Multihaul 3000 Product Family

R4.1.2.2

Technical Description

ERICSSON

TAKING YOU FORWARD

ERICSSON
TAKING YOU FORWARD

Since January 2006 Marconi is a member of the Ericsson group.

MHL 3000 family is part of the Ericsson Marconi Multi-Service Transport portfolio.

Occurrence of **blank pages** is intentional to accommodate double-sided printing.

Multihaul 3000

Topic 3: Technical Description

Release 4.1.2.2

THIS DOCUMENT IS UNCONTROLLED WHEN PRINTED

Table of Contents

Blank Page

List of Figures

Blank Page

List of Tables

Blank Page

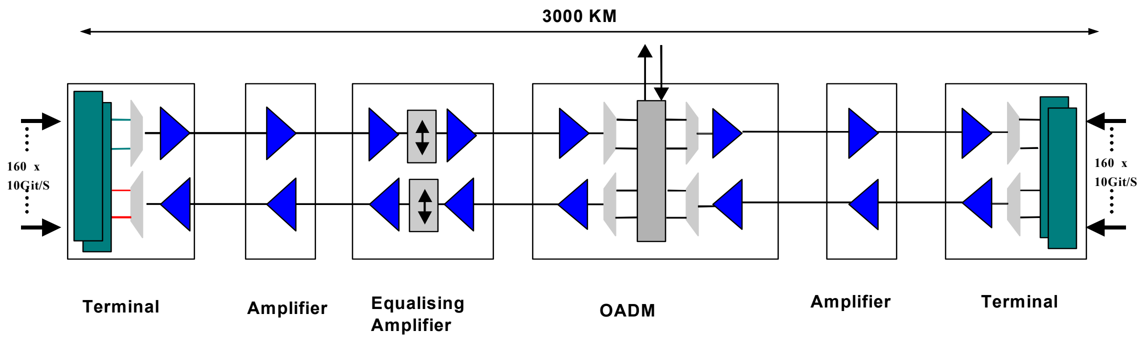
Chapter 1: Product Overview

1.1 Introduction

This manual describes product architecture and features for the Multihaul 3000 DWDM system.

The Multihaul 3000 is an advanced and flexible transport platform. It can be configured to provide an optimised solution for Long Haul (<700 km) applications, referred to here as standard reach, Extended Long Haul (<1500 km) and Ultra Long Haul (up to 4000 km) applications, referred to as extended reach, typically found in regional and backbone networks. It provides scaleable capacity up to 80 Channels @ 10Gbit/s for Long Haul applications and up to 160 channels @ 10Gbit/s for Extended Long Haul and Ultra Long Haul applications in release 4.3.

Figure 1-1: Multihaul 3000 Architecture



Within the Multihaul 3000 product family, the following classes of node may be broadly identified: the Terminal, the Line Amplifier, the Equalising Amplifier and the Add/Drop Multiplexer. The Terminals are required at each end of the link. They perform the essential function of multiplexing the client signals into a composite WDM signal and preparing it for transmission on the optical fibre. The Line Amplifiers, typically spaced at distances between 50 and 150KM apart for multi-span systems, amplify the composite WDM signal to offset the attenuation of the fibre. For ELH and ULH links, Equalising Amplifiers are needed at regular intervals to compensate for channel dependent gain/attenuation along the transmission path. The add/drop multiplexers allow channels to be dropped from the composite WDM signal or inserted into it. Both fixed and fully configurable OADMs are supported.

The Multihaul 3000 supports 1.25G, 2.5G and 10G client channels directly via appropriate transponder solutions which offer flexible reach options. For shorter reach applications (typically up to 1500KM), standard NRZ transponders may be used. Full-unregenerated reach of up to 4000KM is achieved by the use of transponders, which employ RZ (soliton) technology in conjunction with dispersion management techniques.

If Multihaul 3000 transponders are used, the system supports optical path protection (OSNCP) in conjunction with transponder 1+1 card protection. Multiplexing options for 1.25G and 2.5G channels are also provided for efficient wavelength utilisation. Compatible coloured interfaces from other Marconi products may be directly interfaced to the system without the need for transponders.

Amplification is provided by a range of EDFAs, which can be combined, with Raman amplification. A network configuration is designed to achieve lowest cost and optimised system performance by utilising the most appropriate amplification at each node. Raman amplification is required for span lengths with loss greater that 28dB.The system supports automatic channel power balancing so that channels may be added and removed without the need for manual reconfiguration of the system.

1.1.1 Multihaul 3000 Feature Overview

The main features of Multihaul 3000 for release 4.1 are described in overview below. This overview should be viewed in conjunction with the issued version of the product feature list, which is the master reference.

- 40/80 Channel operation on G.652, G.654, G.655 fibre
- C Band operation
- Configuration options for LH/ELH/ULH applications
- Configuration options for Terminals, Amplifiers, Equalising amplifiers, Fixed OADM and re-configurable OADM
- Multihop Raman amplification
- Single spans up to 62 dB (40 Channels @ 10G)
- Single Channel OSC
- Dual Channel OSC
- Automatic power equalisation
- Multiplex/de-multiplex low (8) and high (40) initial channel count
- Single Channel Optical Levelling Unit supports coloured interfaces
- 8 Channel Optical Levelling Unit supports coloured interfaces
- Fixed OADM, 4 or 8ch. @2.5G and 10G
- Full ROADM with access to all channels
- Fully managed optical channel extender
- Optical Performance Monitoring (Historical Log of analogue values)
- Enhanced fault management (pre-FEC BER)
- Transport of IP Messages
- EOW and Auxiliary functions

- Java Craft Terminal
- 10GRZ Muxponder
- 10G NRZ Muxponder
- 2.5G transponders
  - 2.5G Multirate, Extended Reach, G709, FEC, Link Mode,TTP
  - 2.5G Multirate, Standard Reach, G709 (OH), FEC, Link Mode,CTP/TTP
  - 2.5 Metro Transponder G709 (OH), FEC, Link Mode,CTP/TTP
- 10G transponders
  - LH/ELH variant using NRZ G709, Standard FEC,
  - LH/ELH variant NRZ G709, Standard FEC or EFEC, 80 channel tuneable, configurable for STM-64 (or10GbE WAN PHY) and 10GbE LAN PHY
  - ULH variant using RZ, G709 EFEC, 80 Channel Tuneable (50GHz)
- Enhanced BW7R alarm IO (16 operator inputs and 8 operator outputs)

1.2 Multihaul 3000 Key Technologies

1.2.1 *Flexible Transponder Reach Options*

Standard Reach NRZ transponders are available at both 2.5GBit/s and 10GBit/s rates. While these transponders do not have the same Ultra Long Haul reach as an RZ transponder they are cost optimised for shorter spans. The same amplifier, dispersion and control techniques are applied to both NRZ and RZ soliton transmission formats.

1.2.2 *G709 Wrapper Technology With Standard FEC And Extended FEC*

The 10G RZ and NRZ transponders implement an ITU G709 conformant wrapping function that adds overhead data and Forward Error Correction (FEC) information to the client signal to provide an Optical Channel signal with a bit rate of 10.7Gbit/s. The FEC algorithm used is a Reed-Solomon (255-239) which provides approximately 6.4 dB of coding gain which allows a signal with an uncorrected Bit Error Rate of 10^{-4} to be corrected to produce a Bit Error Rate of 10^{-15}. The RZ transponder additionally supports an enhanced FEC coding scheme, which increases the effective coding gain (>8dB) and supports extended system reach. The overhead remains compatible with the G709 standard.

The overhead information transported within the optical channel supports the monitoring and control of optical channels within the context of an all-optical transport network. Both 10G transponders support link mode operation, which allows the optical channel overhead to be transparently passed via the client interface to the next section.

1.2.3 Advanced Amplifier Technology

Amplification is provided by a range of EDFAs, which caters for span losses of up to 34dB. For the ELH and ULH applications, the EDFAs are characterised by extremely low noise figures and gain ripple. For the LH applications the EDFAs are cost optimised for the reduced reach.

All amplifier units incorporate advanced control circuitry where programmable hardware is used to ensure fast and accurate control of amplifier gain. The amplifiers respond automatically to changes in the number of channels without the need for manual intervention or realignment. Integrated Variable Optical Attenuators allow the amplifier units to automatically compensate for variations in span attenuation including dynamic changes due to fibre ageing and splicing.

Raman Amplification can be employed as required to cope with span losses of up to and beyond 34dB for multi-hop or 37dB for single hop systems, or to improve the noise performance of a system with lower losses. The Multihaul 3000 Raman Pumps utilise multiple wavelengths selected to provide the optimum gain flatness for all of the channels within a band.

The use of amplifiers is extremely modular and flexible, allowing the system performance and network cost to be optimised by utilising the most appropriate amplification at each node.

1.2.4 Dispersion Managed Solitons

The Multihaul 3000 achieves Ultra Long Haul transmission by the application of dispersion managed soliton technology to the transmitted data. A soliton is a pulse that is shaped in such a way that the factors which causes the pulse to spread (disperse) are balanced by other factors, which cause it to contract so that the pulse shape is maintained. In theory, it would be possible to transmit a pure soliton pulse over unlimited distances. In practice there are practical problems preventing the use of theoretical Solitons. The approach used for the Multihaul 3000 employs a Dispersion Managed Soliton approach in which extended energy Solitons are launched but their pulse shape is allowed to change along the transmission fibre. The pulse form is periodically corrected at regular intervals by applying the appropriate Dispersion Compensation hence the term dispersion managed. The result of this dispersion management is an average soliton effect that enables Ultra Long Haul transmission.

The generation of Solitons is achieved by transponders that generate RZ (Return to Zero) signals rather than the NRZ (Non Return to Zero) format used in conventional systems. The Soliton modulation, sometimes referred as chirped RZ, provides considerable advantages over the conventional NRZ approach in terms of improved receiver performance, reduced non-linearity and reduced PMD penalty. These advantages mean that Dispersion Managed Soliton based transmission systems can achieve far greater reach than previous generation NRZ systems.

1.2.5 Broadband Dispersion Compensation

The Multihaul 3000 exploits the broadband nature of amplifiers and employs broadband dispersion compensation providing 100% slope compensation for the dominant fibre types. The use of broadband dispersion compensation rather than sub-band dispersion compensation reduces the complexity of equipment at each compensating node and the complexity of the system as a whole. Equally important, once the amplifier nodes have been commissioned with their dispersion compensators, it is not necessary to revisit the sites to install additional dispersion compensation when new channels are added.

1.2.6 Dynamic Channel Power Control

One of the major problems associated with ELH and ULH DWDM transmission is that attenuation and gain is wavelength dependent. As the channels propagate the difference in power levels between the channels increases and can result in a reduction in the OSNR performance of the system. The Multihaul 3000 employs advanced dynamic channel power equalisation technology to adjust channel power levels to the correct level. This is performed periodically to ensure that the power levels of the optical channels remain consistent over the whole of the transmission path.

1.2.7 Direct Interfacing of Compatible Clients

The Multihaul 3000 allows the direct interfacing of compatible coloured client signals from external equipment without the need for transponders. The transponder is replaced by an Optical Levelling Unit (OLU), which allows the power level of the each client to be controlled in the same way as that of a transponder.

1.2.8 Fully Configurable And Fixed OADM Options

The R-OADM is a fully configurable Optical Add/Drop Multiplexer that allows flexible access to all 80 channels within a band. There is no limitation on the number of channels that can be dropped and added at a node. The F-OADM is a fixed Optical Add/Drop Multiplexer configuration that provides static access to between 4 and 8 predefined channels.

1.2.9 Comprehensive Element Management

Full management and control facilities are provided by the associated Local Craft Terminal and by the Marconi Element Management Platform Service On.

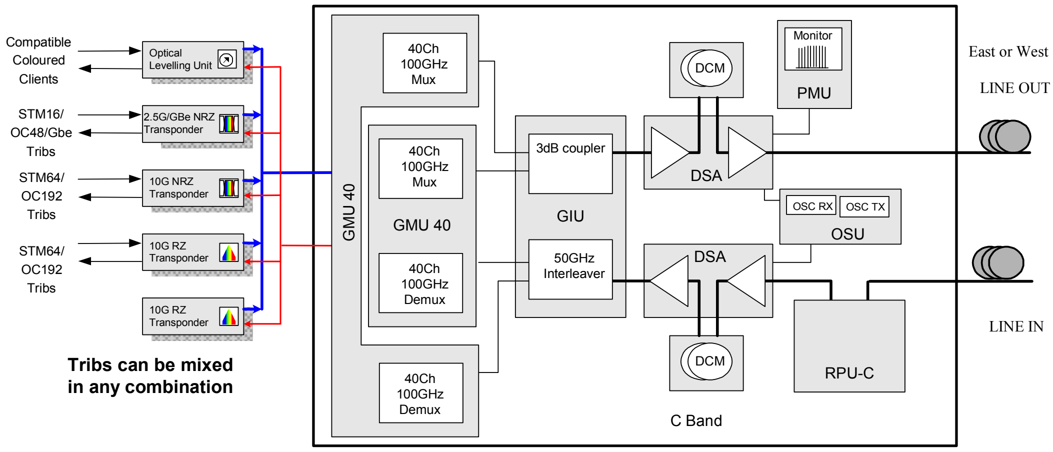
1.3 Transmission Architecture

The following sub-sections describe the traffic architecture of the Multihaul 3000. The system is highly configurable and the exact node configuration is tailored to the requirements of a specific span or network e.g. LH, ELH or ULH, with/without Raman, Bi-directional or Unidirectional power equalisation etc. The following sub-sections and the diagrams in these sub-sections illustrate the principal Node configurations for the Multihaul 3000 system but many other configurations are possible depending on the transmission parameters and application.

In the following description, each of the grey shaded boxes represents a slide in unit. A brief overview of these units is provided in the section below.

1.3.1 Terminal Network Element

Figure 1-3: Terminal Network Element



The system supports the transmission of up to 80 client signals. In the transmit direction, grey client signals are presented at the client interfaces of the transponder cards. The transponder maps the client signal to the payload of a coloured optical channel, adding the optical channel overhead. According to the transponder type, the payload may also be extended with an FEC or Enhanced FEC code to allow error correction at the receiving end.

If the client signal is already coloured with a suitable wavelength and frame structure then it is interfaced via a simple levelling unit that allows control of the power level but does not alter the other optical or electrical characteristics of the signal.

Within the C Band, the optical channels are subdivided into two groups of 40, referred to as the Group 1 and the Group 2. The channels, with frequencies separated by 100GHz, are presented to the input of a Group Multiplexer Unit and multiplexed together. The multiplexed "Group 2" aggregate is then interleaved with the multiplexed "Group 1" aggregate to obtain a composite band signal consisting of 80 optical channels spaced at 50 GHz.

The optical signal may be pre-amplified before adding dispersion pre-compensation via a DCM. A Booster amplifier increases the optical power level ready for transmission.

In the receive direction, a VOA integrated into the preamplifier allows programmable attenuation to compensate for reduced attenuation in the line section (shorter spans). The DCM placed in the mid-stage of the amplifier compensates for dispersion on the line while the final amplifier boosts the signal, compensating for the insertion loss of the DCM.

In the C Band up to 80 signals with 50 GHz spacing are de-interleaved into two sub-groups of 40 (Group 1 and Group 2) each with 100 GHz spacing. The sub-groups are further de-multiplexed to separate out the individual optical channels.

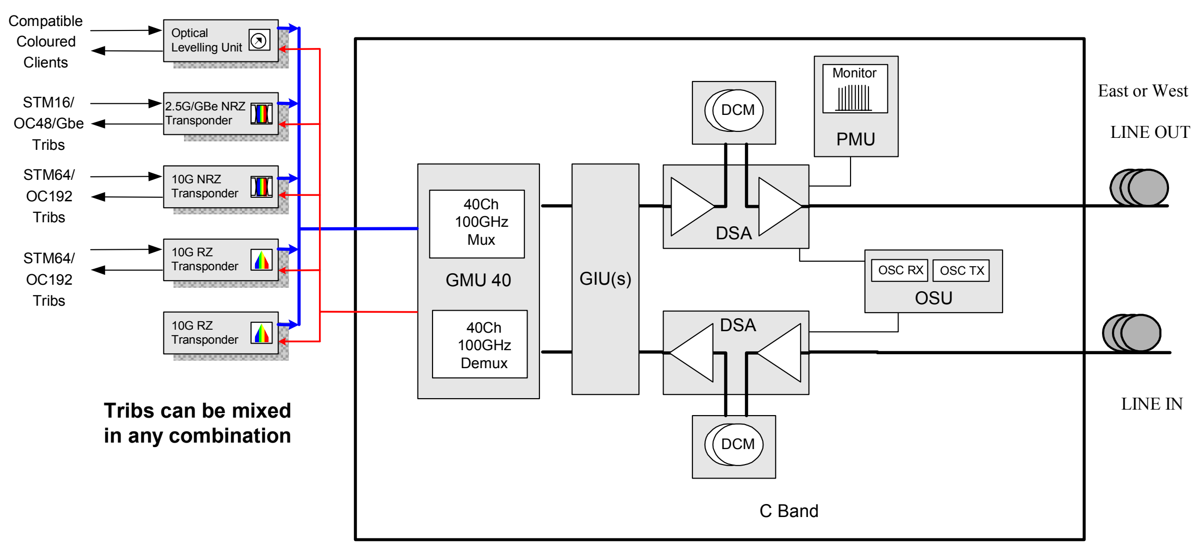
Each optical channel is presented to the receiver portion of the relevant transponder where it is first converted to electrical form. The FEC-corrected client signal is extracted and the optical channel overhead is terminated and processed. The client signal is presented at the client interface as an optical signal with the original bit rate and framing structure.

Depending on span length and noise considerations, Raman amplification may be configured. If present, a Raman Pump launches optical energy into the receiving fibre, providing signal gain and boosting the level of the received signal.

The 1510 nm OSC for the C band is extracted from the received line signal at the EDFA and processed. In the transmit direction, the OSC signal is multiplexed with the composite WDM signal before it is passed to the line.

The description above applies to a single band terminal equipped for up to 80 channels. The modular nature of the system allows for sub equipping for 40 channels as shown in Figure 1-5.

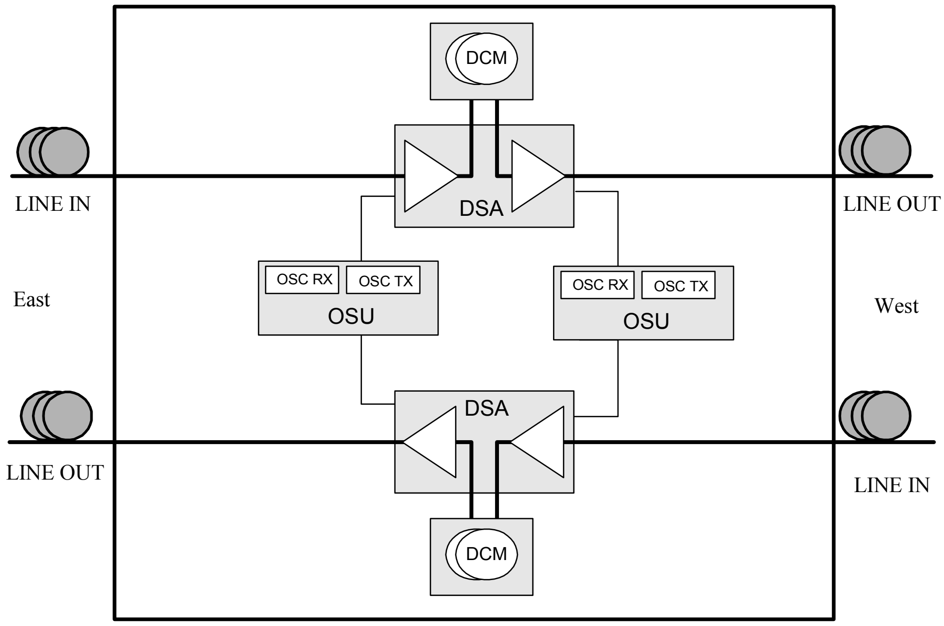
Figure 1-5: Sub Equipping for 40 Channels



1.3.2 Amplifier Network Element

Figure 1-7 illustrates the Amplifier network element.

Figure 1-7: Amplifier Network Element



The Line Amplifiers are used to amplify the composite WDM signal. The amplifier consists of two symmetrical paths from West to East and from East to West. The Optical Supervisory Signal (OSC) is also extracted and terminated within the amplifier node.

The preamplifier stage is equipped with a built in VOA to compensate for variations in span attenuation. The preamplifier then boosts the signal for presentation to the Booster Amplifier. Depending on fibre type and number of spans, dispersion compensating elements and levelling components may appear in the mid-stage between the Preamplifier and Booster. The Booster amplifier boosts the signal in preparation for onward transmission. The OSC is re-inserted before the signal is applied to the output.

Depending on span length and noise considerations, Raman amplification may be configured. If present, a Raman Amplifier back-pumps optical energy into the receiving fibre, providing signal gain and boosting the level of the received signal.

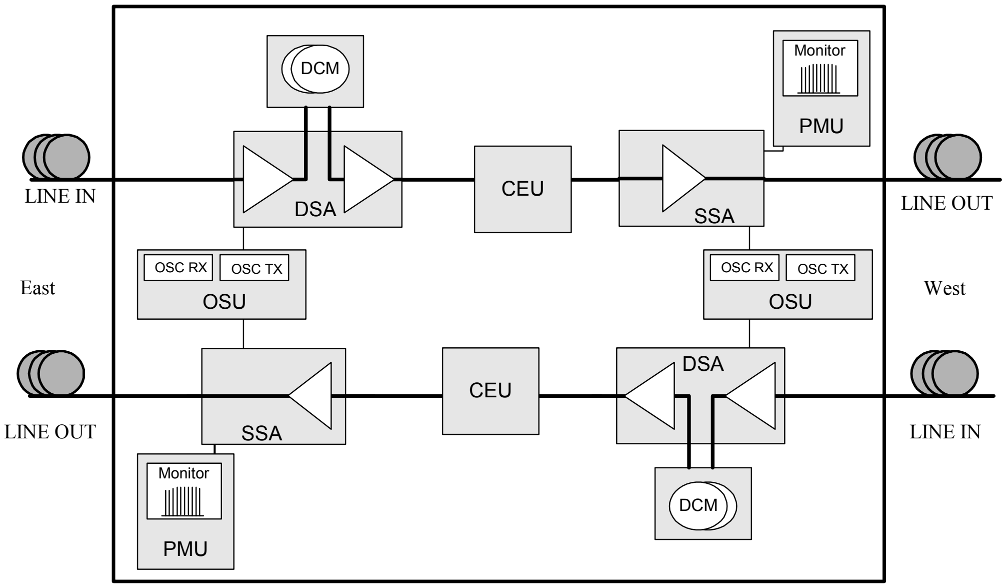
The way in which DCM modules are used depends on the fibre type and the link length. For SSMF, DCM will probably be required at every amplifier node. For G655 type fibres (LEAF, TrueWave), DCM may be applied less often, depending on the availability of the appropriate DCM units.

Note: This represents the typical fully equipped configuration of the line amplifier on a span of single mode fibre with average to high attenuation. There are however various alternative configurations depending on span loss and fibre type.

1.3.3 Equalising (Levelling) Amplifier Network Element

The figures below illustrate the Equalising (Levelling) Amplifier network element.

Figure 1-9: Equalising (Levelling) Amplifier Network Element Using a CEU



The equalising (levelling) amplifier network element is a variant of the normal line amplifier network element that is used to compensate for variations in channel power levels. It is estimated that an equalising amplifier is required approximately every eight spans, in order to ensure that the signal to noise degradation on the weakest (most attenuated) channel does not become a limiting factor for the transmission distance.

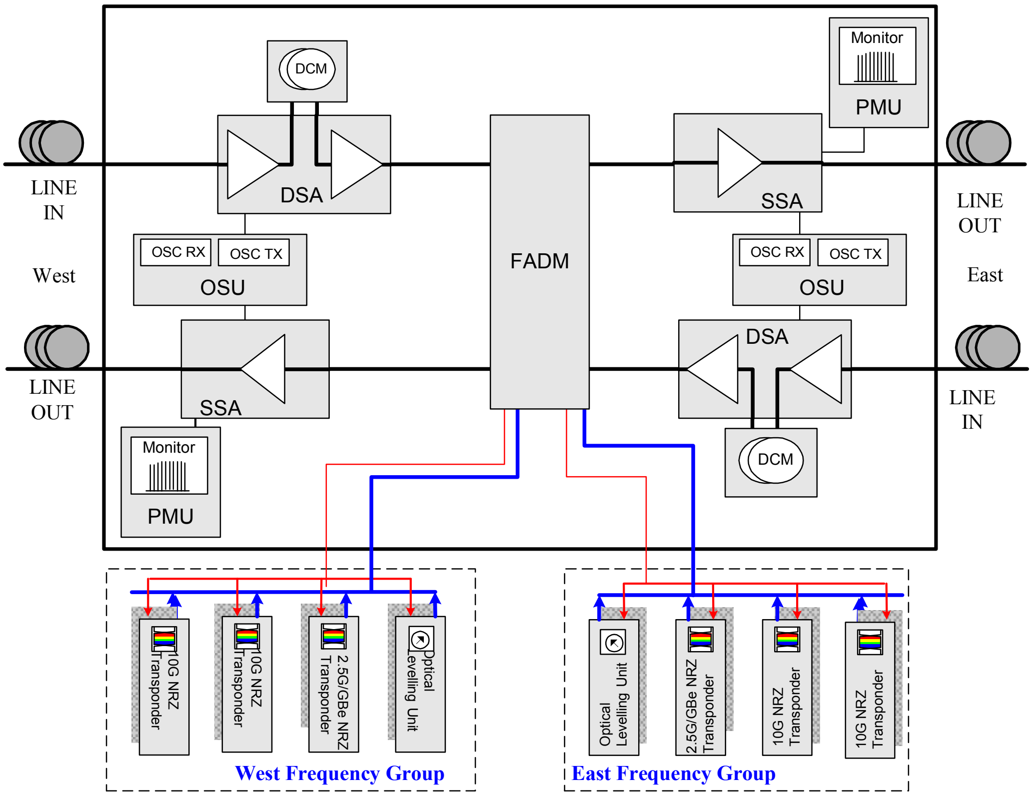
Channel power equalisation is achieved through the use of a Channel Equaliser Unit. The Channel Equalisation Unit uses control information from a Power Monitor Unit to selectively adjust the power of channels in order to restore the desired Channel Power Profile. It is an "all Optical" solution and require no O-E-O conversion. Similarly, it is dynamic, responding automatically to dynamic variations in channel powers.

The Power Monitor Unit at each equalising node is configured with the required Channel Power Profile. The PMU automatically adjusts this profile based on the actual number of channels in the system. At a terminal the Power Monitor Unit (PMU) monitors the output power levels of the Transponders and sends control signals back to each transponder to adjust transmission levels to the correct values. At Levelling nodes along the route, the PMU provides feedback to equalising units that correct the power profile to that required. The target power profile remains static as long as the channel count is also static. This ensures that the channel powers always converge to the target profile and are not subject to oscillation or limiting.

1.3.4 Optical Add/Drop Network Element

Figure 1-11 illustrates the layout of the fixed Optical Add/Drop network element.

Figure 1-11: Layout of the fixed Optical Add/Drop Network Element

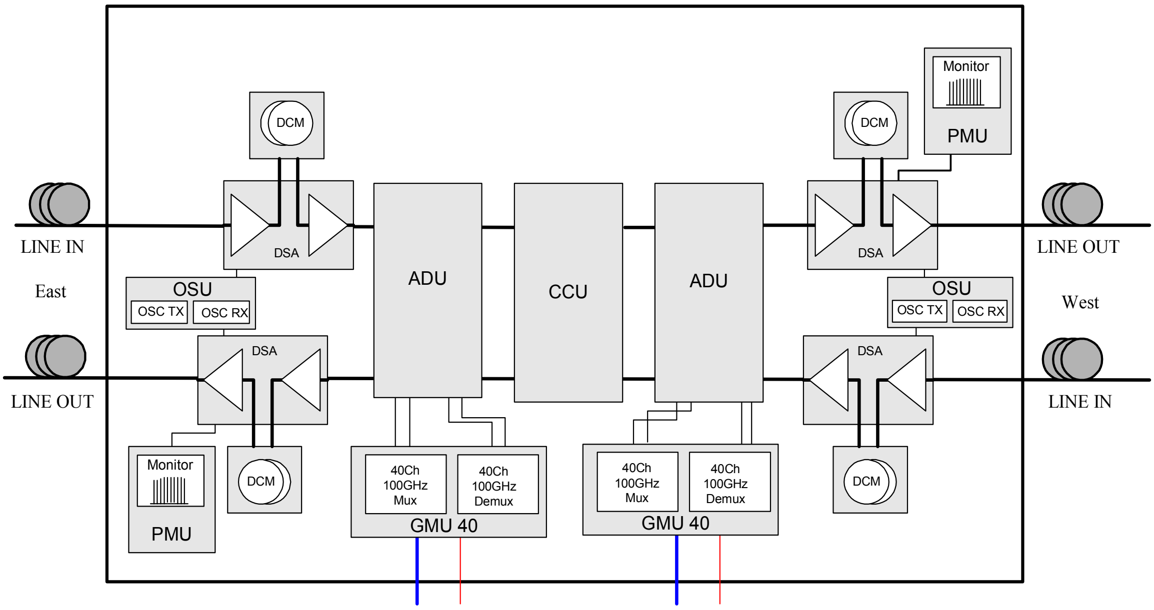


The Fixed Optical Add/Drop Multiplexer (FOADM) is a variant of the Line Amplifier in which up to eight of the optical channels in each band may be dropped and re-inserted. To achieve this, a Fixed Add Drop Unit (FADU) is inserted into the optical path. This unit bi-directionally de-multiplexes and re-multiplexes up to four contiguous channels within a band. Up to two units can be configured in any one NE.

One or two amplifier stages are required to accommodate the insertion loss resulting from the Add Drop Function and the DCMs. In the configuration shown above the DCM in the midstage of the first unit provides post compensation for the express and drop traffic.

Figure 1-13 illustrates the layout of the re-configurable Optical Add/Drop network element.

Figure 1-13: Optical Add/Drop Network Element.



The Optical Add/Drop Multiplexer (OADM) is a variant of the Line Amplifier in which a number of the optical channels in each band may be dropped and re-inserted. To achieve this, a Channel Control Unit is inserted into the optical path. This unit can separate the channels in an aggregate signal and selectively pass or block them. A splitter on the drop side of the Channel Control Unit allows a portion of the power from the composite WDM signal to be passed to the drop side de-multiplexer where the desired drop channels can be extracted. Similarly, a coupler on the "Add" side of the Channel Control Unit allows the multiplexed signals from the Add transponders to be combined with the through traffic. The Channel Control Unit is set to "block" the passage of any channels that have been "dropped" so that they do not interfere with channels of the same wavelength that have been "added".

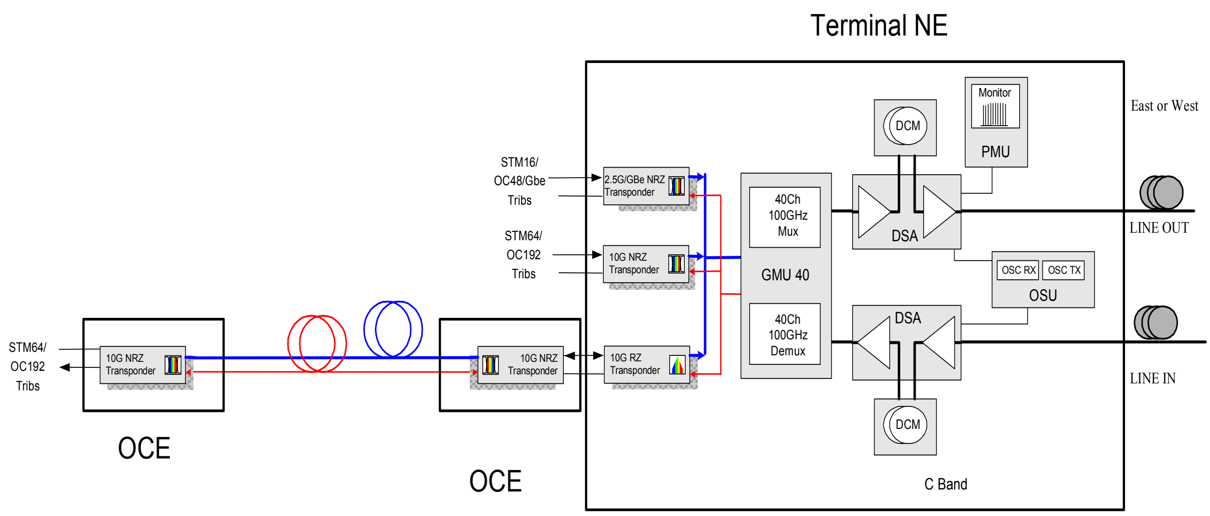
Two dual amplifiers are required to accommodate the insertion loss resulting from the Add Drop Function and the DCMs as shown in the generic representation below. The DCM in the midstage of the first unit provides post compensation for the express and drop traffic. The DCM in the midstage of the second amplifier provides "pre compensation" for the express and "add" traffic.

The approach employed ensures that the OADM is fully configurable, giving access to all 40 channels.

1.3.5 *Optical Channel Extender*

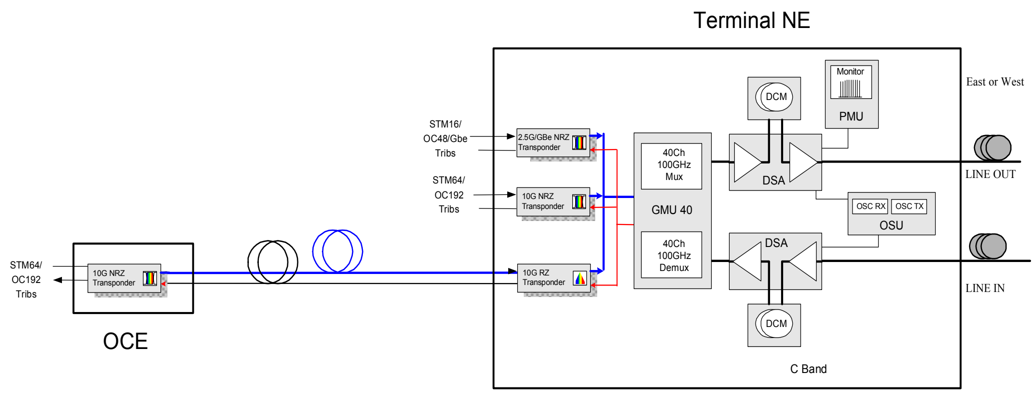
The Optical channel extender is used as a means of extending the reach of client equipment when it is located at a distance greater than the reach of either the Multihaul 3000 or client equipment optics. This is achieved by using additional transponders located at the client site connected in to the MHL300 NE. There are two ways of configuring an OCE. The symmetric configuration is illustrated in Figure 1-15.

Figure 1-15: Symmetric OCE Configuration



In this case a separate NE is created at the terminal site and the remote NE at the customer site is managed remotely via GCC0. Transponders used must be of the same type to ensure optical interworking (i.e. RZ-RZ or NRZ-NRZ). A Second possible configuration is the asymmetric OCE. In this case the remote transponder is connected up directly to the client side of the local transponder. This configuration is only available with NRZ transponders and is illustrated below.

Figure 1-17: Asymmetric OCE Configuration



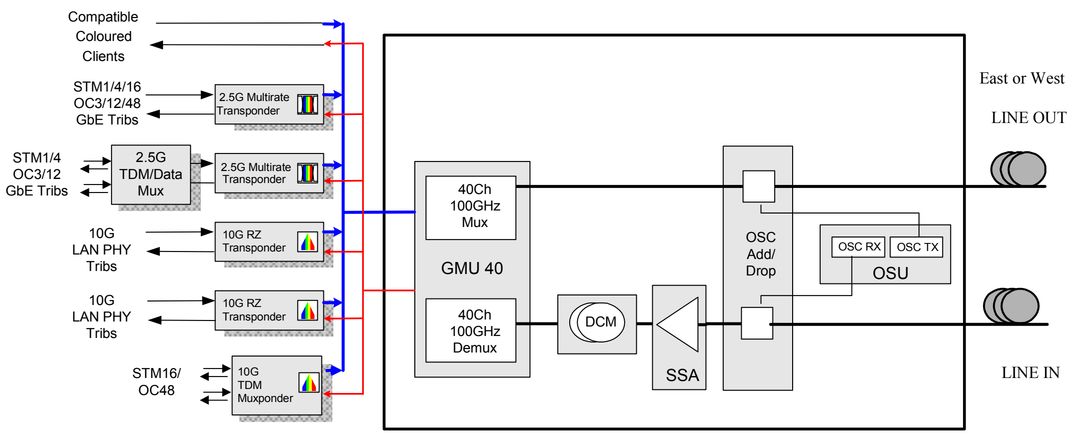
In both cases the OCE connections are configured as unmanaged 'dark fibre' ports.

1.3.6 Terminal Network Element

The system supports the transmission of up to 40 client signals in C-band by assigning them a distinct wavelength and multiplexing them together onto the line.

In the transmit direction, grey client signals are presented at the client interfaces of the transponder cards. The transponder maps the client signal to the payload of a coloured optical channel, adding the optical channel overhead. FEC or Enhanced FEC code is as added, according to the transponder type, to allow error correction at the receiving end, resulting in increased optical budget.

Figure 1-19: Terminal Network Element



If the client signal is already coloured with a suitable wavelength and frame structure and can be set to the appropriate power then it will be interfaced directly to the optical mux. If it cannot be set to the appropriate level then it is interfaced via a simple levelling unit, which allows control of the power level but does not alter the other optical or electrical characteristics of the signal.

The channels, with frequencies separated by 100GHz, are presented to the input of a Group Multiplexer Unit (GMU-40) and multiplexed together.

In the receive direction the DWDM signal is demultiplexed to feed the relevant transponders. An optional pre-amplifier is available for high span losses. The pre-amplifier includes a VOA and allows programmable attenuation to compensate for reduced attenuation in the line section (shorter spans). An optional DCM compensates for dispersion on the line.

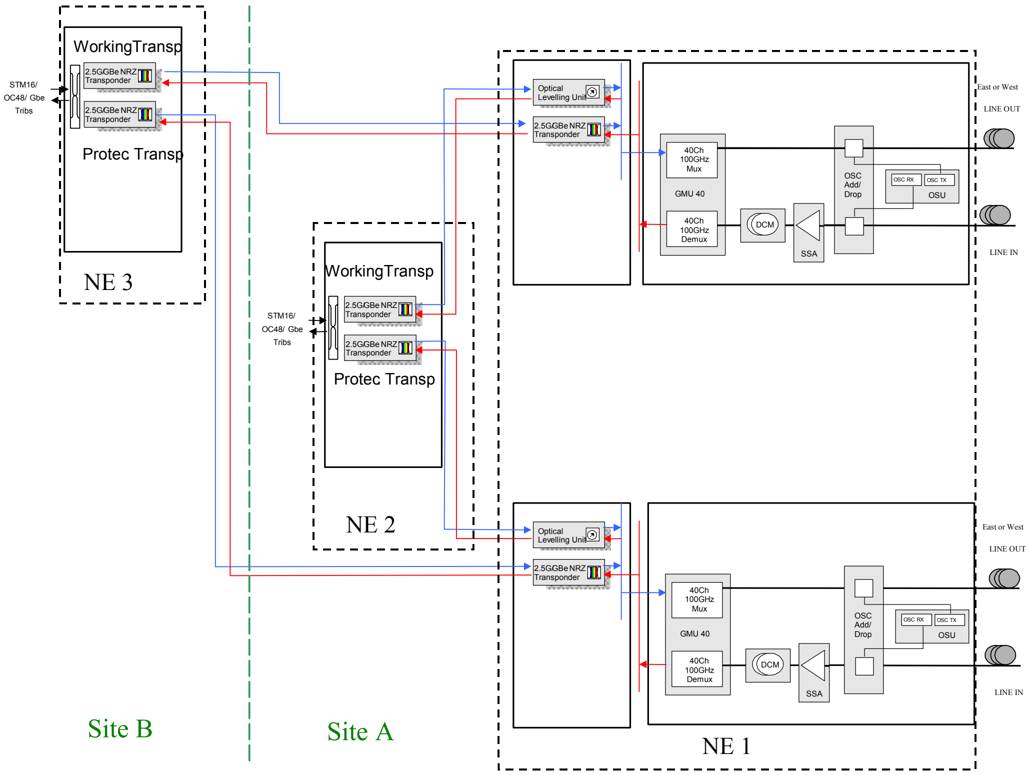
For relatively small numbers of channels (cost effective) The GMU-40s may be replaced by a number of 2 channel add/drop filters connected in series. Each optical channel is presented to the receiver portion of the relevant transponder where it is first converted to electrical form. The FEC-corrected client signal is extracted and the optical channel overhead is terminated and processed. The client signal is presented at the client interface as an optical signal with the original bit rate and framing structure.

There is an optional Optical Supervisory Channel (OSC) at 1510 nm. The OSC provides management communication for nodes that are not connected to the DCC via transponders. The OSC also supports Aux and EOW. The OSC is inserted and extracted via OSC add/drop filters. In the case of pre-amplified nodes the OSC extract is at the input of the amplifier.

1.3.7 Protected Terminal Network Element

The system supports the ability to completely protect client signals via totally independent optical paths. This is achieved by configuring transponders in a totally separate network element and then connecting them to two independent terminals. Connection can be either via transponders in the terminal NEs or via OLU-8 levelling interfaces depending on location of the different NEs and the available loss budget. There is no restriction on the terminal configuration, and there is also no requirement for the terminal configurations to be identical. A 40-channel terminal is illustrated below. The protected terminal network element is the part identified as at site B.

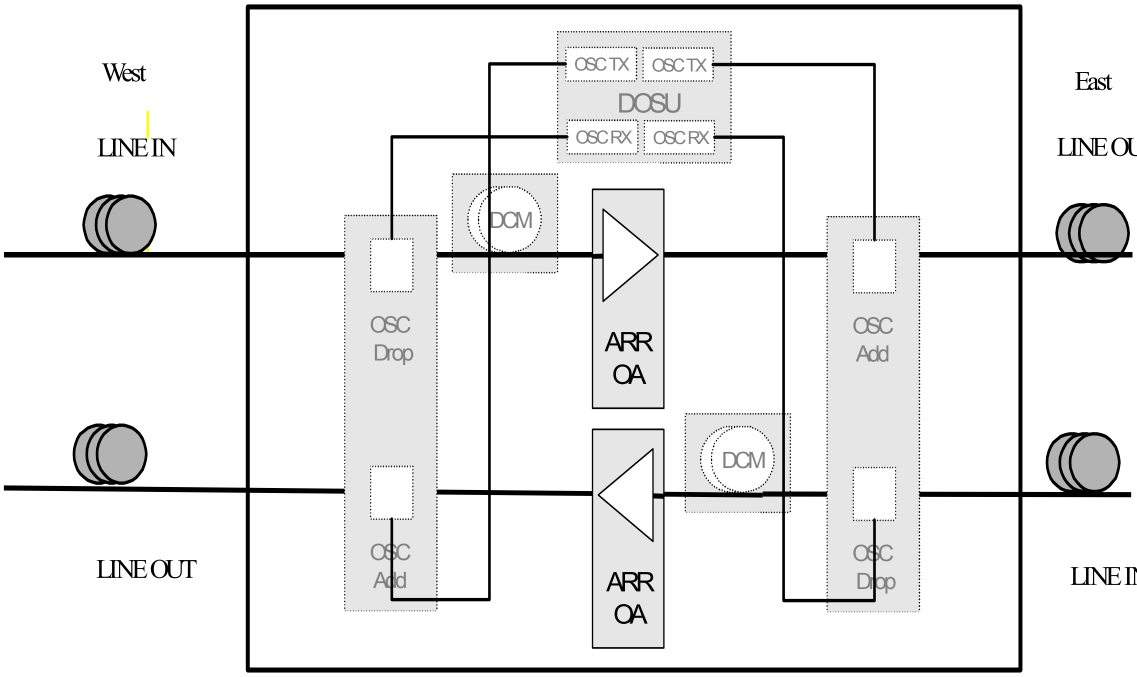
Figure 1-20: Protected Terminal Network Element



1.3.8 Amplifier Network Element

This only applies to the ARR. for line systems with in-line amplifiers. The Amplifier NE is basically the ARR amplified add/drop node without any traffic channels. OSC card is optional on base customer requirement. DCM module, if required according to network modelling prescription, can be added before ARR amplifier card.

Figure 1-21: Amplifier Network Element



1.3.9 Optical Add/Drop Network Element

Three different types of OADM configurations are supported:

- Passive serial OADM
- Passive parallel OADM
- Amplified serial OADM

1.3.9.1 Passive serial OADM is for low channel count nodes

2channel fixed add/drop filters are used. The filters allow fixed add/drop of two adjacent channels in a 100GHz grid. Channels to be dropped are pre-selected during network design, but a filter upgrade can be done in field if the traffic is protected.

1.3.9.2 Passive parallel OADM is for high channel count nodes

Two GMU_40 cards are equipped in back to back configuration. This configurations allows to access (add/drop) to all channels. Pass through traffic is managed via optical patch-cord.

1.3.9.3 Amplified serial OADM

An amplified serial OADM consists of a combination of ARR amplifiers and 2ch FADUs. The filters allow fixed add/drop of two adjacent channels in a 100GHz grid, ARR amplifier increases span length enabling amplified ring with circumference more than 100 km.

In all configurations, OSC at 1510 nm is an optional. The OSC provides management communication for nodes that are not connected to the DCC via transponders. The OSC also supports Aux and EOW. The OSC is inserted and extracted via OSC add/drop filters. The Dual OSU is a single card and provides OSC for both side West and East in the same card.

Figure 1-22: Passive Add/drop 2ch FADU for low channel count

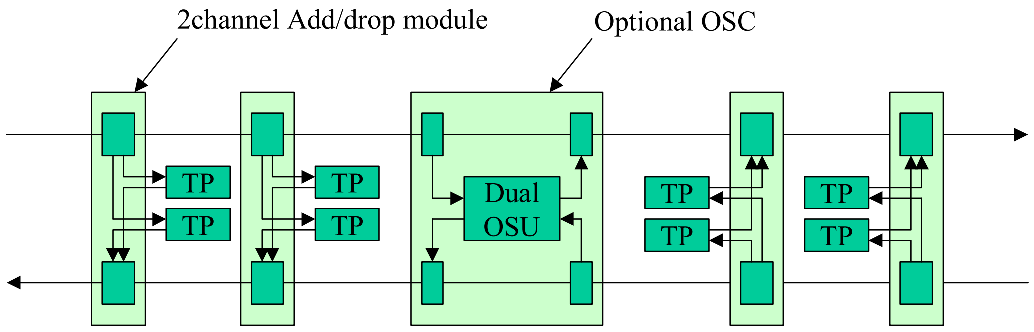


Figure 1-23: Passive Add/drop GMU-40 for high channel count

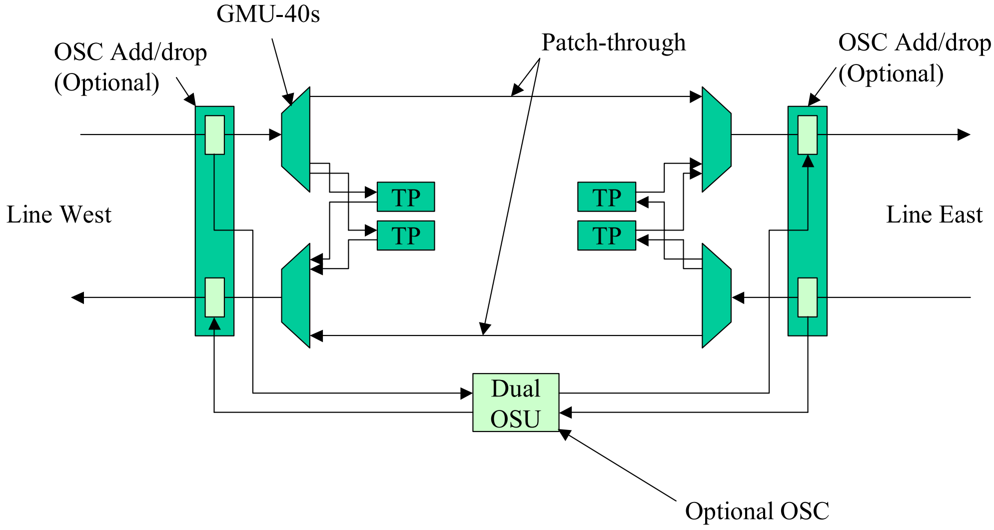
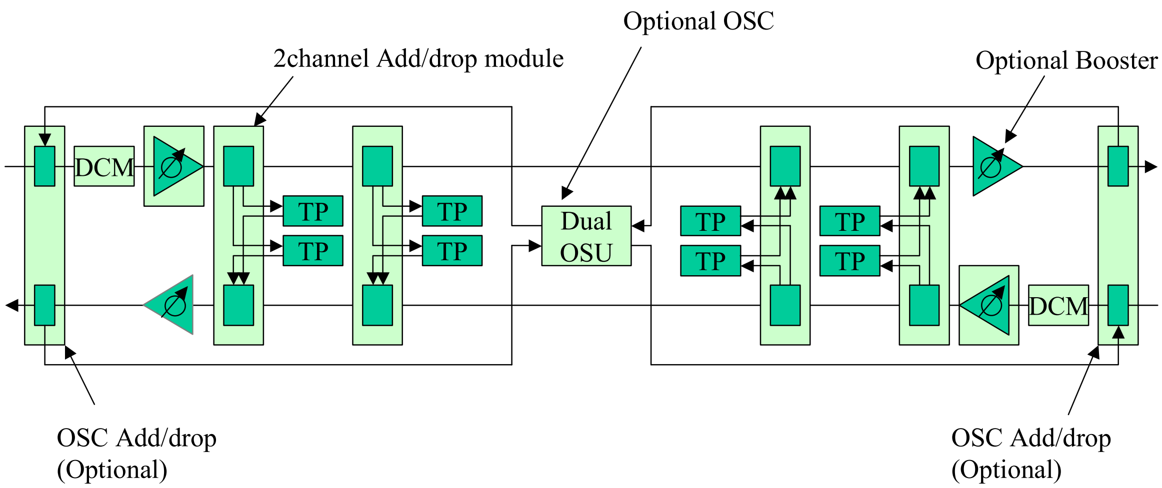


Figure 1-24: ARR Amplified Add/Drop



1.4 Overview of Transmission Units

1.4.1 Transmission Cards

The following sub-sections provide a brief description of the transmission units used in the Multihaul 3000 equipment.

1.4.1.1 10G RZ Transponder Unit (RZ-T)

The 10G RZ transponder is a bi-directional interface unit, with independent traffic paths for transmit traffic (Client to WDM) and receive traffic (WDM to client). The STM64/OC192 or OTN equivalent framed client interface is accessed via front panel optical connectors; the internal WDM interface is accessed via an optical front panel connector.

The client signals have a data rate of 9.98 or 10.7 Gbit/s and normally have STM64/OC192 frame structures. The transponder maps the client signal to the payload of an optical channel, adding the optical channel overhead and Forward Error Correction (FEC) or Enhanced FEC overhead. The resultant 10.7 Gbit/s data stream is then converted to an RZ encoded optical signal with a specific wavelength.

The overhead information transported within the optical channel supports the monitoring and control of optical channels within the context of an all-optical transport network. It also supports link mode operation, which allows the optical channel overhead to be transparently passed via the client interface to the next section.

On the client side, S64.2b, I64.1r, I64.2r and the equivalent G.959.1 interface variants are supported. On the WDM side the transponder is 80-channel tuneability

The transponder can support the following Client traffic signals:

- 9.95328 Gbit/s (STM-64) async
- 9.95328 Gbit/s (STM-64) bit sync
- 9.95328 Gbit/s IP/ATM (non SDH/SDH frame)

1.4.1.2 10G NRZ Transponder Unit (NRZ-T)

The 10G NRZ transponder is a bi-directional interface unit, with independent traffic paths for transmit traffic (Client to WDM) and receive traffic (WDM to client). The STM64/OC192 or equivalent OTN framed client interface is accessed via front panel optical connectors; the internal WDM interface is accessed via an optical front panel connector.

The transponder can support the following Client traffic signals:

- 9.95328 Gbit/s (STM-64) async
- 9.95328 Gbit/s (STM-64) bit sync
- 9.95328 Gbit/s IP/ATM (non SDH/SDH frame)

The transponder maps the client signal to the payload of an optical channel, adding the optical channel overhead and Forward Error Correction (FEC) overhead. The resultant 10.7 Gbit/s data stream is then converted to an NRZ encoded optical signal with a specific wavelength.

The overhead information transported within the optical channel supports the monitoring and control of optical channels within the context of an all-optical transport network. It also supports link mode operation, which allows the optical channel overhead to be transparently passed via the client interface to the next section. On the client side, S64.2 and the equivalent G.959.1 interface are supported.

1.4.1.3 10G T2 NRZ Transponder Unit

The 10G T2 NRZ transponder is a tributary unit that performs client to DWDM channel adaptation. It has full-band tuneability it also supports EFEC and additional client options.

The main features of the transponder are as follows:

- ITU-T G.691 compliant, Client Options S64.2B client interface with front panel optical connectors
- The WDM interface runs at 11.1Gbps (carrying Ethernet 10G LAN PHY with G709 wrapper) and ITU-T G.709 compliant 10.709Gbps DWDM interface with front panel optical connectors
- Reed Solomon (255,239) FEC encoding/decoding and error correction

- 80 wavelength tuneable, wavelength locked DWDM laser
- DWDM transmit output power controlled by Variable Optical Attenuator
- Receive digital wrapper monitoring for payload BIP errors
- DWDM receiver with active slicing control
- Client Automatic Laser Shutdown (ALS) system
- Receive and transmit client SDH/SDH traffic monitoring for B1 errors and J0 section trace
- Client diagnostic loop-backs (client receive to client transmit) with full jitter reduction.
- EFEC Support.

In the direction from client, the transponder accepts a low-level digital optical signal of any wavelength in the region of 1300-1600nm. By means of an optical-electrical-optical process, it interleaves a digital overhead and produces a high level digital optical signal on an accurately controlled specific wavelength. The digital overhead includes Forward Error Correction (FEC) coding and a path overhead. Full clock re-timing is included to ensure a nominally jitter-free output signal suitable for onward transmission over a number of optically amplified fibre sections.

In the direction to the client, it accepts a noisy, low-level digital NRZ optical signal of a specific wavelength in the region of 1550nm. By means of an optical-electrical-optical process, it removes the overhead, extracting the path overhead and correcting errors using the FEC algorithm and produces a nominally noise and jitter-free, high level digital optical signal to present to the client.

The path overhead processing allows for monitoring of any errors introduced over the DWDM optical network as well as providing for optical path trace labelling. The transponder incorporates an Automatic Laser Shutdown mechanism on the client interface, which is designed to shut down the client laser if a fibre break, occurs, in the interests of safety.

1.4.1.4 2.5G NRZ Transponder Unit (NRZ-T2.5)

The 2.5G NRZ transponder is a bi-directional interface unit, with independent traffic paths for transmit traffic (Client to WDM) and receive traffic (WDM to client). The STM4 to 16/OC3 to OC48 or OTN equivalent framed client interface is accessed via front panel optical connectors, the internal WDM interface is accessed via an optical front panel connector.

The transponder can support the following Client traffic signals:

- 622.08Mbit/s (STM-4)
- 2.48832Gbit/s (STM-16)
- 622.08Mbit/s (non SDH/SDH frame)
- 2.48832Gbit/s (non SDH/SDH frame)

The transponder maps the client signal to the payload of an optical channel, adding the optical channel overhead. The resultant 2.7Gbit/s data stream is then converted to an NRZ encoded optical signal with a specific wavelength.

The overhead information transported within the optical channel supports the monitoring and control of optical channels within the context of an all-optical transport network. It also supports link mode operation, which allows the optical channel overhead to be transparently passed via the client interface to the next section. The transponder implements a full G709 client mapping and overhead structure with a G709 compliant Reed Solomon FEC offering 6.4dB of coding gain.

1.4.1.5 2.5G NRZ Multirate Transponder Unit

The 2.5G NRZ transponder is a bi-directional interface unit, with independent traffic paths for transmit traffic (Client to WDM) and receive traffic (WDM to client). The STM4 to 16/OC3 to OC48 framed client interface is accessed via front panel optical connectors; the internal WDM interface is accessed via an optical front plane connector.

The transponder can support the following Client traffic signals:

- 622.08Mbit/s (STM-4)
- 2.48832Gbit/s (STM-16)
- 622.08Mbit/s (non SDH/SDH frame)
- 2.48832Gbit/s (non SDH/SDH frame)
- 1.25Gbit/s (Gigabit Ethernet)
- Fibre Channel

The transponder maps the client signal to the payload of an optical channel, adding the optical channel overhead. The resultant 2.7Gbit/s data stream is then converted to an NRZ encoded optical signal with a specific wavelength. The overhead information transported within the optical channel supports the monitoring and control of optical channels within the context of an all-optical transport network. It also supports link mode operation, which allows the optical channel overhead to be transparently passed via the client interface to the next section. It supports the G709 standard overhead format but implements a proprietary FEC approach, which offers a reduced coding, gain.

1.4.1.6 2.5G Dual Gig E Multiplexer Card LX Variant

The 2.5G Dual Gig E Multiplexer Card is used in conjunction with 2G5 Gigabit Transponder. This Multiplexing unit packet interleaves/deinterleaves two asynchronous Gigabit Ethernet optical interfaces together in order to produce a standard concatenated STM–16/OC–48 optical payload. This signal is then fed in to a 2G5 transponder, which converts from a grey wavelength to a colored one. Transparency is maintained for both Gigabit Ethernet signals carried between system nodes. The purpose of this card is to utilize bandwidth at 2.5Gb/s, which in turn reduces the inherent cost of Gigabit Ethernet circuits. This variant of the card operates at1310nm and is intended for long haul applications.

1.4.1.7 2.5G Dual Gig E Multiplexer Card SX Variant

This multiplexing unit is similar to the LX Variant, except that this variant operates at 850nm and is intended for short haul applications. The above descriptions are also applicable to this variant.

1.4.1.8 2.5G TDM Multiplexer Card

This Multiplexing Unit is used in conjunction with an unprotected 2.5G transponder. The Multiplexing Unit byte interleaves/deinterleaves four asynchronous 155/622Mbits/s optical interfaces together to produce a non–standard 2.5Gbits/s optical signal based on an STM–16/OC–48 frame. This signal is then fed into a 2.5G transponder, which converts from a grey wavelength to a colored one. The purpose of this card is to optimise wavelength usage

The multiplex system is based on the standard SDH multiplexing scheme with payload pointer processing etc. If the input signals are not synchronized with each other, then the multiplex rate pointer adjustment will occur in the normal fashion. The multiplex rate can be configured to be taken from any one of the input signals (or internally).

Unlike a normal SDH multiplex, the section overheads are not terminated, but transported using some of the spare bytes in the resulting multiplexed frame. The section overheads do not have a pointer mechanism and cannot be rate adjusted in the same way as the payload, so occasional overhead frame slips will occur. Generally this is not a problem as individual bytes of a critical nature are normally protected by a persistency check or, as in the case of the DCC, by retransmission (at the link layer).

B1 and B2 bytes are recalculated as part of the pointer processing and multiplexing operation. Error rate transparency with B1 and B2 on each client port is maintained by manipulation of these bytes in the multiplexer units. The error rate sent into a multiplexer port will be propagated to the far end of the network. If any additional errors were to occur, these would also be accumulated.

Rate adjustment is only carried out in the multiplexing process and not in the demultiplexing process.

1.4.1.9 2.5G Metro NRZ-HP Transponder Units (G.709 High Power Metro)

The NRZ-HP transponder is a tributary unit that performs client to DWDM channel adaptation.

The main features of the transponder are as follows:

- ITU-T G.957 compliant, S-16.1 client interface with front panel optical connectors
- Proprietary 2.666Gbps DWDM interface with optical front-plane connectors. Interface will support ITU-T G.709 compliant signals
- Proprietary Reed Solomon (255,239) FEC encoding/decoding providing error correction at the DWDM port with a FEC gain of greater than 5.5 dB
- Receive digital wrapper monitoring for payload BIP errors
- DWDM receiver operates over the range 0 to -26 dBm

- Client Automatic Laser Shutdown (ALS) system
- Receive and transmit client SDH/SDH traffic monitoring for B1 errors and J0 section trace
- Client diagnostic loop-backs (client receive to client transmit) with full jitter reduction.

In the direction from client, the transponder accepts a low-level digital optical signal of any wavelength in the region of 1300-1600nm. By means of an optical-electrical-optical process, it interleaves a digital overhead and produces a high level digital optical signal on an accurately controlled specific ITU wavelength. The digital overhead includes Forward Error Correction (FEC) coding and a path overhead. Full clock re-timing is included to ensure a nominally jitter-free output signal suitable for onward transmission over a number of optically amplified fibre sections.

In the direction from the client, it accepts a low-level digital NRZ optical signal of a specific ITU wavelength in the region of 1529.55nm to 1561.01nm. By means of an optical-electrical-optical process, it removes the overhead, extracting the path overhead and correcting errors using the FEC algorithm and produces a nominally noise and jitter-free, high level digital optical signal to the client.

The path overhead processing allows for monitoring of any errors introduced over the DWDM optical network as well as providing optical path trace labelling. The transponder incorporates an Automatic Laser Shutdown mechanism on the client interface, which is designed to shut down the client laser in the event of a fibre break, in the interests of safety.

1.4.1.10 10G RZ Muxponder Unit

The 10G RZ TDM Muxponder Unit is a single-slot unit that allows multiplexing up to four STM16 data streams into a full standard G.709 OTU2 signal mapped as ODTU12.

The card has four ports, where optical transceivers (SFP modules) can be inserted, which enable the card to support STM-16 signals with different optical reaches. This provides a high degree of flexibility both in terms of traffic management and fibre link length.

At the WDM side, there is a 10Gbit/s RZ module with a tuneable laser

1.4.1.11 10G NRZ Muxponder Unit

The 10G NRZ TDM Muxponder Unit is a single-slot unit that allows multiplexing up to four STM16 data streams into a full standard G.709 OTU2 signal mapped as ODTU12.

The card has four ports, where optical transceivers (SFP modules) can be inserted, which enable the card to support STM-16 signals with different optical reaches. This provides a high degree of flexibility both in terms of traffic management and fibre link length.

At the WDM side, there is a 10Gbit/s RZ module with a tuneable laser

1.4.1.12 Optical Levelling Unit 8 (OLU-8)

Optical Levelling Unit (OLU) allows the interfacing of up to 8 compatible coloured clients without the need for a transponder. In the path from Client IN to WDM OUT the optical power is controlled by a VOA (levelled). The VOA attenuation is either controlled manually by LCT, or by the PMU within the Multihaul node. The path from WDM IN to Client OUT is not optically controlled but is just monitored (passive).

1.4.1.13 40 Channel Group Mux Unit (GMU-40 40)

The GMU-4040 card can be used as a multiplexer or a demultiplexer. The GMU-40 either combines 40 individual optical channels into a composite WDM signal, or separates out the individual optical channels from a composite WDM signal. The Optical channels are spaced at 100 GHz. Two GMU-40 40s are required and one to Mux, and the other to De-Mux.

1.4.1.14 8 Channel Group Mux Unit (GMU-40-8)

There are five variants of the GMU-40-8. The multiplexer half of the Group Mux Units combines 8 individual optical channels into a composite WDM signal. The Optical channels are spaced at 100 GHz. The demultiplexer section performs the reverse operation, separating out the individual optical channels from a composite WDM signal. Additionally the GMU-40-8 Head unit also combines and separates the red and blue extension bands.

The GMU-40-8 extension Red 1 and Blue 1 also separates and combines the red 1 and red 2 bands respectively. These filters are only available in-group 1. Expansion beyond group 1 requires the GMU-40-40. This is a bi-directional card.

1.4.1.15 Group Interleaver Unit (GIU)

The Group Interleaver Unit serves to combine two groups of 40 Channels, each on a 100GHz grid, into a single group of 80 channels interleaved on a 50GHz grid and vice versa.

The sub equipped GIU is a shutter card that allows high power extended reach EDFAs to be equipped at terminals. It provides for optical safety for EDFAs facing demultiplexers.

1.4.1.16 Single Stage and Dual Stage Amplifiers (SSA and DSA)

For ELH and ULH applications Multihaul 3000 uses a family of EDFA amplifiers of varying gain. The single stage amplifier consists of a single EDFA block. The Dual stage amplifier consists of separate Preamplifier and Booster EDFAs and accommodates a 12.4dB mid stage loss for DCMs etc. The gain and power of each amplifier stage is as follows:

Table 1-1: The Gain and Output Power of each Amplifier Variant

Amplifier	Code	Output Power	Gain (dB)
Single stage Amp	SSA17-C	21.0dBm	17-18dB
Single stage Amp	SSA21-C	21.0dBm	21-22dB
Single stage Amp	SSA28-C	21.0dBm	27-28dB
Dual stage Amp	DSA17-C	21.0dBm	17-18dB
Dual stage Amp	DSA21-C	21.0dBm	21-22dB
Dual stage Amp	DSA28-C	21.0dBm	27-28dB

A generic approach to their design is employed whereby a common control card is used to control one or two EDFA blocks up to a total of six pumps. In all cases, the amplifier receives a composite WDM signal consisting of up to 80 optical data channels and amplifies them for transmission using an EDFA booster amplifier.

All of the amplifier types may be combined with Raman Pump Units to increase the overall gain.

1.4.1.17 Single Stage and Dual Stage Standard Reach Amplifiers (DSA-LH and SSA-LH)

For LH applications a range of four EDFA amplifiers per band are available. The single stage amplifier consists of a single EDFA block. The Dual stage amplifier consists of separate Preamplifier and Booster stages in a single block and accommodates a 12.4dB mid stage loss for DCMs. The gain and power of each amplifier stage is as follows:

Table 1-3: The Gain and Output Power of each Amplifier Variant

Amplifier	Code	Output Power	Gain (dB)
Single stage Amp	SSA15-LH-C	19.5 dBm	9.5-19.5 dB
Dual stage Amp	DSA20-LH-C	19.5 dBm	19.5-24.5 dB
Dual stage Amp	DSA25-LH-C	19.5 dBm	24.5-29.5 dB
Dual stage Amp	DSA30-LH-C	19.5 dBm	29.5-34.5 dB

1.4.1.18 Metro ARR Amplifier Unit

The Multihaul 3000 Metro ARR Amplifier (SSA 21dB C-Band) Unit provides optical amplification function within the Multihaul 3000 product range using a single Erbium Doped Fibre Amplifier (EDFA). The amplifier also carries out a line build out function using a Variable Optical Attenuator (VOA) to adjust the gain to an optimal value maximising EDFA performance.

1.4.1.19 Optical Supervisory Unit (OSU)

The Optical Supervisory Unit processes the 2Mbit/s optical supervisory signal (OSC) that provides the telemetry within the system. In conjunction with the controller and the Line termination cards, the OSU supports DCC communication, Engineers Order Wire functions, G703 data channels and a number of internal control channels.

1.4.1.20 Dual Optical Supervisory Unit

The Optical Supervisory Unit processes the 2Mbit/s optical supervisory signal (OSC) that provides the telemetry within the system. In conjunction with the controller and the Line termination cards, the OSU supports DCC communication, Engineers Order Wire functions, G703 data channels and a number of internal control channels.

Dual OSU Unit (1510nm) provide two bi-directional OSC1 and OCS2 interfaces for two line ports. The Dual OSU supports G.709 functionality for Och, OMS and OTS overheads. Network Elements with a single line port can use a dual OSU per band operating in uni-directional mode. Network Elements with two line ports (e.g. Amplifiers) require one dual OSU per band. The Dual Optical Supervisory Unit is 1.6" wide and occupies a single slot position.

1.4.1.21 Dual Optical Supervisory Unit In Band Variant

The Dual Optical Supervisory Unit (in-band variant 1560.61 nm) processes the 2Mbit/s optical supervisory signal (OSC) that provides the telemetry within the system. In conjunction with the controller and the Line termination cards, the OSU supports DCC communication, Engineers Order Wire functions, G703 data channels and a number of internal control channels.

The in-band Optical Supervisory Unit variant is fitted with optical units for only one OSC port. This variant is used for very high loss, Raman amplified spans where the out of band (1510nm) OSU cannot provide sufficient optical budget. It operates instead of a traffic channel on 192.1THz.

Each Dual Optical Supervisory Unit provides a bi-directional OSC interface for a single line port and supports G.709 functionality for Och, OMS and OTS overheads. The Optical Supervisory Unit is 1.6" wide and occupies a single slot position.

1.4.1.22 Raman Unit (RPU)

The Raman Unit amplifies incoming signals by pumping high power photonic energy into the fibre on which the signal is to be received. Those signal components whose wavelengths are longer than the pump wavelengths absorb the pumped photonic energy and are thereby amplified.

The Raman unit contains multiple pumps whose wavelengths have been selected to give the optimum gain flatness in their band, see table below for more detail.

Table 1-5: Variants of the Raman unit

Raman Variant	No of Pumps
C-Band co-pumping RPU	2
C-Band counter-pumping RPU	2

The Raman unit incorporates all of the electronics required to accurately control and monitor the pump units.

1.4.1.23 Channel Control Unit (CCU 1C)

This unit is used in a reconfigurable add/drop node to control, which channels are passed and which are blocked. Channels that are to be dropped are blocked from onward transmission to allow the re-use of the wavelength for "add" channels.

The Channel Control Unit is bi-directional and works on a 100GHz grid.

1.4.1.24 Channel Control Unit C (CCU C)

This unit is used in an add/drop node to control, which channels are passed and which are blocked. Channels, which are to be dropped, are blocked from onward transmission to allow the re-use of the wavelength for "add" channels. The Channel Control Unit is unidirectional and works on a 50GHz grid. Two units are required to form an ROADM

1.4.1.25 Channel Equaliser Unit (CEU)

This unit is used to equalise the channel powers within the composite WDM signals and compensate for variations in signal level arising from gain ripple, Raman tilt etc. It uses the same core technology as the Channel Control Unit and can adjust channel power levels and block ASE in unused channels.

1.4.1.26 Power Monitor Unit (PMU)

This unit monitors the power levels of each of the channels in a composite WDM signal. The channel power data is can be compared to a configured channel power profile and the delta data (deviation from desired levels) passed to other parts of the system to allow control (pre-emphasis, levelling etc.). Channel data is also made available to the network element Controller in the form of performance management records.

1.4.1.27 Add/Drop Unit

The Add/Drop provides taps for dropping and adding traffic, as well as detectors and shutters needed to guarantee EDFA shutdown in the instances of fibre breaks.

1.4.1.28 Fixed Add/drop Unit

The Fixed Add/drop unit demultiplexes four adjacent channels out of the DWDM multiplex to allow for optical channel drop and then multiplexes the same channels to allow for optical channel add. The unit is bi-directional, and allows for patching through dropped channels directly.

1.4.1.29 2Skip0 Filter Tray

2Skip0 Filter Tray is used in a 100GHz spaced DWDM system using 24 ITU wavelengths, extending from ITU-T frequency 192.1 THz to 194.4 THz inclusive. In normal operation its fibres are connected using low loss SC/UPC and LC/UPC connectors.

1.4.1.30 OSC Filter Tray

The OSC Filter Tray is used to remove or insert as required a management channel, known as the Optical Supervisory Channel (OSC), from or to the CWDM and DWDM wavelengths in the MHL system, operating at 1510 nm.

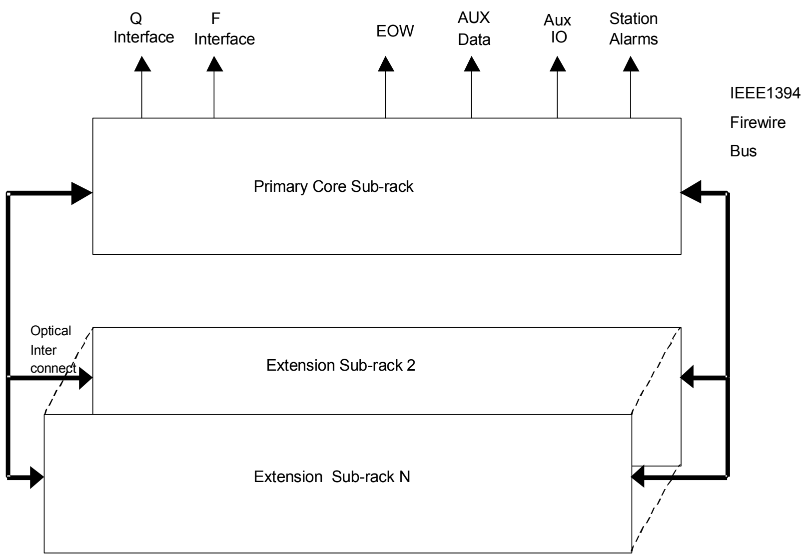
In normal operation its fibres are connected using low loss SC/UPC connectors. A couple of identical filters, one for the Drop function and the other one for the Add function is housed in a Telect tray with SC/SC adapters and fibres management parts.

1.4.2 Network Elements

The Multihaul 3000 product encompasses a number of distinct network element types (Terminal, Line Amplifier, Levelling Amplifier and OADM). Each network element type consists of at least one or more sub-racks. The first sub-rack is referred to as the primary core sub-rack because it provides facilities for managing the network element (Q interfaces, alarm interfaces etc.). The network element may then be expanded with additional Extension sub-racks to achieve the overall functionality.

