       0       -16
"FH38, 4x2"     38 GHz FlexiHopper radio that has a capacity of 4x2 Mbit/s (4E1)        Native TDM
38GHz/ 2xE1             Native TDM                      1000            Andrews         2       2       0       -16
38GHz/ 8xE1             Native TDM                      1200            Andrews         2       8       0       -16
26GHz/ 2xE1             Native TDM                      1000            Andrews         2       2       0       -16
13GHz/ 2xE1             Native TDM                      1000            Andrews         2       2       0       18
"FH26, 4x2"     26 GHz FlexiHopper radio that has a capacity of 4x2 Mbit/s (4E1)        Native TDM

[Name: "Radio Mask" FilterId: {985bb7ff-538e-4baf-b459-3c149d87ac86}]
Radio ID        Mask Type       Freq Offset     Attenuation
```

Radio Equipment Text File

This table shows some radio equipment parameters:

Parameter	"FH38, 4x2"	"FH26, 4x2"
ID	"FH38, 4x2"	"FH26, 4x2"
Description	38 GHz FlexiHopper radio that has a capacity of 4x2 Mbit/s (4E1)	26 GHz FlexiHopper radio that has a capacity of 4x2 Mbit/s (4E1)
Operating Mode	Native TDM	Native TDM
Photo File		
Filename		
Unit Cost	0	
Supplier		
Manufacturer	Nokia	Nokia
Family (Radio Config)	Flexihopper	Flexihopper
Channel Capacity (Radio Config)	2	2
Channels	4	4
Protected	0	0
Min Power	-7	-7
Max Power	16	18
Thresh 1 (dB)	-88	-88
Thresh 2[6] (dB)	-85	-85
Thresh 1 (BER)	3	3
Thresh 2 (BER)	6	6
MTBF	30	30
Noise Figure	0	0
Noise Temperature	0	0
FKTB	-100	-100
Frequency Band	38000	26000
Min Op Freq	37000	24500
Max Op Freq	39500	26500
Freq BW	7	7
Single Value	0	0
MOU Single Rx	0	0
MOU Hot SB Rx	3	3
MOU Hot SB + Space Div. Rx	5	5
MOU OnePlusOne Rx	3	3
MOU OnePlusTwo Rx	6	6
MOU n+m (Single Ant.) Rx	0	0
MOU n+m (Dual Ant.) Rx	0	0
Selective Defined	0	0
Approx Select Defined	0	0
Dispersive Defined	0	0
Wm	30	30
Bm	30	30
TAUm	240	240

Parameter	"FH38, 4x2"	"FH26, 4x2"
Wnm	30	30
Bnm	30	30
TAUnm	240	240
Modulation	Undefined	Undefined
Kn	1	1
Equalizer	0	0
Kn Ratio	1	1
Use Msm Ad	1	0
Wm	1	0
MOU Single Tx	0	0
MOU Hot SB Tx	3	3
MOU Hot SB + Space Div. Tx	3	3
MOU OnePlusOne Tx	3	3
MOU OnePlusTwo Tx	6	6
MOU n+m (Single Ant.) Tx	0	0
MOU n+m (Dual Ant.) Tx	0	0
Radio Type	0	0
Duplexing Method	0	0
Weight	0	0
Use Xpic	0	0
Xpif Value	0	0
ATPC Range	0	0
ATPC Override	0	0
TI Object	0	0
Traffic Channel	0	0
Capacity Type	E1	E1
Multi Radio Compatible	0	0
Modulation Type	Undefined	Undefined
AMC Compatible	0	0
Adaptive Modulation Type	Undefined	Undefined
Selected AMCs		
AMC Thresholds		
Max IP Capacity	0	0
Max Radio Capacity	8192	8192
Residual BER	1e-12	1e-12
RBER Threshold	-79	-79
SES BER	3.869e-4	3.869e-4
SES Threshold	-87.5876	-87.5876
Blocks per Second	8000	8000
Bits per Blocks	1024	1024

This table shows some radio mask parameters:

Parameter	"FH26, 4x2"	"FH26, 4x2"
Radio ID	"FH26, 4x2"	"FH26, 4x2"
Mask Type	Tx	Tx
Freq Offset	4	5
Attenuation	10	12

Examples of T/I Objectives

This section gives some examples of T/I Objectives.

Example of T/I Objectives 1

This table gives examples of T/I objectives for the case where there is an Interferer Radio with a capacity of 4x2 and a bandwidth 7.00 MHz and a Victim Radio Model with an 8x2 capacity and a bandwidth of 14.00MHz:

Frequency Separation (MHz)	T/I Objective (dB)
0.00	15.00
3.50	14.00
7.00	8.00
10.50	-2.00
14.00	-2.00
17.50	-2.00
21.00	-3.00
24.50	-4.00
28.00	-9.00
35.00	-18.00
42.00	-30.00
84.00	-30.00

Example of T/I Objectives 2

This table gives examples of T/I objectives for the case where there is an Interferer Radio with a capacity of 4x2 and a bandwidth 7.00 MHz and a Victim Radio Model with a 16x2 capacity and a bandwidth of 28.00MHz:

Frequency Separation (MHz)	T/I Objective (dB)
0.00	19.00
3.50	18.00
7.00	17.00
10.50	13.00
14.00	4.00
17.50	3.00

Frequency Separation (MHz)	T/I Objective (dB)
21.00	1.00
24.50	-4.00
28.00	-8.00
35.00	-23.00
42.00	-30.00
84.00	-30.00

Example of T/I Objectives 3

This table gives examples of T/I objectives for the case where there is an Interferer Radio with a capacity of 8x2 and a bandwidth 14.00 MHz and a Victim Radio Model with a 4x2 capacity and a bandwidth of 7.00MHz:

Frequency Separation (MHz)	T/I Objective (dB)
0.00	15.00
3.50	13.00
7.00	6.00
10.50	-8.00
14.00	-27.00
17.50	-30.00
84.00	-30.00

Example of T/I Objectives 4

This table gives examples of T/I objectives for the case where there is an interferer radio and a victim radio model with an 8x2 capacity and a bandwidth of 14.00MHz:

Frequency Separation (MHz)	T/I Objective (dB)
0.00	16.00
3.50	13.00
7.00	10.00
10.50	5.00
14.00	-2.00
17.50	-3.00
21.00	-4.00
24.50	-6.00
28.00	-8.00
35.00	-15.00
42.00	-24.00
49.00	-30.00
84.00	-30.00

Example of T/I Objectives 5

This table gives examples of T/I objectives for the case where there is an interferer radio with a capacity of 8x2 and a bandwidth 14.00 MHz and a victim radio model with a 16x2 capacity and a bandwidth of 28.00MHz:

Frequency Separation (MHz)	T/I Objective (dB)
0.00	15.00
3.50	14.00
7.00	13.00
10.50	11.00
14.00	8.00
17.50	2.00
21.00	0.00
24.50	-2.00
28.00	-6.00
35.00	-22.00
42.00	-30.00
84.00	-30.00

Example of T/I Objectives 6

This table gives examples of T/I objectives for the case where there is an interferer radio with a capacity of 16x2 and a bandwidth 28.00 MHz and a victim radio model with a 4x2 capacity and a bandwidth of 7.00MHz:

Frequency Separation (MHz)	T/I Objective (dB)
0.00	15.00
3.50	13.00
7.00	11.00
10.50	8.00
14.00	-3.00
17.50	-15.00
21.00	-19.00
24.50	-22.00
28.00	-27.00
35.00	-30.00
84.00	-30.00

Example of T/I Objectives 7

This table gives examples of T/I objectives for the case where there is an interferer radio with a capacity of 16x2 and a bandwidth 28.00 MHz and a victim radio model with an 8x2 capacity and a bandwidth of 14.00MHz:

Frequency Separation (MHz)	T/I Objective (dB)
0.00	14.00
3.50	13.00
7.00	13.00
10.50	11.00
14.00	7.00
17.50	-2.00
21.00	-3.00
24.50	-5.00
28.00	-7.00
35.00	-13.00
42.00	-21.00
49.00	-30.00
84.00	-30.00

11 ASSET Backhaul Calculations

This section describes the calculations that are used to produce the values that are shown within ASSET Backhaul.

International Specifications Supported by ASSET Backhaul

This table outlines the international specifications that are supported by ASSET Backhaul:

Radio/Performance Factor	Recommendation/Specification	Additional Referenced Specifications
Free Space Loss	ITU-R PN.525-2	
Multipath Fading	ITU-R P.530-15 ITU-R P.530-12 ITU-R P.530-7 Vigants Barnett	ITU-R F.1093-1
Radio Refractive Index	ITU-R P.453-9	
Gaseous Absorption	ITU-R P.676-5	ITU-R P.836-3
Space and Frequency Diversity	ITU-R P.530-15 ITU-R P.530-12 ITU-R P.530-7	
Reduction of Cross Polar Discrimination (XPD)	ITU-R P.530-15 ITU-R P.530-12 ITU-R P.530-7	
Rain Rates and Attenuation	ITU-R P.838-3 Global Crane Attenuation Model	ITU-R P.841-4 ITU-R P.837-4
Radio Signature Parameters	ITU-R F.1093-1	
Error Performance Objectives	ITU-T G.821 ITU-T G.826 and ITU-T G.828 ITU-T Y.1541	ITU-R F.594-4 ITU-R F.695-0 ITU-R F.634-4 ITU-R F.696-2 ITU-R F.697-2 ITU-R F.557-4 ITU-R F.757-2 ITU 1668-1

Azimuth and Elevation Equations (the Spherical Method)

In the **ASSET Backhaul Preferences** dialog box, you can select to use the Spherical Method for azimuth and elevation calculations, which account for the spherical nature of the Earth.

This section describes the azimuth and elevation calculations that ASSET Backhaul uses for the Spherical Method.

Azimuth Calculations using the Spherical Method

This solution assumes that the Earth is a perfect sphere.

The spherical coordinates of the two points are End A (Lat1, Lon1) and End B (Lat2, Lon2).

The angular distance between these two points is given by:

$$b = \arccos\left[\sin(Lat2)\cdot\sin(Lat1)+\cos(Lat2)\cdot\cos(Lat1)\cdot\cos(Lon2-Lon1)\right] \quad (1)$$

Then the Azimuth for End A is given by:

$$A = \arcsin\left[\frac{\cos(Lat2)\cdot\sin(Lon2-Lon1)}{\sin(b)}\right] \quad (2)$$

The Azimuth for End B is given similar to A, reverting the Lat and Lon coordinates, i.e.

$$B = \arcsin\left[\frac{\cos(Lat1)\cdot\sin(Lon1-Lon2)}{\sin(b)}\right] \quad (3)$$

The total solution that is valid in the whole coordinate space will finally be:

If (Lat2 > Lat1) && (Lon2 > Lon1)

A = A

B = 180 - B

else if (Lat2 < Lat1) && (Lon2 < Lon1)

A = 180 – A

B = B

else if (Lat2 < Lat1) && (Lon2 > Lon1)

A = 180 – A

B = 360 + B

else if (Lat2 > Lat1) && (Lon2 < Lon1)

A = 360 + A

B = 180 - B

Elevation Calculations using the Spherical Method

The elevation calculations also need to consider the Earth's curvature. If h_1 and h_2 are the heights of the antennas for End A and B above sea level (including the ground and mast heights), then we can set as

$$R_1 = R + h_1 \quad (4)$$

$$R_2 = R + h_2 \quad (5)$$

where *R* is the Earth's radius in meters.

The distance between the two antennas is:

$$d = \sqrt{R_1^2 + R_2^2 - 2 \cdot R_1 \cdot R_2 \cdot \cos(b)} \quad (6)$$

where *b* is given above.

Therefore the elevations are given by:

$$\phi_1 = 90 - \arccos\left[\frac{R_1 - R_2 \cos(b)}{d}\right] \quad (7)$$

$$\phi_2 = 90 - \arccos\left[\frac{R_2 - R_1 \cos(b)}{d}\right] \quad (8)$$

Objectives Equations

On the **Objectives** sub-tab on the **Calculation** tab in the **Link Database**, you can both set the objective that the radio link must meet in order to allow it to insert into the end-to-end link, and also check if the link you are configuring meets the objective set.

This section describes the equations used by ASSET Backhaul to set the objectives and check if the links meet them. The equations fall into different categories, depending on which ITU recommendation they are based on:

Recommendation	Used For
ITU-T G821	Links below primary rate.
ITU-R F.1668	Real digital fixed wireless links used in hypothetical reference paths and connections.
ITU-T Y.1541	Packet-switched networks.

The following values are used in these equations:

- Errored Second (ES) – A one-second period in which one or more bits are in error or during which Loss Of Signal or Alarm Indication Signal is detected
- Severely Errored Second (SES) – A one-second period which has a Bit Error Ratio (BER) $\geq 10^{-3}$ or during which Loss Of Signal or Alarm Indication Signal is detected
- Errored Second Ratio (ESR) – The ratio of ES to total seconds in the available time during a fixed measurement interval

- Severely Errored Second Ratio (SESR) – The ratio of SES to total seconds in the available time during a fixed measurement interval

---

Note: In the Link Profile/Budget reports, the following calculated values are used:

- ES/Month, calculated as ESR Objective * 2,592,000 (the number of seconds in a 30-day month)
- SES/Month, calculated as SESR Objective * 2,592,000
- BBE/Month, calculated as BBER Objective * 2,592,000

Objectives Calculations for Links Below Primary Rate (ITU-T G821)

This section describes the equations used for calculating and testing objectives that are below the primary rate, and therefore fall under ITU-T G821. There are three grades of objectives at this rate, high, medium and local.

High Grade Objective Calculation

ITU-R F.634-4 defines how to calculate error performance objectives for High Grade links.

Currently calculations exist for links in the range 280-2500km, and links over 2500km.

For links 280-2500km, ESR and SESR objectives are calculated as follows:

- ESR should not exceed (d/2500) * 0.0032 in any month
- SESR should not exceed (d/2500) * 0.00054 in any month

For links over 2500km, the same link scaling can be used, but SESR should not exceed the objective 0.0005 + (d/2500) * 0.00004

Medium Grade Objective Calculations

ITU-R F.696-2 defines how to calculate error performance objectives for Medium Grade links.

Four Classes are defined within Medium Grade, and each has an upper link length limit. This table describes how error performance objectives are set for each class:

Performance Parameter	Fraction of time in any month			
	Class 1 (280km)	Class 2 (280km)	Class 3 (50km)	Class 4 (50km)
SESR	0.00006	0.000075	0.00002	0.00005
ESR	0.00036	0.0016	0.0016	0.004

If the link is shorter than the period of its specified class, the link should be allocated the objectives for a link having the full length of the period for that class.

For links greater than 280km length:

- For Class 1 links, use the link scaling methods for High Grade links.
- For Class 2-4 links, objectives are equal to an integer multiple of the objectives for that class for the lowest integer multiple of link lengths for that class that just exceeds the actual link length.

For example, for a Class 3 link 110km long, the period is 50km. The lowest integer multiple of 50km that is greater than 110km is 3, so ESR = 3 * ESR for Class C = 0.0048. Similarly, SESR = 0.00006.

Local Grade Objective Calculations

ITU-R F.697-2 defines how to calculate error performance objectives for Local Grade links:

- Maximum ESR allowed is 0.012 in any month
- Maximum SESR allowed is 0.00015 in any month

Objectives Calculations for Real Digital Fixed Wireless Links (ITU.R-F.1668)

This section describes the equations used for calculating and testing error performance objectives for real digital fixed wireless links used in 27,500km hypothetical reference paths and connections and therefore fall under ITU.R-F.1668.

Note: All objectives quoted are only based on the ITU recommendations, but are not set by the ITU-R.

The ITU-R divide the reference link into three sections:

- Long haul – for National to International links over large distances
- Short haul – for National links between exchanges
- Access – for the path access element

ASSET Backhaul does not deal with the long haul section, as network planners are unlikely to plan for it, but access and short haul are dealt with, and in fact use the same equations. The following equations are used:

- Access objectives equations
- Link length scaling equation
- Performance objective equation
- Actual outage equation

Long Haul Objectives Calculations

Different tables of error performance parameters are used for SDH and PDH connections. The values of these parameters are based on variable A, which is calculated using the link length and the user-defined A1 parameter (in the range 1-2%).

The algorithm for calculating A from A1 and the link length is:

$A=(A1+0.002)L_{link}/100$ for 50-100km links

$A=A1+2\times10^{-5}L_{link}$ for 100km or greater links

Once A has been calculated, error performance objectives should be calculated using the following tables.

For SDH links:

Rate (Mbit/s)	1 664 (VC-11, TC-11)	2 240 (VC-12, TC-12)	6 848 (VC-2, TC-2)	48 960 (VC-3, TC-3)	150 336 (VC-4, TC-4)
ESR	0.01 x A	0.01 x A	0.01 x A	0.02 x A	0.04 x A
SESR	0.002 x A	0.002 x A	0.002 x A	0.002 x A	0.002 x A
BBER	$5\times10^{-5}\times A$	$5\times10^{-5}\times A$	$5\times10^{-5}\times A$	$5\times10^{-5}\times A$	$1\times10^{-4}\times A$

For PDH links:

Rate (Mbit/s)	<Primary Rate	1.5 to 5	>5 to 15	>15 to 55	>55 to 160	>160 to 400
ESR	0.04A	0.04A	0.05A	0.075A	0.16A	N/A
SESR	0.002A	0.002A	0.002A	0.002A	0.002A	0.002A
BBER	N/A	$2A\times10^{-4}$	$2A\times10^{-4}$	$2A\times10^{-4}$	$2A\times10^{-4}$	$1A\times10^{-4}$

Short Haul Objectives Calculations

According to ITU 1668-1 there are no limits on link length for short-haul links and no methods are specified for scaling the link length.

Different tables of error performance parameters are used for SDH and PDH connections. The values of these parameters are based on variable B, which is calculated using the user-defined B parameter (in the range 7.5-8.5%).

Once B has been defined, error performance objectives should be calculated using the following tables.

For SDH links:

Rate (Mbit/s)	1 664 (VC-11, TC-11)	2 240 (VC-12, TC-12)	6 848 (VC-2, TC-2)	48 960 (VC-3, TC-3)	150 336 (VC-4, TC-4)
ESR	0.01 x B	0.01 x B	0.01 x B	0.02 x B	0.04 x B
SESR	0.002 x B	0.002 x B	0.002 x B	0.002 x B	0.002 x B
BBER	$5\times10^{-5}\times B$	$5\times10^{-5}\times B$	$5\times10^{-5}\times B$	$5\times10^{-5}\times B$	$1\times10^{-4}\times B$

For PDH links:

Rate (Mbit/s)	<Primary Rate	1.5 to 5	>5 to 15	>15 to 55	>55 to 160	>160 to 400
ESR	0.04B	0.04B	0.05B	0.075B	0.16B	N/A
SESR	0.002B	0.002B	0.002B	0.002B	0.002B	0.002B
BBER	N/A	$2B\times10^{-4}$	$2B\times10^{-4}$	$2B\times10^{-4}$	$2B\times10^{-4}$	$1B\times10^{-4}$

Access Objectives Calculations

ITU 1668-1 describes the objectives for the access element of the link. You can define the C parameter within the range 0.075 to 0.085 (7.5% to 8.5%), and then the error performance objectives can be calculated from the following tables.

For SDH:

Rate (Mbit/s)	**1 664** **(VC-11, TC-11)**	**2 240** **(VC-12, TC-12)**	**6 848** **(VC-2, TC-2)**	**48 960** **(VC-3, TC-3)**	**150 336** **(VC-4, TC-4)**
ESR	0.01 x C	0.01 x C	0.01 x C	0.02 x C	0.04 x C
SESR	0.002 x C	0.002 x C	0.002 x C	0.002 x C	0.002 x C
BBER	$5\times10^{-5}\times C$	$5\times10^{-5}\times C$	$5\times10^{-5}\times C$	$5\times10^{-5}\times C$	$1\times10^{-4}\times C$

For PDH:

Rate (Mbit/s)	**<Primary Rate**	**1.5 to 5**	**>5 to 15**	**>15 to 55**	**>55 to 160**	**>160 to 400**
ESR	0.04C	0.04C	0.05C	0.075C	0.16C	Not applicable
SESR	0.002C	0.002C	0.002C	0.002C	0.002C	0.002C
BBER	N/A	$2C\times10^{-4}$	$2C\times10^{-4}$	$2C\times10^{-4}$	$2C\times10^{-4}$	$1C\times10^{-4}$

Actual Outage Calculation

Using the monthly unreliability figure, the amount of seconds during a month that the link will be out is calculated as:

Outage period calculated = Total Worst Month Unreliability % / 100) x Seconds in a month

For example, for a link with total worst month reliability factor of 99.996, the unreliability = 0.004

Outage period calculated = 0.004/100 x 2678400 = 107.4

Calculating Actual ESR, SESR and BBER for Links

As well as calculating the objectives for a link based on your requirements, ASSET Backhaul calculates the actual performance of the link, in terms of its ESR, SESR and BBER.

To calculate these values, ASSET Backhaul uses the following:

- The BER value that causes a severely errored second (BER_{SES}) and its threshold (Rx_{SES})
- The residual BER (*RBER*) and its threshold (Rx_{RBER})
- Number of blocks per second (N_{blocks})
- Number of bits per block (n_{bits})

Usually these are provided by the equipment manufacturer, but if these are not available, then ASSET Backhaul will perform an approximation.

Approximation Method for Calculating ESR, SESR and BBER

When calculating the actual ESR, SESR and BBER for links, if the equipment manufacturer has not supplied values for certain parameters (BER_{SES}, Rx_{SES}, *RBER*, Rx_{RBER}, N_{blocks} and n_{bits}), then ASSET Backhaul will calculate approximate values for them.

The BER_{SES} can be estimated using the following table:

Path	Bit Rate Supported (Mbps)	BER_{SES}	N_{blocks} (Blocks/s)	n_{bits} (bits/block)
VC-11	1.5	5.4 x $10^{-4}\alpha$	2,000	832
VC-12	2	4.0 x $10^{-4}\alpha$	2,000	1,120
VC-2	6	1.3 x $10^{-4}\alpha$	2,000	3,424
VC-3	34	6.5 x $10^{-5}\alpha$	8,000	6,120
VC-4	140	2.1 x $10^{-5}\alpha$	8,000	18,792
VC-4-4c	600	5.1 x $10^{-6}\alpha$	8,000	75,168
VC-4-16c	2,400	1.1 x $10^{-6}\alpha$	8,000	300,672
VC-4-64c	9,600	8.1 x $10^{-6}\alpha$	8,000	1,202,688

Notes:

- In this table, α (the number of errors per burst) can be assumed to be 1, which corresponds to Poisson error distribution
- This table (which is taken from ITU-R F.1605) is extended for bit rates higher than VC-4 in terms of linear interpolation, using the values of VC-3 and VC-4

Tip: You can also use this table for PDH channels, using the values for the traffic rate in the table that most closely matches the one you are using.

The BER_{SES} for different bits/block is given by this formula:

$$BER_{SES} = \frac{c_B \cdot a}{n_{bits}}$$

Where

α is the number of errors per burst

c_B is a number that depends on the number of bits per block, which is n_{bits}

The number of blocks per second, N_{blocks}, and number of bits per block, n_{bits}, can be approximated, based on the table above. By using the two values for VC-3 and VC-4, since they correspond to 8,000 blocks per second, the approximate c_B for the other bit rates and the respective BER_{SES} can be calculated.

Note: ASSET Backhaul uses the TDM radio capacity/bitrate when approximating N_{blocks} and/or n_{bits} from this table.

After the BER_{SES} has been estimated, the received signal level that corresponds to that BER is calculated, using a linear interpolation in the semilog graph of received level versus BER, if that value is not given in the vendor.

The general equation to use for this is:

$$Rx_{SES} = Threshold2 + (Threshold2 - Threshold1)/(\log 10(BER2) - \log 10(BER1)) * (\log 10(BER_{SES}) - \log 10(BER2))$$

Where Rx_{SES} is the received level that causes SES.

For example, if the BERs are 10^{-6} and 10^{-3}, then the equation would be as follows:

$$Rx_{SES} = Rx_{10^{-6}} - \frac{Rx_{10^{-6}} - Rx_{10^{-3}}}{3} \cdot \left(6 + \log 10\left(BER_{SES}\right)\right)$$

Where $Rx_{10^{-6}}$ and $Rx_{10^{-3}}$ are the received level thresholds for the BER at 10^{-6} and 10^{-3} respectively.

If the residual BER (RBER) is not defined by the equipment manufacturer, then it is given the default value of 10^{-12}. Based on this, the received signal level is calculated using the general equation:

$$Rx_{RBER} = Threshold2 + (Threshold2 - Threshold1)/(\log 10(BER2) - \log 10(BER1)) * (\log 10(RBER) - \log 10(BER2))$$

For example, if the BERs are 10^{-6} and 10^{-3} again, then the equation would be as follows:

$$Rx_{RBER} = Rx_{10^{-6}} - \frac{Rx_{10^{-6}} - Rx_{10^{-3}}}{3} \cdot \left(6 + \log 10\left(RBER\right)\right)$$

Using these values, ASSET Backhaul can calculate the ESR, SESR and BBER for the links in the **Link Database**.

SESR, BBER and ESR Calculation

When you have the required parameters - Rx_{SES}, Rx_{RBER}, N_{blocks}, n_{bits} - you can calculate the *SESR*, *BBER* and *ESR*.