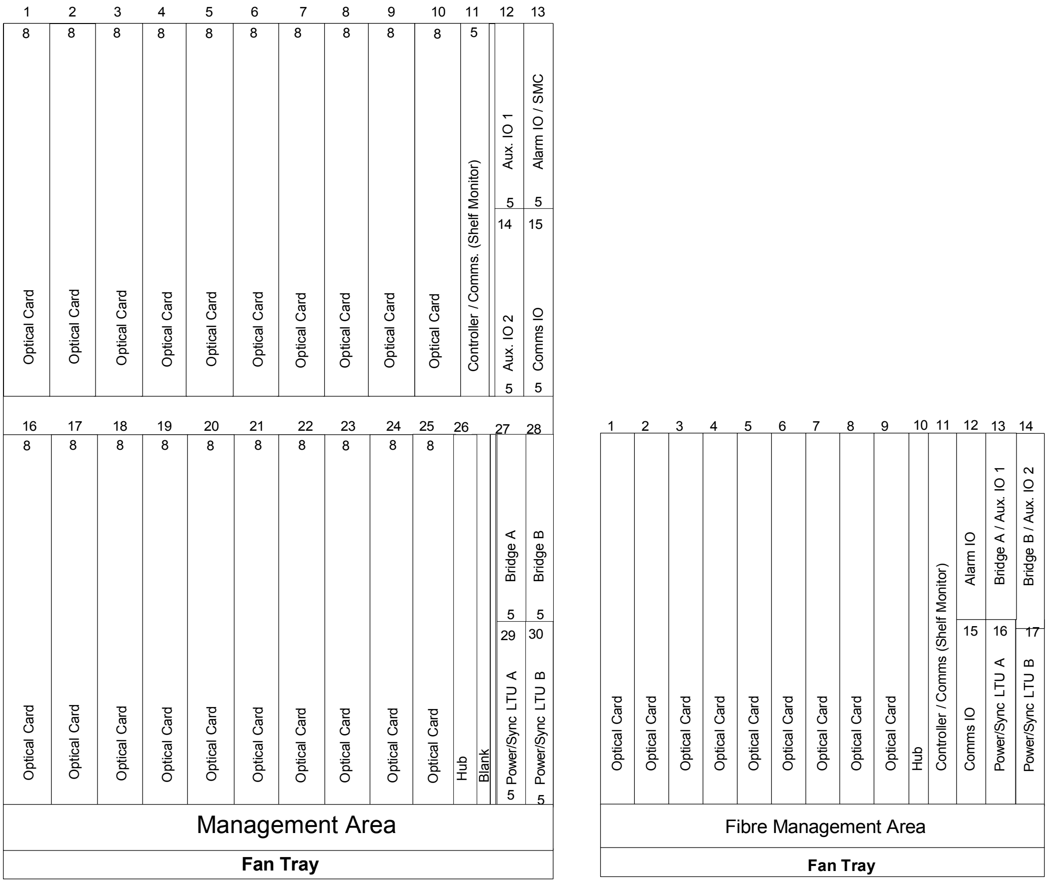
The sub-racks are linked for control purposes via an IEEE 1394 firewire bus that supports flexible data interchange between cards in the system. Irrespective of the number of sub-racks required, the network element is presented to the Element manager as a single controllable entity.

Figure 1-25: Multihaul 3000 Sub- Rack



1.4.2.1 Dual and Single Row Subracks

Figure 1-27: 20 Slot Double Row and Single Row Sub-racks



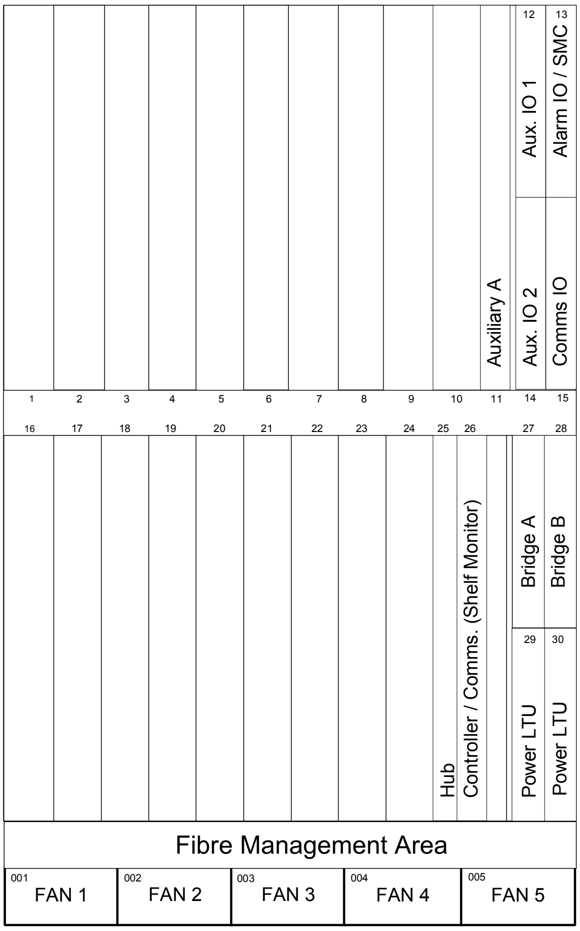
Multihaul 3000 supports modular equipping based on the use of four generic subracks types as shown above. Both the Double Row and the Single Row sub-rack can be equipped with Line Termination Units (LTUs) to support the primary network element interfaces such as Q interface, rack alarms, overhead termination etc. These functions are only required once within a network element. They can also be used without these LTUs as extension subracks.

Based on a 1.6" pitch, the double and single row sub-racks provide 19,9 slot and 20 slot dual core positions respectively, into which the various transmission units such as amplifiers, transponders and monitors can be fitted. Additional specific slots are provided for the network element Controller, a Hub unit for intra-shelf communication and Dual Bridge units for inter-shelf communication.

1.4.2.2 19 Slot Sub-rack

The 19 Slot Dual row sub-rack is a double row shelf which supports the primary network element interfaces such as Q interface rack alarms, overhead termination etc. These functions are only required once within a network element Additional specific slots are provided for the network element Controller, a Hub unit for intra-shelf communication and dual Bridge units for inter-shelf communication. See Figure 1-29 for the physical layout of a core sub-rack.

Figure 1-29: 19 Slot Dual Row Subrack Physical Layout



1.4.2.3 DCM Sub-rack

Each DCM sub-rack can house two single height Dispersion Compensation Modules or one Dual height Dispersion Compensation Module (DCM 150). Each DCM has its own non-volatile inventory information, which is accessed via a serial control bus.

1.5 Architecture

1.5.1 Overview

Figure 1-31: Control Architecture of the Multihaul 3000

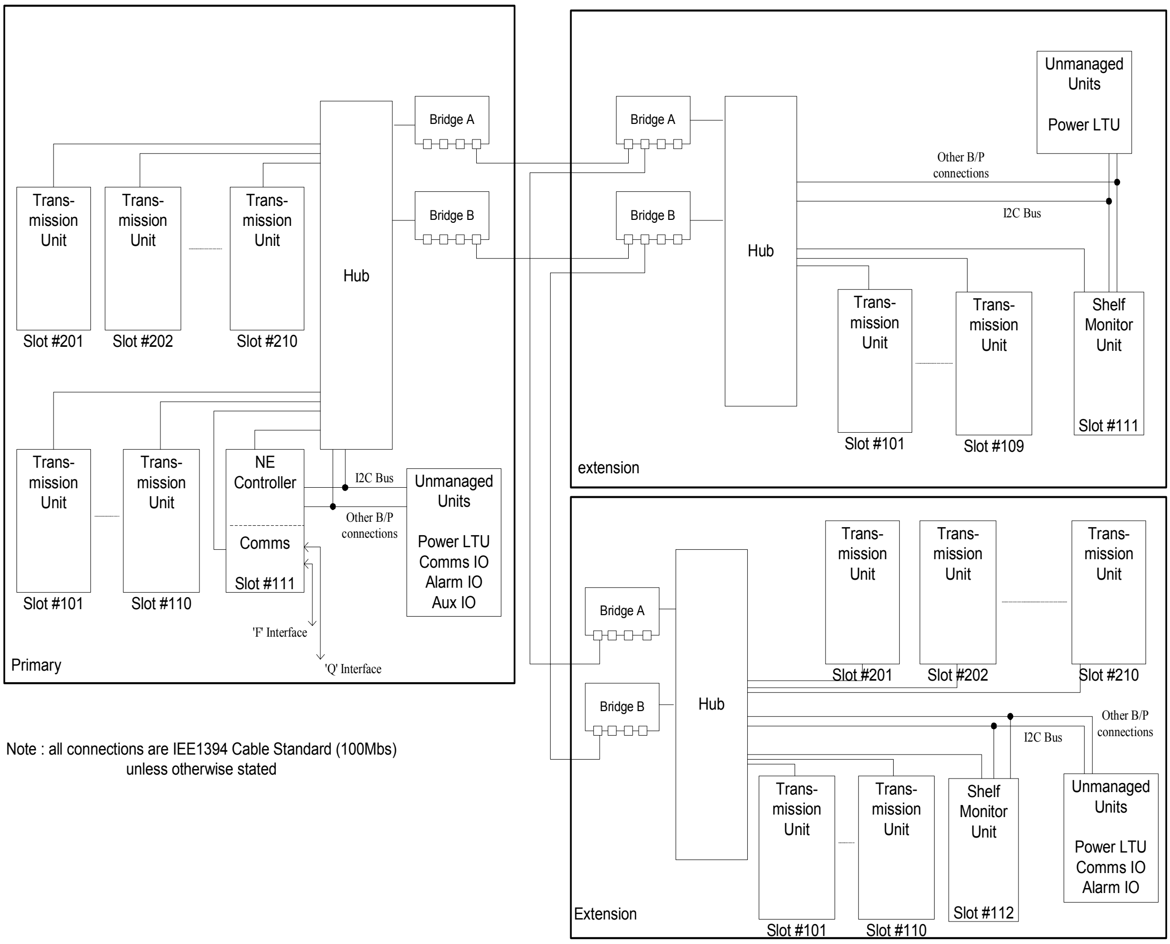


Figure 1-31 shows the control architecture of the Multihaul 3000 product. The network element Controller in the Core sub-rack is responsible for the Equipment Management Function (EMF) within the system. It communicates with the managed units and transmission units, configuring them as necessary and collecting event and performance information. It also supports the major control interfaces such as shelf/rack alarms, Local Craft Terminal interface and Element Management Interface.

The IEEE1394 supports communication within and between sub-racks. Within a sub-rack, the Hub Unit interconnects all units thus allowing multi-master communication. The Sub-racks are interconnected by bridge units, which relay messages, based on the target address specified. If the target address indicates that the message is for a unit in the same sub-rack then the message will pass via the hub but stop at the Bridge unit. If however the target address indicates that the message is for a unit in a different sub-rack then the bridge relays the message to be received by the bridge of target sub-rack and relayed to the target unit via the Hub of that sub-rack. An overview of the principal control units is given below.

1.5.2 Network Element Controller Shelf Monitor Unit

One network element Controller/Comms Card is required in each Core and extension shelf. In the first core shelf, the microprocessor based controller card carries out the central equipment management functions within the network element. It receives commands and status requests from one of three sources:

- From an Element Manager via the Comms IO LTU
- From a Local Terminal connected via the F or Ethernet port on the Comms IO LTU.
- From the Remote NEs/Managers via embedded DCC/GCCO channels, which are extracted/inserted on designated cards and transported via the IEEE1394 busses.

Software Programs for the network elements are stored on the System Memory Unit, which plugs into the Controller Card.

The same network element Controller hardware is used a Shelf Monitor in additional sub-racks. In this application, the card is responsible for monitoring the Fan Units associated with the shelf.

1.5.2.1 Bridge Unit

The Bridge card provides Intra-sub-rack Communications. The Bridge enables control and status information to be transmitted between sub-racks, allowing inter-card communication between sub-racks.

The Bridge examines the destination address of the IEE1394 messages from a sub-rack to determine whether its destination is on that particular sub-rack. If it is, the Bridge functions as a transparent device and allows the information to travel to its destination. If the traffic destination is a different sub-rack, the Bridge transmits the traffic via an IEEE1394 serial interface to the remote sub-rack, where another Bridge Unit terminates the signal.

Each Bridge card can support up to four rack interconnecting cables (fitted with screwlocks). The Bridge card is duplicated in all sub-racks to provide resilience against failure of a single unit.

1.5.2.2 Hub Unit

The Hub card provides the interface between the internal bus and the equipment cards of a sub-rack. Thirty IEEE1394 ports are provided, each one connecting to a different card via the sub-rack backplane. The card acts as a repeater such that all data received on one of its ports is synchronised to the card’s local clock and repeated out on all of the other 29 ports on the card.

The Hub card also contains the sub-rack inventory and is considered as an integral part of the Sub-rack structure.

1.5.2.3 Comms IO LTU

The Comms IO Card provides the physical interfaces from the Controller/Comms Card to the Element Manager (Qx), Administrative LAN, Local Craft Terminal (F) and modem. The first two interfaces are Ethernet 10Base-T while the other two are RS232.

For the Ethernet interface this card handles OSI layer 1, physical signalling layer and media Attachment Unit (MAU) while the Controller/Comms Card handles the layer 2, the data link layer. Note that the Comms IO LTU does not provide a crossover function (normal for a 10BASE-T interface). The cabling provides this function.

The Comms IO Card provides termination of the RS232 interfaces by the use of RS232 Transceivers on the Card.

Non-volatile Inventory data for this unit can be accessed by the network element Controller.

1.5.2.4 Auxiliary/EOW Unit

The AUXILIARY/EOW unit provides customer access to OSC data channels via a pair of Auxiliary LTUs. It also provides an Engineering Order Wire (EOW) function via a front panel connector into which a handset can be plugged.

1.5.2.5 Auxiliary/EOW LTU

The AUXILIARY/EOW LTU provides the physical interfaces for three 64kbit/s Auxiliary data channels via 3 RJ-45 connectors, plus a 4-wire interface via a 9-way D-type connector. Two Aux LTUs can be fitted with each Auxiliary card.

1.5.2.6 Power LTU

The power LTU provides filtering and surge protection to meet EN 300 132-2. Station supply indicators are mounted on the unit (green LED’s). Operational working voltage is 38.5 - 75.0 volts. Optional +ve battery supply grounding is also available. Two single feed LTUs are required per Sub-rack. Each power LTU has a 3 way power D Type for power input and a single station supply green LED.

1.5.2.7 Alarm IO LTU

The ALARM IO LTU contains all circuitry necessary to provide suitable external interfaces (via relays) to the required alarm scheme via a D Type connector and provides the end-of-shelf indicators with an alarm acknowledge button.

The alarm scheme supported on the Multihaul 3000 equipment is:

- Bw7R.
- Enhanced Bw7R

Bw7R

This LTU provides all functionality to support sub-rack and rack alarm reporting according to the Bw7R standard common in ETSI regions. The Bw7R LTU also provides 6 off external inputs from powered or dry loop sources, which the customer can use to include any alarms generated local to the NE location into network Management. The cabling from this LTU is not normally the responsibility of Marconi Communications and no cable assemblies are specified.

Enhanced Bw7R

This LTU provides all functionality to support sub-rack and rack alarm reporting according to the Bw7R standard common in ETSI regions. The Bw7R LTU also provides 16 off external inputs from powered or dry loop sources and 8 outputs, which the customer can use to include any alarms generated local to the NE location into network Management. The cabling from this LTU is not normally the responsibility of Marconi Communications and no cable assemblies are specified. The cabling from this LTU is not normally the responsibility of Marconi Communications and no cable assemblies are specified.

1.6 Typical Equipment Configurations

1.6.1 Terminal Network Element

Figure 1-33: Rack Layout for 40 Channel Terminal

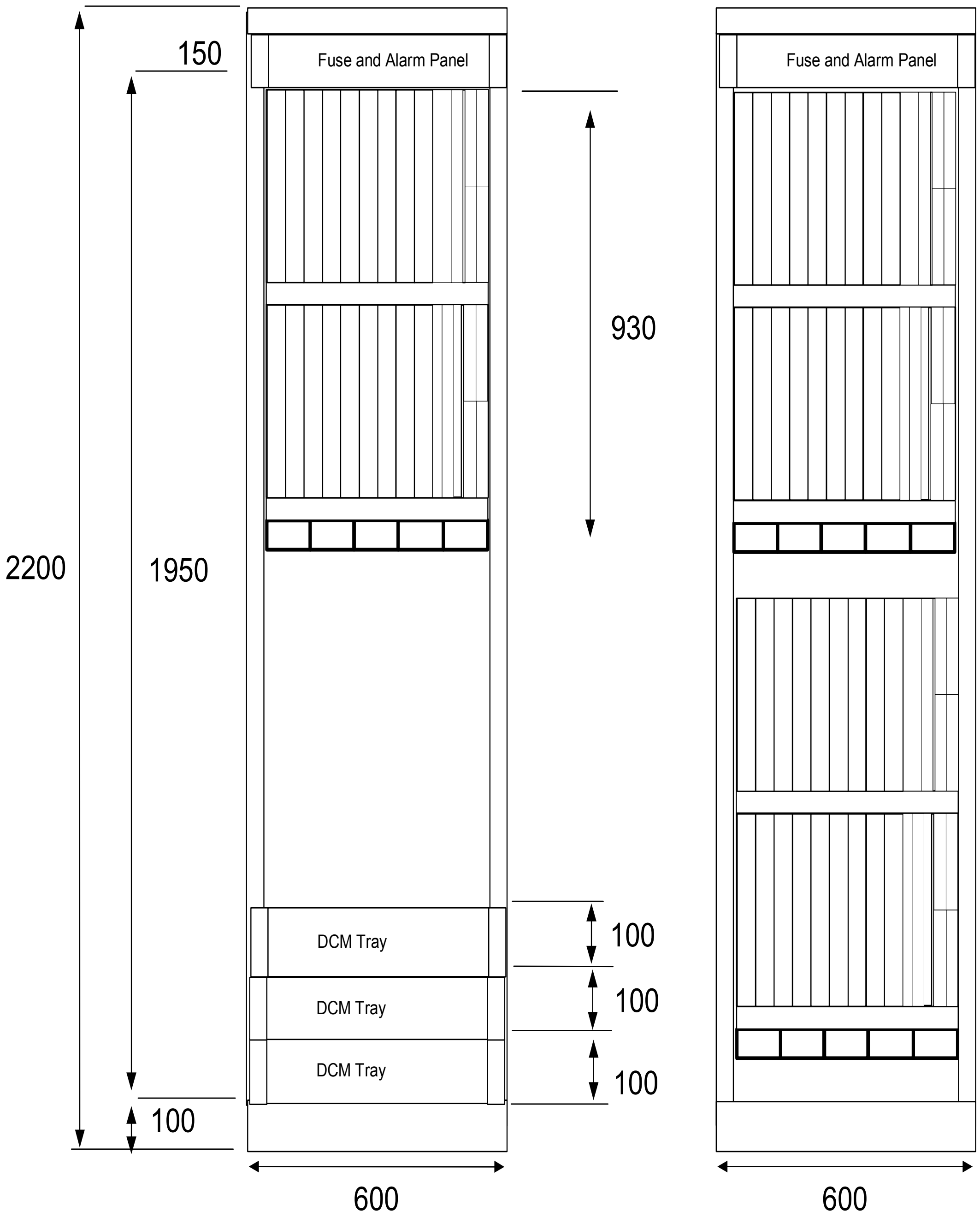


Figure 1-35: Rack Layout for 80 Channel Terminal

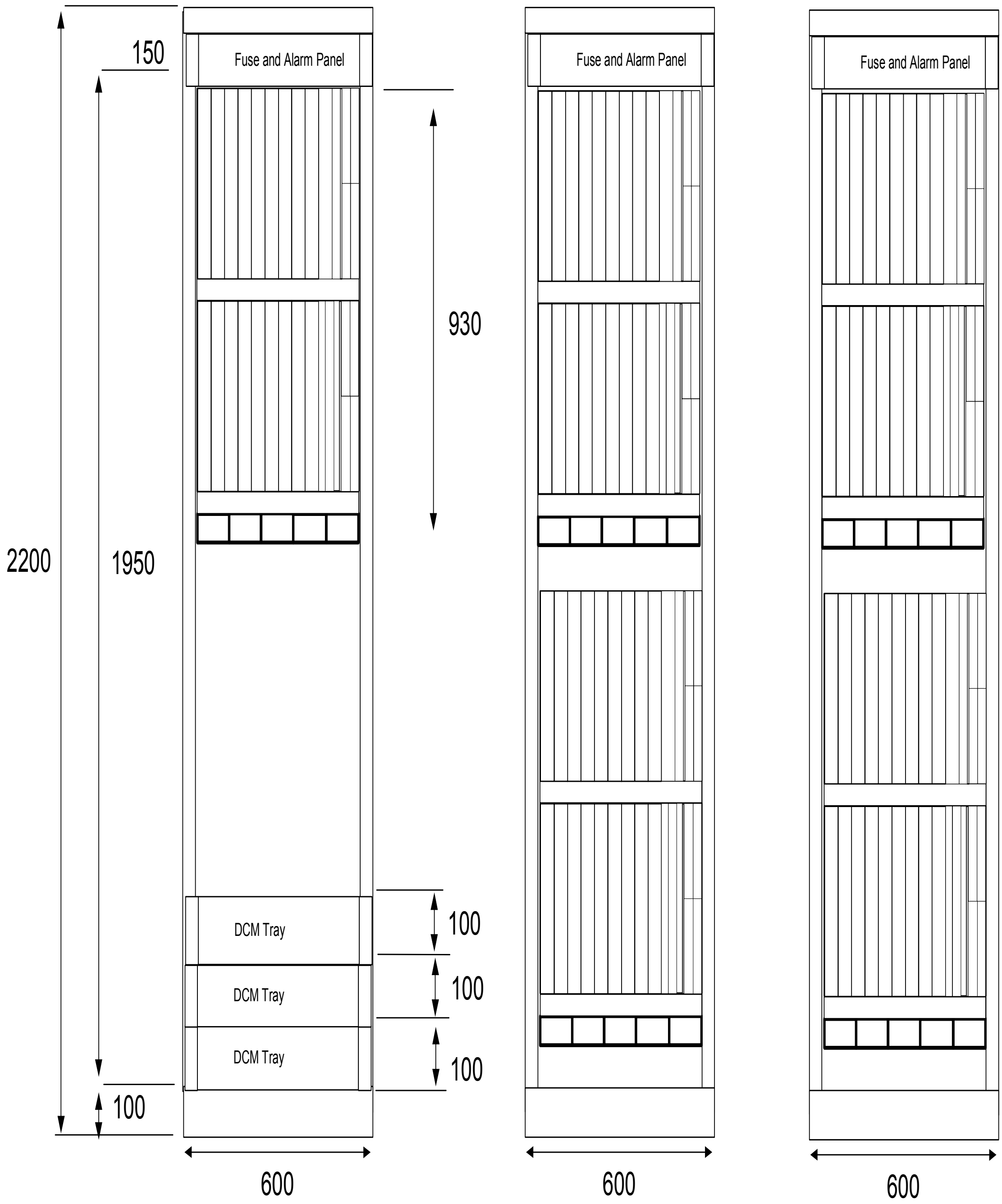
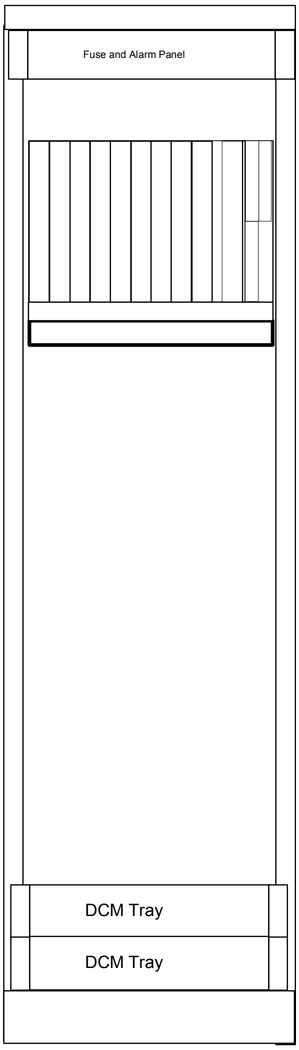


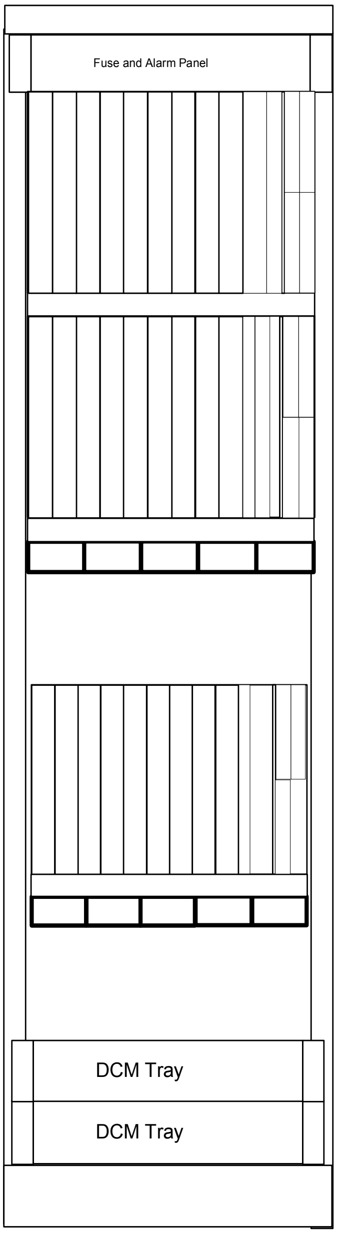
Figure 1-37: Amplifier Network Element



An amplifier with or without Raman can be housed in a single row sub-rack and fits in a single ETSI Rack

1.6.2 Equaliser Amplifier Network Element

Figure 1-39: Amplifier Network Element

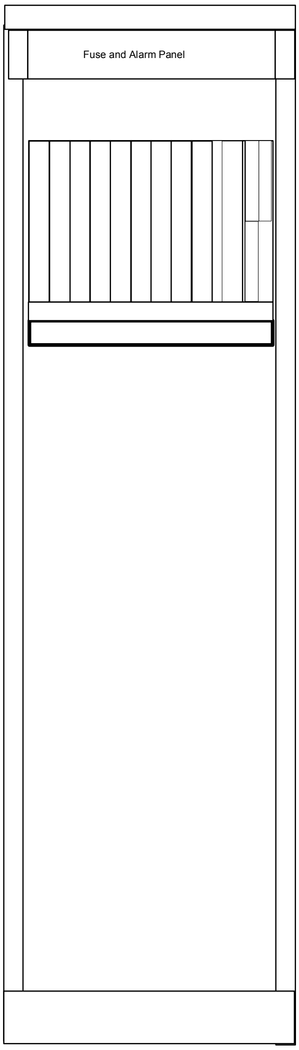


A single band equaliser without Raman can be housed in a single Dual row Core sub-rack and fits in a single ETSI Rack

A single band equaliser with Raman requires both a single dual row sub-rack and a single row sub-rack but can still be housed in a single ETSI Rack

1.6.3 OCE Rack Layout

Figure 1-41: OCE Rack Layout



An amplifier with or without Raman can be housed in a single row sub-rack and fits in a single ETSI Rack

1.7 Optical Path

1.7.1 Wavelength Scheme

The system supports 80 channels at 10Gbit/s in the C band. The same wavelength grid is used for every type of fibre. 2.5Gbit/s channels may also be used but this reduces the overall capacity of the system. The following sub-sections describe the wavelength schemes used by the Multihaul 3000.

The following table shows the C-band wavelengths used by the Multihaul 3000. Groups C1 and C2 comprise channels 1-40 and 41-80, respectively. Each is numbered according to increasing channel frequency

Table 1-7: C-Band Wavelength Allocation

Group C1				**Group C2**			
Frequency Group	**Channel No.**	**Frequency THz**	**Wavelength nm**	**Frequency Group**	**Channel No.**	**Frequency THz**	**Wavelength nm**
1	1	192.1	1560.61	6	41	192.05	1561.01
	2	192.2	1559.79		42	192.15	1560.20
	3	192.3	1558.98		43	192.25	1559.39
	4	192.4	1558.17		44	192.35	1558.58
	5	192.5	1557.36		45	192.45	1557.77
	6	192.6	1556.55		46	192.55	1556.96
	7	192.7	1555.75		47	192.65	1556.15
	8	192.8	1554.94		48	192.75	1555.34
2	9	192.9	1554.13	7	49	192.85	1554.54
	10	193.0	1553.33		50	192.95	1553.73
	11	193.1	1552.52		51	193.05	1552.93
	12	193.2	1551.72		52	193.15	1552.12
	13	193.3	1550.92		53	193.25	1551.32
	14	193.4	1550.12		54	193.35	1550.52
	15	193.5	1549.32		55	193.45	1549.72
	16	193.6	1548.51		56	193.55	1548.91
3	17	193.7	1547.72	8	57	193.65	1548.11
	18	193.8	1546.92		58	193.75	1547.32
	19	193.9	1546.12		59	193.85	1546.52
	20	194.0	1545.32		60	193.95	1545.72
	21	194.1	1544.53		61	194.05	1544.92
	22	194.2	1543.73		62	194.15	1544.13
	23	194.3	1542.94		63	194.25	1543.33
	24	194.4	1542.14		64	194.35	1542.54
4	25	194.5	1541.35	9	65	194.45	1541.75
	26	194.6	1540.56		66	194.55	1540.95

Group C1				Group C2			
Frequency Group	Channel No.	Frequency THz	Wavelength nm	Frequency Group	Channel No.	Frequency THz	Wavelength nm
	27	194.7	1539.77		67	194.65	1540.16
	28	194.8	1538.98		68	194.75	1539.37
	29	194.9	1538.19		69	194.85	1538.58
	30	195.0	1537.40		70	194.95	1537.79
	31	195.1	1536.61		71	195.05	1537.00
	32	195.2	1535.82		72	195.15	1536.22
5	33	195.3	1535.04	10	73	195.25	1535,43
	34	195.4	1534.25		74	195.35	1534,64
	35	195.5	1533.47		75	195.45	1533,86
	36	195.6	1532.68		76	195.55	1533,07
	37	195.7	1531.9		77	195.65	1532,29
	38	195.8	1531.12		78	195.75	1531,51
	39	195.9	1530.33		79	195.85	1530,72
	40	196.0	1529.55		80	195.95	1529,94

1.7.2 Channel Performance

The DWDM system is designed for a Beginning of Life (BOL) BER < 10^{-15} along the system length and also between each pair of optical amplifiers. The target end of Life (EOL) performance is also BER < 10^{-15}. Good BER performance between each amplifier pair is a natural requirement of the OADM functionality of Multihaul 3000, which allows for a fully configurable Add/Drop function at any desired node along the line. This is achieved by careful dispersion management at all amplifier nodes, particularly at OADM nodes using broadband dispersion compensation.

1.8 Operation and Control

All management operations can be carried out from the Local Craft Terminal and/or the Element Manager. The Element Manager has priority of access to the elements and can restrict the LCT to read-only access; irrespective of whether the LCT was already logged in.

1.8.1 Local Control Terminal (LCT)

All NEs can be locally managed via a Local Craft Terminal connected to either the modem port or the ‘F’ interface. The Local Craft Terminal software is a Java based application, which is loaded onto the operators PC. The Craft Terminal application provides local alarm, performance monitoring and configuration management. An appropriate Security hierarchy is provided for all other management access levels. The Craft Terminal application can log into a remote element via the embedded communication channels within the section overhead, to provide equivalent functionality to that obtained when connected directly to the NE, Back-up and Restore, Software Download

The Back-up and Restore facility allows the Multihaul 3000 functionality to be configured by downloading configuration data, alarm and performance parameter default data from a floppy disk or CD. Downloading is performed during commissioning. The operator makes any subsequent minor alterations that may be required via the LCT.

1.8.2 Remote Management Control and GCCO

Remote management of NEs is achieved via a LCT or Element Managers connected to the ‘Q’ interface via a combination of local LANs, DCNs and embedded DCCs. The Element Manager/information model supported is MV36/Qx.

The NEs contain both seven Layer OSI and TCP/IP stack implementations. The seven Layer OSI stack handles Qx based management comms traffic over the ‘Q’ interface as well as the Qecc interfaces. The TCP/IP tunnelling allows transport of IP messages over the DCC transport layer.

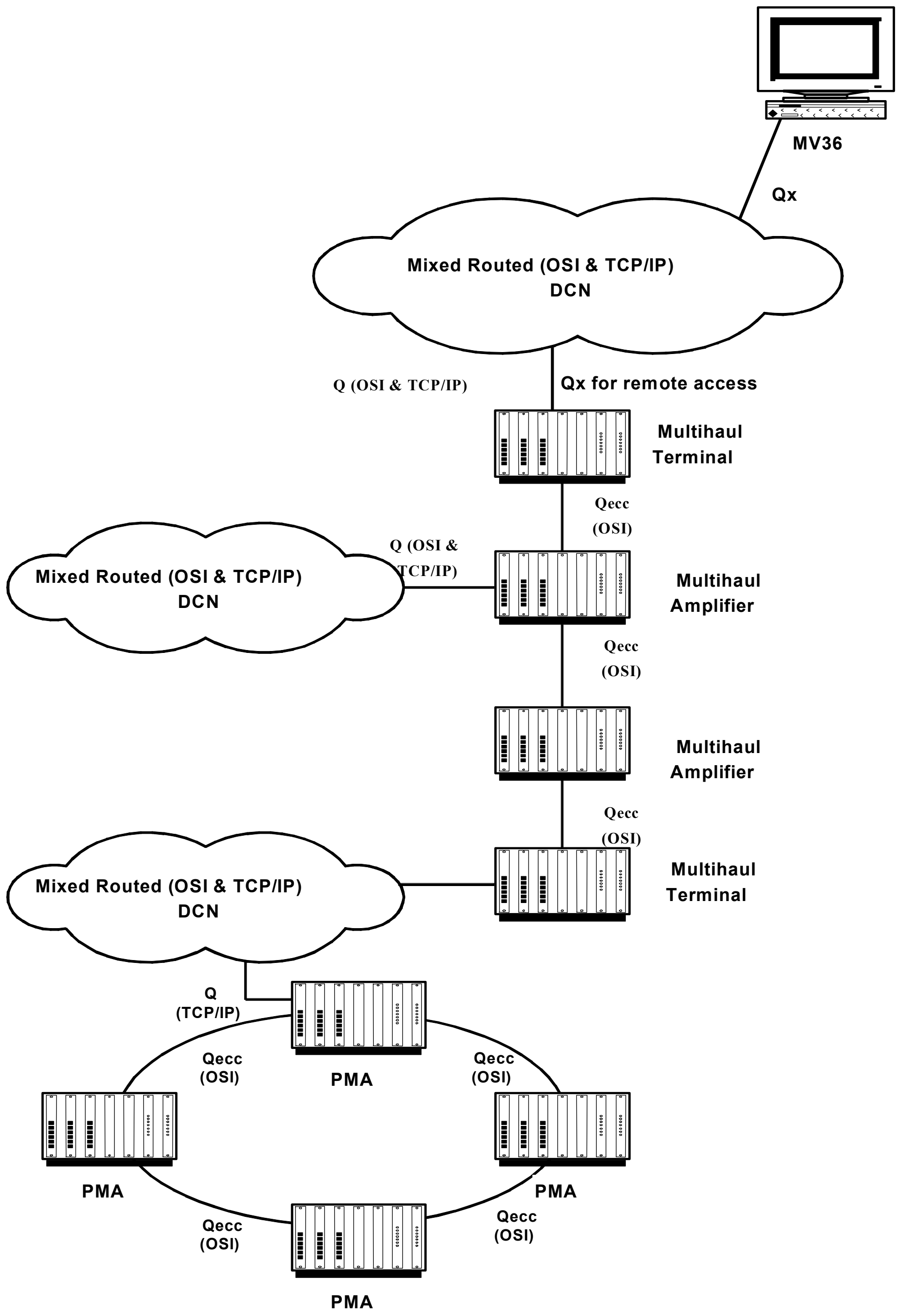
Two embedded ‘Qecc’ interfaces are provided per via the OSC telemetry channel:

- OTS_DCC @192kbit/s
- OMS_DCC @ 576kbit/s.

Additionally each G.709 transponder provides access to GCC0 (2 per link mode and one per termination mode)

The IS-IS dynamic routing protocol is provided for routing within the OSI domain. The NE can route Qx/OSI based comms traffic between its 'Q' and 'Qecc' interfaces. Figure 1-43 illustrates the remote management control features.

Figure 1-43: Data Communication Architectures

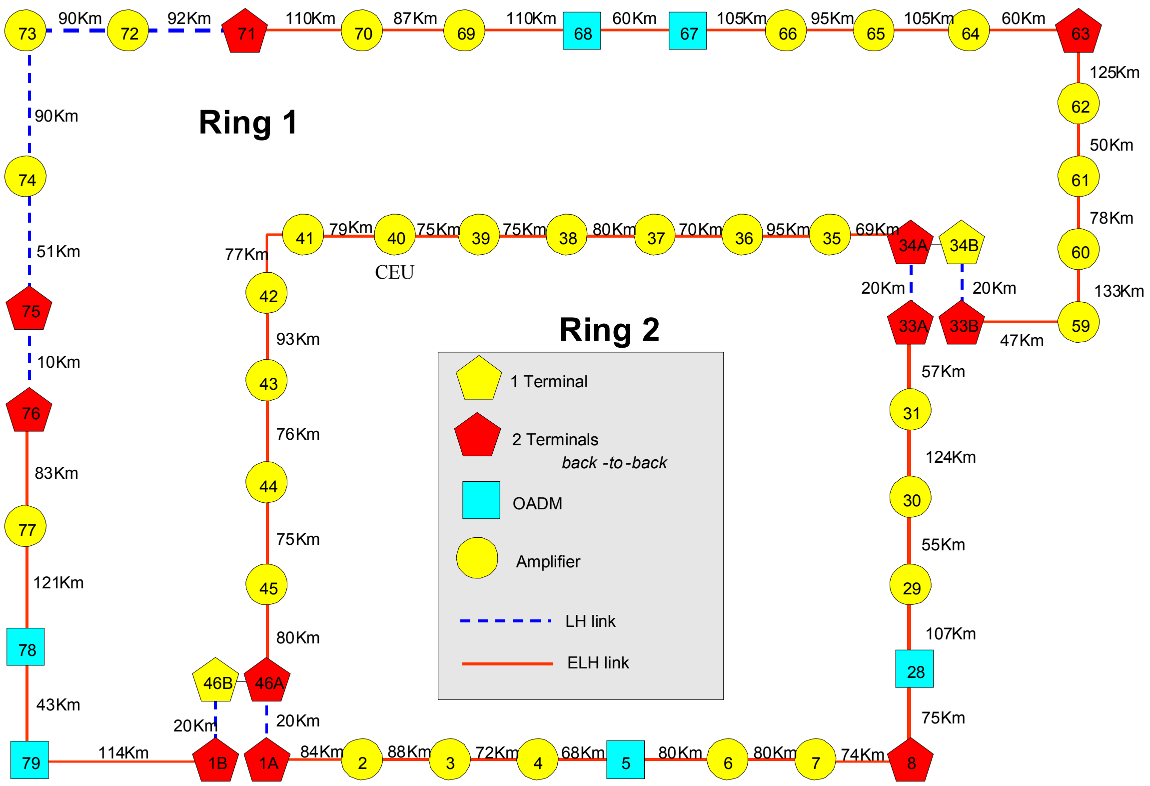


Chapter 2: Multihaul 3000 Applications

2.1 Introduction

Multihaul 3000 can be used in a variety of situations including pan-continental or national backbones (point –point links or with intermediate optical add/drop nodes) and long single spans such as festoons. In conjunction with OMS32xx it can be used to build highly flexible and cost efficient pan-continental networks (mesh or ring) incorporating sophisticated traffic restoration features.

Figure 2-1: New Customer Network

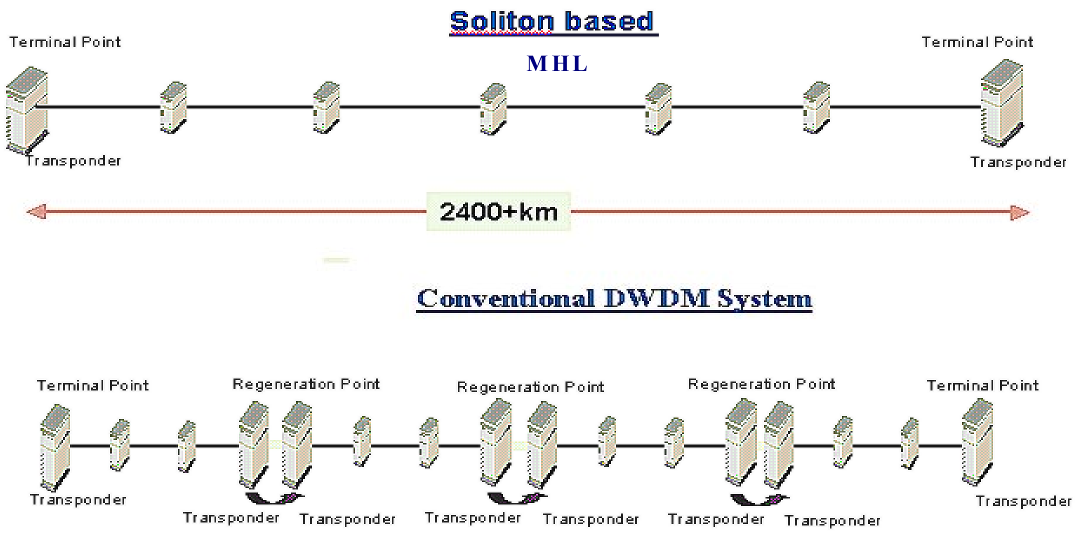


2.2 Ultra Long Haul Point-Point Transmission

The most straightforward application of Multihaul 3000 is for the point-to-point transmission of traffic between two major network nodes separated by a very long distance. The Multihaul 3000 is designed to transmit 80 10G channels over distances of up to 3,000km) without the need for intermediate electrical regeneration.

The maximum distance achievable depends on the details of the route including the distribution of span losses and distances, the fibre type and the PMD characteristics of the fibre. Conventional DWDM line systems require a complete electrical regeneration for each channel every 500-600 Km. For longer links, back to back terminals are required which implies, for a high count of channels, the deployment of a considerable amount of OEO conversion equipment (Transponders). A 2400 km route carrying 40 channels will require a minimum of 320 line cards for 600km conventional Line Systems whereas the ULH system needs only 80 line cards. This leads to very significant cost benefits compared with conventional DWDM systems, saving up to 35% at 1000 km and up to 70% at 3000 km on equipment costs.

Figure 2-3: Ultra Long Haul Point-Point Transmission



A practical example of Ultra long transmission is shown in Figure 2-5 for a Perth – Adelaide route (approx. 2800km) in Australia.

Figure 2-5: Ultra Long Transmission Route

Detailed design issues for this kind of route focus on minimizing transmission capex and opex costs for the operator. For example, minimising the number of intermediate amplifier nodes required along the route by using Raman amplification and/or high gain EDFAs reduces capex and the need for maintenance visits to remote areas. In very remote desert regions, minimising node power consumption (avoiding Raman amplification) can be important to allow solar powering of sites.

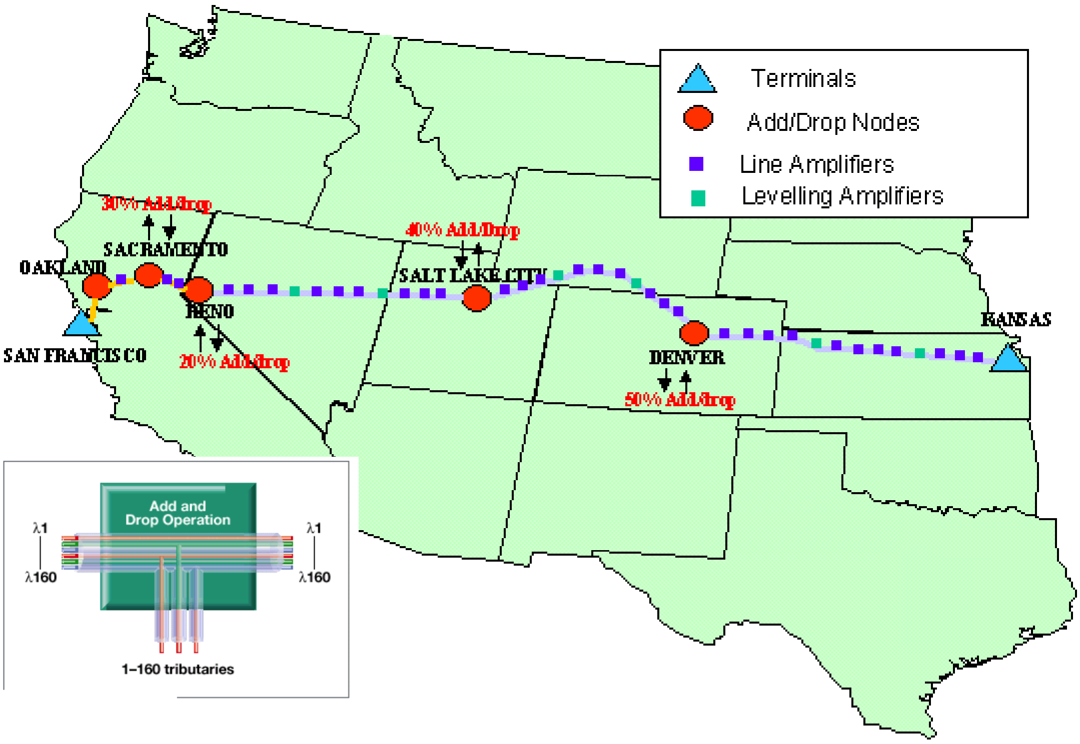
2.3 Ultra Long Haul Transmission with Remotely Configurable Optical Add/Drop Multiplexers

The Multihaul 3000 includes a fully configurable OADM capability that allows intermediate access to traffic on a ULH link. Thus, traffic interchanges between intermediate cities can be accommodated as well as pan-continental express traffic flowing between the largest metropolitan cities.

Inclusion of OADMs within a route reduces to some extent the total distance that can be achieved. The rule of thumb is that the number of possible spans making up a route is reduced by one for every OADM included. Thus, on a typical route with say 80km spans, the total system range is reduced by 80km. This still allows very long haul routes to be implemented.

The Multihaul 3000 is a fully configurable OADM system that allows flexible access to all 80 channels within a C band. There is no limitation on the number of channels that can be dropped and added at a node. Once a channel is dropped at a node, the same wavelength can be immediately reused to add traffic onto the link.

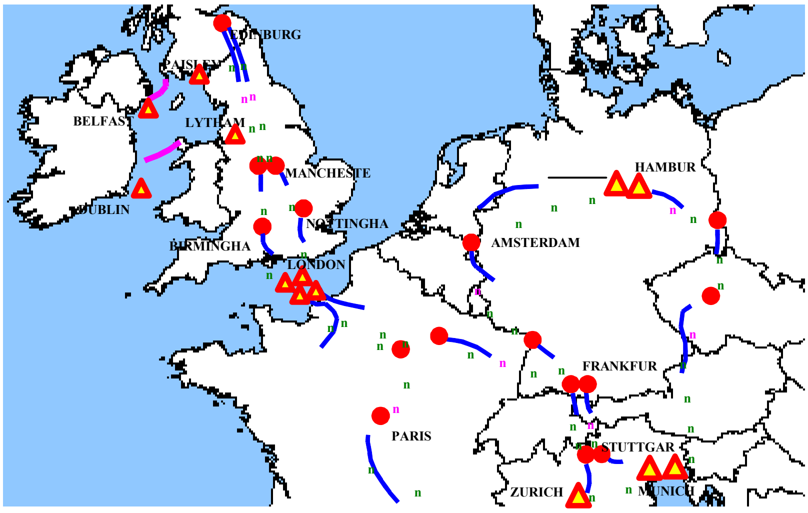
Figure 2-7: Ultra Long Haul Transmission with Intermediate Wavelength Add/Drop Application



Multihaul 3000 nodes can also be remotely configured allowing new circuits to be provided instantaneously across the carrier backbone without any on site intervention, creating the opportunity for new service creation and relieving the backbone of congestion. Provided that the necessary transponders are installed, one or more wavelengths can be immediately configured at the Drop/Insert and later redirected through the node, simply by managing operations from the remote OSS.

All Multihaul 3000 network elements automatically re-adjust their optical parameters to optimize system performance when additional optical channels are added to the system. This eliminates the need for skilled engineers to visit intermediate nodes to recalibrate the system whenever additional channels are added or removed from the network.

Figure 2-9: Multihaul 3000 Virtual Rings



2.4 Interoperability with SDH/SDH and other DWDM Networks

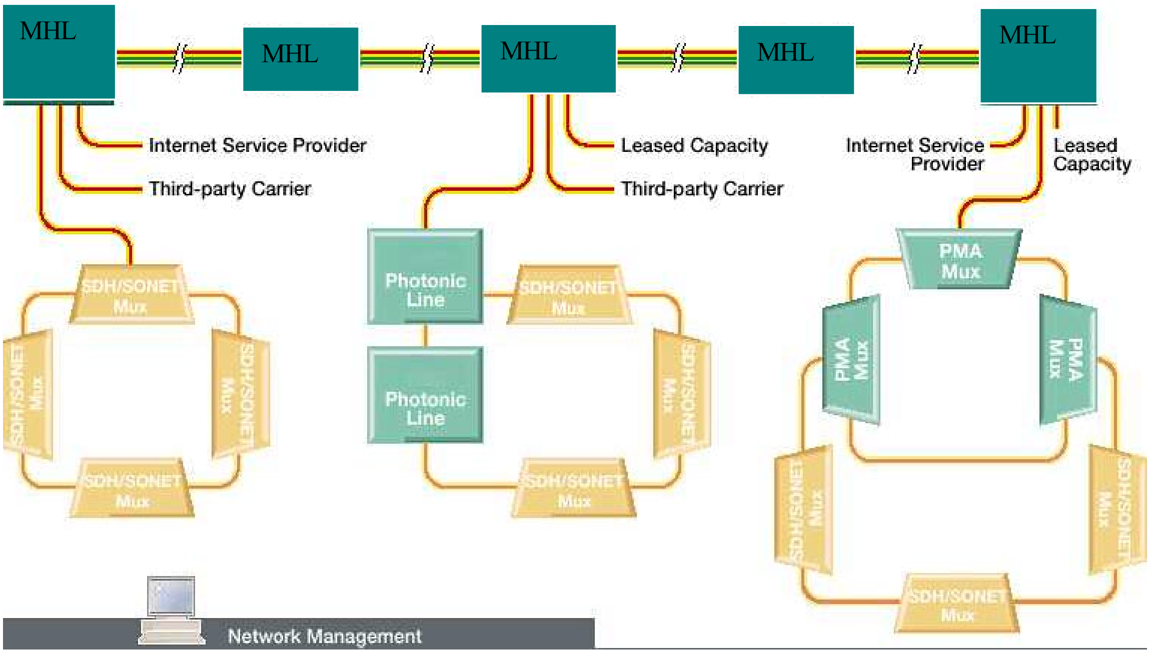
The Multihaul 3000 can be used to interconnect to SDH/SDH and other DWDM networks to create complete end – end network solutions:

- Multihaul 3000 can be interconnected to SmartPhotoniX products, PLT, PMA, PMM or via client-side optics to give scalable network solutions

Enhanced traffic management and performance monitoring is provided via digital-wrapper framing of the client traffic allowing optical trail management across Multihaul 3000, PMA etc. All SmartPhotoniX products are managed under the same network Management System (MV36/MV38) (Rel 4.0 MV36 only)

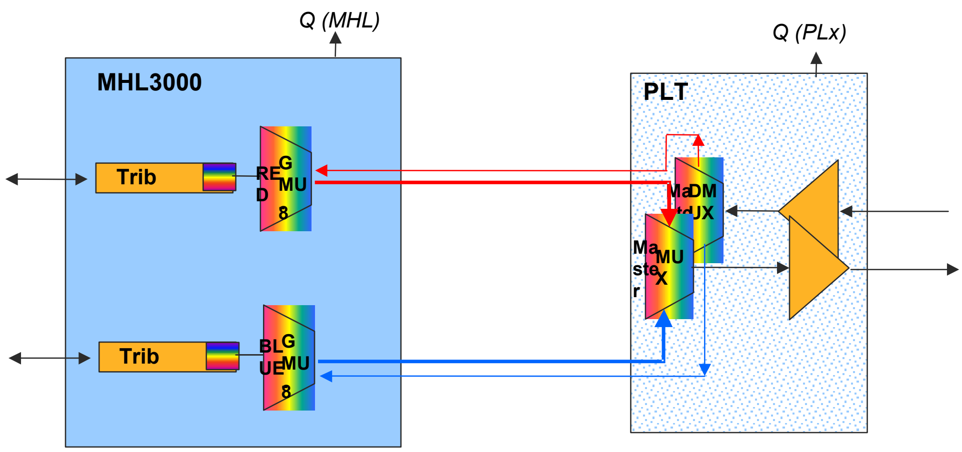
- In later releases Multihaul 3000, in conjunction with the OMS32xx family, will provide integrated network solutions for a Multilayer switched optical network, minimising the need for back-to-back transponders between Multihaul 3000 and OMS network elements.

Figure 2-11: Interoperability with SDH/SDH and Other DWDM Networks



2.4.1 Interoperability with PLx Product

Figure 2-13: Multihaul 3000 Interworking with PLx Terminal NE



MHL3000 allows extending PLx Terminal NE with tributary and GMU-40-8 units of the MHL3000 product in order to benefit of all advantages of MHL3000 platform on PLx network scenarios.

The inter-working architecture assumes that the PLx is equipped with some types of MUX/DMUX (e.g. Group Mux - 1C Head 8Ch) and the associated tributary cards, while MHL3000 can hosts the GMU-40-8 cards and related tributaries that are needed to complete the 40/80 channel grid. The assumption is that at least the *Group Mux - 1C Head 8Ch* is present on PLx.

If so the following type of GMU-40-8 filters may be equipped on MHL for this purpose:

– - Group Mux - 1C Ext Blue1 8Ch

– - Group Mux - 1C Ext Blue2 8Ch

– - Group Mux - 1C Ext Red1 8Ch

– - Group Mux - 1C Ext Red2 8Ch

PLx and MHL NEs will be visible to the Management Systems as distinct NEs – that can be reached via independent Q interface.

2.5 Festoon Point to Point Transmission Links

Multihaul 3000 can also be used to implement long single span links (in excess of 200km) for sea or inland water crossings. In this case only Multihaul 3000 nodes are required. Reduced channel counts apply for these high span loss systems.

Typical scenarios include inter-island connectivity or inter-country connectivity for example connecting mainland UK to Eire or interconnection of Scandinavian countries, for example, Sweden to Denmark.

Release 4.1.2 permits a maximum span loss of 62dB for 40 10G channels.

Blank Page

Chapter 3: Transmission Slide-in Units

3.1 Introduction

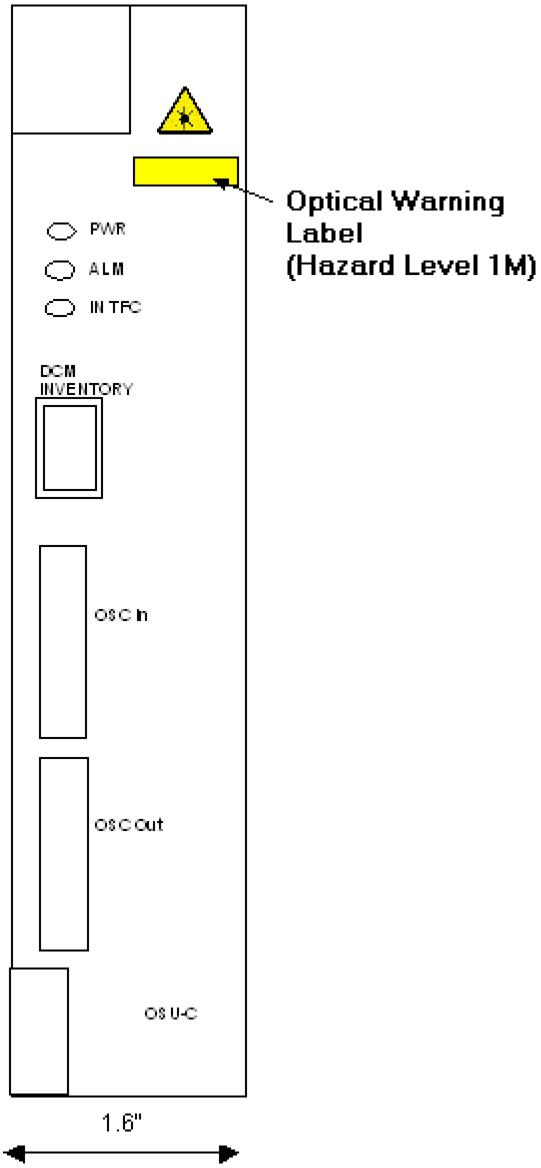
The following sub-sections describe in detail, the transmission units that are used by the Multihaul 3000 and include information on connector Pinouts and LED indications.

3.2 C-Band Optical Supervisory Unit

The Optical Supervisory Channel (OSC) is an optical channel that carries section overhead (SOH) data from one network element to the next. The Section Overhead data is used for system management and control and includes the following features:

- Aux/EOW Channels - to provide data channels for data or voice communications between NE locations
- DCC - System management communications between NE controllers at each NE
- System Control - Information including equipped wavelengths and levelling requirements are used to control units such as amplifiers and Raman units
- Section Trace - A message sent from one NE to the next to ensure they are correctly connected
- The C-Band Optical Supervisory Unit (OSU-C) provides the interface to an optical supervisory channel operating at a wavelength of 1510nm
- Two cards may be fitted i.e. OSU-C (E) and OSU-C (W)
- The C-Band Optical Supervisory Unit uses the OSC to detect line breaks. If a line break is detected the OSU forces the Raman units to shut down
- An interface is provided on the OSU to allow inventory information to be read from DCM and line interface trays. Up to seven trays can be connected in a daisy chain to one OSU
- The OSU-C has two front panel optical connectors for connection to the Optical Supervisory Channel.

Figure 3-1: OSC C- Band Unit



3.2.1 C-Band Optical Supervisory Unit LEDs

Table 3-1: C-Band Optical Supervisory Unit LEDs

Colour	Indicates	Managed	Note:
Green	Power OK	Unmanaged	Lit when all on-board power supplies are on and functioning correctly.
Red	Fault	Managed	Lit to indicate an alarm condition.
Amber	Resource	Managed	Lit to indicate that the card is functioning and is activated to carry traffic.

3.2.2 DCM Inventory Connector

- Connector - Electrical - RJ45
- Location - Front panel
- Use - To connect to DCM or line interface trays to allow inventory to be read.

3.2.3 OSC In Connector

- Connector - Optical - SC/UPC
- Location - Front panel
- Use - For connection of the received OSC channel to the OSU-C from the amplifier
- Wavelength - 1510nm (C Band variant).

3.2.4 OSC Out Connector

- Connector - Optical - SC/UPC
- Location - Front panel
- Use - For connection of the transmit OSC channel from the OSU to the amplifier
- Wavelength - 1510nm (C Band variant).

3.2.5 Labels

Optical warning label (Hazard Level 1M).

3.3 Dual Optical Supervisory Unit

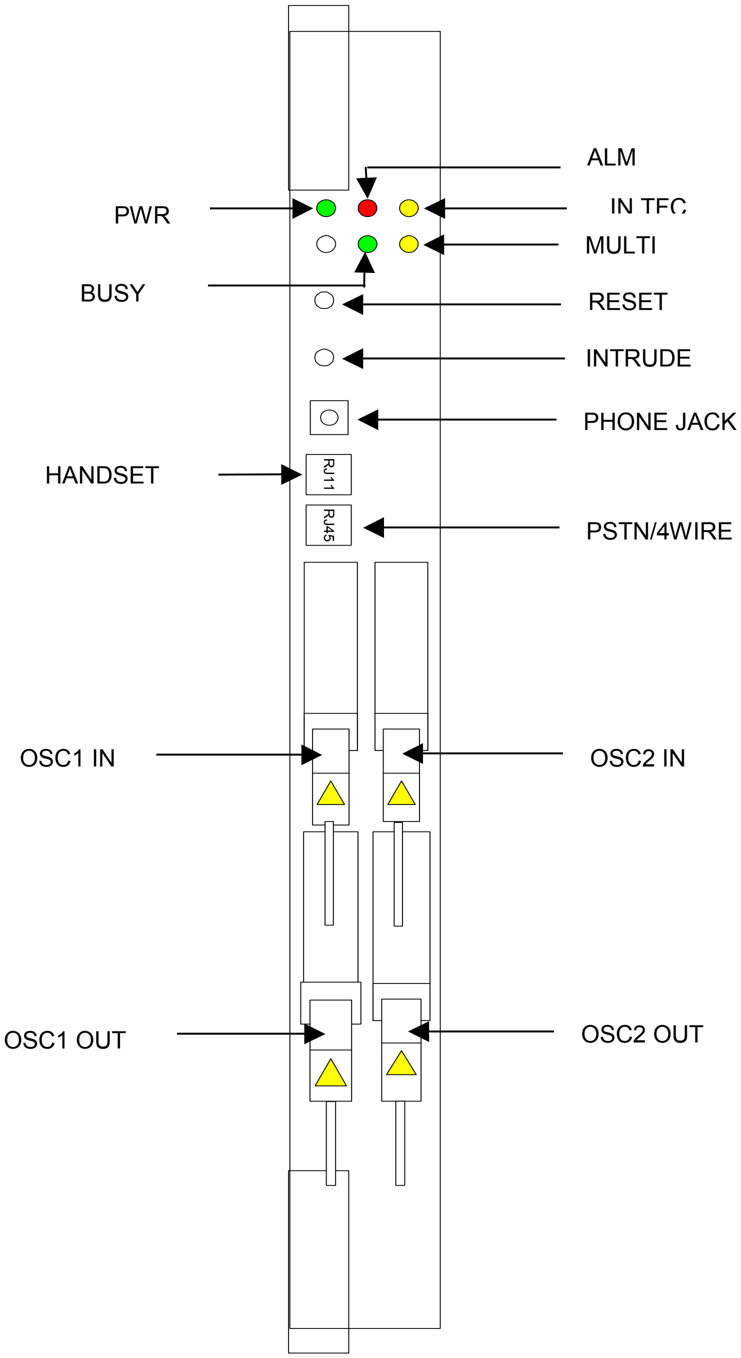
The Optical Supervisory Unit processes the 2Mbit/s optical supervisory signal (OSC) that provides the telemetry within the system. In conjunction with the controller and the Line termination cards, the OSU supports DCC communication, Engineers Order Wire functions, G703 data channels and a number of internal control channels.

Dual OSU Unit (1510nm) provide two bi-directional OSC1 and OCS2 interfaces for two line ports. The Dual OSU supports G.709 functionality for Och, OMS and OTS overheads. Network Elements with a single line port can use a dual OSU per band operating in uni-directional mode. Network Elements with two line ports (e.g. Amplifiers) require one dual OSU per band. The Dual Optical Supervisory Unit is 1.6” wide and occupies a single slot position.

Table 3-3: Allowable Slots in Subrack

Unit	Allowable Slots, dual row Sub-rack	Allowable slots, single row Sub-rack
Dual Optical Supervisory Unit (E and W)	10, 25	9
Single Optical Supervisory Unit (West)	9, 24	8
Single Optical Supervisory Unit (East)	10, 25	9

Figure 3-3: Dual Optical Supervisory Unit (D-OSU-C) Front Fascia



3.3.1 Dual Optical Supervisory Unit D-OSU-C LEDs

There are Five LEDs mounted on the unit front fascia. Three LEDs are for alarm monitoring and the other two are for monitoring EOW status as shown in Figure 3-3 and described in Table 3-4 and Table 3-5.

3.3.1.1 Alarm LEDs

Table 3-4: Dual Optical Supervisory Unit D-OSU-C Alarm LEDs

Name	Colour	Description
PWR (Power)	Green	The green LED is illuminated when all power supplies required to communicate with the card are on. Supplies monitored are: +3.3V (on-card PSU) +1.8V (on-card PSU) If any of these supplies drops by more than approximately 5%, the LED goes off. [Note: Other supplies are monitored, failure of these supplies are reported as alarms]
ALM (Alarm)	Red	This is illuminated by the microprocessor when instructed by the Mux Controller, or if failure attributable to the unit is detected by the microprocessor, such as watchdog time-out.
IN TFC (In traffic)	Amber	This denotes the unit is an available resource (i.e., it has been logically added to the system), and is illuminated by the microprocessor when instructed by a command from the Mux Controller card. This LED is flashed whilst software download is in progress.

3.3.1.2 EOW Status LEDs

Table 3-5: Dual Optical Supervisory Unit D-OSU-C Status EOW LEDs

Name	Colour	Description
BUSY	Green	OFF = EOW Idle ON = EOW In Use Flashing = EOW omnibus call in progress, awaiting answer.
MULTI	Yellow	ON = EOW speech in progress Flashing = EOW call in progress, awaiting answer.

3.3.2 Optical Interfaces

The optical connections are made on the front panel using downward pointing shuttered connectors to maximise optical safety. The OSC1 and OSC2 ports are connected to the East and West facing side of the DSA amplifier respectively.

Note: On an OSU there are four optical connectors on the front panel. SC/PC connectors are used for the optical connections.

Table 3-6: Dual Optical Supervisory Unit D-OSU-C Optical Interface Connectors

Name	Function
OSC1 IN	OSC In East
OSC1 OUT	OSC Out East
OSC2 IN	OSC In West
OSC2 OUT	OSC Out West

3.3.3 Electrical Interface

These are as described in Table 3-7

Table 3-7: Dual Optical Supervisory Unit D-OSU-C Electrical Interface Connectors

Name	Function
Phone Jack/RJ11	For EOW Phone Handset
RJ45 EOW Extension / PSTN Interface RJ45	Four wire interface for EOW extension. Two pins are used for the PSTN interface. It is intended to use the connector for PSTN or 4-Wire NOT both simultaneously

3.3.4 EOW Switches

Two switches are provided for EOW control on the front fascia.

Table 3-8: Dual Optical Supervisory Unit D-OSU-C EOW Switches

Switch	Function
RESET (Recessed)	Clear line of all calls (Reset state machines in call processor)
INTRUDE	Press and hold to intrude on a selective call Press to join / leave an omnibus call

3.4 Dual Optical Supervisory Unit In Band Variant

The Dual Optical Supervisory Unit (in-band variant 1560.61 nm) processes the 2Mbit/s optical supervisory signal (OSC) that provides the telemetry within the system. In conjunction with the controller and the Line termination cards, the OSU supports DCC communication, Engineers Order Wire functions, G703 data channels and a number of internal control channels.

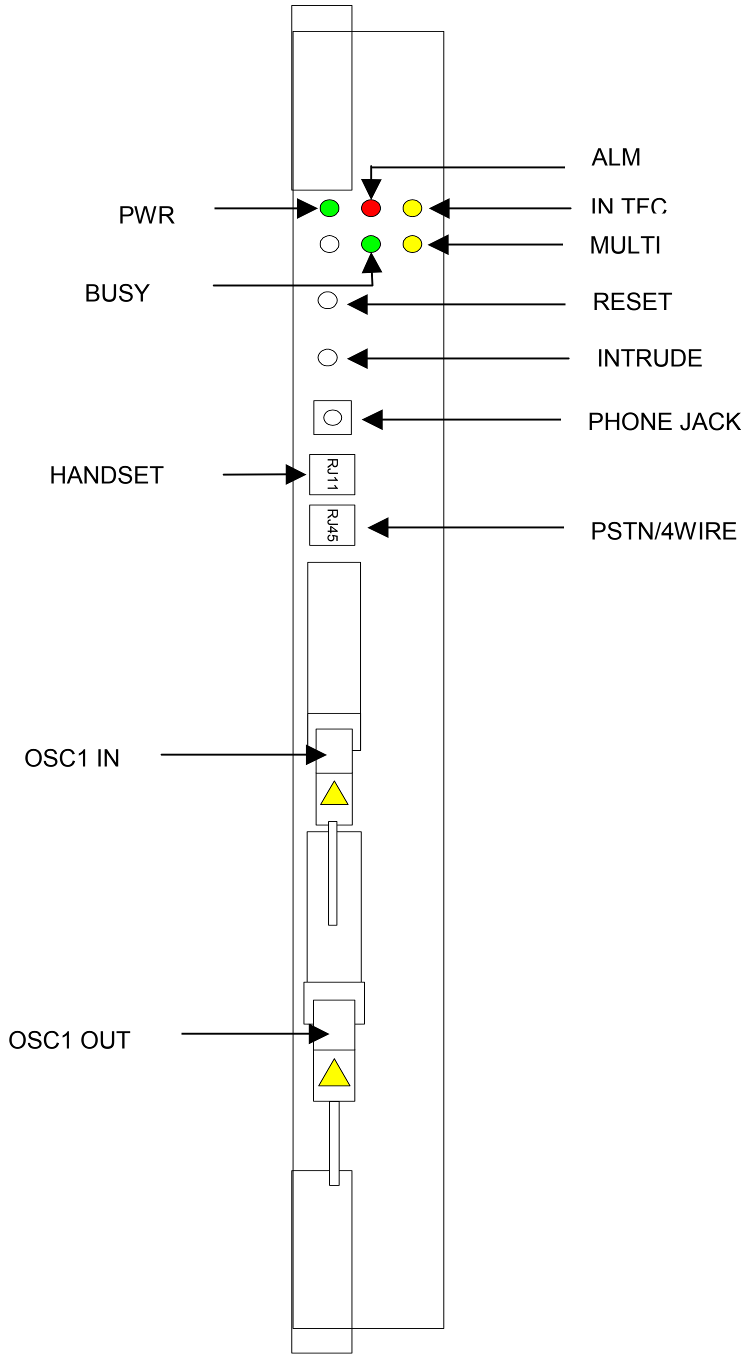
The in-band Optical Supervisory Unit variant is fitted with optical units for only one OSC port. This variant is used for very high loss, Raman amplified spans where the out of band (1510nm) OSU cannot provide sufficient optical budget. It operates instead of a traffic channel on 192.1THz.

Each Dual Optical Supervisory Unit provides a bi-directional OSC interface for a single line port and supports G.709 functionality for Och, OMS and OTS overheads. The Optical Supervisory Unit is 1.6” wide and occupies a single slot position.

Table 3-9: Allowable Slots in Subrack

Unit	Allowable Slots, dual row Sub-rack	Allowable slots, single row Sub-rack
Dual Optical Supervisory Unit (E and W)	10, 25	9
Single Optical Supervisory Unit (West)	9, 24	8
Single Optical Supervisory Unit (East)	10, 25	9

Figure 3-4: Dual Optical Supervisory Unit In Band Variant Front Fascia



3.4.1 Dual Optical Supervisory Unit (In-Band Variant) LEDs

There are Five LEDs mounted on the unit front fascia. Three LEDs are for alarm monitoring and the other two are for monitoring EOW status as shown in Figure 3-3 and described in Table 3-4 and Table 3-5.

3.4.1.1 Alarm LEDs

Table 3-10: Dual Optical Supervisory Unit (In-Band Variant) Alarm LEDs

Name	Colour	Description
PWR (Power)	Green	The green LED is illuminated when all power supplies required to communicate with the card are on. Supplies monitored are: +3.3V (on-card PSU) +1.8V (on-card PSU) If any of these supplies drops by more than approximately 5%, the LED goes off. [Note: Other supplies are monitored, failure of these supplies are reported as alarms]
ALM (Alarm)	Red	This is illuminated by the microprocessor when instructed by the Mux Controller, or if failure attributable to the unit is detected by the microprocessor, such as watchdog time-out.
IN TFC (In traffic)	Amber	This denotes the unit is an available resource (i.e., it has been logically added to the system), and is illuminated by the microprocessor when instructed by a command from the Mux Controller card. This LED is flashed whilst software download is in progress.

3.4.1.2 EOW Status LEDs

Table 3-11: Dual Optical Supervisory Unit (In-Band Variant) Status EOW LEDs

Name	Colour	Description
BUSY	Green	OFF = EOW Idle ON = EOW In Use Flashing = EOW omnibus call in progress, awaiting answer.
MULTI	Yellow	ON = EOW speech in progress Flashing = EOW call in progress, awaiting answer.

3.4.2 Optical Interfaces

The optical connections are made on the front panel using downward pointing shuttered connectors to maximise optical safety. The coloured optical multiplexer source is connected to the input, and the output of the single OSU is connected to the multiplexer card input corresponding to the same wavelength.

Note: On an OSU there are two optical connectors on the front panel. SC/PC connectors are used for the optical connections.

Table 3-12: Dual Optical Supervisory Unit (In-Band Variant) Optical Interface Connectors

Name	Function
OSC1 IN	OSC In East
OSC1 OUT	OSC Out East

3.4.3 Electrical Interface

Electrical Interface connectors are described in Table 3-7.

Table 3-13: Dual Optical Supervisory Unit (In-Band Variant) Electrical Interface Connectors

Name	Function
Phone Jack/RJ11	For EOW Phone Handset
EOW Extension / PSTN Interface RJ45	Four wire interface for EOW extension. Two pins are used for the PSTN interface. It is intended to use the connector for PSTN or 4-Wire NOT both simultaneously

3.4.4 EOW Switches

Two switches are provided for EOW control on the front fascia.

Table 3-14: Dual Optical Supervisory Unit (In-Band Variant) EOW Switches

Switch	Function
RESET (Recessed)	Clear line of all calls (Reset state machines in call processor)
INTRUDE	Press and hold to intrude on a selective call Press to join / leave an omnibus call

3.5 Dual Stage Amplifier (ELH)

The Dual Stage Amplifier units have three variants:

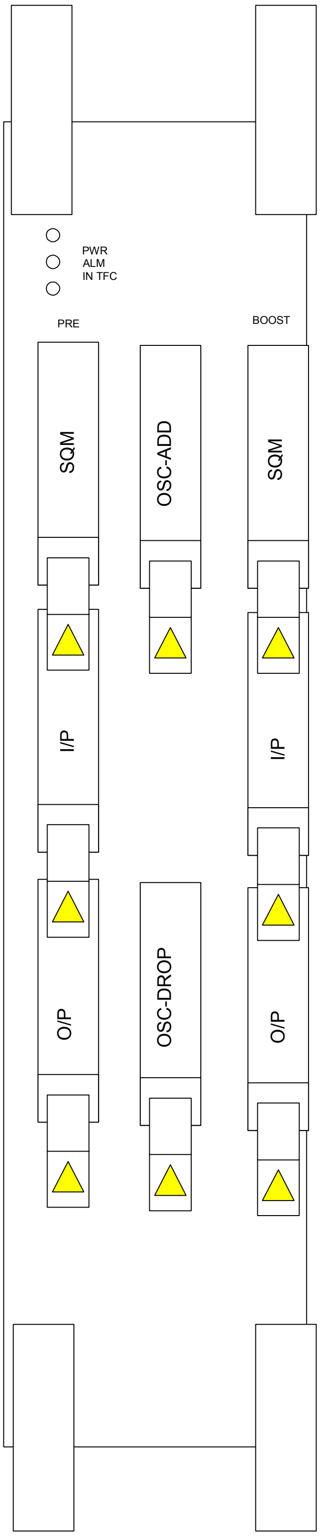
- DSA 17dB C-Band
- DSA 21dB C-Band
- DSA 28dB C-Band

The Multihaul 3000 Dual Stage Amplifier Units carry out an optical amplification function within the Multihaul 3000 product range using a pair of Erbium-Doped Fibre Amplifiers (preamplifier and boosters EDFAs respectively). The differences between each variant of the DSA are the EDFA fitted. The DSA unit provides mid stage access between the preamplifier and booster stages for the connection of high loss components, such as dispersion compensation modules.

The DSA incorporates an Automatic Laser Shutdown mechanism, which is designed to shutdown pump lasers in the event of a fibre break, in the interests of safety. The current status of each EDFA can be determined by the tri-colour LED located near the top of the corresponding column of optical connectors.

Note: As soon as the amplifier is inserted in a powered slot the ALS mechanism will start to function.

Figure 3-5: Dual Stage Amplifier



3.5.1 Optical Interfaces

All optical connections are made on the front panel using downwards pointing, shuttered connectors to maximise optical safety.

- WDM traffic input (INPUT)
- Main high power output (OUTPUT)
- Reduced power output for signal monitoring purposes (MONITOR)
- Optical Supervisory Channel output (OSC OUTPUT)
- Optical Supervisory Channel Input (OSC Input).
- First stage output
- Second stage Input

The DSA receives a composite WDM signal for a given band consisting of up to 80 channels (up to 10Gbit/s) and an optical supervisory channel, at the Preamp INPUT port.

The OSC is demultiplexed from the incoming WDM signal and is made available at the OSC OUTPUT port. The OSC is multiplexed into the outgoing WDM signal by connecting the OSC from the OSU into the OSC INPUT port. The WDM traffic is amplified by each amplifier to a set power level and made available at the corresponding OUTPUT ports alongside a reduced power version of the same signal (MONITOR), (~20dB down on output).

3.5.2 LEDs

Table 3-15: Dual Stage Amplifier LEDs

Colour	Name	Managed/Unmanaged	Function
Green	Power	Unmanaged	Lit when all on-board power supplies are on and functioning correctly.
Red	Fault	Managed	Lit to indicate an alarm condition.
Amber	Resource	Managed	Lit to indicate that the card is functioning and is activated to carry traffic.
Tri-colour Output Status LED		Managed	
Red/Green Flashing	Automatic Laser Shutdown (ALS) active - all pumps disabled		
Green	Minimal optical power present		
Orange	Normal operating power levels present at port		

WARNING!

The tri-colour output status led is made up of individual red and green LEDS. If the red led fails, the output will go to green rather than orange. While this is not an optical safety hazard, it could be misleading.

3.5.3 Labels

Optical warning label (Hazard Level 1M).

3.6 Single Stage Amplifier ELH

The Single Stage Amplifier units have three variants:

- SSA 17dB C-Band
- SSA 21dB C-Band
- SSA 27dB C-Band

The Multihaul 3000 Single Stage Amplifier Units carry out an optical amplification function within the Multihaul 3000 product range using a single Erbium Doped Fibre Amplifier (EDFA). The difference between each variant of the SSA is the EDFA fitted.

The amplifier also carries out a line build out function using a Variable Optical Attenuator (VOA) to reduce the input power to maximise EDFA performance.

The SSA incorporates an Automatic Laser Shutdown mechanism, which is designed to shutdown pump lasers if a fibre break occurs, in the interests of safety. The current status of the EDFA can be determined by the tri-colour LED located near the top optical connector (MONITOR) of the unit.

Note: As soon as the amplifier is inserted in a powered slot the ALS mechanism will start to function.

3.6.1 Optical Interfaces

All optical connections are made on the front panel using downwards pointing, shuttered connectors to maximise optical safety. The SSA has two input:

- WDM traffic input (INPUT)
- Optical Supervisory Channel input (OSC input).

The SSA has three outputs:

- Main high power output (OUTPUT)
- Reduced power output for signal monitoring purposes (MONITOR)
- Optical Supervisory Channel output (OSC OUTPUT).

The SSA receives a composite WDM signal for a given band consisting of up to 80 channels (up to 10Gbit/s) and an optical supervisory channel, at the INPUT port.

The OSC is demultiplexed from the incoming WDM signal and is made available at the OSC OUTPUT port.

The WDM traffic is amplified to a set power level and made available at the OUTPUT port alongside a reduced power version of the same signal (MONITOR).

3.6.2 Single Stage Amplifier LEDs

Table 3-17: Single Stage Amplifier LEDs

Colour	Name	Description
Green	Power OK (unmanaged)	Lit when all on board supplies are on and functioning correctly.
Red	Fault (managed)	Lit to indicate an alarm condition.
Amber	Resource (Managed)	Lit to indicate that the card is functioning and is activated to carry traffic.

Table 3-19: Tri-Colour Output Status LED - Unmanaged

Red/Green Flashing	Automatic Laser Shutdown (ALS) active - all pumps disabled
Green	Minimal optical power present
Orange	Normal operating power levels present at port

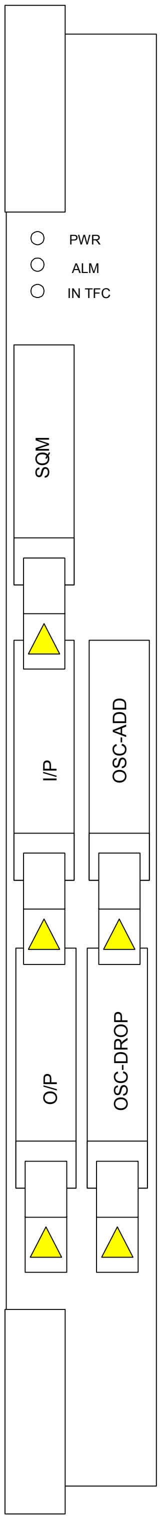
WARNING!

The tri-colour output status led is made up of individual red and green LEDS. If the red led fails, the output will go to green rather than orange. While this is not an optical safety hazard, it could be misleading.

3.6.3 Labels

Optical warning label (Hazard Level 1M).

Figure 3-7: Single Stage Amplifier



3.7 DSA/SSA Amplifier Unit

The DSA/SSA Unit performs the following basic functions:

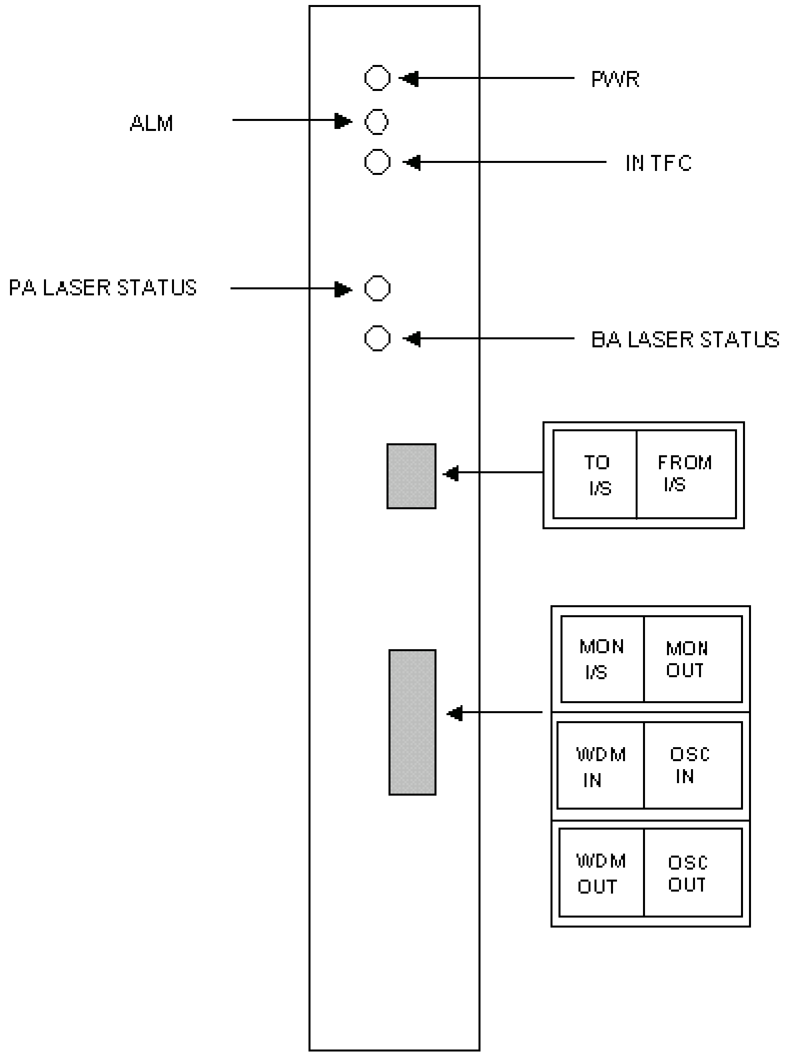
- Receives a WDM signal containing between 0 and 80 traffic channels from a specified band, via a front panel connection, from another card such as an Interleaver or a Line Interface unit, or another Amplifier, depending on the system configuration.
- Used in conjunction with Raman amplification provides support for Raman Shutdown.
- OSC signal branching (extraction/insertion).
- Regulates the optical power level by means of optical attenuators for span aging margins, inter-stage loss calibration and optimal performances.
- Optical amplification:
- DSA - two stages of optical amplification:
  - Pre-amplification of the received WDM channels using a gain flattened Preamp EDFA gain block, with the units main input on the front panel.
  - Booster amplification of the WDM channels, using a gain flattened Booster EDFA gain block, with the units main output on the front panel.
  - Front panel mid-stage access (Pre Output, Booster Input) allowing the front panel connection of high loss components e.g. Dispersion Compensation Modules.
- SSA
  - Optical amplification of the received WDM channels using a gain flattened SSA EDFA gain block, with the units input and output on the front panel (no mid-stage access available).
  - Used in Terminal (launch side) and in Line Amplifier when Dispersion Compensation is not required, or after an Optical Add Drop Multiplexer (triple stage in combination with a DSA).
- Micro-controller for power and VOAs setting, alarm and monitoring functions.
- Inventory data and calibration data store for unit parameters, where EDFA specific data is stored within the EDFA block.
- Provides a Signal Quality Monitor (SQM) output for each gain block, to the front panel.
- Performs the APR/ALS function based on detected Loss of Signal.

- Performs the control algorithm to control the output power depending on channel count, and input power.

3.7.1 Front Panel Description

A basic diagram of the DSA/SSA amplifier Unit front panel is shown in Figure 3-9

Figure 3-9: DSA/SSA Amplifier Unit Front Fascia Layout



3.7.2 Optical Connectors

All optical connections on the Amplifier units are made via the front panel of the unit, using SC/UPC type connectors. These connectors allow easy, low-loss enough connections to be made. All connectors point downwards, to reduce the risk of direct exposure to transmission line power levels and to reduce dust and contaminants accumulation on the optical surfaces during commissioning. Front connectors are listed in Table 3-21.

Table 3-21: DSA/SSA Front Connectors

Connector	Function
WDM IN	Input from the transmission line to the amplifier (including OSC)
WDM OUT	Output from the amplifier to the transmission line (including OSC)
TO I/S	Output power from an internal section (typically Preamp) to an inter-stage
FROM I/S:	Input power from an inter stage to an internal section (typically Booster)
MON I/S	Tapped first gain section (Preamp) output for monitoring purposes
MON OUT	Tapped output power to monitor the output from the amplifier to the line
OSC OUT	Optical Supervisory Channel extraction from the incoming line
OSC IN	Optical Supervisory Channel insertion into the outgoing line

Note: “MON I/S” tapped power is a reduced version of the first gain stage (Preamp) output power, being the latter eventually not accessible from outside. In a standard DSA configuration, a VOA is placed in between the Preamp output (physical point in the optical circuit, not externally accessible) and the “TO I/S” connector, where the optical power is externally accessible; this VOA is for Inter-Stage Loss Calibration and Line Raman Tilt Control.

Differently termed connectors can be present in Dual Unit EDFA versions (such as WEST or EAST variants of the previous list) or in Raman Pumps.

3.7.3 DSA/SSA Amplifier Unit Front Panel Indications

There are five LEDs mounted on the unit front plate as listed in

Name	Colour	Function
ALM	Red	Illuminated by the microprocessor when instructed by the Controller/Comms, or if failure attributable to the unit is detected by the microprocessor, such as watchdog time-out
IN TFC	Amber	Indicates that the unit is an available resource (i.e., it has been logically added to the system), and is illuminated by the microprocessor when instructed by a command from the Controller/Comms card . This LED is flashed whilst software download is in progress
PWR	Green	Illuminated when all main power supplies on the card are on. If any single supply drops by more than approximately 5%, the LED goes off
LASER1 STATUS	Bi-color	Green light indicates no laser output at that point in time out from first section (“TO I/S” port). SSA LED is simply marked “LASER status” and is referred to EDFA output (WDM OUT” port). Orange/Yellow indicates that there is light output. Flashing Red/Green indicates that the amplifier first section is in ALS and will output a 300mS burst of light every 100 seconds.
LASER2 STATUS	Bi-color	Green light indicates no laser output at that point in time out from second section (“WDM OUT” port). This LED is not present in SSA variants. Orange/Yellow indicates that there is light output. Flashing Red/Green indicates that the amplifier second section is in ALS and will output a 300mS burst of light every 100 seconds

3.8 Group Interleaver Unit

The Group Interleaver Unit (GIU) in conjunction with the Group Multiplexer Unit (GMU-40) performs the optical multiplexing function within the Multihaul 3000 product. The GIU takes two groups of 40 channels from the GMU-40s and multiplexes them onto a single fibre containing 80 channels, which is connected to the Tx amplifier unit.

The card also performs the equivalent demultiplexing function in the Rx direction.

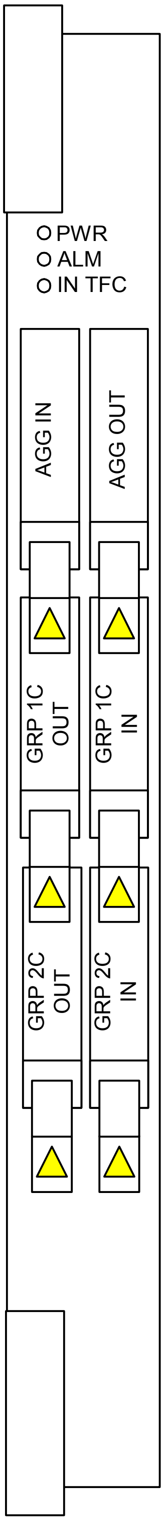
The multiplexed signal consists of 80 DWDM channels spaced at 50 GHz intervals. The GIU also forms part of the ALS system within the Multihaul 3000 product and ensures that the attached optical amplifiers shut down in the event of a fibre break.

There are two variants of the GIU within the Multihaul 3000 product:

- C-Band Group Interleaver Unit (GIU-C)
  - The GIU-C is a 1.6” wide slide in unit designed to fit into the Multihaul 3000 Subracks. Optical connections to the card are made via optical connectors on the front of the card. The card consists of the optical devices, which perform the multiplexing and demultiplexing functions, an optical shutter and power monitor, which provide the ALS
  - The GIU-C can be used in 40 channel and 80 channel systems
- C-Band Group Interleaver Unit (GIU-S)
  - The GIU-S is used in 40 channel only systems
  - The GIU-S is deployed in 40 channel system terminals and fixed channel add drops to provide optical safety when ER amplifiers are used.

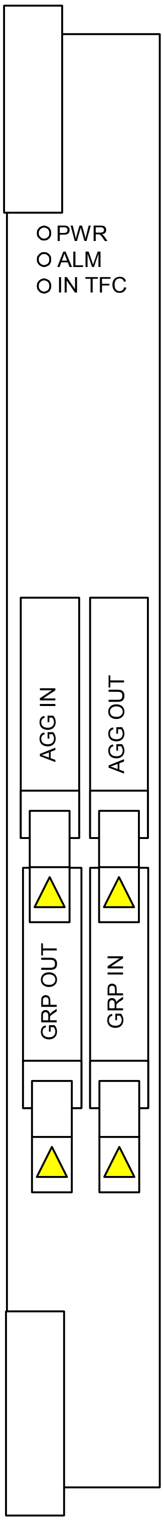
A basic diagram of the GIU-C front panel is shown in Figure 3-11:

Figure 3-11: Group Interleaver Unit



A basic diagram of the GIU-S front panel is shown in Figure 3-13:

Figure 3-13: Group Interleaver Unit- Shutter



3.8.1 Optical Connections

The GIU-C unit has six optical ports on the front panel. The GIU-S has four optical ports on the front panel. These are to be connected as follows:

- **AGG IN:** The aggregate port of the demultiplexing side of the interleaver. The output of the Rx Amplifier unit should be connected to this port. Note that the high optical powers are present on this port

- **AGG OUT:** The aggregate port of the multiplexing side of the interleaver

- **GRP 1C OUT:** The Group 1 port of the demultiplexing side of the interleaver

- **GRP 2C OUT:** The Group 2 port of the demultiplexing side of the interleaver

- **GRP 1C IN:** The Group 1 port of the multiplexing side of the interleaver

- **GRP 2C IN:** The Group 2 port of the multiplexing side of the interleaver.

3.8.2 LED Descriptions

The GIU has the following LEDs used to indicate the status of the unit.

Table 3-23: Group Interleaver Unit LEDs

Colour	Name	Description
Green	Power LED	Lit when all on-board power supplies are on and functioning correctly.
Red	Alarm LED	Lit to indicate an alarm condition.
Amber	In Traffic LED	Lit to indicate that the card is functioning and is activated to carry traffic.

Note: All three LEDs are illuminated when the unit is first powered on. This indicates the unit is in initialisation.

3.8.3 Labels

Optical warning label (Hazard Level 1M).

3.9 Group Mux 8 Units

The Group Mux 8 units are fitted in a core subrack. The optical connections to transponders are carried out by optical patch cords with MTP connector or Hydra cables (1MTP to 8 LC).

The Group Mux 8 card performs the following basic functions:

- Multiplex and Demultiplex 8 optical channels (plus upgrade port channels) into a composite WDM signal.
- Inventory data storage

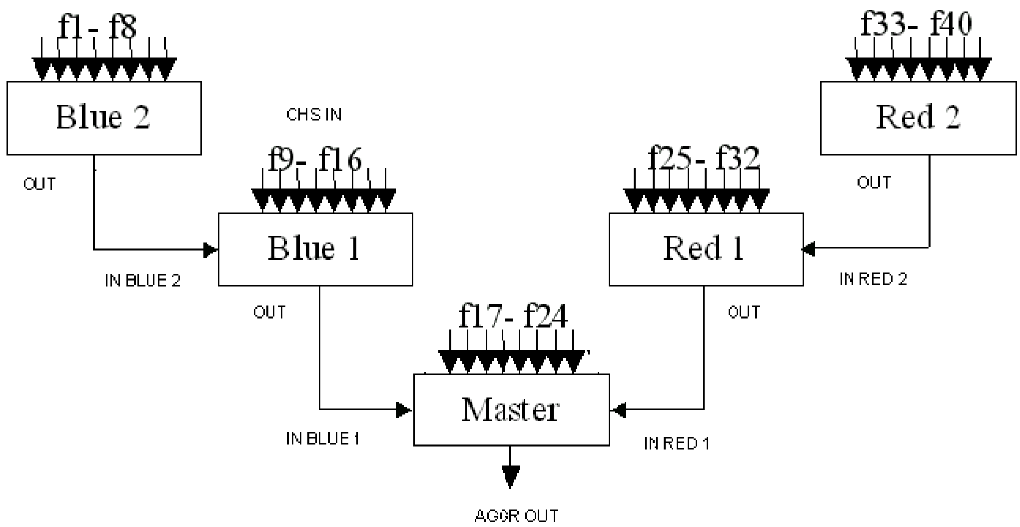
The units provide a modular multiplexing/demultiplexing structure. Each unit multiplexes and demultiplexes 8 optical channels from the transponders into a composite WDM signal with 100GHz spacing. "Central" units provide upgrade port for the "lateral" band.

The mux/demux unit will have 5 variants for C band, which are:

- Master
- Red 1
- Red 2
- Blue 1
- Blue 2

3.9.1 Structure of the full chain (40 channels)

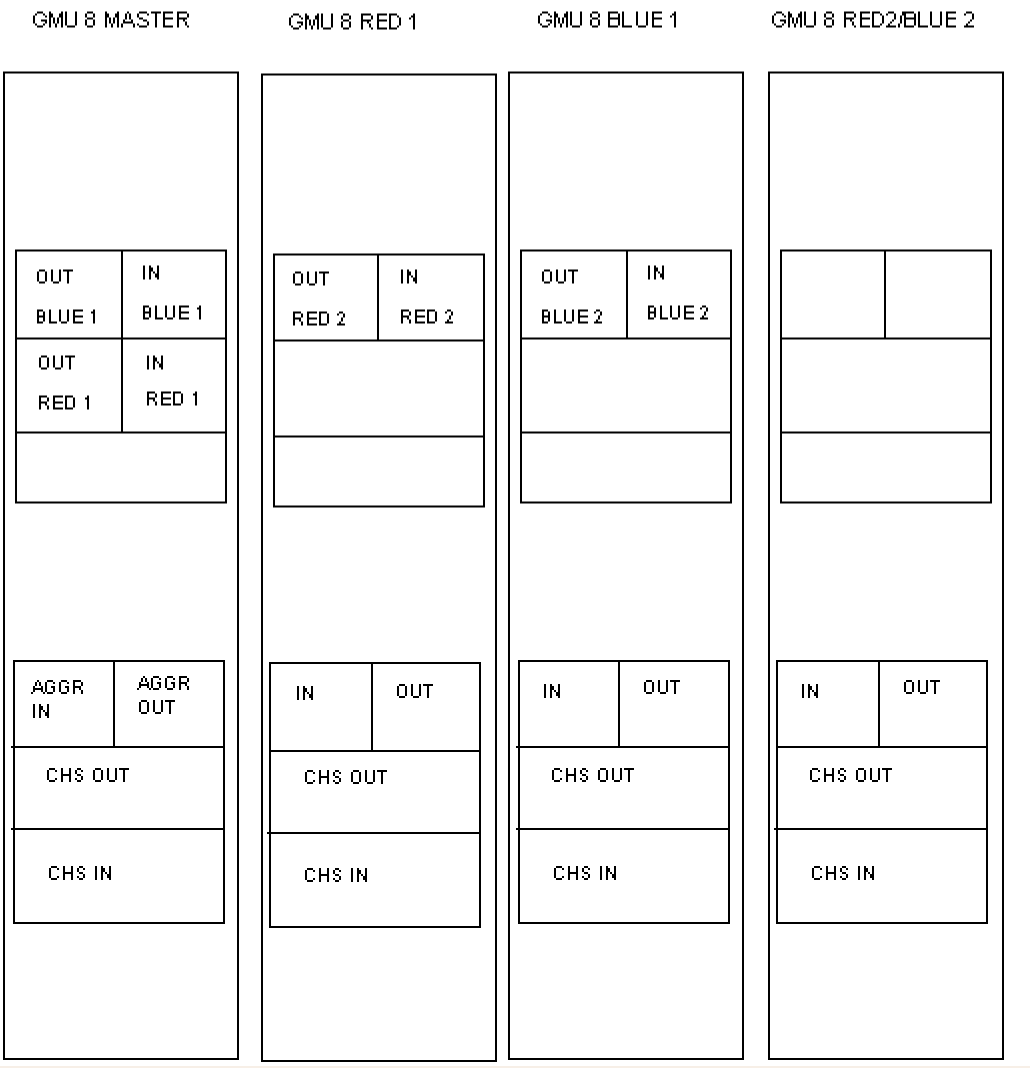
Figure 3-15: Mux Chain Structure



Note: This is the mux structure; the demux structure is exactly the same with the arrows' toward inverted.

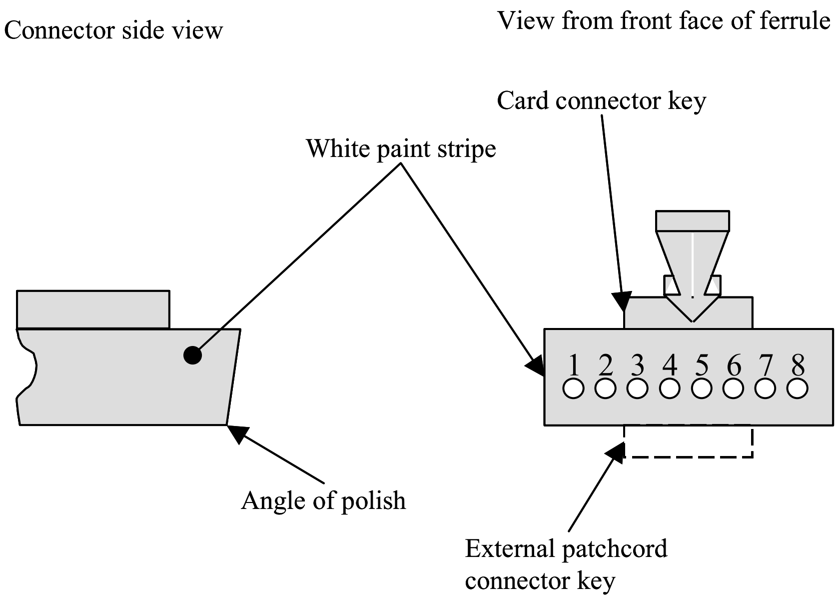
3.9.2 Group Mux 8 Units Front Fascia Layout

Figure 3-17: Group Mux 8 Units Front Fascia Layout



Optical MT connector on front panel is shown in the picture below. Connector is MTP (polish angle as reported in following figure).

Figure 3-19: MTP Connector Fibre Positioning



Lower frequency is in left position (card connector fibre 1) higher frequency is in right position (card connector fibre 8).

3.9.3 GMU8 Units Optical Interface Connectors

Table 3-25: GMU8 Units Optical Interface Connectors

Connector	Connector Type
CHS (Input to Mux)	8 fibre MTP connector
IN RED 1/2 (Red upgrade input to Mux)	SC connector
IN BLUE 1/2 (Blue upgrade input to Mux **)	SC connector
AGGR OUT (Mux Output)	SC connector
CHS (Output from DeMux)	8 fibre MTP connector
OUT RED 1/2 (Red upgrade output from DeMux *)	SC connector
OUT BLUE 1/2 (Blue upgrade output from DeMux **)	SC connector
AGGR IN/IN (DeMux Input)	SC connector

Notes

1 * Only present in Master/Red1 variant

2 ** Only present in Master/Blue1 variant

3.10 Group Multiplexer 40 Unit

The Multiplexer half of the Group Mux Unit combines 40 individual optical channels into a composite WDM signal. The optical channels are spaced at 100 GHz. The demultiplexer section performs the reverse operation, separating out the individual optical channels from a composite WDM signal.

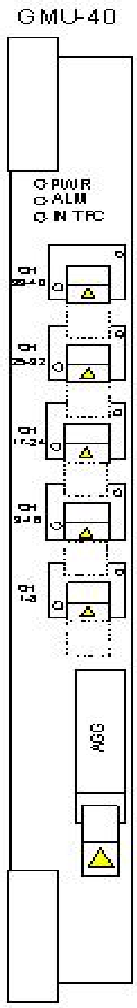
The optical components are thermally managed by on-card circuitry which also provides control, monitoring and inventory functions.

This unit is 1.6" card width format. Optical connections to the card are made via five MT connections (5 x 8 channels). Two GMU-40-40s are supplied under the SE code, one to multiplex the signals from the transponders, and one to de-multiplex the signals to the transponders.

3.10.1 Front Panel Description

A basic diagram of the GMU-40 front panel is shown in Figure 3-21.

Figure 3-21: Group Multiplexer Unit



3.10.2 Optical Connections

The unit has six optical ports on the front panel. These ports are to be connected as follows:

- **AGG:** The aggregate port of the GMU-40. This port should be connected to the appropriate Group Input on the GIU

- **CHAN x-y:** Channel connections x to y of the GMU-40. This port should be connected to the front of the associated transponders.

3.10.3 LED Descriptions

The GMU-40 has the following LEDs used to indicate the status of the unit.

Table 3-27: Group Multiplexer Unit LEDs

Colour	Name	Description
Green	Power LED	Lit when all on-board power supplies are on and functioning correctly.
Red	Alarm LED	Lit to indicate an alarm condition.
Amber	In Traffic LED	Lit to indicate that the card is functioning and is activated to carry traffic.

Note: All three LEDs are lit when the unit is first powered on. This indicates the unit is in initialisation.

3.10.4 Labels

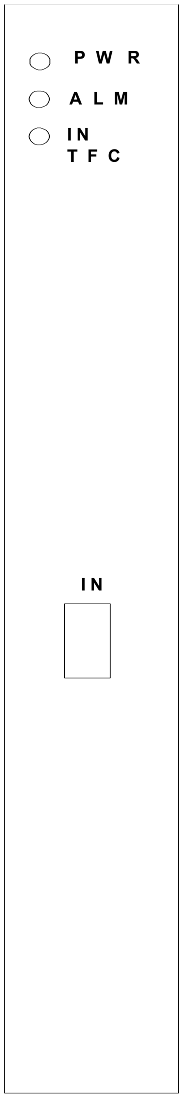
Optical warning label (Hazard Level 1M).

3.11 Power Monitor Unit (PMU)

The main system function of the Power Monitor Unit (PMU) is to measure the power and wavelength of up to 80 DWDM channels, and use this information to control system levelling functions and transponder power levels. This function is performed by an optical spectrum analyser module, which continuously scans the spectrum and reports the channel power and wavelength information to an on-board micro controller circuit. The scan time is variable and adjusts automatically depending on the average input power level.

After capturing the spectral information, the PMU compares the power in each channel against a pre-defined ideal spectrum. It then broadcasts the difference for each channel on the IEEE-1394 bus. The manner in which this information is used depends on the type of NE. In terminal nodes, this information is used by transponders to adjust the WDM laser output power. In add/drop nodes this information is used to control which channels are dropped. In levelling nodes, this information is used to control the Channel Equaliser Unit. The PMU can also be used to read OSNR.

Figure 3-23: PMU Front Panel



3.11.1 Power Monitor Unit LEDs

Table 3-29: Power Monitor Unit LEDs

Green	Power	Lit when all on-board power supplies are on and functioning correctly
Red	Fault	Lit to indicate an alarm condition
Amber	Resource	Lit to indicate that the card is functioning and is activated to carry traffic.

3.11.2 Optical Connector

In - DWDM input signal. SC/UPC connector.

3.12 Fixed Add/Drop Units

The Fixed OADM units are housed within the core subrack. The optical connections are carried out by optical patch cords with SC/UPC or LC/UPC (for add/drop port) connectors.

There are six variants of the Fixed Add Drop Unit (FADU):

- CH 21 to 24, C-Band
- CH 17 to 20, C-Band
- CH 13 to 16, C-Band
- CH 9 to 12, C-Band
- CH 19 to 22, C-Band
- CH 15 to 18, C-Band

All variants are 1.6" wide and occupy a single slot position. The FADU allows four channels to be added and dropped in two line directions. From a hardware perspective, the FADUs can be inserted into any location in a dual row or single row subrack.

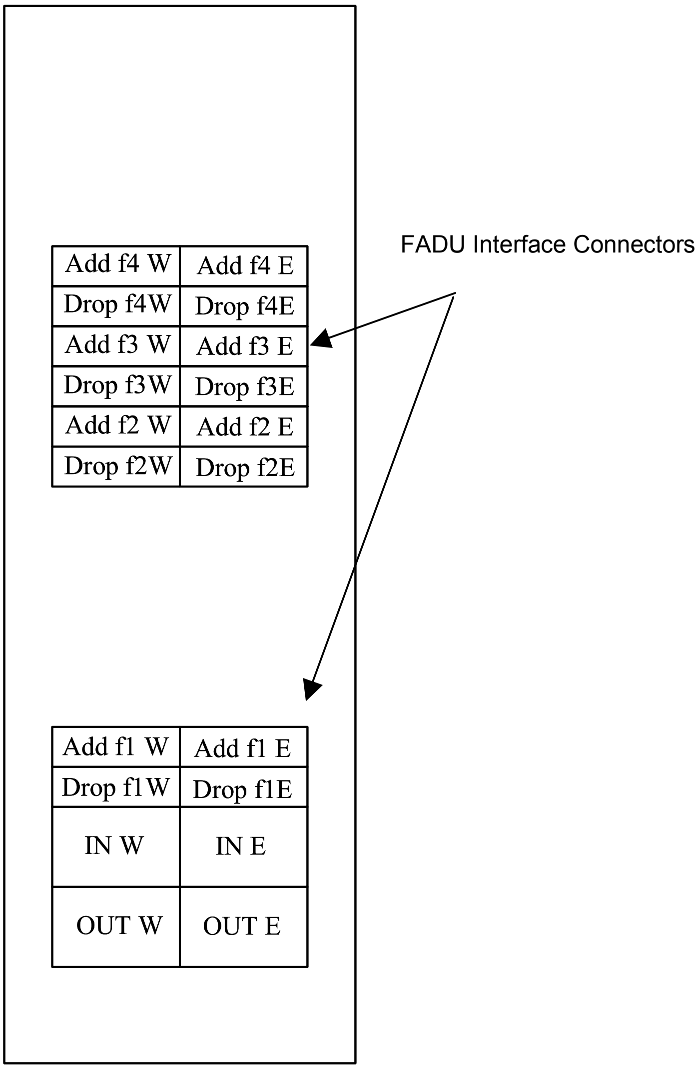
The OADM unit performs the following basic functions:

- Drop four channels (100GHz spaced) if present for each direction.
- Add up to four channels for each direction.
- Reinsertion of dropped channels (with an external patchcord) without regeneration (glass-through).
- Inventory data storage.

3.12.1 Fixed Add Drop Unit Front Fascia

Figure below shows front panel layout (f1 is the lowest frequency)

Figure 3-25: Fixed Add Drop Unit



3.12.2 Fixed OADM Unit Input and Output Ports

The Unit has the following ports: -

Table 3-31: Fixed OADM Unit Input and Output Ports and Connectors

Input	Optical Connector Type
IN East (IN E)	SC/UPC
Drop f1E,	LC/UPC
Drop f2E	LC/UPC
Drop f3E	LC/UPC
Drop f4E	LC/UPC
Out East (OUT E)	SC/UPC
Add f1E	LC/UPC
Add f2E	LC/UPC
Add f3E	LC/UPC
Add f4E	LC/UPC
In West (IN W)	SC/UPC
Drop f1W	LC/UPC
Drop f2W	LC/UPC
Drop f3W	LC/UPC
Drop f4W	LC/UPC
OUT West (OUT W)	SC/UPC
Add f1W	LC/UPC
Add f2W	LC/UPC
Add f3W	LC/UPC
Add f4W	LC/UPC

3.13 Add/Drop Unit

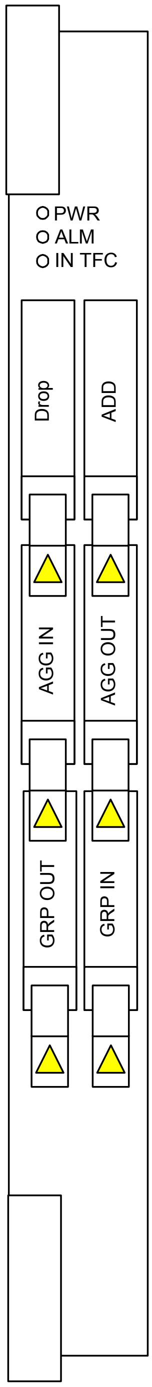
The add-drop unit fits into an add/drop Multihaul 3000. The Add-Drop card provides add and drop access to the through traffic whilst maintaining satisfactory optical safety performance. The unit monitors the power level of optical channels and has a shutter to block channels for optical safety, for example, if there is a break in fibre or excessive power. Any number of channels can be added or dropped through this unit.

The card comprises optical couplers for Add/drop separation and merging functions, optical monitor & shutter under hardware control to provide satisfactory optical safety performance and 3dB couplers for either maintaining loss budgets or to allow tri-directional operation.

There are two variants of this card:

- **2-port Standard Add/Drop** – Allows add and drop access to through traffic travelling in a node having two WDM ports; East and West.
- **3-port Extended Add/drop** – Allows add and drop access to through traffic travelling in a node having three WDM ports; East, West and South.

Figure 3-27: Add/Drop Unit



The front panel is 1.6’’ wide, comprising three LEDs and optical connectors (SC/UPC connectors).

3.13.1 Add/Drop Unit LEDs

Table 3-33: Add/Drop Unit LEDs

Colour	Managed/Unmanaged	Function
Green	Power (unmanaged)	Lit when on-board PSU is functioning correctly.
Red	Fault (managed)	Lit to indicate an alarm condition.
Amber	Resource (managed)	Lit to indicate that the card is functioning and is activated to carry traffic.

3.13.2 Optical Connections

- AGG IN - (Aggregate Input)
- GRP OUT -
- DROP (Drop Channels)
- AGG OUT - (Aggregate Output)
- GRP IN -
- ADD (Add channels)

3.13.3 Labels

Optical warning label (Hazard Level 1M).

3.14 Channel Control Unit 1C

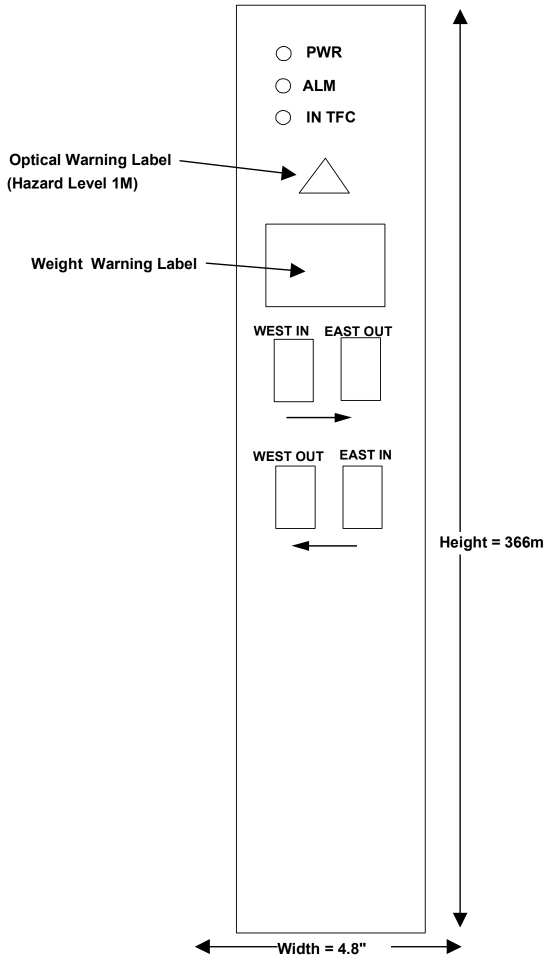
WARNING! **Heavy Equipment**

The Channel Control Unit weighs in excess of 5Kg. Exercise caution when handling it.

The CCU provides a blocking function whereby high attenuation is applied to those optical channels required to be switched off, as instructed by the Power Monitor Unit. This can occur either when the system starts up, or if the channel is being added or dropped.

The blocking functions are provided in a single module on the CCU, such as a Liquid Crystal Cross-connect (LCX) module. A single LCX module has four optical ports and allows simultaneous east-to-west and west-to-east connectivity.

Figure 3-29: Channel Control Unit



3.14.1 Channel Control Unit LEDs

Table 3-35: Channel Control Unit LEDs

Green	Power (unmanaged)	Lit when all on-board power supplies are on and functioning correctly
Red	Fault (managed)	Lit to indicate an alarm condition
Amber	Resource (managed)	Lit to indicate that the card is functioning and is activated to carry traffic.

3.14.2 Optical Connections

All connectors are SC/UPC connectors.

- East In
- East Out
- West In
- West Out.

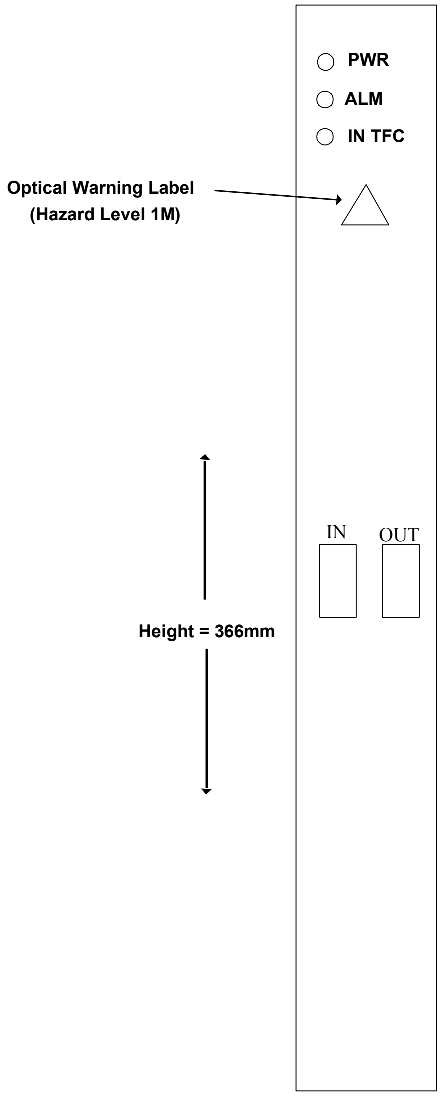
3.14.3 Labels

Optical warning label (Hazard Level 1M).

3.15 Channel Equalising Unit

The Channel Equalising Unit provides a levelling function, whereby optical amplitude control of the through-channels is carried out. This is via a control signal from the associated Power Monitor Unit.

Figure 3-31: Channel Equalising Unit



3.15.1 Channel Equalising Unit LEDs

Table 3-37: Channel Equalising Unit LEDs

Green	Power (unmanaged)	Lit when all on-board power supplies are on and functioning correctly.
Red	Fault (managed)	Lit to indicate an alarm condition.
Amber	Resource (managed)	Lit to indicate that the card is functioning and is activated to carry traffic.

3.15.2 Optical Connections

All connectors are SC/UPC connectors:

- Input
- Output

3.15.3 Labels

Optical warning label (Hazard Level 1M).

3.16 Raman Pump Unit

The Raman Unit amplifies incoming signals by pumping high power photonic energy into the fibre on which the signal is to be received. Those signal components whose wavelengths are longer than the pump wavelengths absorb the pumped photonic energy and are thereby amplified.

The Raman unit contains multiple pumps whose wavelengths have been selected to give the optimum gain flatness in their band, see table below for more detail.

Table 3-39: Variants of the Raman unit

Raman Variant	No of Pump Wavelengths
C-Band	2

The Raman unit incorporates all of the electronics required to accurately control and monitor the pump units. The measured weight of a fully assembled unit is 4.5Kg. The Raman Pump unit can be used for counter propagating or co propagating Raman pumping.

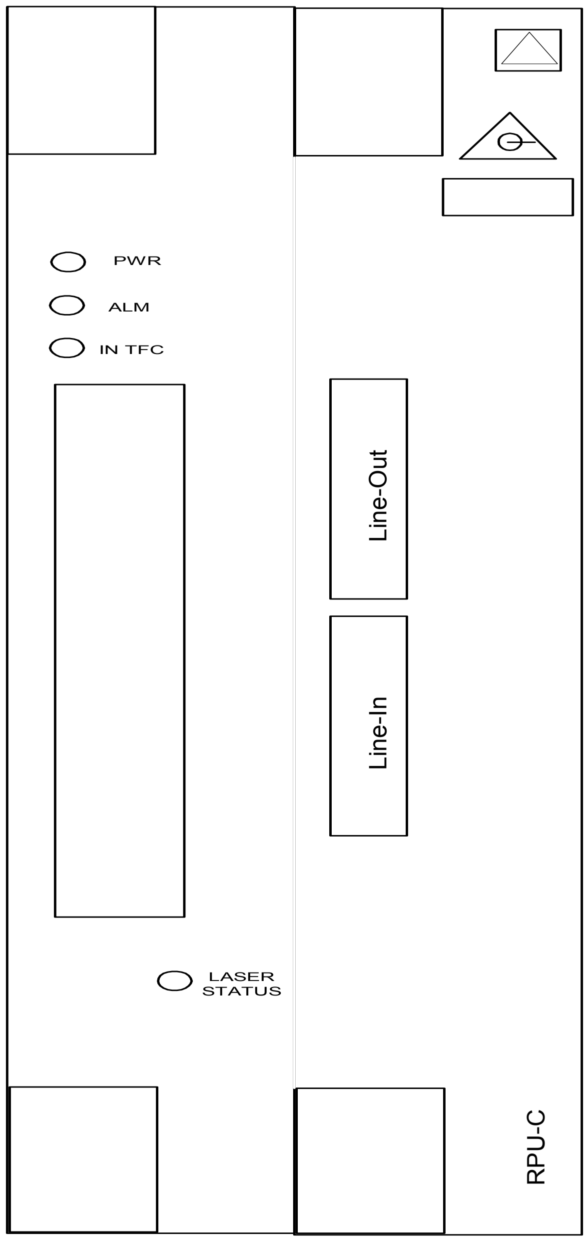
The RPU performs the following basic functions:

- Receives and passes through the traffic line while using Raman back pumping to achieve around 10dB gain.
- Uses information from the appropriate DSA/SSA to achieve the target input power for that amplifier while maintaining the optimum noise figure.
- ALS system based on Loss of (OSC) Frame
- Optical amplification
- C-Band unit consists of four laser diodes (pumps). These are paired such that the RPU pumps at two different wavelengths; 1426nm and 1453nm. Each wavelength uses a pair of pumps to ensure an even polarisation is achieved (i.e. the pumps are polarised at 90° to each other).
- The Raman units are commissioned using proprietary software to set the output power at each wavelength to a certain ratio ensuring that gain is flat across the spectrum.

3.16.1 Front Panel Description

The Front panel of the C Band RPU is shown in Figure 3-33.

Figure 3-33: Front panels of the C Band RPU



3.16.2 Optical Connectors

All the optical fibre inputs and outputs are fed through the front panel and held in place using bracket to hold the bulkhead. The fibre cannot be disconnected at the front panel.

As can be seen in Figure 3-33 the C-Band unit has three optical connections; Line-In, Lineout, Mid-C In.

3.16.3 LEDS Description

There are three LEDs mounted on the unit front plate.

3.16.4 Card Fault LED (RED)

This is illuminated by the microprocessor when instructed by the Controller/Comms, or if failure attributable to the unit is detected by the microprocessor, such as watchdog time-out.

3.16.5 Resource Available LED (AMBER)

This denotes the unit is an available resource (i.e., it has been logically added to the system), and is illuminated by the microprocessor when instructed by a command from the Controller/Comms card. This LED is flashed whilst software download is in progress.

3.16.6 Power Supplies Good (GREEN)

The green LED is illuminated when all main power supplies on the card are on. If any single supply drops by more than approximately 5%, the LED goes off.

3.16.7 Laser On/Off & ALS (Red/Green)

There is a bi-colour LED mounted on the daughter card, situated at the bottom of the front panel.

Green light indicates, no laser output at that point in time (Note that optical power could still be present depending on the state of the traffic line coming into the RPU).

Orange/Yellow indicates that the lasers are active.

Flashing Red/Green indicates that the amplifier is in ALS.

3.17 10G RZ Transponder Unit

The 10G RZ transponder is a tributary unit that performs client to DWDM channel adaptation. It has full-band tuneability it also supports EFEC and additional client options.

The main features of the transponder are as follows:

- ITU-T G.691 compliant, Client Options I64.1, S64.2 I-64.2 client interface with front panel optical connectors
- ITU-T G.709 compliant 10.709Gbps DWDM interface with front panel optical connectors
- Reed Solomon (255,239) FEC encoding/decoding and error correction
- LH/ELH variant using NRZ G709, Standard FEC
- LH/ELH variant NRZ G709, Standard FEC or EFEC, 80 channel tuneable, configurable for STM-64 (or10GbE WAN PHY) and 10GbE LAN PHY
- ULH, RZ, G.709 EFEC, 80 channel tuneable
- 80 wavelength tuneable, wavelength locked DWDM laser
- Soliton pulse shaping on DWDM transmit interface
- DWDM transmit output power controlled by Variable Optical Attenuator
- Receive digital wrapper monitoring for payload BIP errors
- DWDM receiver with active slicing control
- Client Automatic Laser Shutdown (ALS) system
- Receive and transmit client SDH/SDH traffic monitoring for B1 errors and J0 section trace
- Client diagnostic loop-backs (client receive to client transmit) with full jitter reduction.

In the direction from client, the transponder accepts a low-level digital optical signal of any wavelength in the region of 1300-1600nm. By means of an optical-electrical-optical process, it interleaves a digital overhead and produces a high level digital optical signal on an accurately controlled specific wavelength. The digital overhead includes Forward Error Correction (FEC) coding and a path overhead. Full clock re-timing is included to ensure a nominally jitter-free output signal suitable for onward transmission over a number of optically amplified fibre sections.

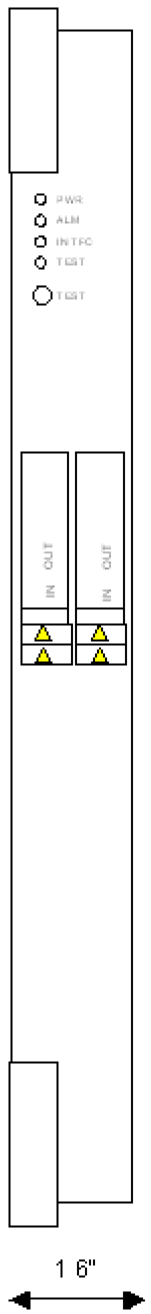
In the direction to the client, it accepts a noisy, low-level digital Rz optical signal of a specific wavelength in the region of 1550nm. By means of an optical-electrical-optical process, it removes the overhead, extracting the path overhead and correcting errors using the FEC algorithm and produces a nominally noise and jitter-free, high level digital optical signal to present to the client.

The path overhead processing allows for monitoring of any errors introduced over the DWDM optical network as well as providing for optical path trace labelling. The transponder incorporates an Automatic Laser Shutdown mechanism on the client interface, which is designed to shut down the client laser if a fibre break, occurs, in the interests of safety.

3.17.1 Front Panel Description

A basic diagram of the RZ Transponder Unit is shown below:

Figure 3-35: 10G RZ Transponder Front Panel



3.17.2 Optical Interfaces

The client optical connections are made on the front panel using downward pointing shuttered connectors to maximise optical safety. Each transponder has one client input and one client output as well as WDM input and output.

3.17.3 10G RZ Transponder LEDs

Table 3-41: 10G RZ Transponder LEDs

Colour	Name	Managed/ Unmanaged	Description
Green	Power	Unmanaged	Lit when all on-board power supplies are on and functioning correctly.
Red	Fault	Managed	Lit to indicate an alarm condition.
Amber	In traffic	Managed	Lit to indicate that the card is functioning and is activated to carry traffic.
Amber	Test	Managed	Lit to indicate that the client laser is activated because a client ALS 'manual restart for test' is in operation.

3.17.4 2s 90s Push Button

The push button, labelled as '2s 90s' on the front panel, initiates a two-second client ALS 'manual restart' when pressed and released. The button initiates a 90-second 'manual restart for test' when pressed and held for more than twelve seconds.

Note: The push button only works when ALS has been activated; it is inoperable during normal operation.

3.17.5 Labels

Optical warning label (Hazard Level 1).

Due to the front plug-up nature of the transponders, it is always imperative to have the cross-connection for a particular channel removed before physical connection of the WDM LC connectors. This prevents unwanted errors on present traffic due to the sudden addition of light. For commissioning from scratch, this is unlikely to be an issue, but should be regarded as "best practice" nonetheless.

Note: When 10G RZ 80Ch transponders are configured in CTP mode, uncorrectable subframes are present if the interlink signal is looped back on itself (be it at the interlink side of this transponder or any transponder further down the path),if the WDM Rx signal is in LOS/LOM or LOF.

3.18 10G NRZ Transponder Unit

The NRZ transponder is a tributary unit that performs client to DWDM channel adaptation.

The main features of the transponder are as follows:

- ITU-T G.691 compliant, I-64.2 client interface with front panel optical connectors
- ITU-T G.709 compliant 10.709Gbps DWDM interface with front panel optical connectors
- Reed Solomon (255,239) FEC encoding/decoding and error correction
- DWDM transmit output power controlled by Variable Optical Attenuator
- Receive digital wrapper monitoring for payload BIP errors
- DWDM receiver with active slicing control
- Client Automatic Laser Shutdown (ALS) system
- Receive and transmit client SDH/SDH traffic monitoring for B1 errors and J0 section trace
- Client diagnostic loop-backs (client receive to client transmit) with full jitter reduction

In the direction from client, the transponder accepts a low-level digital optical signal of any wavelength in the region of 1300-1600nm. By means of an optical-electrical-optical process, it interleaves a digital overhead and produces a high level digital optical signal on an accurately controlled specific wavelength. The digital overhead includes Forward Error Correction (FEC) coding and a path overhead. Full clock re-timing is included to ensure a nominally jitter-free output signal suitable for onward transmission over a number of optically amplified fibre sections.

In the direction to the client, it accepts a noisy, low-level digital NRZ optical signal of a specific wavelength in the region of 1529.55 to 1561.01. By means of an optical-electrical-optical process, it removes the overhead, extracting the path overhead and correcting errors using the FEC algorithm and produces a nominally noise and jitter-free, high level digital optical signal to present to the client.

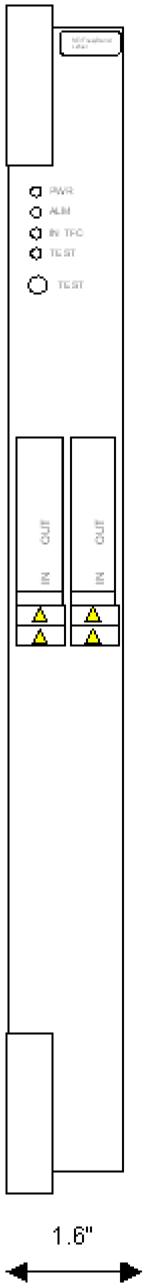
The path overhead processing allows for monitoring of any errors introduced over the DWDM optical network as well as providing for optical path trace labelling.

The transponder incorporates an Automatic Laser Shutdown mechanism on the client interface, which is designed to shut down the client laser in the event of a fibre break.

3.18.1 Front Panel Description

A basic diagram of the NRZ Transponder Unit is shown below:

Figure 3-37: 10G NRZ Transponder Front Panel



3.18.2 Optical Interfaces

Both client and WDM optical connections are made on the front panel using downward pointing shuttered connectors to maximise optical safety. For each transponder, there are input and output connectors for both client and WDM traffic.

3.18.3 10G NRZ Transponder LEDs

Table 3-43: 10G NRZ Transponder LEDs

Colour	Name	Managed/Unmanaged	Function
Green	Power	Unmanaged	Lit when all on-board power supplies are on and functioning correctly.
Red	Fault	Managed	Lit to indicate an alarm condition.
Amber	In traffic	Managed	Lit to indicate that the card is functioning and is activated to carry traffic.
Amber	Test	Managed	Lit to indicate that the client laser is activated because a client ALS 'manual restart for test' is in operation.

3.18.4 2s 90s Push Button

The push button, labelled as '2s 90s' on the front panel, initiates a two-second client ALS 'manual restart' when pressed and released. The button initiates a 90-second 'manual restart for test' when pressed and held for more than twelve seconds.

Note: The push button only works when ALS has been activated; it is inoperable during normal operation.

3.18.5 Labels

- Optical warning label (Hazard Level 1).
- SE/Freq/Band label

Note: Due to the front plug-up nature of the transponders, it is always imperative to have the logical cross-connection for a particular channel removed before physical connection of the WDM LC connectors. This prevents unwanted errors on present traffic due to the sudden addition of light. For commissioning from scratch, this is unlikely to be an issue, but should be regarded as "best practice" nonetheless.

3.19 10G T2 NRZ Transponder Unit

The 10G T2 NRZ transponder is a tributary unit that performs client to DWDM channel adaptation. It has full-band tuneability it also supports EFEC and additional client options.

The main features of the transponder are as follows:

- ITU-T G.691 compliant, Client Options S64.2B client interface with front panel optical connectors
- The WDM interface runs at 11.1Gbps (carrying Ethernet 10G LAN PHY with G709 wrapper) and ITU-T G.709 compliant 10.709Gbps DWDM interface with front panel optical connectors
- Reed Solomon (255,239) FEC encoding/decoding and error correction
- 80 wavelength tuneable, wavelength locked DWDM laser
- DWDM transmit output power controlled by Variable Optical Attenuator
- Receive digital wrapper monitoring for payload BIP errors
- DWDM receiver with active slicing control
- Client Automatic Laser Shutdown (ALS) system
- Receive and transmit client SDH/SDH traffic monitoring for B1 errors and J0 section trace
- Client diagnostic loop-backs (client receive to client transmit) with full jitter reduction.
- EFEC Support.

In the direction from client, the transponder accepts a low-level digital optical signal of any wavelength in the region of 1300-1600nm. By means of an optical-electrical-optical process, it interleaves a digital overhead and produces a high level digital optical signal on an accurately controlled specific wavelength. The digital overhead includes Forward Error Correction (FEC) coding and a path overhead. Full clock re-timing is included to ensure a nominally jitter-free output signal suitable for onward transmission over a number of optically amplified fibre sections.

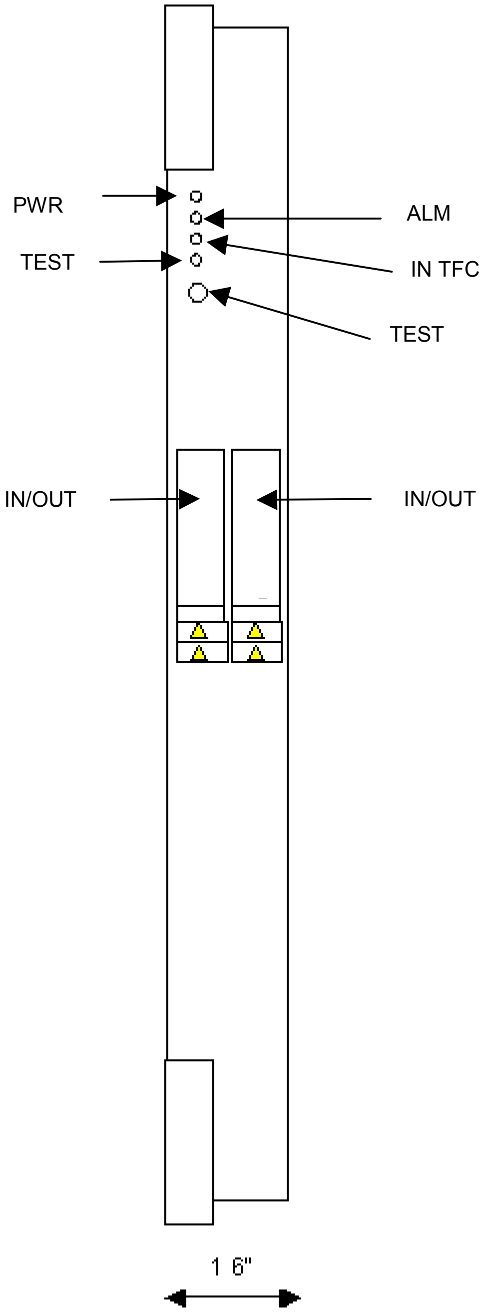
In the direction to the client, it accepts a noisy, low-level digital NRZ optical signal of a specific wavelength in the region of 1550nm. By means of an optical-electrical-optical process, it removes the overhead, extracting the path overhead and correcting errors using the FEC algorithm and produces a nominally noise and jitter-free, high level digital optical signal to present to the client.

The path overhead processing allows for monitoring of any errors introduced over the DWDM optical network as well as providing for optical path trace labelling. The transponder incorporates an Automatic Laser Shutdown mechanism on the client interface, which is designed to shut down the client laser if a fibre break, occurs, in the interests of safety.

3.19.1 Front Panel Description

A basic diagram of the 10G T2 NRZ Transponder is shown in Figure 3-39.

Figure 3-39: 10G T2 NRZ Transponder Front Panel



3.19.2 Optical Interfaces

The client optical connections are made on the front panel using downward pointing shuttered connectors to maximise optical safety. Each transponder has one client input and one client output as well as WDM input and output.

3.19.3 10G T2 NRZ Transponder LEDs

Table 3-45: 10G NRZ Transponder LEDs

Colour	Name	Managed/ Unmanaged	Description
Green	Power	Unmanaged	Lit when all on-board power supplies are on and functioning correctly.
Red	Fault	Managed	Lit to indicate an alarm condition.
Amber	In traffic	Managed	Lit to indicate that the card is functioning and is activated to carry traffic.
Amber	Test	Managed	Lit to indicate that the client laser is activated because a client ALS 'manual restart for test' is in operation.

3.19.4 2s 90s Push Button

The push button, labelled as '2s 90s' on the front panel, initiates a two-second client ALS 'manual restart' when pressed and released. The button initiates a 90-second 'manual restart for test' when pressed and held for more than twelve seconds.

Note: The push button only works when ALS has been activated; it is inoperable during normal operation.

3.19.5 Labels

Optical warning label (Hazard Level 1).

Due to the front plug-up nature of the transponders, it is always imperative to have the cross-connection for a particular channel removed before physical connection of the WDM LC connectors. This prevents unwanted errors on present traffic due to the sudden addition of light. For commissioning from scratch, this is unlikely to be an issue, but should be regarded as "best practice" nonetheless.

3.20 2.5G NRZ Transponder Units (G.709 Extended Reach)

The NRZ transponder is a tributary unit that performs client to DWDM channel adaptation.

The main features of the transponder are as follows:

- ITU-T G.957 compliant, S-16.1 client interface with front panel optical connectors
- ITU-T G.709 compliant 2.666Gbps DWDM interface with optical front-plane connectors
- Reed Solomon (255,239) FEC encoding/decoding and error correction and DWDM port
- DWDM transmit output power controlled by Variable Optical Attenuator
- Receive digital wrapper monitoring for payload BIP errors
- DWDM receiver with active slicing control
- Client Automatic Laser Shutdown (ALS) system
- Receive and transmit client SDH/SDH traffic monitoring for B1 errors and J0 section trace
- Client diagnostic loop-backs (client receive to client transmit) with full jitter reduction

In the direction from client, the transponder accepts a low-level digital optical signal of any wavelength in the region of 1300-1600nm. By means of an optical-electrical-optical process, it interleaves a digital overhead and produces a high level digital optical signal on an accurately controlled specific wavelength. The digital overhead includes Forward Error Correction (FEC) coding and a path overhead. Full clock re-timing is included to ensure a nominally jitter-free output signal suitable for onward transmission over a number of optically amplified fibre sections.

In the direction to the client, it accepts a noisy, low-level digital NRZ optical signal of a specific wavelength in the region of 1529.55nm to 1561.01nm. By means of an optical-electrical-optical process, it removes the overhead, extracting the path overhead and correcting errors using the FEC algorithm and produces a nominally noise and jitter-free, high level digital optical signal to present to the client.

The path overhead processing allows for monitoring of any errors introduced over the DWDM optical network as well as providing for optical path trace labelling. The transponder incorporates an Automatic Laser Shutdown mechanism on the client interface, which is designed to shut down the client laser in the event of a fibre break, in the interests of safety.

3.20.1 Optical Interfaces

Both client and WDM optical connections are made on the front panel using downward pointing shuttered connectors to maximise optical safety. For each transponder, there are input and output connectors for both client and WDM traffic.

3.20.2 2.5G NRZ Transponder LEDs

Table 3-46: 2.5G NRZ Transponder LEDs

Colour	Name	Managed/Unmanaged	Function
Green	Power	Unmanaged	Lit when all on-board power supplies are on and functioning correctly.
Red	Fault	Managed	Lit to indicate an alarm condition.
Amber	In traffic	Managed	Lit to indicate that the card is functioning and is activated to carry traffic.
Amber	Test	Managed	Lit to indicate that the client laser is activated because a client ALS 'manual restart for test' is in operation.

3.20.3 2s 90s Push Button

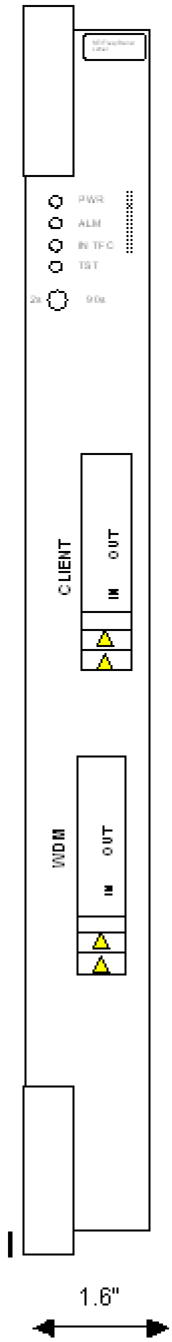
The push button, labelled as '2s 90s' on the front panel, initiates a two-second client ALS 'manual restart' when pressed and released. The button initiates a 90-second 'manual restart for test' when pressed and held for more than twelve seconds.

Note: The push button only works when ALS has been activated; it is inoperable during normal operation.

3.20.4 Labels

- Optical warning label (Hazard Level 1)
- SE/Freq./Band label.

Figure 3-40: 2.5G NRZ Transponder Unit



Note: Due to the front plug-up nature of the transponders, it is always imperative to have the cross-connection for a particular channel removed before physical connection of the WDM LC connectors. This prevents unwanted errors on present traffic due to the sudden addition of light. For commissioning from scratch, this is unlikely to be an issue, but should be regarded as “best practice” nonetheless.

3.21 2.5G NRZ-SR Transponder Units (G.709 Standard Reach)

The NRZ-SR transponder is a tributary unit that performs client to DWDM channel adaptation.

The main features of the transponder are as follows:

- ITU-T G.957 compliant, S-16.1 client interface with front panel optical connectors
- Proprietary 2.666Gbps DWDM interface with optical front-plane connectors. Interface will support ITU-T G.709 compliant signals
- Proprietary Reed Solomon (255,239) FEC encoding/decoding and error correction and DWDM port, provides FEC gain of greater than 5.5 dB
- DWDM transmit output power controlled by Variable Optical Attenuator
- Receive digital wrapper monitoring for payload BIP errors
- DWDM receiver with operable over the range 0 to -20 dBm
- Client Automatic Laser Shutdown (ALS) system
- Receive and transmit client SDH/SDH traffic monitoring for B1 errors and J0 section trace
- Client diagnostic loop-backs (client receive to client transmit) with full jitter reduction.

In the direction from client, the transponder accepts a low-level digital optical signal of any wavelength in the region of 1300-1600nm. By means of an optical-electrical-optical process, it interleaves a digital overhead and produces a high level digital optical signal on an accurately controlled specific wavelength. The digital overhead includes Forward Error Correction (FEC) coding and a path overhead. Full clock re-timing is included to ensure a nominally jitter-free output signal suitable for onward transmission over a number of optically amplified fibre sections.

In the direction to the client, it accepts a noisy, low-level digital NRZ optical signal of a specific wavelength in the region of 1529.55nm to 1561.01nm. By means of an optical-electrical-optical process, it removes the overhead, extracting the path overhead and correcting errors using the FEC algorithm and produces a nominally noise and jitter-free, high level digital optical signal to present to the client.

The path overhead processing allows for monitoring of any errors introduced over the DWDM optical network as well as providing for optical path trace labelling. The transponder incorporates an Automatic Laser Shutdown mechanism on the client interface, which is designed to shut down the client laser in the event of a fibre break, in the interests of safety.

3.21.1 Optical Interfaces

Both client and WDM optical connections are made on the front panel using downward pointing shuttered connectors to maximise optical safety.

3.21.2 2.5G NRZ SR Transponder LEDs

Table 3-48: 2.5G NRZ SR Transponder LEDs

Colour	Name	Managed/Unmanaged	Function
Green	Power	Unmanaged	Lit when all on-board power supplies are on and functioning correctly.
Red	Fault	Managed	Lit to indicate an alarm condition.
Amber	In traffic	Managed	Lit to indicate that the card is functioning and is activated to carry traffic.
Amber	Test	Managed	Lit to indicate that the client laser is activated because a client ALS 'manual restart for test' is in operation.

3.21.3 2s 90s Push Button

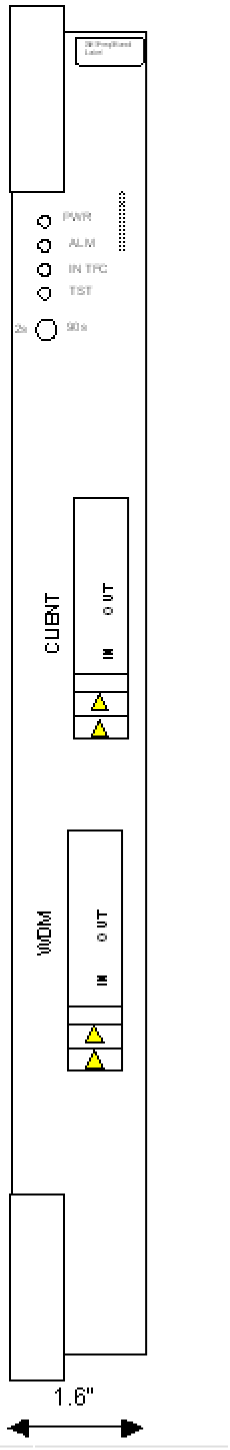
The push button, labelled as '2s 90s' on the front panel, initiates a two-second client ALS 'manual restart' when pressed and released. The button initiates a 90-second 'manual restart for test' when pressed and held for more than twelve seconds.

Note: The push button only works when ALS has been activated; it is inoperable during normal operation.

3.21.4 Labels

- Optical warning label (Hazard Level 1)
- SE/Freq./Band label.

Figure 3-42: 2.5G NRZ Transponder Unit



Note: Due to the front plug-up nature of the transponders, it is always imperative to have the cross-connection for a particular channel removed before physical connection of the WDM LC connectors. This prevents unwanted errors on present traffic due to the sudden addition of light. For commissioning from scratch, this is unlikely to be an issue, but should be regarded as “best practice” nonetheless.

3.22 2.5G Metro NRZ-HP Transponder Units (G.709 High Power Metro)

The NRZ-HP transponder is a tributary unit that performs client to DWDM channel adaptation.

The main features of the transponder are as follows:

- ITU-T G.957 compliant, S-16.1 client interface with front panel optical connectors
- Proprietary 2.666Gbps DWDM interface with optical front-plane connectors. Interface will support ITU-T G.709 compliant signals
- Proprietary Reed Solomon (255,239) FEC encoding/decoding providing error correction at the DWDM port with a FEC gain of greater than 5.5 dB
- Receive digital wrapper monitoring for payload BIP errors
- DWDM receiver operates over the range 0 to -26 dBm
- Client Automatic Laser Shutdown (ALS) system
- Receive and transmit client SDH/SDH traffic monitoring for B1 errors and J0 section trace
- Client diagnostic loop-backs (client receive to client transmit) with full jitter reduction.

In the direction from client, the transponder accepts a low-level digital optical signal of any wavelength in the region of 1300-1600nm. By means of an optical-electrical-optical process, it interleaves a digital overhead and produces a high level digital optical signal on an accurately controlled specific ITU wavelength. The digital overhead includes Forward Error Correction (FEC) coding and a path overhead. Full clock re-timing is included to ensure a nominally jitter-free output signal suitable for onward transmission over a number of optically amplified fibre sections.

In the direction from the client, it accepts a low-level digital NRZ optical signal of a specific ITU wavelength in the region of 1529.55nm to 1561.01nm. By means of an optical-electrical-optical process, it removes the overhead, extracting the path overhead and correcting errors using the FEC algorithm and produces a nominally noise and jitter-free, high level digital optical signal to the client.

The path overhead processing allows for monitoring of any errors introduced over the DWDM optical network as well as providing optical path trace labelling. The transponder incorporates an Automatic Laser Shutdown mechanism on the client interface, which is designed to shut down the client laser in the event of a fibre break, in the interests of safety.

3.22.1 Optical Interfaces

Both client and WDM optical connections are made on the front panel using downward pointing shuttered connectors to maximise optical safety.

3.22.2 2.5G NRZ SR Transponder LEDs

Table 3-50: 2.5G NRZ SR Transponder LEDs

Colour	Name	Managed/Unmanaged	Function
Green	Power	Unmanaged	Lit when all on-board power supplies are on and functioning correctly.
Red	Fault	Managed	Lit to indicate an alarm condition.
Amber	In traffic	Managed	Lit to indicate that the card is functioning and is activated to carry traffic.
Amber	Test	Managed	Lit to indicate that the client laser is activated because a client ALS 'manual restart for test' is in operation.