SESR is actually the outage percentage for the SES threshold. Therefore the fade margin F_{SES} that corresponds to the Rx_{SES} threshold is:

$$F_{SES} = Rx_{level} - Rx_{SES}$$

Where

Rx_{level} is the received signal level, as this is calculated in the Link Budget, and therefore:

$$SESR = P_t\left(BER_{SES}\right) \Rightarrow SESR = \frac{p_0 x 10^{-F_{SES}/10}}{100}$$

and p_0 is given by

$$p_0 = Kd^{3.2}(1+\left|\varepsilon_p\right|)^{-0.97}10^{0.032f - 0.00085h_L} \quad (\%)$$

K is the geoclimatic factor (set in the **Link Database**, on the **Propagation Prediction** subtab of the **Calculation** tab)

d is the link length (km)

f is the center frequency at each end (GHz)

h_L is the altitude of the lower antenna (m)

$|\varepsilon_p|$ is the magnitude of the path inclination (mrad)

Similarly, the fade margin for the BBER is calculated as:

$$F_{RBER} = Rx_{level} - Rx_{RBER}$$

$$P_{tR}\left(RBER\right) = \frac{p_0 x 10^{-F_{RBER}/10}}{100}$$

The slope m of the BER distribution curve on a log-log scale for BER in the range BER_{SES} to *RBER* is given by:

$$m = \left|\frac{\log_{10}\left(RBER\right) - \log_{10}\left(BER_{SES}\right)}{\log_{10}\left(P_{tR}\right) - \log\left(SESR\right)}\right|$$

and the *BBER* is then:

$$BBER = SESR \cdot \frac{a_1}{2.8 \cdot a_2 \cdot (m-1)} + n_{bits} \cdot RBER$$

a_1 is the number of errors per burst for the BER in the range from 10^{-3} to BER_{SES}, with a range from 1 to 30, and a_2 is the number of errors per burst for the BER in the range from BER_{SES} to

RBER, ranging from 1 to 20. n_{bits} is the number of bits per block. The values that would be used for the calculation of *BBER* would be the mean ones, in other words a_1=15, and a_2=10.

Finally, *ESR* is calculated by:

$$ESR = SESR \cdot \sqrt[m]{N_{blocks}} + n_{bits} \cdot N_{blocks} \cdot RBER$$

Where N_{blocks} is the number of blocks per second.

Objectives Calculations for Packet Switched Networks (ITU-T Y.1541)

This section describes the equations used for calculating and testing objectives for packet switched networks, which fall under ITU-T Y.1541.

Ethernet/IP Throughput Calculation

On the **Objectives** subtab of the **Performance** tab for a link in the **Link Database**, if you have chosen to map Ethernet/IP traffic over a Native TDM radio link, ASSET Backhaul calculates the available capacity that the mapped Ethernet/IP can achieve, based on the packet size and type.

It is calculated based on the following equation:

$$C_{MappedEthernet} = C_{TDM} \cdot \frac{N - N_{header}}{N}$$

Where

C_{TDM} is the available throughput over the TDM link. This is also known as the payload rate, and is based on the traffic channel type - the defined values are described in the table below.

N is the packet size in bytes.

N_{header} is the header size, which for IPv4 is 38 bytes and for IPv6 is 58 bytes.

This table shows the available throughputs/payload rates for the different traffic channel types:

Traffic Channel	Payload Rate (kbps)
E0	64
E1	1,920
E2	7,680
E3	30,720
E4	122,880
E5	491,520
T1	1,536
T2	6,144
T3	43,008
T4	258,048
J1	1,536
J2	6,144

Traffic Channel	Payload Rate (kbps)
J3	30,720
J4	92,160
J5	491,520
STS-1/STM-0	50,112
STS-3/STM-1	150,336
STS-12/STM-4	601,344
STS-9	451,008
STS-18	902,016
STS-24	1,202,688
STS-36	1,804,032
STS-48/STM-16	2,405,376
STS-192/STM-64	9,621,504
STS-768/STM-256	38,486,016

TDM Throughput Calculation

On the **Objectives** subtab of the **Performance** tab for a link in the **Link Database**, if you have chosen to map TDM traffic over a Native IP radio link, ASSET Backhaul calculates the total TDM traffic that can be delivered, as well as the number of TDM channels.

The TDM frames have to be converted into a format that can be encapsulated in IP packets. Also, the packets must contain information about the destination of the TDM frames (using a UDP header), and the interworking function (a control header that performs the mapping).

Therefore, the packet format of the TDM-mapped frames is as follows (all values are in octets):

IP Header	UDP Header	Common Interworking Function	TDM Payload
38 (IPv4) or 58 (IPv6)	8	4	*M*

Where

UDP is a method of labeling multiple voice traffic flows between two IP addresses

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Important: The TDM payload can be structure-agnostic or structure-aware. In ASSET Backhaul it is assumed that it is structure-agnostic, which means that data from one technology is mapped over the other one with the appropriate header information, irrespective of the structure of the technology.

The type of payload would have an impact on the available mapped TDM throughput.

In general, the number of octets M that a packet can contain is given by the following equation:

$M = N - \text{Control Header}$

Where

N is the packet size

Control Header is 50 or 70 bytes, depending on the packet type

The total TDM traffic that the ethernet/IP radio can accommodate is calculated using the following equation

$$C_{MappedTDM} = C_{Ethernet,IP} \cdot \frac{M}{N}$$

This can also be expressed as a number of TDM channels (L):

$$L = floor\left[\frac{C_{TDM}}{C_{channel}}\right]$$

Where

C_{TDM} is the throughput of the TDM channel (E0, E1, STM-1, STM-4 and so on)

$floor$ signifies rounding to the smallest integer

Packet Error Rate (PER) Calculation

If you have a Native IP or Hybrid IP and TDM radio link, the Packet Error Rate (PER) is displayed on the **Objectives** subtab of the **Performance** tab in the **Link Database**.

Important: A uniform error distribution is assumed. This is not realistic, because errors usually appear in bursts, and this can lead to an underestimation of the link's performance.

The PER is calculated using the following equation, which assumes that the error distribution is uniform:

$$PER = 1 - \left(1 - BER_{received}\right)^{N_{bit}}$$

Where

$BER_{received}$ is the bit error rate for the received signal

N_{bit} is the packet size in bits, which is usually given in octets as *N*, so N_{bit} is 8 x *N*

$BER_{received}$ can be estimated using the theoretical BER curves for QAM signals, assuming that the lines in the semilog graph are straight lines for BER values lower than 10^{-6}

Note: For more information, see *Fixed Broadband Wireless System Design*, by H.R. Anderson (Wiley, 2003).

In this case, the calculation would be:

$$\log_{10}\left(BER_{received}\right) = Rx_{10^{-6}} - Rx_{signal} - 6$$

Where

Rx_{signal} is the received signal according to the link budget

$Rx_{10^{-6}}$ is the receiver threshold for BER performance at 10^{-6}

Optimum Packet Size and Optimum Available Capacity Calculations

If you have a Native IP or Hybrid IP and TDM radio link, the optimum packet size (in bytes) is displayed on the **Objectives** subtab of the **Performance** tab in the **Link Database**.

Calculating the Optimum Packet Size

Based on the Packet Error Rate objective (PER_{obj}), the optimum packet size ($N_{op,bit}$) can be calculated.

PER_{obj} corresponds to the maximum packet error rate that is allowed over the link, and therefore to the maximum/optimum packet size and available capacity.

$N_{op,bit}$ is calculated as:

$$N_{op,bit} = \frac{\log(1 - PER_{obj})}{\log(1 - BER_{received})}$$

Therefore the size of the packet in octets is:

$$N_{opt} = \frac{N_{op,bit}}{8}$$

Important: If the PER is very small (so small that it can be assumed to be zero), then the calculated packet size can be quite large. However, due to constraints in delay requirements, it is unlikely that high packet sizes could be possible, especially in microwave links. Therefore, the maximum packet size that should be realistically considered in ASSET Backhaul is 1518 bytes (the Ethernet V2 frame format) - any calculated value exceeding this should be replaced with this lower value.

Calculating the Optimum Available Capacity

The optimum available capacity can be calculated as:

$$C_{\max optimum} = C_{Ethernet,IP} \cdot \left(1 - \frac{N_{header}}{N_{opt}}\right)$$

Where

$C_{Ethernet,IP}$ is the Ethernet/IP radio capacity

N_{header} is the header size in octets

Selective Fading Outage Equations

This section describes the different methods that you can use to calculate the outage caused by selective fading.

You can choose the required method on the **Signature** tab when defining radio equipment, unless you are using the Vigants method (which is chosen in the **Link Database**).

Signature Information Method

Choose the Signature Information method whenever possible, and enter signature parameters for both minimum and non-minimum phase fades.

This method is ideal for links that use high bandwidth, a particularly long hop distance or a low frequency (of less than approximately 10GHz). All of the parameters mentioned make a link sensitive to attenuation, therefore the more accurate the fading information the more realistic the radio link modeling will be.

These items are shown on the tab:

W = Minimum signature width (GHz) of the curve

B = Depth of the signature curve

TAU(*t*) = reference delay (ns) used in measurements

The suffix used for each of these parameters is used to denote either a minimum (m) or non-minimum (nm) phase condition.

Approximation Method

If no signature information is available and the outage caused by selective fading is thought to be relevant, then you should use the **Approximation Method** on the **Signature** tab.

Warning: The approximation method might give unrealistic values and therefore take care when you do use it. If you choose to use this method but do not define any values here, ASSET Backhaul will not use the approximation calculation method for selective multipath fading at all.

Note: For approximation to work, you need to have defined the corresponding modulation type, K_n and BPS (Bits Per Symbol) on the **BACKHAUL** tab of the **Preferences** dialog box, or manually type the K_n value.

The Approximation method is based on the ITU-R P.530-7 and ITU-R F. 1093-1 recommendations. The difference is that a signature constant is approximated from the specified modulation scheme or manually defined by you.

K_n value – a normalized system parameter – is characteristic of the system parameters such as modulation method, roll-off factor and type of equalizer. By using a rectangular approximation, K_n can be calculated using the following formula:

$$K_n = T^2 \times W \times \lambda_a / \tau_r$$

Where:

T	= System baud period (ns) symbol time
W	= signature width (GHz)
λ_a	= average of linear signature depth ($1-b_c(f)$)
τ_r	= reference delay for λ_a (ns)

You can choose whether an equalizer is used or not. The signal in an equalizer is monitored and corrected, lessening the interference affecting a radio signal.

Dispersive Fade Margin Method

The dispersive fade margin method is based on the fade margin approach as defined by ITU-F.1093-1. Most equipment manufacturers publish this data in the equipment specification sheets.

In ASSET Backhaul, selective fading is calculated using the ITU-R P.530-7, 530-12 or 530-15 method. The priority in which ASSET Backhaul will calculate the Dispersive Fade Margin is:

- Using the **Signature Information For Selective Multipath Fading** value.

  If the radio on the linkend is AMC-enabled, then ASSET Backhaul uses the signature values for the Operating Modulation Mode assigned on the **Radio** subtab of **Linkend Settings** tab of the **Link Database**.
- Using a default value.

Using the Signature Information For Selective Multipath Fading Value

ASSET Backhaul uses the values defined in **Signature Information** for **Selective Multipath Fading**. Dispersive fade margin will be then calculated using the following formulae:

$$S = 2\Delta f e^{\frac{-B}{3.8}}$$

$$A_D = 17.6 - 10\log\left(\frac{S}{158.4}\right)$$

Where:

Δf is signature width

B is signature depth

Using a Default Value

A default value of 40dB is used only when no signature information has been defined in the radio equipment database.

Vigants Method

You do not have to add any values on the **Signature** tab when defining Radio Equipment to use the Vigants method. You define it in the **Link Databas**e, on the **Propagation Prediction** tab.

If you are using Vigants, the average probability of outage due to multipath is given by:

$$P = 6.1 \cdot 10^{-7} \cdot c \cdot f \cdot d^3 \cdot T_0 \cdot 10^{-F/10}$$

Where:

f (GHz) is the frequency.

d (km) is the path length. This is raised to the power of 3 and hence has a significant effect on the outage and, in turn, on the performance objectives in terms of availability expectations.

F (dB) is the fade margin.

T_0 is the duration of the fading season, which may be given or calculated by:

$$c = c_{cl}(s_{rough}/15.2)^{-1.3}$$

Where**:**

c_{cl} is the climate factor

s_{rough} is the terrain roughness ($6 \le s_{rough} \le 42$)

Note: P here is a number rather than a percentage, and therefore because p_{req} is a percentage, then $p_{req} = 100 \cdot P$ and so:

$$F_{multipath} = 10 \cdot \log_{10}\left(\frac{6.1 \cdot 10^{-5} \cdot c \cdot f \cdot d^3 \cdot T_0}{p_{req}}\right)$$

For more information, see Space Diversity Engineering, A. Vigants, BSTJ, January 1975 or http://www.wmux.com/company/resource_center/disperse.html .

For more information on average probability of outage due to multipath fading, see Multipath Occurrence Factor Calculation on page 338.

Interference Equations

In ASSET Backhaul, interfering transmissions are modeled as hypothetical links established between interferers and the wanted receiver. Adjustments are made for differences in frequency and polarization where necessary.

ASSET Backhaul performs interference analysis on a per-linkend basis for each linkend included in the **Interference Wizard**. The greater the number of links, the greater the number of calculations performed.

There are a number of stages to calculating interference, described in the following sections:

1. Calculate the possibility of interference.
2. Calculate how significant the interference is.
3. Calculate the interference margin.
4. Calculate the threshold degradation.
5. Calculate the total interference.

Notes:

- For the purposes of interference calculations, in the case of multi-radio and cross-polar links, each sublink within a group is considered as a separate link.
- These calculations are generally for links using FDD. For more information on the differences for TDD links, see How Interference Is Calculated Differently for TDD Links on page 331.

Calculating the Possibility of Interference

Firstly, ASSET Backhaul must calculate whether or not a potential interfering radio's frequency is close enough to the receiving radio's frequency to cause any interference.

To do this, the following equation is used.

FO = Frequency Overlap between the receiver's Frequency Range and the interferer's Frequency Range

The Frequency Range is calculated as between Center Frequency - (Bandwidth/2) and Center Frequency + (Bandwidth/2)

- If FO is negative, then there is no overlap, and the value indicates the distance between the two ranges.
- If FO < -G, where G is the Guard Band, then the radio will cause no interference.
- If - G < FO < 0, then the radio will cause adjacent channel interference.
- If FO > 0, then the radio will cause co-channel interference.

Calculating the Significance of Interference

To calculate if the interfering radio causes significant interference, ASSET Backhaul calculates the level of interference caused.

$I_{r,t}$ = Interference received at Radio *r*, caused by Radio *t*

$$I_{r,t} = P_t + Gain_{r,t} - TotalLoss_{r,t}$$

Where

P_t = Transmit power at Radio *t*

$Gain_{r,t}$ = Total gain of the antennas at Radio *r* and Radio *t*

$TotalLoss_{r,t}$ = The sum of all losses at Radio *r* and Radio *t* - Attenuator Loss, Dry Radome Loss, Waveguide/Feeder Loss, Branching Loss, Miscellaneous Loss, Free Space Loss, Obstruction Loss, Atmospheric Absorption

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Notes:

- If you are using AMC, then the **Interference Wizard** calculates the interference based on the transmit power set for the modulation type that satisfies the capacity requirements of that link. This is shown on the **Adaptive Modulation** subtab of the **Performance** tab for a link in the **Link Database.** For more information, see Viewing Link Adaptive Modulation Performance Results on page 163.
- If you have selected to consider correlated fading in the **Interference Wizard**, the level of interference calculation is slightly different. For more information, see Calculating the Significance of Interference with Correlated Fading on page 303.

Calculating the Significance of Interference with Correlated Fading

If you have selected to consider correlated fading in the **Interference Wizard**, the level of interference calculation is slightly different:

$$I_{r,t} = P_t + Gain_{r,t} - TotalLoss_{r,t} - F_{cor}$$

Where

P_t, $Gain_{r,t}$ and $TotalLoss_{r,t}$ represent the same values

F_{cor} is correlated fading, which is calculated as:

$$F_{cor} = [(\phi\_\max - \Delta\phi)/\phi\_\max] * [(s\_\max - \Delta s)/s\_\max] * F_{\max,cor}$$

Where

$\phi\_\max$ is the maximum angle separation (degrees)

$s\_\max$ is the maximum distance separation (km)

$F_{\max,cor}$ is the maximum correlated fading (dB)

$\Delta\phi$ is the angle that the victim link is creating with the interfering linkend

Δs is the distance separation between the victim and the interfering linkend

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Note: F_{cor} should be 0 if:

- $\phi\_\max$ is less than $\Delta\phi$

  - or -

- $s\_\max$ is less than Δs

Calculating the Interference Margin

We now calculate the Interference Margin:

$$IntMar_{r,t} = TI_{r,t} - TI_{obj(r,t)}$$

Where:

$$TI_{r,t} = \frac{T_r}{I_{r,t}}$$

Where:

T_r = Threshold of Radio *r*

$TI_{obj(r,t)}$ = Value taken from the T/I Objective table for Radio *r*, given its frequency separation from the transmitting radio *t*. If no value is found, then the default value will be used.

If the Interference Margin is less than 0.0, then the interference caused by the interfering signal is significant.

ASSET Backhaul then uses the T/I Objective table for Radio *r* to estimate the amount of interference the radio can filter out and then calculate the new interference value $I'_{r,t}$, using the algorithm:

$$I'_{r,t} = I_{r,t} - (TI_{obj(r)} - TI_{obj(r,t)})$$

Where

$TI_{obj(r)}$ = Value taken from the T/I Objective table for Radio *r* with a frequency separation of 0

Note: If no T/I Objective table is found, then $TI_{obj(r,t)}$ will be equivalent to $TI_{obj(r)}$, and there will be no change in the interference level.

Calculating Threshold Degradation

The Threshold Degradation caused by an interferer is calculated as:

$$ThreshDeg_{r.t} = 10\log_{10}(10^{\frac{I'_{r,t}}{10}} + 10^{\frac{FKTB}{10}}) - FKTB$$

Where:

FKTB = The thermal noise at the receiver

Calculating Total Interference

The Total Interference received by a radio is calculated as follows:

$$I_r = 10\log_{10}\sum_{t=0}^{T} 10^{\frac{I'_{r,t}}{10}}$$

The Total Interference Margin is calculated as:

$$IntMar_r = TI_r - TI_{obj(r)}$$

Where:

$$TI_r = \frac{T_r}{I_r}$$

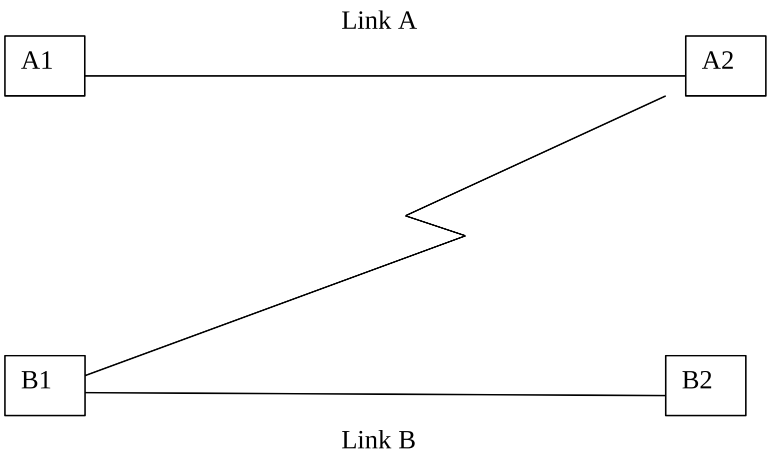
Note: ASSET Backhaul uses the T/I Objective for 0 separation, which is why the total interference value has the T/I filter applied.

The Total Threshold Degradation is calculated as:

$$ThreshDeg_r = 10\log_{10}(10^{\frac{I_r}{10}} + 10^{\frac{FKTB}{10}}) - FKTB$$

Example of Calculating Co-Channel Interference

Consider the following network:

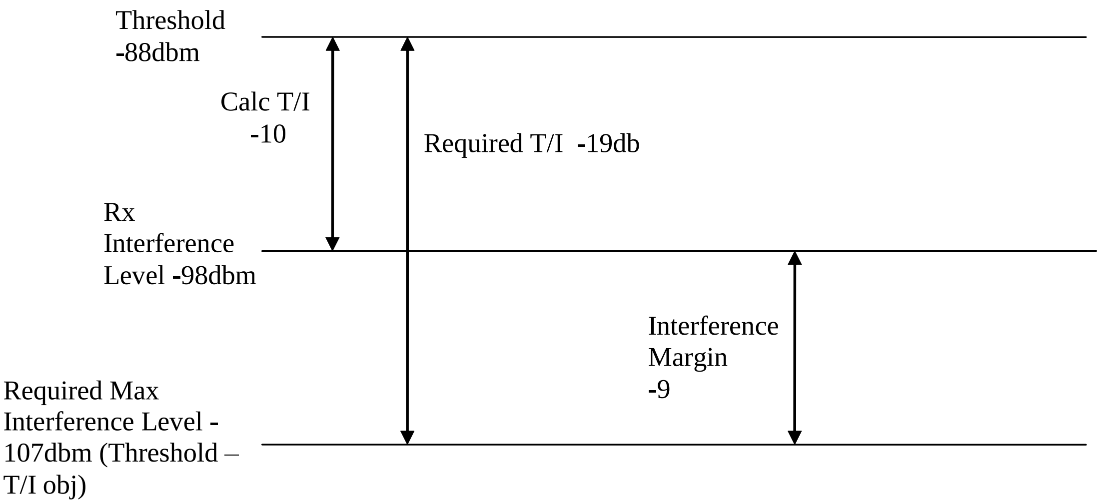


- Link A (A1-A2) is interfering with link B (B1-B2)
- The level of interference received at B1 is -98 dBm
- The threshold at B1 is 88dBm @ BER 10^{-6}
- The T/I Objective for a Co-channel at the same bandwidth is 19dB

Therefore:

- The required maximum interference level is -88 -19 = -107 dBm
- The calculated T/I is -88 - (-98) = 10
- The interference margin is -107 - (-98) = -9
- This represents significant interference

This diagram describes this example:



Example of Co-channel Interference

Example of Calculating Adjacent Channel Interference

Consider the following report, which shows interference from an adjacent channel link, Link0:

Adjacent Channel Interferers:			
Tx Link	Interference before filter discrimination (T/I)(dBm)	Interference power after filter discrimination (T/I)(dBm)	Interf. Freq. (GHz)
Link0	-45.73	-114.73	14.627000
Link6	-133.62	-202.62	14.627000
Link4	-221.33	-290.33	14.627000

Band Name	Channel Name	T/I Objective	Calc. T/I	Interf. Margin
"Band 15GHz, 16x2"	G1	-49.40	-42.27	7.13
"Band 15GHz, 16x2"	G1	-49.40	45.62	95.02
"Band 15GHz, 16x2"	G1	-49.40	133.33	182.73

According to this report:

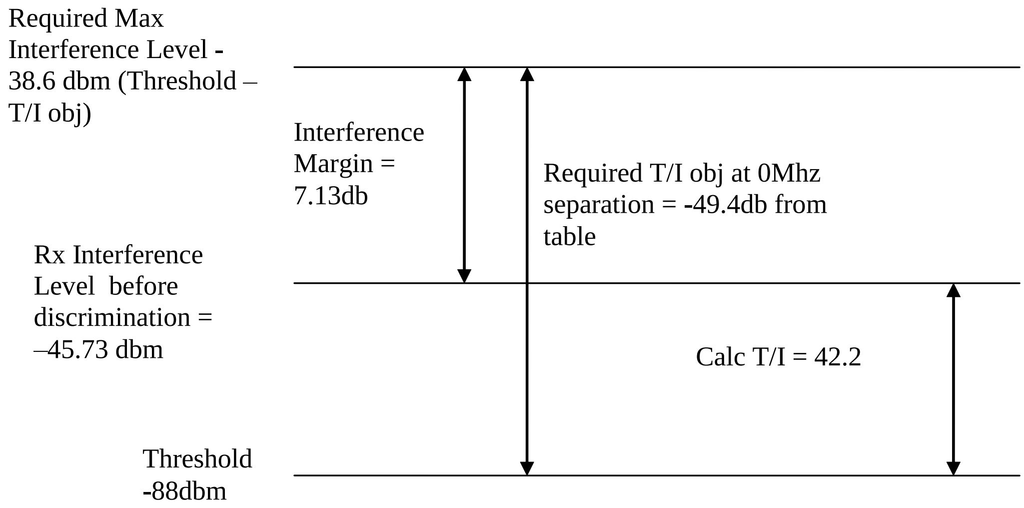
- The Interference before filter discrimination is -45.73 dBm
- The T/I Objective for 0 MHz separation is -49.40 dBm
- The Calculated T/I is -42.27 dB
- The Interference Margin is 7.13

On the **Fade Margin** subtab of the **Performance** tab, the Threshold value is set to -88 dBm @ BER 10^{-6}.

Based on these values, the interference can be calculated as:

- Calculated T/I is -88 - (-49.4) = -38.6
- Interference Margin is -38.6 - (-45.73) = 7.13
- This does not represent significant interference

This diagram describes this example:



Calculating Co-channel Interference with Dual Polar Links

If you are calculating co-channel interference using dual polar links, there are two separate modifications to the calculations, depending on whether the radio equipment of the link uses XPIF or not:

- If the radio equipment of the link uses XPIF, the interference power is reduced by the XPD and XPIF value of the radio equipment. In other words:

  New interference power = Previous interference power - XPD - XPIF

- If the radio equipment of the link does not use XPIF, the interference power is only reduced by the XPD value of the radio equipment. In other words:

  New interference power = Previous interference power – XPD

Calculating the Rx Level if ATPC is Used

If you have selected to use ATPC on a linkend, the following formula is used to calculate the Rx level:

Rx Level = Pmax + Antenna Gain - FSL - Antenna Mask Losses - ATPC - NFD

Where:

Pmax = The maximum transmit power set on the link

Antenna Gain = The isotropic gain of ends A and B

FSL = Free Space Loss

Antenna Mask Losses = Entry and exit losses

ATPC = The ATPC Range set on a link

NFD =The Net Filter Discrimination. For more information, see Calculating Mask Discrimination and Net Filter Discrimination on page 308.