3.22.3 2s 90s Push Button

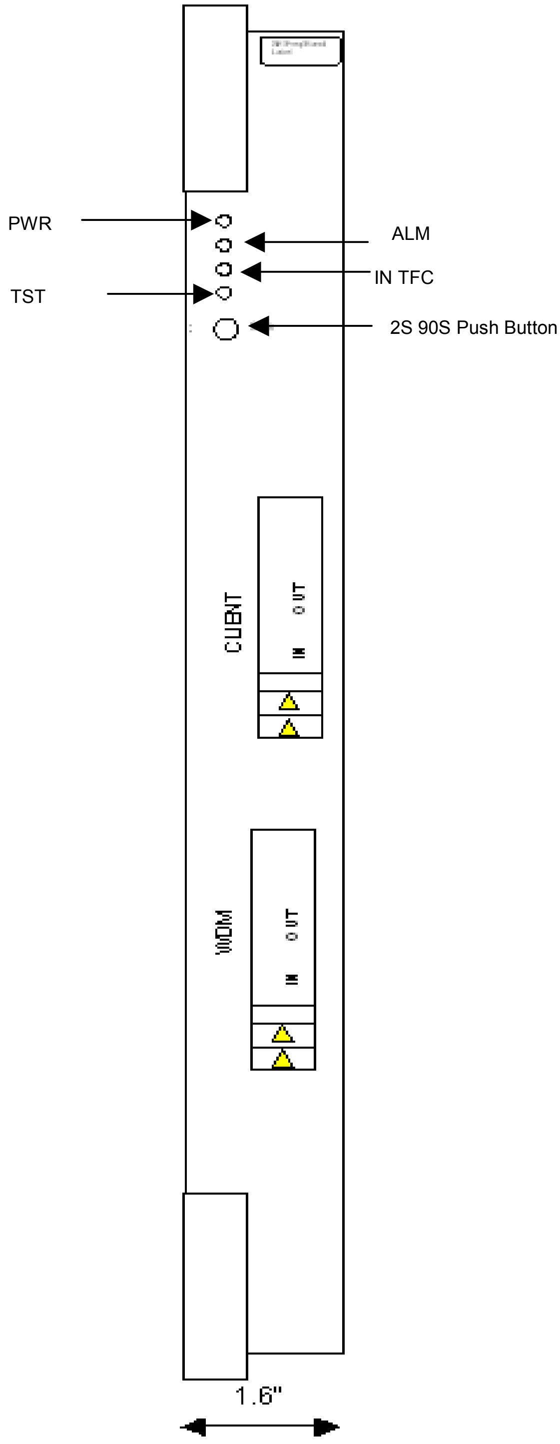
The push button, labelled as '2s 90s' on the front panel, initiates a two-second client ALS 'manual restart' when pressed and released. The button initiates a 90-second 'manual restart for test' when pressed and held for more than twelve seconds.

Note: The push button only works when ALS has been activated; it is inoperable during normal operation.

3.22.4 Labels

- Optical warning label (Hazard Level 1)
- SE/Freq./Band label.

Figure 3-44: 2.5G Metro NRZ Transponder Unit



Note: Due to the front plug-up nature of the transponders, it is always imperative to have the cross-connection for a particular channel removed before physical connection of the WDM LC connectors. This prevents unwanted errors on present traffic due to the sudden addition of light. For commissioning from scratch, this is unlikely to be an issue, but should be regarded as “best practice” nonetheless.

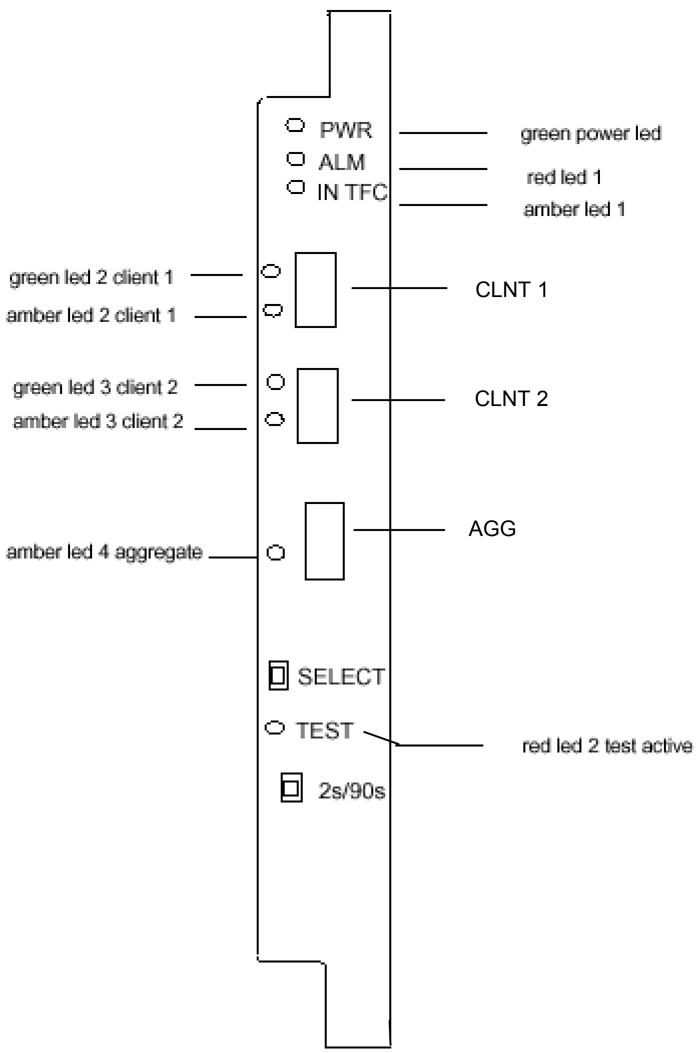
3.23 2.5G Dual Gig E Multiplexer Card SX Variant

This multiplexing unit is similar to the LX Variant, except that this variant operates at 850nm and is intended for short haul applications. The following descriptions are also applicable to this variant.

3.24 2.5G Dual Gig E Multiplexer Card LX Variant

The 2.5G Dual Gig E Multiplexer Card is used in conjunction with 2G5 Gigabit Transponder. This Multiplexing unit packet interleaves/deinterleaves two asynchronous Gigabit Ethernet optical interfaces together in order to produce a standard concatenated STM–16/OC–48 optical payload. This signal is then fed in to a 2G5 transponder, which converts from a grey wavelength to a colored one. Transparency is maintained for both Gigabit Ethernet signals carried between system nodes. The purpose of this card is to utilize bandwidth at 2.5Gb/s, which in turn reduces the inherent cost of Gigabit Ethernet circuits. This variant of the card operates at1310nm and is intended for long haul applications.

Figure 3-45: 2.5G Dual Gig E Multiplexer Card Front Fascia



3.24.1 2.5G Dual Gig E Multiplexer Card LEDs (T4)

Table 3-51: 2.5G Dual Gig E Multiplexer Card LEDs

Name	Colour	Function
PWR (Power)	Green LED 1	Lit when all on-board power supplies are on and functioning correctly.
ALM (Alarm)	Red LED 1	Indicates unit failure
IN TFC (In Traffic)	Amber LED 1	Indicates unit in traffic (i.e. do not remove from shelf).
CLNT1 (Client Port 1)	Amber LED 2	Test Select Indicator Client 1 (Flashing)/In Traffic (Full Illumination)
CLNT1 (Client Port 1)	Green LED 2	Test Select Indicator Client 1 (Flashing)/In Traffic (Full Illumination
CLNT2 (Client Port 2)	Amber LED 3	Test Select Indicator Client 1 (Flashing)/In Traffic (Full Illumination
CLNT2 (Client Port 2)	Green LED 3	Test Select Indicator Client 1 (Flashing)/In Traffic (Full Illumination
AGG (Aggregate)	Amber LED 4	Test Select Indicator Aggregate
TST (Test)	Red LED 2	Indicates laser test active

3.24.2 Select Push Button

Initiates ALS restart or test override for optical interface n, where n=1,2,3, (press and hold for >12s)

3.24.3 2s 90s Push Button

When depressed the amber LED that was flashing previously becomes extinguished, and the next amber LED starts flashing indicating the next optical port that is selected. Applicable to Amber LED's 2 to 4 inclusive.

3.24.4 Labels

- Optical warning label (Hazard Level 1)

3.24.5 2.5G Dual Gig E Multiplexer Card Optical Interfaces

Interface connectors listed in Table 3-52 are provided on the front fascia of the 2.5G Dual Gig E Multiplexer Card, which provide the following signal interfaces

- 2 Gigabits Ethernet In/Out
- 1 x 2G5 (proprietary) In/Out.

Table 3-52: 2.5G Dual Gig E Multiplexer Card Optical Interfaces

Connector	Function
CLNT1 (connectors 2 x LC)	Client optical input/output
CLNT2 (connectors 2 x LC)	Client optical input/output
AGG (connectors 2 x LC)	Client optical input/output

3.25 2.5G TDM Multiplexer Card

This Multiplexing Unit is used in conjunction with an unprotected 2.5G transponder. The Multiplexing Unit byte interleaves/deinterleaves four asynchronous 155/622Mbits/s optical interfaces together to produce a non–standard 2.5Gbits/s optical signal based on an STM–16/OC–48 frame. This signal is then fed into a 2.5G transponder, which converts from a grey wavelength to a colored one. The purpose of this card is to optimise wavelength usage

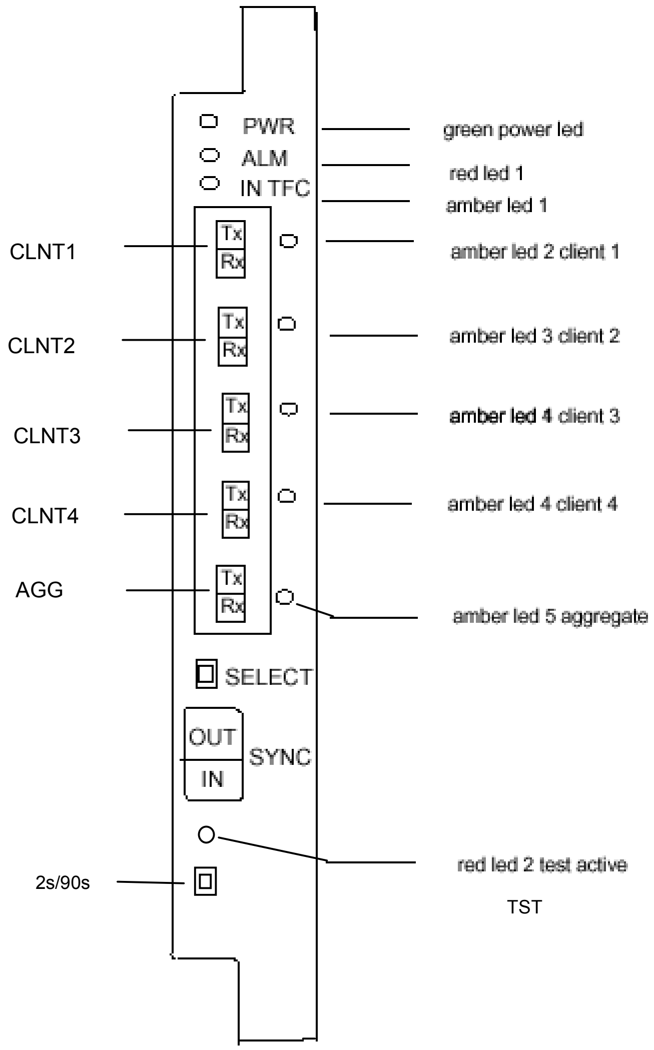
The multiplex system is based on the standard SDH multiplexing scheme with payload pointer processing etc. If the input signals are not synchronized with each other, then the multiplex rate pointer adjustment will occur in the normal fashion. The multiplex rate can be configured to be taken from any one of the input signals (or internally).

Unlike a normal SDH multiplex, the section overheads are not terminated, but transported using some of the spare bytes in the resulting multiplexed frame. The section overheads do not have a pointer mechanism and cannot be rate adjusted in the same way as the payload, so occasional overhead frame slips will occur. Generally this is not a problem as individual bytes of a critical nature are normally protected by a persistency check or, as in the case of the DCC, by retransmission (at the link layer).

B1 and B2 bytes are recalculated as part of the pointer processing and multiplexing operation. Error rate transparency with B1 and B2 on each client port is maintained by manipulation of these bytes in the multiplexer units. The error rate sent into a multiplexer port will be propagated to the far end of the network. If any additional errors were to occur, these would also be accumulated.

Rate adjustment is only carried out in the multiplexing process and not in the demultiplexing process.

Figure 3-46: 2.5G TDM Multiplexer Card Front Fascia



3.25.1 2.5G TDM Multiplexer Card LEDs (T4)

Table 3-53: 2.5G TDM Multiplexer Card LEDs

Name	Colour	Function
PWR (Power)	Green LED 1	Lit when all on-board power supplies are on and functioning correctly.
ALM (Alarm)	Red LED 1	Indicates unit failure
IN TFC (In Traffic)	Amber LED 1	Indicates unit in traffic (i.e. do not remove from shelf).
CLNT1 (Client Port 1)	Amber LED 2	Client port 1 selected when lit with respect to ALS restart or test override.
CLNT2 (Client Port 2)	Amber LED 3	Client port 2 selected when lit with respect to ALS restart or test override
CLNT3 (Client Port 3)	Amber LED 4	Client port 3 selected when lit with respect to ALS restart or test override
CLNT4 (Client Port 4)	Amber LED 5	Client port 4 selected when lit with respect to ALS restart or test override
AGG (Aggregate)	Amber LED 6	Server interface selected when lit with respect to ALS restart or test override.
TST (Test)	Red LED 2	Indicates laser test active

3.25.2 Select Push Button

Initiates ALS restart or test override for optical interface n, where n=1,2,3,4 or 5 (press and hold for >12s)

3.25.3 2s 90s Push Button

When depressed the amber LED that was flashing previously becomes extinguished, and the next amber LED starts flashing indicating the next optical port that is selected. Applicable to Amber LED’s 2 to 6 inclusive.

3.25.4 Labels

- Optical warning label (Hazard Level 1)

3.25.5 2.5G TDM Multiplexer Card Optical Interfaces

Interface connectors listed in Table 3-52 are provided on the front fascia of the 2.5G TDM Multiplexer Card, which provide the following signal interfaces

- 4 x STM–1/4 In/Out
- 1 x 2G5 (proprietary) In/Out

Table 3-54: 2.5G TDM Card Optical Interfaces

Connector	Function
CLNT1 (connectors 2 x LC)	Client optical input/output
CLNT2 (connectors 2 x LC)	Client optical input/output
CLNT3 (connectors 2 x LC)	Client optical input/output
CLNT4 (connectors 2 x LC)	Client optical input/output
AGG (connectors 2 x LC)	Client optical input/output

3.25.6 2.5G TDM Multiplexer Card Electrical Synchronisation Interfaces

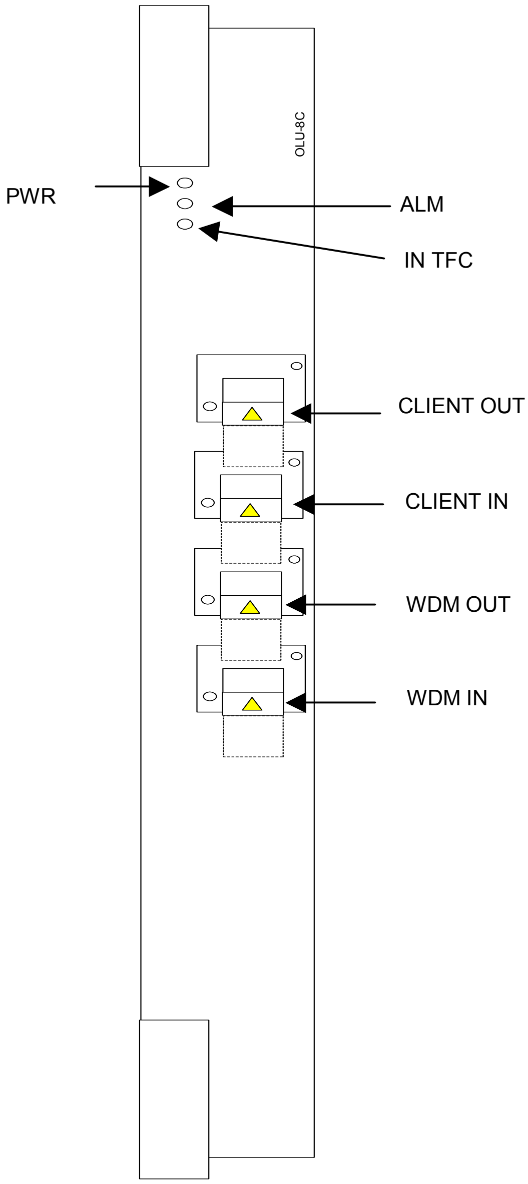
Table 3-55: 2.5G TDM Multiplexer Card Electrical Synchronisation Interfaces

SYNC Connector	Function
OUT (RJ45)	Connector used for balanced and unbalanced external synchronization outputs
IN (RJ45)	Connector used for balanced and unbalanced external synchronization inputs

3.26 Optical Levelling Unit (OLU-8)

Optical Levelling Unit (OLU) allows the interfacing of up to 8 compatible coloured clients without the need for a transponder. In the path from Client IN to WDM OUT the optical power is controlled by a VOA (levelled). The VOA attenuation is either controlled manually by LCT, or by the PMU within the Multihaul node. The path from WDM IN to Client OUT is not optically controlled but is just monitored (passive).

Figure 3-47: Optical Levelling Unit (OLU-8)



3.26.1 Optical Levelling Unit LEDs

There are three LEDs mounted on the unit front plate.

Table 3-56: Optical Levelling Unit LEDs

Name	Colour	Description
Power	Green	Lit when all on-board power supplies are on and functioning correctly. LED is OFF If one of the supply rails fail.
Alarm	Red	Lit to indicate an alarm condition. LED active under important alarm active conditions. The LED is Under microprocessor control
In traffic	Amber	Lit to indicate that the card is functioning and is activated to carry traffic. The LED is under microprocessor control.

3.26.2 Optical Interfaces

All optical connections are made on the front fascia using downward pointing shuttered MTP connectors to maximise optical safety. The client's coloured optical source and receiver are connected to the CLIENT IN and CLIENT OUT ports while the WDM IN and OUT ports are connected to the multiplexer unit, which corresponds to the same wavelength as the client.

Cross-connection operation is achieved when each wavelength is associated to each OLU-8 channel (e.g. channel 24 to port 8). If the optical connection between the OLU-8 and the Mutiplexer/DeMultiplexer unit is via an MTP-MTP patchcord then the cross-connection is determined by the port on the Mutiplexer/DeMultiplexer.

If the hydra cables (MTP-SC) are used then cross connections can be assigned to any channel. This configuration is useful when the transponder and client coloured optics are used together.

3.26.3 OLU-8 Shutter Configuration

It is possible for the user to set a single parameter for the Shutter mode of an OLU-8 unit. The shutter mode applies to all of the client ports of the OLU-8 unit. When the shutter mode is set to enabled (Default) and if a client port receives LOS on its input then the shutter on its WDM output is closed (VOA set to maximum attenuation). The shutter remains closed for 10 seconds after the LOS on its client input has cleared. The shutter is always open if the shutter mode is set to disabled. If a port is disabled then the shutter is automatically set to closed.

If the electrical power of the unit is lost (e.g. failure or simply because the unit is not fitted in to the subrack with the optical connections.), then the shutter is closed (the VOA has maximum attenuation on loss of power).

3.27 10G RZ Muxponder Unit

The 10G RZ TDM Muxponder Unit is a single-slot unit that allows multiplexing up to four STM16 data streams into a full standard G.709 OTU2 signal mapped as ODTU12.

The card has four ports, where optical transceivers (SFP modules) can be inserted, which enable the card to support STM-16 signals with different optical reaches. This provides a high degree of flexibility both in terms of traffic management and fibre link length.

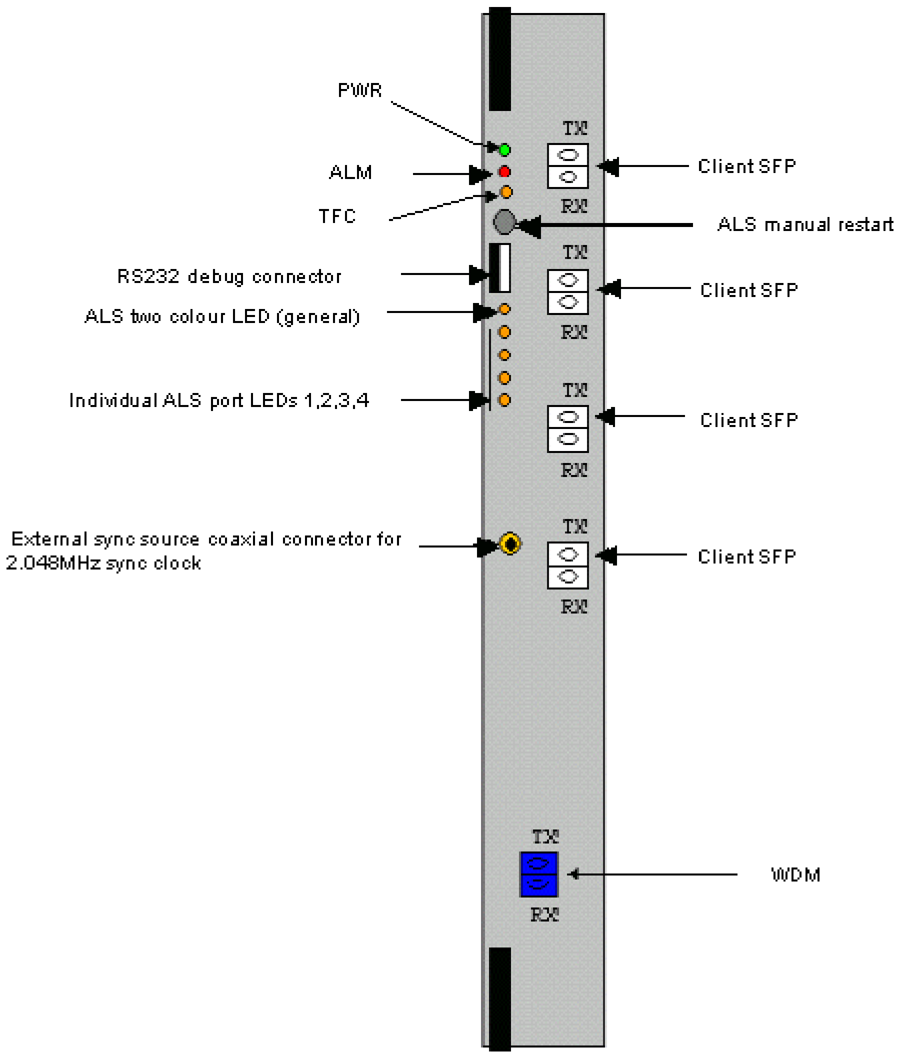
At the WDM side, the 10Gb/s optical module the following options are available:

- 10Gbit/s RZ module, tunable laser

3.27.1 10G RZ Muxponder Front Panel Description

Figure 3-49 shows the front fascia of the 10G RZ Muxponder Unit.

Figure 3-49: 10G RZ Muxponder Front Fascia



Note: ALS manual restart button is not supported but it is available via JCT.

3.27.2 10G RZ Muxponder Front Panel Indications

There are four LEDs on the front fascia of the unit as described in Table 3-58.

Table 3-58: 10G RZ Muxponder LEDs

Name	Colour	Description
Power	Green	Lit when all on-board power supplies are on and functioning correctly.
Alarm	Red	Lit to indicate an alarm condition.
In traffic	Amber	In a card protection scheme, the LED indicates which card (worker or protection) is currently carrying traffic. On warm restart, the LED is given by the software the state it had before the software reset (LED on if unit was equipped). This is to take in account that the card could be still carrying traffic
ALS	Two Colours Amber/Red	This LED is lit Amber if any of the client ports is emitting light for laser restart activity. It is lit Red, if any of the client ports is emitting light for laser test activity. This will be illuminated for 90 seconds If any port is being laser tested, the period over which the laser will be on; otherwise it will be lit for the whole time in which at least a port is under test activity.

3.27.3 External Synchronisation Source Coaxial Connector

10G TDM Muxponder provides a coaxial connector for external synchronisation input on the front fascia of the unit. The external synchronisation input port supports the following synchronisation signals. These are configurable via JCT/MT:

- 2.048MHz Clock (conforming to G.703 sec. 13 – balanced, unbalanced, high impedance

3.27.4 Pluggable SFP Modules

10G TDM Muxponder provides SFP modules for the four client interfaces. In this release only S16.1 (15km) option is supported.

3.28 10G NRZ Muxponder Unit

The 10G NRZ TDM Muxponder Unit is a single-slot unit that allows multiplexing up to four STM16 data streams into a full standard G.709 OTU2 signal mapped as ODTU12.

The card has four ports, where optical transceivers (SFP modules) can be inserted, which enable the card to support STM-16 signals with different optical reaches. This provides a high degree of flexibility both in terms of traffic management and fibre link length.

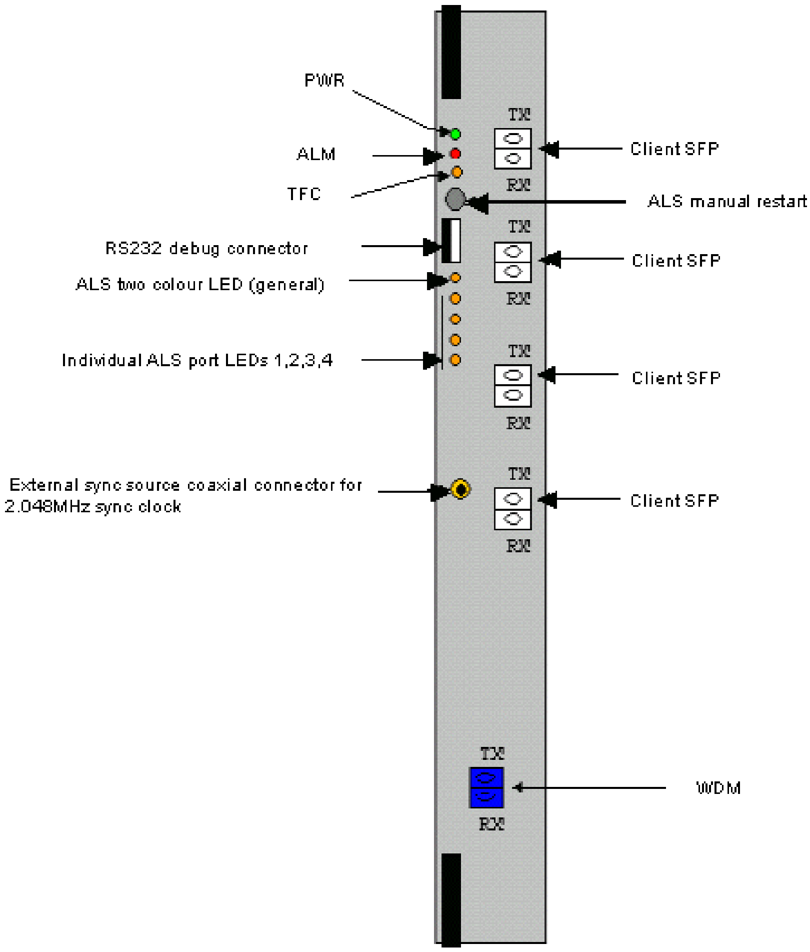
At the WDM side, the 10Gb/s optical module the following options are available:

- 10Gbit/s NRZ module, tuneable laser

3.28.1 10G NRZ Muxponder Front Panel Description

Figure 3-51 shows the front fascia of the 10G NRZ Muxponder Unit.

Figure 3-51: 10G NRZ Muxponder Front Fascia



Note: ALS manual restart button is not supported but it is available via JCT.

3.28.2 10G NRZ Muxponder Front Panel Indications

There are four LEDs on the front fascia of the unit as described in Table 3-60.

Table 3-60: 10G NRZ Muxponder Front Panel Indications

Name	Colour	Description
Power	Green	Lit when all on-board power supplies are on and functioning correctly.
Alarm	Red	Lit to indicate an alarm condition.
In traffic	Amber	In a card protection scheme, the LED indicates which card (worker or protection) is currently carrying traffic. On warm restart, the LED is given by the software the state it had before the software reset (LED on if unit was equipped). This is to take in account that the card could be still carrying traffic
ALS	Two Colours Amber/Red	This LED is lit Amber if any of the client ports is emitting light for laser restart activity. It is lit Red, if any of the client ports is emitting light for laser test activity. This will be illuminated for 90 seconds If any port is being laser tested, the period over which the laser will be on, otherwise it will be lit for the whole time in which at least a port is under test activity.

3.28.3 External Synchronisation Source Coaxial Connector

10G TDM Muxponder provides a coaxial connector for external synchronisation input on the front fascia of the unit. The external synchronisation input port supports the following synchronisation signals. These are configurable via JCT/MT:

- 2.048MHz Clock (conforming to G.703 sec. 13 – balanced, unbalanced, high impedance

3.28.4 Pluggable SFP Modules

10G TDM Muxponder provides SFP modules for the four client interfaces. In this release only S16.1 (15km) option is supported.

3.29 3 Port Add Drop Multiplex Unit

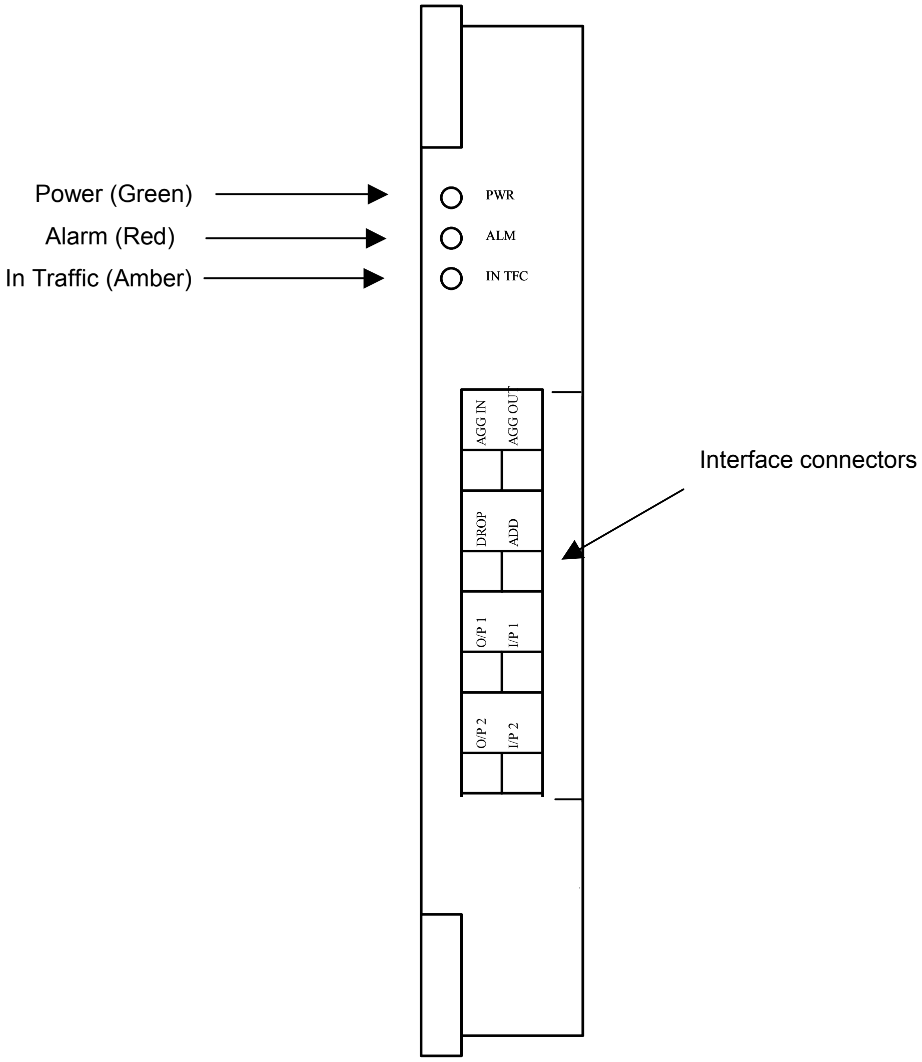
The three port Add/Drop Multiplex unit provides taps for dropping and adding traffic in a number of line directions, as well as detectors and shutters needed to guarantee EDFA shutdown in the instances of fibre breaks. The unit allows add and drop accesses to through traffic travelling in a node having three WDM ports; East, West and South.

The card comprises power splitting/coupling functions with optical power monitors and optical shutters under hardware control. 3dB couplers are used on both the Add and drop side to divide/combine two paths of traffic.

Note: A fully assembled unit weighs approximately 3 kg.

3.29.1 Front Panel Description

Figure 3-53: 3 Port Add Drop Multiplex Unit Front Fascia



3.29.2 3 Port Add Drop Unit Front Indications

There are three LEDs on the front fascia of the unit. Two of these are under the direct control of the microprocessor. The third LED indicates the state of all the on-board power supply rails see Table 3-62.

Table 3-62: 3 Port Add Drop Unit LEDs

Name	Colour	Description
Power	Green	Lit when all on-board power supplies are on and functioning correctly. LED is OFF If one of the supply rails fail.
Alarm	Red	Lit to indicate an alarm condition. LED active under important alarm active conditions. The LED is Under microprocessor control
In traffic	Amber	Lit to indicate that the card is functioning and is activated to carry traffic. The LED is under microprocessor control.

3.29.3 Interface Connectors and Signals

Table 3-64: Connectors and Signals

Connector	Signal
AGG IN	Aggregate IN
AGG OUT	Aggregate OUT
ADD	Add Channels
DROP	Drop Channels
I/P 1	Input 1
O/P 1	Output 1
I/P 2	Input 2
O/P 2	Output 2

I/P3 and O/P3 are not connected in 1HAT61121ACM version

3.30 Channel Control Unit (CCU80)

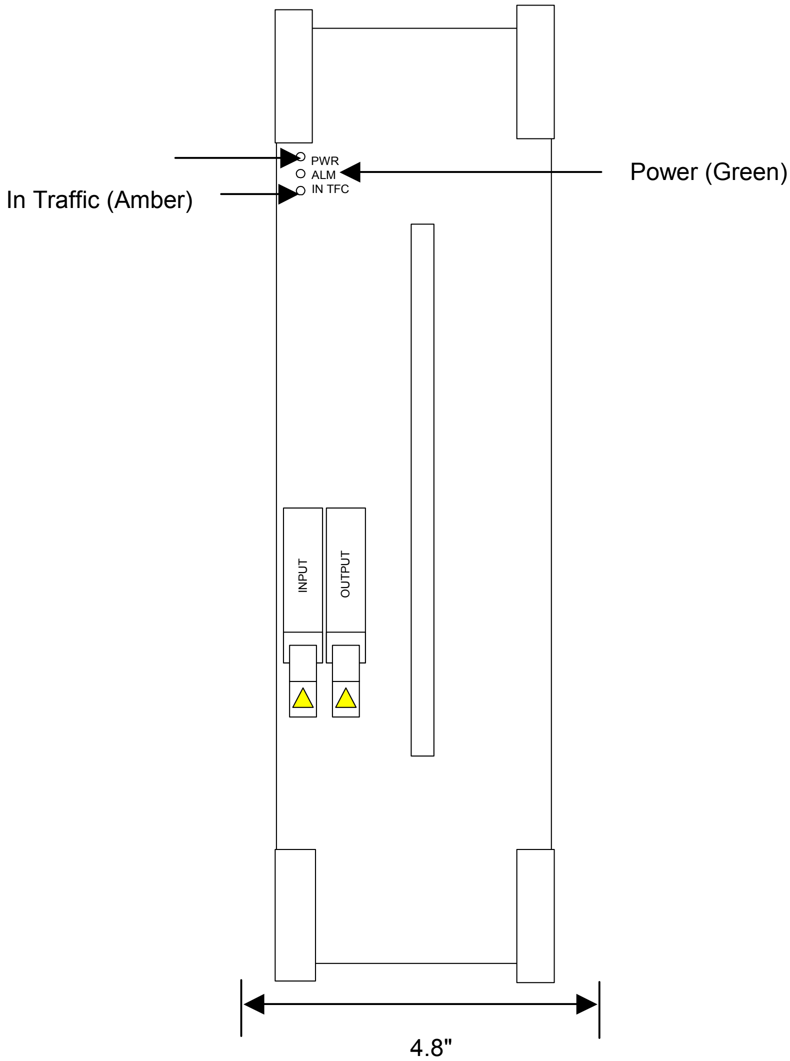
Single path Channel Control (CCU80) unit 1HAT61119ADG uses an 80-channel, 50GHz Dynamic Channel Blocker and Equaliser module (DCBE). The unit width is 122mm (4.8”) and weighs 3.5Kg (approx).

The Single Path CCU performs the following basic functions

- Attenuate any number of optical channels for levelling or blocking.
- Provision of microprocessor-based alarms.
- Inventory Data Storage.
- Calibration Storage.
- Fibre Management.

3.30.1 Channel Control Unit (CCU80) Front Fascia

Figure 3-55: Channel Control Unit (CCU80) Front Fascia



3.30.2 Channel Control Unit (CCU80) Unit LEDs

There are three LEDs on the front fascia of the unit. Two of these are under the direct control of the microprocessor. The third LED indicates the state of all of the on-board power supply rails. Description and the functionality of each LEDs is as in Table 3-66

Table 3-66: CCU80 Unit LEDs

Name	Colour	Description
Power	Green	Lit when all on-board power supplies are on and functioning correctly. LED is OFF If one of the supply rails fail.
Alarm	Red	Lit to indicate an alarm condition. LED active under important alarm active conditions.
In traffic	Amber	Lit to indicate that the card is functioning and is activated to carry traffic.

3.31 2Skip0 Filter Tray

2Skip0 Filter Tray is used in a 100GHz spaced DWDM system using 24 ITU wavelengths, extending from ITU-T frequency 192.1 THz to 194.4 THz inclusive. In normal operation its fibres are connected using low loss SC/UPC and LC/UPC connectors. As shown in Figure 3-58 the filter is housed in a tray with SC/SC and LC/LC adapters and fibres management parts.

Note: There are no electrical connections to the filter It is a purely optical device.

The 2 Skip0 filter tray is fitted in a dedicated 4 Draw Fibre Management Subrack and provides the following provisions: -

- 2-channel (4-port) 100GHz Drop section – containing a broadband 2-channel filter (2Skip0) and two subtended single channel filters (Drop channels XX and XX+1).
- 2-channel (4-port) 100G Add section – as per Drop filter module but with channels XX and XX+1 ports reversed (for loss matching). XX = ITU-T 1st of 2 Add/Drop channel numbers.
- SC/SC and LC/LC adapters (blue coloured) for all connectors are provided.
- Protection for 900 µm fibre from the OADM to the SC/SC and LC/LC adapters is provided. This protection is removeable to inspect and clean OADM connectors
- Fibre entrance is provided on both sides of the tray.
- It is possible to route any fibre entering from both entrance to any adapters fixed on the tray
- Fibre Cable protection chains are provided to protect the bend radius
- Storage facility for external fibre is provided for cables entering from the two sides

3.31.1 2skip0 Filter Tray Functionality

Figure 3-57 Shows a schematic block diagram of a 2 channels 2skip0 filter tray.

Figure 3-57: Schematic Block Diagram of 2 channels 2skip0 Filter Tray

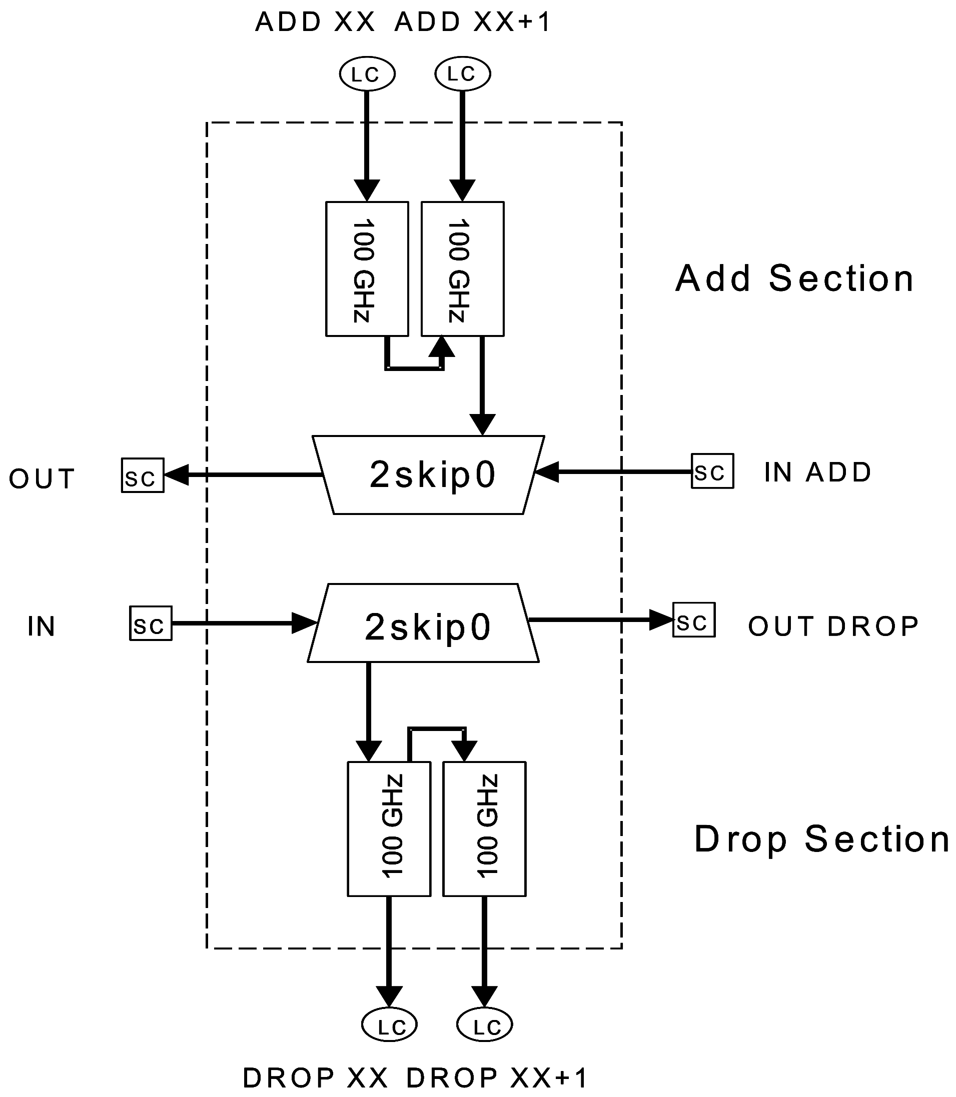
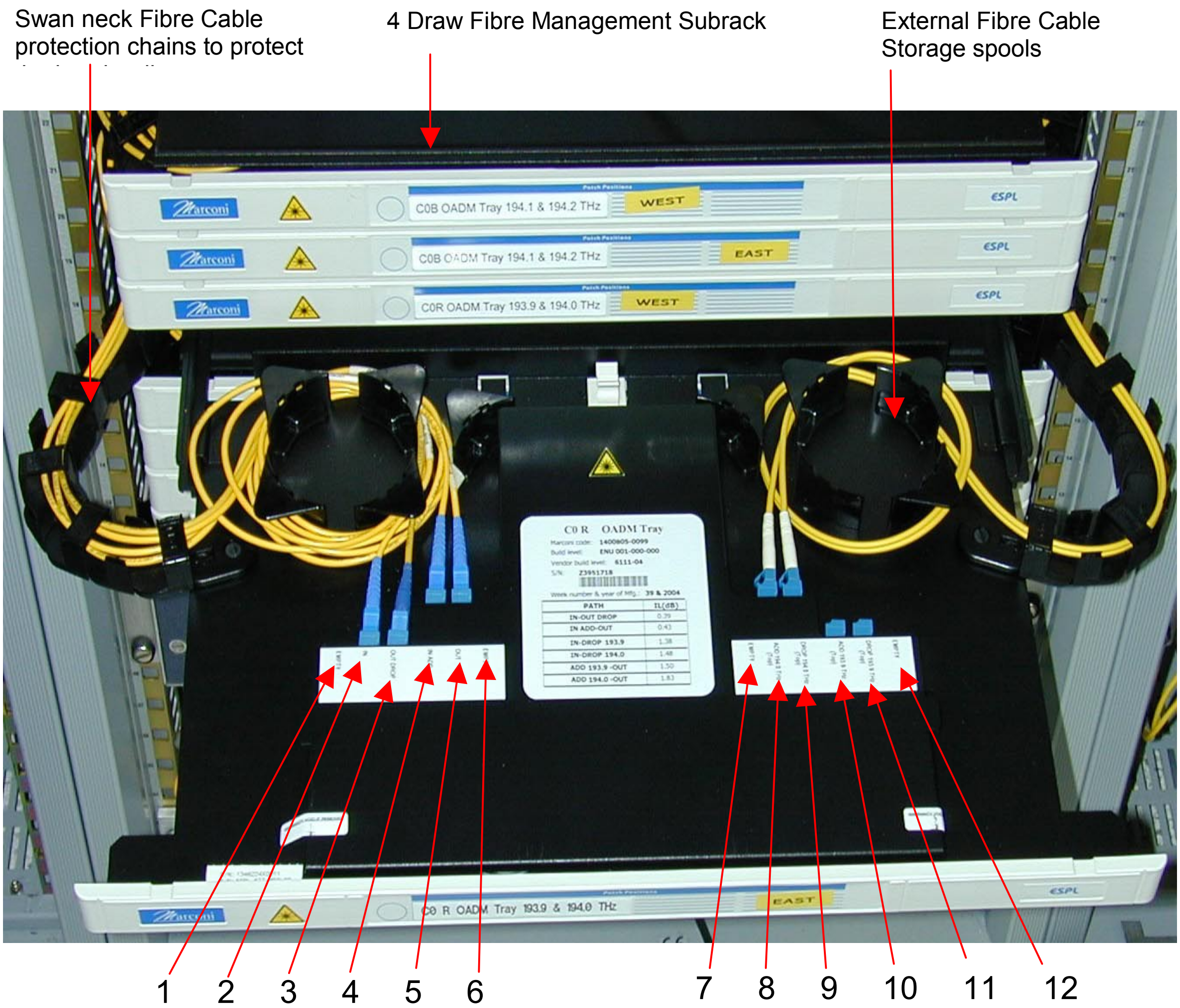


Figure 3-58: 2Skip0 Filter Trays In a 4 Draw Fibre Management Subrack



Slot Numbers see Table 3-68 **Slot Numbers see** Table 3-68

3.31.2 2Skip0 Filter Tray 12 Slot Assignments and Connector Types

Looking at the tray from the front-top, from the left to the right, the 12 slots for adapters are used as listed in Table 3-68.

Table 3-68: 2Skip0 Filter Tray 12 Slot Assignments and Connector Types

Slot Number	Lable Assignment	Connector type
1	Empty	NA
2	IN	SC/SC
3	OUT DROP	SC/SC
4	IN ADD	SC/SC
5	OUT	SC/SC
6	Empty	NA
7	Empty	NA
8	Empty/ ADD XX+1 (TOP) *	NA/ Duplex LC/LC
9	ADD XX+1 (TOP) (e.g. ADD 194.4 THz (TOP)) DROP XX+1 (BOTTOM) (e.g. DROP 194.4 THz (BOTTOM)) DROP XX+1 (TOP)*	Duplex LC/LC
10	ADD XX (TOP) (e.g. ADD 194.3 THz (TOP)) DROP XX (BOTTOM) (E.g. DROP 194.3 THz (BOTTOM)	Duplex LC/LC
11	Empty/ DROP XX (TOP)*	NA/ Duplex LC/LC
12	Empty	NA

1 LC latches and SC keys are placed on the left hand for adapters in slot positions from 1 to 6 (left side of the tray, looking at it from the front-top) and on the right hand for positions from 7 to 12 (right side of the tray).

2 * Due to different suppliers slot assignment may vary.

3.32 OSC Filter Tray

The OSC Filter Tray is used to remove or insert as required a management channel, known as the Optical Supervisory Channel (OSC), from or to the CWDM and DWDM wavelengths in the MHL system, operating at 1510 nm.

In normal operation its fibres are connected using low loss SC/UPC connectors. A couple of identical filters, one for the Drop function and the other one for the Add function is housed in a tray with SC/SC adapters and fibres management parts.

As shown in Figure 3-58 the filter is housed in a tray with SC/SC and LC/LC adapters and fibres management parts.

Note: There are no electrical connections to the filter It is a purely optical device.

The 2 Skip0 filter tray is fitted in a dedicated 4 Draw Fibre Management Subrack and provides the following provisions: -

- OSC 1 (3-port) Add/Drop section. Black arrows show the Add function, dashed ones the Drop one.
- OSC 2 (3-port) Add/Drop section. Black arrows show the Drop function, dashed ones the Add one.
- SC/SC and LC/LC adapters (blue coloured) for all connectors are provided.
- Protection for 900 µm fibre from the OADM to the SC/SC and LC/LC adapters is provided. This protection is removeable to inspect and clean OADM connectors
- Fibre entrance is provided on both sides of the tray.
- It is possible to route any fibre entering from both entrance to any adapters fixed on the tray
- Fibre Cable protection chains are provided to protect the bend radius
- Storage facility for external fibre is provided for cables entering from the two sides
- The OSC filter fits into 4 Draw Fibre Management Subrack.

3.32.1 OSC Filter Tray Functionality

Figure 3-57 shows a schematic block diagram of a 2 channels OSC filter tray.

Figure 3-59: Schematic Block Diagram of 2 channels OSC Filter Tray

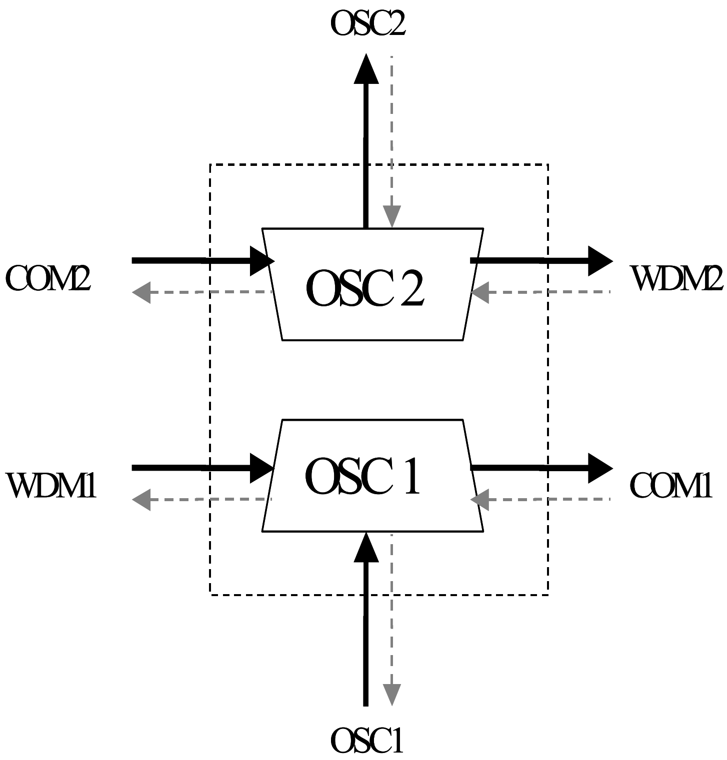
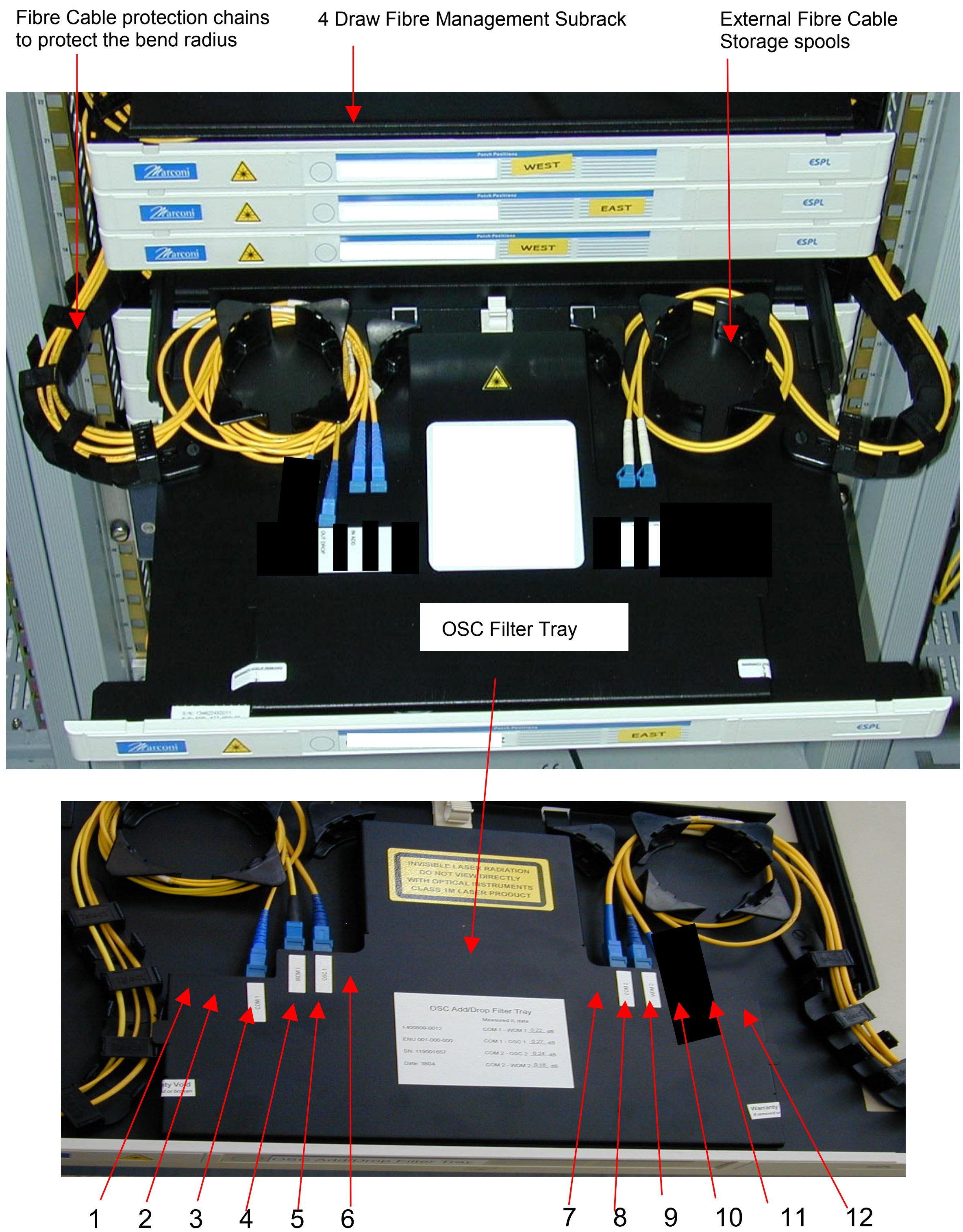


Figure 3-60: OSC Filter Trays In a 4 Draw Fibre Management Subrack



Slot Numbers see Table

Slot Numbers see Table

3.32.2 OSC Filter Tray 12 Slot Assignments and Connector Types

Looking at the tray from the front-top, from the left to the right, the 12 slots for adapters are used as listed in Table 3-68.

Note: SC keys have to be placed on the left hand for adapters in slot positions from 1 to 6 (left side of the tray, looking at it from the front-top) and on the right hand for positions from 7 to 12 (right side of the tray).

Table 3-69: OSC Filter Tray 12 Slot Assignments and Connector Types

Slot Number	Lable Assignment	Connector type
1	COM 1	SC/SC
2	WDM 1	SC/SC
3	OSC 1	SC/SC
4	Empty	NA
5	Empty	NA
6	Empty	NA
7	Empty	NA
8	Empty	NA
9	Empty	NA
10	COM 2	SC/SC
11	WDM 2	SC/SC
12	OSC 2	SC/SC

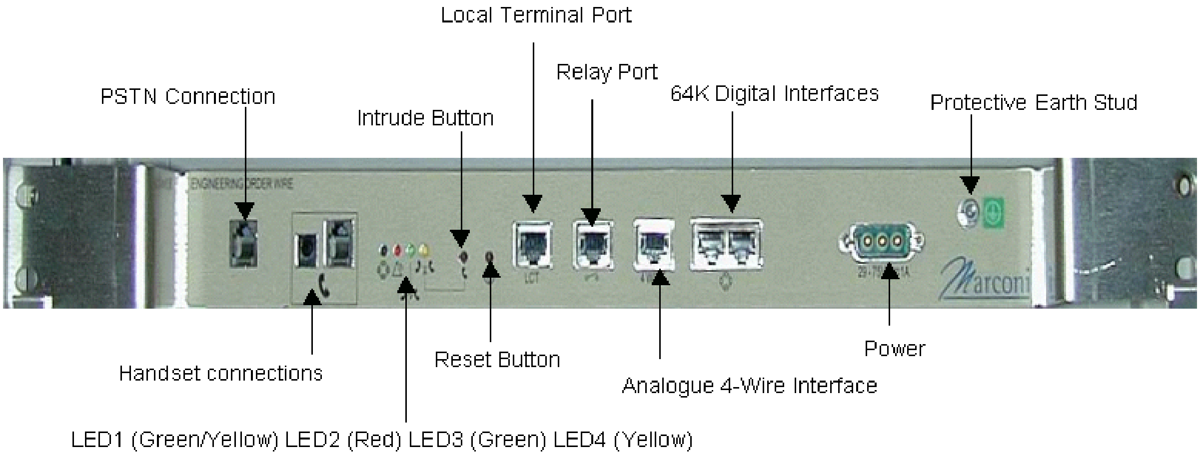
3.33 PSTN Engineers Order Wire (EOW) Unit

The EOW Unit is a stand-alone unit, designed to interface to the Multihaul MH3000 to provide EOW Unit functions between nodes and across the network when external PSTN access is required. It is also possible for an PSTN caller provided with the dedicated PSTN line number and the node number required at the secondary dial tone to dial in to the EOW network and connect to any other EOW within the network.

3.33.1 PSTN EOW Unit Front Panel Description

Table 3-70 shows the front fascia layout of EOW Unit:

Table 3-70: EOW Unit Front Fascia Layout



3.34 EOW Unit General Specification

EOW Unit General Specification is as in Table 3-72.

Table 3-72: EOW Unit General Specification

EOW Unit t	Specification
Enclosure	1U aluminium enclosure with dual-purpose brackets for ETSI and 19" rack-mounting practices. The unit (without brackets) is 44mm high, 396mm wide and 75mm deep
Weight	1 Kg (including brackets).
Power supply	48V DC nominal (29V DC to 75V DC), positive or negative ground permitted
Power consumption	Maximum 4 Watts
Ring/buzzer level	100dB at 30 centimeters

3.35 PSTN EOW Unit Front Indications

There are four LEDs provided on the front fascia of the unit, their indications being as in Table 3-74, from left to right:

Table 3-74: PSTN EOW Unit Front Indications

Name	Colour	Description
LED 1	Green/yellow Green = Slave Yellow = Master	Indicates the node type
LED 2	Red	Indicates that there is an alarm on the unit.
LED 3	Green	Indicates that an EOW Unit in the network is in use In conjunction with handset procedures this is also used to indicate values of numbers. For single digit values, the LED is flashed a number of times indicate the value of the digit (0 is 10 flashes). For multi-digit values, the LED is flashed for each digit with a pause of 1 second between flash sequences.
LED 4	Yellow	Indicates intrusion and third-party functions

3.36 EOW Unit Connectors Specification

3.36.1 PSTN connection (RJ11)

PSTN connection (RJ11 are listed in Table 3-76.

Table 3-76: PSTN connection (RJ11

Connector (RJ 11) Pin Number	Function
Pin 2	Ring Line 2
Pin 5	Tip Line 2

The PSTN port provides a 2-Wire Local Loop Interface that can be connected via cable to a remote PSTN POTS telephone socket (assumed to be FCC 68.500 eight-position) within 250 meters, in the same building, using standard IDC cable.

3.36.2 Handset connections

Two handset sockets (Bantam jack and RJ11) are provided so that both types of handset in use on other Marconi equipments can be used with the EOW unit. To guarantee operation with good audio quality, only one handset should be fitted.

Note: No damage will be caused if both handsets are fitted.

3.36.3 2-Wire Interface (Bantam)

Connector: ADC Bantam PC834J Stereo Phonejack

3.36.4 2-Wire Interface (RJ11)

Connector (RJ-11) Pinouts are listed in Table 3-78.

Table 3-78: Connector (RJ-11) Pinouts

Connector Pin Number	Function
Pin 1	Screen (0V)
Pin 2	Tip
Pin 3	Not Used
Pin 4	Ring
Pin 5	Not Used
Pin 6	Screen (0V)

In conjunction with handset procedures the handset speaker is used to indicate values of numbers. For single digit values, the speaker is 'pipped' a number of times indicate the value of the digit (0 is 10 pips). For multi-digit values, the speaker is pipped for each digit with a pause of 1 second between pip sequences.

3.36.5 Intrude Button

This button allows the operator to intrude into an already established call, and to initiate dialling to third parties.

3.36.6 Reset Button

This button allows all EOW Units in the network to be reset (i.e. put into their initial state). Pressing this button does not affect EOW Unit configuration information.

This button is recessed into the unit so that it cannot be accidentally pressed.

3.36.7 Local Terminal Port

Local Terminal Port Connector (RJ-45) Pinouts are listed in Table 3-80.

Signal Parameters: RS232, 9600 Bits/s fixed, 8 data bits, 1 stop bit with no parity.

Table 3-80: Local Terminal Port Connector (RJ-45) Pinouts

Connector Pin Number	Function
Pin1	
Pin 2	DSR
Pin 3	Ground (0V)
Pin 4	TX out
Pin 5	DTR
Pin 6	RX in
Pin 7	RTS
Pin 8	CTS

3.36.8 Relay Port

Relay Port Connector (RJ-45) Pinouts are listed in Table 3-82

Table 3-82: Relay Port Connector (RJ-45) Pinouts

Connector Pin Number	Function
Pin 1	Pole
Pin 2	N/C
Pin 3	N/O

Maximum signal to be applied to the RJ-45 is 1A at 75Vdc

3.36.9 Analogue 4-Wire Interface

Analogue 4-Wire Interface ConnectorRJ-45) Pinouts are listed in Table 3-84.

Table 3-84: Analogue 4-Wire Interface ConnectorRJ-45) Pinouts

Connector Pin Number	Function
Pin 1	Data out (A)
Pin 2	Data out (B)
Pin 3	Data in (A)
Pin 6	Data in (B)

3.36.10 64K Digital Interfaces

64K Digital Interfaces ConnectorRJ-45) Pinouts are listed in Table 3-86.

Table 3-86: 64K Digital Interfaces ConnectorRJ-45) Pinouts

Connector Pin Number	Function
Pin 1	EOW Unit Unit clock/sync in (A) for co-directional interface
Pin 2	EOW Unit Unit clock/sync in (B) for co-directional interface
Pin 3	EOW Unit UNIT clock/sync in (A) for contra-directional interface
Pin 4	EOW Unit Unit clock/sync in (B) for contra-directional interface
Pin 5	EOW Unit Unit data in (B) for co-directional interface
Pin 6	EOW Unit data in (A) for co-directional interface
Pin 7	EOW Unit data out (B) for contra-directional interface
Pin 8	EOW Unit data out (A) for contra-directional interface

3.36.11 Power Connector

Power Connector Pinouts are listed in Table 3-88.

Table 3-88: Power Connector Pinouts

<table>
<tr><td>Connector Type</td><td>Single 3-way male sub-D power connector with locking screws</td></tr>
<tr><td>Input voltage range</td><td>29 to 75V</td></tr>
<tr><td colspan="2">Pin A1 is nearest the left end of the connector

</td></tr>
<tr><td>Connector Pin Number</td><td>Function</td></tr>
<tr><td>Pin A1</td><td>DC +</td></tr>
<tr><td>Pin A2</td><td>CHASSIS EARTH</td></tr>
<tr><td>Pin A3</td><td>DC –</td></tr>
</table>

3.36.12 Protective Earth

A Protective Earth Connection stud is provided.

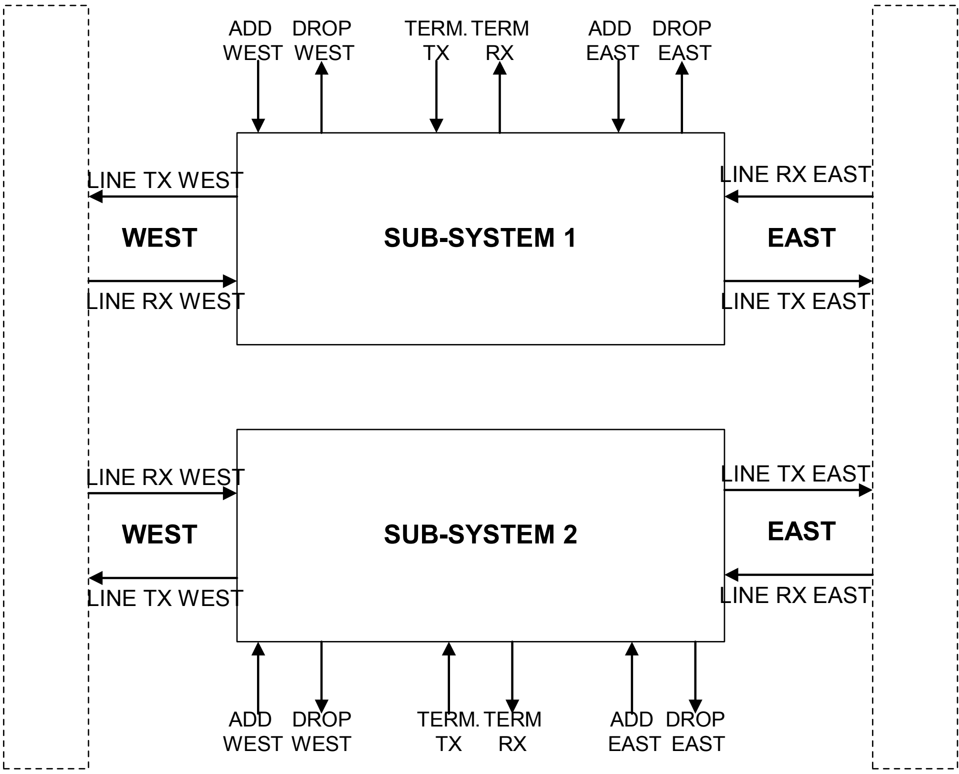
Chapter 4: Configuration Of Multihaul 3000 Systems

4.1 Logical System Configuration

4.1.1 Overview of Logical Configuration

The Multihaul 3000 is a highly flexible WDM platform that supports a wide range of network element configurations in order to achieve overall link requirements. The logical configuration of the Multihaul 3000 can be described in terms of the line and tributary ports which it supports is as shown below in Figure 4-1.

Figure 4-1: Multihaul 3000 Logical Configuration



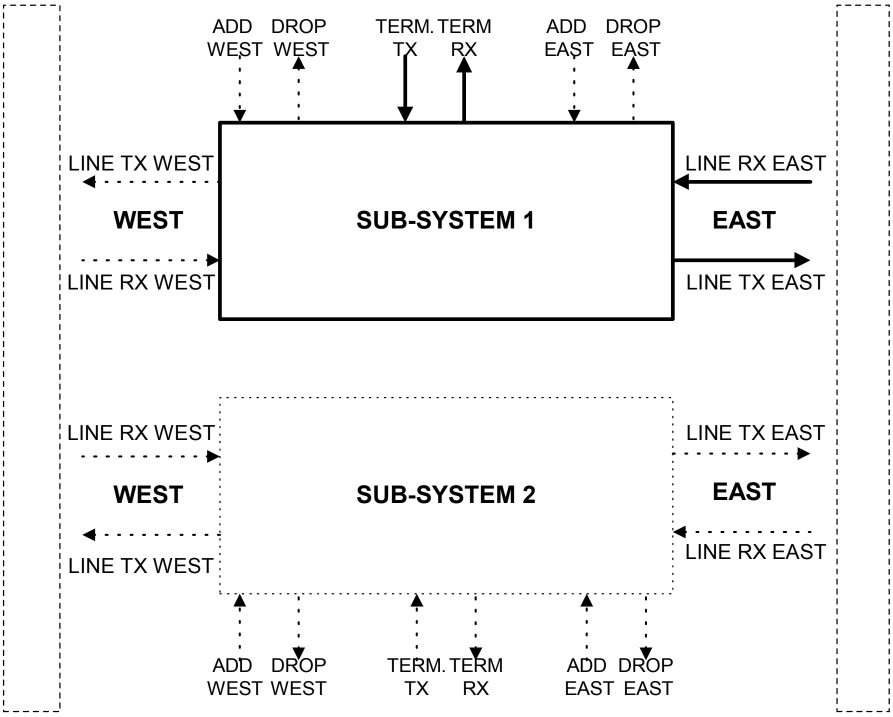
As shown in the diagram above the Multihaul 3000 supports up to two sub-systems, which may be either independent of each other or associated. A sub-system is a complete single band WDM Node, which supports up to two line interfaces, up to two add/drop ports and a termination port. This allows a network element to be equipped as two independent single band nodes or a dual band system.

The Two Line interfaces are denoted as Line West and Line East. By definition, Line West is on the West Side of the NE and faces East. Line east is on the East Side of the NE and faces West.

4.1.2 Logical Configuration of Terminal Nodes

A C-Band terminal configuration requires a single line port and a termination port for the tributary interfaces as shown below in Figure 4-3.

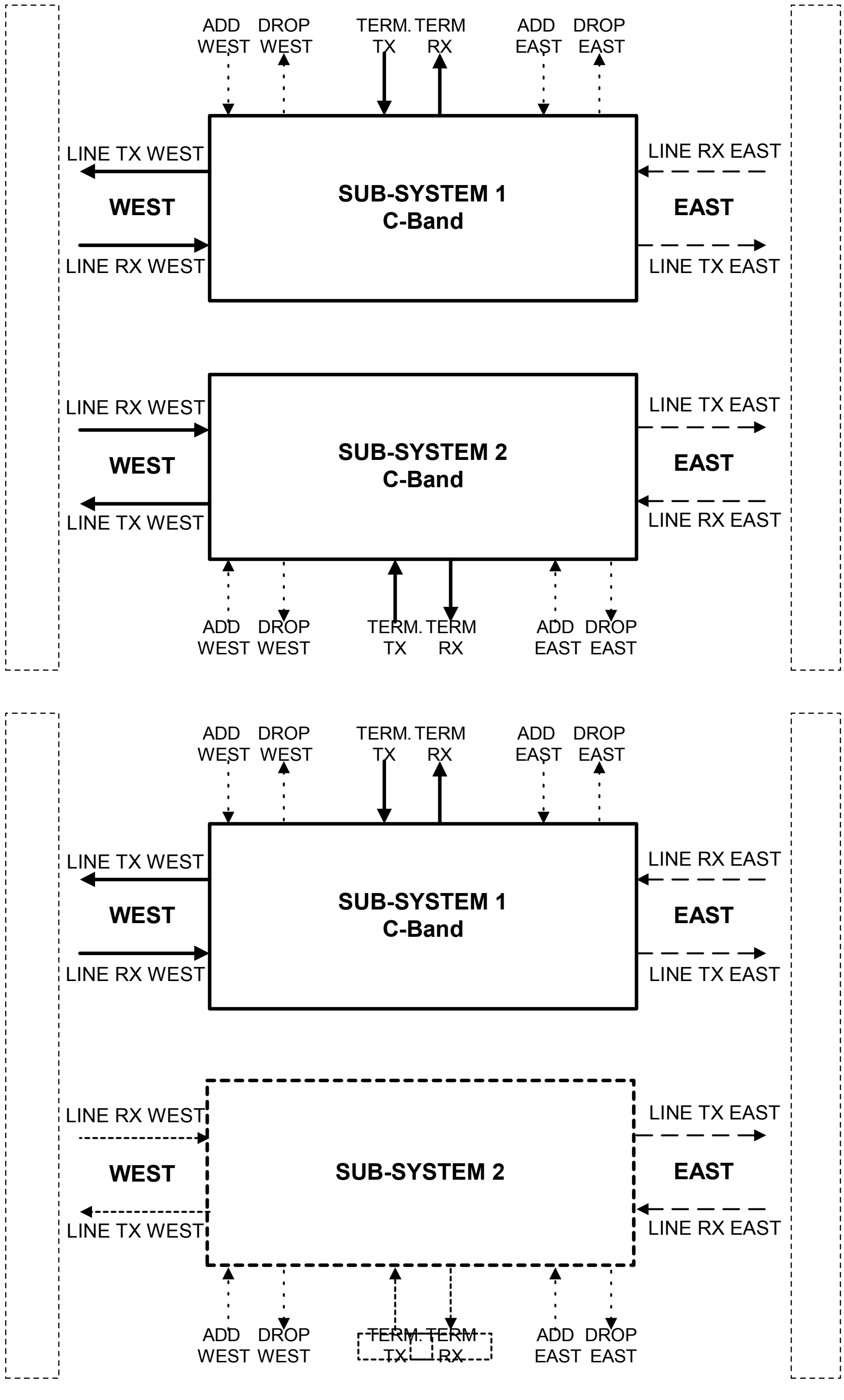
Figure 4-3: C-Band Terminal Configuration



It should be noticed that Terminal configurations could either have a port on the East Side of the NE, as shown above, or have a port on the West Side of the NE.