Note: This formula will also be used for links that do not have ATPC set, where ATPC is set to 0.

Calculating Mask Discrimination and Net Filter Discrimination

Mask Discrimination (MD) and Net Filter Discrimination are calculated as described in Appendix 3b (Determination of the Masks Discrimination and the Net Filter Discrimination in the Fixed Service) of the HCM Agreement of Vilnius 2005. Contact the European Radiocommunications Office (ERO) for more information.

The calculation can be summarized as follows:

$$MD = 10\log\left(\frac{TxArea}{CoChannelOverlapArea}\right)$$

$$NFD = 10\log\left(\frac{CoChannelOverlapArea}{OffsetOverlapArea}\right)$$

The areas are calculated by dividing the masks up into flat (F) and slope (S) elements and using the following formulae to calculate the area for the element before summing all elements together.

$$F = \left(f_c 10^{\frac{-b}{10}} \right)$$

For the element F :

$$f_c = |f_i - f_{i+1}|$$

$$b = t_i + r_i$$

Where:

b = The sum of the attenuation of the transmitter (t_i) and receiver (r_i) masks at the beginning of an element (dB)

f_i = Frequency at the beginning and at the end of the element (MHz)

f_c = Bandwidth of the element

F = Partial elements areas under the spectrum masks in the common frequency range.

$$S = \frac{10^{-\frac{b}{10}}}{\frac{1n(1)}{10}a}\left(1 - 10^{-\frac{a}{10}f_c}\right)$$

For the element S :

$$a = \frac{t_1 - t_{-1} + r_i - r_{i-1}}{f_c}$$

$$f_c = \left| f_i - f_{i-1} \right|$$

$$b = t_{i-1} + r_{i-1}$$

If the two corresponding elements of the masks represent inverted inclinations, the parameter a may become 0. When a=0, the formula for flat elements (F) shall be used.

Where:

b = The sum of the attenuation of the transmitter (t_i) and receiver (r_i) masks at the beginning of an element (dB)

f_i = Frequency at the beginning and at the end of the element (MHz)

f_c = Bandwidth of the element

S = Partial elements areas under the spectrum masks in the common frequency range

$TxArea$ = The area for Tx Spectrum mask only; r_i = 0

$CoChannelOverlapArea$ = Tx Spectrum and Rx Selectivity masks are aligned

$OffsetOverlapArea$ = Tx Spectrum & Rx Selectivity masks are offset by frequency

Rainfall Fading Equations

Rainfall can cause attenuation, and this will have a greater effect than attenuation due to atmospheric gases. The highly variable properties of rainfall make it complicated to calculate rain attenuation, but there are a number of dedicated algorithms to assist you.

Calculating Specific Attenuation and Rainfall

The relation between the specific attenuation α and the rainfall *R* can be approximated by empirical formula ITU-R P.838:

$$\gamma = \mathrm{kR}^{\alpha}$$

Where:

k and α are functions of frequency, polarization and rain temperature.

To derive values for k and α, the following information is needed:

- The drop size distribution
- The drop size-shape relation
- A model for drop orientation
- An average fall velocity distribution
- Dielectric properties of drops
- The polarization used

About the Polarisation Effect on Propagation

Raindrops are not spherical. Surface tension tends to shape a water droplet forming in the atmosphere into a sphere. However, gravity pulling down and air pressure pushing up transform the droplet into a thick disc shape with the long horizontal axis. Being longer in the horizontal plane makes the drop more efficient as an antenna in this plane. A radio wave sets up a current in the drop which then acts as a transmit antenna causing special scattering of the signal.

When falling through the atmosphere, the droplet does so in a 'falling leaf' manner. This results in the orientation of its major axis taking on a rocking motion. It is this falling leaf motion that results in scattering of energy into the orthogonal polarization.

As the frequency increases, the wavelength becomes smaller and the efficiency of the droplet as an antenna in the vertical plain increases. The difference between effects for vertical and horizontally polarized waves becomes smaller.

Equation for Predicting Specific Attenuation Due to Rain

For predicting specific attenuation due to rain in a homogenous rainfall area, ITU-R P.530-7 gives equation 38:

$$\gamma_R = kR^{\alpha}$$

Where the coefficients k and α are frequency and polarization dependent.

Since rainfall rate varies along the hop, ITU-R P.530-7 gives formula 37 to model the actual circumstances. This value is then used in ITU-R P.530-7 formula 38 and thus the actual unavailability (caused by rain) can be calculated.

ITU-R P.838.3 gives values for the frequency-dependent coefficients up to 1000 GHz, shown in the following table. According to ITU-R these values have been tested and found reliable up to about 40 GHz. ASSET Backhaul uses these coefficient values and automatically uses interpolation if the actual frequency is between the values given:

Frequency (GHz)	**ITU-R** (k_H)	**ITU-R** (α_H)	**ITU-R** (k_V)	**ITU-R** (α_V)
1	0.0000259	0.9691	0.0000308	0.8592
1.5	0.0000443	1.0185	0.0000574	0.8957
2	0.0000847	1.0664	0.0000998	0.9490
2.5	0.0001321	1.1209	0.0001464	1.0085
3	0.0001390	1.2322	0.0001942	1.0688
3.5	0.0001155	1.4189	0.0002346	1.1387
4	0.0001071	1.6009	0.0002461	1.2476
4.5	0.0001340	1.6948	0.0002347	1.3987
5	0.0002162	1.6969	0.0002428	1.5317
5.5	0.0003909	1.6499	0.0003115	1.5882
6	0.0007056	1.5900	0.0004878	1.5728
7	0.001915	1.4810	0.001425	1.4745
8	0.004115	1.3905	0.003450	1.3797
9	0.007535	1.3155	0.006691	1.2895
10	0.01217	1.2571	0.01129	1.2156
11	0.01772	1.2140	0.01731	1.1617
12	0.02386	1.1825	0.02455	1.1216
13	0.03041	1.1586	0.03266	1.0901
14	0.03738	1.1396	0.04126	1.0646
15	0.04481	1.1233	0.05008	1.0440
16	0.05282	1.1086	0.05899	1.0273
17	0.06146	1.0949	0.06797	1.0137
18	0.07078	1.0818	0.07708	1.0025
19	0.08084	1.0691	0.08642	0.9930
20	0.09164	1.0568	0.09611	0.9847
21	0.1032	1.0447	0.1063	0.9771
22	0.1155	1.0329	0.1170	0.9700
23	0.1286	1.0214	0.1284	0.9630
24	0.1425	1.0101	0.1404	0.9561
25	0.1571	0.9991	0.1533	0.9491
26	0.1724	0.9884	0.1669	0.9421
27	0.1884	0.9780	0.1813	0.9349
28	0.2051	0.9679	0.1964	0.9277
29	0.2224	0.9580	0.2124	0.9203

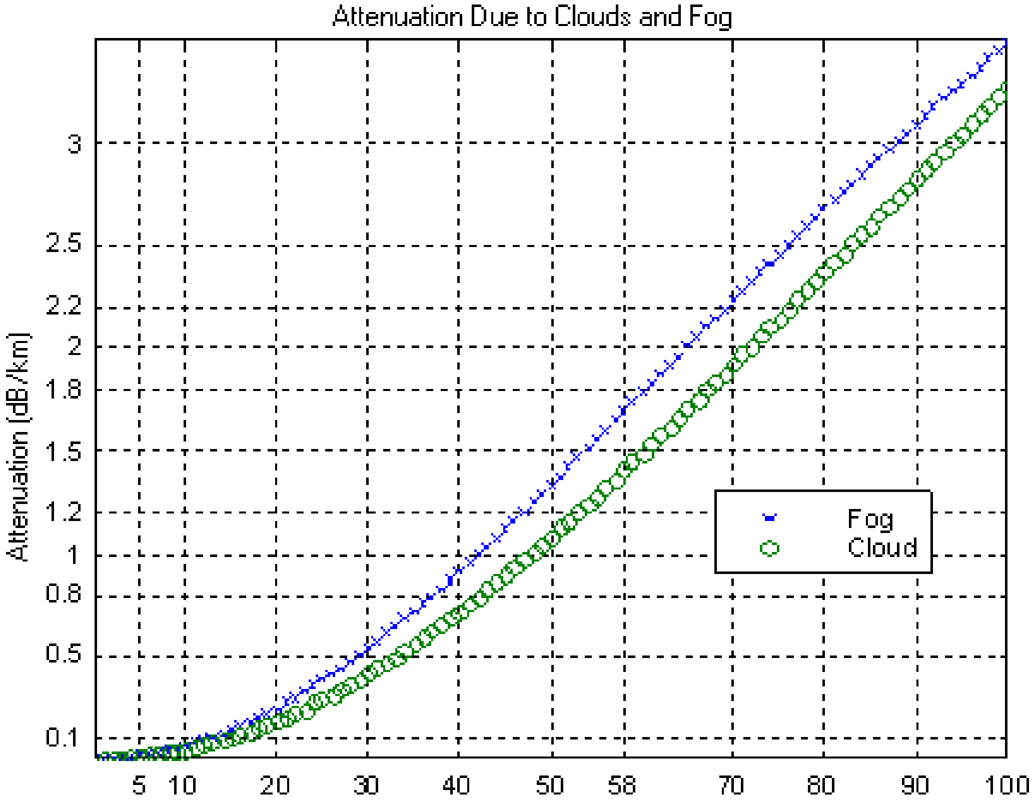
Frequency (GHz)	ITU-R (k_H)	ITU-R (α_H)	ITU-R (k_V)	ITU-R (α_V)
30	0.2403	0.9485	0.2291	0.9129
31	0.2588	0.9392	0.2465	0.9055
32	0.2778	0.9302	0.2646	0.8981
33	0.2972	0.9214	0.2833	0.8907
34	0.3171	0.9129	0.3026	0.8834
35	0.3374	0.9047	0.3224	0.8761
36	0.3580	0.8967	0.3427	0.8690
37	0.3789	0.8890	0.3633	0.8621
38	0.4001	0.8816	0.3844	0.8552
39	0.4215	0.8743	0.4058	0.8486
40	0.4431	0.8673	0.4274	0.8421
41	0.4647	0.8605	0.4492	0.8357
42	0.4865	0.8539	0.4712	0.8296
43	0.5084	0.8476	0.4932	0.8236
44	0.5302	0.8414	0.5153	0.8179
45	0.5521	0.8355	0.5375	0.8123
46	0.5738	0.8297	0.5596	0.8069
47	0.5956	0.8241	0.5817	0.8017
48	0.6172	0.8187	0.6037	0.7967
49	0.6386	0.8134	0.6255	0.7918
50	0.6600	0.8084	0.6472	0.7871
51	0.6811	0.8034	0.6687	0.7826
52	0.7020	0.7987	0.6901	0.7783
53	0.7228	0.7941	0.7112	0.7741
54	0.7433	0.7896	0.7321	0.7700
55	0.7635	0.7853	0.7527	0.7661
56	0.7835	0.7811	0.7730	0.7623
57	0.8032	0.7771	0.7931	0.7587
58	0.8226	0.7731	0.8129	0.7552
59	0.8418	0.7693	0.8324	0.7518
60	0.8606	0.7656	0.8515	0.7486
61	0.8791	0.7621	0.8704	0.7454
62	0.8974	0.7586	0.8889	0.7424
63	0.9153	0.7552	0.9071	0.7395
64	0.9328	0.7520	0.9250	0.7366
65	0.9501	0.7488	0.9425	0.7339
66	0.9670	0.7458	0.9598	0.7313
67	0.9836	0.7428	0.9767	0.7287
68	0.9999	0.7400	0.9932	0.7262
69	1.0159	0.7372	1.0094	0.7238

Frequency (GHz)	**ITU-R (** k_H **)**	**ITU-R (** α_H **)**	**ITU-R (** k_V **)**	**ITU-R (** α_V **)**
70	1.0315	0.7345	1.0253	0.7215
71	1.0468	0.7318	1.0409	0.7193
72	1.0618	0.7293	1.0561	0.7171
73	1.0764	0.7268	1.0711	0.7150
74	1.0908	0.7244	1.0857	0.7130
75	1.1048	0.7221	1.1000	0.7110
76	1.1185	0.7199	1.1139	0.7091
77	1.1320	0.7177	1.1276	0.7073
78	1.1451	0.7156	1.1410	0.7055
79	1.1579	0.7135	1.1541	0.7038
80	1.1704	0.7115	1.1668	0.7021
81	1.1827	0.7096	1.1793	0.7004
82	1.1946	0.7077	1.1915	0.6988
83	1.2063	0.7058	1.2034	0.6973
84	1.2177	0.7040	1.2151	0.6958
85	1.2289	0.7023	1.2265	0.6943
86	1.2398	0.7006	1.2376	0.6929
87	1.2504	0.6990	1.2484	0.6915
88	1.2607	0.6974	1.2590	0.6902
89	1.2708	0.6959	1.2694	0.6889
90	1.2807	0.6944	1.2795	0.6876
91	1.2903	0.6929	1.2893	0.6864
92	1.2997	0.6915	1.2989	0.6852
93	1.3089	0.6901	1.3083	0.6840
94	1.3179	0.6888	1.3175	0.6828
95	1.3266	0.6875	1.3265	0.6817
96	1.3351	0.6862	1.3352	0.6806
97	1.3434	0.6850	1.3437	0.6796
98	1.3515	0.6838	1.3520	0.6785
99	1.3594	0.6826	1.3601	0.6775
100	1.3671	0.6815	1.3680	0.6765
120	1.4866	0.6640	1.4911	0.6609
150	1.5823	0.6494	1.5896	0.6466
200	1.6378	0.6382	1.6443	0.6343
300	1.6286	0.6296	1.6286	0.6262
400	1.5860	0.6262	1.5820	0.6256
500	1.5418	0.6253	1.5366	0.6272
600	1.5013	0.6262	1.4967	0.6293
700	1.4654	0.6284	1.4622	0.6315
800	1.4335	0.6315	1.4321	0.6334

Frequency (GHz)	ITU-R (k_H)	ITU-R (α_H)	ITU-R (k_V)	ITU-R (α_V)
900	1.4050	0.6353	1.4056	0.6351
1000	1.3795	0.6396	1.3822	0.6365

Graph Showing Attenuation Due to Cloud and Fog

The levels of attenuation due to thick clouds and fog are shown in this graph:



Graph showing attenuation due to clouds and fog

From this graph you can see that attenuation caused by rainfall is much more significant than attenuation caused by thick cloud or fog.

Calculating the Rain Intensity

There is a function to derive the precipitation for given probability levels from Baptista Climpara 98 global precipitation map. It uses a series of lookup tables, along with interpolation techniques and a formula to calculate the Rain Intensity at a given probability.

Therefore there are three stages to calculating the Rain Intensity:

1. Extract values from the lookup tables.
2. If required, interpolate the values.
3. Insert these values into the rain intensity formula.

Extracting Values from the Automatic Rain Zone Lookup Tables

To use the rain intensity formula, certain values need to be defined.

The values known at the start are Longitude, Latitude and Probability.

For the other values, there are three tables containing values for rain distribution parameters.

The tables are 2D matrices of equal dimensions:

- The Longitude (on the X axis) goes from 0 to 360, in incremented steps of 1.5
- The Latitude (on the Y axis) goes from 90 to –90, in decremented steps

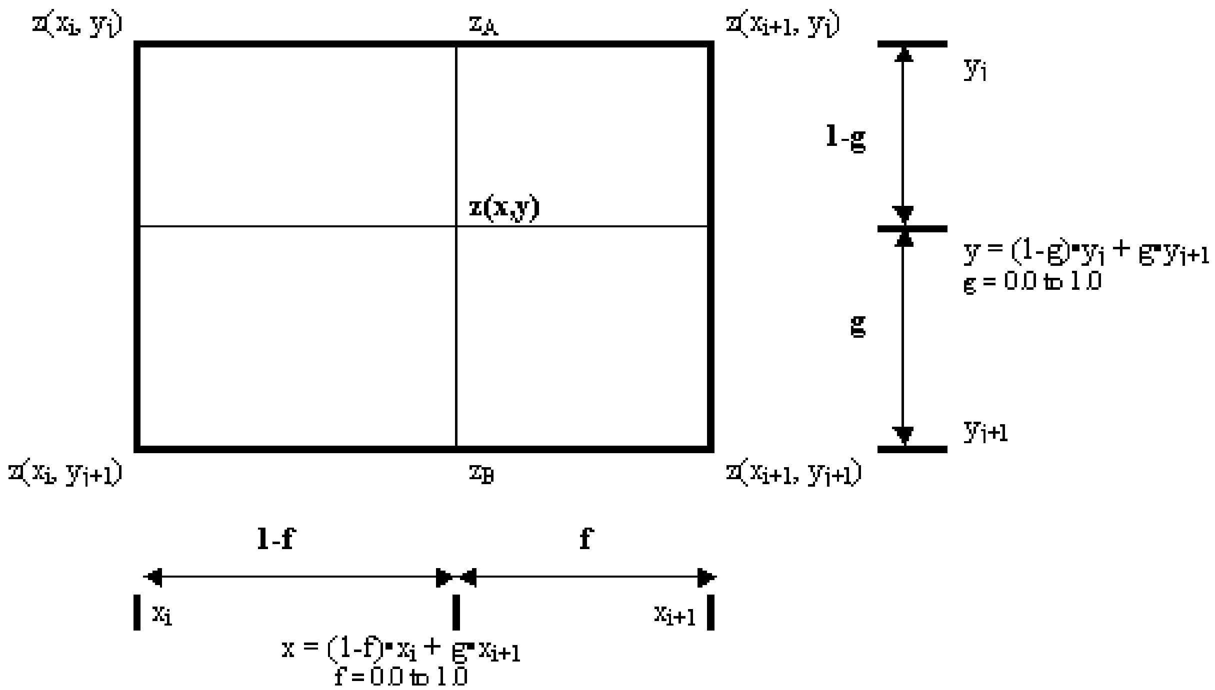
These two axes provide an index that can be used to extract from the other tables.

For example, if the link had a longitude of 6, then this will be the entry under the 4th column. The link has a latitude of 39, which is the entry under the 35th row. At this point, the index [4:35] can be used to extract the corresponding values from the other tables used in the calculation.

Interpolating Values for the Automatic Rain Zone

When you use the lookup tables, you can only use longitude and latitude values that have an exact entry in the corresponding matrix. If this is not the case, you need to use interpolation.

Bilinear interpolation can be described using this diagram:



Using linear interpolation

Use linear interpolation along the top and the bottom horizontal lines to determine z_A and z_B:

$$z_A = (1 - f) \bullet z(x_i, y_j) + f \bullet z(x_{i+1}, y_j)$$

$$z_B = (1 - f) \bullet z(x_i, y_{j+1}) + f \bullet z(x_{i+1}, y_{j+1})$$

Use linear interpolation along the vertical line between z_A and z_B to determine $z(x, y)$:

$$z(x, y) = (1 - g) \bullet z_A + g \bullet z_B$$

– or –

$$z(x, y) = (1 - f) \bullet (1 - g) \bullet z(x_i, y_j) + f \bullet (1 - g) \bullet z(x_{i+1,} y_j) + (1 - f) \bullet g \bullet z(x_i, y_{j+1}) + f \bullet g \bullet z(x_{i+1}, y_{j+1})$$

Using the Rain Intensity Formula

After you have extracted the values from the lookup tables (using interpolation if required), you have all of the data required to calculate the Rain Intensity.

530-12 Calculation Method

If you have chosen ITU-R P.530-12 as the rainfall calculation method, then the following formula provides the rain rate:

$$(-BB + sqrt(pow(BB,2) - 4.0 * AA * CC)) / (2.0 * AA)$$

Where

$$AA = a * b$$

$$BB = a + c * (\log(P / P0))$$

$$CC = \log(P / P0)$$

$$a = 1.11$$

$$b = (Mcp + Msp) / (22932 * P0)$$

$$c = 31.5 * b$$

$$P0 = \mathrm{Pr}6p * (1 - \exp(-0.0117 * (Msp / \mathrm{Pr}6p)))$$

P =Probability (defaults to 0.01, but can be set in the dialog)(%)

Lat =Latitude

$Long$ =Longitude

$\mathrm{Pr}6p$ =Value extracted from the table

Msp =Value extracted from the table

Mcp =Value extracted from the table

530-15 Calculation Method

If you have chosen ITU-R P.530-15 as the rainfall calculation method, then the formula used for 530-12 also provides the rain rate here but the following parameters are different:

$$a = 1.09$$

$$b = (Mcp + Msp)/(21797 * P0)$$

$$c = 26.02 * b$$

$$P0 = \Pr 6p * (1 - \exp(-0.0079 * (Msp / \Pr 6p)))$$

Calculating the Rain Unavailability

If you have chosen ITU-R P.530-12 as the rainfall calculation method, then the following formula provides the rain unavailability P_r (%) for a fade margin *A* (dB):

$$P_r = \begin{cases} 10^{\left(-0.546+\sqrt{0.546^2-4\cdot 0.043\cdot\log_{10}\left(\frac{A}{0.12\cdot A_{0.01}}\right)}\right)\Big/(2\cdot 0.043)} & lat \geq 30° \\ 10^{\left(-0.855+\sqrt{0.855^2-4\cdot 0.139\cdot\log_{10}\left(\frac{A}{0.07\cdot A_{0.01}}\right)}\right)\Big/(2\cdot 0.139)} & lat < 30° \end{cases}$$

Where $A_{0.01}$ is an estimate of the path attenuation exceeded for 0.01% of the time, calculated as:

$A_{0.01} = \gamma_R \cdot d_{eff}$ dB

Where

- γ_R is the specific attenuation (dB/km), calculated according to the ITU-R P.838-3 equation:

  $$y_R = k \cdot R_{0.01}{}^{a}$$

  Where

  - The k and a parameters depend on the frequency and polarization of the signal
  - $R_{0.01}$(mm/hour) is the rainfall rate, which cannot exceed 100mm/hour

- d_{eff} is the effective path length, calculated as $d_{eff} = \dfrac{d}{1 + d/d_0}$, where
  - d_0 is derived from $d_0 = 35e^{-0.015 \cdot R_{0.01}}$

If you have chosen ITU-R P.530-15 as the rainfall calculation method, then the following formula provides the rain unavailability P_r (%):

$$P_r = 10\left(-C_2 + \sqrt{C_2^2 - 4\cdot C_3 \cdot \log_{10}\left(\frac{A}{C_1 \cdot A_{0.01}}\right)}\right)/(2\cdot C_3)$$

Where

- $A_{0.01}$ is calculated in the same way as for 530-12, except that the effective path length d_{eff} is calculated as $d_{eff} = d \cdot r$, where:
  - $r = \dfrac{1}{0.477 \cdot d^{0.633} \cdot R_{0.01}^{0.073 \cdot a} \cdot f^{0.123} - 10.579 \cdot (1 - \exp(-0.024 \cdot d))}$
  - $r = \max(r, 2.5)$
- $C_0 = \begin{cases} 0.12 + 0.4 \cdot \log_{10}\left((f/10)^{0.8}\right) f \geq 10GHz \\ 0.12 \; f < 10GHz \end{cases}$
- $C_1 = \left(0.07^{C_0}\right) \cdot \left\lfloor 0.12^{(1-C_0)} \right\rfloor$
- $C_2 = 0.855 \cdot C_0 + 0.546 \cdot (1 - C_0)$
- $C_3 = 0.139 \cdot C_0 + 0.043 \cdot (1 - C_0)$

Crane Model Attenuation Calculations

The Crane Model for the propagation of electromagnetic waves through rain is an outage prediction method developed in the USA by Robert Crane. It provides an alternative prediction method to the ITU-R recommendations P.530, 837 and 838.

For more information on Crane's theories, see *Electromagnetic Propagation Through Rain,* by Robert K. Crane (Wiley-Interscience, 1996).

Calculating Attenuation for Path Lengths in Subrange 1

To calculate attenuation for path lengths where $0 < d \leq \delta(R)$, the Crane Model uses the following equation:

$$A_T(R,d) = \gamma(R)\left(\frac{e^{y\delta(R)} - 1}{y}\right) \quad (16)$$

Calculating Attenuation for Path Lengths in Subrange 2

To calculate attenuation for path lengths where $\delta(R) \leq d < 22.5$ km, the Crane Model uses the following equation:

$$A_T(R,d) = \gamma(R)\left(\frac{e^{y\delta(R)} - 1}{y} + \frac{e^{zd} - e^{z\delta(R)}}{z} e^{\alpha B}\right) \quad (17)$$

Where

A_r is horizontal path attenuation (dB)

R is the rain rate (mm/h) obtained from the Crane Model rain rates

d is the path length (km)

$\gamma(R)$ is specific attenuation (dB/km) (κR^{α}), where κ and α are regression co-efficients. The regression coefficients are calculated as in ITU-R P.838-3.

B is calculated as $\ell\eta(b)$ or $0.83 - 0.17^{\ell\eta(R)}$

c is calculated as $0.026 - 0.03^{\ell\eta(R)}$ (km-1)

$\delta(R)$ is calculated as $3.8 - 0.6^{\ell\eta(R)}$ (km-1)

u is calculated as $c + \dfrac{B}{\delta(R)}$ (km-1)

y is calculated as $\alpha \cdot u$ (km-1)

z is calculated as $\alpha \cdot c$ (km-1)

Calculating Attenuation for Path Lengths 22.5 km or Above

To calculate attenuation for path lengths greater than 22.5km, the Crane Model uses the following equations:

Calculate (or look up) R, by scaling the percentage of year exceeded by the actual distance using the following formula:

$$P' = \left(\frac{22.5}{d}\right)P \quad (24)$$

Where:

P' is the modified value for percentage of year exceeded

P is the value of the percentage of year exceeded from the Crane Rain Rates per region table

d is the path length (d >22.5) (km)

Calculate the attenuation as for a 22.5km path (in other words, $d = d_0 = 22.5km$)

Link Budget Equations

The **Link Budget** tab in the **Link Database** is a summary tab showing gains and losses at a glance. The values on this tab are automatically produced, based on the other tabs in the Link Database.

Free Space Loss Calculation

The free space loss is the value of attenuation in ideal conditions, given by the equation:

$$L_{FS} = 32.5 + 20 \cdot \log_{10}(f) + 20 \cdot \log_{10}(d)$$

Where:

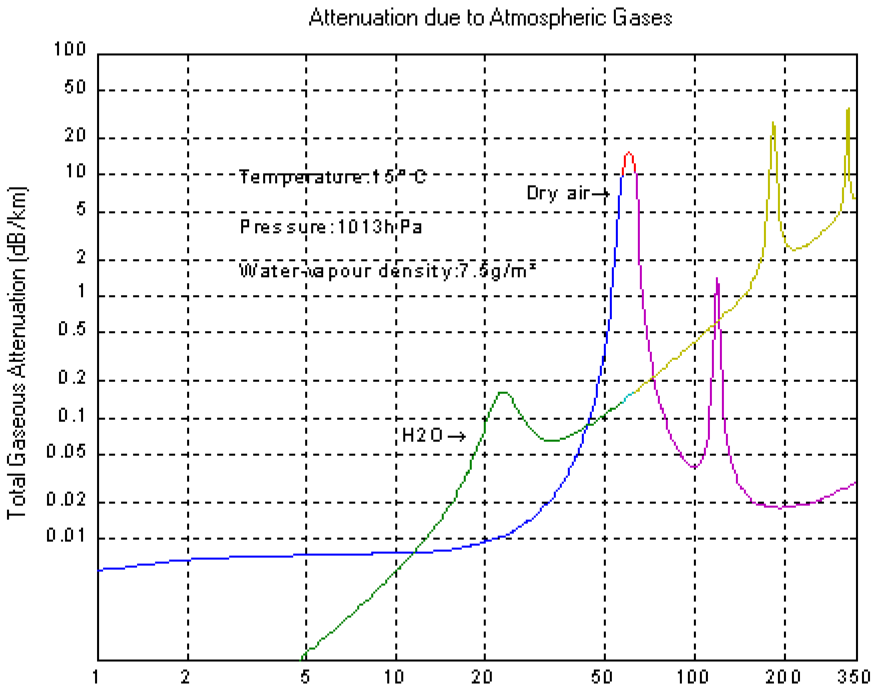
L_{FS} is the free space loss (dB)

d is the hop length (km)

f is the radio frequency (MHz)

Atmospheric Absorption Calculation

Atmospheric absorption (attenuation) is calculated using approximation method given by ITU-R P.676-7 recommendation. This graph shows the atmospheric attenuation caused by the two main/dominant absorbers, dry air and water vapor ($H_2 0$):



Specific attenuation due to atmospheric gases (oxygen and water vapor) at sea level in standard atmosphere

In summary, atmospheric absorption (A) is calculated as:

A = (γ_0 + y_w) * *distance*

Where

γ_0 is the attenuation caused by dry air

y_w is the attenuation caused by water vapor

distance is the hop length (km)

γ_0 and y_w are calculated using separate equations, described below.

Attenuation Caused by Dry Air Calculation

For dry air, the attenuation γ_0 (dB/km) is given by the following equations:

For $f \leq$ 54 GHz:

$$\gamma_0 = \left[\frac{7.2 r_t^{2.8}}{f^2 + 0.34 r_p^2 r_t^{1.6}} + \frac{0.62 \xi_3}{(54 - f)^{1.16 \xi_1} + 0.83 \xi_2} \right] f^2 r_p^2 x 10^{-3}$$

For 54 GHz < $f \leq$ 60 GHz:

$$\gamma_0 = \exp\left[\frac{\ln \gamma_{54}}{24}(f-58)(f-60) - \frac{\ln \gamma_{58}}{8}(f-54)(f-60) + \frac{\ln \gamma_{60}}{12}(f-54)(f-68) \right]$$

For 60 GHz < $f \leq$ 62 GHz:

$$\gamma_0 = \gamma_{60} + (\gamma_{62} - \gamma_{60}) \frac{f-60}{2}$$

For 62 GHz < $f \leq$ 66 GHz:

$$\gamma_0 = \exp\left[\frac{\ln \gamma_{62}}{8}(f-64)(f-66) - \frac{\ln \gamma_{64}}{4}(f-62)(f-66) + \frac{\ln \gamma_{66}}{8}(f-62)(f-64) \right]$$

For 66 GHz < $f \leq$ 120 GHz:

$$\gamma_0 = \left[3.02 x 10^{-4} r_t^{3.5} + \frac{0.283 r_t^{3.8}}{(f - 118.75)^2 + 2.91 r_p^2 r_t^{1.6}} + \frac{0.502 \xi_6 [1 - 0.0163 \xi_7 (f - 66)]}{(f-66)^{1.4346 \xi_4} + 1.15 \xi_5} \right] f^2 r_p^2 x 10^{-3}$$

For 120 GHz < $f \leq$ 350 GHz:

$$\gamma_0 = \left[\frac{3.02 x 10^{-4}}{1 + 1.9 x 10^{-5} f^{1.5}} + \frac{0.283 r_t^{0.3}}{(f - 118.75)^2 + 2.91 r_p^2 r_t^{1.6}} \right] f^2 r_p^2 r_t^{3.5} x 10^{-3} + \delta$$

with:

$$\xi_1 = \varphi(r_p, r_t, 0.0717, -1.8132, 0.0156, -1.6515)$$

$$\xi_2 = \varphi(r_p, r_t, 0.5146, -4.6368, -0.1921, -5.7416)$$

$$\xi_3 = \varphi(r_p, r_t, 0.3414, -6.5851, 0.2130, -8.5854)$$

$$\xi_4 = \varphi(r_p, r_t, -0.0112, 0.0092, -0.1033, -0.0009)$$

$$\xi_5 = \varphi(r_p, r_t, 0.2705, -2.7192, -0.3016, -4.1033)$$

$$\xi_6 = \varphi(r_p, r_t, 0.2445, -5.9191, 0.0422, -8.0719)$$

$$\xi_7 = \varphi(r_p, r_t, -0.1833, 6.5589, -0.2402, 6.131)$$

$$\gamma_{54} = 2.192\,\varphi(r_p, r_t, 1.8286, -1.9487, 0.4051, -2.8509)$$

$$\gamma_{58} = 12.59\,\varphi(r_p, r_t, 1.0045, 3.5610, 0.1588, 1.2834)$$

$$\gamma_{60} = 15.0\,\varphi(r_p, r_t, 0.9003, 4.1335, 0.0427, 1.6088)$$

$$\gamma_{62} = 14.28\,\varphi(r_p, r_t, 0.9886, 3.4176, 0.1827, 1.3429)$$

$$\gamma_{64} = 6.819\,\varphi(r_p, r_t, 1.4320, 0.6258, 0.3177, -0.5914)$$

$$\gamma_{66} = 1.908\,\varphi(r_p, r_t, 2.0717, -4.1404, 0.4910, -4.8718)$$

$$\delta = -0.00306\,\varphi(r_p, r_t, 3.211, -14.94, 1.583, -16.37)$$

$$\varphi(r_p, r_t, a, b, c, d) = r_p^a r_t^b \exp\left[c(1 - r_p) + d(1 - r_t)\right]$$

where:

f is the frequency in GHz

r_p is *p*/1013 where *p* is pressure in hPa. The default used is 1013.

r_t is 288/(273+*T*) where *T* is temperature in degrees Celsius. If no adequate temperature data is available, mean temperature values can be obtained from the maps given in ITU-R P.1510. However, the default value used is 15.

Attenuation Caused by Water Vapor Calculation

For water vapor, the attenuation γ_w(dB/km) is given by the following equation:

$$\gamma_w = \left[\frac{3.98\eta_1 \exp[2.23(1-r_t)]}{(f-22.235)^2+9.42\eta_1^2} g(f,22) + \frac{11.96\eta_1 \exp[0.7(1-r_t)]}{(f-183.31)^2+11.14\eta_1^2} + \frac{0.081\eta_1 \exp[6.44(1-r_t)]}{(f-321.226)^2+6.29\eta_1^2} + \frac{3.66\eta_1 \exp[1.6(1-r_t)]}{(f-325.153)^2+9.22\eta_1^2} + \frac{25.37\eta_1 \exp[1.09(1-r_t)]}{(f-380)^2} + \frac{17.4\eta_1 \exp[1.46(1-r_t)]}{(f-448)^2} + \frac{844.6\eta_1 \exp[0.17(1-r_t)]}{(f-557)^2} g(f,557) + \frac{290\eta_1 \exp[0.41(1-r_t)]}{(f-752)^2} g(f,752) + \frac{8.3328x10^4\eta_2 \exp[0.99(1-r_t)]}{(f-1780)^2} g(f,1780) \right] f^2 r_t^{2.5} \rho x10^{-4}$$

with

$$\eta_1 = 0.955 r_p r_t^{0.68} + 0.006\rho$$

$$\eta_2 = 0.735 r_p r_t^{0.5} + 0.0353 r_t^4 \rho$$

$$g(f, f_i) = 1 + \left(\frac{f - f_i}{f + f_i} \right)^2$$

where ρ is the water-vapor density in g/m³. The default value used is 7.5.

Obstruction Loss Calculation

The obstruction loss calculation depends on the diffraction model that you have selected in the **Preferences** dialog box, on the **Diffraction** tab, and also on the terrain on which you are planning.

If you have selected the **Terrain Averaging** diffraction model, the obstruction loss is calculated using ITU-R P.530-12 equation 2:

$$A_d = 20h / F_1 + 10$$

where

h is the height difference (in m) between the most significant path blockage and the path trajectory (this will be a negative value if the top of the object of interest is above the virtual line of sight)

F_1 is the radius of the first Fresnel ellipsoid, given by ITU-R P.530-12 equation 3:

$$F_1 = 17.3\sqrt{\frac{d_1 d_2}{fd}}$$

Where

f is the frequency (GHz)

d is the path length (km)

d_1 and d_2 are the distances (km) from the terminals to the path obstruction

If you have selected one of the Knife Edge diffraction models, the obstruction loss is calculated in a slightly different way for each model.

Rx Antenna Signal Strength Calculation

The signal strength at the receiving antenna (Rx level) is calculated using the following formula:

$$P_{RX} = P_{TX} - L_{BRL} - L_{Misc} - L_{TX,att} + G_{TX} - L_{TX,rad} - L_{FS} - L_{atm} - L_{obs} - L_{RX,rad} + G_{RX} - L_{RX,att} - L_{Misc} - L_{RX,BRL}$$

Where:

P_{RX} is received power level

P_{TX} is transmitted power level

L_{BRL} is branching loss

L_{Misc} is miscellaneous loss

$L_{XX,att}$ is attenuation caused by xx's attenuator

G_X is gain from x antenna

$L_{XX,rad}$ is attenuation caused by dry radome

L_{FS} is free space loss

L_{atm} is attenuation caused by atmospheric gases

L_{obs} is diffraction loss

Total Antenna Gain Calculation

The total antenna gain is the sum of the receiver and transmitter antenna gain. Accurate antenna gain values can be found in the manufacturer's datasheets.

About the Optimum Spacing Calculation for Antennas

On the **Feeders** subtab of the **Linkend Settings** tab in the **Link Database**, if you choose to use the **Optimum Diversity Spacing** option, the following calculations are used to set the optimum spacing between the diverse and main antenna.

The reflection analysis is used as the basis, in order to find the position of the antenna where:

- The reflected wave is not interfering with the direct signal
- The height of the reflected signal is the maximum

The heights h_1 and h_2 of the antennas above a reflection area of inclination angle *v* are:

$$h_1 = h_{1G} + y_1 - y_0 + x_0 \cdot 10^3 \cdot \tan v$$ (m) (1)

$$h_2 = h_{2G} + y_2 - y_0 - (d - x_0) \cdot 10^3 \cdot \tan v$$ (m) (2)

Where:

- h_{1G} and h_{2G} are the heights of the antennas above ground level. Tidal variations will also be considered if the reflection point is on the sea
- y_1 and y_2 are the heights of the ground above sea level for Sites 1 and 2
- y_0 and x_0 are the distance and height of the reflection point
- $\tan v$ is the tangent of the inclination angle *v* at the reflection point
- d is the hop length

The distances d_1 and d_2 of each possible reflecting surface from Sites 1 and 2 respectively are calculated from:

$$d_1 = d(1+b)/2$$ (km) (3)

$$d_2 = d(1-b)/2$$ (km) (4)

where:

$$b = 2\sqrt{\frac{m+1}{3m}} \cos\left[\frac{\pi}{3} + \frac{1}{3}\arccos\left(\frac{3c}{2}\sqrt{\frac{3m}{(m+1)^3}}\right)\right]$$ (5)

$$m = \frac{d^2}{4\alpha_e(h_1 + h_2)} \cdot 10^3$$ (6)

$$c = (h_1 - h_2)/(h_1 + h_2)$$ (7)

$\alpha_e = k\alpha$ is the effective radius of the Earth (based on the actual radius α of 6375km)

If there are reflected rays, then the distances between the minima due to destructive interference between the direct and the reflected rays would be at (f in GHz):

$$\theta_1 = \frac{150\,d}{f \cdot \left(h_2 - d_2^2/(12.74k)\right)}$$ (m) (8)

$$\theta_2 = \frac{150\,d}{f \cdot \left(h_1 - d_1^2/(12.74k)\right)}$$ (m) (9)

The optimum spacing is given by

$$S_j = n_j \cdot \theta_j / 2$$

with:

j = 1 or 2, below the main antenna

$$n_j = ceil\left(d_1 + d_2 / \theta_j\right)$$

In addition, n_j must be an odd number, therefore If $\sim \mathrm{mod}\left(n_j, 2\right)$ then $n_j = n_j + 1$.

Therefore, if the Optimum Diversity Spacing option is selected:

- The diversity antenna will be placed S_j m below the main antenna

  - or -

- If there is no clearance for that height, the diversity antenna will be placed S_j m above the main antenna

  - or -

- If there are no reflection points, then the spacing between antennas should be 23m or at a height where there is 0 first Fresnel zone clearance (whichever is the lowest value)

Note: This value will be calculated each time you change the position and/or height of the main antenna and/or the operating frequency, and then click the **Apply** button.

Fade Margin Equations

The values on the **Fade Margin** tab of the **Link Database** are automatically produced based on other values in the Link Database.

Flat Fade Margin Calculation

The flat fade margin of a radio link hop (FFM) is given by the following equation:

$$FFM = P_{RX} - P_{th}$$

where P_{th} is the radio's threshold (or sensitivity) value. The way that flat fading is calculated is dependent on the chosen calculation method.

Interference Margin Calculation

The interference margin is calculated by subtracting the C/I objective from the calculated T/I:

$$IntfnM = T / I_{calc} - C / I_{obj}$$

T / I_{calc} is calculated as

$$T / I_{calc} = Threshold - Intfn_{Link}$$

Where

$Threshold$ is the currently selected threshold on the radio equipment

$Intfn_{Link}$ is the interference from the link

Threshold Degradation Calculation

Threshold degradation describes how much the cumulative interference will decrease the radio's sensitivity. It is based on the equation where interference is considered to cause extra internal noise for the radio equipment.

Threshold degradation can be calculated as follows:

$$10\log_{10}\left(10^{PcumInt/\ 10}+10^{FkTB/\ 10}\right)-FkTB$$

Flat Fade Margin After Interference Calculation

The value of flat fade margin (FFM) after interference is calculated using the equation:

$$FFM\mathrm{int}=FFM-th\mathrm{deg}$$

Composite Fade Margin Calculation

The composite fade margin (CFM) is calculated using the following equation:

$$CFM=FFM_{\mathrm{int}}+DFM=-10\log_{10}\left(10^{-FFM_{\mathrm{int}}/10}+10^{-DFM/10}\right)$$

Required FM Against Rain Calculation

The necessary margin due to rain fading can be calculated based on the long-term statistics of the rain attenuation.

Using the 530-7 or 530-12 Calculation Method

$R_{0.01}$(mm/hour) is the rain rate exceeded for 0.01% of the time and γ_R (dB/km) is the specific attenuation for the frequency, polarization and rain rate. Therefore, an estimate of the path attenuation exceeded for 0.01% of the time is given by:

$$F_{0.01}=\gamma_R\cdot d_{eff}\ \text{dB}$$

Where

$$d_{eff}=\frac{d}{1+d/d_0}$$

and

$$d_0=35e^{-0.015\cdot R_{0.01}}$$

To calculate this value, ASSET Backhaul uses ITU-R P.530-7 formula 38 or ITU-R P.530-12 formula 35.

For radio links with latitudes equal to or greater than 30 degrees (north or south), the attenuation for a percentage of time p (in the range 0.001% to 1%) is given by the equation:

$$\frac{F_p}{F_{0.01}} = 0.12 \cdot p^{-(0.546+0.043 \cdot \log_{10} p)}$$

For latitudes below 30 degrees, the following formula is used instead:

$$\frac{F_p}{F_{0.01}} = 0.07 \cdot p^{-(0.855+0.139 \cdot \log_{10} p)}$$

Therefore, given the required availability, the necessary fade margin that needs to be available in the link can be computed for the two cases from:

$$F_{rain} = 0.12 \cdot F_{0.01} \cdot p_{req}^{-(0.546+0.043 \cdot \log_{10} p_{req})}$$

$$F_{rain} = 0.07 \cdot F_{0.01} \cdot p_{req}^{-(0.855+0.139 \cdot \log_{10} p_{req})}$$

Using the 530-15 Calculation Method

For ITU-R P.530-15, the required fade margin for rainfall is calculated as:

$$F_{rain} = F_{001} * C_1 * p_{req}^{-\left(C_2 + C_3 * \log_{10}\left(p_{req}\right)\right)}$$

Where:

$$C_1 = \left(0.07^{C_0}\right) \cdot \left\lfloor 0.12^{(1-C_0)} \right\rfloor$$

$$C_2 = 0.855 \cdot C_0 + 0.546 \cdot \left(1 - C_0\right)$$

$$C_3 = 0.139 \cdot C_0 + 0.043 \cdot \left(1 - C_0\right)$$

Important: The maximum value for the required fade margin for both multipath and rainfall cases is calculated as:

$$F_{req} = \max\left(F_{multipath,} F_{rain}\right)$$

TDD Equations

This section describes the calculations that are used for scenarios involving TDD (Time Division Duplexing) radios and links.

How the Maximum Capacity is Calculated for TDD Radios

If you are defining a TDD radio, then the maximum capacity ($C_{\max imum}$) is calculated in a different way to FDD radios.

FDD assumes that the throughput is delivered in a single direction without any loss of time, but TDD throughput is shared in both directions. This means that there are several potential delays - the transition delay (as the equipment switches from transmitting to receiving) and the propagation delay.

Maximum aggregated traffic capacity is calculated as follows:

$$C_{\max imum} = \frac{T_{frame}}{T_{frame} + T_{latency}} \cdot C_{\max}$$

Where

$C_{\max}$ is the maximum theoretical throughput for the link (Bits per highest available modulation order symbol x Bandwidth)

T_{frame} is the period of the TDD slot

If the transition gap is greater than the latency, then $T_{latency}$ = transition gap; otherwise $T_{latency}$ = latency, as defined on the radio.

The propagation delay is dependent on the link, so is included into this calculation when the TDD radio is set on the link.

The distance between the radio stations (or hop length) is calculated in km, and then the propagation delay (in ms) is calculated using the following equation:

$$T_{prop} = \frac{HopLength}{300}$$

If T_{prop} is greater than the sum of the transition gap and latency, then $T_{latency}$ = T_{prop} + Transition Gap.

Then the required capacity is calculated differently, depending on the radio type.

Native TDM Radios

If the radio is Native TDM, the defined Radio Capacity represents the throughput in a single direction. Therefore the link should be able to accommodate twice that value, in other words

$$C_{\max imum} \geq 2 \cdot RadioCapacity$$

(If it is greater, then it is assumed to be equal, because the additional capacity cannot be used for TDM operation).

Native IP Radios

If the radio is Native IP, then the IP Interface Capacity is equal to the $C_{\max imum}$.

Hybrid IP and TDM Radios

If the radio is Hybrid IP and TDM, then the IP Interface Capacity is calculated based on the defined (TDM) Radio Capacity:

$$IPInterfaceCapacity = C_{\max imum} - 2 \cdot RadioCapacity$$

(If it is less than 0, then it is assumed to be 0, and so the minimum value is 0).

Example Calculation

As an example, consider the scenario where the bandwidth is 7 MHz and the highest modulation order is 16-QAM (4 bits per modulation symbol).

Therefore:

- The theoretical capacity C_{max} is 28 Mbps
- The frame size is 5 ms, with a latency of 1 ms, so the maximum aggregated capacity on the TDD link is 23.33 Mbps
- If the TDM channel selected is 6xE1, then the radio capacity is 12.288 Mbps, but the required capacity is twice this (to allow for both directions) - 24.576 Mbps
- If the required capacity is 24.576 Mbps, but the maximum aggregated capacity available is 23.33 Mbps, then there is insufficient capacity

Calculating the Maximum Achievable Throughput for TDD Links

On the Radio A and B subtabs of the **Linkend Settings** tab for a link, the **Maximum Achievable Throughput** is calculated and shown.

If the link uses TDD, then this calculation is based on the modulation scheme (or if the link is using AMC, the highest available modulation type), the bandwidth and the symmetry of a link.

For radio A, the equation for Maximum Achievable Throughput is as follows:

1. Calculate the maximum raw capacity, which is defined as:

$$MaxRawCapacity = \frac{T_{frame}}{T_{frame} + T_{latency}} \cdot \frac{a}{100} \cdot B \cdot n_{\mathrm{mod},A}$$

   Where

   a is the number of frames that the link transmits from linkend A to linkend B

   B is the bandwidth

   $n_{\mathrm{mod},A}$ is the number of bits per modulation symbol for the modulation scheme of radio A

   Note: For PmP links, you can calculate the maximum achievable throughput for the carrier by replacing $n_{\mathrm{mod},A}$ with $n_{\mathrm{mod},car}$, which represents the number of bits per modulation symbol of the operating modulation type on the carrier. In this case, *a* represents the number of frames that the link transmits from the carrier to the multipoint linkend.

2. To determine the Maximum Achievable Throughput, subtract the control overhead (IP/Ethernet) from the Maximum Raw Capacity.

Similarly, for radio B, the equation for Maximum Achievable Throughput (b) is as follows:

1. Calculate the maximum raw capacity, which is defined as:

$$MaxRawCapacity = \frac{T_{frame}}{T_{frame} + T_{latency}} \cdot \frac{b}{100} \cdot B \cdot n_{\mathrm{mod},B}$$

Where

b is the number of frames that the link transmits from linkend B to linkend A

$n_{\mathrm{mod},B}$ is the number of bits per modulation symbol for the modulation scheme of radio B

2. To determine the Maximum Achievable Throughput, subtract the control overhead (IP/Ethernet) from the Maximum Raw Capacity.

Calculating the Actual Delay for Asynchronized Transmission on a TDD Link

On the **Frequency** subtab of the **Linkend Settings** tab for a link in the **Link Database**, you can specify that the link will use asynchronous transmission. This means that the initial frame is sent from End A to End B after a particular delay, calculated using the Delay parameter specified.

The actual delay (T_{delay}) is calculated as follows:

$$T_{delay} = \left(\frac{Delay}{FrameSize + T_{latency}} \right)$$

How Interference Is Calculated Differently for TDD Links

TDD radios and links have a different interference effect to those using FDD.

Unlike the paired spectrum of TDD radios (where two different channels operate simultaneously), TDD uses unpaired radios, so that the same link acts as the interferer and the victim:

Operating Mode of Radio	Link Status
Transmitting	Interferer
Receiving	Victim

This means that interference caused to FDD links due to TDD links is variable and will have peak levels, while the interference caused to TDD links due to FDD links will be constant.

On the other hand, interference to TDD links from TDD transmissions only occur when the victim linkend is in receiving mode, while the interfering linkend is in transmitting mode.

Important: You should always consider the level of interference at a linkend as the maximum possible that can be measured at that linkend.

FDD Link-TDD Link Interference

Interference levels for an FDD link caused by a TDD link (and vice versa) are calculated in the same way as interference between FDD links.

However, there are fewer frequencies to consider because both TDD linkends transmit over the same frequency channel.

The strongest interfering linkend of the TDD link is considered.

TDD Link-TDD Link Interference

To calculate interference levels between TDD links, a more elaborate equation may be needed to account for the hop length, frame size, latency, any synchronization options and the symmetry of the traffic.

If the traffic is asymmetric, this means that the number of frames transmitted from End A to End B is different to the number of frames transmitted from End B to End A.

A basic way to simulate this is by using the asymmetry ratio; where the number of frames from End A to End B is $n_{forward} = a$ and the number of frames from End B to End A is $n_{reverse} = b$.

After the number of frames per direction has been specified, the transmission and reception patterns can be calculated for each TDD base station. The frames can be represented as square pulses, and so if $T'_{frame} = T_{frame} + T_{latency}$, then each transmitting pattern for End A would be:

$$T_{trans,A}(t) = \sum_{n=-\infty}^{\infty} \sum_{k=0}^{n_{forward}-1} \Pi\left(\frac{t - T_{delay} - (k + 100\,n) \cdot T'_{frame}}{T_{frame}} \right)$$

Where T_{delay} corresponds to the synchronization operation (if the link is synchronized, T_{delay} = 0 ms). The function $\Pi(t)$ signifies the square function and it is defined as:

$$\Pi\left(\frac{t - T}{T_{frame}} \right) = \begin{cases} 0 \,|\, t - T \,| < T_{frame} / 2 \\ 1 \,|\, t - T \,| \geq T_{frame} / 2 \end{cases}$$

Where

T is the location of the center of the pulse

T_{frame} is the duration of the pulse

As an example, for T = 5 ms and T_{frame} = 2 ms, then Π would be a pulse that would start at 4 ms till 6 ms. Therefore, $T_{trans,A}(t)$ is a train of rectangular pulses that represent the transmitted frames of End A.