It is equally also possible to have 2 subsystems independently, in order to produce, for example, a dual C band system as detailed in Figure 4-5.

Figure 4-5: Dual C-Band System



4.2 Physical Provisioning

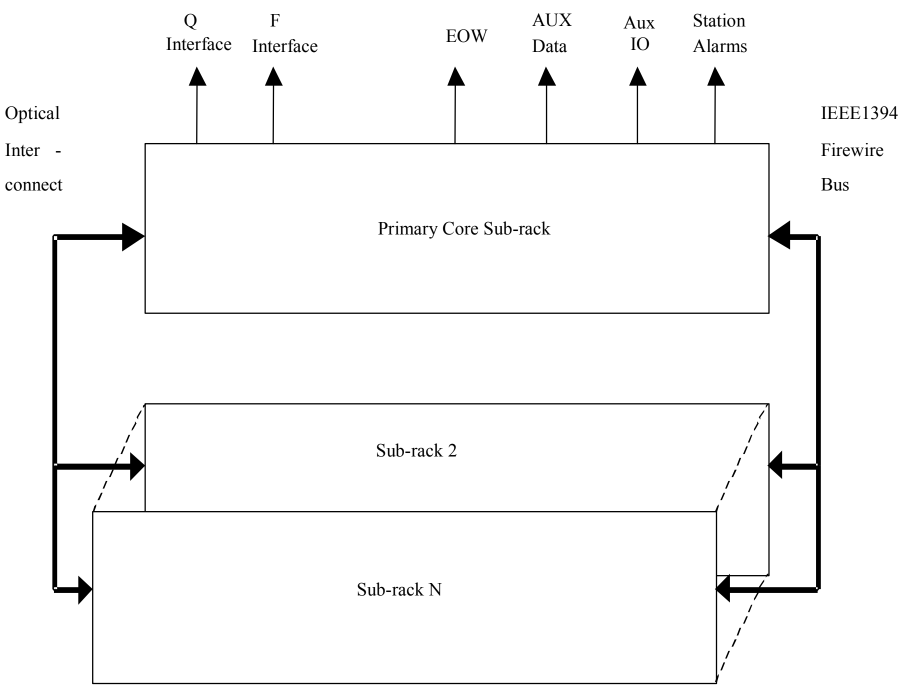
4.2.1 Overview of Physical Configuration

The Multihaul 3000 system is intended to provide an open framework for implementing WDM nodes. The system scales from simple configurations requiring only a single sub-rack to large configurations requiring up to 20 sub-racks. The system is also intended to support the introduction of new unit types in the future, as new technologies become available.

The Multihaul 3000 product encompasses a number of distinct network element types (Terminal, Line Amplifier, Levelling Amplifier and OADM). Each network element type consists of at least one or more sub-racks. The first sub-rack is referred to as the primary core sub-rack because it provides facilities for managing the network element (Q interfaces, alarm interfaces etc.). The network element may then be expanded with additional sub-racks to achieve the overall functionality.

The sub-racks are linked for control purposes via an IEEE 1394 firewire bus that supports flexible data interchange between cards in the system. Irrespective of the number of sub-racks required, the network element is presented to the Element manager as a single controllable entity. The extended sub-racks 2.N may be of type single row or dual row.

Figure 4-7: Multihaul 3000 Subracks



4.2.1.1 Dual Row Sub-rack

The Dual row sub-rack is a double row shelf which supports the primary network element interfaces such as Q interface, rack alarms, overhead termination. These functions are only required once within a network element Additional specific slots are provided for the network element Controller, a Hub unit for intra-shelf communication and dual Bridge units for inter-shelf communication.

Figure 4-9: Slot Physical Layout of a Core Sub-Rack

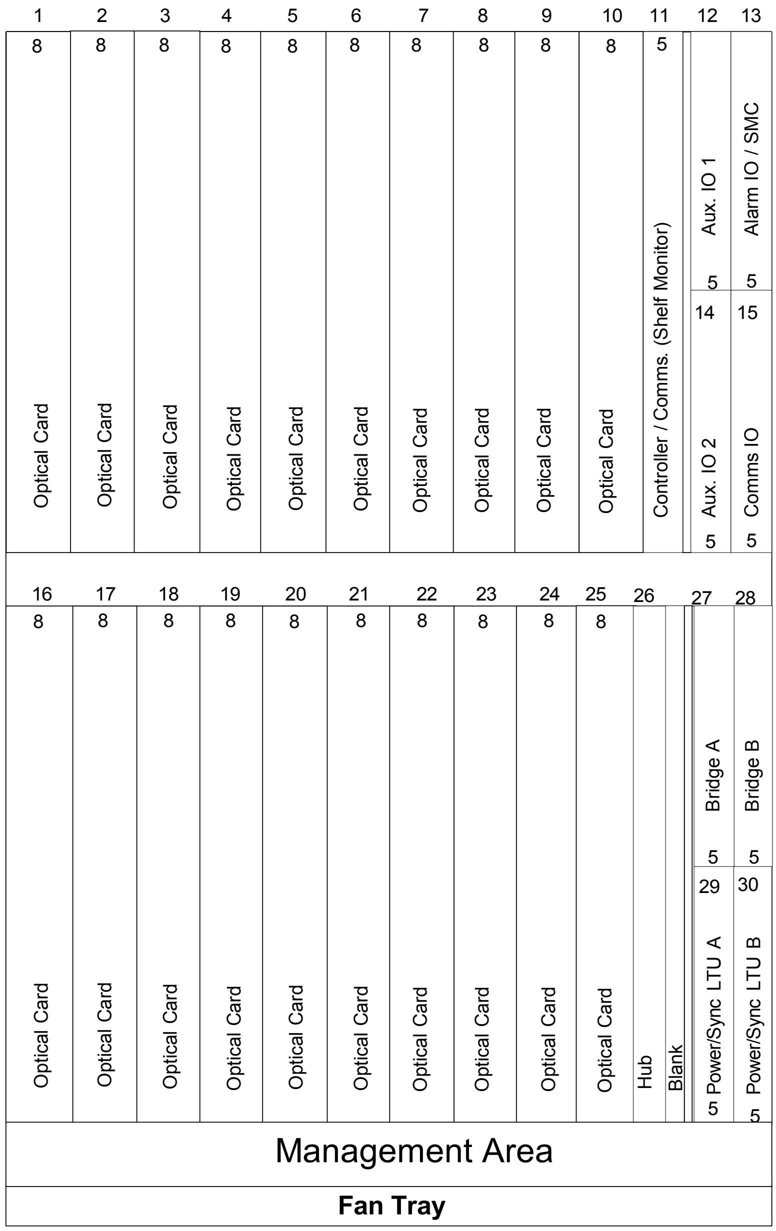
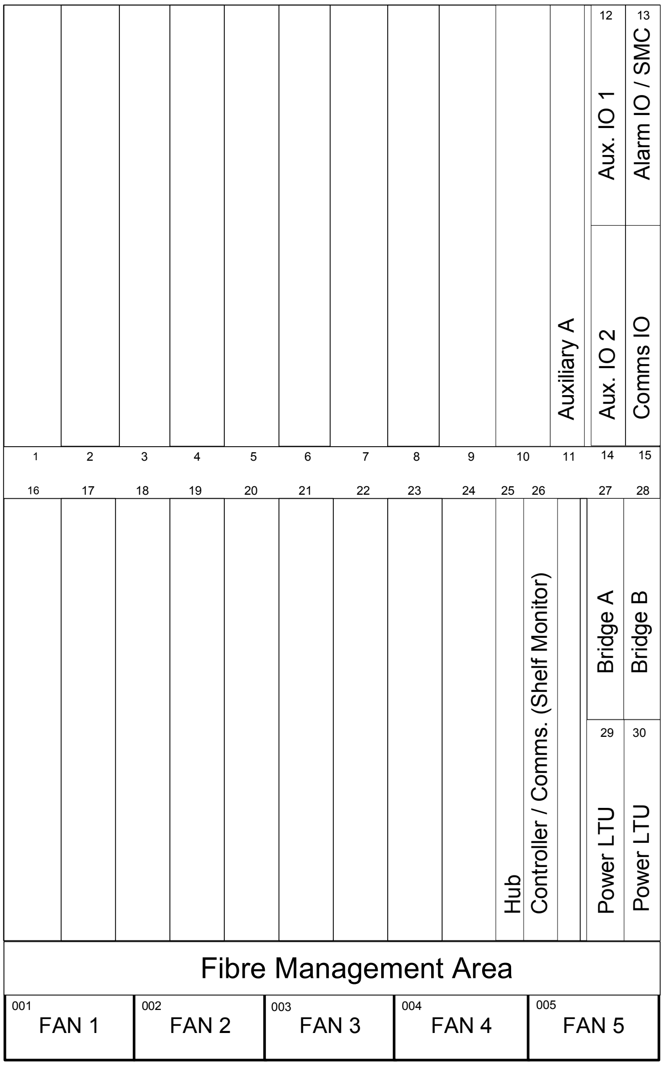


Figure 4-11: 19 Slot Dual Row Subrack Physical Layout



Every Node requires at least one core sub-rack. This is referred to as the Primary Core Sub-rack and must be the first sub-rack within the system. The minimum equipping for the Primary Core Sub-rack if this is a dual row subrack is as shown in Figure 4-11.

Table 4-1: Primary Core Sub-Rack Minimum Equipping

Unit	Quantity	20 Slot Rack Allowable Slot	19 Slot Rack
Hub	1	26	25
Controller/Comms	1	11	26
Power LTU A	2	29, 30	29,30
Alarm IO LTU	1	13	13
Comms IO LTU	1	15	15

This configuration offers all of the primary control features required for a single sub-rack network element. If the network element will consist of more than one sub-rack then the primary core needs to be equipped with 2 additional bridge cards to support communication between the shelves as follows:

Table 4-3: Primary Core Subrack Equipping if More than One Sub-Rack Present

Unit	Quantity	20 Slot Subrack Allowable Slot	19 Slot Subrack
Bridge	2	27, 28	27, 28

Further additional units will be required if the Core Shelf needs to support auxiliary data channels and EOW functions as follows:

Table 4-5: Primary Core Subrack Equipping to Support Auxiliary Data Channel and EOW Function

Unit	Quantity	20 Slot Subrack Allowable Slot	19 Slot Subrack
Aux IO LTU	2	12, 14	13

If the sub-rack is being used as an extension sub-rack (i.e. it is not the primary Core Sub-rack within the sub-system and is not responsible for network element control) then it will be equipped to act as follows:

Table 4-7: Core Subrack Equipping when used as an Extension Subrack

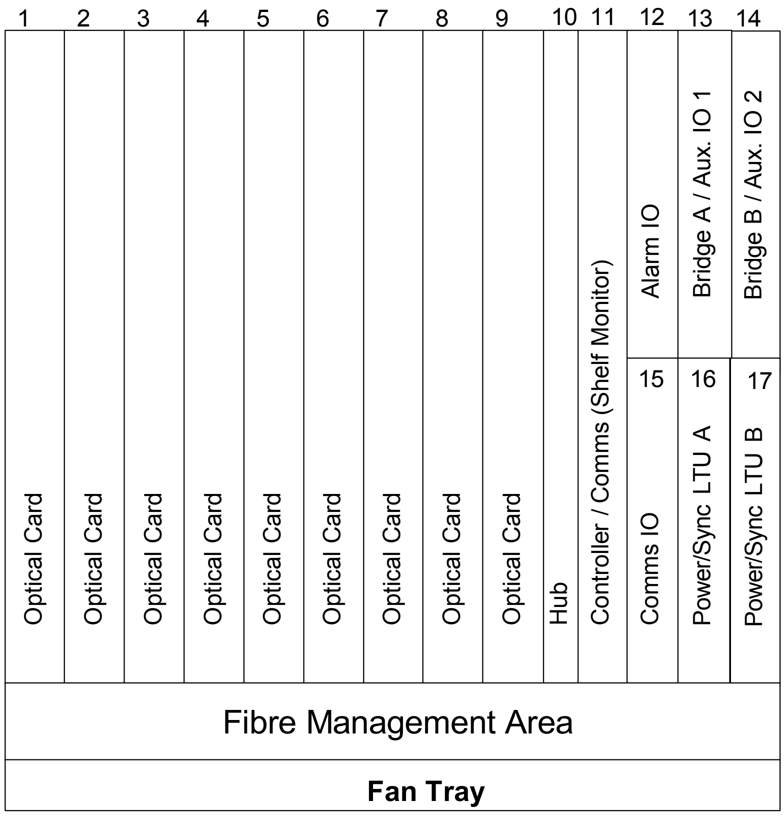
Unit	Quantity	20 Slot Subrack Allowable Slot	19 Slot Subrack
Hub	1	26	25
Shelf Monitor Unit	1	11	26
Bridge	2	27, 28	27,28
Power LTU	2	29, 30	29,30
Alarm IO LTU	1	12	13

The core sub-rack also provides 20 slot positions based on a 1.6” pitch into which any of transmission units may be fitted.

4.2.1.2 Single Row Core Sub-rack

The single row core sub-rack is a single row shelf that supports the primary network element interfaces such as Q interface rack alarms, overhead termination etc. These functions are only required once within a network element. Additional specific slots are provided for the network element Controller, a Hub unit for intra-shelf communication, and Dual Bridge units for inter-shelf communication. See Figure 4-9 and Figure 4-11 for the physical layout of a core sub-rack. It can also be used as an extension subrack in complex nodes.

Figure 4-13: Single Row Core Sub-Rack



The minimum equipping level for the Sub-rack is illustrated below. This is the basic requirement to support communication and management functions for the shelf.

Table 4-9: Minimum Equipping Level for the Sub-Rack

Unit	Quantity	Allowable Slot
Hub	1	10
Controller/Comms	1	11
Power LTU A	2	16,17
Alarm IO LTU	1	12
Comms IO LTU	1	15

This configuration offers all of the primary control features required for a single sub-rack network element. If the network element will consist of more than one sub-rack then the primary core needs to be equipped with 2 additional bridge cards to support communication between the shelves as follows:

Table 4-11: Single Sub-Rack Equipping

Unit	Quantity	Allowable Slot
Bridge	2	13, 14

Further additional units will be required if the Core Shelf needs to support auxiliary data channels and EOW functions as follows:

Table 4-13: Equipping to Support Auxiliary Data Channels and EOW Functions

Unit	Quantity	Allowable Slot
Aux IO LTU	2	13, 14

If the sub-rack is being used as an extension sub-rack (i.e. it is not the primary Sub-rack within the sub-system and is not responsible for network element control) then it will be equipped to act as follows:

Table 4-15: Equipping if Sub-Rack is Being Used as an Extension Sub-Rack

Unit	Quantity	20 Slot Subrack Allowable Slot	19 Slot Subrack Allowable Slot
Hub	1	10	10
Shelf Monitor Unit	1	11	11
Bridge	2	13, 14	12,13
Power LTU	2	15, 16	14,15
Alarm IO LTU	1	12	N/A

The sub-rack also provides 9 slot positions based on a 1.6" pitch into which any of the transmission units may be fitted.

4.2.1.3 DCM Sub-rack

The DCM subrack is an unmanaged tray that contains the DCM. Inventory data is available through a front panel RJ45 connector. Each sub-rack can hold up to two DCM units, depending on the value of the compensator and the variant.

4.2.2 Provisioning Transmission Units

The following units are the photonic building blocks for the Multihaul 3000.

- Optical Supervisory Unit OSU
- Dual Optical Supervisory Unit DOSU
- Single/Dual Stage Amplifier Unit xSA
- Raman Pump Unit RPU
- Power Monitor Unit PMU
- Channel Equaliser Unit CEU
- Channel Control Unit CCU
- Add/Drop Unit ADU
- Group interleaver unit GIU
- 8 channel Group Mux head Unit GMU-8 HEAD
- 8 channel Group Mux extension Unit GMU-8 EXT

- 40 channel Group Mux Unit GMU-40
- 8 Channel Optical levelling unit OLU-8
- Fixed Add/Drop unit FADU
- 2.5Gbit/s G.709 Multirate transponder (standard reach)
- 2.5Gbit/s G.709 transponder (extended reach)
- 10 Gbit/s NRZ G.709 transponder
- 10 Gbit/s RZ G.709 transponder
- 10 Gbit/s RZ Muxponder
- 10 Gbit/s NRZ Muxponder
- 2.5G Metro Transponder Unit

4.2.2.1 Optical Supervisory Unit

There is one variant of the Optical Supervisory Unit. It is 1.6” wide and occupies a single slot position. The pair of OSUs associated with Sub-system 1 will always be fitted in the primary core at the following locations.

Table 4-17: OSU Fitting Locations

Unit	Allowable 20 Slots, dual row Sub-rack	Allowable slots, single row Sub-rack	Allowable 19 slots, Sub-rack
Single Optical Supervisory Unit (West)	9, 24	8	1
Single Optical Supervisory Unit (East)	10, 25	9	24

The above locations are particularly significant for the following reasons:

- They are interconnected by backplane signals that allow overhead information to pass transparently west <-> East (single OSU only)
- They are interconnected by a backplane signals that allow synchronisation signals information to pass transparently west <-> East (single OSU only)
- The OSUs interface to the Aux card in 19 slot subracks.

The OSC signal is extracted from and added to the SSA/DSA units in all cases.

4.2.2.2 Raman Units

There is one variant of the Raman Pump Unit. It is used in C band Single Band Systems both as a Contra-directional pump. It is 3.2” wide and occupies two slot positions. Each Raman Unit provides contra-directional Raman Amplification for the C-Band for one line port. The power levels associated with Raman Units make it essential to observe the equipping rules in order to ensure that the start-up and shutdown mechanisms operate correctly. The basic rules are as follow:

- The Raman unit will only activate if the OSU unit on that port is receiving a correctly framed signal.
- The Raman units will shutdown if the OSU unit on that port indicates loss of frame.

Raman units must therefore occupy very specific slots in the Primary Core Sub-rack as follows:

Table 4-19: Raman Unit Slot Occupancy

Unit	Allowable Slot (Dual row subrack)	Allowable slot (Single row subrack)	Allowable 19 slot Subrack
Raman C Band (West)	1, 5	1, 5	1
Raman C Band (East)	3, 7	3, 7	3

If any of the Raman units are not required the above slots can be reused for other units. For a C-Band system where upgrade to L-Band is allowed for (in a future release), spare slots must be reserved for the L Band Raman units.

4.2.2.3 Standard Reach Amplifier Units

Sub-racks

Amplifier units are fitted in pairs consisting of one WE (input from West, output to East) and one EW (input from East, output to West). Standard reach amplifier variants are 1.6” wide and occupy a single slot position. Amplifier units may be fitted in a 19 slot, 20 and 9 slot dual row or single row sub-racks. xSA Amplifier Units are always equipped as ALS pairs i.e. the West to East Amplifier is partnered with its East to West equivalent and they are interconnected via backplane signals to ensure that a loss of signal in one direction activates a laser shutdown in the opposing direction.

In any pair, the amplifier unit on the Left Hand Side transmits west to east while that on the Right Hand Side transmits East to West. The xSA Standard reach amplifier units may be equipped in the following slots in the 20 and 9 slot dual row subrack.

Table 4-21: The XSA Standard Reach Amplifier Units Occupancy

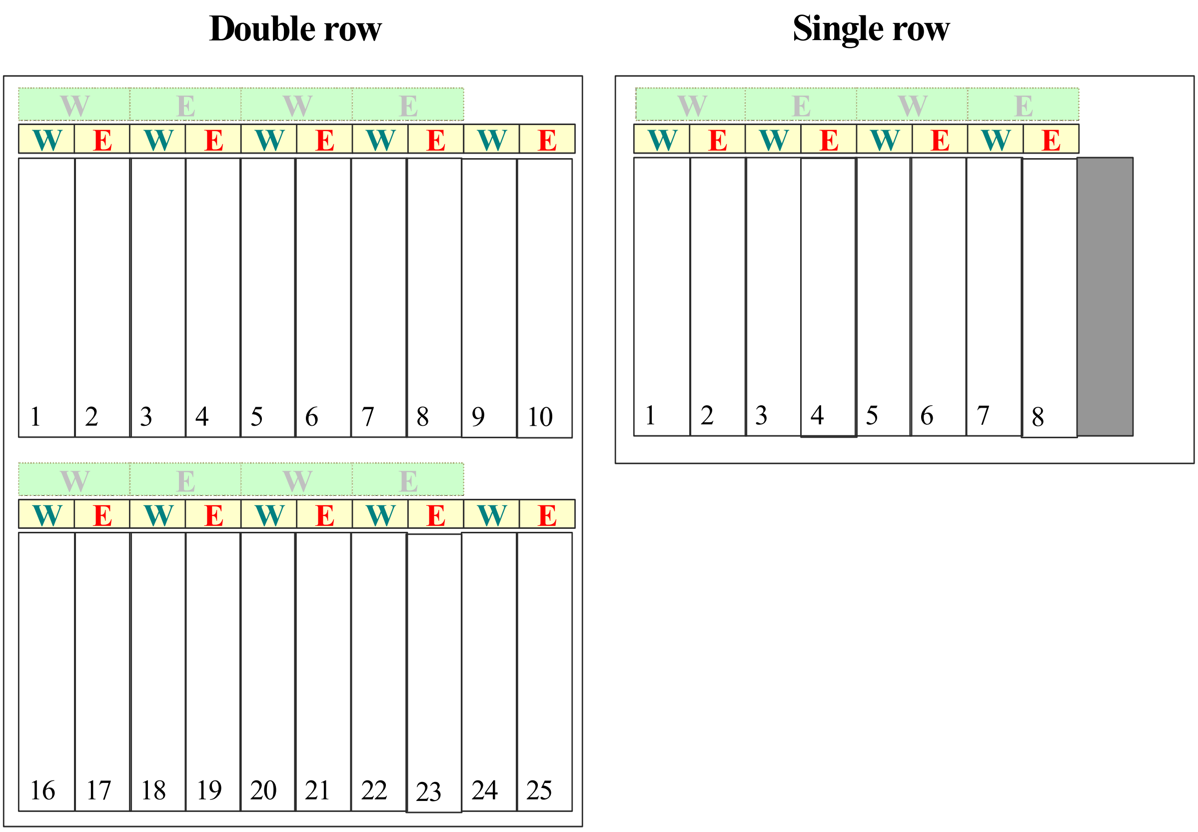
Unit	Allowable 20 Slot (dual row Sub-rack)							
	1st	2nd	3rd	4th	Others			
Amplifier Unit (West To East)	7	5	3	1	22	20	18	16
Amplifier Unit (East To West)	8	6	4	2	23	21	19	17

The table above indicates the clear preference for the equipping of amps i.e. Slots 207 and 208 will always be used for the first xSA amplifier pair. The second xSA amplifier pair (if required) is placed in 205 and 206. The single row subrack can be equipped as follows.

Table 4-23: Single Row Subrack Equipping

Unit	Allowable Slot (single row Sub-rack)			
Amplifier Unit (West to East)	1	3	5	7
Amplifier Unit (East to West)	2	4	6	8

Figure 4-15: Double and Single Row Sub-Racks, SR OAs



The xSA Standard reach amplifier units may be equipped in the following slots in the 19-slot dual row subrack.

Table 4-13: The XSA Standard Reach Amplifier Units Occupancy

Unit	Allowable 19 Slot (dual row Sub-rack)			
	1st	2nd	3rd	4th
Amplifier Unit (West To East)	6	2	16	20
Amplifier Unit (East To West)	8	4	18	22

4.2.2.4 Extended Reach Amplifier Units

Sub-racks

Amplifier units are fitted in pairs of one WE (input from West, output to East) and one EW (input from East, output to West). Extended Haul amplifier variants are 3.2” wide and occupy two slot positions. Amplifier units may be fitted in R 4.1 or 19 slot dual row or single row sub-racks. xSA Amplifier Units are always equipped as ALS pairs i.e. the West to East Amplifier is partnered with its East to West equivalent and they are interconnected via backplane signals to ensure that a loss of signal in one direction activates a laser shutdown in the opposing direction. In any pair, the amplifier unit on the Left Hand Side transmits west to east while that on the Right Hand Side transmits East to West. The xSA extended reach amplifier units may be equipped in the following slots in the dual row subrack.

Table 4-25: XSA Extended Reach Amplifier Units Equipping Preference

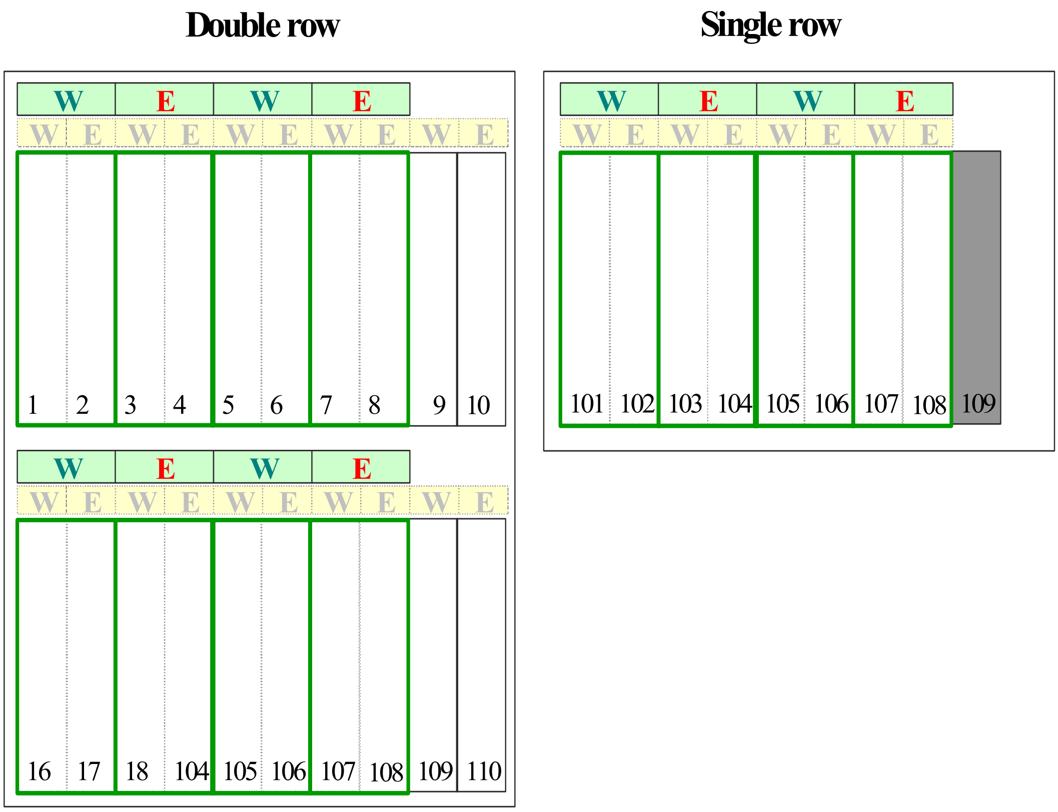
Unit	Allowable Slot (dual row Sub-rack)			
	1^{st}	2^{nd}	3^{rd}	4^{th}
Amplifier Unit (West to East)	5.6	20.21	1.2	16.17
Amplifier Unit (East to West)	7.8	22.23	3.4	18.19

The table above indicates the clear preference for the equipping of amps i.e. Slots 6.9 will always be used for the first xSA amplifier pair. If no Raman is fitted then the second xSA amplifier pair (if required) is placed in 20.23. If Raman is required on the East Side then slots 2.5 will be used and finally slots 16.19. In some OADM configurations, all of the above slot combinations will be used for xSA amplifiers (i.e. 4 pairs, 8 in total). The single row subrack can be equipped as follows.

Table 4-27: Single Row Subrack Equipping

Unit	Allowable Slot (single row Sub-rack)
Amplifier Unit (West to East	1.2,5.6
Amplifier Unit (East to West	3.5,7.8

Figure 4-17: Double and Single Row Sub-Racks, ER OAS



The xSA Extended reach amplifier units may be equipped in the following slots in the 19-slot dual row subrack.

Table 4-13: The XSA Extended Reach Amplifier Units Occupancy

Unit	Allowable 19 Slot (dual row Sub-rack)			
	1st	2nd	3rd	4th
Amplifier Unit (West To East)	6	2	16	20
Amplifier Unit (East To West)	8	4	18	22

4.2.2.5 Group Mux 8 Units

There are 5 variants of GMU-40-8, each capable of multiplexing and demultiplexing 8 channels and providing extension ports where appropriate. Variants are as follows:

- Group 1 head
- Group 1 extension blue 1
- Group 1 extension blue 2
- Group 1 extension red 1
- Group 1 extension red 2

GMU-40-8 cards are 1.6” wide and occupy a single slot. GMU-40-8 cards may occupy any slot in either single or double row subracks, but the suggested location for dual row subracks is slots 16-25 (80 channel terminal) and for single row subracks is slots 3-8 (40 channel terminal)

4.2.2.6 Group Mux 40 Units

There are two variants of the Group mux unit, each capable of multiplexing or demultiplexing 40 channels as follows:

- Group 1C
- Group 2C

For the standard application in a dual band system the Group Mux Units should be fitted in the core sub-rack in pairs as follows:

Table 4-29: Group Mux Units Equipping

Unit	Dual row Sub-rack	Single row Sub-rack
Group Mux Unit 1C	16,17	1,2
Group Mux Unit 2C	16,17	1,2

In other configurations (OADMs, Dual C band systems) flexible equipping of the required GMU-40s to any available slot in any rack is allowed. It is highly recommended that the pairing is maintained.

4.2.2.7 Group Interleaver Units

There are two variants of the Group interleaver unit, one of which are capable of interleaving and de-interleaving two groups of 40 channels and one provides for optical safety functions when required. The variants are as follows:

- C-Band GIU
- Sub equipped GIU(s)

All variants are 1.6” wide and occupy a single slot position. For all applications the Group Interleaver Units may be fitted in any slot in the core sub-rack, but the recommended positions are as follows:

Table 4-31: Group Interleaver Units Equipping

Unit	Suggested Slots (dual row subrack)
Group Interleaver Unit - C Band	1, 3
Group Interleaver Unit - L Band	1, 3

4.2.2.8 Add Drop Units

There are two variants of the Add Drop Unit. They are both 1.6” wide and occupy one slot position. Add Drop units are used in pairs as part of an OADM and are interconnected via the backplane. They are therefore equipped in pairs the same way as extended reach amplifiers as follows: -

Table 4-33: Add Drop Unit Equipping

Unit	Allowable Slot (dual row Sub-rack)			
Add Drop Unit (West to East)	16	20	1	5
Add Drop Unit (East to West)	18	22	3	7

Table 4-35: Add Drop Unit Equipping

Unit	Allowable Slot (single row Sub-rack)	
Add Drop Unit (West to East)	1	5
Add Drop Unit (East to West)	3	7

4.2.2.9 Power Monitor Units

There is one variant of the Power Monitor Unit. It is 1.6" wide and occupies a single slot position. From a hardware perspective, the PMUs can be inserted into any location in a single or dual row Sub-Rack.

4.2.2.10 Channel Control Units

There are two variants of the Channel Control Unit as follows:

- Channel Control Unit - C-Band Group 1
- Channel Control Unit - C Band

The first variant is 4.8" wide and occupies three slot positions. It is bi-directional and supports both east-west and west-east traffic paths. From a hardware perspective, the CCU-1Cs can be inserted into any location in a single or dual row Sub-Rack provided that three adjacent slots are available. In practice, the following locations are preferred to maintain uniformity between NE types.

Table 4-37: Channel Control Unit Equipping

Unit	Preferred Slot (dual row Sub-rack)		
Channel Control Unit	16.18	21.23	2.4

Table 4-39: Channel Control Unit Equipping

Unit	Preferred Slot (single row Sub-rack)	
Channel Control Unit	1.3	6.8

The second variant is 3.2" wide and occupies two slot positions. It is a unidirectional card, so two are required per direction. From a hardware perspective, the CCU Cs can be inserted into any location in a single or dual row Sub-Rack; usual practice would be to equip a pair for bidirectional operation in adjacent slots. The following locations are preferred to maintain uniformity between NE types.

Table 4-41: Channel Control Unit Equipping

Unit	Preferred Slot (dual row Sub-rack)		
Channel Control Unit	16,18	20,22	1,3

4.2.2.11 Channel Equaliser Unit

The CEU is 1.6” wide and occupies a single slot position. Each CEU performs the equalisation for a single direction of traffic. From a hardware perspective, the CEUs can be inserted into any location in a dual row or single row Sub-Rack but in practice, the following locations are preferred to maintain uniformity between NE types.

Table 4-43: Channel Equaliser Unit Equipping

Unit	Preferred Slot (dual row Subrack)				Preferred slot (single row)		
Channel equaliser Unit	16	17	2	3	1	2	3

4.2.2.12 Fixed Add/drop units

There are 9 variants of the fixed add drop unit. All variants are 1.6" wide and occupy a single slot position. The FADU allows for four channels to be added and dropped in two line directions. The frequencies that can be added and dropped are fixed and are illustrated below.

Table 4-45: Frequency Bands

Ch. n.	f [THz]	Wavelength [nm]	Filters 1st set	Filters 2nd set
1	192,10	1560,61	Red2 A	
2	192,20	1559,79		
3	192,30	1558,98		
4	192,40	1558,17		
5	192,50	1557,36	Red2 B	
6	192,60	1556,55		
7	192,70	1555,75		
8	192,80	1554,94		
9	192,90	1554,13	Red1 A	
10	193,00	1553,33		
11	193,10	1552,52		Red1 C
12	193,20	1551,72		
13	193,30	1550,92	Red1 B	
14	193,40	1550,12		
15	193,50	1549,32		Master D
16	193,60	1548,51		
17	193,70	1547,72	Master A	
18	193,80	1546,92		
19	193,90	1546,12		Master C
20	194,00	1545,32		
21	194,10	1544,53	Master B	
22	194,20	1543,73		
23	194,30	1542,94		
24	194,40	1542,14		

From a hardware perspective, the FADUs can be inserted into any location in a dual row or single row Sub-Rack but in practice, the following locations are preferred to maintain uniformity between NE types.

Table 4-47: FADU Equipping

Unit	Preferred Slot single row	Preferred Slot dual row
FADU	1	16, 17

4.2.2.13 2.5G NRZ Transponder Units (G.709 SR Multirate)

There are 80 versions of Transponder units as follows:

- C Band 80 x 2.5G NRZ Transponders

Table 4-49: 2.5G NRZ Transponder Units (G.709 SR Multirate) Equipping

Unit	Preferred Slot single row	Preferred Slot dual row
2.5G NRZ Transponder	1 to 8	18 to 25, 3-10

4.2.2.14 2.5G NRZ Transponder Units (G.709 extended reach)

There are 80 versions of Transponder units as follows:

- C Band 80 x 2.5G NRZ Transponders

Table 4-51: 2.5G NRZ Transponder Units (G.709 extended reach) Equipping

Unit	Preferred Slot single row	Preferred Slot dual row
2.5G NRZ Transponder	1 to 8	18 to 25, 3-10

4.2.2.15 10G RZ Transponder Units

There is one version of Transponder units as follows:

- C Band 80 Lambda RZ Transponders

Table 4-53: 10G RZ Transponder Units Equipping

Unit	Preferred Slot single row	Preferred Slot dual row
10G RZ Transponder	1 to 8	18 to 25, 3-10

4.2.2.16 10G NRZ Transponder Units

There are 80 versions of Transponder units as follows:

- C Band 80 x 10G NRZ Transponders

Table 4-55: 10G NRZ Transponder Units Equipping

Unit	Preferred Slot single row	Preferred Slot dual row
10G NRZ Transponder	1 to 8	18 to 25, 3-10

4.2.2.17 10G NRZ TDM Muxponder

There are 5 versions of the 10G NRZ TDM Muxponder:

C Band 5 x 10G NRZ TDM Muxponders tuneable (16channels at 50GHz)

The client ports are implemented as SFPs, which supports the following physical interface.

- S16.1 (15km)

The card is 40.6mm wide and occupies a single slot position. It can be fitted in any slot.

4.2.2.18 10G RZ TDM Muxponder

There is only 1 version of the 10G RZ TDM Muxponder as C Band 10G NRZ TDM Muxponders tuneable (full band tuneable)

The client ports are implemented as SFPs, which supports the following physical interface.

- S16.1 (15km)

The card is 40.6mm wide and occupies a single slot position. It may be fitted in any slot.

4.2.2.19 OLU

There is one variants of the OLU, which is 1.6” wide and occupies a single slot. They can be equipped in any slot in the single or dual row core subrack.

Blank Page

Chapter 5: Synchronisation

5.1 Introduction

Timing in Multihaul 3000 systems is carried out by means of a Master NE running from an internal oscillator. All other NEs in the link operate with a combination of loop and through timing to synchronise to the master NE.

Note: The above refers to timing for the OSUs only. The tributary cards are timed according to the rate received.

Synchronisation is provided for the following purposes:

- Providing synchronisation between OSC links to minimise risk of losing data.

5.2 Multihaul 3000 Synchronisation Architecture

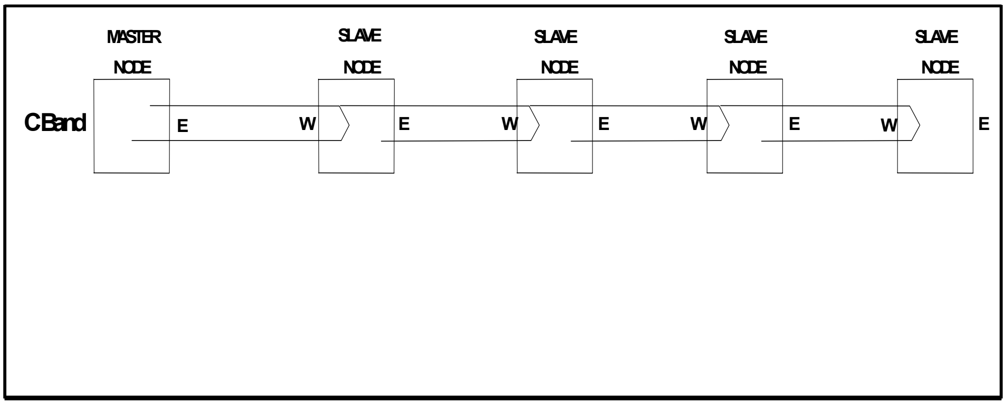
The following sub-sections describe the Multihaul 3000 synchronisation architecture.

5.2.1 OSC Synchronisation

- The timing of the OSC is illustrated in Figure 5-1. The arrows show the flow of the synchronisation clocks from node to node.

- The West Terminal NE acts as a clock master (running from an internal oscillator). All other NEs operate in slave mode and synchronise to the clock master. Multihaul 3000 Line Transmission

Figure 5-1: Multihaul 3000 Line Transmission

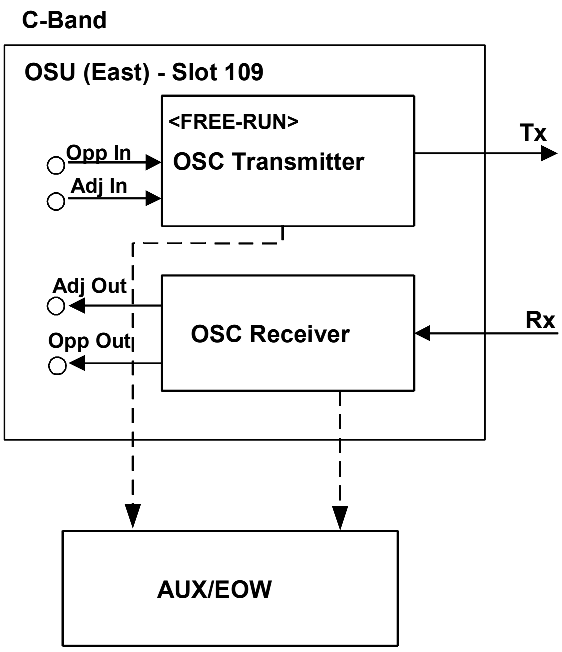


5.2.2 Clock Master Mode

The timing of the OSCs for a NE operating in Clock Master mode is derived as shown in Figure 5-3.

- The OSC transmit clocks operate in free run mode on each OSC Unit. These oscillators are stable to better than +/- 50 ppm.
- The OSC transmit clock and recovered receive clock from the C-Band OSU are used to synchronise the AUX/EOW interfaces.
- The contents of Auxiliary and EOW channels are buffered so that only byte slips can occur.

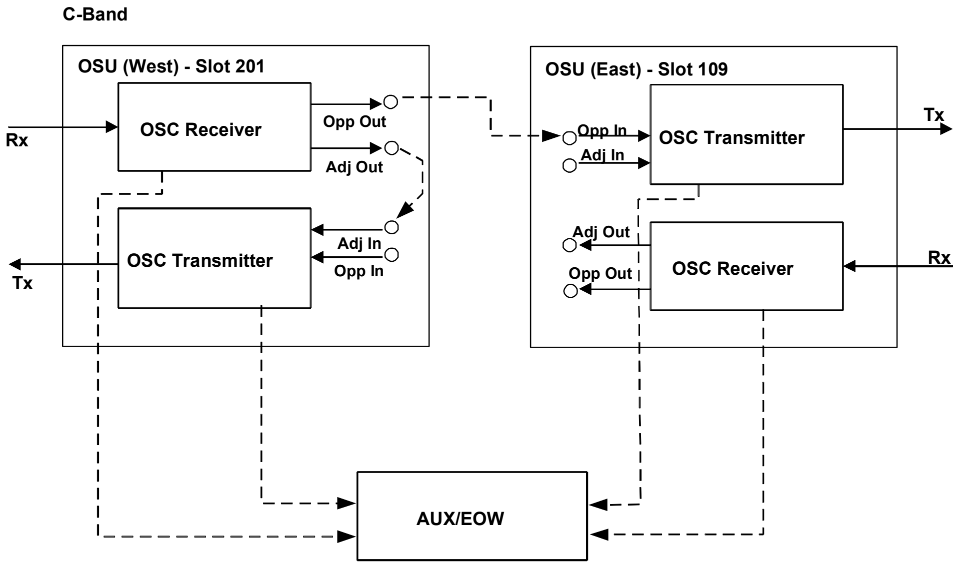
Figure 5-3: OSC Synchronisation: Master Mode



5.2.3 *Slave Mode*

The timing of the OSCs for a NE operating in Slave mode are derived as shown in Figure 5-5

Figure 5-5: OSC Synchronisation: Slave Mode



5.3 10G Muxponder Synchronisation

The 10G Data Muxponder allow generating T0 reference clock from a set of configurable synchronization sources. The reference clock T0 is used for timing the OTU2 output signal and for the generation of any intermediate multiplexed signal (e.g. STM-64).

The following synchronization sources are provided:

- OCh Rx;
- External Sync input (on front panel);
- External Synch from backplane1 #;
- External Synch from backplane2 #;
- Internal Oscillator (with Holdover*).

Notes:

1 # The availability of this feature is link to the presence of new LTU

2 * Holdover: T0 is locked to an internal on–board oscillator which uses the latest accumulated holdover frequency value to smooth synch slips.

Note: It is not be possible to select any client interface of the Data Muxponder as synchronisation source, because the data client interfaces have a sync. stability not compatible with SDH/OTN requirements (e.g. Ethernet 100 ppm, FC 200 ppm).

Each synchronization source is assigned a priority and the selection for the T0 is based on the highest priority or manually forced by the user. Possible priority values are: 1 to 5. It is not possible to assign the same priority twice. Priority assignment is user configurable via MT. In addition Holdover is always provided when all the sources are not available.

Table 5-1: Default Priority Setting

Synch Source	Priority
OCh Rx	1
External Sync input (on front panel)	2
External Synch from backplane1	3
External Synch from backplane2	4
Internal Oscillator	5

The selection mechanism is revertive: the highest priority source is always and automatically re-established when available again after a failure.

The time between the higher priory source is newly available after a fault and its return to work as synch source is called WTR time (=Wait To Restore time) and is fixed by default at 5 minutes. WTR time is user configurable via MT (range [0,30 min]; step [30 sec]; default [5 min]). This time ensures that the original source is stable when reverting back.

Notes:

1 It is possible to configure forced protection switch to any synchronization source via MT.

2 It is possible to configure manual protection switch to any synchronization source via MT.

3 It is possible to lockout the currently selected synchronization source.

5.3.1 External Synchronization (front Panel)

The 10G Data Muxponder provides a coaxial connector for external synchronization input on the front plate of the unit. The presence of an external synchronization source is a mandatory requirement for 10G Data Muxponder applications, where the GEthernet client inputs do not provide any synch reference (and the synch at WDM line may not be enough precise). The external synchronization input for each individual 10G Data Muxponder is required in addition to the centralized external synchronization input (on shelf LTU), based on the following assumptions:

- Centralized external synch inputs from new LTU card (e.g. Comms LTU future release) may not be available in some equipment configurations. One example may be CPE NE, where the reduced number of slots available on the small shelf may not allow any LTU unit.

- There may be applications in which 10G Data Muxponders within the same NE carry traffic of different user. In these cases the user may request to provide its own synchronization signal to the Muxponder.

5.3.2 Synch Role Configuration

A Muxponder [MXP] within a NE can be configured in one of the following way:

- Master;
- Vice-Master;
- Slave
- Stand-alone

The first three modes assume that the MXP follows the distributed synchronization scheme implemented via back plane, while mode 4 implies that the Muxponder does not participate to the distributed synchronization scheme. The above configurations may be present within the same NE at the same time. Only one Master and one Vice-master may be present within the same NE. These have the following characteristics:

5.3.2.1 Master:

Derives T0 from one of the following sources:

- OCh port
- On front panel card External Port
- Internal oscillator (Hold-over/Free-run);
- Back-plane Ext synch1 – derived from Power LTU or Comms IO/LTU
- Back-plane Ext synch2 – derived from Power LTU or Comms IO/LTU

It propagates its T0 clock to Internal bus synch (1) It does not listen to Internal bus synch (2)

5.3.2.2 VICE-Master:

Derives T0 from one of the following sources:

- Internal bus synch (1) -- Only option if this signal is available, otherwise:
- OCh port
- On front panel card External Port
- Internal oscillator (Hold-over/Free-run);
- Back-plane Ext synch1 – derived from Power LTU or Comms IO/LTU
- Back-plane Ext synch2 – derived from Power LTU or Comms IO/LTU

It propagates its T0 clock to Internal bus synch (2)

Note: In normal working condition (no faults) both internal buses are synchronous.

5.3.2.3 Slave:

Derives T0 from one of the following sources:

- Internal bus synch (1)
- Internal bus synch (2)

Note: in normal working condition (no faults) both internal buses are synchronous.

5.3.2.4 Stand-Alone:

Derives T0 from one of the following sources:

- OCh port
- On front panel card External Port
- Internal oscillator (Hold-over/Free-run);
- Back-plane Ext synch1 – derived from Power LTU or Comms IO/LTU
- Back-plane Ext synch2 – derived from Power LTU or Comms IO/LTU

It does not propagate propagates its T0 clock. It does not listen to Internal bus synch (1) or Internal bus synch (2

5.3.3 Synch Source Selection

Muxponder in Master, Vice-Master and Stand-alone working mode selects one of the synchronization sources, based on the following priority criteria:

- Manually configured priorities;
- Quality assessment of the synch. Source signal

5.3.4 Synch Source fail

For the STM-N synchronization source, the fail criteria is as follows:

- LOS (loss of incoming signal)
- LOF (loss of frame)
- MS-AIS detection
- EBER

5.3.5 Out of Frequency Criteria:

If the selected synchronization source changes “slowly” its frequency (if the source reaches a Δf in a period $\geq$ N times the time constant of PLL), PLL unit sends an alarm and declared the source failed. The default value of N is 10. Δf is equal to 10 ppm.

For the OTU2 synchronization source, the fail criteria is as follows:

- LOS (loss of incoming signal)
- LOF (loss of frame)
- AIS detection
- EBER (it can be disabled by LCT/NMS)

For the 2048 Kb/s ext. synchronization source (framed and unframed), the fail criteria is as follows:

- LOS
- AIS (only applicable to framed signal)
- LOF (only applicable to framed signal)
- LOM (only applicable to framed signal)
- EBER (it can be disabled by LCT/NMS, only applicable to framed signal))

Blank Page

Chapter 6: Add/Drop Features

6.1 Introduction

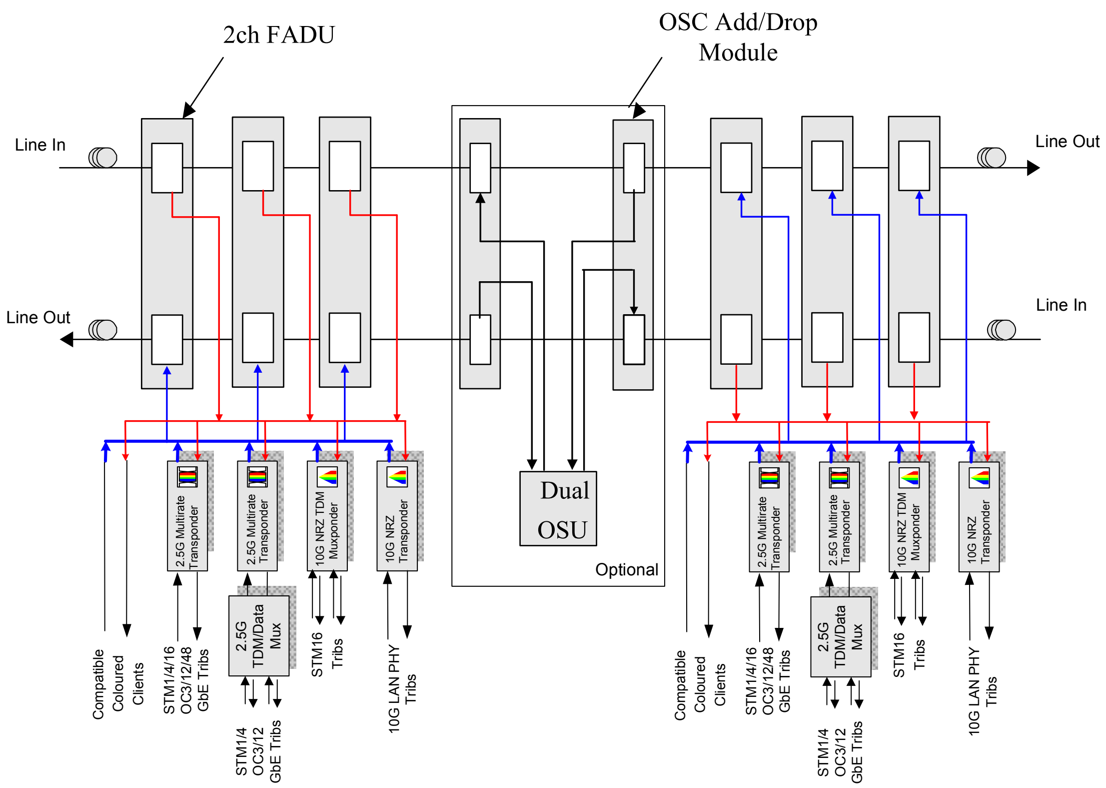
OADM configurations are based on two technologies. Thin film filters can be equipped in-groups of four to allow fixed add/drop of channels in a 100GHz grid. Channels to be dropped are pre-selected and factory configurable. Optical patch through can be used to regain the channel if the OADM has been over provisioned. A reconfigurable OADM is realised using a broadcast and select architecture with a 40-channel blocker/attenuator (CCU) controlling the power level of the transmitted channels. By using an interleaver and deinterleaver along with a pair of CCUs 100% flexible add/drop capacity is achieved for 80 channels in each band.

6.2 Fixed OADM

6.2.1 *Metro Low Channel Count Passive Fixed OADM*

Figure 6-1 shows the transmission units required to implement a fixed OADM accessing 6 channels on each line. The OSU and associated OSC Add/drop filters are optional, and are required if DCCs cannot get to the node via transponder GCCs, or if Aux or EOW are required.

Figure 6-1: Metro Low Channel Count Passive Fixed OADM



The 2.5G Data Mux with DWDM SFP is not allowed in ARR rings: the card must be used with a 2.5G transponder. Different size nodes can be obtained by changing the number of add/drop modules and transponders.

The associated sub-racks for both nodes are listed in Table 6-1 below:

Table 6-1: Associated Sub-Racks for Both Nodes

Sub-rack Type	4 ch.	10 ch.	Comment
Dual Row SR	-	1	
Single Row SR	1	-	
Filter Chassis	1	2	Houses 2ch FADUs and optional OSC Add/drop.

The subracks are illustrated in Figure 6-2 for 4 channel with OSU and Aux and in Figure 6-3 10 channel without OSU and Aux cases.

Figure 6-2 : Subracks for 4 Channel with OSU and Aux

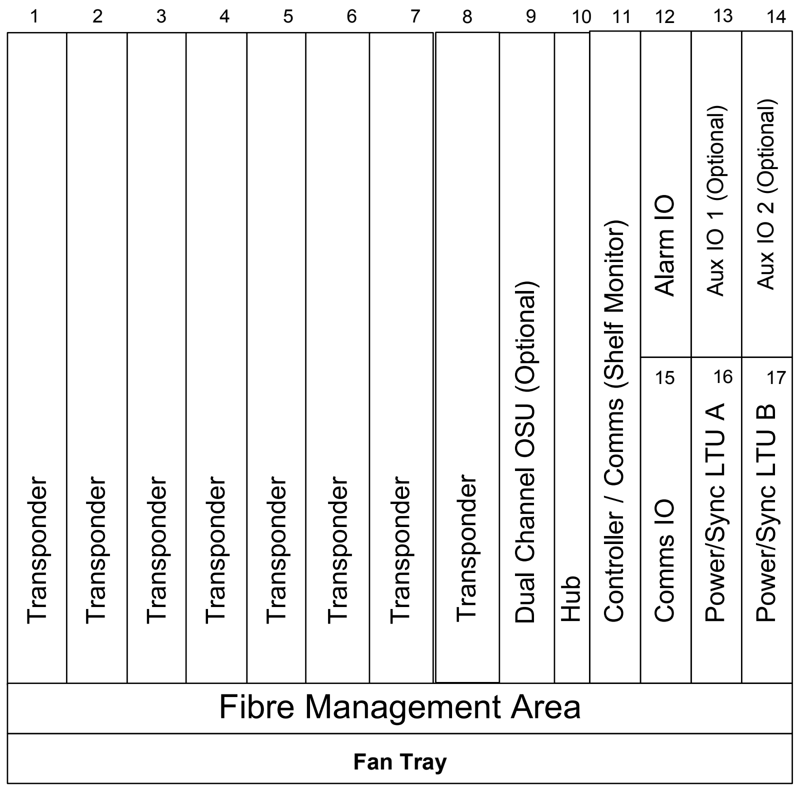
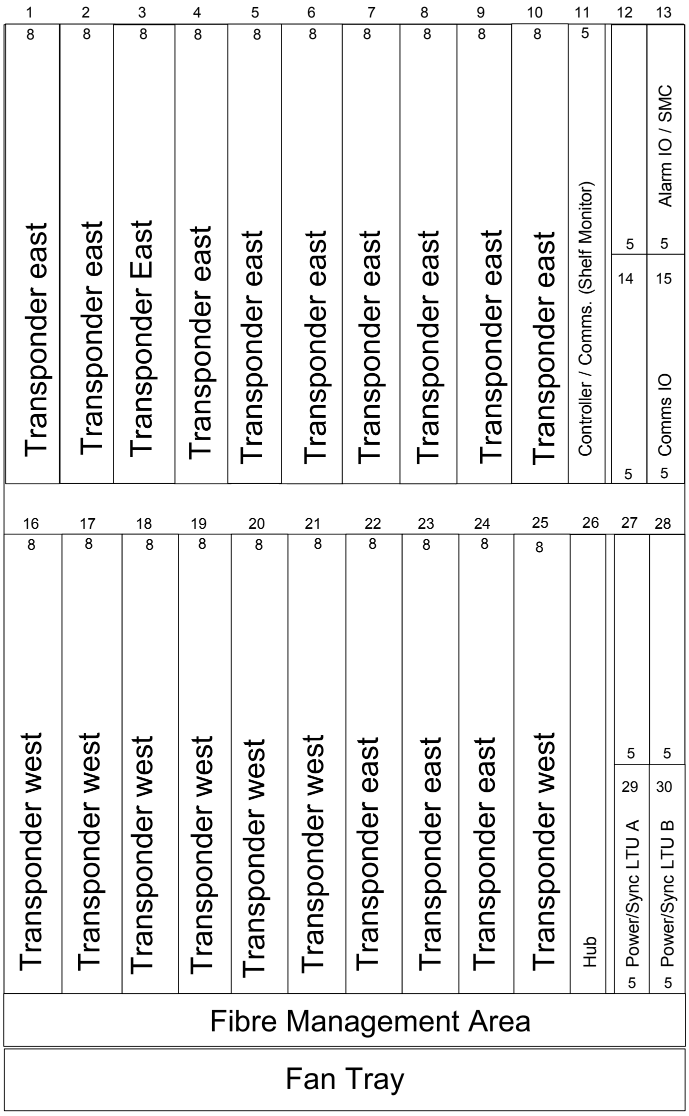


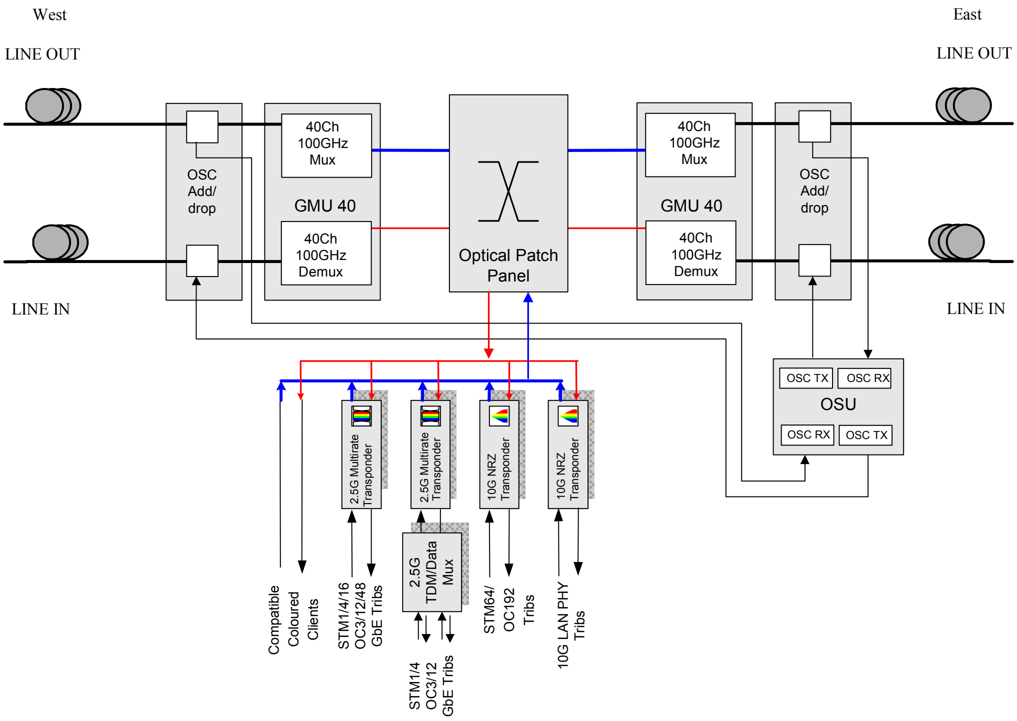
Figure 6-3: Subracks for 10 Channel with OSU and Aux



6.2.2 Metro High Channel Count Passive Fixed OADM

Figure 6-4 shows the transmission units required to implement a fixed OADM accessing a large number of channels on each line. The OSU and associated OSC Add/drop filters are optional, and are required if DCCs cannot get to the node via transponder GCCs, or if Aux or EOW are required.

Figure 6-4: Metro High Channel Count Passive Fixed OADM



The subracks are illustrated in Figure 6-5 for 8 channel and Figure 6-6 for 16 channel nodes without OSU and Aux cases. Additional subracks can be added for higher channel counts.

Figure 6-5: Subracks for 8 Channel with OSU and Aux

Figure 6-6: Subracks for 16 Channel with OSU and Aux

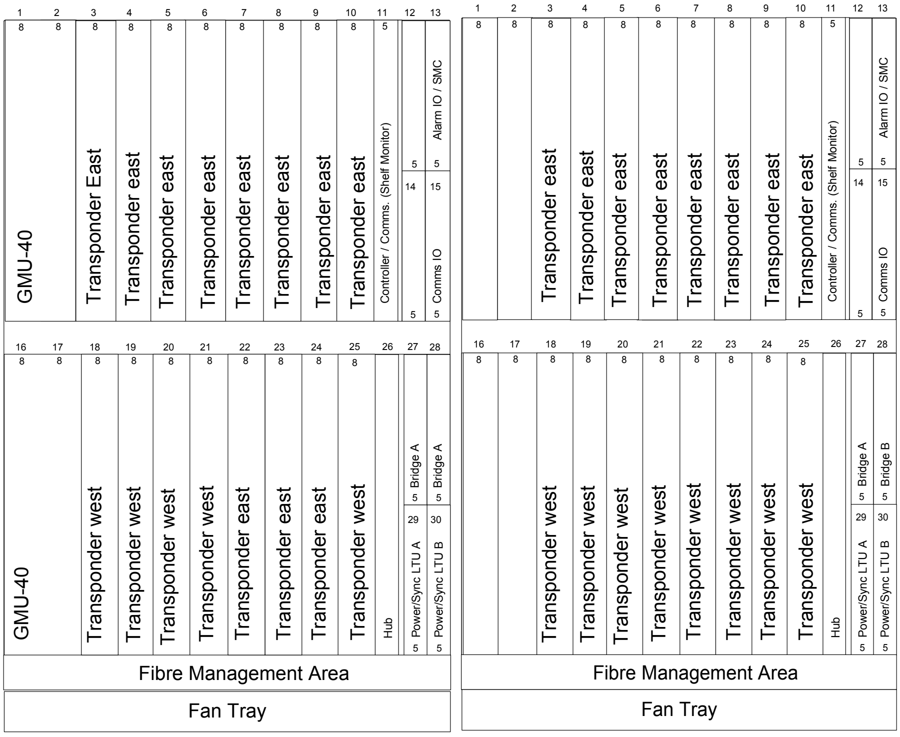


Figure 6-7: 4 Channel LH Fixed OADM

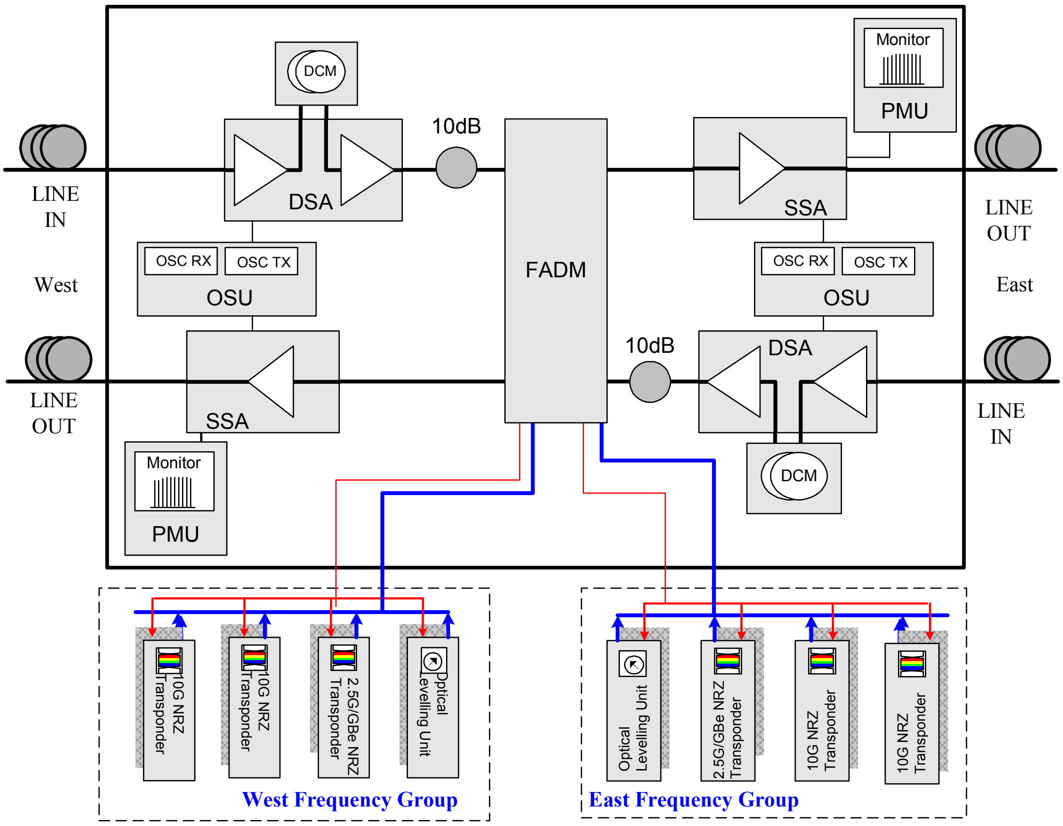
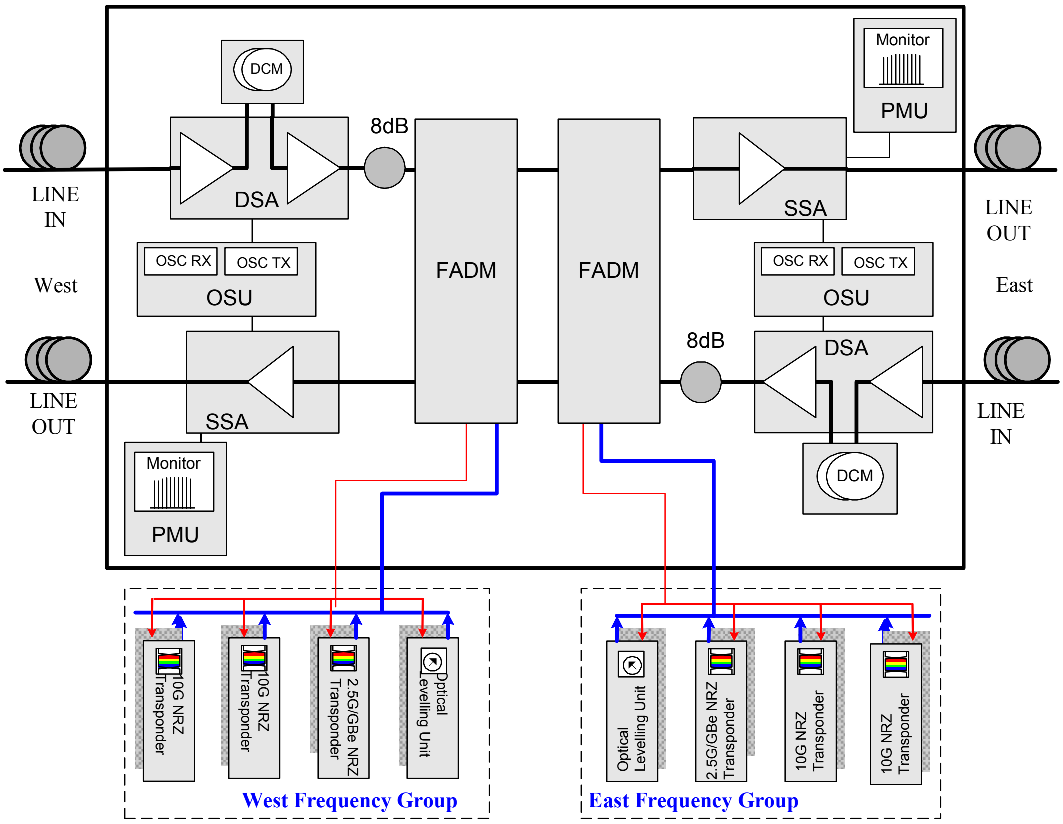


Figure 6-7 shows the transmission units required to implement an LH 4 channel fixed OADM. The 8-channel version is illustrated below.

Figure 6-9: 8 Channel Fixed LH OADM

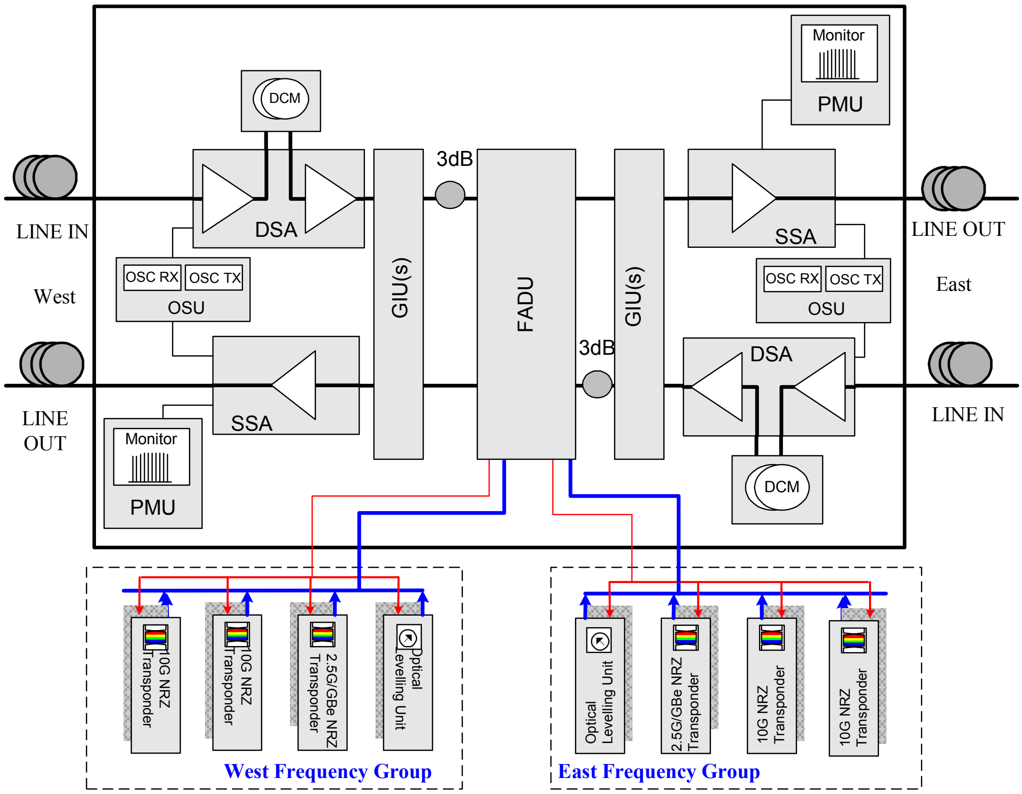


The associated sub-racks for both nodes are captured in Table 6-2 below:

Table 6-2: Sub-Racks for Both Nodes

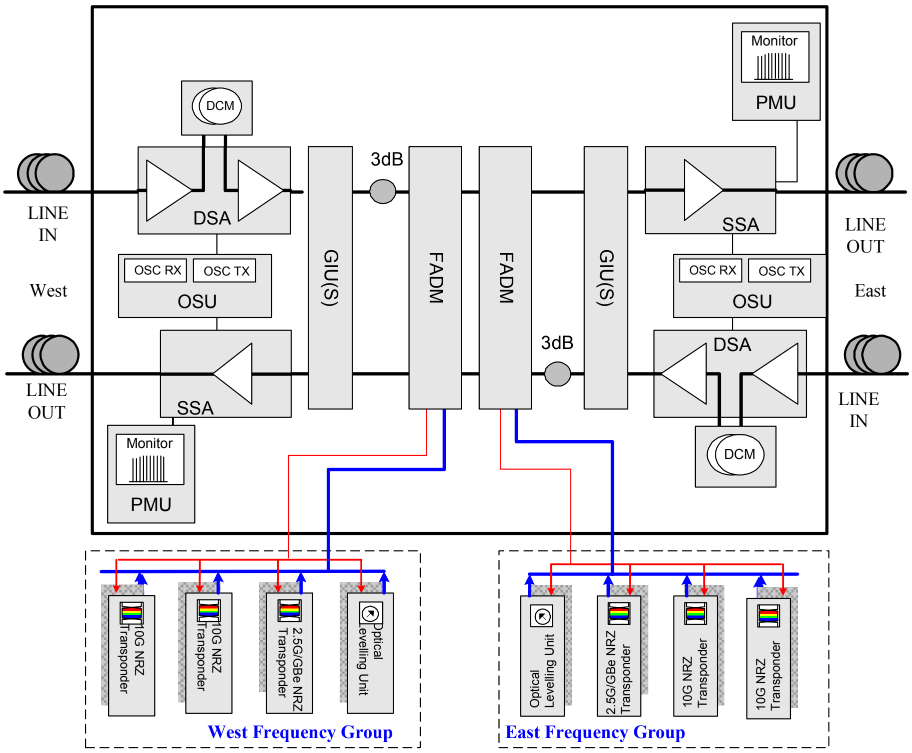
Sub-rack Type	No.	Comment
Dual row SR	1-5	Houses control, amps, Mux/demux and transponders
Single row SR	1	Houses transponders
DCM Tray	1	

Figure 6-11: 4 Channel Fixed ELH OADM



The schematic above shows the transmission units required to implement a 4 channel fixed ELH OADM. The 8-channel version is illustrated in Figure 6-13

Figure 6-13: 8 Channel Fixed OADM



The associated sub-racks for both nodes are captured in Table 6-4:

Table 6-4: 19 Slot Associated Sub-Racks

Sub-rack Type	4 ch.	8 ch.	Comment
Dual Row SR	1	1	Houses control amps and Levellers
Single Row SR	-	1	Houses control amps and Levellers
Line Interface Unit	-	-	Not required directly interfaced
DCM Tray	2	2	

6.3 Reconfigurable OADM

Figure 6-15: Reconfigurable OADM

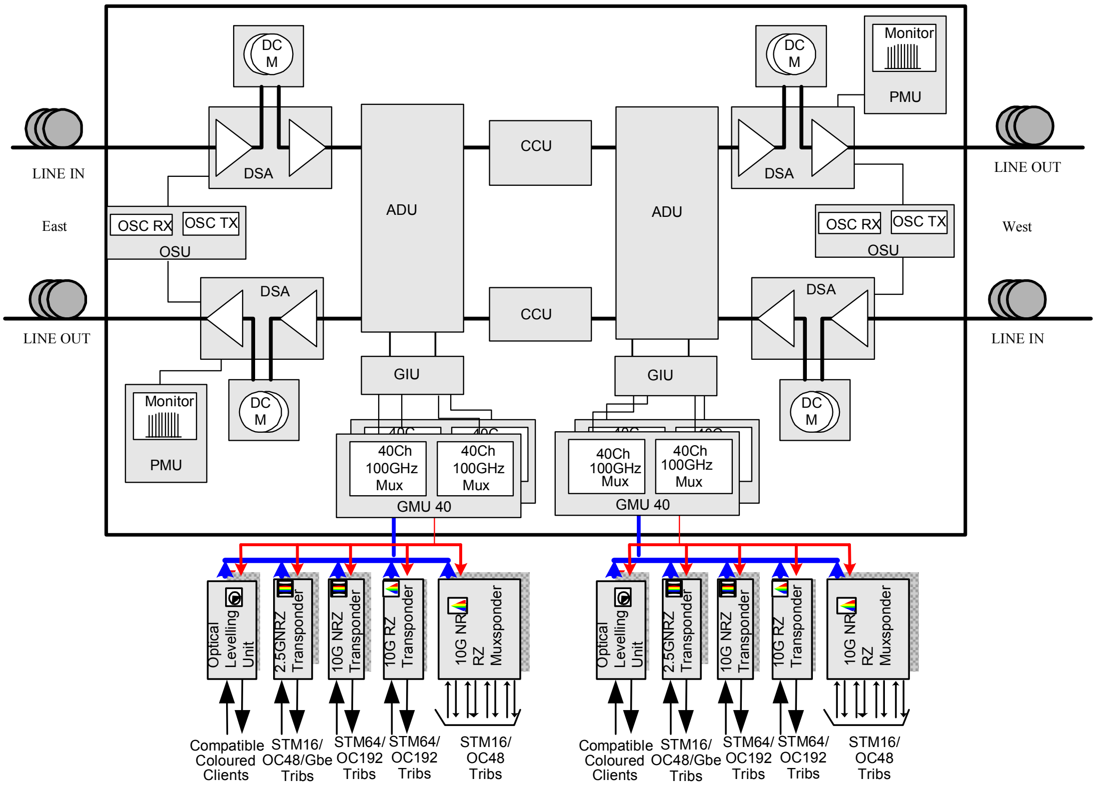


Figure 6-15 above shows the transmission units required to implement a single band OADM with eighty channels per direction cases. The associated sub-racks are captured in the table below:

Table 6-6: 19 Slot Associated sub-racks

Sub-rack Type	40 ch.	80 ch.	Comment
Dual row SR	2-6	2-12	
Single row SR	-	-	
Line Interface Unit	-	-	
DCM Tray	2.4	2.4	

6.3.1 Internal Cross-connection Options

Internal Cross-connections options on Multihaul 3000 equipment are Bi-directional as follows:

- Line to Line.
- Line to Trib and Trib to Line.
- Wavelength interchange (Using region group).