Similarly, the reception pattern at End B would be:

$$T_{rec,B}(t) = T_{trans,A}(t - t_{AB})$$

Where t_{AB} is the propagation delay of the signals from End A to End B.

The transmission frames of End B would occur at:

$$T_{trans,B}(t) = \sum_{n=-\infty}^{\infty} \sum_{l=0}^{n_{reverse}-1} \Pi\left(\frac{t - T_{delay} - (l + n_{forward} + 100\,n) \cdot T'_{frame}}{T_{frame}} \right)$$

and hence the receiving frames in End A from End B would be:

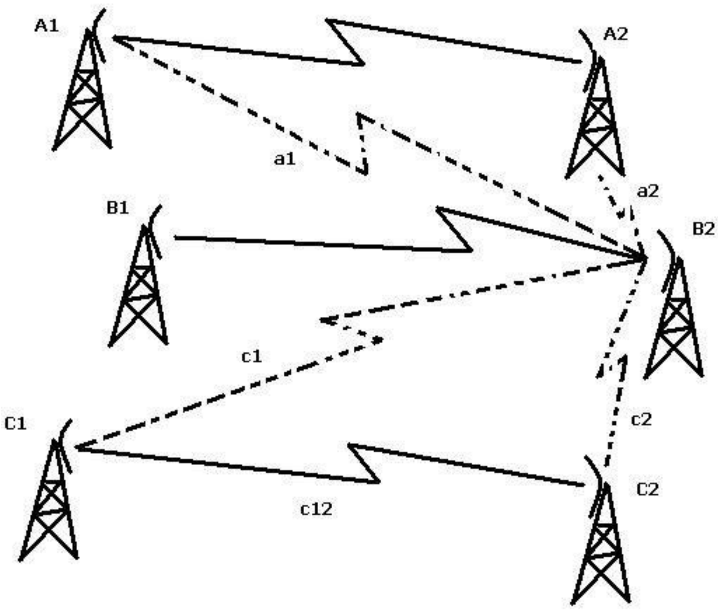
$$T_{rec,A}(t) = T_{trans,B}(t - t_{AB})$$

Which would be the frames emanating from End B, delayed by the required time that the waves need to traverse the link's path.

To see an example, see Example of Interfering TDD Radios on page 333.

Example of Interfering TDD Radios

This picture shows an example of interfering TDD radios:



Interference example between TDD links

The victim linkend is B2.

The frame size is 2 ms for all links, latency is user-defined for links A1-A2 and B1-B2, with a value of 1 ms, whereas for link C1-C2 it is 0.115 ms (including the propagation delay and transition gap).

Links A1-A2 and B1-B2 are synchronized - in other words, the 1st frame from End1 to End 2 is transmitted at 0 s. However, the link C1-C2 has a delay of 0.75 ms - that is, the first frame from C1 is transmitted at 0.75 ms.

For simplicity, we also assume that there is a 50/50 symmetry and thus $n_{forward} = n_{reverse} = 1$ without loss of generality.

The distances from B2 to each BTS are as follows:

a1 = 3 km, a2 = 1.2 km, b1 = 2,4 km, c1 = 4.2 km, c2 = 0.6 km

Therefore the propagation delays would be:

t_{a1} = 0.01 ms, t_{a2} = 0.004 ms, t_{b1} = 0.008 ms, t_{c1} = 0.014 ms, t_{c2} = 0.002 ms

The interfering powers are calculated as follows (as in the FDD case):

$$I_{A1} = -27\,dBm\left(2 \cdot 10^{-3}\,mW\right),\; I_{A2} = -33\,dBm\left(0.5 \cdot 10^{-3}\,mW\right),$$
$$I_{B1} = -15\,dBm\left(0.0316\,mW\right),\; I_{C1} = -30\,dBm\left(1 \cdot 10^{-3}\,mW\right),$$
$$I_{C2} = -36\,dBm\left(0.25 \cdot 10^{-3}\,mW\right)$$

The transmission patterns of the interfering BTSs are known and therefore their reception at the B2 BTS can be calculated as follows:

$$I_{A1\to B2}(t) = 2 \cdot 10^{-3} \sum_{n=-\infty}^{\infty} \Pi\left(\frac{t - 0.01 - 6 \cdot n}{2}\right)$$

$$I_{A2\to B2}(t) = 0.5 \cdot 10^{-3} \cdot \sum_{n=-\infty}^{\infty} \Pi\left(\frac{t - 0.004 - 3 \cdot (1 + 2 \cdot n)}{2}\right)$$

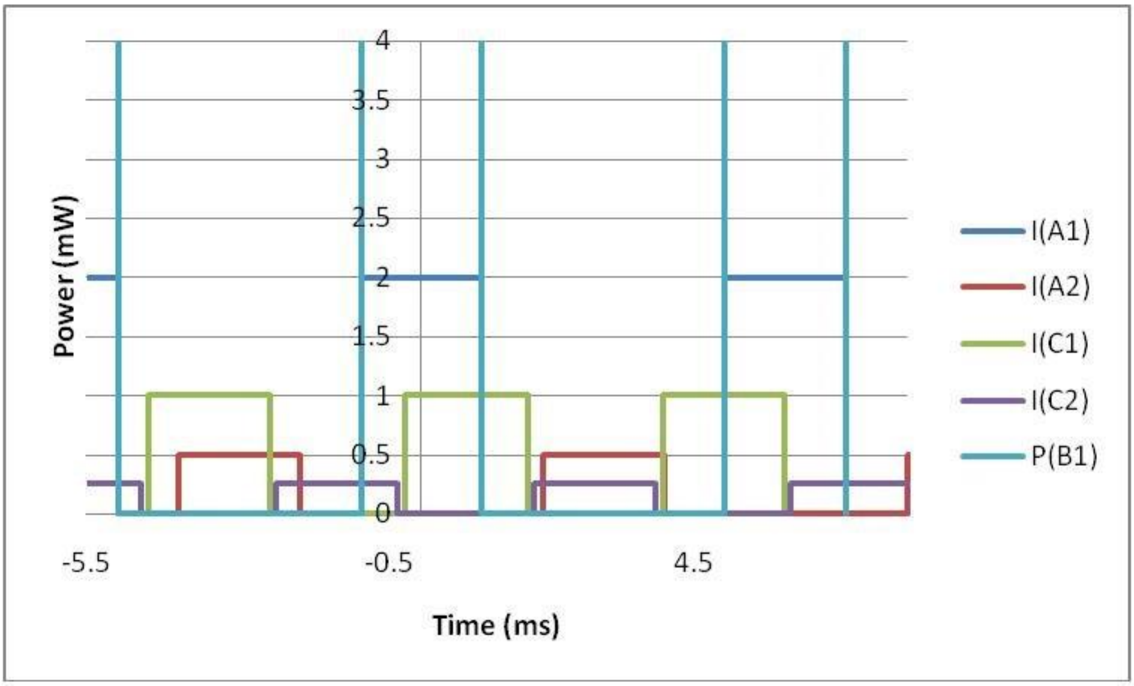
$$I_{C1\to C2}(t) = 1 \cdot 10^{-3} \cdot \sum_{n=-\infty}^{\infty} \Pi\left(\frac{t - 0.014 - 0.75 - 4.23 \cdot n}{2}\right)$$

$$I_{C2\to B2}(t) = 0.25 \cdot 10^{-3} \cdot \sum_{n=-\infty}^{\infty} \Pi\left(\frac{t - 0.002 - 0.75 - 2.115 \cdot (1 + 2 \cdot n)}{2}\right)$$

The received frames for B2 from B1 would be:

$$P_{B1\to B2}(t) = 0.0316 \cdot \sum_{n=-\infty}^{\infty} \Pi\left(\frac{t - 0.008 - 6 \cdot n}{2}\right)$$

Interference occurs when there is unwanted received signal inside the P(B1) frames. This graph shows the received frames at BTS B2 from the other BTSs:



The received frames at BTS B2 from the other BTSs

As can be seen, if the BTSs do not have the same configuration in terms of frame size and symmetry, then the calculation of interference is quite unpredictable and such BTSs should be treated as the same way as for FDD radios when calculating interference. In other words, their effects should always be assumed to be present.

However, if the BTSs have the same configuration, then interference can be calculated in a more straightforward way. As the graph shows, the signals from A2 fall outside the reception period of B2 and so could be ignored. However, it would be more beneficial in terms of interference effects if linkend A2 is synchronized to B2, as its interfering signal is less than A1's.

With the same configuration, whether the BTSs are synchronized or not, the propagation delay and any defined frame delay have an impact on the interference calculations. Therefore, interference should only be calculated if there are overlapped frames.

Outage Equations

The values on the **Outage** tab in the **Link Database** are automatically produced, based on other values you have defined.

Note: By default, the outage values are calculated as percentages. However, on the Outage tab they can also be calculated and displayed as:

- Number of seconds per year (whereby the percentage value is multiplied by 31,536,000)
- Number of minutes per year (whereby the percentage value is multiplied by 525,600)

Flat Outage Calculation

The **Flat Outage** shown on the **Outage** tab in the **ASSET Backhaul Link Database** is the outage caused by flat fading for the worst month, and is given the value P_{ns}.

Selective Outage Calculation

Outage caused by selective fading is calculated differently depending on the calculation method chosen.

Selective Outage Calculation Using the Signature Method

If the **Signature Information for Selective Multipath Fading** section has been completed, the selective outage for the worst month is calculated using ITU-R P.530-12 formula 74:

$$P_s = 2.15\eta\left(W_M * 10^{-B_M/20} \frac{\tau_M^2}{|\tau_{r,M}|} + W_{NM} * 10^{-B_{NM}/20} \frac{\tau_M^2}{|\tau_{r,NM}|} \right)$$

Where:

W_x is signature width

B_x is signature depth

τ_x is the reference delay used to obtain the signature in measurements

x denotes either minimum phase (M) or not minimum phase (NM)

Note: If the radio on the linkend is AMC-enabled, then ASSET Backhaul uses the signature values for the **Operating Modulation Mode** assigned on the **Radio** subtab of **Linkend Settings** tab of the **Link Database**.

Selective Outage Calculation Using the Approximation Method

If the **Approximation Method for Selective Multipath Fading** section has been completed, the selective outage for the worst month is calculated as defined by P.530-12 formula 75 and 10:

$$P_S = 2.15\eta\left(\frac{2\tau_m^2}{T^2}\right)K_n$$

Where:

η is multipath activity factor

τ_m is the reference delay (ns) used in measurements

K_n is the normalized signature area

T is the Baud period (ns)

Note: If the radio on the linkend is AMC-enabled, then ASSET Backhaul uses the approximation method values for the **Operating Modulation Mode** assigned on the **Radio** subtab of **Linkend Settings** tab of the **Link Database**.

Selective Outage Calculation Using the Dispersive Fade Margin Method

In case of the default dispersive fade margin method, the selective outage for the worst month is calculated using different formulae depending on whether you are using ITU-R P.530-7 or ITU-R P.530-12.

For 530-7, ASSET Backhaul uses formula 19, where A is replaced by dispersive fade margin:

$$p_w = Kd^{3.6} f^{0.89}\left(1+|\varepsilon_P|\right)^{-1.4} 10^{-A/10} \quad (\%)$$

For 530-12, ASSET Backhaul uses formula 7:

$$p_w = Kd^{3.2}\left(1+|e_p|\right)^{-0.97} \times 10^{0.032f - 0.00085h_L - A/10} \quad (\%)$$

The selective outage is then given by $P_s = p_w / 100$

Note: If the radio on the linkend is AMC-enabled, then ASSET Backhaul uses the dispersive fade margin values for the **Operating Modulation Mode** assigned on the **Radio** subtab of **Linkend Settings** tab of the **Link Database**.

Cross-Polarisation Outage (Clear-Air) Calculation

When ASSET Backhaul calculates total outage probability due to clear-air effects (P_t) for the worst month, it uses the value of outage probability due to clear-air cross-polarization (P_{XP}). To calculate this value, ASSET Backhaul:

3. Calculates XPD_0 using the equation:

$$XPD_0 = \begin{cases} XPD_g + 5 & \text{for} \quad XPD_g \leq 35 \\ 40 & \text{for} \quad XPD_g > 35 \end{cases}$$

   Where XPD_g = XPD at the boresight = minimum of the antenna gain at 0 degrees for VH and HV

4. Finds the multipath activity parameter η:

$$\eta = 1 - e^{-0.2(P_0)^{0.75}}$$

   Where P_0 = Multipath occurrence factor = $p_w/100$ when A = 0 dB

   p_w is calculated slightly differently, depending on which ITU-R propagation model you are using. For more information on this, see Multipath Occurrence Factor Calculation on page 338.

5. Determines Q, using the calculation:

$$Q = -10\log\left(\frac{k_{XP}\eta}{P_0}\right)$$

   Where:

$$k_{XP} = \begin{cases} 0.7 & \mathit{for\ one\ transmit\ antenna} \\ 1 - 0.3\exp\left[-4\times10^{-6}\left(\frac{s_t}{\lambda}\right)^2\right] & \mathit{for\ two\ transmit\ antennas} \end{cases}$$

   Where:

   s_t is the vertical separation between two transmit antennas (in meters)

   λ is the carrier wavelength (in meters)

6. Determines C, using the calculation:

$$C = XPD_0 + Q$$

7. Calculates P_{XP}, using the equation:

$$P_{XP} = P_0 \times 10^{-\frac{M_{XPD}}{10}}$$

Where M_{XPD} (dB) is the equivalent XPD margin for a reference BER, given by:

$$M_{XPD} = \begin{cases} C - \dfrac{C_0}{I} & \text{without XPIC} \\ C - \dfrac{C_0}{I} + XPIF & \text{with XPIC} \end{cases}$$

Where C_0 / I is the carrier-to-interference ratio for a reference BER and $XPIF$ is the laboratory-measured cross-polarization improvement factor when using a cross-polar interference canceler (XPIC).

For C_0 / I , ASSET Backhaul uses the T/I values as follows:

- If you have configured antenna masks, ASSET Backhaul uses the T/I value for the same radio (carrier X and interferer X) at 0 MHz separation
- If you have not configured antenna masks, ASSET Backhaul uses the default T/I value, as set in the **Interference Wizard**

Multipath Occurrence Factor Calculation

Depending on which ITU-R propagation method you are using, ASSET Backhaul calculates the multipath occurrence factor (p_0 , in %) in a different way.

The calculated p_0 is used to calculate the percentage of time that a fade *F* (dB) is exceeded in the average worst month. For more information, see Average Worst Month Calculation on page 339.

For ITU-R P.530-7

If you are using ITU-R P.530-7, ASSET Backhaul calculates p_0 as follows:

$$p_0 = Kd^{3.6}(1+|\varepsilon_p|)^{-1.4} f^{0.89} \quad \%$$

Where

K is the geoclimatic factor (set in the **Link Database**, on the **Propagation Prediction** subtab of the **Calculation** tab)

d is the link length (km)

f is the center frequency at each end (GHz)

h_L is the altitude of the lower antenna (m)

$|\varepsilon_p|$ is the magnitude of the path inclination (mrad), equal to $|h_r - h_e| / d$, where h_r and h_e are the antenna heights (m) above sea level

For ITU-R P.530-12

If you are using ITU-R P.530-12, ASSET Backhaul calculates p_0 as follows:

$$p_0 = Kd^{3.2}(1+|\varepsilon_p|)^{-0.97} 10^{0.032\,f - 0.00085\,h_L} \ \%$$

Where the parameters are the same as those for ITU-R P.530-7.

For ITU-R P.530-15

If you are using ITU-R P.530-12, ASSET Backhaul calculates p_0 as follows:

$$p_0 = K \cdot d^{3.4} \cdot \left(1+|\varepsilon_p|\right)^{-1.03} \cdot f^{0.8} \cdot 10^{-0.00076 \cdot h_L} \ \%$$

Where the parameters are the same as those for ITU-R P.530-7.

For Vigants

For the Vigants calculation, please see Vigants Method on page 301.

Average Worst Month Calculation

Based on the correct calculation for the propagation method, you can calculate the percentage of time that a fade *F* (dB) is exceeded in the average worst month:

$$p_w = p_0 \cdot 10^{-F/10} \ \%$$

This can be converted into the average annual distribution:

$$p = p_w \cdot 10^{-\Delta G/10} \ \% \Rightarrow p = p_0 \cdot 10^{-\Delta G/10} 10^{-F/10} \ \%$$

Where:

$$\Delta G = 10.5 - 5.6 \log\left(1.1 \pm |\cos 2\xi|^{0.7}\right) - 2.7 \log d + 1.7 \log\left(1+|\varepsilon_p|\right)$$

ΔG is the logarithmic geoclimatic conversion factor (dB)

p_0 is the multipath occurrence factor (in %), calculated differently depending on which calculation method you are using. For more information, see Multipath Occurrence Factor Calculation on page 338.

d is the path length (km)

ξ is latitude (degrees North or South)

The positive sign is used where ξ is 45 degrees or less and the negative sign is used for where ξ is more than 45 degrees.

Therefore, the necessary fade margin for the required availability A_{req} (%) can be calculated using:

$$p_{req} = 1 - A_{req}$$

$$F_{multipath} = -\Delta G + 10 \cdot \log_{10} \frac{p_0}{p_{req}} \text{ dB}$$

Total Annual Outage Calculation

ITU-R Calculation Methods

Total annual outage $P_{t,w/odiv.}$ is calculated using formula 134 of ITU-R P.530-12:

$$P_t = \begin{cases} P_{ns} + P_s + P_{XP} \\ P_d + P_{XP} & \text{if diversity is used} \end{cases}$$

Where:

P_{ns} is outage caused by flat fading

P_s is outage caused by selective fading

P_{xp} is the reduction of cross-polar discrimination

P_d is the total outage probability

Vigants Barnett Calculation Method

For the Vigants calculation, please see Vigants Method on page 301.

Converting from Worst Month to Annual Period Figures

Use the following equations to convert worst month figures to annual figures.

8. Take the outage percentage p_w.
9. Calculate the logarithmic geoclimatic conversion factor ΔG from:

$$\Delta G = 10.5 - 5.6 \log \left(1.1 \pm |\cos 2\xi|^{0.7}\right) - 2.7 \log d + 1.7 \log \left(1 + |\varepsilon_p|\right) \text{dB}$$

where $\Delta G \leq 10.8$ dB and the positive sign is employed for $\xi \leq 45°$ and the negative sign for $\xi > 45°$ and where:

ξ is the latitude (°N or °S)

d is the path length (km)

$|\varepsilon_p|$ is the magnitude of path inclination

10. Calculate the percentage of time p for the average year from:

$$p = p_w 10^{-\Delta G/10}$$

Outage After Diversity Calculation

Outage after diversity is calculated using ITU-R P.530-7 (formula 73), 530-12 (formula 119) or 530-15 (formula 149).

Improvement Factor Calculations

The improvement factor is a ratio between two outage values, calculated using this equation:

$$I = \frac{P_n + P_{ns}}{P_t}$$

Where:

P_t is the total annual outage, calculated using ITU-R P.530-7 (formula 88) or 530-10 (formula 134)

There are also separate equations for space, frequency, space2frequency and space4frequency diversity improvement factors.

Frequency Diversity Improvement Factor Calculation

The frequency diversity improvement calculation is as follows:

$$I_{ns,f} = \frac{80}{fd}\left(\frac{\Delta f}{f}\right)10^{F/10}$$

Where:

f is carrier frequency (GHz)

F is flat fade margin (dB)

Important: This equation is only valid for the following ranges:

- Path length : 30-70 km
- Frequency : 2-11 GHz
- If Δf is more than 0.5 GHz, use Δf = 0.5
- Δf / main f <= 5%

Space2Frequency Diversity Improvement Factor Calculation (ITU-R. P.530-7)

This section describes the space2frequency diversity improvement calculation for ITU-R P.530-7.

Space2frequency diversity is a combination of space and frequency diversity, with 2 receivers at each linkend and a total of 3 antennas.

To calculate this:

11. Calculate the multipath occurrence factor P_0.

    Where $P_0 = \left(p_w \times 10^{A/10}\right)/100$

    For information on how to calculate P_0, see Multipath Occurrence Factor Calculation on page 338.

12. Calculate the vertical space diversity improvement factor I.

13. Calculate the total outage probability P_d.

Vertical Space Diversity Improvement Factor Calculation

When you are calculating the space2frequency diversity improvement factor for ITU-R. P. 530-7, you must calculate the vertical space diversity improvement factor I.

To do this, use the following equation:

$$I = \left[1 - \exp\left(-3.34 \times 10^{-4} S^{0.87} f^{-0.12} d^{0.48} P_0^{-1.04}\right)\right] 10^{(A-V)/10}$$

Where:

$V = \left|G_1 - G_2\right|$, G_1, G_2 being the gain of the two antennas (dBi)

A is the fade depth (dB) for the unprotected path

P_0 is the multipath occurrence factor

S is the vertical separation (center-to-center) of receiving antennas (m)

f is frequency (GHz)

d is path length (km)

Important: This equation is only valid for the following ranges:

- Path lengths of 43 to 240 km
- Frequencies of 2 to 11 GHz
- Vertical antenna separations of 3 to 23 m

Total Outage Probability Calculation (S2F 530-7)

When you are calculating the space2frequency diversity improvement factor for ITU-R. P530-7, you must calculate the total outage probability P_d.

To do this, use the following equation:

$$P_d = \left(P_{ds}^{\ 0.75} + P_{dns}^{\ 0.75}\right)^{4/3}$$

Space2Frequency Diversity Improvement Factor Calculation (ITU-R. P.530-12)

This section describes the space2frequency diversity improvement calculation for ITU-R P.530-12.

Space2frequency diversity is a combination of space and frequency diversity, with 2 receivers at each linkend and a total of 3 antennas.

To calculate this:

14. Calculate the non-selective correlation coefficient k_{ns}.
15. Calculate the square of the selective correlation coefficient k_s.
16. Calculate the non-selective outage probability P_{dns}.
17. Calculate the selective outage probability P_{ds}.
18. Calculate the total outage probability P_d.

Non-Selective Correlation Coefficient Calculation

If you are calculating the space2frequency diversity improvement factor for ITU-R. P. 530-12, you must calculate the non-selective correlation coefficient k_{ns}.

There are three separate portions to this calculation, one for the space diversity, one for the frequency diversity and one that brings these two parts together.

- or -

If you are calculating the space4frequency diversity improvement factor for ITU-R. P. 530-12, you must calculate:

- The vertical space diversity factor
- The outage probability due to non-selective fading
- The frequency diversity improvement factor

Important: For the space4 frequency calculations, the diversity antenna heights and the receiver frequencies of the diversity radios are used.

Space Diversity Portion

Note: You should proceed through this section as if the system was using only space diversity; in other words, ignore the fact that there are 2 sets of frequencies being received at each linkend.

---

19. Calculate (or look up) P_{ns}, which is the non-selective (flat) outage probability for the linkend across the main antennas (in other words, the flat outage figure for the linkend). This value should be stored as a number between 0 and 1, not a percentage, for use in the algorithms that follow.

20. Calculate the multipath activity factor η for each linkend:

$$\eta = 1 - e^{-0.2(P_0)^{0.75}}$$ (Equation 1)

Where:

$P_0 = p_w / 100$ = Multipath occurrence factor corresponding to the percentage of time p_w (%) of exceeding A = 0 dB in the average worst month, whose percentage value is calculated from:

$$p_0 = Kd^{3.2}(1 + |\varepsilon_p|)^{-0.97} 10^{0.032 f - 0.00085 h_L}$$ (%) (Equation 2)

Where:

K is the geoclimatic factor (set in the **Link Database**, on the **Propagation Prediction** sub-tab of the **Calculation** tab)

d is the path length (km)

f is the receiver frequency (GHz) of the main antenna at that linkend

h_L is the altitude of the lower diversity antenna (m)

$|\varepsilon_p|$ is the magnitude of the path inclination (mrad), equal to $|h_r - h_e| / d$ (Equation 3), where h_r and h_e are the diversity antenna heights (m) above sea level (in other words, their altitudes)

21. Calculate the vertical space diversity improvement factor $I_{ns,s}$ (I) from:

$$I = \left[1 - \exp\left(-0.04 x S^{0.87} f^{-0.12} d^{0.48} p_0^{-1.04}\right)\right] 10^{(A-V)/10}$$ (Equation 4)

Where:

$V = |G_1 - G_2|$ (dB)

A is the fade depth (dB) for the unprotected link, corresponding to the flat fade margin *F*

S is the vertical separation (center-to-center) of the receiving antennas at the linkend (m)

f is receiver frequency (GHz) of the main antenna at the linkend

d is path length (km)

G_1, G_2 is the gains of the two antennas (dBi) at the linkend

p_0 is the multi-path occurrence factor (%), as calculated in Equation 2 above

---

Important: Equation 4 is only valid for the following ranges:

- Path length : 43-240 km
- Frequency : 2-11 GHz
- Vertical antenna separation : 3-23 m

If the actual values fall out of these ranges, the **ASSET Backhaul Message Log** will warn you, but the calculations will still be performed with the out-of-range values.

---

22. Calculate the non-selective correlation coefficient for space diversity $k_{ns,s}$:

$$k_{ns,s} = \sqrt{1 - \frac{I_{ns,s} \times P_{ns}}{\eta}}$$ (Equation 6)

Frequency Diversity Portion

Note: You should proceed through this section as if the system was using only frequency diversity; in other words, ignore the fact that there are 2 antennas on one of the linkends.

---

23. Calculate (or look up) P_{ns}, which is the non-selective (flat) outage probability for the linkend. This value should be stored as a number between 0 and 1, not a percentage, for use in the algorithms that follow.

Tip: This is the same P_{ns} value as used for the space diversity portion.

---

24. Calculate the multipath activity factor η for each linkend, using the same algorithms as for the space diversity portion, but use the receiver frequencies for the diversity radios and the antenna heights of the main antennas.

25. Calculate the frequency diversity improvement factor $I_{ns,f}$ for each linkend.

$$I_{ns,f} = \frac{80}{fd}\left(\frac{\Delta f}{f}\right)10^{F/10}$$ (Equation 7)

Where:

Δf is the frequency separation (GHz)

f is receiver frequency (GHz) of the main radio (in other words, not the diversity frequency) at the linkend

F is flat fade margin (dB) for the unprotected link

If Δf is more than 0.5GHz, use Δf = 0.5

Important: Equation 7 is only valid for the following ranges:

- Path length : 30-70km
- Frequency : 2-11GHz
- Δf / main f <= 5%

If the actual values fall out of these ranges, the ASSET Backhaul Message Log will warn you, but the calculations will still be performed with the out-of-range values.

26. Calculate the non-selective correlation coefficient for frequency diversity $k_{ns,f}$:

$$k_{ns,f} = \sqrt{1 - \frac{I_{ns,f} \times P_{ns}}{\eta}}$$ (Equation 8)

Final Portion

Calculate the non-selective correlation coefficient k_{ns} :

k_{ns} = $k_{ns,s}$ X $k_{ns,f}$ (Equation 9)

Square of the Selective Correlation Coefficient Calculation (S2F)

When you are calculating the space2frequency diversity improvement factor for ITU-R P.530-12, you must calculate the square of the selective correlation coefficient k_s .

To do this:

27. Calculate the correlation coefficient r_w of the relative amplitudes, using Equation 10, which is:
    - For k_{ns}^2 equal to or less than 0.26, $r_w = 1 - 0.9746\,(1 - k_{ns}^2)^{2.17}$
    - For k_{ns}^2 greater than 0.26, $r_w = 1 - 0.6921\,(1 - k_{ns}^2)^{1.034}$

28. Calculate the square of the selective correlation coefficient k_s , using Equation 11, which is:
    - For r_w less than 0.5, k_s^2 = 0.8238
    - For r_w between 0.5 and 0.9628, $k_s^2 = 1 - 0.195\,(1 - r_w)^{0.109 - 0.13\log(1 - r_w)}$
    - For r_w greater than 0.9628, $k_s^2 = 1 - 0.3957\,(1 - r_w)^{0.5136}$

Non-selective Outage Probability Calculation (S2F)

When you are calculating the space2frequency diversity improvement factor for ITU-R P. 530-12, you must calculate the non-selective outage probability P_{dns}.

To do this, use Equation 12, which is:

$$P_{dns} = \frac{P_{ns}}{I_{ns}}$$

Where:

P_{ns} is the non-selective (flat) outage probability for the linkend used in the Non-Selective Correlation Coefficient Calculation on page 343.

I_{ns} is the vertical space diversity improvement factor used in the Non-Selective Correlation Coefficient Calculation on page 343.

Selective Outage Probability Calculation (S2F)

When you are calculating the space2frequency diversity improvement factor for ITU-R P. 530-12, you must calculate the selective outage probability P_{ds}.

To do this, use Equation 13, which is:

$$P_{ds} = \frac{P_s^2}{\eta(1-k_s^2)}$$

Where:

P_s is the selective outage probability for the main antennas, which is displayed on the **Outage** subtab of the **Performance** tab for a link in the **Link Database**.

Total Outage Probability Calculation (S2F 530-12)

When you are calculating the space2frequency diversity improvement factor or the space4frequency diversity improvement factor for ITU-R P. 530-12, you must calculate the total outage probability P_d.

To do this, use the Equation 14, which is:

$$P_d = \left(P_{ds}{}^{0.75} + P_{dns}{}^{0.75}\right)^{4/3}$$

Space4Frequency Diversity Improvement Factor Calculation

This section describes the space4frequency diversity improvement calculation for ITU-R P. 530-12.

Space4frequency diversity is a combination of space and frequency diversity, with 4 receivers at each linkend.

To calculate this:

29. Calculate the multipath activity factor η.
30. Calculate the diversity parameter m_{ns}.
31. Calculate the non-selective outage probability P_{dns}.
32. Calculate the square of the equivalent non-selective correlation coefficient k_{ns}.
33. Calculate the equivalent selective correlation coefficient k_s.
34. Calculate the selective outage probability P_{ds}.
35. Calculate the total outage probability P_d (the same calculation as used for Space2Frequency diversity)

Multipath Activity Factor Calculation

When you are calculating the space4frequency diversity improvement factor for ITU-R P. 530-12, you must calculate the multipath activity factor η.

To do this, use Equation 1 from the Non-Selective Correlation Coefficient Calculation on page 343, using the diversity antenna heights and the receiver frequencies of the diversity radios.

Diversity Parameter Calculation

When you are calculating the space4frequency diversity improvement factor for ITU-R P. 530-12, you must calculate the diversity parameter m_{ns}.

To do this, use Equation 15, which is:

$$m_{ns} = \eta^3 \left(1 - k_{ns,s}^2\right)\left(1 - k_{ns,f}^2\right)$$

Where:

$k_{ns,s}$ is calculated using Equation 6 for the Non-Selective Correlation Coefficient Calculation on page 343, using the diversity antenna heights and receiver frequencies of the diversity radios

$k_{ns,f}$ is calculated using Equation 8 for the Non-Selective Correlation Coefficient Calculation on page 343, using the diversity antenna heights and receiver frequencies of the diversity radios

Non-selective Outage Probability Calculation (S4F)

When you are calculating the space4frequency diversity improvement factor for ITU-R P. 530-12, you must calculate the non-selective outage probability P_{dns}.

To do this, use Equation 16, which is:

$$P_{dns} = \frac{P_{ns}^4}{m_{ns}}$$

Where:

P_{ns} is the non-selective (flat) outage probability for the linkend across the main antennas, in other words, the flat outage figure for the unprotected linkend.

Square of the Selective Correlation Coefficient Calculation (S4F)

When you are calculating the space4frequency diversity improvement factor for ITU-R P. 530-12, you must calculate the square of the selective correlation coefficient calculation k_{ns}.

To do this, use Equation 17, which is:

$$k_{ns}^2 = 1 - \sqrt{\eta}\left(1 - k_{ns,s}^2\right)\left(1 - k_{ns,f}^2\right)$$

Selective Correlation Coefficient Calculation

When you are calculating the space4frequency diversity improvement factor for ITU-R P. 530-12, you must calculate the selective correlation coefficient k_s.

To do this, use Equations 10 and 11 of the Square of the Selective Correction Coefficient Calculation for Space2Frequency Diversity.

Selective Outage Probability Calculation (S4F)

When you are calculating the space4frequency diversity improvement factor for ITU-R P. 530-12, you must calculate the selective outage probability P_{ds}.

To do this, use Equation 18, which is:

$$P_{ds} = \left[\frac{P_s^2}{\eta\left(1 - k_s^2\right)}\right]^2$$

Where:

P_s is the selective outage probability for the main antennas, displayed on the **Outage** subtab of the **Performance** tab in the **Link Database**.

Space2 Diversity Improvement Factor Calculation

The space2 diversity improvement calculation is the same as the space2frequency diversity improvement factor calculation for ITU-R P. 530-12, except for the frequency diversity portion, which we will be performing for the linkend that has two antennas.

Space4 Diversity Improvement Factor Calculation

The space2 diversity improvement calculation is the same as the space2frequency diversity improvement factor calculation for ITU-R P. 530-12, except for the frequency diversity portion, which we will be performing for both of the linkends with two antennas.

Outage Probability due to Clear-Air Effects Calculation

The total outage probability due to clear-air effects is calculated as follows (assuming diversity is used):

$$P_t = \begin{cases} P_{ns} + P_s + P_{XP} \\ P_d + P_{XP} \end{cases}$$

Where:

P_t is the total outage probability due to clear-air effects

P_{ns} is the outage probability due to non-selective fading

P_s is the outage probability due to selective fading

P_{XP} is the outage probability due to clear-air cross-polarization

P_d is the outage probability due to diversity

Outage Probability due to Precipitation Calculation

The total outage probability due to precipitation is determined by:

$$P_{tr} = \begin{cases} P_{rain} & \text{if } P_{rain} > P_{XPR} \\ P_{XPR} & \text{if } P_{rain} < P_{XPR} \end{cases}$$

Where

P_{tr} is the total outage probability due to precipitation

P_{rain} is the unavailability caused by rain (P_r)

P_{XPR} is the outage probability due to cross-polarization during precipitation conditions

Outage Probability due to Cross-Polarisation During Precipitation Conditions

To calculate total outage probability due to precipitation (P_r), the value of outage probability due to cross-polarization during precipitation conditions (P_{XPR}) is required. To calculate this value:

36. Determine $A_{0.01}$.

    This is the path attenuation due to rain exceeded for 0.01% of the time. This value is known elsewhere in ASSET Backhaul as the Required Fade Margin due to Rain and Rain Unavailability.

37. Determine the equivalent path attenuation A_p:

    $$A_p = 10^{((U - C_0/I + XPIF)/V)}$$

    Where

    $U = U_0 + 30 \log f$, with U_0 = 15 dB

    $$V(f) = 12.8\ f^{\,0.19} \qquad \text{for} \quad 8 \le f \le 20 \text{ GHz}$$

    $$V(f) = 22.6 \qquad \text{for} \quad 20 < f \le 35 \text{ GHz}$$

    C_0/I is calculated as follows:

    - If you have configured antenna masks, use the T/I value for the same radio (carrier X and interferer X) at 0 MHz separation
    - If you have not configured antenna masks, use the default T/I value, as set in the Interference Wizard

    $XPIF$ is the laboratory-measured cross-polarization improvement factor when using a cross-polar interference canceler (XPIC).

38. Calculate parameters m and n:

    $$m = \begin{cases} 23.26 \log \left[A_p / \ 0.12\ A_{0.01} \right] & \text{if } m \le 40 \\ 40 & \text{otherwise} \end{cases}$$

    and

    $$n = \left(-12.7 + \sqrt{161.23 - 4m} \right) / 2$$

39. Determine the outage probability P_{XPR}, based on

    $$P_{XPR} = 10^{(n-2)}$$

40. According to the total outage probability due to precipitation calculation, the total outage probability due to precipitation is the greater value of the Rain Unavailability (P_r) and the cross-polarization outage probability due to precipitation (P_{XPR}).

Retrieve P_r (calculated as described in Calculating the Rain Unavailability on page 317) and compare this to P_{XPR}. The value returned for P_{rain} in the **Link Database**, on the **Reliability** subtab of the **Performance** tab (described as Rain (0.01%, 25mm/h) (Pr) (%) should be the higher value.

Geoclimatic Factor Calculations

The geoclimatic (K) factor is calculated as follows, depending on the calculation method chosen on the **Propagation Prediction** tab in the **Link Database**.

For ITU-R P.530-7

Geoclimatic factor K is calculated as

$$K = 5 \cdot 10^{-7} \cdot 10^{-0.1(C_0 - C_{Lat} - C_{Lon})} \cdot p_L^{1.5}$$

Where

- C_{Lat} (dB) is:
  - 0 where ξ (the absolute latitude N or S) is 53 degrees or under
  - 53 + ξ for ξ between 54-59 degrees
  - 7 where ξ is 60 degrees or over
- C_{Lon} is:
  - 3 for longitudes in Europe and Africa
  - -3 for longitudes in North and South America
  - 0 for all other longitudes
- C_0 is a coefficient taken from the following table, based on three ranges for the lower antenna and three types of terrain:

Altitude of lower antenna	Type of link terrain	Coefficient value (dB)
Low altitude (0-400m)	Plain	0
Low altitude (0-400m)	Hills	3.5
Medium altitude (400-700m)	Plains	2.5
Medium altitude (400-700m)	Hills	6
High altitude (> 700m)	Plains	5.5
High altitude (> 700m)	Hills	8
High altitude (> 700m)	Mountains	10.8

- $|\varepsilon_p|$ is the path inclination in mrad, equal to $|h_r - h_e| / d$, where h_r and h_e are the antenna heights (m) above sea level

For ITU-R P.530-12

Geoclimatic factor K is calculated as:

$$K = 10^{-3.9 - 0.003 dN_1} s_\alpha^{-0.42}$$

Where

- dN_1 is the point refractivity gradient in the lowest 65m of the atmosphere not exceeded for 1% of an average year (calculated using ITU-R P.453)
- s_α is the standard deviation of the terrain heights (m)

For ITU-R P.530-15

Geoclimatic factor K is calculated as

$$K = 10^{-4.4-0.0027 dN_1} \left(10 + s_a\right)^{-0.46}$$

Where dN_1 and s_α are the same as for the ITU-R P.530-12 calculation.

Reliability Equations

The values on the **Reliability** tab are automatically produced, based on other values in the **Link Database**.

For information on the unavailability caused by rain, see Rainfall Fading Equations on page 310.

Note: By default, the reliability values are calculated as percentages. However, on the Reliability tab they can also be calculated and displayed as:

- Number of seconds per year (whereby the percentage value is multiplied by 31,536,000)
- Number of minutes per year (whereby the percentage value is multiplied by 525,600)

Unavailability Caused by Equipment Calculation

This value P_e shows how much unavailability is caused by equipment failure, and is calculated using the following equations, where:

$MTTR$ is Mean Time To Repair

$MTBF$ is Mean Time Between Failures

Unavailability Without Diversity

[1] Unavailability $$P(e) = \frac{MTTR}{MTTR + MTBF}$$

[2] Availability $$1 - P(e) = 1 - \frac{MTTR}{MTTR + MTBF}$$

Unavailability With Diversity

Independent areas occurring at the same time is based on:

[3] Unavailability $$P(f \times e) = P(f) \times P(e)$$

[4] Availability $1-P(f\times e)=1-(P(f)\times P(e))$

Calculating Equipment Availability for Multi-radio Links

The method of calculating equipment availability for multi-radio links is different, depending on the radio (n + m) configuration:

- If m is 0 (where no sublink is used for protection), then equipment availability is calculated as it is for single operating mode
- If m is 1, then equipment availability is calculated using ITU-R F. 557-4

Protection Switching

Protection switching can often improve system availability.

For example, in radio-relay systems, the so-called multi-line switching method is typically used. In this method, one or P(P>1) protection radio channels are prepared for N working channels. When one of the N working channels is interrupted, the signal in the interrupted channel will immediately be recovered by one of the protection channels over m radio hops. In this case, the unavailability due to equipment failure (U) of each radio channel is calculated using the following formula (assuming that the failure rate of switching equipment is negligibly small):

$$U=\frac{2}{N}\left[\binom{N+P}{P+1}\right](mq)^{P+1} \quad (1)$$

Where

m is the number of radio hops contained in a switching section (in this case, it is always 1)

q is the probability of an interruption of each hop (also expressed as MTTR/MTBF)

$$\binom{N+P}{P+1}=\frac{(N+P)!}{(P+1)!(N-1)!}$$

In many cases, the number of the protection channels (P) is 1, and so the formula can be re-written as:

$$U=\frac{2}{N}\left[\binom{N+1}{2}\right](mq)^{2}$$

Annual Availability and Reliability Calculation

Annual availability

Annual availability is calculated as follows:

$$P_A=100-P_{UA}$$

Annual unavailability

Annual unavailability for each link end is calculated as:

$$P_{ua} = P_{e-A} + P_{e-B} - P_{e-A} * P_{e-B} + P_r$$

Where:

P_{e-A} is the equipment unavailability at End A

P_{e-B} is the equipment unavailability at End B

P_r is the unavailability due to rain

Note: In most cases, the values of P_{e-A} and P_{e-B} are equal and are often referred to as P_e. $P_{e-A/B}$ is calculated using the method described for P_e in Unavailability Caused by Equipment Calculation on page 353.

Annual reliability

Annual reliability P_{Re} is then calculated using the following formula:

$$P_{\mathrm{Re}} = 100 - P_{U\mathrm{Re}}$$

Annual unreliability

Annual unreliability $P_{U\mathrm{Re}}$ is a sum of outage and unavailability, that is:

$$P_{U\mathrm{Re}} = P_T + P_{UA}$$

Worst Month Availability and Reliability Calculation

Worst month availability P_{WMA} is calculated using the following formula:

$$P_{WMA} = 100 - P_{WAUA}$$

Worst month unavailability P_{WMA} is calculated using ITU-R P.841, formula 5.

Total worst month reliability $P_{WM\mathrm{Re}}$ is then calculated using the following formula:

$$P_{WM\mathrm{Re}} = 100 - P_{WMU\mathrm{Re}}$$

Total worst month unreliability $P_{WMU\mathrm{Re}}$ is calculated using ITU-R P.841-4, formula 1.

The annual percentage of unavailability and unreliability is converted to a worst month percentage.

The average annual worst-month time percentage p_w is calculated from the average annual time percentage of p using the conversion factor *Q*:

$$p_w = Qp$$

where 1 < *Q* < 12

Q is calculated using ITU-R P.841-4, formula 2

Note: For global planning purposes the following values for the parameters Q_1 and β should be used:

Q_1 = 2.85, β = 0.13

Converting Average Month to Shorter Worst Periods

When you are using ITU-R P.530-12, you can convert worst month periods to shorter worst periods that you define.

The shortest worst period of time T is converted into hours.

Depending on the selection of terrain type, there is a different formula. The percentage of time p_w of exceeding a deep fade A in the average worst month can be converted to a percentage of time p_{sw} of exceeding the same deep fade during a shorter worst period of time by the relations:

$p_{sw} = p_w(89.34T^{-0.854} + 0.676)\%$ $1h \le T < 720h$ for relatively flat paths

$p_{sw} = p_w(119T^{-0.78} + 0.295)\%$ $1h \le T < 720h$ for hilly paths

$p_{sw} = p_w(199.85T^{-0.834} + 0.175)\%$ $1h \le T < 720h$ for hilly land paths

Intermodulation Equations

This section describes how the intermodulation analysis is performed in ASSET Backhaul.

The possible intermodulation products are calculated for every linkend in the filter. 2nd and 3rd order products are taken into account. The level of higher order products is considered too low to be of concern. The order of products gives rise to the ordinal value used below. The ordinal value is either 2 or 3.

If the ordinal value is 2 with 2 channels to mix, the algorithms will be:

If nA – mB is within testing link frequency band report interference

OR If nA + mB is within testing link frequency band report interference

OR If mB - nA is within testing link frequency band report interference

OR If mB is within testing link frequency band report interference

OR If nA is within testing link frequency band report interference

Where:

A and B are the frequencies of the 2 links being analyzed to find the intermodulation frequencies they generate

n and m are the whole number multipliers applied to A and B where n + m <= the ordinal value

The bandwidth of an intermodulation frequency is:

nWidth of A frequency band + mWidth of B frequency band

If the channels to mix is 3 then this formula is used:

nA + mB + oC

with all combinations of + and – as shown above m and so on for greater quantities of mixing of frequencies.

This will result in the number of equations to be calculated equaling the sum of the number of frequencies on the site to the power of the ordinal.

For example, 5 channels on a site will result in:

(5) + (5 * 5) + (5 * 5 * 5) = 155 calculations

You can view the algorithms used in the Intermodulation Display window.

Automatic Link Planner Equations

The algorithm used by the automatic link planner is metaheuristic. It does not set out to determine the best solution, just one that is better than the initial solution.

The algorithm uses simulated annealing, based on the following input criteria:

- Minimum and maximum power for Ends A and B
- The power step by which each of the powers can change (for example, steps of 1dB)
- The band and available channels to which each link can be assigned
- 'Hard' and 'soft' constraints
- The modulation types available for each link, with their respective min and max powers and corresponding threshold values (automatic capacity planning only)

The search algorithm runs in the following stages:

1. Determines the possible states of the parameters.
2. Calculates the initial temperature.
3. Starts the algorithm.
4. Calculates the energy.
5. Selects neighboring solutions.
6. Searches for the optimal solution.

How the Search Algorithm Determines the Possible States of the Parameters

The first step of the search algorithm is to determine all the possible states for all of the applicable parameters:

- For channels, frequency designation, polarization and modulation scheme, the available values are defined on the **Link-Specific** tab of the **Automatic Link Planner Wizard**.
- For power, if the **'Include Power in the optimal solution search'** option has been selected on the **General Prerequisites** tab of the Automatic Planner Wizard, then the possible values for power are calculated using the **Power Step (in dB)** value (defined on the same tab).

  The power range (determined by the minimum and maximum powers) is divided by the power step to give all of the possible values.

Initial Temperature Calculation

The temperature at each iteration of the search algorithm is calculated as follows.

However, the following values must first be assigned:

- The initial temperature
- The number of successive iterations in which the temperature remains the same
- Parameter α , which controls the cooling process

The initial temperature depends on the initial acceptance probability (p_0) of the first solutions, which is set as $p_0 = 0.8$.

The algorithm is initially run for 2 steps, without restricting any solutions, and the mean increase Δ of the system's energy is calculated:

$$\Delta = E_{medium} + (E_{\max} - E_{\min})$$ (Equation 5)

Where

E_{medium} is the medium energy value

$E_{\max}$ and $E_{\min}$ are the maximum and minimum energy values, which are calculated in the first L steps.

Then the initial temperature can be calculated as:

$$T_0 = \frac{-\Delta}{\ln p_0}$$ (Equation 6)

The decrease rate of the temperature at each iteration can then be defined using the following equation, where α =0.9:

$$T_{k+1} = a \cdot T_k$$ (Equation 7)

How the Search Algorithm is Started

When the **Plan** button is clicked in the **Planner**, the algorithm runs as follows:

1. The Initial function provides the algorithm with an initial solution to the optimization problem.

   This solution can be:

   - The current configuration as defined in ASSET Backhaul.

     If any links are not correctly configured, ASSET Backhaul should warn the user.
   - A completely random solution.
2. Starting with the initial solution, the algorithm runs for a number of iterations equal to the number of considered links x 2, generating solutions at random.
3. The energy of each iteration is recorded.
4. The maximum violation for each constraint is recorded, although constraints are not being considered at this stage.
5. After these iterations, the following values are calculated:
   - The mean increase in energy (Δ)
   - The mean energy (E_{mean})
   - The maximum values for each violation ($V_{\max}$)

Energy Calculation

The Energy function is the objective function that needs to be minimized. The value of the Energy function indicates the energy of the system for the respective solution.

The composition of the Energy function depends on the planning mode being used:

- If the planner is being run in frequency planning mode only, then the Energy function will include the sum of the interference degradation on each linkend:

  $$E_{\deg rad}(x_i) = \sum_{k=1}^{K} I_k^{\deg rad}$$ (Equation 1)

  Where:

  K is the number of linkends in the network
- If the planning is being run in frequency and capacity planning mode, then the Energy function will also include capacity optimization, which is calculated as:

  $$E_{capacity}(x_i) = \sum_{k=1}^{K} C_k$$ (Equation 2)

  Where:

  C_k is the difference from the maximum capacity that the linkend k can achieve

The Energy function also includes the constraint penalties, which will increase the total Energy value. These constraints will penalize the solution to a varying degree, depending on the extent of the violation.

The general calculation of the penalties is as follows:

$$p_s = a_v |\Delta V|^{p_v}$$ (Equation 3)

Where:

ΔV is the magnitude of the violation

a_v and p_v are scaling factors

This means that the total Energy for automatic frequency and capacity planning is calculated as:

$$E(x_i) = w_1 \sum_{k=1}^{K} I_k^{\deg rad} + w_2 \sum_{k=1}^{K} C_k + \sum_{z=0}^{Z} \sum_{x=0}^{X_z} p_z^x$$ (Equation 4)

Where:

w_1 and w_2 are weighting factors, so that the two terms (interference degradation and capacity optimization) have similar effects. They are calculated as:

$$w_1 = \frac{1000}{V_{maxPerInterferer}}$$

and

$$w_2 = \frac{1000}{V_{\max Capacity}}$$

Where

$V_{maxPerInterferer}$ is the maximum violation of the threshold degradation per interferer

$V_{\max Capacity}$ is the maximum capacity violation

Z is the total number of constraints

X_z is the number of violations for each constraint

How the Algorithm Selects the Neighboring Solutions

The search algorithm uses the neighbor function to produce solutions that have a similar cost to the preceding one - this may exclude a very good solution, but more often excludes very bad solutions.

When finding the neighbors of a solution, it is important to define the direction and length of the movement, so that the constraints can be altered accordingly. It is more efficient to change a smaller number of parameters, and find a feasible direction within a low-dimensional subspace.

ASSET Backhaul uses the directed selection method to choose neighboring solutions.

In directed selection, half of the linkends are grouped and put into order. Each linkend can belong to one (and only one) of four possible groups. These groups are defined in the following table:

Group	Description
Highest threshold degradation	Includes the linkends with the highest threshold degradation. From those, 20% are chosen randomly, and new channels are randomly assigned to them. Another 20% are chosen, and their designation is changed (if the 'Allow Designation Changes' option has been selected on the General Prerequisites tab of the Automatic Planner).
Highest availability (Automatic frequency and capacity planning only)	Includes the linkends which are AMC-enabled and have the highest availability. From those, 20% are chosen randomly and a higher modulation scheme is assigned to them.
Maximum violation of availability (Only used if: The 'Include power in the optimal solution search' option is selected on the General Prerequisites tab of the Automatic Planner - and - The Soft Availability Constraints option is selected on the Constraints tab of the Automatic Planner)	Includes the linkends with the greatest availability violation. From those, 20% are chosen randomly and a higher power is assigned to them.