Note: Multihaul 3000 does not support Tributary to Tributary connections.

The internal cross-connect functionality within a Multihaul 3000 is provided by the combination of two units namely:

- The Channel Control Unit
- The Add/Drop units C Band

The Channel Control unit sits between the Add drop units and provides variable attenuation of each of the 80 optical channels. This allows levelling of the through channels or blocking of any channels added/dropped at that particular node.

In the Multihaul 3000 there are two Optical Add/Drop Units, one handling channels in the East/West direction and the other for the West/East direction.

6.3.2 Line to Line Cross-Connections

Cross-connections are carried by the Channel Control Unit, which connects 80 optical channels or blocks at 80 wavelengths, $\lambda1$ to $\lambda80$, from one OSU (East or West) to the other OSU (West or East).

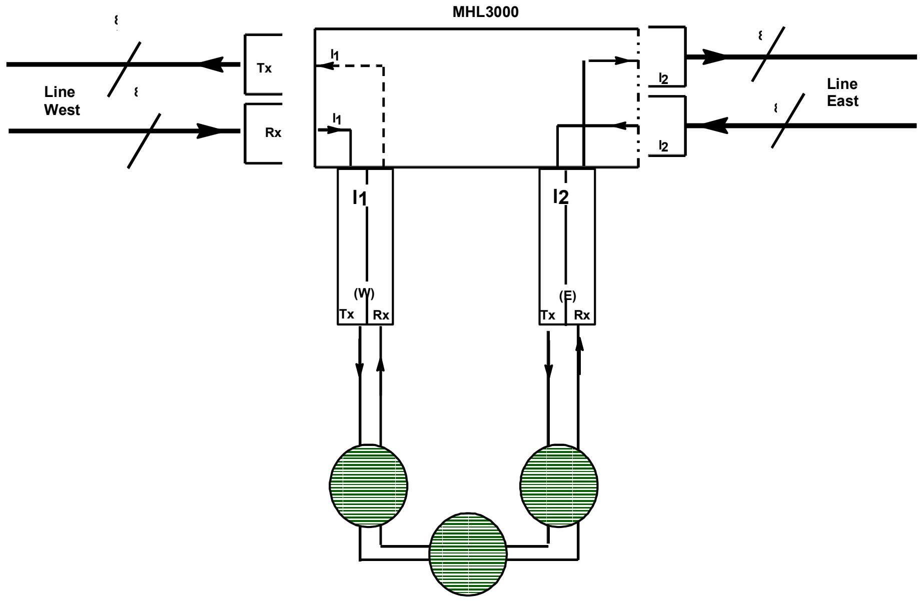
6.3.3 Line To/From Trib

It is also possible to add/drop up to 80 optical signals from/to the corresponding transponder cards.

6.4 Wavelength Interchange

Wavelength Interchange is a process of converting one Photonic Channel to another Photonic Channel at a different wavelength. Any of the 80 Optical Channels within a band can be converted to one other of these Channels. E.g. exchanging Line l1 to l2 is achieved by cross-connecting l1 to Trib 1, externally linking Trib 1 o/p to Trib 2 i/p and cross-connecting Trib 2 to Line l2. The OCh path overhead can be passed through the external Trib1/Trib2 links.

Figure 6-17: Normal Multihaul 3000 Configuration (Entry/Exit on Different Wavelengths)



The following diagrams illustrate some of the possible configurations permissible for internal and external connections.

Figure 6-19: Normal (Unprotected) Trib to Line Connection

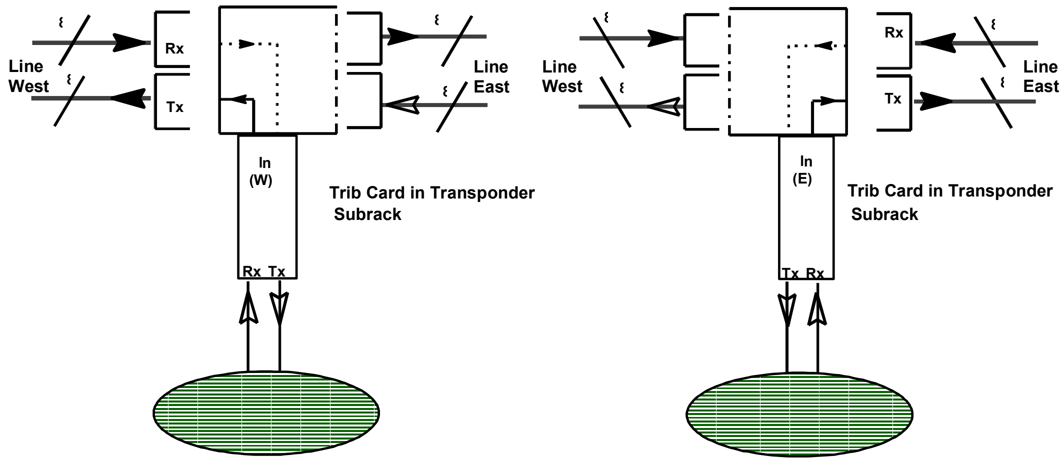
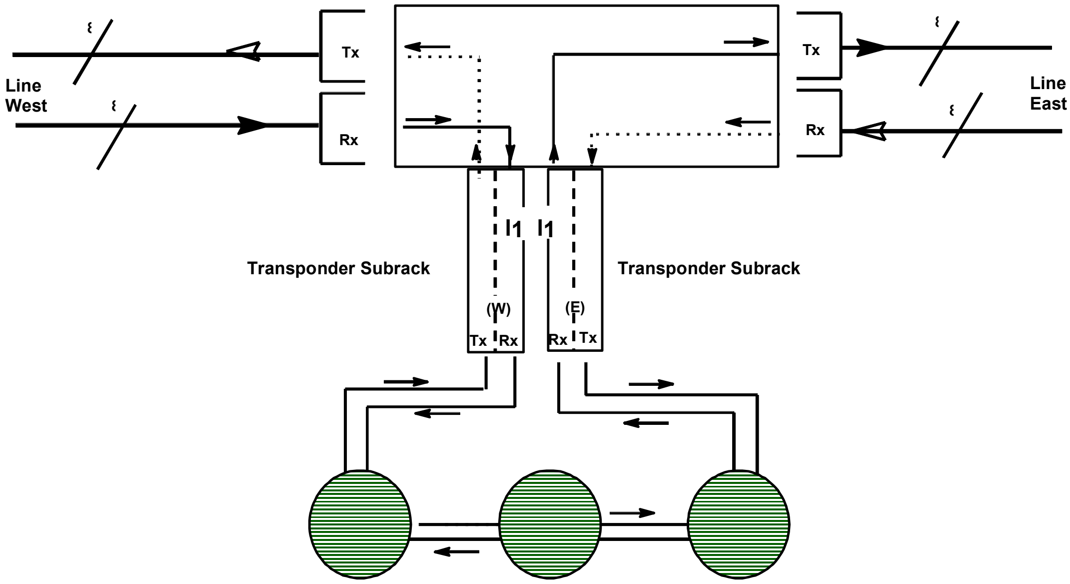


Figure 6-21: Normal Multihaul 3000 Configuration (Entry/Exit on Same Wavelength)



Blank Page

Chapter 7: Network Communications

7.1 Introduction

CAUTION!

Network data communications configuration parameters must not be altered without the authorisation of the network design authority. To do so can result in loss of network data communications and may only be resolved through recourse to a site visit.

The following external communication channels are provided between:

- The Element Management System (for operator use) and the Multihaul 3000 equipment, via an external Ethernet 10BaseT (LAN) through the Q interface.

A Local Craft Terminal and any Multihaul 3000 network element through the ‘F’ or Ethernet interface.

A modem and any Multihaul 3000 network element, not just a Gateway Element through the ‘F’ interface.

An internal communication channel is provided between:

- Multihaul 3000 NEs of the network via two ‘Qecc’ Channels embedded within the Optical Supervisory Channel (OSC).
- GCCO via Transponder

7.1.1 Element Managers Supported

MV36/Qx Element Managers/information models are supported.

7.1.2 Implementation

The Controller/ Communications cards on the core subrack of the Multihaul 3000, micro controllers on the individual units and configuration memory carry out the control and communication function of the Multihaul 3000.The Controller/Comms cards on the core and extension subracks are connected to a Comms IO LTU on the core subrack.

The two Comms IO LTU Ethernet 10BaseT interfaces provide:

A Q interface between a network elements connected to an Element Management System

- An interface to access a company’s Administrative LAN.

The two Comms IO LTU RS232 interfaces provide:

- The ‘F’ interface to the LCT
- The ‘F’ interface to a modem.

7.2 Protocols Used For Network Communications

The Multihaul 3000 communications subsystem supports the Qx (OSI) protocols. The Communications subsystem provides communications functions to allow Element Management Systems (EMS) to communicate with the central control function of the network element (NE) and also onward transmission of messages from the EMS destined for other connected NEs.

7.2.1 OSI Environment

The OSI environment supported by Multihaul 3000 is that provided by a mixture of SDH/SDH NEs and associated commercial OSI routers. IS-IS routing functionality is provided.

7.2.2 TCP/IP Environment

The TCP/IP environment supported is compatible with commercial IP routers and platforms

7.2.3 Protocol Layers

The NEs contain both seven Layer OSI and TCP/IP stack implementations.

The TCP/IP stack handles based management comms traffic over the ‘Q’ interface.

The 7 Layer OSI stack handles Qx based management comms traffic over the ‘Q’ interface as well as the Qecc interfaces.

The IS-IS dynamic routing protocol is provided for routing within the OSI domain.

7.2.4 Data Communication Channels

Two ‘Qecc’ interfaces are provided per NE:

- OTS_DCC @192kbit/s
- OMS_DCC @ 576kbit/s.

7.2.5 Functions

7.2.5.1 OSI Stack

The OSI stack handles the Qx traffic arriving via the ‘Q’ interface and Qx traffic destined for other NEs (via the DCCs) within the same DCN.

7.2.5.2 TCP/IP Stack

The TCP/IP stack handles the comms traffic for the Administrative LAN via the ‘Q’ interface.

7.2.6 COMMS Application

The comms application handles stack configuration, collation of comms performance data and alarms and transfer of this data to the controller function via the MPI.

7.2.7 External Interfaces

7.2.7.1 Q’ Interface

10Base2 and 10Base5 Ethernet are available as options for the ‘Q’ interface.

The ‘Q’ interface is capable of conveying the following DCN traffic types:

- **Qx**: This is routed via the 7 layer OSI stack

7.2.7.2 ‘Qecc’ Interfaces

‘Qecc’ DCN traffic to be routed over either one or both of the embedded data comms channels within the SOH.

The ‘Qecc’ interfaces are capable of conveying the following DCN traffic types:

- **Qx:** This is routed via the 7 layer OSI stack

7.3 Data Communications Applications

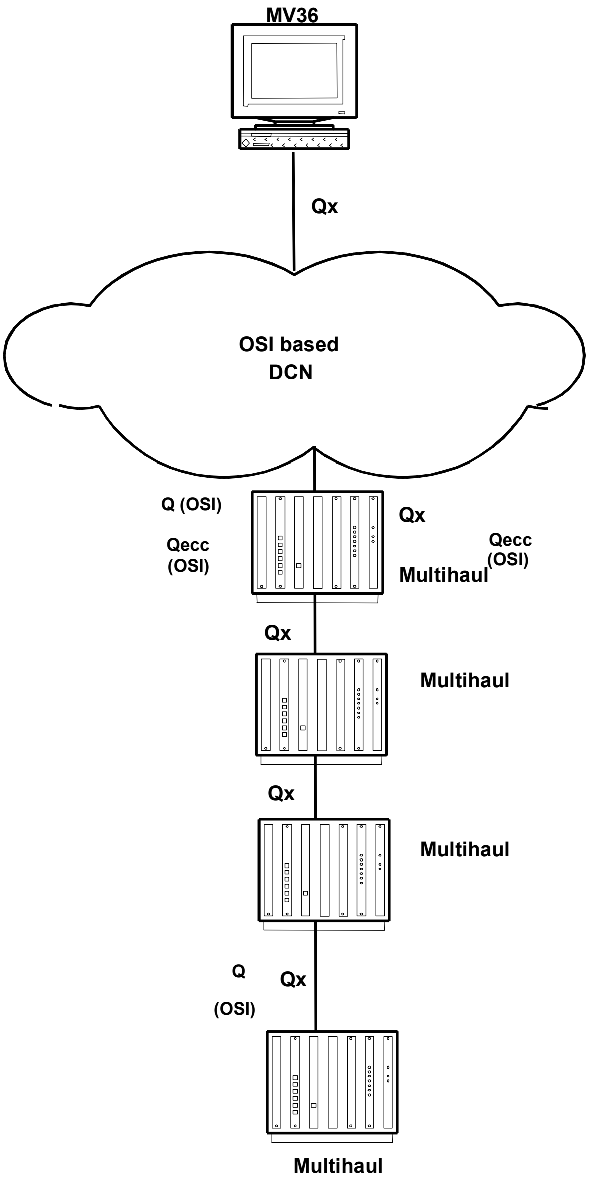
The sub-sections that follow contain diagrams representing examples of the types of networks in which the Multihaul 3000 can operate. These are:

- Qx Applications
  - Pure WDM Application
  - Mixed WDM/SDH Application

7.3.1 Qx Applications

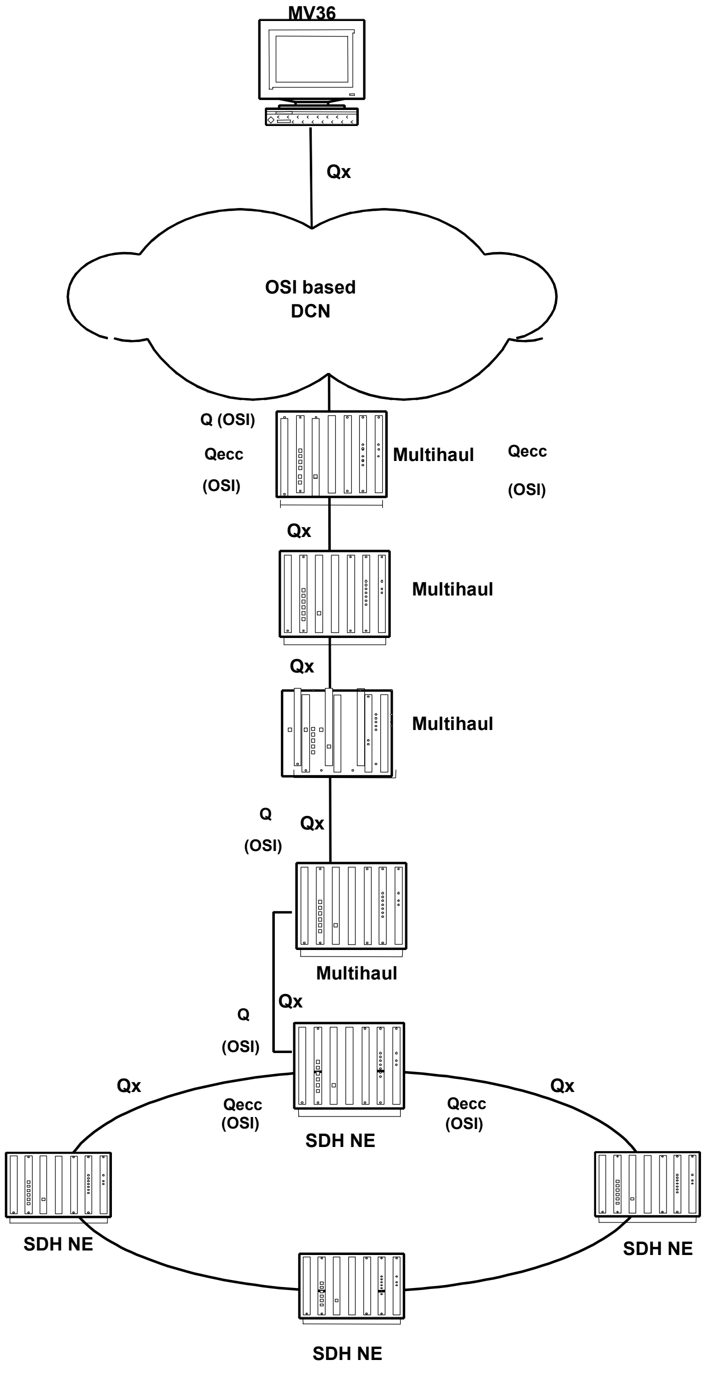
7.3.1.1 Pure WDM Application

Figure 7-1: Pure Qx Application



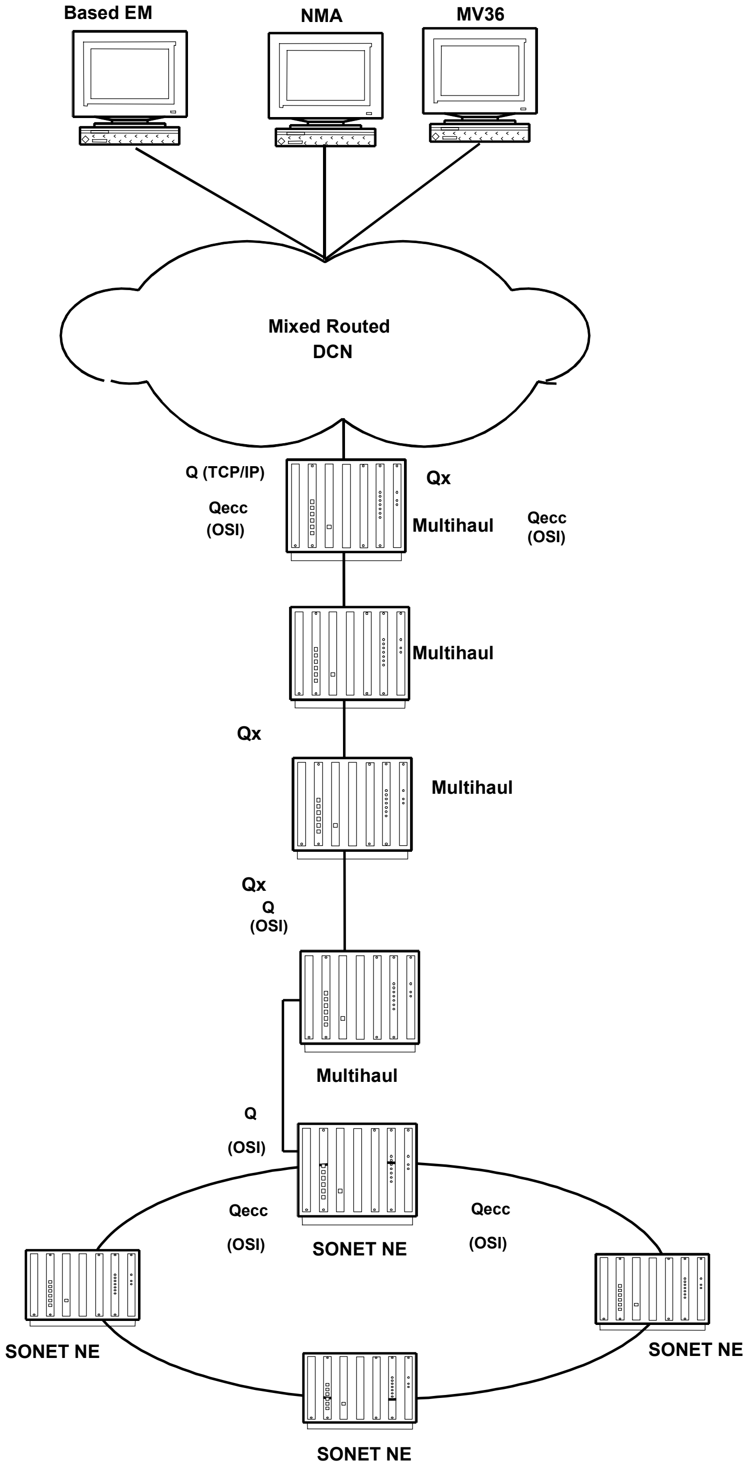
7.3.1.2 Mixed WDM/SDH Application

Figure 7-3: Mixed WDM/SDH Qx Application



7.3.1.3 Mixed Qx Applications

Figure 7-5: Mixed Qx Application



Chapter 8:
General Notes on Equipping

8.1 Introduction

Multihaul 3000 Subrack, are populated with slide-in cards. This chapter provides information relevant to individual cards and their installation.

Slide-in units are fitted with front panels to provide protection from physical and electrical damage when fitted in the shelf, as well as to ensure that EMC requirements are achieved.

8.1.1 Removal/Insertion of Slide-In Units

The insertion, withdrawal or replacement of any SIU does not physically disturb any other SIU, unless the relevant SIUs together form one module.

8.2 Extraction of a Traffic SIU

Note: The suppression of alarms from the various SIUs downstream of the removed cards is implemented as part of the alarm filtering process in the NEC.

The channel-equipped byte in the SOH is used to indicate which wavelengths are present on the Transmit Section output. This information is used by the MHL3000 receiving the section signal. The channels present are determined by the Power Monitor Unit from:

- Its input detectors
- The channel equipped byte data received on the other OSU
- The cross-connection status supplied to it by the NEC.

The channel equipped byte data is passed between the opposite OSU and PMU via IEEE1394 intra card communications message. Changes in the state of other Traffic SIUs when one traffic SIU is extracted is described in Table 8-1

Channel Termination units used, as regenerators for OTS-N-to-OTS-N connections causes actions as if they are performing OTS-N to Channel Termination and Channel Termination to OTS-N connections.

Table 8-1: Actions on Extracting a Traffic SIU

Extracted Card/Unit	Cross-connection	Transmitted Signal on other port
Add/Drop Unit	OTS-N to OTS-N	At associated output port and for the associated wavelengths (this depends on connections set up): OCh signals not expected Insert OCh FDI or OCI in OSC Transmit Line port ALS active
OSU	OTS-N to OTS-N	No Action
Dual/Single Stage Amplifier	OTS-N to OTS-N	At associated output port and for the associated wavelengths (this depends on connections set up): OCh signals not expected Insert OCh FDI or OCI in OSC Transmit Line port ALS active
Metro Single Stage Amplifier	OTS-N to OTS-N	At associated output port and for the associated wavelengths (this depends on connections set up): OCh signals not expected Insert OCh FDI or OCI in OSC Transmit Line port ALS active
Channel control Unit (Card Type 4 & 19)	OTS-N to OTS-N	No Action (As long as Fibres still intact)
Channel Equaliser Unit (Card Type 11)	OTS-N to OTS-N	No Action (As long as Fibres still intact)
Power Monitor Unit	OTS-N to OTS-N	No action
OSU	OTS-N to Och Termination	No Action
Dual/Single Stage Amplifier	OTS-N to Och Termination	No Action Note: At the transmit port of the same line section the Tx Output will be shutdown autonomously by ALS implemented in H/W
Metro Single Stage Amplifier	OTS-N to Och Termination	No Action
Add/Drop Unit	OTS-N to Och Termination	No Action A transponding Channel Unit will autonomously suppress the client output/insert AOZ/AIS at client output
Channel Control Unit	OTS-N to Och Termination	No Action A transponding Channel Unit will autonomously suppress the client output/insert AOZ/AIS at client output

Extracted Card/Unit	Cross-connection	Transmitted Signal on other port
Power Monitor Unit	OTS-N to Och Termination	No Action
Transponding Channel Unit	OTS-N to Och Termination	No action
OLU & 8 Ch OLU	OTS-N to Och Termination	No action
TDM Mux	OTS-N to Och Termination	No Action
GbE Mux	OTS-N to Och Termination	No Action
Group Mux Unit	OTS-N to Och Termination	No Action
Group Interleaver Unit	OTS-N to Och Termination	No Action
OSU	Och Termination to OTS-N	No Action
Dual/Single Stage Amplifier	Och Termination to OTS-N	No Action Note: At the transmit port of the same line section the Tx Output will be shutdown autonomously by ALS implemented in H/W
Metro Single Stage Amplifier	Och Termination to OTS-N	No Action
Add/Drop Unit	Och Termination to OTS-N	No Action A transponding Channel Unit will autonomously suppress the client output/insert AOZ/AIS at client output
Power Monitor Unit	Och Termination to OTS-N	No Action
Transponding Channel Unit	Och Termination to OTS-N	At associated output port and for the associated wavelength (this depends on connections set up): OCh signals not expected Insert OCh OCI in OSC
OLU & 8 Ch OLU	Och Termination to OTS-N	At associated output port and for the associated wavelength (this depends on connections set up): OCh signals not expected Insert OCh OCI in OSC
TDM Mux	Och Termination to OTS-N	No Action
GbE Mux	Och Termination to OTS-N	No Action
Group Mux Unit	Och Termination to OTS-N	No Action
Group Interleaver Unit	Och Termination to OTS-N	No Action

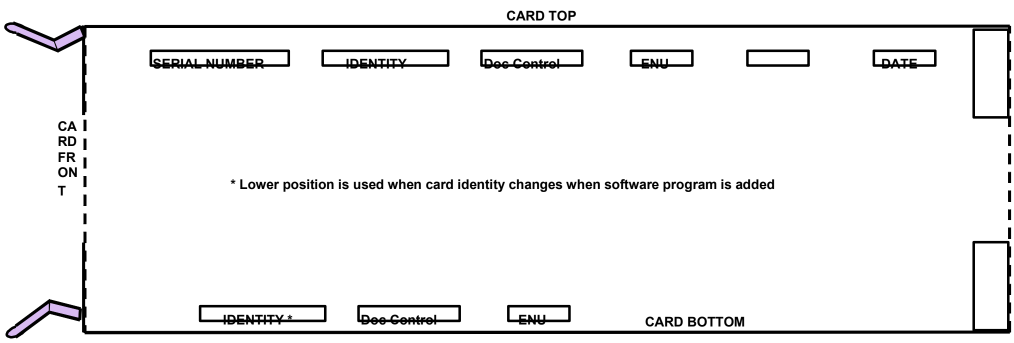
8.2.1 Management Data Communications

An optional card able to access the overhead data buses, an Engineering Order Wire /Auxiliary (AUX/EOW) card, can be used to provide engineering equipment management data communications.

8.3 Card Label Positions

The card-labelling scheme is illustrated below.

Figure 8-1: Example of Card Labelling



8.4 General Features Of Card Installation

WARNING!

The optical safety rules outlined in safe working practices chapter, and relevant card replacement details in the LCT operator manual must be read and understood before any optical card is removed from the subrack or disconnected.

8.4.1 External Connections

Fibre-optic cable connections to Optical Cards are via connectors, bracket mounted on the front of the card. On-card fibres, running from the connectors into the card, are protected by a guard, or cable guides.

8.4.2 Card Complement

The card complement of a Subrack will depend on the application of the particular Multihaul 3000 in the network. Certain types of card protection schemes may involve duplication of cards.

8.4.3 Installing the Cards into the Correct Slots

The sequence in which cards are installed is not important. It should be noted however, that some cards have fibre connections made at their front panels, therefore it may be more convenient to install these cards last.

Card slots are identified by the numbering scheme 1-N (counting from left to right), when viewing the shelf from the front. Which card types can populate what slots, are illustrated in the Card configuration tables at the beginning of the Installation chapter.

Note: A mechanical card keying mechanism prevents cards from being fitted in the wrong slots (which could otherwise result in damage to the cards).To maintain EMC integrity, all un-populated card (and LTU) slot positions should be fitted with dummy blanking plates. A range of plates are available to suit the different slot widths, these are detailed in the previous chapters of this section.

When fitting a unit next to an EMC blanking plate; first remove the EMC blanking plate as this will aid in the unit sliding into the shelf.

All cards go through an automatic self-test routine after they are powered-up.

8.5 Safety Precautions

8.5.1 Safe Working Practices

When working on the Multihaul 3000 equipment, it is important that in addition to complying with the provisions of any safety notices displayed on the equipment or highlighted in the Operator Manual, the working practices outlined in Topic 2 The Essential Safety Information and below are adopted.

Personnel should not be allowed to work on the equipment unless they have received adequate instruction in the techniques involved and the relevant safety precautions.

Note: In order to comply with safety requirements 60950-1, the equipment must be professionally installed in a restricted access location. A protective earth connection should be made.

- Do NOT point an unterminated or broken optical fibre end or an unmated connector towards the eye or other parts of the body.
- Handle optical fibre carefully as broken fibre can be very sharp. Keep exposed fibre ends away from any part of the body.
- **Never use a magnifying glass** (e.g. watchmaker's eyeglass) as an aid to viewing any part of an optical system, fibre, or optical connector. If it is required to inspect an unterminated fibre end, an approved indirect viewing medium (video-scope) with adequate attenuation / filtering should be used.
- Use only approved methods and materials for cleaning optical connectors.
- On the equipment cards, the EMC fingers are constructed from stainless steel and are very thin. They should be handled with care as damaged EMC Fingers may cause cuts or abrasions.

- When making optical measurements involving the use of a test lead, ensure that:
- The connection to the optical source is the last to be made and the first to be broken.
- The optical measurement path is closed before re–applying power to the optical source.
- Do not apply power to optical source cards when they are not fitted in the sub-rack.
- Do not connect an optical output to line unless the distant end is safely terminated.
- Handle optical fibre carefully as broken fibre can be very sharp and cause eye or skin injury.
- Care must be observed when disposing of broken fibres to ensure any shards are disposed of in an appropriate rigid sealed container.

WARNING!

Under certain fault conditions, when operating with automatic laser shutdown (ALS), it is possible for the laser to restart automatically for a test period.

Note: Testing for output power is therefore not a guarantee of laser safety.

Caution should be observed when lifting or removing amplifiers and other units, as they are heavy.

Some of the unit outer casings get very hot. If units need to be removed, they should be withdrawn slightly, to remove power, so that their back-plane pins are not touching the back-plane connector. They should then be left for several minutes to cool-down prior to removing completely from the Subrack.

8.5.2 Housekeeping

Maintain good ‘housekeeping’ practices. In particular:

- Pieces of glass fibre (e.g. off–cuts, etc.), however small must be collected and properly disposed of in a suitably labelled rigid sealed container.
- When working above another Multihaul 3000 Subrack, care must be taken not to drop small items, particularly metal items such as screws. The mesh of the screen at the top of a Subrack is large enough to allow very small objects through.

8.6 Cleaning Procedures for Optical Connectors

For information please refer to procedure for inspection and cleaning of optical connectors document 1QDE 10774 ABU-YYA.

8.6.1 EMC Covers

All Multihaul 3000 Subrack must have all card slot positions and all LTU positions fitted to maintain the EMC performance and thermal airflow of the equipment. All unoccupied slots must be fitted with EMC covers.

8.6.2 Static Sensitive Warning

WARNING!

Equipment referred to in this specification contains static sensitive devices therefore an **ESP wristband MUST be worn and clipped to the sub-rack at all times**. Other relevant anti-static precautions are also to be observed at all times during commissioning work.

8.7 Multihaul 3000 Safety Shutdown Mechanisms

8.7.1 Optical Safety according to BS EN 60825-1 and IEC 60825

There are optical source devices used in this product which have been classified by their manufacturers under BS EN 60825-1: 1994 as class 3B laser products, and so can potentially emit invisible optical radiation up to Class 3B (Class 4 with Raman).

Automatic Power reduction and control circuitry is used to limit the power available from the devices so that the radiation actually accessible to the operator does not exceed the Hazard Level 1 limits or Hazard Level 1M classification as derived from IEC 60825-1 Amendment 2: 2001-01.

With the Automatic Power Reduction circuits active, the Multihaul 3000 unit types represent the following Hazard levels: -

Table 8-2: Multihaul 3000 Unit Types Hazard Levels (HL1)

Multihaul 3000 Unit	Wavelength	Hazard Level
CEU	1510-1560	1
CCU	1510-1560	1
10G Transponders	1510-1560	1
10G Muxponders	1510-1560	1
2.5G Transponders	1510-1560	1
DCM	1510-1560	1
OSU	1510-1560	1

Table 8-3: Multihaul 3000 Unit Types Hazard Levels (HL1M)

Multihaul 3000 Unit	Wavelength	Hazard Level
RPU	1410-1500	1M
DSA/SSA	1510-1560	1M
ADU	1510-1560	1M
FADU	1510-1560	1M
GMU-40	1510-1560	1M
GIU	1510-1560	1M
LIT	1510-1560	1M

The classification of the Raman pump units has been based on their maximum achievable output power.

The classification of the Transponder unit (Client Side) has been based on its maximum possible output power ignoring ALS. The unit can be delivered with ALS (client side) enabled or disabled.

CAUTION!

Currently all Transponders are delivered with their client side ALS disabled. To enable ALS the associated 'link' must be removed.

The EDFA / laser modules and associated circuitry for the Multihaul 3000 have been assessed for safety related failures. The total failure rate for each of the mechanisms is less than 500 Fits.

No attempt should be made to adjust or tamper with the laser or it's control circuitry as this may result in Class 1 or Class 1M emission limits being exceeded. High output power latch circuits are provided to ensure that the output power cannot exceed it's specified operating limits. In the event of a fault occurring, these circuits remove power from the laser drive circuitry.

Connection to other than proprietary Marconi equipment may result in optical output power levels in excess of Class 1 or Class 1M limits thereby exceeding Hazard Level 1 or Hazard Level 1M. For appropriate laser safety information, refer to the associated equipment handbook.

8.7.2 ALS in Multihaul 3000

There are four cards that are capable of generating optical radiation. These are the OSU, the transponders, the erbium fibre amplifiers and the Raman pumps. Additionally, ports on cards that do not generate their own radiation may present hazards, as they will transmit energy from active cards. In the Multihaul 3000, all optical connection points are maintained at or below Hazard Level 1M due to either low level of accessible power or Automatic Power Reduction mechanisms and Automatic Laser Shutdown mechanisms.

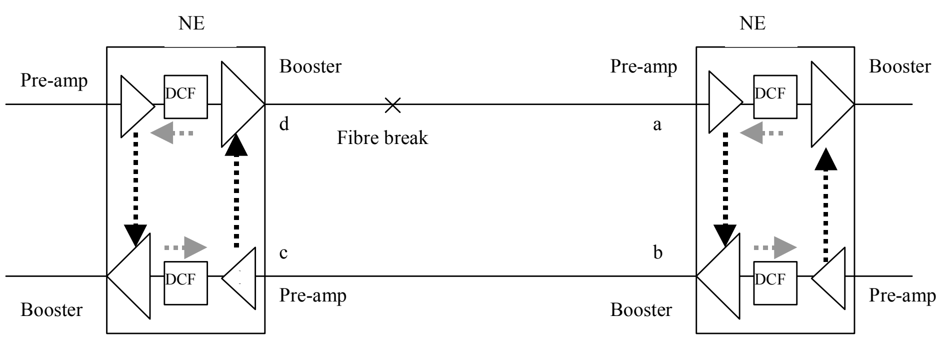
8.8 Automatic Laser Shutdown for XSA amplifiers.

Potential hazards occur when either the cabled fibre between two network elements is damaged remotely from the network element, or when a connector is accidentally disconnected. High power EDFAs transmitting power towards the break are shut down to prevent hazardous exposure. Only amplifiers surrounding the breakpoint are switched off, the limits to this shut off are described as the ALS section.

An ALS section is defined as being between two pairs of amplifiers, a pair being one amplifier facing east and one facing west. These amplifiers can be either single stage or dual stage, and are placed in adjacent slots in the rack, as otherwise the amplifiers will fail to start. The amplifiers rely on loss of signal detection (LOS) to determine if a break has occurred.

There is a monitor photodiode on the input stage of every amplifier that is constantly monitored by a dedicated ALS circuit. If at any time this monitor detects that the power level has dropped below a pre-set threshold, the ALS circuit switches off the output of the other half of the amplifier pair. Figure 8-3 illustrates how this mechanism protects fibre breaks.

Figure 8-3: Fibre Break Protection Mechanism



In this example a break has occurred between two pairs of dual stage amplifiers. The input monitor at point A detects loss of signal and signals this to the amplifier in the opposing direction. The booster at point B then switches its output off. LOS is detected at the input of the next amp (point C above), which cuts its signal to the booster at point D, which then switches off preventing exposure at the break.

Single stage amplifiers operate in the same way, but additionally they will also switch off their first gain stages if they detect LOS at their input monitors. This is to prevent Q-switching of equipment when it restarts and does not affect the safety of the equipment. For the same reason, the first stage of a dual stage amplifier will also switch off on detection of loss of signal, whilst the second stage remains on at a power equivalent to minimum channel operation to keep the subsequent section alive.

After a line break, the EDFAs will pause for 100 seconds (as required by ITU-T G.664) and then begin an automatic restart procedure. The automatic restart procedure can be inhibited via the EM/LCT and can be used to allow live working on broken fibres. In this state, the EDFA booster will produce a low power coded try pulse. Whilst in the restart state, the paired input signal is monitored, and if the coded pulse is detected LOS is cleared and the booster emits a coded try pulse. At the end of the trial pulse the booster checks the state of the pre-amp, and operates as normal if the coded signal has been detected. Single stage amplifiers behave in the same manner as dual stage amplifiers. The use of OTDRs and CW light sources cannot then cause a spurious restart or damage the equipment. This procedure will be repeated until the EDFA has successfully restarted. Monitoring the input of the booster stage protects the midstage of the dual stage amplifier, and shutting off the pre-amplifier if no light is detected. Restart is by trial pulse. Standard reach amplifiers may have this mechanism disabled via software, but only when the amp is in ALS. If this mechanism is disabled, the generation but not the detection of coded pulses will be inhibited.

8.8.1 Raman Amplifiers

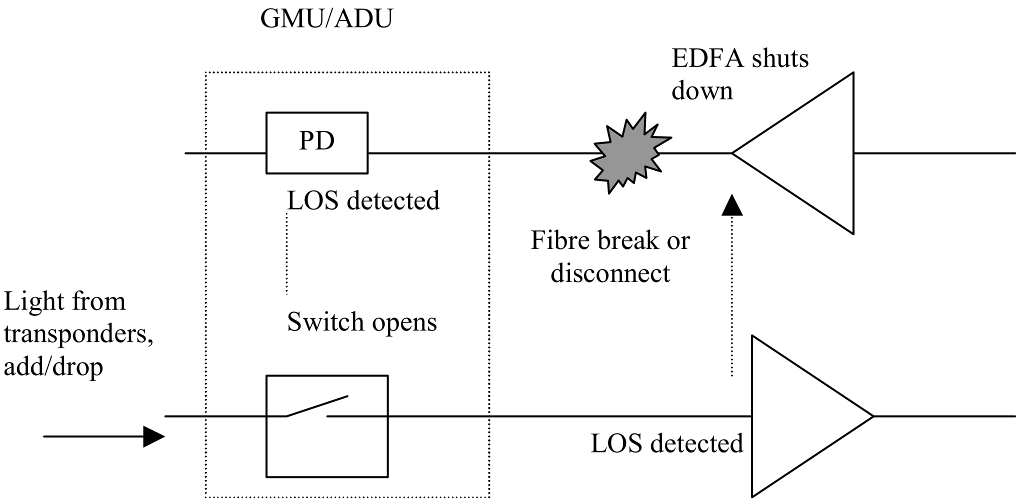
Raman amplifiers emit light against the flow of traffic that is they emit from the in port. They use high powers in the 1400-1500nm regions to achieve distributed gain in the transmission fibre. In the event of a fibre break or accidental disconnection, the Raman pump switches of quickly to prevent the potential exposure to optical radiation becoming hazardous.

This is achieved by monitoring the optical supervisory channel. Instead of monitoring the signal power levels in this channel, the frame alignment word is detected, and if this cannot be detected the Raman amplifier is shut down. Also, the OSC ceases transmitting in the reverse direction, causing the OSC at the other end to shut down as well. After 100 seconds the OSC will attempt to restart by sending trial signals in each direction. If these are successfully received at both ends the OSC restarts. Once the OSC has restarted, the Raman pumps are safe to start, as the OSC has checked the integrity of the fibre.

8.8.2 Terminal/Add-Drop

In the terminals the ALS section is not completed in one direction, as instead of an amplifier pair there is a Mux/demux chain and transponders. In this situation the ALS section is completed by the use of a shutter and detector mounted on either the GIU or shutter cards. This arrangement is illustrated below.

Figure 8-5: Terminal Add-Drop (1)

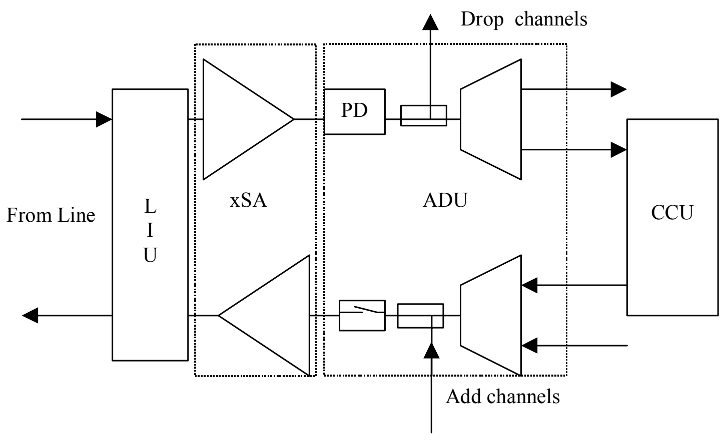


In this example, the link between the EDFA facing the transponders and the GIU is broken. The detector on the GIU card detects loss of signal, and closes a shutter on the transmit path blocking the light from the transponders. This causes loss of signal to be detected at the input of the other amplifier in the pair, which in turn causes the output of the first amplifier to shut down, protecting the break.

After the amplifier has switched off, it will pause for 100 seconds and then send a restart pulse towards the monitor. This will cause the switch to open, sending a pulse of light from the transponders towards the other amplifier. This will be detected as if a second amplifier pair had sent a pulse back; indicating that the line is intact and the amplifier can restart. It should be noted that if the shutter card or Interleaver were not fitted, the node would not start up, thus ensuring safety.

In the add/drop network element a further complication is introduced, as there are more than one sources of light that can be detected by the amplifier. A similar arrangement is used which functions in the same way that cuts off all light entering the amplifier. This is illustrated below.

Figure 8-7: Terminal Add-Drop (2)



In order to restart this section, on detecting a pulse both the local and remote shutters are opened for the duration of the pulse, allowing the NE to restart when there are no local transponders present. The remote shutter only opens for the duration of the pulse unless all links are intact. This requires the cards to be placed in adjacent slots in the same way as EDFAs.

8.8.3 ALS Auto Restart Disable.

The equipment is safe to within the limits of hazard level 1M at all times however, there are circumstances when it is desirable to disable automatic ALS restart. This can be done via the LCT/EM on all cards that emit light towards the line, namely the OSU, xSA and RPU cards. In doing this the software will prevent the cards from generating restart pulses.

CAUTION!

This is not a safety feature and at all times the equipment should be treated as hazard level 1m even if this feature is in operation.

Chapter 9:
Event Reporting and Processing

9.1 Events

The Event Handling Subsystem is concerned with the capture, verification, classification, logging, reporting and indication of changes in the status of a NE.

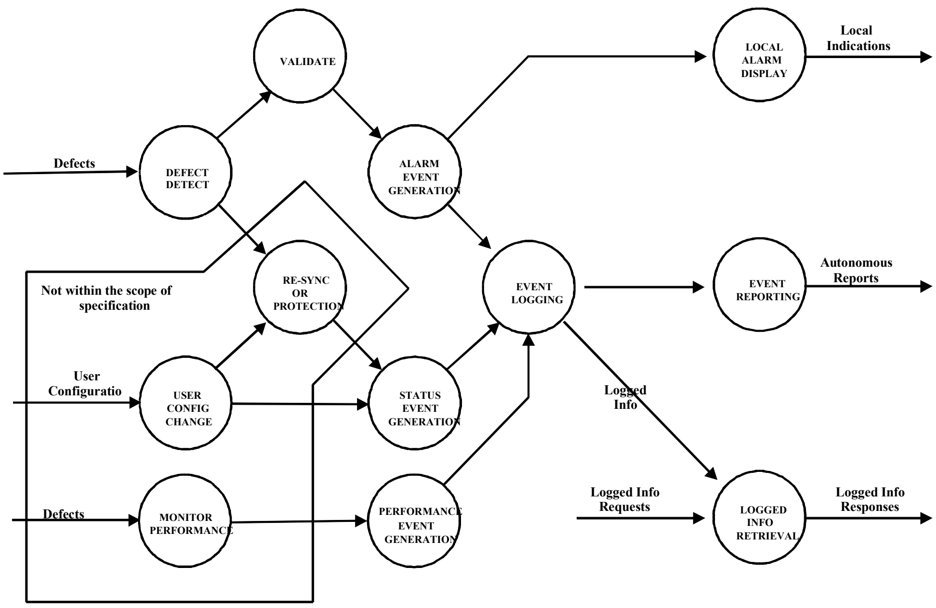
Instances of change are generally regarded as events. Events are detected by various means as follows:

- Defect monitors detect defects that are then validated, the resultant outputs from the EHS (Event Handling Subsystem) being **alarm events**, which can then be filtered.

- Any re-configuration of a NE is regarded as a **status event.**

- Exceeding a performance threshold is regarded as a **performance event.**

Figure 9-1: Simplified Functional Diagram of the Event Handling Subsystem

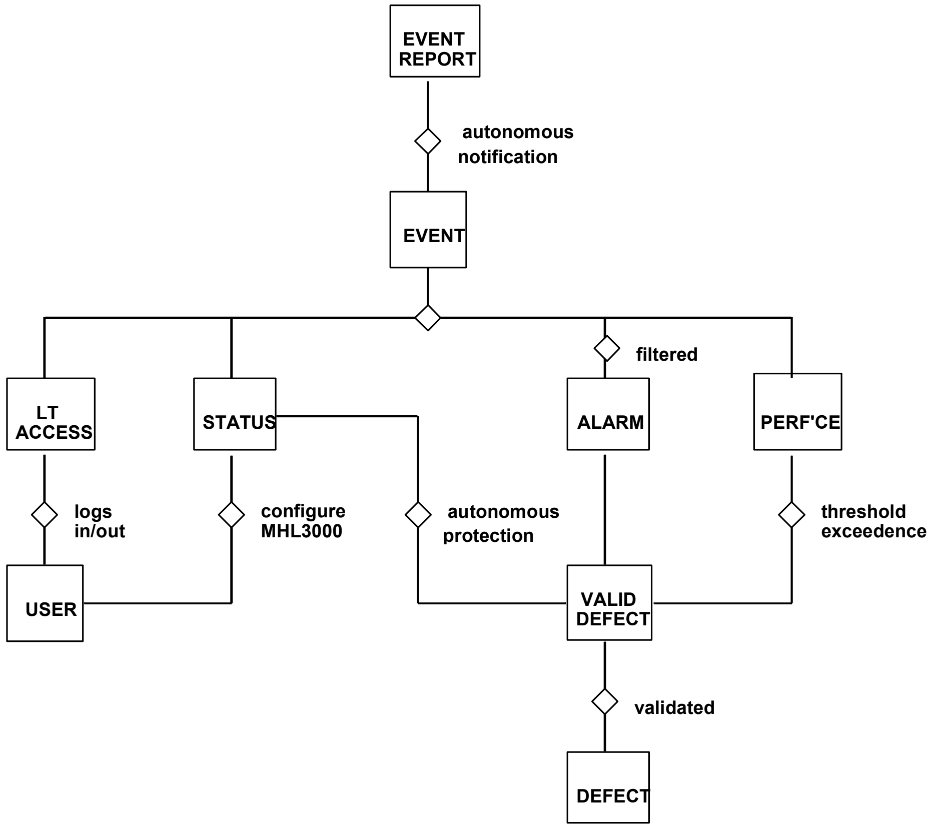


All three types of event pass through a two-stage logging procedure, not only assisting alignment or NE and EM on restoration of an EM link but also providing both LT and EM operators with a historical event search facility.

Autonomous generation of event reports is supported for alarm, status and performance events, whilst more traditional card and shelf indicators and rack extensions are supported for the indication of alarm events in the immediate proximity of the Subrack installation.

Figure 9-3 describes the relationship between the different entities associated with the recognition of events and the generation of event reports.

Figure 9-3: Event Type Relationships

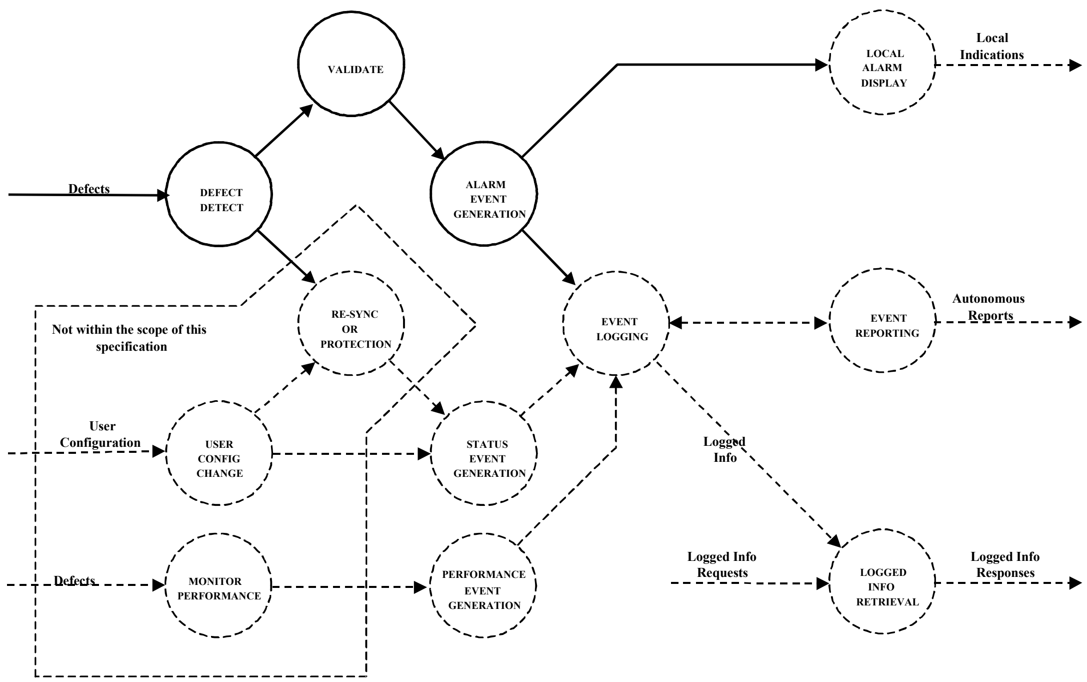


Note: The event report carries information about an event. An event is merely a change of state of something at a given instant in time. In the case of the event handling subsystem, an event can be one of the following: LT Login, LT Logout, Status (operator invoked or autonomous change of equipment config state), Alarm raise, Alarm clear or Performance (exception reports not scheduled reports).

9.2 Alarm Event Generation

As shown in Figure 9-5, the detected defects cause protection to take place. They are also validated with a view to generating alarms. This section details the various processes that comprise this validation.

Figure 9-5: Alarm Event Generation



Alarm indications are given by two means:

- Local alarm scheme comprising card front LEDs and coloured indicator lamps on the ALARMS I/O LTU and top of rack display modules.

- Autonomous messages via a rack alarm bus to Local Terminal and Element Manager allowing alarm information to be displayed in textual form.

9.2.1 Defect Detection

The presence or absence of a particular defect is signalled to the EHS by a dedicated defect monitor. Defect monitors are implemented either in hardware (to detect traffic condition or card hardware deviations), or in software (to detect problems with memory devices, logical operator configuration mismatches or threshold analogue monitors).

Fault defect monitors are provided within the Multihaul 3000 such that all types of fault defects can be monitored. The fault defect monitors detect conditions that may be indicative of a fault of the equipment itself or of a defect external to the equipment.

Fault defect events are validated to become alarm events. Alarm events are correlated (where necessary to enhance operator clarity) and used to give indications both within the environment of the NE (by means of a local alarm scheme) and remotely from the NE (by means of filtered message based reports).

Note: Due to the modular nature of the Multihaul 3000, any single type of fault defect can be detected at multiple points within the Multihaul 3000. Where this occurs, each defect is qualified with a unique identity that indicates its source.

The unique identity used to indicate the source of a defect to an operator adopts the following general format:

- Subrack
- Card Slot
- Source Type
- Source Number.

9.2.2 Defect Actions

The remote defect indication (RDI assumed now to be Backward Defect Indication BDI) consequential action is applicable to the Multihaul 3000 section and path overheads only. It is used to convey overhead receiver failure back to the remote overhead transmitter. Insertion of RDI in the backward direction is configurable on a per monitored entity basis.

None of the defects detected at the Section level automatically cause any consequential action at the channel level.

The detection of any of the Optical Channel Loss-Of-Signal, Payload Type Identifier Unequipped, Payload Type Identifier Mismatch and Trace Identifier Mismatch faults at the channel level. Each individually cause the client output laser (not the optical channel laser) on a Transponding Channel Termination unit to be shutdown, if so configured by the operator. The operator can configure the effect of each of these four defects for each client output individually.

9.2.3 Alarm Event Process Partitioning

9.2.3.1 Processing

The alarm event processing functions are distributed on different cards within the NE.

Traffic cards perform all processes that must operate at a sub one-second rate.

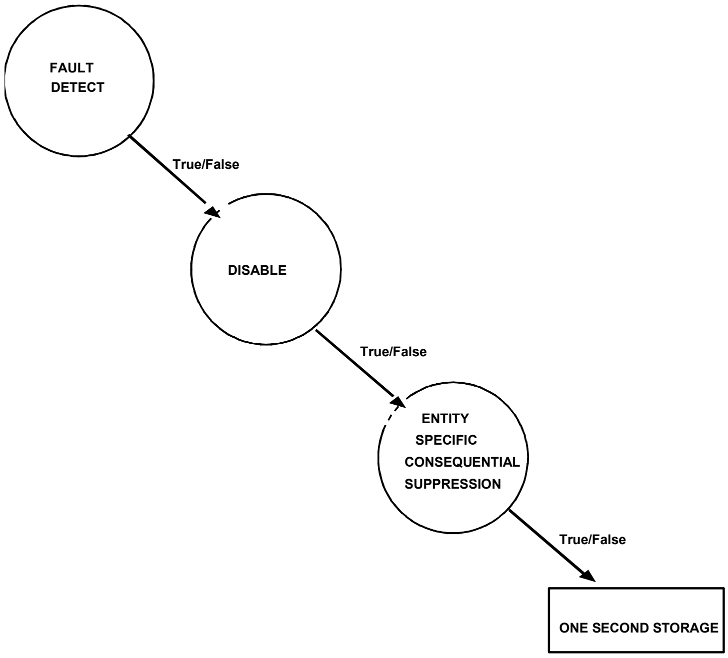
The Controller card via the Control Bus recovers the pre-processed fault detector information once every second.

The method of ensuring that all alarms reported pertain to the same second is for the Controller to issue a broadcast ‘freeze’ command via the Control Bus. On receipt of this ‘freeze’, traffic cards send their current alarm bitmaps to the controller.

9.2.3.2 Traffic Cards

Each traffic card performs Defect Detection, Alarm Disable and Entity-Specific Consequential Suppression in the order illustrated in Figure 9-7.

Figure 9-7: Traffic Card Fault Event Validation and Storage



Each of these functions is described individually in the following sub-sections.

9.2.3.3 Disable

Once disabled, the traffic card considers the defect monitor output to be false, regardless of its real state.

Note: This may give rise to a clearing alarm event if the defect condition was detected before the monitor was disabled.

Safety critical alarms are not disabled or inverted.

A listing of all alarms to which the disable option has been applied can be obtained via the HCI.

9.2.3.4 Entity-Specific Consequential Suppression

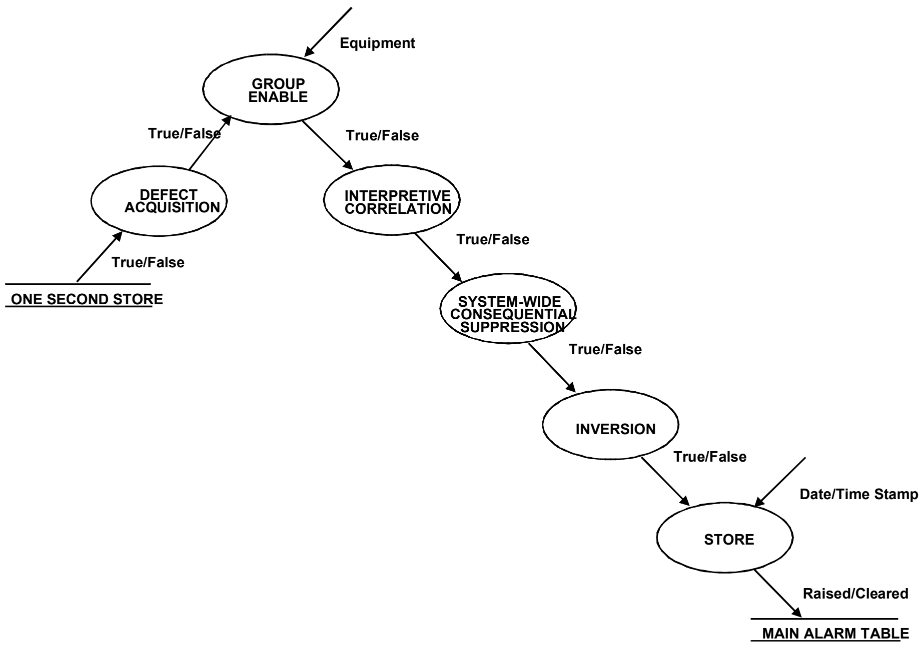
The consequential suppression mechanism ensures that where a defect condition arises which may, or will, cause a NE to raise multiple alarm events, and then the only alarm event generated is for the fundamental defect.

Note: The Multihaul 3000 implements two levels of consequential suppression. The lowest level (specified here) is performed on the individual traffic cards, and rationalises the defects detected for self-contained entities such as SOH and OCH-OH. The higher level is performed on the Controller, and rationalises system-wide alarm scenarios to ensure conflicting or misleading indications are not given for multiple cards.

9.3 Controller Card

The Controller performs Fault Acquisition (once each second), Group Enable, Interpretative Correlation, System-Wide Consequential Suppression and Inversion in the order illustrated in Figure 9-9.

Figure 9-9: Controller Defect/Alarm Event Evaluation and Storage



9.3.1 Defect Acquisition

Defect acquisition is carried out once each second by the Controller via the Control Bus (an IEEE 1394 Interface) alarm/performance poll mechanism. Additionally, the Controller includes its own alarms generated during the last second.

The Defect acquisition process can be interrupted by any of the following three events:

- Physical card removal
- Control Bus Protocol fail
- Slot Fail

The occurrence of these events results in the appropriate behaviour as described in the following sub-sections.

9.3.2 Card Removal

The Controller detects the absence/presence of a card for each card slot in the Subrack. This is achieved by means of an IEE1394 message extended from each card slot to the Controller.

Upon removal of a card, the Controller clears all alarms previously reported from that card, and generates clearing alarm event reports as appropriate. An alarm is raised for the now vacant card slot.

9.3.3 Control Bus Protocol Fail

This is detected by the Controller when Control Bus messages are received from polled cards which indicate errors in transmitted or received message data, or where Control Bus communications are totally lost with the card in a particular slot.

Under these conditions, the Controller assumes that the Alarm State of the card is now indeterminate and consequently latches all alarms previously reported from that card.

9.3.4 Slot Fail

The Controller detects Slot fail when application level communications is lost with a card in a particular slot. Loss of application level communications is assumed when a card does not respond to a message sent via the Control Bus within a given time. The time takes into consideration the impact on the NE of a particular task being forced to wait.

Under these conditions, the Controller clears all alarms previously reported from that card, generating clearing alarm event reports as appropriate. A “card/slot fail” alarm is raised for the slot containing the unresponsive card.

9.3.5 Group Enable

Where NEs are only partly provisioned (are deficient in cards or contain cards with unused circuits), the Controller does not generate alarm reports pertaining to the un-provisioned entities.

9.3.6 Interpretative Correlation

Interpretative correlation is performed in order to more accurately diagnose the real cause and source of defects, and to ultimately place the correct indication of failure on the correct SIU. This is necessary due to the analogue nature of the Multihaul 3000 design, and the resulting absence of the opportunity for real-time intercard signalling using diagnostics embedded in the traffic interfaces.

This is used where it is possible to interpret the same defect reported from many sources as being indicative of the failure of a centralised service internal to the Multihaul 3000.

When every input is reporting a Defect, the input Defects are suppressed and a different, more meaningful defect derived in their place.

Note: Normal, system level suppression suppresses the input faults.When one or more inputs are not reporting a defect, the individual input defects are passed on for reporting.

9.3.7 System Wide Consequential Suppression

The consequential suppression mechanism ensures that where a defect condition arises which may, or will, cause a NE to detect multiple defect events, and then the only alarm event generated is for the fundamental defect.

Note: The Multihaul 3000 implements two levels of consequential suppression. The lowest level is performed on the individual traffic cards, and rationalises the defects detected for self-contained entities such as SOH and OCH-OH. The higher level (specified here) is performed on the Controller, and rationalises system-wide defect scenarios to ensure conflicting or misleading indications is not given for multiple cards.

9.3.8 Alarm Inversion

Operator configurable alarm inversion attributes are supported for each Alarm.

Alarm inversion is used to designate the accepted normal (Defect free) condition of the monitor.

Alarm inversion is applied as an Exclusive-OR function to any Alarm that has been configured as inverted. This results in the following perceived behaviour:

- When not inverted, the Alarm is raised and cleared in the normal manner
- When inverted, the sense of the monitor is reversed causing alarm 'raise' events to be generated when the defect condition subsides and vice-versa
- Upon operator configuration of the invert attribute, inversion is applied immediately. Alarm 'raise' or 'clear' events are generated as necessary.

It is not acceptable for consequential defects to become apparent once inversion has been applied to a specific alarm. In order to achieve this behaviour, alarm inversion is always carried out after system-wide consequential defect suppression.

9.3.9 Alarm State Storage

Any defect events surviving the validation process are considered to be alarm events.

Alarm events are always reflected into a central repository. This repository always contains the current state of all alarms possible from the current configuration of the NE, so that search functions for raised alarms can be carried out. The allowable states of each alarm in the table are raised or cleared.

An alarm event is recognised whenever the state of a particular alarm changes in the central repository. This event is used to trigger two separate actions:

- Generation of an alarm event report
- Notification to the local alarm scheme.

9.4 Status And Performance Event Generation

9.4.1 Status Events

Status events are recognised whenever changes are made to the configuration database of the NE. Configuration can change under the following circumstances:

- Reconfiguration by EM
- Reconfiguration by LT
- Autonomous reconfiguration by the NE.

Note: For autonomous actions, status events may be raised in conjunction with alarm events where they reflect an autonomous change of NE State in response to the detection of a defect condition.

The source of a state change is classified as follows:

- Reconfiguration by EM: source = 'Management'
- Reconfiguration by LT: source = 'Management'
- Autonomous Reconfiguration: source = 'Resource'.

Table 9-1: Operator Configuration Options

Status Event Type	Attribute
Management	Inhibited/Not Inhibited (Default)
Resource	Inhibited/Not Inhibited (Default)

You can configure two attributes (See Table 9-1). The attributes are used to filter the output of the subsystem, determining whether status event reports are generated.

The details of a status event are identified to an operator by means of the following three basic pieces of information:

- Attribute Identifier - identifies the configurable item which has changed
- New Value - the new configuration attributed to the configurable item.
- Source - set to either 'Management' or 'Resource' dependent upon whether the status event was generated by an operator action or an autonomous action respectively.

9.4.2 Performance Events

Performance events are detected whenever performance parameter counts exceed operator-defined thresholds.

The EM operator can configure 2 attributes, one for SUE and TUE threshold events and one for 15min/24hr ES/SES threshold events. The attributes are known as 'inhibit' and are used to filter the output of the subsystem, determining whether status event reports are generated.

The attributes of each performance even are as follows:

Threshold type - the type of Output Device Error:

- SUE
- TUE
- 15minES
- 15minSES
- 24hrES
- 24hrSES.

Primitive type - identifies the primitive whose parameter count has exceeded threshold. This is interpreted to represent:

- RS B1 Block Error STM-n/OC-n
- OCH-OH Block Error
- OCH-OH BQI.

Source - identifies the function to which the primitive is deemed to belong. This is interpreted to represent:

- Terminated Path.

Primitive no. - identifies the monitored entity whose parameter count(s) have exceeded the threshold. For cards where more than one source of any type exists, an integer number is used for each source, starting at 1.

9.5 Event Logs

Event logs exist with the NE to store current, active and historical event records. The following sub-sections describe the types of event log that are generated by the Multihaul 3000.

9.5.1 Current Alarm Event Log

This log is of the “table” type and has sufficient capacity to store the current state of all alarms.

9.5.2 Historical Alarm Event Log

The Historical Event Logs. Alarm Event, Management Status Event, Resource Status Event and Performance Event provides an indication of historical changes of event states on a cyclic basis. Events/Alarms are applied to the logs via a priority inhibit/filtering process.

This log is of the “wrapping stack” type and has the capacity to store a minimum of 100 typical-length event records.

9.5.3 Status Event Log

This log is of the “wrapping stack” type and has the capacity to store a minimum of 100 typical-length event records.

9.5.4 Performance Event Log

This log is of the “wrapping-stack” type and has the capacity to store a minimum of 100 typical-length records.

9.5.5 Local Terminal (LCT) Access Log

The LCT Access Log holds the last five LCT operators' login attempts on a cyclic basis at any given time (all previous attempts being lost).

This log is of the “wrapping-stack” type and has the capacity to store a minimum of 100 event records.

9.5.6 Retrieval of Log Records

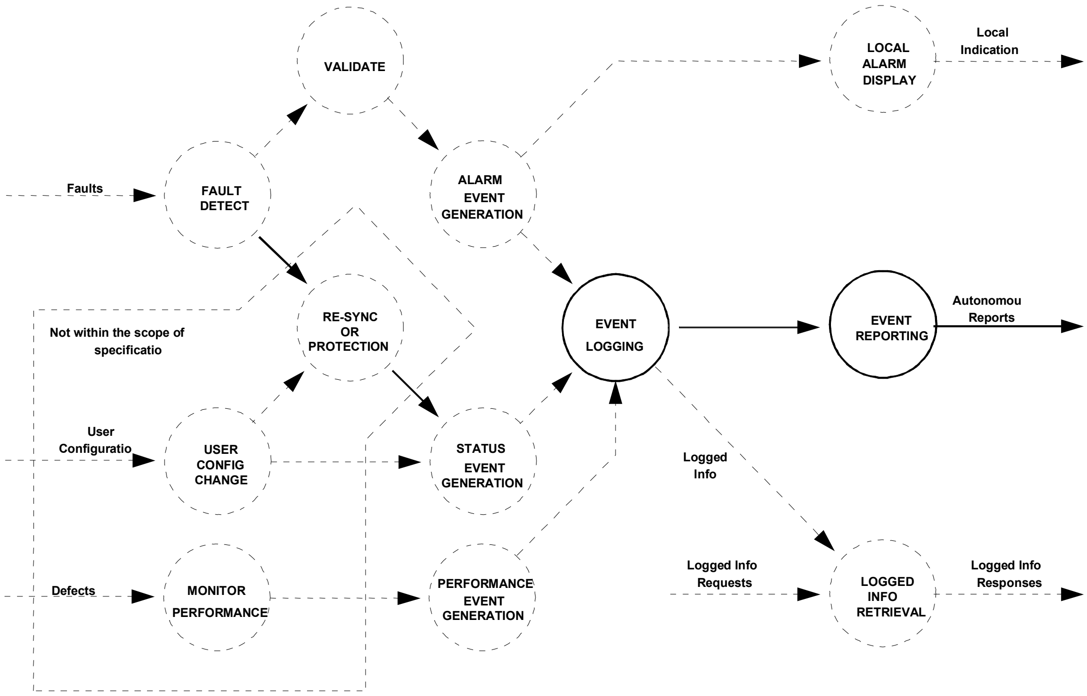
Both the Element Manager and Local Terminal operators can retrieve the contents of the various logs within the Multihaul 3000. All retrieved records are displayed in chronological order, the most recent first.

Time-range scoping of the historical alarm log only captures alarms for which records were entered in the log during the selected time period. As records are only entered into the log upon alarm clear conditions, no records are expected in the historical log for alarms that remain raised at the end of the selected time period.

9.6 Event Reporting

Figure 9-11 illustrates the event report generation process:

Figure 9-11: Event Report Generation



Autonomous event reports are only sent to both the Element Manager and the Local Terminal.

The LT has specific controls governing the reporting and logging of events dependent upon inhibit attributes and the connection state of the LT itself.

The operator is allowed to retrieve the inhibit state of each alarm each type of status event and each type of performance event.

The occurrence of alarm, status or performance events is signalled by the Controller to the LT using a proprietary mechanism in the handshake protocol between the two devices.

9.6.1 Event Forwarding and Logging

Events are forwarded to management devices to raise operator awareness of changes in the Alarm and configuration states of the NE as well as its short-term traffic path performance.

Events are not only logged to provide the operator with a limited memory of alarm, status and performance events, but also to provide a method by which the EM can re-align its database with that of the NE following a period of disconnection.

Note: The short-term memory of old events are referred to as historical events, whereas events that are retained for re-alignment purposes are referred to as current events.

Events are reported to the LT and logged according to their origin, their inhibit attribute and the operational state of the NE, i.e. whether an LT is connected or not.

There are two distinct methods for determining forwarding and logging of events, primarily because of the difference between the nature of alarms (which are state-based entities) and status and performance events (which are more typical of triggers).

The essential requirements of the two distinct methods are shown in Figure 9-13 and Figure 9-15.

Figure 9-13: Forwarding and Logging of Alarm Events

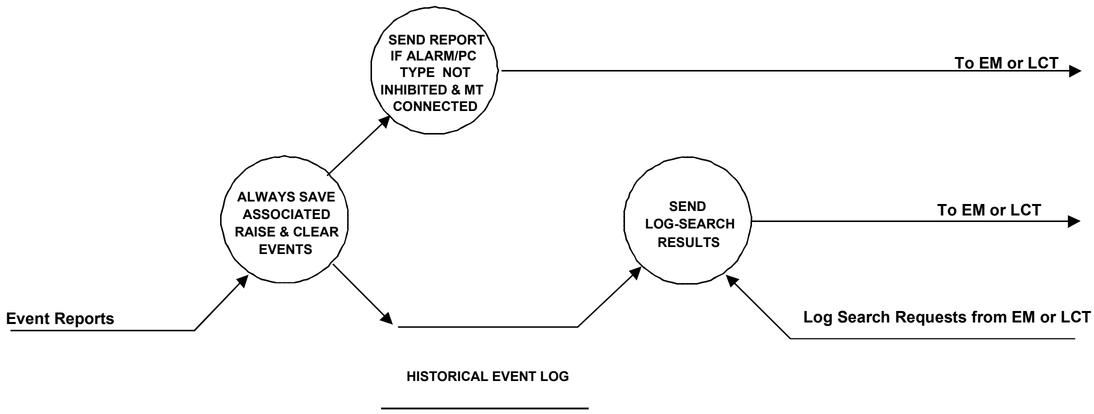
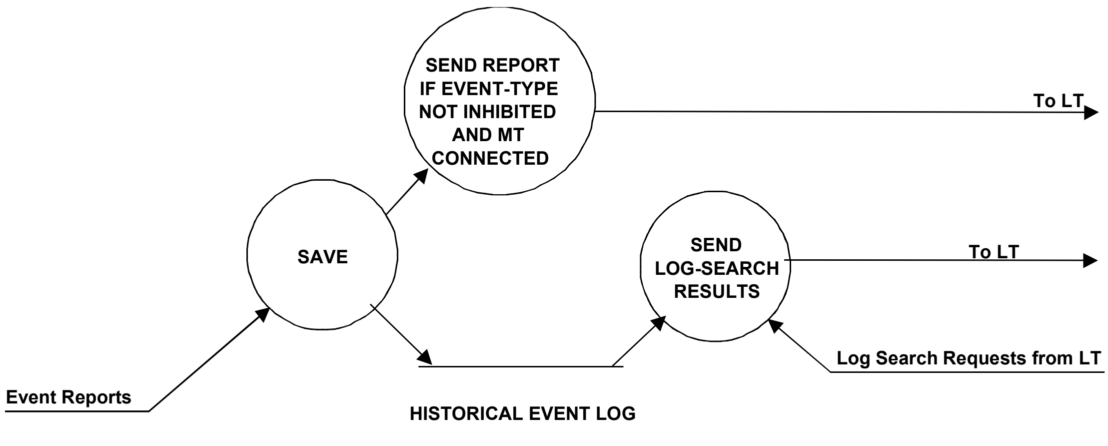


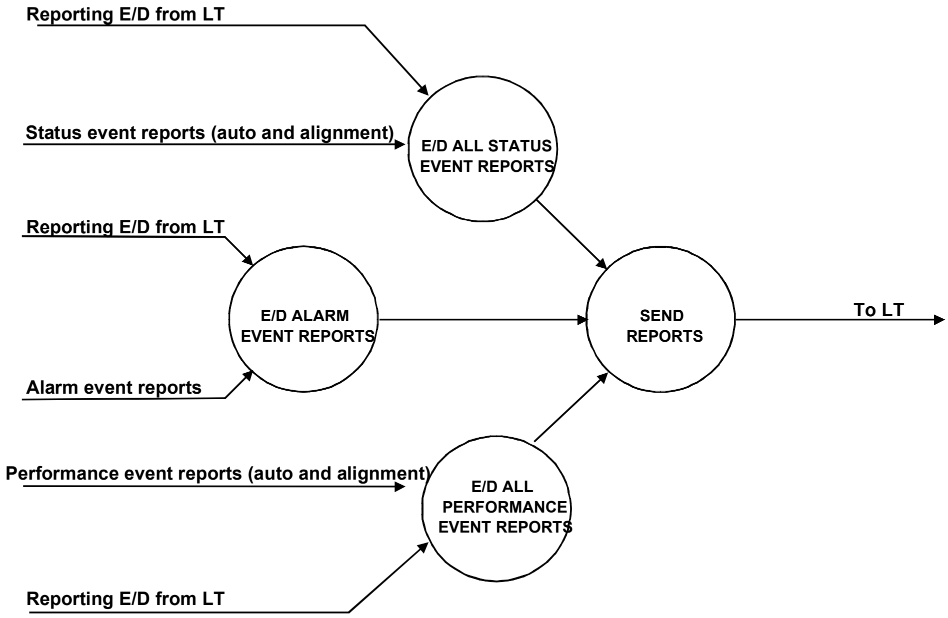
Figure 9-15: Forwarding and Logging of Status and Performance Events



Although the MT operator controls the forwarding of reports by setting inhibit attributes for the individual event types, the NE provides the means whereby the operator can apply a global inhibit to all event reports of a particular type.

Figure 9-17 illustrates the global event report enable/disable.

Figure 9-17: Global Event Report Enable/Disable



9.6.1.1 Alarm Events

Raising alarm events is autonomously reported to the LT, dependent upon the prevailing state of the inhibit attribute for the relevant alarm the enable/disable state of alarm event reporting and the presence of the LT.

Clearing alarm events is autonomously reported to the LT, dependent upon the presence of the LT and whether the corresponding raising alarm event was reported to the LT.

It should be noted that clearing alarm events is always be reported if the corresponding raising alarm event was reported, irrespective of the inhibit state of the relevant alarm at the time of clearing and the enable/disable state of the alarm event reporting.

For each clearing alarm event, an event record is created and placed in the 'historical alarm event' log.

The Inhibit State is used to retrospectively determine whether the EM may expect to have received any report concerning this alarm, and consequently is set to reflect the state of the inhibit attribute at the time the alarm raise event was detected.

9.6.1.2 Status Events

Status events are autonomously reported to the LT, dependent upon the prevailing state of the inhibit attribute for the relevant state change source (resource or management), the enable/disable state of status event reporting and the presence of the LT.

Status event records are generated for each status event and are placed in the appropriate log dependent on the same criteria.

9.6.1.3 Performance Events

Performance events are autonomously reported to the LT, dependent upon the prevailing state of the inhibit attribute for the relevant threshold type crossed, the enable/disable state of performance event reporting and the presence of the LT.

Performance event records are generated for each performance event and placed in the appropriate log dependent on the same criteria.

9.6.1.4 LT Access Events

Each time the LT operator logs in or out, this is recognised as an LT access event. This also extends to both forced and timed logouts.

For LT, access events are autonomously reported to the EM, dependent upon the prevailing enable/disable state of LT Access event reporting and the presence of the EM. TL1 does not autonomously report to the EM.

LT access event records are created and entered in the LT Access Log for each LT login/logout event dependent on the same criteria.

9.7 On Card Indicators

An amber SIU identifier is provided for each functional unit in the Subrack (Excluding the Hub and PSU units). In general, one identifier LED is located on the front of each SIU, although the Controller is an exception, carrying one for the Comms Function and one for the Controller function.

The Amber SIU identifier LED operates under two different conditions as follows:

- Under the control of the Controller card
  - Where a unit is an available resource (i.e. it has been logically added to the system), and a message is received from the Controller unit instructing the SIU to illuminate its LED.
- Under the control of the SIU
  - The LED is flashed whilst software download is in progress.

A red SIU identifier LED is provided for each functional unit in the Subrack (Excluding the Hub Unit). In general, one identifier LED is located on the front of each SIU, although the Controller is an exception, carrying its own and one for the SMC card.

The Red SIU identifier LED operates under three different conditions as follows:

- Under the control of the Controller card
  - Where an equipment Defect has been detected, a relevant indication is being given on the end-of-shelf and top-of-rack display units and a message is received from the Controller card instructing the SIU to illuminate its LED consistent with those indications.

    For BW7R, the red LED is lit in line with the 'Local Indication' column of the tables in section 11 e.g. LED On or Off

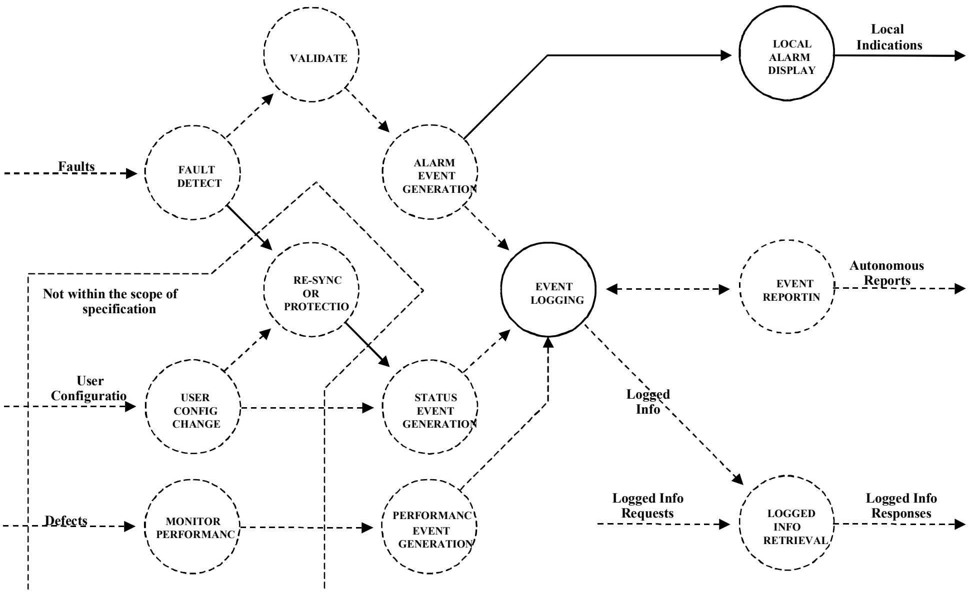
– Where the operator specifically requests the illumination of the LED on a specific SIU, resulting in a message from the Controller card instructing the SIU to illuminate its LED. This can be regarded as 'Operator Override'.

Defects on a PSU are captured by discrete circuitry on the power card itself and are displayed by the SIU identifier LED. The SIU identifier is illuminated if output power fails the output rails out of spec or the card-input fuse fails.

9.8 Local Alarm Schemes

A local alarm scheme is provided so that any operator within the immediate environs of the Multihaul 3000 is made aware of the presence of defects within the equipment.

Figure 9-19: Local Alarm Display



The Multihaul 3000 supports the BW7R and EBW7R local alarm scheme, which has its own type of Alarm IO LTU.

Local alarm condition information is made available to the operator in four different ways:

- On card indicators (LEDs) on the front of individual traffic cards.
- By an End of Shelf Display. The components of this display consist of LEDs and a push-button on the Alarms IO LTU, one for each Subrack.
- A rack alarm extension facility is made available, which can optionally be used to display local alarm conditions. This facility is provided by an interface built into the Alarms IO LTU.
- The LCT can display details of local alarms to the operator in the form of a list.

9.8.1 *End of Shelf Display*

An indication of the shelf alarm status is provided to the operator (if required) via an end of shelf display. Additionally, a number of rack alarm extensions are available.

These components of the alarm scheme constitute a combination of LEDs, pushbutton and interface connector, and are located at the right hand side of the shelf. They are incorporated into the design of the separate slide-in Alarms LTU which, due to its location within the Subrack, has a double-width front plate.

Variants of this LTU exist to provide the different end-of-shelf display and rack alarm extension interface connector requirements for UK, and International local alarm schemes.

The variations in operation of the Controller required to support the Bw7R local alarm scheme, are provided by customer specific builds of the Controller firmware and associated Local Terminal software.

9.8.1.1 Push Button Activity

The activation of the push button associated with the external Subrack Alarm IO performs a ‘receive attention’ control function across all Subrack.

Note: If an external Subrack becomes isolated from the Core Subrack then it continues to display its own indications regardless of the activation of the Core Subrack ‘receive attention’ control function.

The activation of the push button associated with an Extension Subrack Alarm IO LTU performs a ‘receive attention’ control function only on that subracks alarms.

Note: The Distributed PSU Fail defect is not effected by the receive attention control function.

9.8.2 *Operating Procedures*

Operating procedures associated with the display and selection of alarm reporting facility options are covered in the LCT operator manual (supplied under separate cover), together with the fault diagnosis details.

9.8.3 *Bw7R LTU*

This LTU provides all functionality to support sub-rack and rack alarm reporting according to the Bw7R standard common in ETSI regions. The Bw7R LTU also provides 6 off external inputs from powered or dry loop sources, which the customer can use to include any alarms generated local to the NE location into network Management. The cabling from this LTU is not normally the responsibility of Marconi Communications and no cable assemblies are specified.

9.8.4 *Enhanced Bw7R LTU*

This LTU provides all functionality to support sub-rack and rack alarm reporting according to the Bw7R standard common in ETSI regions. The Bw7R LTU also provides 16 off external inputs from powered or dry loop sources and 8 outputs, which the customer can use to include any alarms generated local to the NE location into network Management. The cabling from this LTU is not normally the responsibility of Marconi Communications and no cable assemblies are specified.

Blank Page

Chapter 10: Performance Monitoring

10.1 Introduction

Performance Monitoring is the continuous collection and processing of performance primitives derived from 'Monitored Entities' (MEs) within the Multihaul 3000, and the systematic storage and reporting of the performance parameters 'Primitives' derived from such processing. The primitives are derived by examining some aspect of each of the appropriate signals present in the equipment, including those being transmitted through, generated by or received by the equipment.

For Performance Primitives, an impairment event, for example, a fault, whether of a transient nature or not, being any physical, abnormal, situation which interferes in some way or other with the correct transmission of a signal, is thereby detected.

For example, OTU Block Errors' is a performance primitive derived from a Photonics OTU function and is used as the basis for the generation and storage of performance parameters such as ES (Errored Seconds) and SES (Severely Errored Seconds).

The Performance Monitoring Subsystem is non-intrusive. This means that configuration, collection of data; processing and the generation of reports must not cause any traffic errors or degradation to the transmitted signal. The derivation of the performance primitives must not require removal of the normal traffic.

The information obtained from the Performance Monitoring Subsystem is used to determine the long-term performance of sections/optical channels carried by NE equipments. This section is specifically relevant to performance processing up to the formation of 15min and 24hr reports.

10.1.1 Performance Measurement

Block Error Monitoring via the DWDM OTU and ODU, and via the SDH / SDH RS: primitive counts is processed and presented to the operator according to principles based on ETSI specification EN 300 417-7-1 V1.1.1 (200-10) ref. 0.6.11)

- Errored Seconds (ES)
- Severely Errored Seconds (SES)
- UnAvailable Seconds (UAS)
- UnAvailable Time (UAT) Logs
- Severely Errored Period (SEP) Logs
- 15min / 24hr Records

10.1.2 Error Detection Mechanisms

The Transponders provides the (post FEC) error detection mechanisms at the DWDM layer: These units use the 'ODUk PM Error Detection Code (BIP-8)', and 'OTUk PM Error Detection Code (BIP-8)'.

10.1.3 Grade of Service Parameters

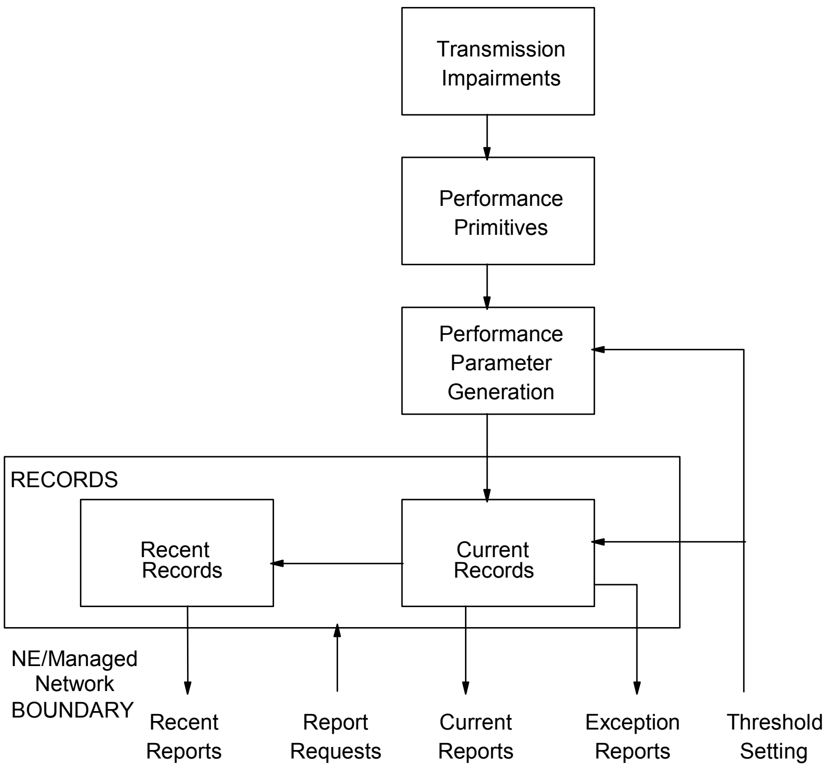
Performance data produced by NE is available to the EM (Element Manager) and to the LT (Local Terminal). The operator is able to obtain sufficient information to enable the long-term Grade of Service parameters to be determined e.g.:

- Availability
- BBER (Background Block Error Ratio)
- ESR (Errored Second Ratio)
- SESR (Severely Errored Second Ratio)

10.2 Monitoring Process

The Performance Monitoring process is shown in Figure 10-1.

Figure 10-1: Performance Monitoring Process



Transmission impairments acting on the transport layers lead to 'impairment events' and the generation of performance primitives at monitored entities within equipment. The primitive data is collected and formed into the relevant performance parameters e.g., ES and SES. Performance parameters are accumulated over set aggregation periods and stored in designated storage registers to form a Current Record. There are two aggregation periods: 15 minutes and 24 hours. At the end of every aggregation period the Current Record is transferred into a 'Recent' record and the Current Record is reset ready to begin the next aggregation period. A number of additional 'Recent Records' are kept such that the Current and Recent Records form a contiguous set of performance parameter records for each Monitored Entity.

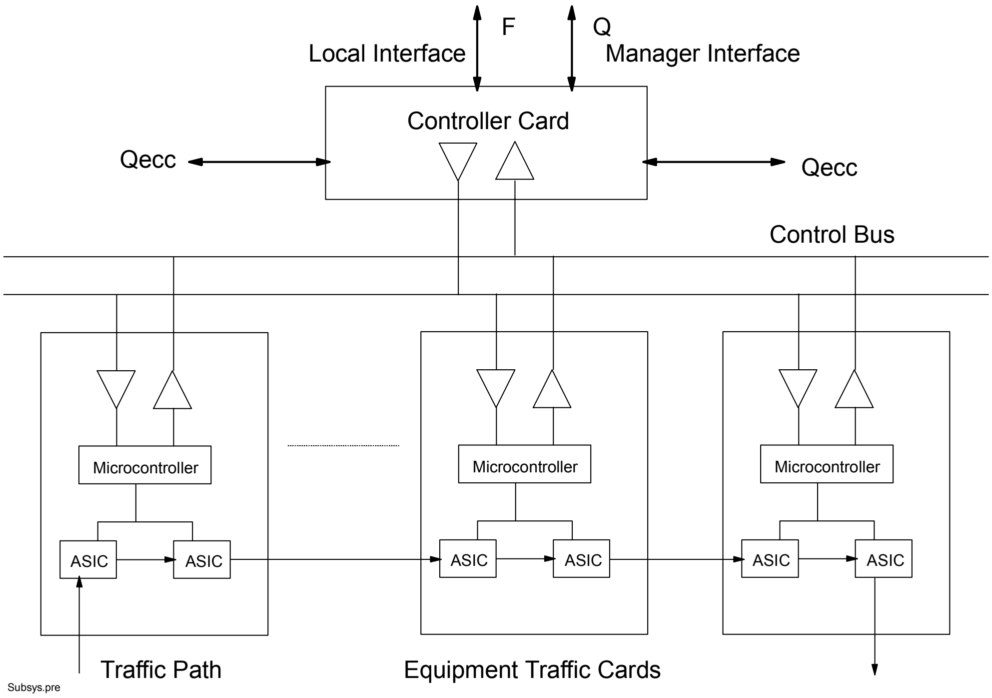
The LT and EM operators are able to access information contained in the records by requesting Current and Recent Performance Reports; the EM operator is also be able to request scheduled reports.

The thresholds for the generation of Performance parameters, such as SES, is configurable via the EM / LT. The facility to enable and disable the reporting of any particular Performance Parameters will be provided.

10.3 Subsystem Elements

The main elements of the Performance Monitoring Subsystem are shown Figure 10-3.

Figure 10-3: Subsystem Elements



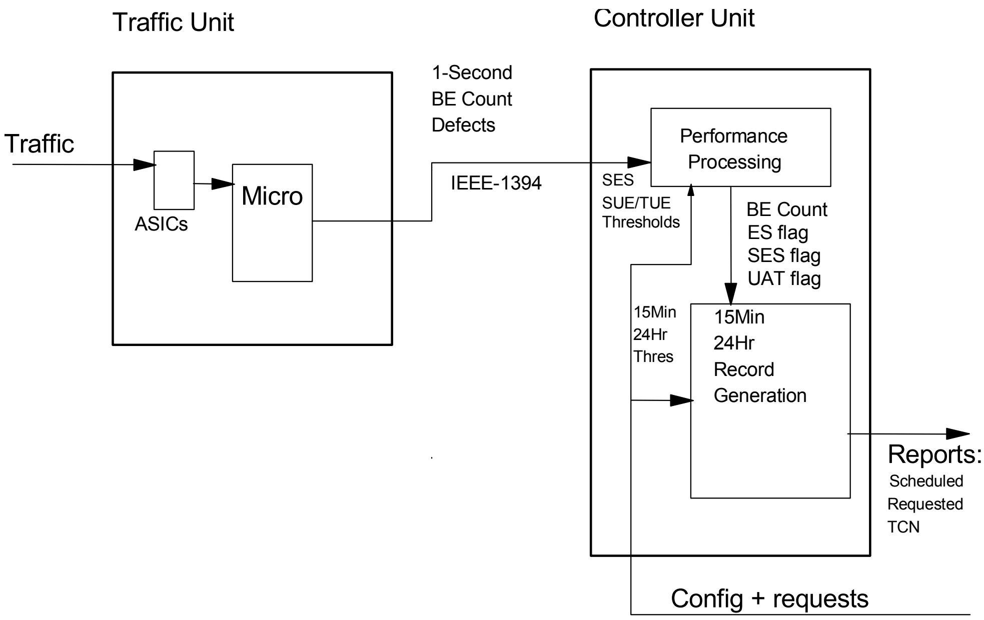
10.3.1 Performance Processing Partitioning

The various FPGAs on the Traffic Units (i.e. the Transponders) continuously monitor the System Performance and generate the primitive counts from the monitored entities. In order to keep the FPGA (hardware) counters to a reasonable size, the micro controllers on each unit polls the FPGAs and then transfer the count value to RAM. The polling rate for the SDH / SDH RSOH is every 8ms ±100μs.

The micro controllers on the Traffic Units accumulate the error counts from each FPGA until, at one-second intervals, the Controller Unit collects the performance parameters from the micro controllers within the equipment. The Micro Controller counters are then reset ready for the collection of the next set of 1 second data, the `1 second` interval being the basic resolution of the performance monitoring subsystems. Note that the term Micro Controller in this context is used in a rather general way. The implementation can either be by using a genuine Micro Controller or a microprocessor plus additional circuitry.

The split of functionality between the Traffic Units and the Controller Unit is further illustrated in Figure 10-5 below.

Figure 10-5: Performance Processing Partitioning



10.4 Monitored Entities

10.4.1 DWDM based

WARNING!

10G NRZ and 2.5G ER Transponders configured in CTP mode are not able to re-insert a valid OTU BIP-8 value on the outgoing linkside interface. This means that if the linkside of a CTP Transponder is connected to the WDM side of another Transponder, that Transponder will report a 100% OTU errors.

The DWDM based monitored entity types and the associated primitives that can be derived are shown in Figure 10-7 below. Note that all DWDM based primitives are Block error based, and hence this is not shown explicitly in the table but should be assumed throughout. Performance counts is maintained at the lowest level
(i.e. at the most fully defined level).

Figure 10-7: DWDM-based Monitored Entity Types and Derived Primitives

Monitored Entity Type	Protected ODU group	Derived Primitives
OTUk Termination	No	OTUk Deliv Egress NE
(Unprotected)		OTUk Deliv Egress FE
OTUk Termination	Yes	OTUk A Egress NE
(Unprotected)		OTUk A Egress FE
		OTUk B Egress NE
		OTUk B Egress FE
ODUk Termination	No	ODUk Deliv Egress NE
(Unprotected)		ODUk Deliv Egress FE
ODUk Termination	Yes	ODUk Deliv Egress NE
(Protected)		ODUk Deliv Egress FE
		ODUk A Egress NE
		ODUk A Egress FE
		ODUk B Egress NE
		ODUk B Egress FE
ODUk Non-Intrusive Monitor	No	ODUk Deliv Egress NE
(Unprotected)		ODUk Deliv Egress FE
		ODUk Deliv Ingress NE*
		ODUk Deliv Ingress FE
ODUk Non-Intrusive Monitor	Yes	ODUk Deliv Egress NE
(Protected)		ODUk Deliv Egress FE
		ODUk A Egress NE
		ODUk A Egress FE
		ODUk B Egress NE
		ODUk B Egress FE
		ODUk A Ingress NE*

Monitored Entity Type	Protected ODU group	Derived Primitives
		ODUk A Ingress FE
		ODUk B Ingress NE*
		ODUk B Ingress FE

Note: *: - For Hudson 2 based CTP transponders the following primitives will not be monitored.

- At an OTUk Termination the OTUk is removed and processed. This includes processing, for performance monitoring purposes, of the detected Block Errors.
- At an ODUk Termination the ODUk is removed and processed. This includes processing, for performance monitoring purposes, of the detected Block Errors.
- At an ODUk Non-intrusive Monitor the ODUk is non-intrusively monitored. This includes non-intrusive processing, for performance monitoring purposes, of the locally detected Block Errors.

10.5 SDH / SDH Based: Regenerator Section

For the case where a client channel comprises SDH / SDH framed traffic the DWDM NEs performs client channel error monitoring. This covers the generation and collection of performance 'Primitives' at anomaly S reference points. The processing of these Primitives, and the formation of Data Reports and Logs (Records) by the Equipment Controllers.

For the Multihaul 3000 Product Family this is achieved by means of non-intrusive monitoring of the B1 Byte of the SDH / SDH RSOH. The function is autonomously disabled for non-SDH / SDH framed traffic.

Table 10-1: SDH-based Monitored Entity Types and Derived Primitive

Monitored Entity Type	Derived Primitives
STM-n / OC-n RS Non-intrusive Monitor	B1 Block Errors

10.6 Performance Primitives

10.6.1 General

The Performance Primitive measured by the MHL3000 NEs is as follows:

- DWDM based Block Errors based on the post FEC performance of the G.709 OTU and ODU
- SDH / SDH based Block Errors based on the RS B1 byte of the SDH / SDH framed client traffic

10.6.2 OTUk SM error detection

For section monitoring, a one-byte error detection code signal is defined. This byte provides a bit interleaved parity-8 (BIP-8) code. The OTUk BIP-8 is computed over the bits in the OPUk (columns 15 to 3824) area of OTUk frame i, and inserted in the OTUk BIP-8 overhead location in OTUk frame i+2.

The Error Check Block is defined as a single OPUk frame. If one or more parity errors in this ECB are detected locally by the BIP-8 byte then a single Near-end Block Error is declared. If one or more parity errors in this ECB are detected remotely via the BEI byte then a single Far-end Block Error is declared.

10.6.3 ODUk PM error detection

For path monitoring, a one-byte error detection code signal is defined. This byte provides a bit interleaved parity-8 (BIP-8) code. Each ODUk BIP-8 is computed over the bits in the OPUk (columns 15 to 3824) area of ODUk frame i, and inserted in the ODUk PM BIP-8 overhead location in the ODUk frame i+2

The Error Check Block is defined as a single OPUk frame. If one or more parity errors in this ECB are detected locally by the BIP-8 byte then a single Near-end Block Error is declared.

10.6.4 RS error detection

One byte (B1) in the RSOH of the SDH / SDH frame is allocated for RS error monitoring. This function is a Bit Interleaved Parity 8 (BIP-8) code using even parity. In the Transmit direction, the BIP-8 is computed over all bits of the previous STM-n frame after scrambling and is placed in byte B1 before scrambling. The received Bl Byte is compared with a locally generated BIP-8 and any discrepancies are considered a Bl error.

A single Near-end Block Error is recorded if one or more BIP errors are detected in an STM-n / OC-n frame.

10.7 Collection Of Primitive Data

10.7.1 Traffic Unit Micro Controller Polling

The local micro controllers on each Traffic Unit polls the appropriate FPGAs (typically every 8ms) and transfers the accumulated primitive counts to RAM; this is in order to limit the size of the hardware counters. The counters in the FPGAs and the micro controller reading sequence are designed such that no recordable events are missed during the read sequence. All counters are large enough to accommodate the maximum count possible for each primitive. If the maximum count is reached this value is held until read, i.e. counters are not reset to zero. The error count registers is cleared (by the hardware) when read; this is to avoid multiple counting of errors which may occur because the registers are read by the microprocessor more often than they are written to by the hardware.

Each polling by the micro controllers adds the next count to the existing count, until once every second, the Controller Unit halts the count and reads the accumulated one-second counts from the micro controllers.

10.7.2 Controller Unit Polling

The Controller Unit polls each Equipment Unit at nominal one-second intervals, and gathers the performance (and alarm) data from all the relevant micro controllers in the NE. The accuracy of the 1-second periods is 1000ms ±20ms. To ensure the data is relevant to the same 1-second interval the Controller Unit issues a global 'End Of Second' command and then collects the data sequentially from each Micro controller.

When the micro controllers receive the 'End Of Second' command they stop the present counts and start collecting the next set of 1-second data. The complete set of Performance Data will be collected from all units within one second under all configurations of Equipments, there are no restrictions imposed on configuration.

In the case that the Controller Unit is not in communication with a Traffic Unit, the Controller Unit assumes that there are no faults or errors on the traffic unit from a performance monitoring point of view. However the associated performance records is marked as incomplete, and any reports presented to the operator based on such incomplete records will have this indicated via the ‘Report Notes’ indication

10.7.3 DWDM Based Counts

The maximum numeric values of the Block Error Counts required to be stored in one second (and 8ms) are given in Table 10-2 other periods can be scaled accordingly

Table 10-2: Max 1sec and 8ms DWDM Counts

Primitive	Payload	Bit Rate		Max 8ms Block Error Count	Max 1sec Block Error Count
	STM-1/OC-3/155.52Mbit/s	155.52	Mbit/s	10	1276
	STM-4/OC-12/622.08Mbit/s	622.08	Mbit/s	41	5104
	STM-16/OC-48/2.48832Gbit/s	2.48832	Gbit/s	163	20420
OTUk	STM-64/OC-192/9.95328Gbit/s	9.95328	Gbit/s	656	82028
ODUk	1.25Gbit/s Gigabit Ethernet	1.25	Gbit/s	82	10258
Block	Fibre Channel 25M	265.625	Mbit/s	17	2180
Errors	Fibre Channel 50M	531.25	Mbit/s	35	4360
	Fibre Channel 100M	1.0625	Gbit/s	70	8719
	Fibre Channel 200M	2.125	Gbit/s	140	17439
	(DVB-ASI)	270.0	Mbit/s	18	2216
	10Gbit/s Gigabit Ethernet	10	Gbit/s	656	82028

10.8 Derivation of DWDM Based Counts

10.8.1 General

The block size is defined In G709 ITU specification and is equal to the number of the bits in the OPUk see Table 10-3 to Table 10-6 below. The bit rates and capacity of the OTUk signals are defined in G709 ITU specification. The bit rates and capacity of the ODUk signals are defined in Table 10-4.

The bit rates and capacity of the OPUk and OPUk-Xv Payload are defined in Table 10-5. The OTUk/ODUk/OPUk/OPUk-Xv frame periods are defined in Table 10-5

Table 10-3: The Bit Rates and Capacity of the ODUK Signals

OTU type	OTU nominal bit rate	OTU bit rate tolerance
OTU1	255/238 × 2 488 320 kbit/s	±20 ppm
OTU2	255/237 × 9 953 280 kbit/s	
OTU3	255/236 × 39 813 120 kbit/s	
NOTE – The nominal OTUk rates are approximately: 2 666 057.143 kbit/s (OTU1), 10 709 225.316 kbit/s (OTU2) and 43 018 413.559 kbit/s (OTU3).		

Table 10-4: ODU Types and Capacity

ODU type	ODU nominal bit rate	ODU bit rate tolerance
ODU1	239/238 × 2 488 320 kbit/s	±20 ppm
ODU2	239/237 × 9 953 280 kbit/s	
ODU3	239/236 × 39 813 120 kbit/s	
NOTE – The nominal ODUk rates are approximately: 2 498 775.126 kbit/s (ODU1), 10 037 273.924 kbit/s (ODU2) and 40 319 218.983 kbit/s (ODU3).		

Table 10-5: OPU Types and Capacity

OPU type	OPU Payload nominal bit rate	OPU Payload bit rate tolerance
OPU1	2 488 320 kbit/s	±20 ppm
OPU2	238/237 × 9 953 280 kbit/s	
OPU3	238/236 × 39 813 120 kbit/s	
OPU1-Xv	X * 2 488 320 kbit/s	±20 ppm
OPU2-Xv	X * 238/237 * 9 953 280 kbit/s	
OPU3-Xv	X * 238/236 * 39 813 120 kbit/s	
NOTE – The nominal OPUk Payload rates are approximately: 2 488 320.000 kbit/s (OPU1 Payload), 9 995 276.962 kbit/s (OPU2 Payload) and 40 150 519.322 kbit/s (OPU3 Payload). The nominal OPUk-Xv Payload rates are approximately: X*2 488 320.000 kbit/s (OPU1-Xv Payload), X*9 995 276.962 kbit/s (OPU2-Xv Payload) and X*40 150 519.322 kbit/s (OPU3-Xv Payload).		

Table 10-6: OTUk/ODUk/OPUk Frame Periods

OTU/ODU/OPU type	Period (Note)
OTU1/ODU1/OPU1/OPU1-Xv	48.971 μs
OTU2/ODU2/OPU2/OPU2-Xv	12.191 μs
OTU3/ODU3/OPU3/OPU3-Xv	3.035 μs
NOTE – The period is an approximated value, rounded to 3 digits.	

OTU2

The OTU2 frame period is calculated as follows (see Table 10-6 above):

$(4 * 8 * 4080)/ ((255 / 237) * 9.95328 * 10^9) = 12.191\mu s$

The number of blocks per second are:

For STM-64 traffic:

No. of G.709 blocks per second = $1 / (12.191 * 10^{-6}) = 82027.73$

OTU1

The OTU1 frame period is calculated as follows (Table 10-6 above):

$(4 * 8 * 4080)/ ((255 / 238) * 2.48832 * 10^9) = 48.971\mu s$

The number of blocks per second is therefore:

For STM-16 traffic:

No. of G.709 blocks per second = $1 / (48.971 * 10^{-6}) = 20420.25$

Sub OTU1

For sub OTU1 data rates, scaling the OTU1 value derives the number of blocks per second.

For example the number of G.709 blocks per second for STM-4 traffic is:

$20420.25 * 622.08 * 10^6 / (2.48832 * 10^9) = 5104.41$

10.8.2 DWDM Based Counts

There is an extra payload type (PTI) of 42 that can be set to any bit rate between 155M and 2.48832GB/s. To calculate the OTU/ODU Max 8ms and 1 sec block error counts the NEC the following equations are used.

10.8.3 SDH / SDH Based Counts

Table 10-7: Max 1sec and 8ms primitive counts for SDH / SDH based monitoring

Primitive	Max 8ms Block Error Count	Max 1sec Block Error Count
RS B1 Block Errors	64	8000

10.8.4 Derivation of SDH / SDH based counts

The Block Error Count is the number of errored Blocks that have occurred in the period calculated locally using the respective BIP-8 byte(s); i.e. one or more BIP errors in the Block causes a single Block Error to be declared.

10.9 Processing Of Primitives

10.9.1 Regenerative Spurs

Cards configured in Regenerative spurs use a PEM switch value of ‘8’ when reporting alarms. This group can't be made in config rule set 2.

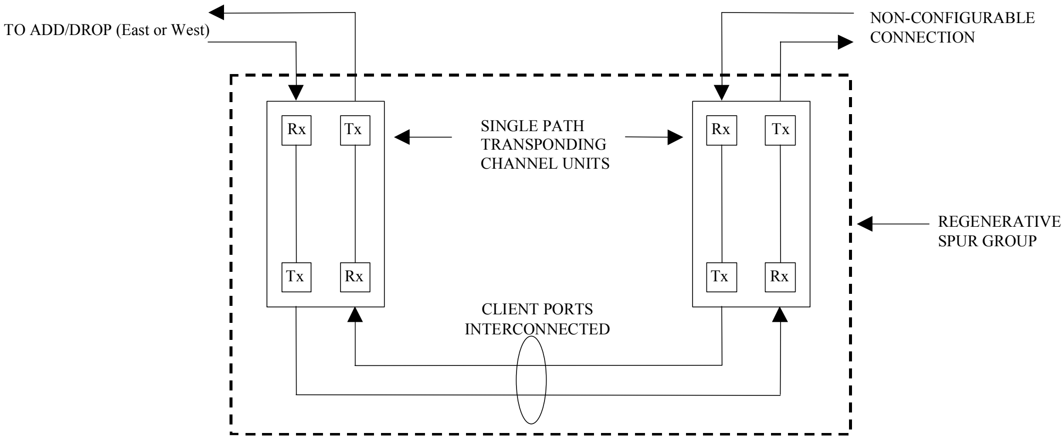
This group consist of only two Transponding Channel Termination Units (Single Path) in Link mode. One transponder is connected to a line port, and the other is connected to a 'Single Channel' port. They may be of different optical channel frequencies. The cards in the group are of the same type with the following exceptions: -

- It is possible to Group a 10GTransponder with a 2.5G SR Transponder.

- The cards cannot belong to any other equipment group. Only one card can have an existing connection when the group is created. If the Group is created when one of its transponders is already carrying a connection, the naming card is the transponder carrying the connection. Otherwise the Naming Card is the one specified first (Left window on LCT) when the group is created.

- If the group is created without an existing connection the operator is only be allowed to create an add/drop connection from naming card in the group. On creation of this connection the other card in the group automatically gets an 'non-configurable' connection (source and sink set to match transponder slot and channel (No direction required)). If the group is created with an existing connection the other card in the group automatically gets a 'non-configurable' connection.

- If the operator chooses to delete the add/drop connection from the group then the 'non-configurable' connection is deleted. The operator shouldn't be able to delete the 'non-configurable' connection from the group



Notes:

1 The cards do not have to be physically adjacent.

2 The cards are directly interconnected at their client ports.

3 The client port cabling is not visible to management terminals but is implied by this group.

The NEC configures both of the cards in the group with the same payload type. The consequential actions for traffic/overhead defects of this group is as a standard Regen group.

When the group is created the card with the lowest subrack & slot location is referred to as Card A, and the other card is referred to as Card B. E.g. if the two transponders to be configured in a group are in Transponder subrack 2, and one is in slot 16 and the other in 3, then the card in slot 3 is referred to as Card A. Also if both cards are is slot 16, but one is in transponder subrack 1 and the other in transponder subrack 2, the card in subrack 1 is referred to as Card A. Note: this allocation is for Event and performance reporting purposes only. Performance reports are associated with the group (not with the Line ports).

When the group is created, all the traffic configuration (add/drop port], fault detector config, thresholds [except client input power low threshold] etc.) From the Naming Card is adopted by the other transponder. The group is rejected if the Interlink OTU FEC mode for the two CTP transponders in the group are different, HCI Req: - A warning should be presented to the use stating that the FEC modes need to be the same.

Notes: -

1 If the Naming card Payload type is not supported by the other transponder then the action of grouping the cards or creation of the through connection should be rejected.

2 Once the group is created any attempt to change the Interlink FEC mode is rejected. HCI Red: Grey the option out on both cards.

The traffic and payload configuration is always addressed at the naming card. Traffic configuration (add/drop port config, fault detector config, thresholds [except client input power low threshold] etc.) and payload type changes during the lifetime of the group applies to both cards, See Table 10-8 for traffic/performance adoption details

Note: Once the group is created any attempt to set a payload type that is not valid for both cards within the group, is rejected.

Table 10-8: Regenerative Spur Traffic/Performance Adoption

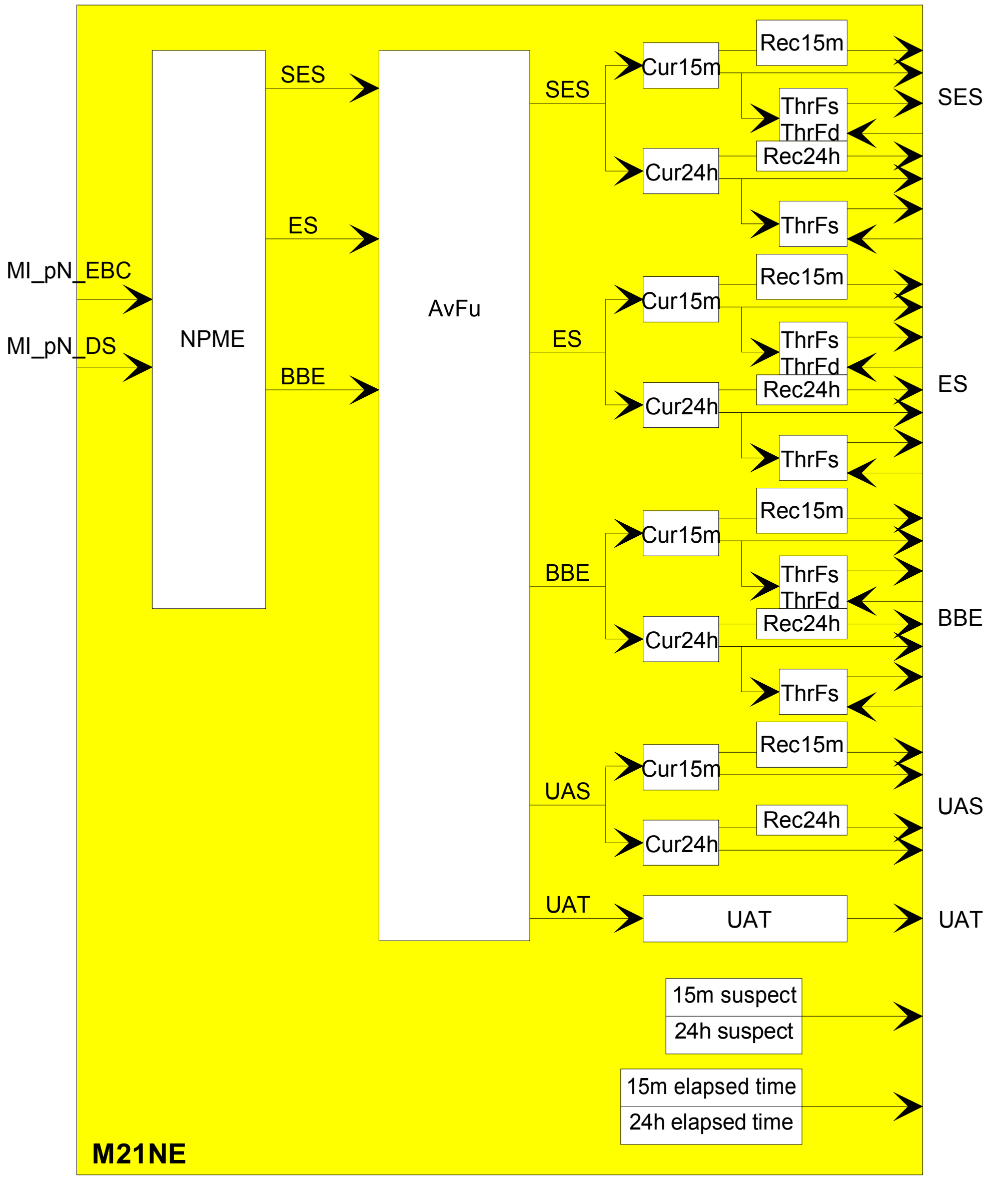
Configurable Object	CTP transponder
OCh	
Degraded BER threshold (Pre FEC)	Not Copied
Excessive BER Threshold (Pre FEC)	Not Copied
WDM OTU	
Detect Trace ID Mismatch	Not Copied
Enable FEC monitoring	Not Copied
Enable OTU monitoring	Not Copied
OTU Egress DS Threshold	Not Copied
OTU Egress Consecutive DS On Threshold	Not Copied
OTU Egress Consecutive DS Off Threshold	Not Copied
FEC Mode	Not Copied
OTU Egress Consequential Actions	Not Copied
OTU Egress Performance Thresholds (BBE,ES, SES, SEP)	Not Copied
Performance event reporting states (Exception reports & SUE/TUE reports)	Not Copied
ODU	Egress
Detect Trace ID Mismatch	Copied
Enable ODU Monitoring	Copied
Payload Type (Expected)	Copied
ODU Egress DS Threshold	Copied

Configurable Object	CTP transponder
ODU Egress Consecutive DS On Threshold	Copied
ODU Egress Consecutive DS Off Threshold	Copied
ODU Egress Consequential Actions	Copied
ODU Egress Performance Thresholds (BBE,ES, SES, SEP)	Copied
Performance event reporting states (Exception reports & SUE/TUE reports)	Copied
	Ingress
Detect Trace ID Mismatch	Copied
Enable ODU Monitoring	Copied
Payload Type (Expected)	Copied
ODU Ingress DS Threshold	Copied
ODU Ingress Consecutive DS On Threshold	Copied
ODU Ingress Consecutive DS Off Threshold	Copied
ODU Ingress Consequential Actions	Copied
ODU Ingress Performance Thresholds (BBE,ES, SES, SEP)	Copied
Performance event reporting states (Exception reports & SUE/TUE reports)	Copied
Interlink OTU	
Detect Trace ID Mismatch	Copied
Enable FEC monitoring	Copied
Enable OTU monitoring	Copied
OTU Ingress DS Threshold	Copied
OTU Ingress Consecutive DS On Threshold	Copied
OTU Ingress Consecutive DS Off Threshold	Copied
FEC Mode	N/A (See note above)
OTU Ingress Consequential Actions	Not Copied
OTU Ingress Performance Thresholds (BBE,ES, SES, SEP)	Copied
Performance event reporting states (Exception reports & SUE/TUE reports)	Copied
OPS	
Input Power Low Threshold	Not Copied
Degraded BER threshold (Pre FEC)	Copied
Excessive BER Threshold (Pre FEC)	Copied

When the group is deleted, the individual cards retain the attributes they had in the group, and the add/drop connection is retained.

10.9.2 Near-End Unidirectional Performance Monitoring Package

Figure 10-9: M.2100 / M.2101 Near-End Performance Monitoring



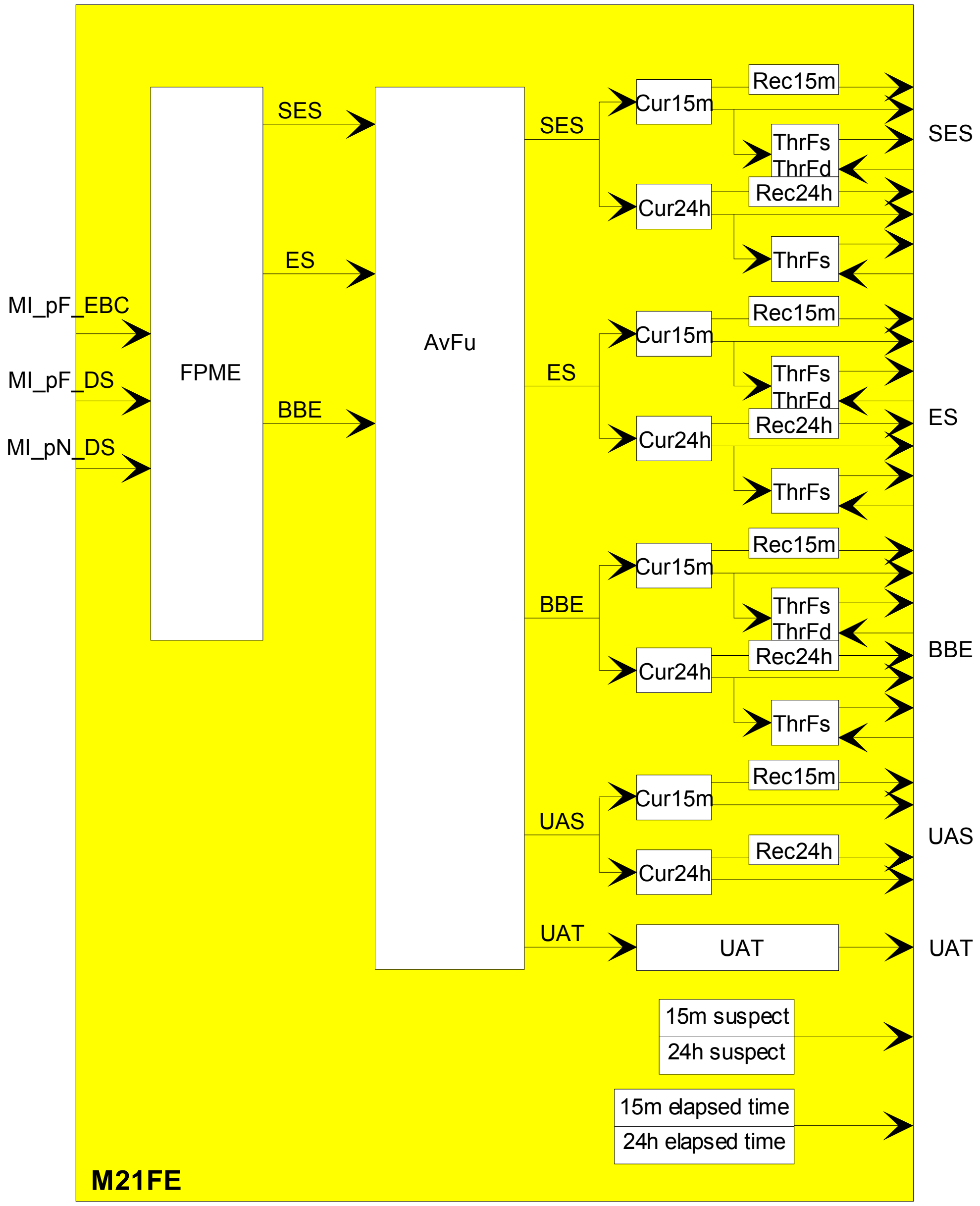
The M.2100/2101 near-end (A/Z direction) maintenance (uni-directional) package (M21NE) computes UAS, ES, SES, and BBE over periods of 15 minute and 24 hour for one direction of transmission using near-end information (A/Z).

The package is used at OTUk and ODUk termination points to monitor the quality in the incoming direction, and at ODUk connection points (via an ODUk non-intrusive monitor respectively) to monitor the quality of the trail portion in the incoming direction of the signal passing through.

- UAT events is computed and logged.
- During a period of unavailable time the counting of BBEs, ESs, and SESs is stopped.
- Performance event (BBE, ES, and SES) counts is monitored for threshold crossing; 15 minutes with both the single or dual thresholding, and 24 hour with single thresholding.

10.9.3 Far-End Unidirectional Performance Monitoring Package

Figure 10-11: M.2100 / M.2101 Far-End Performance Monitoring



The M.2100/2101 far-end (Z/A direction) maintenance (uni-directional) package (M21FE) computes UAS, ES, SES, and BBE over periods of 15 minute and 24 hour for one direction of transmission using far-end information (Z/A).

The package is used at OTUk and ODUk termination points to monitor the quality in the outgoing direction, and at ODUk connection points (via an ODUk non-intrusive monitor) to monitor the quality of the end to end trail in the reverse direction of the signal passing through.

- UAT events are computed and logged.
- During a period of unavailable time the counting of BBEs, ESs, and SESs is stopped.
- Performance event (BBE, ES, and SES) counts are monitored for threshold crossing; 15 minutes with either the single or dual thresholding, and 24 hour with single thresholding.

10.9.4 Performance Parameter Counts Produced by the NE

For each Error Performance Primitive, the NE generates the following parameter counts.

- ESC
- SESC
- UASC
- SUEC
- SEPC
- BBEC

If an overflow occurs the NE sets an error flag and freezes the count; this flag is reported to the LCT and NM for display to the operator.

10.9.5 Error Performance Ratios Produced by the NMS

NMS functionality is outside the scope of this specification. However the following is provided for information.

The NMS may generate parameters such as the following:

- ESR
- SESR
- SEPI
- BBER

10.9.6 Errored Second (ES) Processing

A second is declared 'Errored' if the one or more Block Errors are detected during the second or certain alarms are raised Errored Seconds Counts are maintained as a long-term performance indicator.

10.9.7 Severely Errored Second (SES) Processing

A second is declared 'Severely Errored' if the number of detected errors reaches the SES threshold or certain alarms are raised. Severely Errored Seconds Counts are maintained as a long-term performance indicator and to determine entry into and exit from SEP and UAT.

10.9.8 DWDM-Based SES Thresholds

The thresholds for SES is configurable on a per Payload Type Identifier (PTI) and per Primitive Type basis in the ranges. The operator is able set and reset these thresholds to their default value via the global 'Default Thresholds' command

Note: That the 'per primitive type' requirement above also implies separate configurability for OTU and ODU.

Table 10-9: SES Thresholds (DWDM-based)

Primitive	Payload	SES Threshold Numeric value (Note 2)	SES Threshold percentage
	STM-1 / OC-3 / 155.52Mbit/s	1 – 638 (191)	
	STM-4 / OC-12 / 622.08Mbit/s	1 – 2552 (766)	
	STM-16 / OC-48 / 2.48832Gbit/s	1 – 10210 (3063)	
OTUk/ODUk	STM-64 / OC-192 / 9.95328Gbit/s	1 – 41014 (12304)	0.001% - 50%
Block Errors	1.25Gbit/s Gigabit Ethernet	1 – 5129 (1539)	(15%)
	Fibre Channel 25M	1 – 1090 (327)	
	Fibre Channel 50M	1 – 2180 (654)	
	Fibre Channel 100M	1 – 4360 (1308)	
	Fibre Channel 200M	1 – 8719 (2616)	
	SDTV	1 – 1108 (332)	
	10Gbit/s Gigabit Ethernet	1 – 41014 (12304)	
	ODU-1	1 – 10210 (3063)	

10.9.9 Derivation of DWDM based SES Thresholds

The threshold range and default value is derived as follows: the default threshold value is set at a 1-second error ratio of 30%; the upper range is set at a 1-second error ratio of 50

- Upper range numeric value is 0.5 * 82028 = 41014.
- Default numeric value is 0.3 * 82028 = 24608.4

The lower percentage range value is such that a numeric granularity of 1 is achievable.

10.9.10 SDH / SDH Based SES Thresholds

The SDH / SDH SES Thresholds are configurable on a per Primitive Type basis in the ranges shown in Table 10-10 below. The operator is able to set/reset these thresholds to their default value via the global 'Default Thresholds' command

Table 10-10: SES Thresholds (SDH / SDH Based

Primitive	Payload Type	SES Threshold (Numeric value)	SES Threshold (Percentage)
RS B1 Block Errors	STM-n / OC-n	1 - 4000 (2400)	0.01% - 50% (30%)

10.9.11 Derivation of SDH / SDH-Based SES Thresholds

The SES Threshold is based on the Block Error Count and the number of errored Blocks calculated locally using the respective BIP-8 byte that causes the second to be declared an SES. The SES Thresholds for particular primitive types apply to all sources of a primitive type within the NE; i.e. they are 'global'.

- Derivation of values (for STM-n / OC-n):
- Upper range numeric value is 0.5 * 8000 = 4000.
- Default numeric value is 0.3 * 8000 = 2400.

Note: The lower percentage range value is such that a numeric granularity of 1 is achievable.

10.10 Severely Errored Period (SEP) processing

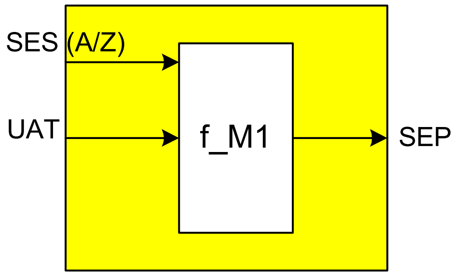
10.10.1 General

An SEP Log is maintained for each Primitive Type on each ME Instance.

Note that the functions f_M1 and f_M2 in the following SEP processing figures are proprietary Marconi functions.

10.10.1.1 Unidirectional SEP Processing

Figure 10-13: Near End Unidirectional SEP Processing



The function f_M1 declares a Near End Unidirectional SEP if in Available Time there are consecutive SES (A/Z) for the configured SEP threshold but less than the SUE threshold.

10.10.1.2 SEP Thresholds

The SEP Threshold defines the number of consecutive SESs occurring in AT that causes the period to be recorded in the SEP log. SEP is not applicable during UAT.

Table 10-11 SEP Thresholds

Primitive	SEP Threshold
All Primitives	1-9 (Default 3)

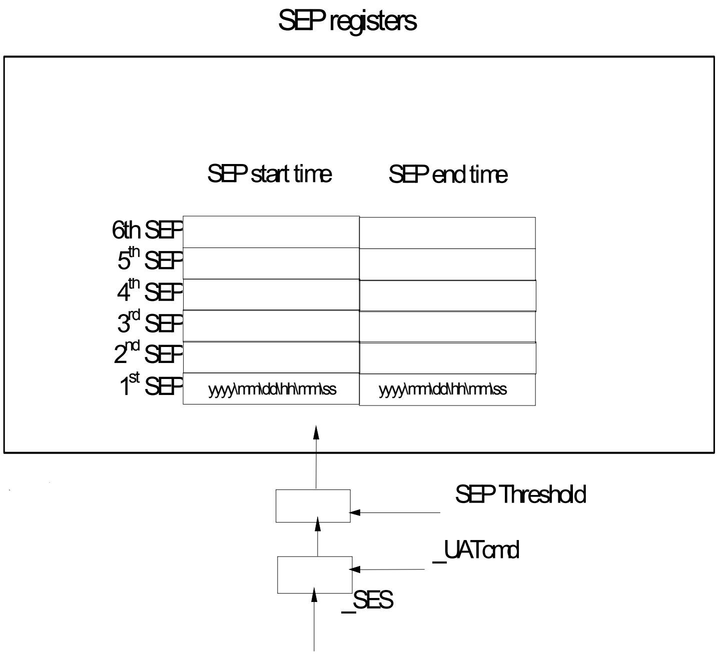
10.10.1.3 SEP Logs

Each time the number of consecutive SESs in available time exceeds the SEP Threshold, a time stamped record of the period is recorded in a separate 'SEP log' for each primitive. Up to six periods are stored. If more than six periods of SEP exceeding the threshold occur then the six most recent are kept, the others are discarded.

The record kept in the SEP log is the absolute length of the period of consecutive SESs, regardless of the length of the SEP threshold period. For example if six consecutive SESs occur followed by one or more non-SESs, and the threshold period is two seconds, a single record of six seconds is added to the 'SEP Log'. The added record comprises the start time of the period, and its duration in seconds.

If the number of consecutive SESs exceeds the SUE threshold then UAT is declared. In these circumstances the SEP period is not recorded in the SEP Log, the period of UAT being recorded in the UAT Log only. See Figure 10-15 below for Near End SEP logs.

Figure 10-15: SEP Registers



10.10.1.4 SEP Count

The NE provides a SEP Count as part of its 15-min / 24-hr reporting.

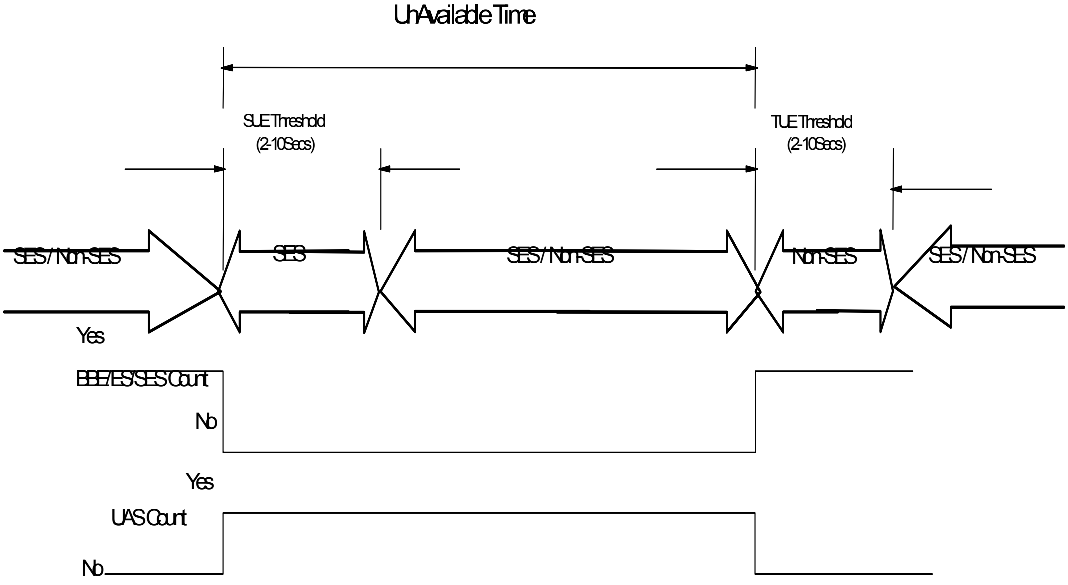
10.11 Unavailable Time (UAT) processing

10.11.1 General

UnAvailable time for a particular monitored entity is determined by the processing of its Performance Primitives. Any monitored entity is always in one of the two states: ‘Available’ or ‘Unavailable’. A UAT Log is maintained for each Primitive Type on each ME Instance.

A period of UAT is declared when, during AT, a period of consecutive SESs occurs which reaches the SUE threshold. The SESs are deemed to be part of the UAT. A period of AT (Available Time) begins when there is a period of consecutive non-SESs that exceeds the TUE threshold. The non-SESs are deemed to be part of the Available Time. During UAT, the UAS counter is incremented but, for performance monitoring purposes, the counting of BBE, ES and SES counts is inhibited.

Figure 10-17: UAT Processing



Note: The counting of BBEs is inhibited during SESs occurring in AT.

10.11.2 UAT Thresholds

The operator has the option to configure the SUE and TUE thresholds on a per Primitive Type basis. The SUE and TUE thresholds is set independently and it is possible for the operator to set any combination within the SUE / TUE ranges. The operator is able to set/reset these thresholds to their default values via the global 'Default Thresholds' command

For a given primitive type the UAT thresholds are the same for near end and far end monitoring.

Table 10-12: SUE / TUE Thresholds

Primitive	SUE / TUE Threshold
All Primitives	2-10 (Default 10)

- The thresholds for Primitives of the same type have the same value for all Monitored Entities.

- UAT is entered and a SUE is sent to the EM when, in AT, the number of consecutive SESs reaches the SUE threshold. UAT is deemed to have begun at the start of the first of these consecutive SESs. Each occurrence of a SUE causes the SUE Count (SUEC) to be incremented.

- AT is re-entered and a TUE sent to the EM, when, in UAT, the number of consecutive non-SESs reaches the TUE threshold. AT is deemed to have begun at the start of the first of these consecutive non-SESs.

10.11.3 UAT Logs

The beginning and the ending of an UAT period is time stamped and stored in a UAT log for each monitored entity. If a period of UAT has begun but has not yet finished the 'UAT start time' for that period is provided in the log, with the 'UAT end time' containing a suitable indication e.g. 'Ongoing' or 'UAT in progress'. Up to six UAT periods are recorded. If more than six periods occur, then the six most recent is retained, and the others are discarded.

10.11.4 BBE Processing

10.11.5 Summary

For near end unidirectional monitoring packages at trail termination BBE counting is suppressed during near end SESs, and during near end unidirectional unavailable time.

For far end unidirectional monitoring packages at trail termination BBE counting is suppressed during far end SESs, and during far end unidirectional unavailable time, and during near end SESs.

For bidirectional monitoring packages at trail termination BBE counting is suppressed as follows:

- In the A/Z direction BBE counting is suppressed during near end (A/Z) SESs, and during bidirectional unavailable time

- In the Z/A direction BBE counting is suppressed during far end (Z/A) SESs, and during bidirectional unavailable time, and during near end (A/Z) SESs

Note: ETSI use the following naming convention:

- UATcmd = unidirectional unavailable time

- UAT = bidirectional unavailable time

10.11.5.1 Unidirectional near end monitoring

The Near-end Background Block Error (NBBE) performance monitoring event signal is equal pN_EBC if the NSES of that second is not set. Otherwise, NBBE is zero.

The BBE (t-10), ES (t-10) and SES (t-10) event signals are output in available time; i.e. if UATcmd is false. Otherwise, the value "0" is provided as output.

10.11.5.2 Unidirectional far end monitoring

The Far-end Background Block Error (FBBE) performance monitoring event signal is equal pF_EBC if the FSES of that second is not set and if that second is not a Near-end Defect Second. Otherwise, FBBE is zero.

The BBE (t-10), ES (t-10) and SES (t-10) event signals are the outputs in available time; i.e. if UATcmd is false. Otherwise, the value "0" is provided as output.

10.11.5.3 Bidirectional monitoring

The Near-end Background Block Error (NBBE) performance monitoring event signal is equal pN_EBC if the NSES of that second is not set. Otherwise, NBBE is zero.

The Far-end Background Block Error (FBBE) performance monitoring event signal is equal pF_EBC if the FSES of that second is not set and if that second is not a Near-end Defect Second. Otherwise, FBBE is zero.

The BBE (t-10), ES (t-10) and SES (t-10) signals are the outputs in available time; i.e. if UAT is false. Otherwise, the value "0" is provided as output.

10.11.6 Fault Conditions

10.11.6.1 Traffic Related Fault Conditions

Defects resulting in near-end SES/far-end SES

Certain traffic related Fault / Alarm Conditions will lead to error performance degradation, or will indicate that degradation has already occurred (i.e. pN_DS or pF_DS). For the purposes of the Performance Monitoring Subsystem the occurrence of any of the Fault / Alarm Conditions are shown in Table 10-14 to Table 10-18.

Note: Declaration of an SES due to the fault / alarm conditions listed performes regardless of any settings regarding enabling / disabling, consequential suppression, inversion or group enabling / disabling.

10.11.7 DWDM and LINK Defects

Table 10-13: OTUk: Defects Resulting In A Near-End SES

Near-end defects	Kind of trail
OTUk SSF OTUk TIM	Applicable to OTUk paths

Table 10-14: ODUk: Defects Resulting In A Near-End SES

Near-end defects	Kind of trail
ODUk SSF ODUk AIS ODUk TIM ODUk OCI	Applicable to ODUk paths

Table 10-15: OTUk: Defects Resulting In A Far-End SES

Far-end defects	Kind of trail
OTUk BDI	Applicable to OTUk paths

Table 10-16: ODUk: Defects Resulting In A Far-End SES

Far-end defects	Kind of trail
ODUk BDI	Applicable to ODUk paths

Note: If a Transponder is configured as 'Payload Unequipped' SES is declared, and if this persists beyond the SES Threshold then UAT is declared in the usual manner.

10.11.7.1 SDH / SDH Defects

Table 10-17: SDH / SDH RS: Defects resulting in a near-end SES

Near-end defects	Kind of trail
Loss of Signal Loss of Frame Trace Identifier Mismatch	Applicable to SDH / SDH RS (Direction: 'Client → WDM')
Loss of Frame Trace Identifier Mismatch	Applicable to SDH / SDH RS (Direction: 'WDM → Client')

10.11.7.2 G.798 Functions (for information)

Table 10-18: G798 DWDM Defects Resulting In A Near-End SES/far-end SES

Function	Defect	Near or Far end SES	G.798 Section No.
OTSn_TT_Sk	(dLOS-P and (not dPMI)) or dTIM dBDI-P	N F	9.2.1.2 9.2.1.2
OMSn_TT_Sk	aTSF-P dBDI-P	N F	10.2.1.2 10.2.1.2
OPSn_TT_Sk	aTSF-P	N	11.2.1.2
OTUk_TT_Sk	CI_SSF or dTIM dBDI	N F	13.2.1.2 13.2.1.2
OTUkV_TT_Sk	CI_SSF or dTIM dBDI	N F	13.2.2.2 13.2.2.2
ODUkP_TT_Sk	CI_SSF or dAIS or dOCI or dLCK or dTIM dBDI	N F	14.2.1.2 14.2.1.2
OSx_TT_Sk	dLOS	N	A.2.1.2

10.12 Alignment Error Defects

10.12.1 General

The adaptation source function of the OTU layer and ODU TCM sublayers generates an incoming alignment error (IAE), if it detects a frame slip. At the trail termination sink function the IAE information is detected and is used to suppress near end.

10.12.2 Incoming Alignment Error Defect (dIAE)

This is used to suppress wrong PM data (EBC and DS) at the OTUk and ODUkT trail termination sink in case of an incoming frame slip to the trail.

10.12.3 Card Related Fault Conditions

Each card within Multihaul 3000 equipments is hard wired to the Controller Unit such that the Controller Unit can detect a ‘Card Out’ condition.

Removal of a Transponder: Assuming the slot is configured and connected the removal of a Transponder is defined to be a ‘Card Out’ condition. The Controller Unit records an SES (and an ES) for all primitives on the affected MEs. The SESs is processed in exactly the same way as SESs caused by excessive Block Errors i.e. if persistent they will lead to UAT after the SUE threshold period.

Removal of other units affecting add / drop traffic: If e.g. an Rx Line Unit or Add Drop Unit is removed this is dealt with from a traffic performance monitoring viewpoint via the traffic related fault / alarm conditions and associated processing.

Removal of Controller Unit: This will cause all performance records and logs to be initialised.

10.12.4 Threshold Default Setting

Where given, the default values for operator configurable thresholds are automatically used when Performance Monitoring is enabled. If the operator subsequently selects different values for given thresholds then these selected values are stored in NVM such that they are not lost on Power Fail. The default values themselves are not configurable by the operator.

10.13 Performance Data Recording

10.13.1 NE Real Time Clock

The NE maintains a Date and Time Clock that is used for the labelling of all of the Performance Data Reports. It is possible for the clock to be set via the EM and via the LT.

Note: For performance monitoring purposes ETSI recommend that the NE RTC is delayed by 10 seconds.). This is in order to accommodate the effects associated with the unavailable time entry / exit calculation. Thus the time stamp as seen by operator equals the PM-RTC plus 10 seconds

10.13.2 Clock Changes

10.13.3 Clock changes of less than 10 seconds

If the Equipment Clock is changed by less than 10 seconds then this is ignored, as far as constructing the 15min and 24hr Current Records is concerned. The Records are completed as normal at the end of the Report Period(s).

This level of clock change could occur for example where the network Operator wishes to reset the Equipment Clocks for all NEs in the network on a weekly basis to correct any clock drift that may occur.

10.13.4 Clock changes of more than 10 seconds

If the change to the clock is greater than 10 seconds the following actions is taken:

The contents of all the 15min and 24hr Current Records are copied into the first Recent Records. For reporting purposes the end time for these Recent Records are set to the new time, and they are marked as suspect / incomplete via the ‘Report Notes’ field.

All the 15min and 24hr Current Records are cleared. For reporting purposes the start time of the new Current Records are set to the new time, and they are marked as suspect / incomplete via the ‘Report Notes’ field.

At the end of the 15min / 24hr, periods the Current Records contain accurate counts but indicate a reduced period i.e. the start time will indicate the period has been curtailed.

This level of clock change would typically occur for the one-hour shift between e.g. GMT and BST or other national equivalents. The same functionality is also required for ‘Date Only’ changes.

For performance monitoring purposes a change of time / date is equivalent to a natural end of the respective period(s).

10.13.4.1 Recording Periods

Performance data reports for the Performance Primitives are generated and recorded in the Controller records for the following periods:

- Current: 1 x 15min 1 x 24hr
- Recent: 16 x 15min 1 x 24hr

At the end of a 15min-performance data-reporting period as defined by the Equipment Clock, the least recent record is discarded. The content of the current record becomes the most recent record and the current registers are cleared ready for the next performance data-reporting period to commence. During this updating procedure, the data is collected. A similar mechanism exists for the 24hr performance data-reporting period.

All records are generated and stored by the Controller Unit for the 15min and 24hr periods even if the reporting to the EM has been disabled. Invoking any performance report type or the occurrence of any performance event report does not affect the processing of the current 15min and 24hr performance data records.

10.13.4.2 Period End Time

The End Time of the 24hr period is configurable by the operator to a 15-minute granularity. The 15min periods falls on the quarter hours of the 24hr period set. The default value for the 24hr End Time is 00.00.

10.13.4.3 Data Loss

If for any reason there is known to be a loss or corruption of data during the compilation of a record (e.g. the Controller Unit goes off line) the records is maintained as normal, but with all counts being suspended.

The required behaviour is illustrated by means of the following examples

Example 1

- Controller Unit goes off-line at 0810hrs.
- After ‘TUE Threshold’ seconds any ME that had been in a state of UAT enters AT and a TUE is generated.
- Controller Unit comes back on-line at 0840hrs
- 15min Record for 0800 – 0815hrs is marked 'Suspect', and (if there were errors between 0800 and 0810hrs) error counts are non-zero.
- 15 min Record for 0815 – 0830hrs is marked 'Suspect' and all error counts is zero.
- 15min Record for 0830 – 0845hrs is marked 'Suspect' and (if there were errors between 0840 and 0845hrs) error counts is non-zero.
- 24hr Record is marked ‘Suspect’ with all counts being suspended during the period that the Controller Unit was off-line (i.e. 0810 – 0840hrs).

Example 2:

- Controller Unit goes off-line at 0905hrs.
- After ‘TUE Threshold’ seconds any ME that had been in a state of UAT enters AT and a TUE is generated.
- Controller Unit comes back on-line at 0910hrs.
- 15min Record for 0900 – 0915hrs is marked 'Suspect' and (if there were errors between 0900 and 0905hrs or between 0910 and 0915hrs) error counts is non-zero.
- 24hr Record is marked ‘Suspect’ with all counts being suspended during the period that the Controller Unit was off-line (i.e. 0905 – 0910hrs).

10.13.5 Start /Stop Performance Primitive Processing

You can start / stop performance monitoring on a per NE (network element) and per ME (Monitored Entity) instance basis. The availability of the command is as follows:

LM and TM Transponder: the command is available as soon as the associated cross connection is created

Tuneable Transponder: the command is available as soon as the associated cross connection is created and the wavelength has stabilised.