Strongest interferers	Includes the linkends that cause the highest interference. From those, 20% are chosen randomly and their power is reduced. Another 20% are chosen, and their polarization is changed (if the 'Allow Polarization Changes' option has been selected on the General Prerequisites tab of the Automatic Planner).

How the Algorithm Searches for the Optimal Solution

After the initial iterations have run, and the parameters have been configured, the search algorithm starts.

For each iteration of the search, the energy is calculated, and the links are grouped according to the categories described in How the Algorithm Selects the Neighboring Solutions on page 360.

The next solution is defined, and the algorithm continues.

The solution with the minimum energy is recorded, and saved as S_{best}.

After the algorithm has run for 2 L iterations, the temperature decreases according to Equation 7 in Initial Temperature Calculation on page 358, where α is set to 0.9.

L will have the same order of magnitude with the number of links (m) in the network, and so it can be set as:

$L = 2 \cdot m$ (Equation 8)

Every 4 L , the solution is set to S_{best} .

The search will stop when at least one of the termination rules have been met:

- A maximum number of steps ($L_{\max}$), which is 46 L .
- A minimum temperature ($T_{\min} = 0.1 \cdot T_0$)
- A minimum energy ($E_{\min} = 0.1 E_{current}$)

Reflection Analysis Equations

This section describes the calculations used by ASSET Backhaul for reflection analysis.

Determining Reflection Points for Basic Reflection Analysis

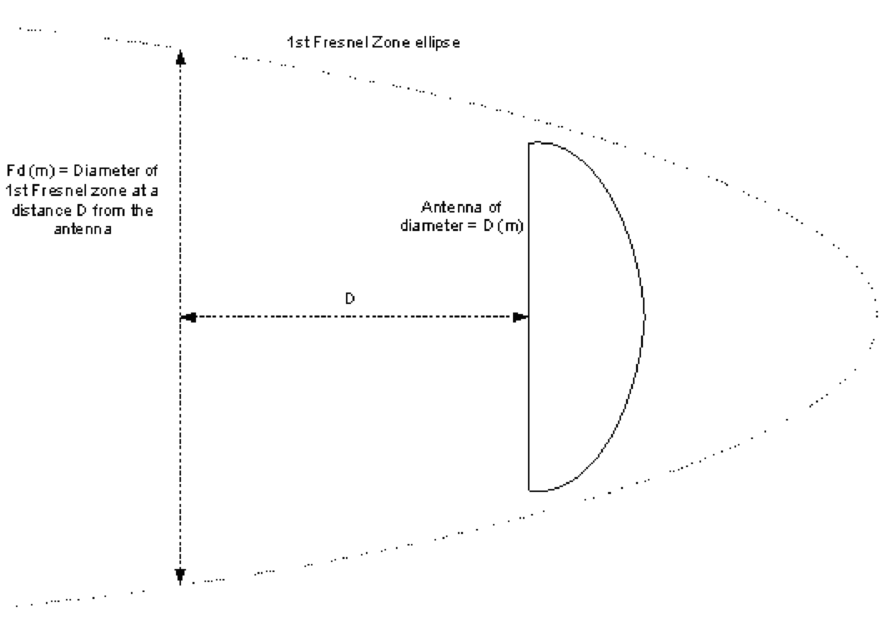
For basic reflection analysis, ASSET Backhaul uses the following method to determine reflection points that may lead to multi-path fading.

1. ASSET Backhaul analyzes the ground area under the link's profile in order to find the point on the surface that has a gradient that results in a grazing angle from transmitter to receiver. In other words, this is the ray drawn from the transmitting antenna to that point on the surface that reflects into the receiving antenna.

2. To allow for slight errors (in terrain gradient, ray tracing and/or height inaccuracies), the receiving area of the far end antenna is defined as the diameter of the antenna, extended by the width of the 1st Fresnel zone at a point that is 1 antenna diameter's distance away from the receiver in the direction of the antenna.

   Note: This extra height, above and below the antenna, is frequency- and path length-dependent.

   This picture shows that the effective extra height 'added' to each side of the antenna diameter is F_d (in m):



For example, consider a link 2.4km long, at a frequency of 38 GHz. If the antenna diameter is 0.3m and the diameter of the 1st Fresnel zone (0.3m from the antenna, in the direction of the transmitter) is 0.0486m (approximately equal to 5cm), then the extra height added is about 0.1m.

If there is no frequency or antenna information available for the link profile, the following table is used as a rough guide:

Range of Path Lengths (km)	Frequency Band (GHz)	Antenna Diameter (m)
0-5	38	0.3
6-10	26	0.6
11-25	15	1.2
26 +	7	1.8

3. Reflection lines are drawn on the **Height Profile** for the center points of reflecting beams - only one line is drawn on the profile to make visual analysis easier, even though the reflection point might encompass an area.

Calculation to Account for Tidal Height Variation

For all K and tidal clutter analysis calculations, ASSET Backhaul accounts for tidal height variation as follows:

1. Assume the DTM at the reflecting point is the median height.
2. Perform the reflection analysis again for the reflecting point for low- and high-tide cases, where:
    - Low-tide level = DTM height - 0.5*Tidal Variation (m)
    - High-tide level = DTM height + 0.5*Tidal Variation (m)
3. The low- and high-tide reflections should be seen as a range, through which the reflection moves.
4. If the receiving antenna is covered by part of that range, then the reflections should be seen as worse than previously calculated.

Specular Reflection Analysis Calculations

For specular reflection analyses, there are a number of stages with corresponding calculations:

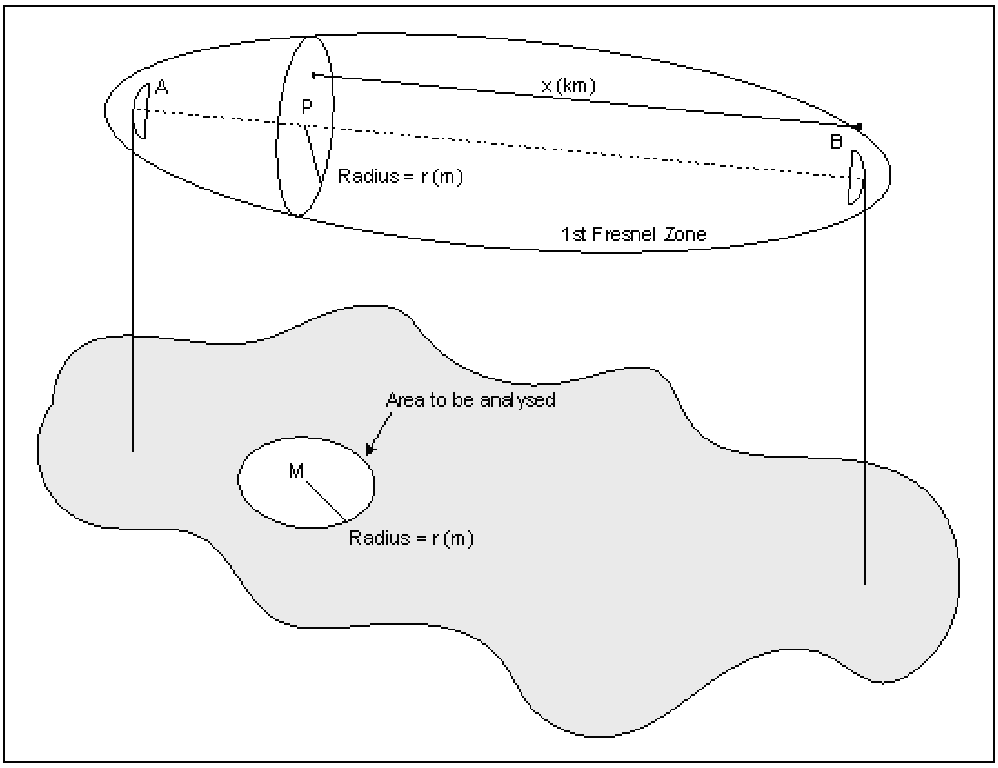
1. Calculate the reflection area to be analyzed.
2. Detect the specular reflection points.
3. Calculate phase difference.
4. Calculate reflection loss (based on ITU-R P 530-12).

Calculating the Reflection Area to be Analyzed

This section describes how to calculate the reflection area that is used for specular reflection analysis:

1. According to ITU-R P.530-12, the area under the path that needs to be analyzed for reflecting surfaces is an area that is a projection of the first Fresnel zone on the surface.
2. For ASSET Backhaul's purposes, this is further restricted to a 2D analysis.

Consider the following profile:



A link is established between A and B.

P is a point on the path A-B, that is x km away from the antenna at B.

The radius of the first Fresnel zone at P is r meters.

Point M is the point on surface directly below P.

3. The areas to be analyzed for reflections are a series of circles (of radius r_i m) centered round a series of points (M_i) for the corresponding series of distances $x_i d$.

4. Find points M_i along the surface directly beneath the path where the incident and reflected ray are equal.

5. Find the corresponding points P_i on the path A-B, calculate the length $x_i d$ then find r_i using the Fresnel ellipsoid formula:

$$F_1 = 17.3\sqrt{\frac{d_1 d_2}{f\left(d_1 + d_2\right)}}$$

Where

F_1 is the radius of the first Fresnel ellipsoid

f is the frequency (GHz)

d is the link length (km)

d_1 and d_2 are the distances from the two linkends respectively (in km)

In our example above, d_1 = $x_i d$ = d - $x_i d$ = r_i and f = average frequency between the transmitting and receiving linkends

Calculation for Detecting Specular Reflection Points

According to ITU-R P.530-12, a specular reflection occurs when the whole wave-front is reflected in phase. Specular reflections can lead to destructive interference at the receiver of a microwave link.

To predict if a portion along the path will cause specular reflections, you can apply the Rayleigh Criterion:

6. Within each defined reflection area, calculate the phase difference value $\Delta\varphi$ between two rays reflected from two different surface portions within the area separated by distance s, using the following algorithm:

$$\Delta\varphi = \frac{\Delta_\pi \sin\theta \cdot s}{\lambda} \approx 42 \sin\theta \cdot fs$$

Where

θ = grazing angle in degrees

f = frequency in GHz

λ = wavelength (m)

s = height separation distance (m), which is the standard deviation of surface heights at that point

7. For each phase difference value $\Delta\varphi$, classify the reflection type of the subarea separated by distance s according to this table:

$\Delta\varphi$	Reflection Type
$\Delta\varphi$ > 10	Diffuse - Fading from ground reflections is unlikely.
$\Delta\varphi$ < 0.1	Specular - Fading from ground reflections is likely.
0.1 < $\Delta\varphi$ < 10	Transition area - Difficult to be conclusive in this area.

8. Classify each circular reflection area as specular or not based on the reflection types of the majority of the $\Delta\varphi$ values that it encloses, according to:

Majority of Reflection Types	Reflection Area Classification
Diffuse	Diffuse
Specular	Specular
Transition + Diffuse	Diffuse
Transition + Specular	Specular

Calculating Phase Difference

The phase difference is calculated as follows:

1. Calculate the heights of the Tx and Rx antennas above the possible specular reflecting areas on or near the path.

   Heights h_1 and h_2 above the reflection area of inclination v are calculated as follows:

   $$h_1 = h_{1G} + y_1 - y_0 + x_0 \times 10^3 \times \tan v \text{ (in m)}$$

   $$h_2 = h_{2G} + y_2 - y_0 - (d - x_0) \times 10^3 \times \tan v \text{ (in m)}$$

   Where:

   y_1, y_2 = altitudes of ground above sea level (in m) at sites 1 and 2 respectively

   h_{1G}, h_{2G} = heights of antennas above ground level (in m) at sites 1 and 2 respectively

   y_0 = altitude of mid-point of reflection area above sea level (in m)

   x_0 = altitude of mid-point of reflection area from site 1 (in km)

   Important: If the reflection area is on the sea, then account must be taken of tidal variations. For more information on how this is done, see Calculation to Account for Tidal Height Variation on page 363.

2. For a range of effective k values (or the default k=4/3, or the user-defined k value), calculate the distances d_1 and d_2 of each possible reflecting surface from site 1 and 2:

   $$d_1 = d(1+b)/2 \text{ (in m)}$$

   $$d_2 = d(1-b)/2 \text{ (in m)}$$

   Where

   $$b = 2\sqrt{\frac{m+1}{3m}}\cos\left[\frac{\pi}{3} + \frac{1}{3}\arccos\left(\frac{3c}{2}\sqrt{\frac{3m}{(m+1)^3}}\right)\right]$$

   $$m = \frac{d^2}{4a_e(h_1 + h_2)} \times 10^3$$

   $$c = (h_1 - h_2)/(h_1 + h_2)$$

3. Calculate the phase difference (in other words, the effective path length difference) between the direct and reflected waves in wavelengths for the same range of effective k values (which should be the same as step 2), using the following equation:

$$\tau = \frac{2f}{0.3d}\left[h_1 - \frac{d_1^2}{12.74k}\right]\left[h_2 - \frac{d_2^2}{12.74k}\right] \times 10^{-3}$$

If $\tau_{\max}$ - $\tau_{\min}$ is less than 1, then diversity can be avoided

If $\tau_{\max}$ - $\tau_{\min}$ is equal to or more than 1, then it is possible that diversity is needed

Calculating Reflection Loss

On sufficiently inclined paths or paths with naturally large clearance, the angles between the direct and surface-reflected wave(s) become large enough to take advantage of the radiation pattern of one or both antennas, in order to discriminate against the reflected wave(s).

Even without this natural advantage, it can be advantageous to tilt one or both antennas slightly upwards, in order to increase the amount of discrimination available.

Based on ITU-R P.530-12, the procedure for calculating reflection loss is as follows:

1. Calculate the angles between the direct and surface-reflected wave(s) at sites 1 and 2 for the relevant range of effective k values obtained in Step 3 of paragraph 6.1.2.5 from:

$$\alpha_1 = \frac{180}{\pi}\left[\frac{h_1}{d_1} - \frac{h_1 - h_2}{d} - \frac{d_2}{12.75k}\right] \times 10^{-3}$$ degrees (97)

$$\alpha_2 = \frac{180}{\pi}\left[\frac{h_2}{d_2} - \frac{h_2 - h_1}{d} - \frac{d_1}{12.74k}\right] \times 10^{-3}$$ degrees (98)

2. Take the level of the surface-reflected signal(s) relative to the direct signal introduced by antenna discrimination from the following (also see About the Reflection Loss Calculations on page 369, Note 1).

   If the surface-reflected wave(s) leaves and enters within the half-width of one or both antennas, the relevant antennas should normally be tilted upwards by about half a beamwidth in order to introduce additional antenna discrimination (see About the Reflection Loss Calculations on page 369, Note 2). Even if the angles-of-arrival of the surface reflected wave are a little outside the half-width of the antennas, a small upward tilt could be advantageous (see About the Reflection Loss Calculations on page 369, Note 2). The total loss due to antenna discrimination can then be estimated from the following (also see About the Reflection Loss Calculations on page 369, Note 1):

$$L_a = 12\left[\left(\frac{\alpha_1 + \alpha_{t1}}{\alpha_{a1}}\right)^2 + \left(\frac{\alpha_2 + \alpha_{t2}}{\alpha_{a2}}\right)^2\right]$$ (100)

   Where α_{t1} and α_{t2} are the angles with which the antennas are tilted upwards.

3. It may be useful on some paths to estimate or measure the effective surface reflection coefficient so as to obtain an overall estimate of the level of the surface reflection(s) in normal propagation conditions. This can be done using the information in paragraph 6.1.2.4. The overall loss in level of the surface-reflected wave(s) is then given by:

$$L_s = L_a - 20\log \rho_{eff}$$ dB (101)

Where L_a is obtained from equation (100). However, because the effective surface reflection coefficient can be enhanced in surface-multipath conditions, it is not critical to calculate its value exactly or at all, in order to calculate appropriate upward tilt angles for the antennas (see Step 5).

4. If one or both antennas are tilted upwards, the corresponding loss in level of the direct signal in normal propagation conditions (where k=4/3) is given by (see About the Reflection Loss Calculations on page 369, Note 1):

$$L_d(k=4/3)=12\left[\left(\frac{\alpha_{t1}}{\alpha_{a1}}\right)^2+\left(\frac{\alpha_{t2}}{\alpha_{a2}}\right)^2\right] \text{ dB (102)}$$

In superrefractive or subrefractive conditions, $L_d(k)$ can be estimated from (see About the Reflection Loss Calculations on page 369, Note 1):

$$L_d(k)=12\left[\left(\frac{\alpha_{t1}-\alpha_d}{\alpha_{a1}}\right)^2+\left(\frac{\alpha_{t2}-\alpha_d}{\alpha_{a2}}\right)^2\right] \text{ dB (103)}$$

Where the angle-of-arrival of the direct signal is given approximately by (see About the Reflection Loss Calculations on page 369, Note 2):

$$\alpha_d=-0.0045\,d\left(\frac{1}{k}-\frac{3}{4}\right) \text{ degrees (104)}$$

5. The maximum possible fade depth in normal propagation conditions (k=4/3) from destructive interference between the direct and surface-related signals can be calculated from:

$$A_{\max}=-20\log\left(10^{-L_d/20}-10^{-L_s/20}\right) \text{ dB (105)}$$

Where

L_d is given by equation (102) and L_s by equation (101) (see About the Reflection Loss Calculations on page 369, Note 2).

6. In superrefractive or subrefractive conditions, in which the direct signal also undergoes an additional loss of $0.5L_{add}$ to account for beam spreading in super-refractive conditions and the surface-reflected gain signal undergoes a gain of -$0.5L_{add}$, the maximum possible fade depth is given by:

$$A_{\max}=-20\log\left(10^{-(L_d+0.5L_{add})/20}-10^{-(L_s-0.5L_{add})/20}\right) \text{ (106)}$$

Where

L_d is given by equation (103) and L_s is given by equation (101) (see About the Reflection Loss Calculations on page 369, Note 2).

Some of these reflection losses can be optimized. For more information, see Optimising Reflection Losses on page 369.

Optimising Reflection Losses

Reflection losses can be optimized in a number of ways:

- Surface multipath fading or surface multipath amplitude distortion can be minimized by optimizing the tilt angles of the antennas.
- Fading can be reduced by:
  - Setting the value of L_{add} in equation (106) so that L_d is less than L_s at $k = \infty$ by about 0.3 dB and minimizing $A_{\max}$ by trial-and-error choice of the tilt angles.

    Note: In practice, a large value of k can be chosen, for example $k = 1 \times 10^9$.
  - Setting ρ_{eff} in equation (101) to a value approaching 1.0 or larger, in order to accomplish the same difference of about 0.3dB (see About the Reflection Loss Calculations on page 369, Note 2). Fade margin can be reduced by 2.5 to 4dB.
- Amplitude distortion due to surface multipath can be reduced by increasing the tilt angles still further, until the relative antenna discrimination against the surface-reflected wave(s) is maximized. This occurs when the difference in discrimination between the direct and surface-reflected waves is maximum.

Important: In order to accurately optimize the tilt angles against surface multipath distortion, the antenna patterns must be available. This is because the model of equation (100) is less accurate outside the half-widths of the antennas, especially as the edge of the main lobe is approached (see About the Reflection Loss Calculations on page 369, Note 1).

Because optimization against amplitude distortion is accomplished against the further loss of flat fade margin, it is recommended that the tilt angles obtained by the optimization against fading are increased by the same proportion until a maximum loss of fade margin of about 6dB is achieved. Although the resulting tilt angles are less optimal against fading itself, the increase in fade depth is only a fraction of a decibel (see About the Reflection Loss Calculations on page 369, Note 3).

Note: Optimal discrimination against surface multipath by antenna uplifting will also tend to discriminate against atmospheric multipath.

About the Reflection Loss Calculations

When calculating reflection losses, the following points should be noted:

Notes:

- This Gaussian beam approximation is most accurate within the beamwidths of antennas. Outside the beamwidths, the actual patterns can be used to obtain a more accurate estimate if required. This is especially important as the edge of the main lobe is approached.
- Upward tilting of the antennas is desirable for improved performance in surface multipath fading conditions, regardless of the level of the surface-reflected wave(s) in normal propagation conditions (in other words, k =4/3).

The objectives of optimizing to minimize fading are:

- Reduce the level of the surface-reflected wave(s) by more than the direct wave
- Reduce the direct wave only enough that the overall fade depth is minimized

The objective of optimizing to minimize amplitude distortion is:

- Maximize the relative difference between the amplitudes of the direct and surface-reflected wave(s), at the expense of increasing the maximum fade depth slightly

Both sets of objectives can be achieved by moving the angle-of-arrival of the surface-reflected waves to steeper points on the antenna pattern.

If necessary, the size of the antennas can be increased to compensate the loss of flat-fade margin in normal conditions from the loss in antenna discrimination in the direction of the direct wave due to upward tilting.

The antenna tilt angles required to minimize the effect of the surface reflection(s) in normal propagation conditions will vary, based on path geometry, antenna beamwidths and the relative level of surface reflection(s). Although the general rule is 'the larger the beamwidth, the larger the tilt angle required', the appropriate ratio of tilt angle to beamwidth will decrease with as the beamwidth increases.

The antenna tilt angles required to minimize the effect of the surface reflection(s) in surface multipath conditions will be larger than those for normal conditions, and should usually be the ones chosen. When an extreme layer (for example, a duct) causes a beam-spreading loss in the direct signal level, there is more chance that the surface-reflected signal(s) will be enhanced simultaneously, therefore resulting in a significant multipath fade and accompanying increase in propagation distortion.

For the purpose of choosing appropriate tilt angles to minimize fade depth based on equation (106), simulation can be carried out in the way described in step 5 - whether you change L_d or L_s, or both simultaneously in order to move them within 0.3 dB of each other does not seem to critically affect the result.

The optimum tilt angles will vary, according to the angles of the surface-reflected waves as described in equations (97) and (98). The larger of the antenna tilt angles corresponds to the larger angle of surface reflection from this antenna. As noted, a typical margin loss for optimal tilt angles is in the range of 2.5-4dB. In any case, if the antenna sizes are increased to compensate for the loss in flat fade margin, another optimization must be run to determine the new optimal tilt angles. In any case, if the antenna sizes are increased to compensate for the flat fade margin loss, another optimization must take place in order to determine the new optimal tilt angles.

The fading should be minimized and the tilt angles increased by equal proportions before the optimization to minimize amplitude distortion is performed. Whether one set of angles or the other (or both) is used will depend on system considerations - for more information, see the notes below.

During surface multipath conditions, some of the antenna discrimination loss in the direction of the strongest ray (normally the direct wave) which occurs as a result of antenna tilting is regained, because this ray tends to have a positive angle-of-arrival.

Notes:

- There are three possible alternatives; the final choice depends on the quality of equalization used in the system. The alternatives are:
  - Optimizing the antenna tilt angles to minimize the minimum fade depth, avoiding an increase in antenna size
  - Optimizing the antenna tilt angles to minimize the amplitude distortion, improving performance sufficiently to avoid diversity
  - Choose antenna tilts that result in a loss of flat fade margin between 2.5 and 6 dB

  It is important to observe that in an optimization to minimize the distortion, there is only a small divergence from the optimal fading condition, which is the minimum fade depth.
- Both ray-tracing analyses and extensive experimental measurements of the angles-of - arrival and amplitudes of the three strongest multipath waves indicate that the atmospheric multipath wave with the larger upward angle-of-arrival tends to be a higher level than the second strongest atmospheric multipath wave.

  This suggests that providing that the antennas are set to upward tilt angles larger than the larger of the two angles-of-arrival (which is typically less than 0.3 degrees for path lengths in the range of 31 to 51km), then antenna discrimination against atmospheric multipath will also increase.

  Therefore, optimal antenna uptilting should normally be based on minimizing the effects of surface multipath.

Passive Repeater Equations

This section describes the equations used for passive repeater calculations.

Back to Back Antennas Passive Repeater Calculations

For back to back antenna passive repeaters, you must first calculate whether or not the passive repeater antenna is in the near or far field of the closest antenna:

Far Field = $2D^2 / \lambda$

Where:

D = antenna diameter

$2D^2 / \lambda$ = signal wavelength = $\dfrac{c}{f}$

c = Speed of Light = 3×10^8 (m/s)

If the antenna is closer than this, you should use the Near Field Path Loss calculation, otherwise use the Far Field one.

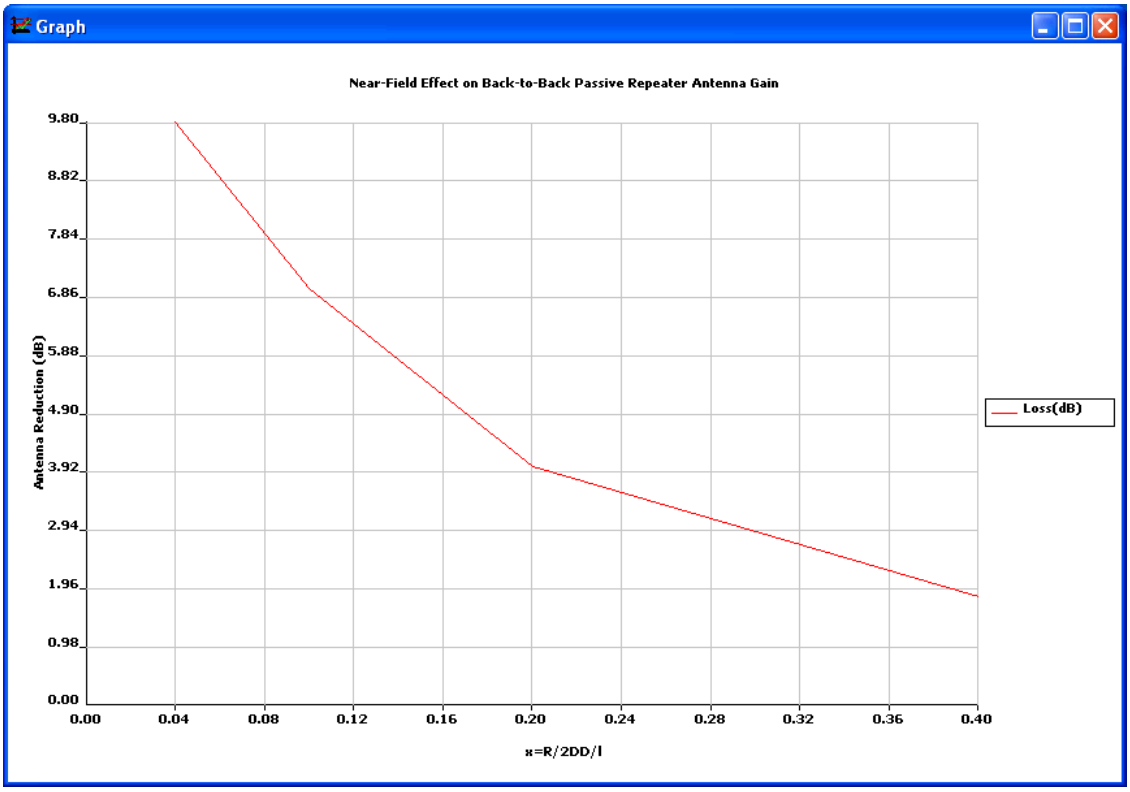
Calculating Loss Under Near Field Conditions (Back to Back Passive Repeaters)

For passive repeater back to back antennas in the near field, first calculate the normalization factor:

$$x = R/2D^2/\lambda$$

Where R = the distance between Passive and Active antennas

Use the following graph to calculate reduction in antenna gain (dBi) of the passive antenna:



Near Field Back to Back Antenna Passive Repeater Loss

Note: You can create your own graph in the **Link Database**. For information on how to do this, see Defining Passive Repeaters on Linkends on page 143.

To calculate the new antenna gain:

Overall antenna gain in the near field = G_r - near field loss from the graph

Where G_r = repeater antenna gain

You should use this gain figure for G_A or G_B when calculating loss under far field conditions.

Calculating Loss Under Far Field Conditions

For back to back antenna passive repeaters, the path loss is calculated as follows:

$$A_{L1+2} = A_{AL1+2} + A_{DR1+2} + A_{B1+2} + A_{F1+2} + A_{M1+2} + A_{P1+2} + A_{O1+2} + A_{AA1+2} - (G_A + G_B)$$

Where :

A_{AL1+2} = Link1 EndA Attenuation Loss + Link2 EndB Attenuation Loss

A_{DR1+2} = Link1 EndA Dry Radome Loss + Link2 EndB Dry Radome Loss

A_{B1+2} = Link1 EndA Branching Loss + Link2 EndB Branching Loss

A_{F1+2} = Link1 EndA Feeder Loss + Link2 EndB Feeder Loss

A_{M1+2} = Link1 EndA Tx Misc Loss + Link2 EndB Rx Misc Loss

A_{P1+2} = Link1 Free Space Path Loss + Link2 Free Space Path Loss

A_{O1+2} = Link1 Obstruction Loss + Link2 Obstruction Loss

A_{AA1+2} = Link1 Absorption Loss + Link2 Absorption Loss

G_A = Antenna Gain of passive repeater directed at start site

G_B = Antenna Gain of passive repeater directed at end site

The received power at Link2 EndB for a back to back antennas passive repeater link is calculated as follows:

Received Power (at Link2 EndB), $Rx_{B2} = Tx_{A1} + G_{A+B} - A_{L1+2}$

Where:

Tx_{A1} = Transmit power Link1EndA (dBm)

G_{A+B} = Combined active antenna gain

Reflective Passive Repeater Calculations

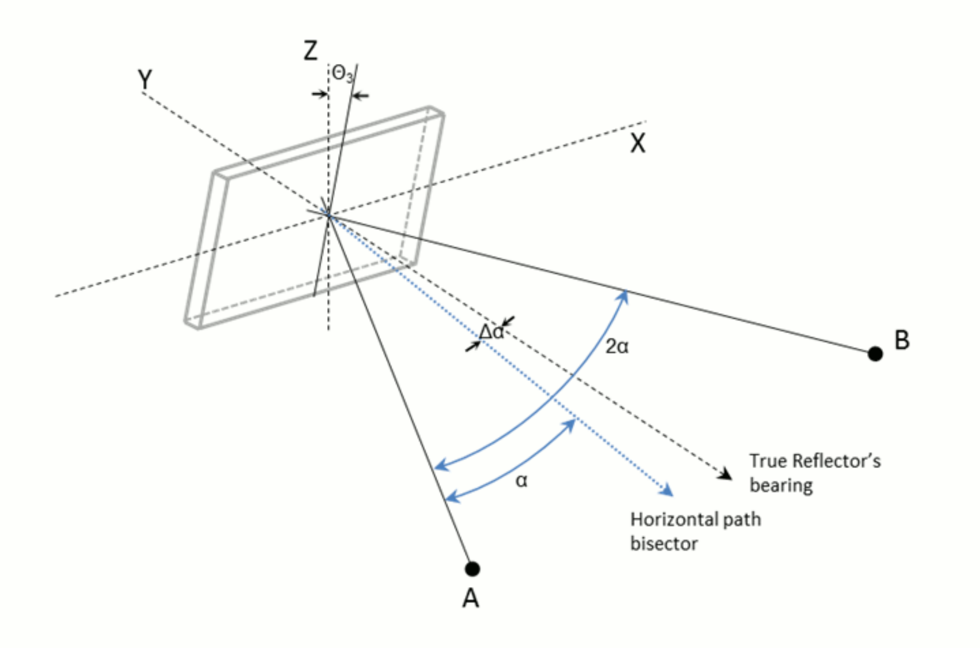
Reflective passive repeater calculations are used to:

- Establish the passive reflector angles
- Determine whether or not the passive repeater antenna is in the near-field of the closest antenna
- Calculate the corresponding receiver powers

Calculating Passive Reflector Angles

This topic describes how the bearing and elevation angles are calculated for reflective passive repeaters, in order to achieve maximum reflection power.

A typical passive repeater installation includes a metallic reflector, which reflects the incoming signal from one end to the other. This picture shows an example:



Calculating passive repeater angles

The horizontal reflection angle from A to B is 2α.

The azimuth and elevation angles from A and B towards the reflector site are φA, ΘA, φB and ΘB respectively.

The horizontal displacement from the bisector is then:

$$\tan \Delta\alpha = \tan\alpha \cdot \left(\frac{\cos\Theta_A - \cos\Theta_B}{\cos\Theta_A + \cos\Theta_B} \right)$$

and the elevation angle is:

$$\tan\Theta_3 = \left(\frac{\tan\Delta\alpha}{\tan\alpha} \right) \cdot \left(\frac{\sin\Theta_A + \sin\Theta_B}{\cos\Theta_A + \cos\Theta_B} \right)$$

Note: The elevation angles are negative when pointing upwards and positive when pointing downwards.

Calculating Loss Under Far-Field Conditions (Reflective Passive Repeaters)

You can calculate the loss under far-field conditions for reflective passive repeaters, A_{L1+2} by using the following calculation:

$$\mathrm{A_{L1+2} = A_{DR} + A_{B1+2} + AF_{1+2} + A_{M1+2} + A_L + A_S + A_{O1+2} + A_{AA1+2} - G_R}$$

Where

A_L = Free space path loss for the longest path

A_S = Free space path loss for the shortest path

G_R = Gain of the passive repeater ($G_R = 20 * \log_{10}(139.5 * f^2 * Y * \cos\frac{\psi}{2})$)

Where:

f = frequency (GHz)

Y = Area of reflector

Ψ = Angle in space at the repeater point

Calculating Loss Under Near-Field Conditions

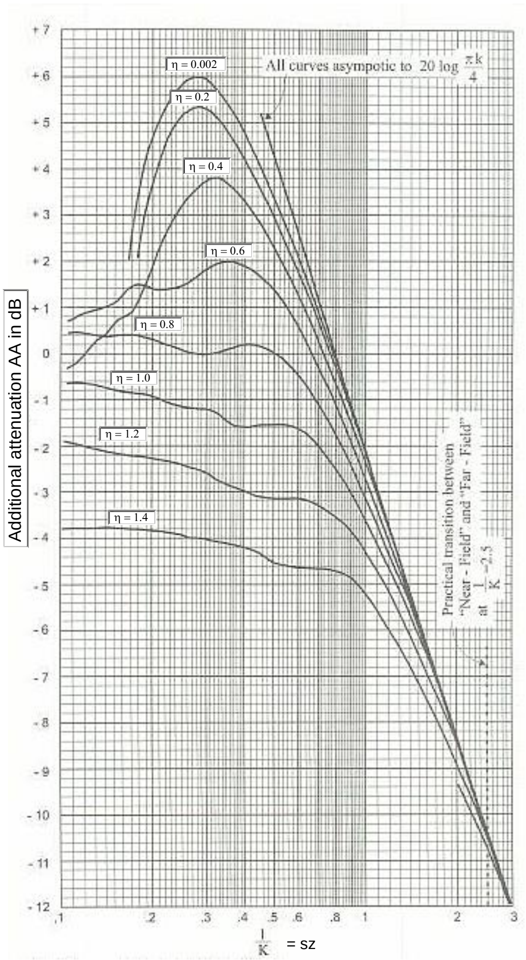
The total loss, A_{L1+2} is calculated as:

$$A_{DR1+2} = A_{B1+2} + A_{F1+2} + A_{M1+2} + A_L + A_A + A_{O1+2} + A_{AA1+2}$$

Where

A_L = Free space path loss for longest path

A_A = Additional attenuation, based on this graph:



Near Field Reflective Antenna Passive Repeater Loss

Note: You can create your own graph in the **Links Database**. For more information on how to do this, see Defining Passive Repeaters on Linkends on page 143.

Calculating Received Power

Received Power (at Link2 EndB) is defined as:

$$Rx_{B2} = Tx_{A1} + G_{A+B} - A_{L1+2}$$

Where

Tx_{A1} = Transmit Power at Link1EndA (dBm)

G_{A+B} = Combined Active Antenna Gain

AMC Equations

When using Adaptive Modulation Coding (AMC), the following calculations should be considered.

Performance and Fade Margin

In AMC mode, the performance and fade margin calculations are similar to those for any other microwave link.

However, the fade margin for every available modulation scheme must be computed, based on the transmit powers and receiver thresholds defined for each modulation scheme.

This series of fade margins is translated into a series of unavailability percentages p_{mode} (%) covering modulation type, where *mode* represents BPSK, QPSK, 16-QAM and so on.

Capacity

The capacity can be calculated based on the operating bandwidth and number of bits per modulation symbol.

If n_{bits} is the number of bits for every mode and B is the operating bandwidth, then the total throughput that each modulation type can sustain is $c_{\text{mode}} = n_{bits} \times B$. For example, a signal with 7 MHz bandwidth, calculated with 16 QAM, would have a capacity of 4 bits/symbol x 7 MHz = 28 Mbps.

7. ASSET Backhaul checks that there is a mode with availability p_{req}. p_{req} is calculated as:

   $$p_{req} = 100 - A_{req} - \left(Pe_1 + Pe_2\right) + Pe_1 * Pe_2$$

   Where Pe_1 and Pe_2 are the equipment failure at each linkend.

8. If the equipment failure is higher than the required unavailability (in other words, $Pe_1 + Pe_2 - Pe_1 * Pe_2 > 100 - A_{req}$) or the calculated above is negative, then p_{req} is set as $p_{req} = Pe_1 + Pe_2 - Pe_1 * Pe_2$.

9. If high priority data has been specified (C_{high}), then it should also be checked that there is a mode with the availability $A_{\mathrm{mode}} = 100 - p_{\mathrm{mode}}$, such as $A_{\mathrm{mode}} \geq$ 99.999% and $C_{\mathrm{mode}} \geq C_{high}$. The availability of the high priority data is always set to equal 99.999%.

10. Given the required availability, the necessary fade margins can also be calculated for two cases of fading:

    - Due to multipath. For more information on these calculations, see Multipath Occurrence Factor Calculation on page 338.
    - Due to rain. For more information on these calculations, see Required FM Against Rain Calculation on page 327 and Crane Model Attenuation Calculations on page 318.

    The calculation of the necessary fade margin which corresponds to the required availability would include the respective rain rate for that percentage $R_{req} = R(p_{req})$ according to the link's region, and then the calculation of F_{rain} for R_{req} and *d*, using the above formulas.

    For example, if you require a 0.001% unavailability, the rain rate for that percentage in the region is found from the available tables, and then using the formulas described above, the corresponding fade margin is calculated.

11. The fade margin required for the link to operate in a specific availability is the maximum value of the two calculated fade margins:

    $$F_{req} = \max(F_{multipath}, F_{rain}).$$

Note: F_{req} may not always provide the desired availability. It depends on the multipath and rain effects collectively, and therefore the availability of F_{req} may be overestimated. In this case, F_{req} should be regarded as the suggested fade margin rather than the definitively required one.

About the Default Transmit Power Values for Modulation Types

These values are used as the AMC thresholds for a link if the radio is AMC-enabled and either:

- The **Default Values** option is selected in the **AMC Thresholds** dialog box

  - or -

- You have not defined the **Minimum** and **Maximum Transmit Power** values yourself

This table describes the maximum default transmit power values (in dBm) for the various combinations of modulation types and operating frequencies:

Modulation	6 GHz	7-8 GHz	11-15 GHz	18 GHz	23-28 GHz	32-38 GHz
BPSK	28	27	25	23	23	20
QPSK	27	26	24	22	22	19
8 PSK	27	26	24	22	22	19
16 QAM	26	25	23	21	21	18
32 QAM	25	24	22	20	20	17
64 QAM	25	24	22	20	20	17
128 GAM	25	24	22	20	20	17
256 QAM	23	22	22	18	18	15

The minimum default transmit power value for all modulation types and operating frequencies is -5 dBm.

Note: For those modulation types not listed in the table above, the default values used are based on the listed modulation type with the same number of bits/symbol. For example, in the case of 16 PSK, the values used are based on the 16 QAM modulation type.

Similarly, for those frequencies not listed in the table above, the closest frequency range values should be used. For example, in the case of 3 GHz the values for 6 GHz should be used, for 20 GHz, the values for 18 GHz should be used, and so on.

About the Default Receiver Threshold Values for Modulation Types

These values are used as the AMC thresholds for a link if the radio is AMC-enabled and either:

- The **Default Values** option is selected in the **AMC Thresholds** dialog box

  - or -

- You have not defined the **Receiver Threshold** values yourself

This table describes the default receiver threshold values (in dBm) for the various combinations of modulation types, bandwidths and operating frequencies:

Bandwidth (MHz)	Modulation Type	Receiver Threshold (dBm) for BER=10^{-6} Frequency f_c (GHz)			
		6-8	11-15	18-28	32-38
7 (ETSI)	BPSK	-93.0	-92.5	-92.0	-91.5
	QPSK	-92.0	-91.5	-91.0	-90.5
	8 PSK	-89.5	-89.0	-88.5	-88.0
	16 QAM	-86.5	-86.0	-85.5	-85.0
	32 QAM	-84.5	-84.0	-83.5	-83.0
	64 QAM	-82.0	-81.5	-81.0	-80.5
	128 QAM	-79.5	-79.0	-78.5	-78.0
	256 QAM	-76.5	-76.0	-75.5	-75.0
10 (FCC)	BPSK	-92.0	-91.5	-91.0	-90.5
	QPSK	-91.0	-90.5	-90.0	-89.5

Bandwidth (MHz)	Modulation Type	Receiver Threshold (dBm) for BER=10^{-6} Frequency f_c (GHz)			
		6-8	11-15	18-28	32-38
	8 PSK	-88.5	-88.0	-87.5	-87.0
	16 QAM	-85.0	-84.5	-84.0	-83.5
	32 QAM	-84.0	-83.5	-83.0	-82.5
	64 QAM	-80.0	-79.5	-79.0	-78.5
	128 QAM	-77.0	-76.5	-76.0	-75.5
	256 QAM	-75.5	-75.0	-74.5	-74.0
14 (ETSI)	BPSK	-90.0	-89.5	-89.0	-88.5
	QPSK	-89.0	-88.5	-88.0	-87.5
	8 PSK	-87.0	-86.5	-86.0	-85.5
	16 QAM	-84.5	-84.0	-83.5	-83.0
	32 QAM	-81.5	-81.0	-80.5	-80.0
	64 QAM	-79.5	-79.0	-78.5	-78.0
	128 QAM	-76.5	-76.0	-75.5	-75.0
	256 QAM	-73.5	-73.0	-72.5	-72.0
20 (FCC)	BPSK	-89.0	-88.5	-88.0	-87.5
	QPSK	-88.0	-87.5	-87.0	-86.5
	8 PSK	-86.0	-85.5	-85.0	-84.5
	16 QAM	-83.0	-82.5	-82.0	-81.5
	32 QAM	-81.0	-80.5	-80.0	-79.5
	64 QAM	-76.5	-76.0	-75.5	-75.0
	128 QAM	-75.0	-74.5	-74.0	-73.5
	256 QAM	-72.0	-71.5	-71.0	-70.5
28 (ETSI)	BPSK	-87.5	-87.0	-86.5	-86.0
	QPSK	-86.5	-86.0	-85.5	-85.0
	8 PSK	-85.0	-84.5	-84.0	-83.5
	16 QAM	-82.0	-81.5	-81.0	-80.5
	32 QAM	-78.5	-78.0	-77.5	-77.0
	64 QAM	-75.5	-75.0	-74.5	-74.0
	128 QAM	-72.0	-71.5	-71.0	-70.5
	256 QAM	-70.0	-69.5	-69.0	-68.5
30 (FCC)	BPSK	-87.5	-87.0	-86.5	-86.0
	QPSK	-86.5	-86.0	-85.5	-85.0
	8 PSK	-84.0	-83.5	-83.0	-82.5
	16 QAM	-80.5	-80.0	-79.5	-79.0
	32 QAM	-77.5	-77.0	-76.5	-76.0
	64 QAM	-75.0	-74.5	-74.0	-73.5
	128 QAM	-72.5	-72.0	-71.5	-71.0
	256 QAM	-70.0	-69.5	-69.0	-68.5
40 (ETSI)	BPSK	-86.5	-86.0	-85.5	-85.0

Bandwidth (MHz)	Modulation Type	Receiver Threshold (dBm) for BER=10^{-6} Frequency f_c (GHz)			
		6-8	11-15	18-28	32-38
	QPSK	-85.5	-85.0	-84.5	-84.0
	8 PSK	-83.5	-83.0	-82.5	-82.0
	16 QAM	-80.5	-80.0	-79.5	-79.0
	32 QAM	-78.0	-77.5	-77.0	-76.5
	64 QAM	-75.0	-74.5	-74.0	-73.5
	128 QAM	-72.5	-72.0	-71.5	-71.0
	256 QAM	-69.5	-69.0	-68.5	-68.0
50 (FCC)	BPSK	-85.5	-85.0	-84.5	-84.0
	QPSK	-84.5	-84.0	-83.5	-83.0
	8 PSK	-82.0	-81.5	-81.0	-80.5
	16 QAM	-80.0	-79.5	-79.0	-78.5
	32 QAM	-77.5	-77.0	-76.5	-76.0
	64 QAM	-74.0	-73.5	-73.0	-72.5
	128 QAM	-71.0	-70.5	-70.0	-69.5
	256 QAM	-67.5	-67.0	-66.5	-66.0
56 (ETSI)	BPSK	-85.0	-84.5	-84.0	-83.5
	QPSK	-84.0	-83.5	-83.0	-82.5
	8 PSK	-81.5	-81.0	-80.5	-80.0
	16 QAM	-79.5	-79.0	-78.5	-78.0
	32 QAM	-76.0	-75.5	-75.0	-74.5
	64 QAM	-73.0	-72.5	-72.0	-71.5
	128 QAM	-70.0	-69.5	-69.0	-68.5
	256 QAM	-67.5	-67.0	-66.5	-66.0

Note: For those modulation types not listed in the table above, the default values used are based on the listed modulation type with the same number of bits/symbol. For example, in the case of 16 PSK, the values used are based on the 16 QAM modulation type.

Similarly, for those frequencies not listed in the table above, the closest frequency range values should be used. For example, in the case of 3 GHz the values for 6 GHz should be used, for 16 GHz, the values for 15 GHz should be used, and so on.

12 Array Descriptions

This section describes the different types of arrays available in ASSET Backhaul.

For information on creating, managing and displaying arrays, see Using the Microwave Coverage Wizard on page 213.

Received Power (dBm):

Indicates the received power for each pixel. It is calculated from predictions for each PmP hub/carrier by adding their respective transmit power, subtracting the transmitter losses and adding the respective receiver antenna gain for the antenna specified in the **Microwave Coverage Wizard**. Receiver losses correspond to those defined in the **Radio Equipment** dialog box for the receiving radio set specified in the **Microwave Coverage Wizard**.

In the case where AMC is being used, the transmit power is the respective power of the operating modulation.

Best Server by Received Power:

Indicates the PmP hub/carrier with the highest received power.

Nth Best Server by Received Power:

Indicates the selected Nth PmP hub/carrier in terms of received power. N can be from 1 to the number of covering MW nodes, and is specified in the Microwave Coverage Wizard.

Received Field Strength (mV/m):

This is calculated from received power (dBm), subtracting the receiver antenna gain, using the formula:

$$E(\mathrm{mV/m}) = 10^{\left(P_r(\mathrm{dBm}) - G_r(\mathrm{dB}) + 20\log_{10} f(\mathrm{GHz}) + 77.213\right)/20}$$

Best Server by Received Field Strength:

Indicates the PmP hub/carrier with the highest received field strength.

Nth Best Server by Received Field Strength:

Indicates the selected Nth PmP hub/carrier in terms of received field strength. N can be from 1 to the number of covering MW nodes, and is specified in the Microwave Coverage Wizard.

Fade Margin:

Indicates the fade margin for each PmP hub/carrier. It is calculated from the received power (as described above), subtracting the receiver threshold value for the receiving radio set specified in the Microwave Coverage Wizard. The threshold value will correspond to Threshold 1 or 2, as defined on the carrier of the hub.

Best Server by Fade Margin:

Indicates the PmP hub/carrier with the highest fade margin.

Interference:

Indicates the cumulative interference levels for each pixel and PmP hub/carrier, from each of the microwave nodes in the area.

Threshold Degradation Due to Interference:

Indicates the increase of the noise floor of the receiver radio equipment for each pixel and PmP hub/carrier, due to the cumulative interference levels from each of the microwave nodes in the area.

Fade Margin after Interference:

Indicates the same as the Fade Margin array, but subtracts the threshold degradation for each pixel and each hub/carrier.

13 Glossary of Terms

B

BBER

Background Block Error Rate. The ratio of errored blocks to total blocks during a month (excluding all blocks during SES and unavailable time).

BER

Bit Error Rate. The ratio of number of errored bits to the total number of bits received.

BPS

Bits Per Symbol. The average number of binary digits for a symbol.

BSC

Base Station Controller. A piece of equipment that controls one or more BTSs.

BTS

Base Transceiver Station.

C

C/I

Carrier to interference ratio.

D

DTM

Digital Terrain Mapping.

E

ESR

Errored Second Ratio. The ratio of errored seconds (defined as those in which one or more bits are in error) to total seconds.

F

FDD

Frequency Division Duplex. A full-duplex technique that consumes more spectrum than TDD, but does not require synchronisation between base stations.

G

GSM

Global System for Mobile Communications. A global 2g wireless digital communications standard covering cellular telephony, two-way radio and paging, and short messaging. It is a TDM system, operating on 3 frequency bands - GSM 900 (900MHz), DCS 1800 (1.8GHz) and PCS 1900 (1.9GHz).

I

ITU

International Telecommunications Union. The ITU is the leading publisher of telecommunication technology, regulatory and standards information. Within the ITU, governments and the private sector coordinate global telecom networks and services.

L

LOS

Line of Sight. This is where the transmitter and receiver have visual contact with each other.

M

Mbps

Megabits per second. Mbps can also be referred to as Mbit/s.

Do not confuse Mbps with MBps. MBps refers to Megabytes per second.

MSC

Mobile Switching Centre. In a cellular network, this is a switch or exchange that interworks with location databases.

P

PDH

Plesiosynchronous Digital Hierarchy. Plesiosynchronous means almost synchronized, and so PDH differs from SDH in that it accounts for how different traffic sources can lead to slightly different phase characteristics. PDH is implemented across the world, according to 3 standards - T-carrier (North America), E-carrier (ITU-T countries), J-carrier (Japan).

PLMN

Public Land Mobile Network.

PmP

Point to Multipoint. Describes links between one point (A) and a number of other points (B, C, D etc.).

PtP

Point to Point. Describes links between one point and another single point.

Q

QPSK

Quadrature Phase Shift Keying. A modulation technique using orthogonal carriers to gain the maximum information from the channel.

S

SDH

Synchronous Digital Hierarchy. An ITU-T standard for digital broadband communications, used to transmit digital information in time-synchronized containers. This allows relatively simple modulation and demodulation of the optical signals at the transmitting and receiving end, and can be used to carry high capacity information over long distances.

SESR

Severely Errored Second Ratio. The ratio of severely errored seconds (defined as those which have a bit error ratio of $\geq 10^{-3}$) to total seconds.

T

T/I

Threshold to interference ratio. This is calculated by dividing the threshold value (dBm) of the radio equipment by the co-channel interference (dBm) experienced on the link. This can then be compared to the T/I Objectives of the equipment when analysing interference on the link.

TDD

Time Division Duplex. A half-duplex technique that consumes less spectrum than FDD, but requires very tight timing co-ordination between base stations.

X

XPD

Cross Polar Discrimination. Defines the dB level of a signal that begins as one polarisation but ends as the opposite polarisation due to atmospheric effects, such as rainfall.

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