The following requirements apply:

- The default behaviour is that the performance monitoring is autonomously started on all MEs unless the operator requests otherwise.
- When performance monitoring of an ME is started, the transport layer is assumed to be in the Available State until proved otherwise i.e. all performance counters are set to zero.
- Issuing ‘Start’ or ‘Stop’ against an individual ME that does not exist, or is in an inappropriate state is reported as an error.
- Issuing ‘Stop’ against an ME causes all current and historic records for that ME to be frozen; and the counting of errors in the current record.
- Issuing ‘Stop’ against an ME when already stopped is not reported as an error.
- Issuing ‘Start’ against an individual ME for which performance monitoring is already in progress has no effect and is not be reported as an error. Issuing ‘Start’ globally when performance monitoring is already in progress on one or more MEs which does not have an effect on those MEs (and will not be reported as an error, but causes performance monitoring on the other MEs to be started.

Note: When performance monitoring on an ME has not yet been started, or has been stopped, the DS input and the EBC input is assumed to be not connected.

10.13.6 Resetting 15min and 24hr Records

The operator is able to reset current records (per NE and per ME instance) as follows:

- Reset all current 15min records.
- Reset all current 24hr records.
- Reset all current 15min records and all current 24hrs records by one HCI command.

The operator is able to reset recent records (per NE and per ME instance) as follows:

- Reset all recent 15min records and all recent 24hr records by one HCI command.

When any recent record is reset its 'Elapsed Time' parameter is set to zero.

10.13.7 Resetting UAT and SEP Registers

The operator is able to reset (i.e. clear) UAT and SEP Registers as follows:

Reset the UAT and SEP Registers for a particular Monitored Entity.

Note: It is recommended that a warning be given in the manual. Suggested wording is as follows: 'It is recommended that the network operator should apply operational procedures to LCT / LCTS strictly controlling the resetting of performance records stored in the NE'. This is to cater for administrations that may use such records for legal purposes etc.

10.14 Changing Payload Type

It should be noted that the 'SES Threshold' is 'Payload Type' dependent. If 'Payload Type' is changed, the new 'SES Threshold' applies immediately. This means that if 'Payload Type' is changed during a 15min / 24hr monitoring period the old threshold applies for the first part and the new threshold for the remaining part of the period.

Further considerations apply if the change is from an SDH / SDH 'Payload Type' to a non-SDH / SDH 'Payload Type' (e.g. Gigabit Ethernet), or vice versa. Changing from an SDH / SDH 'Payload Type' to a non SDH / SDH 'Payload Type':

In this case any 15min / 24hr records which have been stored against the SDH / SDH RS B1 is deleted. The 15min / 24hr records stored against the DWDM OCh-OH continues to be processed as usual.

Changing from a non SDH / SDH 'Payload Type' to an SDH / SDH 'Payload Type':

In this case new current 15min / 24hr records are created for the SDH / SDH RS B1. These new records are marked as Suspect / incomplete by means of the ‘Report Notes’ field (c.f. section 10.19.1 below); the only exception would be in the unlikely event that the change is done exactly on the time boundary between successive windows. The 15min / 24hr records stored against the DWDM OTU and ODU continues to be processed as usual.

10.15 Performance Data Reports

10.15.1 General

A requested or scheduled Performance Data Report comprises of a complete set of performance parameter counts derived from a Monitored Entity accumulated over the duration of a Report Period. The network Operator can mix and match scheduled and requested reports to suit his particular network. For example, scheduling reports may not be acceptable in some networks due to possible Comms congestion. In these cases, EM controlled polling for the Reports would be more appropriate - the collection can be spread over 15 minutes or 24 hours as required.

The Performance Data Reports may be used to generate the long-term performance statistics for the Monitored Entities, but this is outside the scope of the present document.

A Performance Event Report informs the operator that a Performance Parameter for a particular Monitored Entity has reached the (operator configurable) event threshold. If more detailed information is required the operator can request a full report for the monitored entity in question, or schedule performance reporting if this is not currently enabled.

10.15.2 Requested Reports

10.15.2.1 General

The EM / LT operator is able request any single Performance Data Report stored as a Record to be sent to the EM / LT by the NE.

10.15.2.2 Current Report

The contents of the current performance data report is available to the EM / LT operator on request, but the cumulative counts will only give indications relating to the elapsed time of the current performance data reporting period. The time of issue is included in the report.

10.15.2.3 Recent Reports

The contents of the recent performance data reports are available to the EM / LT operator on request. These contain the recent performance history for the monitored entity. The collection of recent records could be used to generate long term performance statistics if autonomous reporting is not used.

The report includes information of the period such that the EM can verify the correct operation of the performance monitoring functions. If a requested recent record does not exist then a suitable message is returned.

10.15.3 Scheduled Reports

10.15.3.1 General

The EM / LT operator has the option to enable / disable the automatic sending of 15min reports, 24hr reports, or both, on a Monitored Entity basis; this enable / disable command is available globally for the whole NE. The default behaviour is that reporting is disabled.

The global enable / disable command is a tap at the end of the processing. Thus if the global disable command is issued no Scheduled Reports are sent by the NE. However if the global enable command is subsequently issued the individual per ME instance enable / disable settings are re-instated.

Once enabled, the appropriate, most recent, performance data report is sent at the end of each successive performance data-reporting period. Enabling of Scheduled Reporting is one method that could be used by a network Operator to gather long term performance information from a monitored entity.

At the end of a 24Hour-reporting period, the newly completed 15min report is sent to the EM before the newly completed 24hr Report. Scheduled Reports are not sent to the LT.

10.15.3.2 Scheduled Reporting Delay

In order to minimise the possibility of communications system overload in large networks, the EM / LT operator is able to configure a delay mechanism in the start of sending Scheduled Reports.

- The operator is able to configure the delay mechanism as follows:
- Delay to be operator configured.
- Delay to be set autonomously by the NE.
- The delay is in the ranges indicated below and depends on whether or not the implementations support the fixed 10-second delay re. UAT processing (see section 10.11 above):
- Implementations supporting the fixed 10-second delay re. UAT processing. The range is between 0 – 889 seconds with 1-second granularity.

- Implementations not supporting the fixed 10-second delay re. UAT processing the range is 0 – 899 seconds with 1-second granularity. For cases where the delay mechanism is 'Delay to be set autonomously by the NE', each NE generates a pseudo-random delay within the above range. The method of generating the delay duration is such as to maximise the probability that each NE within a network commences the sending of Scheduled Reports at a different time. A possible method of achieving this is to base the delay on the output from a random number generator, and to use a unique value (e.g. an equipment serial number) as the seed for the generator. The delay is calculated at Controller Unit start-up, and then remains fixed, so that every report will be delayed by the same amount. The method used in the DWDM Product Family is the same as used in OMS. This is so that in a mixed network containing DWDM and SDH equipments it will be easier to predict the time distribution of performance reports from the overall network.

- The default NE behaviour is 'Delay to be set autonomously by the NE'.

- If the operator selects 'Delay to be operator configured' the default delay is zero seconds.

10.16 Performance Event Reports (TCNs / Exception Reports)

Performance Event Reports are provided to give an early indication of performance degradation and are intended to assist the network Operator in network maintenance. Note that Performance Event Reports are also referred to as Performance Exception Reports or Threshold Crossing Notifications (TCNs). Note that TCNs are not applicable to bi-directional reports.

The following Performance Event Reports are defined:

15min / 24hr TCNs:

- 15min ES
- 24hr ES
- 15min SES
- 24hr SES
- 15min BBE
- 24hr BBE

UAT related:

- SUE
- TUE

The EM / LT operator is able to enable / disable Performance Event Reports as follows.

Per ME instance and globally for the whole NE:

- Enable / disable SUE / TUE events
- Enable / disable Error Threshold Events (i.e. 15min ES Reports etc.)

The default behaviour is that exception reporting is disabled.

The enable / disable command available globally for the whole NE is a tap at the end of the processing. Thus if the global disable command is issued no Performance Event Reports are sent by the NE. However if the global enable command is subsequently issued the individual per ME instance enable / disable settings are re-instated.

When a Performance Event Report is generated, all performance data continues to be recorded as usual in the 15min and 24hr Performance Records.

Performance Event Reports are generated when Parameter Counts derived from Error Performance Primitives reach operator configurable thresholds within the fixed-window performance monitoring boundaries. Therefore they can be sent to the EM at any time. The applicable threshold value and time of occurrence is included in the Event Report. If the Performance Event Report cannot be sent to the EM, these reports are stored in a Performance Event.

The range and default values to be used for each of the performance exception report thresholds are given in the sub sections below. The thresholds for Performance Event Reports are configurable from the EM and LT for each instance of the Monitored Entities (rather than globally for the NE). Performance Event Reports are not sent to the LT.

10.16.1 TCN Mechanisms (15min and 24hr)

The definitions of ‘TR-only’ and ‘TR-RTR’ are as follows:

‘TR only’ – one threshold value is defined; if the event count reaches or exceeds the threshold value, the threshold state is set to true and a threshold report is generated. The threshold state is implicitly reset (to false) at the end of the accumulation period. This mechanism is applicable for 15 minute and 24 hour accumulation periods.

‘TR-RTR’ – two threshold values (set, reset) are defined; if the event count reaches or exceeds the set threshold value and the threshold state is false, the threshold state is set to true and a threshold report is generated. If the threshold state is true, the threshold state is reset (to false) and a reset threshold report is generated at the end of a following accumulation period in which the event count is less than the reset threshold value. There was not an unavailable period in the accumulation period. This mechanism is applicable for 15-minute accumulation periods.

10.17 TCN TR Threshold Ranges and Defaults (15min and 24hr)

The ‘Raise thresholds’ (i.e. ‘TR thresholds’) are defined in Table 10-19. The TR thresholds define the number of ESs, SESs, BBE occurring within a given 15 minute / 24 hour period that causes the NE to send a TR exception report. Default values are shown in brackets.

The ‘TR thresholds’ are configurable on a per ME instance basis. The operator is able to set/reset these thresholds to their default values via the global ‘Default Thresholds’ command.

Table 10-19: ES & SES Performance Report Exception Thresholds (TR)

	ES & SES Performance Report Exception Thresholds (TR)			
Monitored	**15 Minute Report**		**24 Hour Report**	
Entity	**15min ES**	**15min SES**	**24hr ES**	**24hr SES**
	TR Threshold	**TR Threshold**	**TR Threshold**	**TR Threshold**
SDH / SDH RS Non-intrusive Monitor	1 to 900 (180)	1 to 900 (15)	1 to 86400 (1500)	1 to 86400 (20)
OTUk Termination	1 to 900 (180)	1 to 900 (15)	1 to 86400 (1500)	1 to 86400 (20)
ODUk Termination	1 to 900 (180)	1 to 900 (15)	1 to 86400 (1500)	1 to 86400 (20)
ODUk Non-intrusive Monitor	1 to 900 (180)	1 to 900 (15)	1 to 86400 (1500)	1 to 86400 (20)

Table 10-20: BBE Report Exception Thresholds (TR)

	BBE Performance Report Exception Thresholds (TR)	
Monitored	**15 Minute Report**	**24 Hour Report**
Entity	**15min BBE**	**24hr BBE**
	TR Threshold	**TR Threshold**
SDH / SDH RS Non-intrusive Monitor	1 to 224 – 1 (9000)	1 to 224 – 1 (48000)
OTUk Termination	1 to 224 – 1 (9000)	1 to 224 – 1 (48000)
ODUk Termination	1 to 224 – 1 (9000)	1 to 224 – 1 (48000)
ODUk Non-intrusive Monitor	1 to 224 – 1 (9000)	1 to 224 – 1 (48000)

Note: The maximum values for BBE events are smaller than the maximum number of BBEs that could theoretically be detected in the period.

10.17.1 TCN RTR Threshold Ranges And Defaults (15min)

The ‘Reset thresholds’ (i.e. ‘RTR thresholds’) are defined in Table 10-21. The RTR thresholds define the number of ESs, SESs, BBEs occurring within a given 15 minute period that causes the NE to send a RTR exception report. Default values are shown in brackets.

The ‘RTR thresholds’ are configurable on a per ME instance basis. The operator is able to (re) set these thresholds to their default values via the global ‘Default Thresholds’ command

Table 10-21: ES & SES Performance Report Exception Thresholds (RTR)

	ES & SES Performance Report Exception Thresholds (RTR)	
Monitored	**15 Minute Report**	
Entity	**15min ES**	**15min SES**
	RTR Threshold	**RTR Threshold**
SDH / SDH RS Non-intrusive Monitor	0 to 900 (20)	0 to 900 (0)
OTUk Termination	0 to 900 (20)	0 to 900 (0)
ODUk Termination	0 to 900 (20)	0 to 900 (0)
ODUk Non-intrusive Monitor	0 to 900 (20)	0 to 900 (0)

Table 10-22: BBE Performance Report Exception Thresholds (RTR)

	BBE Performance Report Exception Thresholds (RTR)
Monitored	**15 Minute Report**
Entity	**15min BBE**
	RTR Threshold
SDH / SDH RS Non-intrusive Monitor	0 to 224 – 1 (200)
OTUk Termination	0 to 224 – 1 (200)
ODUk Termination	0 to 224 – 1 (200)
ODUk Non-intrusive Monitor	0 to 224 – 1 (200)

Note: The maximum values for BBE events are smaller than the maximum number of BBEs that could theoretically be detected in the period.

10.18 Performance Logs

10.18.1 UAT Logs

The operator is able to request a UAT Log per ME Instance.

10.18.2 SEP Logs

The operator is able to request a SEP Log per ME.

10.19 Performance Reporting Details

10.19.1 Performance Data Reports (Format)

Each Performance Event Report uniquely identifies the ME instance and indicates the name and value of the Threshold that has been exceeded.

Blank Page

Chapter 11: Equipment Monitoring

11.1 Introduction

This chapter describes the equipment monitoring processes and diagnostic facilities provided for the Multihaul 3000.

The main features of the Equipment Monitoring Subsystem are as follows:

- Provides sufficient diagnostic information so that equipment faults can be located to a single equipment unit.

- Processes its inputs either in software or hardware in order to recognise fault events. These fault events are presented to the Event Handling Subsystem for resolution into alarms.

- Provides failure information to enable other subsystems (e.g. the Protection Switching Subsystem) to re-select services within the NE to ensure customer traffic and Qecc comms are maintained.

- Provides internal test facilities that can be used to diagnose both equipment and network faults.

- Provide the means to obtain instantaneous parametric values of primitives associated with the NE hardware and also minimum and maximum values.

11.1.1 Equipment Monitoring Primitives

The Equipment Monitoring Subsystem accepts and interprets various primitives in order to monitor the defect state of the NE. These primitives, in general, take the form of flag or logic states or data values.

The primitives are polled by the Equipment Monitoring Subsystem, and are processed to determine the following NE hardware performance:

- The control states of the NE hardware that is thresholded within the NE hardware itself to imply equipment failures, any resultant defect state being made available to the microprocessor circuitry on each unit.

- The error performance of the optical bearers that is thresholded by the on-card firmware to imply potentially traffic affecting error rates.

Test Routines. In most cases these are pre-defined i.e. not operator configurable. If any threshold needs to be operator configurable then this is stated explicitly.

The hardware on each type of unit presents information to the unit microprocessor circuitry, providing instantaneous values of primitives representing the operating conditions of the analogue functions of the unit.

11.2 Power-On Self Test (Post) Routines

Equipment monitoring of automatic power-up consists of the specific monitoring and self-test processes that operate autonomously during the power-up sequence of a unit or the equipment. Power-up occurs when a unit is plugged into a powered shelf (unit power-up) or when power is applied to an equipped shelf (equipment power-up).

The occurrence of unit power-up is likely to occur more often as units are added to equipment during enhancements or following maintenance activity.

On power-up, each unit executes a range of POST routines to establish, as far as possible, the correct operation of the unit hardware. The POST routines performed by an individual unit are consistent every time the unit powers-up. This ensures that the POST sequence is the same for either unit power-up or equipment power-up scenarios.

11.2.1 POST Sequence

The POST sequence is as follows:

- SIU Identifier (red) LED on
- Memory test routines (where applicable)
  - Boot PROM check
  - RAM
  - EEPROMs
  - Flash Banks
  - Working RAM.
- Custom device register test routines (if applicable)
- SIU Identifier (red) LED off (subject to successful completion of the above routines).

Where devices of a type shown in the above sequence are not present on a particular unit, the sequence of routines is preserved for the types of device, which are present.

A combination of Read / Write tests, CRCs, Parity Walking test patterns and redundancy are used depending on memory type.

Any POST routines that exercise card hardware (such as custom device register test routines) are designed to minimise the possibility of disruption to other equipment units.

11.2.2 Devices Checked During POST

11.2.2.1 General

All memory devices and the registers of all custom devices are tested on power-up.

The memory checks required at power-up are such that all memory locations are included in the checks, either directly by read / write tests or indirectly by their contribution to a checksum.

The following sub-sections define the specific types of test routine:

- PROM: used for storing the Boot-up programmes on all equipment units. See 11.2.2.2
- RAM: used for short-term volatile storage of data (includes packet RAM). See 11.2.2.3
- EEPROM: used for non-volatile storage configuration data (on the SMCs). See 11.2.2.4
- Flash Memory: used for storing main application software, and for example, routing tables. See 11.2.2.5
- Device Registers: internal registers within the FPGAs holding configuration data. See 11.2.2.6
- Memory Device Checks

11.2.2.2 PROM

All PROMs have a checksum(s) included at manufacture, which is checked at power-up by a routine in the Boot application itself and compared with the stored value. Any discrepancy is regarded as a PROM failure. In the event of a PROM failure being detected, the unit halts and extends a Unit Fail condition.

11.2.2.3 RAM

During the Boot sequence, any RAM required for the BOOT process itself is first tested by the Boot code performing read / write tests. Any discrepancy is regarded as a RAM memory failure. In the event of a RAM failure being detected, the unit halts and extends a Unit Failure condition.

11.2.2.4 EEPROM

The EEPROMs (on the SMCs) have checksum(s) contained in them. A new checksum is calculated and stored each time the contents of the EEPROMs are changed. The checksum(s) for each EEPROM are checked at power-up. Any discrepancy is regarded as a 'Config NVM Failure'.

If only a few bits of data are held, then, as an alternative to calculating and maintaining a check-sum, it is acceptable to use other methods of integrity checking, for example, maintaining more than one copy and using a majority voting procedure.

For the purpose of reliability calculations and considerations it is assumed that a Multihaul 3000 is reconfigured 20 times a day for its specified lifetime of 15 years, giving a total of 110,000 reconfigurations and checksum writes.

11.2.2.5 Flash Memory

The flash memory contains checksum(s) that are downloaded with the software download. The checksum value for each area of working flash is checked at power-up. Any discrepancy is regarded as a flash memory failure. If duplicated Flash Banks are available and they both fail, then the unit halts.

11.2.2.6 Custom Device Register Checks

Where possible, FPGA read / write registers are tested to confirm their correct operation. On detection of a failed device, the unit halts and extends a unit failed condition. If the FPGA test is completed successfully, the FPGAs are left in their default ready for configuration proper once normal operation of the unit is established.

11.2.3 POST Target Times

11.2.3.1 Unit Power Up

The time for any individual unit to power-up after plugging into the powered shelf is 30 seconds. The power up time for an individual unit is the time for the unit to complete the self-tests (successfully), to establish normal working with the NE Controller and to clear the on unit failed LED.

11.2.3.2 Equipment Power Up

The time taken for an equipment power up is such that the NE can fully restore normal operation following a temporary power supply break within two minutes.

The duration of a temporary supply break is defined so that all volatile data in all units is lost and requires reloading from NVM.

Normal operation is defined as meaning that all cross connections that existed before the power-up are reconfigured and correctly passing data and conducting all other functions of the NE (except manually applied diagnostics, which is reset). Alarm Performance and Comms are restored to correct operation in the configuration existing just prior to the power loss.

The configuration to be used to measure the Power-up time for NE equipment is a fully equipped shelf with the maximum number of added / dropped optical channels and a full complement of optical channel termination units.

11.3 Automatic Background Test Routines

All background equipment checks are non-intrusive and are at all times invisible to operators, until fault conditions are detected. The effects of defect hysteresis are dealt with by providing separate thresholds for the recognition of the defect and non-defect states of each monitored primitive. Except where indicated, the card hardware makes the defect state information available to the on-card microprocessor by assigning each defect a specific location in a bit-mapped register.

The priority given to the firmware tasks that perform these background tests is such that essential tasks (such as alarm and performance gathering and processing) are uninterrupted during periods of high processor loading.

11.3.1 Memory Checks

All types of memory as defined in section 11.2.2.1Devices Checked during POST, General are tested as a background task.

The background tests are intended to find faults that may lead to traffic corruption but may not necessarily be detected by other monitoring processes within the equipment. For example, it is possible that corruption to FPGA registers could result in traffic disruption, which would not be detected by other equipment monitoring processes.

The background tests evaluate every location of each device so that, under normal operating conditions, device faults and configuration faults caused by memory corruption can be detected within ten minutes of their occurrence.

As a minimum, the memory checks can detect ’stuck at’ 1 or 0 faults for any of the Address and Data lines.

11.3.2 Memory Failures

11.3.2.1 Hard Failures

Peripheral Units: When writing data to RAM memory, read / write tests are used to validate the correct operation of the writing process. Failure of the write process is generally due to a device or unit hard failure and may not be recoverable. On detection of hard memory failures, the unit in question halts. If the faulty unit is a traffic-carrying unit, this causes a time-out on the IEEE1394 bus and results in a unit / slot fail alarm being raised by the NE Controller. If the faulty unit is the NE Controller, application layer time-outs eventually occur with any connected management devices, whilst appropriate extensions and indications are given by the local alarm scheme.

NVM: Read / write tests are only applicable during software download or configuration updates. Failures detected during download result in the download process halting. Failures detected during configuration update result in a specific ’Config NVM Failure’ being raised from the faulty unit.

11.3.2.2 Memory Corruption

Failure of checksums does not necessarily imply a faulty device or unit. For example, if the process of updating NVM is interrupted or not completed for whatever reason, it is possible that an incorrect checksum may result. In order to be more specific as to the exact nature of a memory corruption, large areas of NVM, for example SMC banks, are partitioned and checksums calculated for each partition.

In some cases, it may be possible to reload the corrupt data to the unit from NVM by doing a configuration download. Where it is possible to achieve this without affecting Traffic, this is an autonomous action taken by the NE Controller and reported to the operator. If realignment is not possible without traffic disruption, the download action must be instigated manually.

Where failure of NVM containing executable code that is used in normal operation is detected (for example routines in Boot ROM), the unit halts.

11.4 Watchdog Monitoring

11.4.1 Introduction

The Watchdog monitoring function carries out a continuous check on the correct operation of the unit (micro) controller firmware (hardware watchdog).

11.4.2 Hardware Watchdogs

Under normal operation, the unit (micro) controllers regularly issue a trigger signal to an on-card hardware monostable so that the monostable is kept in the triggered state. Generation of this trigger signal by the (micro) controller in question is not based on an interrupt mechanism. If, for whatever reason, the trigger signals are not issued to trigger the monostable, the monostable resets (or matures) indicating the matured condition. On maturation of the hardware watchdog, the unit goes through a warm reset and reconfiguration procedure.

It is not permissible to indicate a watchdog / warm reset when a unit is initially powered. To this end, the unit firmware uses a particular memory location to determine whether to send a watchdog / warm reset alarm to the NE Controller as part of the one-second-alarm response. Each time it is read, the location is set to a known value.

The firmware ensures that nothing is written to this location if executing from the Boot ROM, whilst a different value is written to this location if executing from the watchdog / warm reset interrupt vector.

The resulting behaviour is that a watchdog / warm reset alarm is only ever returned to the NE Controller during one one-second poll following a watchdog / warm reset, therefore the maximum duration of any such alarm reported to the operator is one second.

In response to watchdog maturation, it is possible to instruct a ’Card Reset’ command to be issued to the affected unit. This causes the unit to execute a Power-up sequence.

Note: This leads to traffic disruption and should only be used as a last resort.

11.5 Error Monitoring

11.5.1 *RX SOH BIP Error Monitoring*

The card firmware on the OSU uses the counts provided to derive the following defect:

- Primitive = Rx SOH BIP Error Count, Defect = Degraded BER

11.5.2 *RX SOH BER 'On/Off Thresholds'*

The determination of the real-time BER (Bit Error Ratio) for the Rx SOH is based on BIP error counts.

Interpretation of the BIP counts is carried-out (by on-card firmware) in separate successive fixed-window periods. If the number of cumulative BIP errors in any single window period exceeds a pre-defined 'On' threshold, then a defect is recognised. The defect is only cleared when the cumulative number of BIP errors in any single window period falls below a pre-defined 'Off' threshold.

The fixed window sizes and cumulative bit error thresholds are pre-defined (i.e. not operator configurable) and are dependent on the BER to be calculated.

11.5.3 *RX SOH 'Degraded BER' Thresholds*

The threshold can be selected, at which 'Degraded BER' defect detection is required, by selecting one of the BER Thresholds shown in Table 11-1individually for each section (East and West).

Table 11-1 Rx SOH 'Degraded BER' Threshold Configuration

'Degraded BER' Threshold
10^{-3}
10^{-4}
10^{-5}
10^{-6} (Default)
10^{-7}
10^{-8}
10^{-9}

11.5.4 *Error Monitoring on G.709 Transponders*

This section applies to Transponding channel units operating in TTP, CTP, and Regen Mode.

Two instances will be monitored:

- Pre FEC: Corrected FEC Error counts (FECCorrErr). (I.e.: errors that have been corrected by the FEC processing).

- Post FEC: Post FEC BIP Monitoring.

Table 11-2 shows what is monitored, the direction of traffic flow and the FEC monitoring required for each mode of transponder.

Table 11-2: Monitoring

Tp Mode	ME	Direction	Pre FEC	Post FEC
	OCh	WDM → Client	Y	N
	ODU	WDM → Client	N	Y
TTP	OTU	WDM → Client	N	Y
	B1*	WDM → Client	N	Y
		WDM ← Client	N	Y
	OCh	WDM → Client	Y	N
	OChr	WDM → Client	Y[1]	N
CTP /	ODU	WDM → Client	N	Y
Regen		WDM ← Client	N	Y[2]
	OTU	WDM → Client	N	Y
		WDM ← Client	N	Y[2]

Notes

[1]: - This will only be present on 10G RZ G709 Transponders when FEC is enabled.

[2]: - Not available on Transponders

11.5.5 Transponder Applicability

Table 11-3 and Table 11-4 show an atomic breakdown of the TTP Transponder and CTP (Link Mode) Transponder.

Table 11-5 shows the points where ‘Degrade’, ‘Degraded BER’ and ‘EBER’ thresholds are required on G.709 Transponding Channel Units.

Y – Denotes that a specific threshold is required for that sink/monitor point.

Table 11-3: TTP Transponder Atomic Diagram

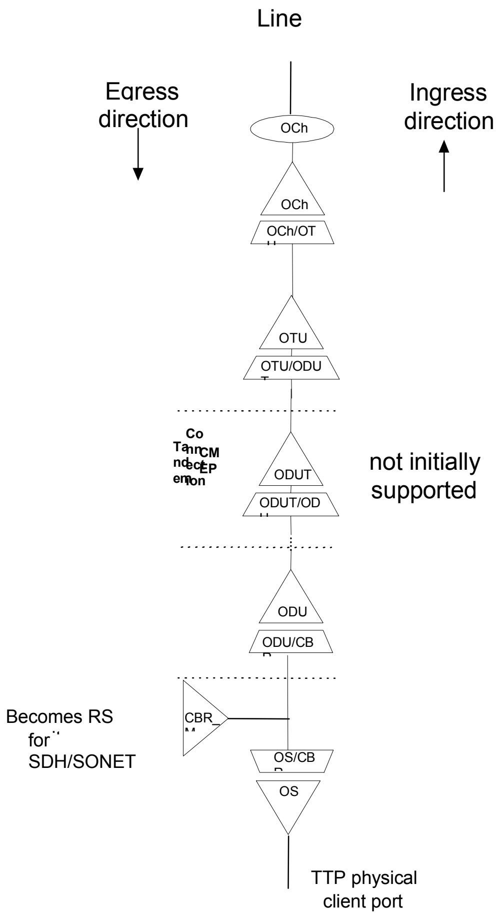


Table 11-4: CTP Transponder Atomic diagram

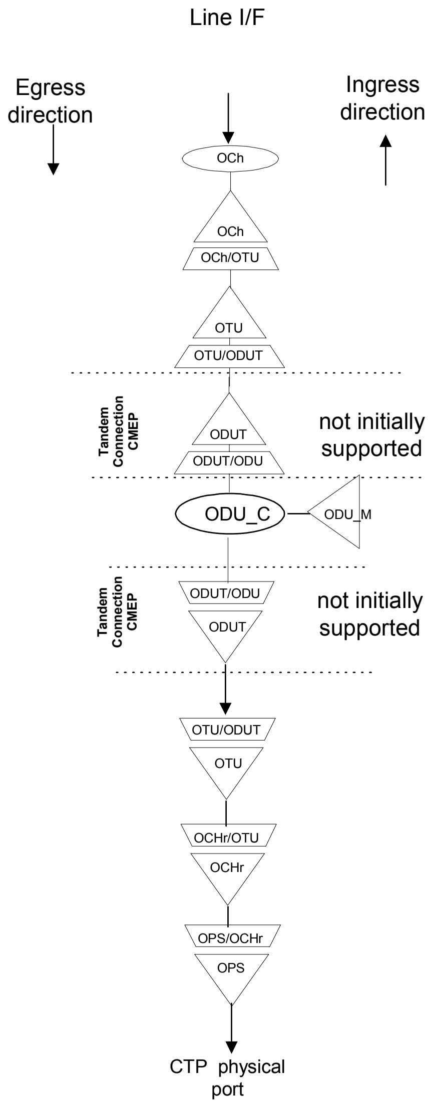


Table 11-5: G.709 Threshold Configuration Points

	Egress					Ingress			
	OCh	**OTU**	**ODU**	**RS - MON**	**ODU – Mon ***	**OChr***	**OTU ***	**RS - Mon**	**ODU – Mon**
DEGRADE		Y	Y	Y	Y		Y	Y	Y
Degraded BER	Y			Y		Y		Y	
EBER	Y			Y		Y		Y	

Note: - Applies the CTP Link mode Transponder only.

11.5.6 Pre FEC Alarms

Pre FEC BIP 8 monitoring is used to create 'Degraded BER' and 'Excessive BER' defects at the OCh/OTUk adaptation.

'Degraded BER' and EBER defects is defined to provide an indication of 'pre FEC' performance i.e. that the FEC function is under stress. These defects are derived on the basis of BIP errors according to the following assumption:

- The number of BIP errors in a Reed-Solomon frame is assumed to be equal to the number of corrected ones plus the number of corrected zeros for the frame. Note however that since the existing algorithms assume BIP-8 this value is capped at a maximum of 8 for each frame.

11.5.7 'Degraded BER' Thresholds

The operator is able to select the BER threshold at which 'Degraded BER' defect detection is desired by means of selecting one of the values shown in Table 11-6.

Table 11-6 Rx OCh: 'Degraded BER' Threshold Configuration

'Degraded BER' Threshold
10^{-5}
10^{-6} (Default)
10^{-7}
10^{-8}
10^{-9}

Note: The values shown in the table will also apply to a Transponder in a Muxponder Group.

11.5.8 'Excessive BER' Thresholds

The operator is able to select the BER threshold at which 'Excessive BER' (EBER) defect detection is desired by means of selecting one of the BER thresholds shown in Table 11-7.

Table 11-7 Rx OCh: 'Excessive BER' Threshold Configuration

'Excessive BER' Threshold
10^{-3} (Default)
10^{-4}
10^{-5}

Note: The values shown in the table will also apply to a Transponder in a Muxponder Group.

11.5.9 BER On/Off Thresholds

Interpretation of the counts is carried out (by on-card firmware) in separate successive fixed-window periods. If the number of cumulative bit errors in any single window period exceeds a pre-defined 'On' threshold, then a defect is recognised. The defect will only be cleared when the cumulative number of bit errors in any single window period falls below a pre-defined 'Off' threshold.

The fixed window sizes and the cumulative bit error thresholds are pre-defined (i.e. not operator configurable) and are dependent on:

- The BER to be calculated
- The payload type (i.e. data rate)

11.5.10 Corrected FEC Error Counts

This is a count of the number of bits corrected by the FEC device.

11.5.10.1 Collection of the Count Data

The micro-controller on the card polls the FEC hardware once every second and transfers the value of the counter to RAM. Within the RAM, the FIFO structure is capable of storing the previous hours worth of counts (i.e. FIFO length = 3600 elements). In this the previous hour's worth of counts is stored at one-second intervals. Each element in the FIFO stores a count for the previous second. An absolute counter is also stored which is a total count since the last counter reset. This is updated each second when the counter is polled.

11.5.10.2 Displaying of the Counter Values to the Operator

The counter is displayed on a operator request basis.

The LCT / LCTS will have a separate window in which the counter will be displayed. Within this window the operator is able to select a time frame of 1s, 5s, 15s, 30s, 1min, 5min, 15min, 30min and 60min. This time frame will be the time over which counter values will be displayed e.g. if the operator sets the time frame to 15min, the total counts for the previous 15min will be displayed (i.e. a total of the previous 15 x 60 values in the FIFO).

The LCT / LCTS will display two values for each counter, an absolute value (the total number of counts since the last reset) and a cumulative value (total count over the selected time frame).

There will also be two buttons within the LCT / LCTS window, a request button and a reset button:

- Request button: updates the display of the absolute counts and displays the total counts over the selected time frame.
- Reset Button: resets and updates the display of the absolute counters.

In total four values will be shown for the counter. The present requested value, and three historical requested value will displayed.

Note: It is recognised that if the operator specifies one of the larger time frames (say 15min, 30min or 60min) the counts may be very large. If overflow occurs the count will not wrap round, but is reported as the max count and also an overflow indication is given.

11.5.11 Pre-FEC Uncorrecteable Subframes

The transponder software will read the Uncorrectable Subframe information from the FEC device (Hudson 2 (address 0x70000118 - 4 bytes long)) every 8ms (Consistent with other performance polls). As long as the value read is equal to zero the OH information will be processed as normal and the transponder will work as normal. However if the data read is not zero for more than 3 polls (24ms) then the following OH data will be frozen at the last read value: -

- ODU APS
- OTU Path Trace
- ODU Path Trace
- ODU BDI
- OPU PLM
- OTU BDI
- ODU FCIF

Note: All other Overhead data will continue being read, This is because it doesn't effect the Client Output traffic.

Once entering this condition the Transponder will wait until 8 consecutive Uncorrectable Subframe polls (64ms) come back as zero before unfreezing the OH data. The timings for persistency are consistent with standard alarm persistencies.

11.5.12 Post FEC Alarms

11.5.12.1 OTU/ODU BIP/BLOCK Error Monitoring

Within the G.709 frame structure two levels of BIP-8 error monitoring are supported, Section Monitoring within the OTUk layer and Path Monitoring within the ODUk layer.

Each OTUk BIP-8 is computed over the bits in the OPUk (columns 15 to 3824) area of OTUk frame i, and inserted in the OTUk PM BIP-8 overhead location in the OTUk frame i+2.

Each ODUk BIP-8 is computed over the bits in the OPUk (columns 15 to 3824) area of ODUk frame i, and inserted in the ODUk PM BIP-8 overhead location in the ODUk frame i+2.

If one or more parity errors in this ECB are detected locally by any of the 8 BIP bytes then a single Near-end Block Error is declared.

Post FEC BIP 8 monitoring will be used to create a ‘Degrade’ defect for the OTUk and the ODUk layers.

Post FEC BIP monitoring is used to determine Block Errors in the usual way i.e. if there is one or more BIP Errors in an ODU / OTU Block (or in an SDH Regen Section Block) then a single Block Error is declared for the given monitored entity. The Block Errors are then used to declare the ‘Degrade’ condition.

11.5.12.2 Rx ODU/OTU ‘Degrade’ ON / OFF Thresholds

The determination of the ‘Degrade’ condition for the Rx ODU/OTU is as follows:

- In the case of the 2.5 Gbit/s & 10Gbit/s Transponding Channel Unit the ‘Degrade’ condition is determined from post FEC performance primitives.

Interpretation of the block error counts is carried out (by on-card firmware) in operator configured window periods. If the number of consecutive DSs equals or exceeds the operator configured ‘On’ threshold, then a defect is recognised. The defect will only be cleared when the number of consecutive non-DSs falls below the operator configured ‘Off’ threshold.

The operator is able to configure DS On / off thresholds as defined in Table 11-8. The DS threshold is configurable either on a per Rx ODU or OTU basis, or globally for the whole NE.

Table 11-8 Rx ODU/OTU: Degraded Seconds On / Off Thresholds

THRESHOLD	RANGE
Consecutive DS ‘On’	1 to 20 (default 5)
Consecutive DS ‘Off’	1 to 20 (default 10)

Notes to Table 11-8

1 The consecutive DS ‘On’ threshold is used to determine the point at which the short-term error performance is deemed to be unacceptable. At the instant the number of consecutive DSs exceeds the ‘On’ threshold, a ‘Degrade’ defect is declared. The consecutive DS ‘Off’ threshold is used to determine the point at which the short-term error performance is deemed to have returned to an acceptable level. Suppose that a ‘Degrade’ condition has been declared; then, at the instant the number of consecutive non-DSs falls below the ‘Off’ threshold, the ‘Degrade’ defect is cleared.

2 In link mode the NE will use the same value for the Rx Link OTU/ODU.

3 The values shown in the table will also apply to a Transponder in a Muxponder Group.

11.5.12.3 Rx ODU/OTU DS Thresholds

The degraded seconds threshold values for a G.709 transponder are shown in Table 11-9 these values apply to both the OTUk SM BIP-8, and ODUk PM BIP-8 error counts.

Table 11-9: G.709 Rx ODU / OTU 'Degraded Second' Threshold Configuration

Primitive	PTI (Note 3)	Payload	DS Threshold numeric value	DS Threshold percentage value
	20,21,35	STM-1 / OC-3 / 155.52Mbit/s	1 – 1276 (128)	0.001% - 100% (10%)
	22,23,36	STM-4 / OC-12 / 622.08Mbit/s	1 – 5104 (510)	0.001% - 100% (10%)
	26,27,37	STM-16 / OC-48 / 2.48832Gbit/s	1 – 20420 (2042)	0.001% - 100% (10%)
ODU/OTU	28,29,38	STM-64 / OC-192 / 9.95328Gbit/s	1 – 82028 (8203)	0.001% - 100% (10%)
Block Errors	25	Gigabit Ethernet	1 – 10258 (1026)	0.001% - 100% (10%)
	30	Fibre Channel 25M	1 – 2180 (218)	0.001% - 100% (10%)
	31	Fibre Channel 50M	1 – 4360 (436)	0.001% - 100% (10%)
	24	Fibre Channel 100M	1 – 8719 (872)	0.001% - 100% (10%)
	32	Fibre Channel 200M	1 – 17439 (1744)	0.001% - 100% (10%)
	33	SDTV	1 – 2216 (222)	0.001% - 100% (10%)
	44	9.5328Gbit/s ODU2 Multiplex	1 – 82028 (8203)	0.001% - 100% (10%)
	46, 49	10.3125Gbit/s (GbE LAN/PHY)	1 – 84988 (8499)	0.001% - 100% (10%)
	47	9.5328Gbit/s ODU2 Multiplex	1 – 82028 (8203)	0.001% - 100% (10%)

Notes: -

1 In link mode the NE uses the same value for the Rx Link ODU / OTU.

2 The values shown in the table applies to a Transponder in a Muxponder Group.

3 The values in the PTI column are for software indexing (within the NE) purposes only as defined in System Management Subsystem Specification for Multihaul

11.5.12.4 Maximum 8ms And 1 Sec Performance Primitive Counts

The maximum numeric values of the Block Error Counts required to be stored in one second (and 8ms) for a G.709 transponder, are given in Table 11-10; Max counts apply to OTUk SM BIP-8 and ODUk BIP-8 error counts.

Table 11-10 G.709: Max 1sec and 8ms DWDM Counts

Primitive	PTI (Note 1)	Payload Type	Bit Rate		Max 8ms Block Error Count	Max 1sec Block Error Count
	20,21,35	STM-1/OC-3/ 155.52Mbit/s	155.52	Mbit/s	10	1276
	22,23,36	STM-4/OC-12/ 622.08Mbit/s	622.08	Mbit/s	41	5104
	26,27,37	STM-16/OC-48/ 2.48832Gbit/s	2.48832	Gbit/s	163	20420
ODU /	28,29,38	STM-64/OC-192/ 9.95328Gbit/s	9.95328	Gbit/s	656	82028
OUT	25	Gigabit Ethernet	1.25	Gbit/s	82	10258
Block	30	Fibre Channel 25M	265.625	Mbit/s	17	2180
Errors	31	Fibre Channel 50M	531.25	Mbit/s	35	4360
	24	Fibre Channel 100M	1.0625	Gbit/s	70	8719
	32	Fibre Channel 200M	2.125	Gbit/s	140	17439
	33	(DVB-ASI)	270.0	Mbit/s	18	2216

Note: The values in the PTI column are for software indexing (within the NE) purposes only.

11.5.12.5 Derivation of DS Thresholds

In a G.709 conformant implementation the OTUk DS Threshold is based on the Block Error Count, and is the number of errored G.709 Blocks calculated locally using the OTUk SM BIP 8 overhead location in the OTUk frame i+2.

The threshold range and default value are derived as follows:

STM-64: The default threshold value is set at a 1-second error ratio of 10%, and the upper range is set at a 1-second error ratio of 100% (the ratios being applied to the maximum 1-second counts given in Table 11-9).

Derivation of values: STM-64: Default numeric value is 0.1 * 82028 = 8202.8

ODUk DS Threshold is based on the Block Error Count, and is the number of errored G.709 Blocks calculated locally using the ODUk SM overhead location in the ODUk frame i+2.

The lower percentage range value is such that a numeric granularity of 1 is achievable. For all data rates the lower percentage range value is shown in Table 11-9as 0.001%. This is for neatness on the HCI and is derived from the max supported data rate (STM-64) i.e. 100 / 82028 = 0.00122

11.5.13 Client Input B1 Monitoring

When the payload type is specified as a STM or OC payload Client input monitoring is invoked, this is based on counts obtained from the B1 BIP-8 byte contained within the regenerator section of the SDH/SDH frame.

Note: This section doesn't apply to RS monitoring on the Gigabit Ethernet Multiplexer unit.

11.5.13.1 Max 8ms and 1sec primitive Counts

The maximum numeric values of B1 block error counts required to be stored in one second (and 8ms) are shown in Table 11-11; other periods can be scaled accordingly.

Table 11-11 Max 1sec and 8ms Primitive Counts for B1 Based Monitoring

Primitive	Max 8ms Block Error Count	Max 1sec Block Error Count
RS B1 Block Errors	64	8000

11.5.14 Client Input Degraded BER Thresholds

The operator is able to select the BER threshold at which the defect 'Client Input Degraded BER' is raised. Possible values for this are shown in Table 11-12 .

Table 11-12 Client Input 'Degraded BER' Threshold Configuration

'Degraded BER' Threshold
10^{-5}
10^{-6} (default)
10^{-7}
10^{-8}
10^{-9}

11.5.15 Client Input 'Excessive BER' Thresholds

The operator is able to select the BER threshold at which the defect 'Client Input Excessive BER' is raised. Possible values for this are shown in Table 11-13.

Table 11-13 Client Input 'Excessive BER' Threshold Configuration

'ExBER' Threshold
10^{-3}
10^{-4}
10^{-5}
10^{-6} (default)
10^{-7}
10^{-8}
10^{-9}

11.5.16 Client Input 'Degrade On/Off Parameters

As with Rx OTU/ODU determination of the 'Degrade Condition' for the client input is determined from Block Errors inferred from the B1 BIP-8 check.

Interpretation of the block error counts is carried out (by on-card firmware) in operator configured window periods. If the number of consecutive DSs exceeds the operator configured 'On' threshold, then a defect is recognised. The defect will only be cleared when the number of consecutive non-DSs falls below the operator configured 'Off' threshold.

The operator is able to configure the DS on/off Thresholds as defined in Table 11-14.

Table 11-14 Client Input 'Degrade' On/Off Threshold Configuration

THRESHOLD	RANGE
Consecutive DS 'On'	1 to 20 (default 5)
Consecutive DS 'Off'	1 to 20 (default 10)

Notes

1 The consecutive DS 'On' threshold is used to determine the point at which the short-term error performance is deemed to be unacceptable. At the instant the number of consecutive DSs exceeds the 'On' threshold, a 'Degrade' defect is declared. The consecutive DS 'Off' threshold is used to determine the point at which the short-term error performance is deemed to have returned to an acceptable level. Suppose that a 'Degrade' condition has been declared; then, at the instant the number of consecutive non-DSs falls below the 'Off' threshold, the 'Degrade' defect is cleared.

2 The values shown in the table will also apply to a Transponder in a Muxponder Group.

11.5.17 Client Input 'Degraded Second' Thresholds

Determination of the Degraded Second condition for the client input is B1 block based. The operator is able to configure a DS threshold as defined in Table 11-15.

If the number of errored blocks received in a second exceeds this threshold the second is declared as being a DS. The default DS Threshold is also shown; this being 10% of the total number of blocks received per second.

Table 11-15 Client Input 'DS' Threshold Configuration

Primitive	Payload	DS Threshold numeric value	DS Threshold percentage value
RS B1 Block Errors	STM – m / OC-n	1-8000 (800)	0.01%-100% (10%)

Note: The values shown in the table will also apply to a Transponder in a Muxponder Group.

11.6 Shelf Monitor Unit

The Shelf Monitor Unit gathers miscellaneous alarms generated in extension, terminating and transponder subracks where a NE Controller is not fitted, and passes them to the NE Controller in the Core Subrack over the IEEE-1394 interface.

The alarm handling aspects of the Shelf Monitor Unit is based on the NE Controller functionality. This is essentially the same as for the NE Controller in a standalone Subrack, including:

- Unit removal for unmanaged (non IEEE-1394) units - Hub, Comms IO, Alarm IO
- Distributed PSU Fail
- Hub PSU Fails
- Fan Fails
- -50V Power Input Fails.

11.7 PSU Monitoring

11.7.1 Introduction

Multihaul 3000 does not have centralised power supply units (PSUs).

All units will take power directly from the station battery supply (TNV class II) and therefore have onboard PSU modules (or discrete solutions) to generate all required derived voltages.

Supply rail monitoring is a permanent safety feature of the Multihaul 3000 equipment power supplies and it is not possible for the operator to disable monitoring.

11.7.2 Monitoring of Station Supply

All station power supplies are monitored for failure.

11.7.3 Monitoring of Onboard PSUs

The units that have onboard PSUs continuously monitor the output supplies derived on card for their own use e.g. +3.3V, +2.5V and +1.8V etc.

The derived output supplies are monitored for undervoltage and overvoltage.

- The threshold for undervoltage are set nominally at between 10% and 20% below the rated output voltage
- The threshold for overvoltage for each supply rail are set nominally at between 10% and 20% above the rated output voltage.

11.8 Comms Monitoring

11.8.1 General

The NE Controller handles all comms functionality. Various checks are continuously performed on the comms interfaces.

11.8.2 Message Passing Interface

For communications related messages (i.e. comms protocols), an intra unit interface is provided on the NE Controller, which allows communication between the controller function and the comms function. This interface is referred to as the Message Passing Interface (MPI). The operation of this interface is monitored using various protocol checks on the messages sent (namely Watch Messages). A Watch Message takes the form of a date/time message sent to the comms function by the controller function every half second. The comms function acknowledges each such message. If a significant number of acknowledgements are not received, then a failure is reported to the Event Handling Subsystem.

In addition to handling the comms protocols, the MPI is also used for control, configuration, software download and event reporting.

11.9 Analogue Monitoring: Display of Instantaneous Values

11.9.1 General

The display of instantaneous values associated with the analogue traffic processing functions within the Multihaul 3000 can be requested via the LT/EM.

The display is not continuously updated, but operates in 'snapshot' mode. If you wish the display to be updated, you can repeat the action of requesting the relevant parameter reading(s) from the NE by utilising a 'refresh' function on the LT / EM.

11.9.2 Instantaneous Analogue Monitoring

Operation of the equipment presents you with three values for each primitive. Listed in 11.9.2 Instantaneous Analogue Monitoring Available Using PMU, indicating:

- Instantaneous value at the time of the snapshot
- Maximum value recorded
- Minimum value recorded.

You can selectively reset the minimum and/or maximum recording register(s) for any displayed parameter.

WARNING!

Determining minimum and maximum values is a hardware function. If, however, the hardware on given unit is not capable of this, the values are determined by the unit firmware polling e.g. once per 8ms. This may, however, give slightly misleading results.

11.9.3 Instantaneous Analogue Monitoring Available Using PMU

The instantaneous analogue primitives can be viewed in a graphical and tabular format, using the PMU.

CAUTION!

For OSNR values that are measured over 22dBm, the MT will display the value as 22dBm or > 22dBm.

Table 11-16 Instantaneous Analogue Monitoring Values Available using PMU

Monitored Entity	Primitive	Units
Channel 1-80 (each)	Channel Frequency	THz
	Channel Power	-15 to +15dBm in 0.1dBm steps
	Channel OSNR	0 to 22dBm in 0.1dBm steps
	Channel Presence	Yes / No
	Channel Expected	Yes / No

Note: The ‘Signal Expected’ indication is ‘Yes’ (preferably an ON enunciator) if the ‘Equipped Wavelengths’ bit for that channel is a ‘1’ in the received Section Overhead.

11.9.4 Analogue Monitoring Points

Figure 19.1 to Figure 19.4 and Table 19.9 illustrate the Analogue Monitoring Points. These are:

- Analogue Monitor Points Terminal
- Analogue Monitor Points Amplifier
- Analogue Monitor Points Leveller
- Analogue Monitor Points Add/Drop
- 10G Mux Monitors.

11.9.5 Primitives Available

The values available for display using the analogue monitoring feature as standard are as shown in Table 11-17. If the viewable range column is blank the value in the allowable range column applies. For analogue monitors on the 10G Data and TDM Muxponders see the standalone muxponder requirements specification.

Table 11-17: Instantaneous Analogue Monitoring Values

Optical Supervisory Unit (Card Type 0, Variant 1)				
PRIMITIVE	DESCRIPTION	UNITS	ALLOWABLE RANGE	VIEWABLE RANGE
OSC Transmit Power Deviation	The deviation from a reference value of the transmit power.	dB	-10 to +10, step 0.1	
OSC Laser Bias Current	The laser bias current of the optical supervisory channel laser.	mA	0 to 150, step 0.1	
Laser Temperature	The temperature of the optical supervisory channel laser.	^{0}C	0 to 80, step 1	
OSC Laser TEC Current	The laser TEC current of the optical supervisory channel laser.	mA	0 to 1500, step 10	
Unit Temperature	The temperature of the OSU measured off the top PCB board	^{0}C	0 to 100, step 0.1	

Optical Supervisory Unit (Card Type 3 Variants 3 & 4)				
PRIMITIVE	**DESCRIPTION**	**UNITS**	**ALLOWABLE RANGE**	**VIEWABLE RANGE**
OSC Port 1 Transmit Power	The OSC lasers absolute transmit power.	dBm	-10 to 13, step 0.1	0 to 13.997, step 0.1
OSC Port 1 Receive Power Note 5	The OSC lasers absolute received power.	dBm	-70 to 5, step 0.1	-60 to -0.12, step 0.1
OSC Port 1 Laser Bias Current	The laser bias current of the optical supervisory channel laser.	mA	0 to 200, step 1	0 to 95, step 1
OSC Port 1 Laser Temperature	The temperature of the optical supervisory channel laser.	^{0}C	0 to 70, step 0.1	20 to 30 , step 0.1
OSC Port 1 Laser TEC Current	The laser TEC current of the optical supervisory channel laser.	mA	-1500 to 1500, step 1	
OSC Port 2 Transmit Power	The OSC lasers absolute transmit power.	dBm	-10 to 13.997, step 0.1	0 to 13.997, step 0.1
OSC Port 2 Receive Power Note 5	The OSC lasers absolute received power.	dBm	-70 to 5, step 0.1	-60 to -0.12, step 0.1
OSC Port 2 Laser Bias Current	The laser bias current of the optical supervisory channel laser.	mA	0 to 200, step 1	0 to 95, step 1
OSC Port 2 Laser Temperature	The temperature of the optical supervisory channel laser.	^{0}C	0 to 70, step 0.1	20 to 30 , step 0.1

Optical Supervisory Unit (Card Type 3 Variants 3 & 4)				
PRIMITIVE	**DESCRIPTION**	**UNITS**	**ALLOWABLE RANGE**	**VIEWABLE RANGE**
OSC Port 2 Laser TEC Current	The laser TEC current of the optical supervisory channel laser.	mA	-1500 to 1500, step 1	
Unit Temperature	The temperature of the OSU measured off the top PCB board	^{0}C	0 to 100, step 0.1	

Group Multiplexer Unit (Card Type 6 Variants 1 & 2)				
PRIMITIVE	**DESCRIPTION**	**UNITS**	**ALLOWABLE RANGE**	**VIEWABLE RANGE**
Heater Power Output	The output power of the Optical Devices heater. Shown as a % of the maximum possible output power.	%	0 to 100, step 0.1	
Optical Device Temperature Deviation	The deviation from the optimal operating temperature of the optical device. A +ve value indicates less than optimal; a –ve value indicates greater than optimal.	^{0}C	0 to 100, step 0.1	
Optical Device Absolute Temperature	The absolute temperature of the optical device.	^{0}C	-100 to 100, step 0.1	
Unit Temperature	The temperature of the GMU measured off the PCB board	^{0}C	0 to 100, step 0.1	

Group Interleaver Unit (Card Type 10 Variant 1)				
PRIMITIVE	DESCRIPTION	UNITS	ALLOWABLE RANGE	VIEWABLE RANGE
De-Interleaver Heater/Cooler Current	The current of the De-Interleaver optical heater/cooler device.	mA	0 to 1660, step 10	
De-Interleaver Temperature Deviation	The deviation from the optimal operating temperature of the De-Interleaver optical device. A +ve value indicates less than optimal; a –ve value indicates greater than optimal.	^{0}C	-9 to 9, step 0.01	
De-Interleaver Absolute Temperature	The absolute temperature of the De-Interleaver optical device.	^{0}C	0 to 100, step 0.01	
Monitor Input Power	The input power of the received signal.	mW	0 to 8.43, step 0.01	
Unit Temperature	The temperature of the GIU measured off the PCB board	^{0}C	0 to 100, step 0.1	

Group Interleaver Unit (Card Type 10 Variant 3)				
PRIMITIVE	**DESCRIPTION**	**UNITS**	**ALLOWABLE RANGE**	**VIEWABLE RANGE**
Monitor Input Power	The input power of the received signal.	mW	0 to 8.43, step 0.01	
Unit Temperature	The temperature of the GIU measured off the PCB board	^{0}C	0 to 100, step 0.1	

Add/Drop Unit (Card Type 12 Variants 1 & 5)				
PRIMITIVE	**DESCRIPTION**	**UNITS**	**ALLOWABLE RANGE**	**VIEWABLE RANGE**
Monitor Input Power	The input power of the received signal.	mW	0 to 8.43, step 0.01	
Unit Temperature	The temperature of the ADU measured off the PCB board	^{0}C	0 to 100, step 0.1	

NRZ/RZ Transponders (Card Type 7)				
PRIMITIVE	**DESCRIPTION**	**UNITS**	**ALLOWABLE RANGE**	**VIEWABLE RANGE**
Client Input Power	The input power of the client signal.	dBm	-33 to 6, step 0.1	
Client Output Power	The output power of the client signal.	dBm	-16 to 13, step 0.1	
Rx Channel Input Power	The input power of the received WDM signal.	dBm	-54 to 13, step 0.1	
WDM Transmitted Output Power (NRZ Transponder)	The output power at the WDM Tx port. This is measure after VOA.	dBm	-20 to 5, step 0.1	
WDM Laser Output Power (RZ Transponder)	The output power of transmitted WDM Laser. Not the same as the output power at the WDM Tx port. Measured before the VOA.	dBm	-10 to 13, step 0.1	
Unit Temperature	The temperature of the Transponder measured off the PCB board	^{0}C	0 to 100, step 0.1	
Tx OCh Laser Bias Current (Not on RZ Transponder)	The Bias current being applied to the WDM laser	mA	0 to 300, step 0.1	
Client Laser Bias Current	The Bias current being applied to the Client laser	mA	0 to 150, step 0.1	
Tx OCh Laser Temperature Deviation(Not on RZ Transponder)	The Temperature deviation of the WDM laser	^{0}C	-9 to 9, step size 0.01	

40G NRZ Transponder (Card Type 25 Variant 1)				
PRIMITIVE	**DESCRIPTION**	**UNITS**	**ALLOWABLE RANGE**	**VIEWABLE RANGE**
Client Input Power	The input power of the client signal.	dBm	TBA	
Client Output Power	The output power of the client signal.	dBm	TBA	
Rx Channel Input Power	The input power of the received WDM signal.	dBm	TBA	
WDM Transmitted Output Power	The output power at the WDM Tx port. This is measure after VOA.	dBm	TBA	
Unit Temperature	The temperature of the Transponder measured off the PCB board	^{0}C	TBA	
Tx OCh Laser Bias Current	The Bias current being applied to the WDM laser	mA	TBA	
Client Laser Bias Current	The Bias current being applied to the Client laser	mA	TBA	
Tx OCh Laser Temperature Deviation	The Temperature deviation of the WDM laser	^{0}C	TBA	

2.5G Metro Transponders (Card Type 15 Variant 3)				
PRIMITIVE	**DESCRIPTION**	**UNITS**	**ALLOWABLE RANGE**	**VIEWABLE RANGE**
Client Input Power	The input power of the client signal.	dBm	-33 to 6, step 0.1	
Client Output Power	The output power of the client signal.	dBm	-16 to 13, step 0.1	
Rx Channel Input Power	The input power of the received WDM signal.	dBm	-54 to 13, step 0.1	
WDM Transmitted Output Power	The output power at the WDM Tx port. This is measure after VOA.	dBm	-20 to 5, step 0.1	
Unit Temperature	The temperature of the Transponder measured off the PCB board	^{0}C	0 to 100, step 0.1	
Tx OCh Laser Bias Current	The Bias current being applied to the WDM laser	mA	0 to 150, step 0.1	
Client Laser Bias Current	The Bias current being applied to the Client laser	mA	0 to 150, step 0.1	
Tx OCh Laser Temperature Deviation	The Temperature deviation of the WDM laser	^{0}C	-9 to 9, step size 0.01	

2.5G SR Transponder (Card Type 15 Variants 1,3 & 4) Primary Mode				
PRIMITIVE	**DESCRIPTION**	**UNITS**	**ALLOWABLE RANGE**	**VIEWABLE RANGE**
Rx Channel Input Power	The input power of the received WDM signal.	dBm	-54 to 13, step 0.1	
WDM Laser Output Power	The output power of transmitted WDM Laser. Not the same as the output power at the WDM Tx port. Measured before the VOA.	dBm	-10 to 13, step 0.1	
Unit Temperature	The temperature of the Transponder measured off the PCB board	^{0}C	0 to 100, step 0.1	

Power Monitor Unit/Signal Quality Monitor (Card Type 5 Variant 1)				
Unit Temperature	The temperature of the PMU measured off the PCB board	^{0}C	0 to 100, step 0.1	

(Dual/Single) Stage Amplifier (Card Type 1, Variants 1, 2, 3, 4, 9, 10)				
PRIMITIVE	**DESCRIPTION**	**UNITS**	**ALLOWABLE RANGE**	**VIEWABLE RANGE**
First Stage Amp Input Power	The input power of the First Stage Amplifier.	dBm	-327.67 to 327.67, step 0.01	-32.767 to 15
First Stage Amp Output Power	The output power of the First Stage Amplifier.	dBm	-32.767 to 32.767, step 0.001	0 to 22
Second Stage Amp Input Power	The input power of the Second Stage Amplifier.	dBm	-327.67 to 327.67, step 0.01	-32.767 to 15
Second Stage Amp Output Power	The output power of the Second Stage Amplifier.	dBm	-32.767 to 32.767, step 0.001	0 to 22
First Stage Amp Laser 1 Drive Current	The drive current of Laser 1 on the First Stage Amplifier.	mA	0 to 150, step 1	
First Stage Amp Laser 2 Drive Current	The drive current of Laser 2 on the First Stage Amplifier.	mA	0 to 150, step 1	
First Stage Amp Laser 3 Drive Current	The drive current of Laser 3 on the First Stage Amplifier.	mA	0 to 150, step 1	
First Stage Amp Laser 4 Drive Current	The drive current of Laser 4 on the First Stage Amplifier.	mA	0 to 150, step 1	
Second Stage Amp Laser 5 Drive	The drive current of Laser 5 on the Second Stage Amplifier.	mA	0 to 150, step 1	

(Dual/Single) Stage Amplifier (Card Type 1, Variants 1, 2, 3, 4, 9, 10)				
PRIMITIVE	**DESCRIPTION**	**UNITS**	**ALLOWABLE RANGE**	**VIEWABLE RANGE**
Current				
Second Stage Amp Laser 6 Drive Current	The drive current of Laser 6 on the Second Stage Amplifier.	mA	0 to 150, step 1	
Second Stage Amp Laser 7 Drive Current	The drive current of Laser 7 on the Second Stage Amplifier.	mA	0 to 150, step 1	
Second Stage Amp Laser 8 Drive Current	The drive current of Laser 8 on the Second Stage Amplifier.	mA	0 to 150, step 1	
Unit Temperature	The temperature of the XSA measured off the PCB board	^{0}C	0 to 100, step 0.1	

Raman Amplifier Unit (Card Type 2 Variants 3 & 5)				
PRIMITIVE	**DESCRIPTION**	**UNITS**	**ALLOWABLE RANGE**	**VIEWABLE RANGE**
Wavelength 1 Total Power	The total power of Wavelength 1.	mW	0 to 655, step 1	0 to 350
Wavelength 2 Total Power	The total power of Wavelength 2.	mW	0 to 655, step 1	0 to 350
Wavelength 3 Total Power	The total power of Wavelength 3.	mW	0 to 655, step 1	0 to 350
Band Total Power	The total power in the band.	mW	0 to 655, step 1	
Wavelength 1 Laser 1 Drive Current	The drive current of Laser 1 Wavelength 1.	mA	0 to 200, step 1	
Wavelength 1 Laser 2 Drive Current	The drive current of Laser 2 Wavelength 1.	mA	0 to 200, step 1	
Wavelength 3 Laser 1 Drive Current	The drive current of Laser 1 Wavelength 3.	mA	0 to 200, step 1	
Wavelength 3 Laser 2 Drive Current	The drive current of Laser 2 Wavelength 3.	mA	0 to 200, step 1	
Unit Temperature	The temperature of the RAU measured off the PCB board	^{0}C	0 to 100, step 0.1	

TDM multiplexer Unit (Card Type 9 Variant 2) (Note 4)				
PRIMITIVE	**DESCRIPTION**	**UNITS**	**ALLOWABLE RANGE**	**VIEWABLE RANGE**
Client Input Port 1	The input power of the Client 1 port.	dBm	-21 to -8, step 0.1	
Client Input Port 2	The input power of the Client 2 port.	dBm	-21 to -8, step 0.1	
Client Input Port 3	The input power of the Client 3 port.	dBm	-21 to -8, step 0.1	
Client Input Port 4	The input power of the Client 4 port.	dBm	-21 to -8, step 0.1	
Client Output Port 1	The output power of the Client 1 port.	dBm	-16 to -8, step 0.1	
Client Output Port 2	The output power of the Client 2 port.	dBm	-16 to -8, step 0.1	
Client Output Port 3	The output power of the Client 3 port.	dBm	-16 to -8, step 0.1	
Client Output Port 4	The output power of the Client 4 port.	dBm	-16 to -8, step 0.1	
Aggregate Input Port	The input power of the Aggregate port.	dBm	-18 to 0, step 0.1	
Aggregate Output Port	The output power of the Aggregate port.	dBm	-6 to 0, step 0.1	

GbE Multiplexer Unit (Card Type 13 Variants 0 & 1)				
PRIMITIVE	**DESCRIPTION**	**UNITS**	**ALLOWABLE RANGE**	**VIEWABLE RANGE**
Client Input Port 1	The input power of the Client 1 port.	dBm	-19 to 6, step 0.1	
Client Input Port 2	The input power of the Client 2 port.	dBm	-19 to 6, step 0.1	
Client Output Port 1	The output power of the Client 1 port.	dBm	-19 to 6, step 0.1	
Client Output Port 2	The output power of the Client 2 port.	dBm	-19 to 6, step 0.1	
Aggregate Input Port	The input power of the Aggregate port.	dBm	-18 to 4, step 0.1	
Aggregate Output Port	The output power of the Aggregate port.	dBm	-19 to 6, step 0.1	

(Dual/Single) Stage Amplifier (Card Type 18, Variants 1 to 5)				
PRIMITIVE	**DESCRIPTION**	**UNITS**	**ALLOWABLE RANGE**	**VIEWABLE RANGE**
First Stage Amp Input Power	The input power of the First Stage Amplifier.	dBm	-327.67 to 327.67, step 0.01	-32.767 to 15
First Stage Amp Output Power	The output power of the First Stage Amplifier.	dBm	-32.767 to 32.767, step 0.001	0 to 22
Second Stage Amp Input Power	The input power of the Second Stage Amplifier.	dBm	-327.67 to 327.67, step 0.01	-32.767 to 15
Second Stage Amp Output Power	The output power of the Second Stage Amplifier.	dBm	-32.767 to 32.767, step 0.001	0 to 22
First Stage Amp Laser 1 Drive Power	The drive Power of Laser 1 on the First Stage Amplifier.	mW	0 to 655, step 0.01	
First Stage Amp Laser 2 Drive Power	The drive Power of Laser 2 on the First Stage Amplifier.	mW	0 to 655, step 0.01	
First Stage Amp Laser 3 Drive Power	The drive Power of Laser 3 on the First Stage Amplifier.	mW	0 to 655, step 0.01	
First Stage Amp Laser 4 Drive Power	The drive Power of Laser 4 on the First Stage Amplifier.	mW	0 to 655, step 0.01	
Second Stage Amp Laser 5 Drive Power	The drive Power of Laser 5 on the Second Stage Amplifier.	mW	0 to 655, step 0.01	
Second Stage Amp Laser 6 Drive Power	The drive Power of Laser 6 on the Second Stage Amplifier.	mW	0 to 655, step 0.01	
Second Stage Amp Laser 7 Drive Power	The drive Power of Laser 7 on the Second Stage Amplifier.	mW	0 to 655, step 0.01	
Second Stage Amp Laser 8 Drive Power	The drive Power of Laser 8 on the Second Stage Amplifier.	mW	0 to 655, step 0.01	
Unit Temperature	The temperature of the XSA measured off the PCB board	^{0}C	0 to 100, step 0.1	

Metro Single Stage Amplifier (Card Type 18, Variants 5)				
PRIMITIVE	**DESCRIPTION**	**UNITS**	**ALLOWABLE RANGE**	**VIEWABLE RANGE**
First Stage Amp Input Power	The input power of the First Stage Amplifier (ASE & Channels).	dBm	-327.67 to 327.67, step 0.01	-37 to 15
First Stage Amp Output Power	The output power of the First Stage Amplifier.	dBm	-32.767 to 32.767, step 0.001	0 to 22
First Stage Amp Laser 1 Drive Current (Only valid in ARR config)	The drive current of Laser 1 on the First Stage Amplifier.	mA	0 to 1.5, step 1	
First Stage Amp Laser 2 Drive Current (Only valid in ARR config)	The drive current of Laser 2 on the First Stage Amplifier.	mA	0 to 1.5, step 1	
First Stage Amp Laser 1 Drive Power	The drive Power of Laser 1 on the First Stage Amplifier.	mW	0 to 655, step 0.01	
First Stage Amp Laser 2 Drive Power	The drive Power of Laser 2 on the First Stage Amplifier.	mW	0 to 655, step 0.01	
ASE Peak Power (Only valid in ARR config)	The ASE power level at the amplifier input side.	dBm	-30 to 10, step 0.1	
Unit Temperature	The temperature of the XSA measured off the PCB board	^0C	0 to 100, step 0.1	

OLU-8 (Card Type 22 Variant 1)				
PRIMITIVE	**DESCRIPTION**	**UNITS**	**ALLOWABLE RANGE**	**VIEWABLE RANGE**
Client Input Power Instantaneous Port x (x:1..8)	The input power of the Client x port.	dBm	-15 to 10, step 0.1	
Client Output Power Instantaneous Port x (x:1..8)	The Output power of the Client x port.	dBm	-20 to 5, step 0.1	
WDM Output Power Instantaneous Port x (x:1..8)	The Output power of the WDM x port.	dBm	-20 to 5, step 0.1	
Unit Temperature	The temperature of the OSU measured off the top PCB board	^0C	0 to 100, step 0.1	

CXU (Card Type 4 Variant 1)				
PRIMITIVE	**DESCRIPTION**	**UNITS**	**ALLOWABLE RANGE**	**VIEWABLE RANGE**
Unit Temperature	The temperature of the CXU measured off the top PCB board	^{0}C	0 to 100, step 0.1	

Channel Equaliser (Card Type 11 Variant 1)				
PRIMITIVE	**DESCRIPTION**	**UNITS**	**ALLOWABLE RANGE**	**VIEWABLE RANGE**
Unit Temperature	The temperature of the Channel Equaliser measured off the top PCB board	^{0}C	0 to 100, step 0.1	

CCU (Card Type 19 Variant 1)				
PRIMITIVE	**DESCRIPTION**	**UNITS**	**ALLOWABLE RANGE**	**VIEWABLE RANGE**
Unit Temperature	The temperature of the CCU measured off the top PCB board	^{0}C	0 to 100, step 0.1	

Notes: -

1 The table contains all the parameters from all the cards.

2 The rationale behind displaying the primitives shown is to aid diagnostics re. the following subset of available monitors:

- External NE and inter-card interfaces i.e. amplifier input and output power, and OSC laser output power
- Laser ageing i.e. laser bias current

Note: It is acceptable for this to be displayed either as an actual current or as a (dimensionless) digital register value corresponding to parameters in the control loop used to set the current.

- Laser temperature deviation

3 On the 10G Transponders:

- Analogue monitoring values are available regardless of whether or not a cross-connection has been configured.
- Laser bias current (OCh): this is not directly measured, but is calculated from the PWM mark / space ratio
- Laser parameters (i.e. bias current, and temperature deviation).
- Laser temperature deviation on the client side is not applicable since the client side laser is not cooled
- Client output power.

4 On the TDM Muxs and the 2.5G/10G Transponders:

- Analogue monitoring values are available regardless of whether or not a cross-connection has been configured.
- Laser bias current (OCh): this is not directly measured, but is calculated from the PWM mark / space ratio
- Laser parameters (i.e. bias current, and temperature deviation).
- Laser temperature deviation on the client side is not applicable since the client side laser is not cooled
- Client output power.

This analogue monitor is know to be inaccurate at very low powers or high temperatures

11.9.6 Historic Analogue Storage

In addition to the instantaneous display and operator-reset facilities, the operator is able to request historical records in a similar way to that done for traffic performance monitoring.

- The situation for analogue monitoring is only analogous, not identical, to traffic performance monitoring.
- The analogue monitoring values stored are the min and max values (i.e. tidemarks) in a given recording period (c.f. G.774.01 ‘General Aspects of digital transmission systems, SDH performance monitoring for the network element view’ ref. 0.6.2).
- The records kept for storing the analogue monitoring values are totally separate from the records for storing the traffic performance monitoring.

The Multihaul 3000 NE: -

- For each card the NE maintains min and max values (tidemarks) for all analogue monitored entities (ME) on the card as follows:
    - Current 15min record and 16 recent 15min records,
    - Current 24hr record and 1 recent 24hr record,
    - All Time' record.
- The min and max values for a card's current 15min record are written to at the time that the operator requests the record; all current 15min records are marked to the operator as 'incomplete'.
- The min and max values for a card's recent 15min record are autonomously written to at the end of the previous 15-minute period.

- If the cards recent 15min record can't be collected by the NEC because the card; has failed, is missing, is the wrong card type or is busy for what ever reason, the 15min record is marked as 'missing'. The data reported in the message is set to 0 in this case.

- The min and / or max values for a card's current 24hr record are autonomously overwritten at the end of each previous 15-minute period as necessary; all current 24hr records are marked to the operator as 'incomplete'.

- The min and / or max values for a card's recent 24hr record are autonomously written to at the end of the final 15-minute period in the previous 24-hour period as necessary.

- The 24hr record is marked as 'incomplete' if any of the associated 15min records are marked as 'incomplete' or 'missing'.

- The min and / or max values in a card's 'All Time' record are:

Autonomously overwritten at the end of each previous 15-minute period as necessary.

In addition they are overwritten when:

The card is manually reset by the operator, or

A request is sent from the LCT to reset Analogue Parameters or reset All Analogue Parameters on the card.

The newly written values (if any) in the 'All Time' record is separately time stamped.

- The NE provides card level 'start / stop' functionality for the recording of the min and max values, with the default being 'start' i.e. the default behaviour is that the data collection is started automatically when the card is equipped and inserted. If the operator issues a 'stop' command during the lifetime of a record it is marked to the operator as 'incomplete'.

- The NE provides the operator with the ability to clear all the recent records on a selected card (i.e. delete the contents of all the recent records on the card).

- The Analogue monitoring data is used the same 24-hour end time as the Pre/Post-FEC data.

NMS functionality is outside the scope of this specification. However the following NMS functionality is suggested:

- As well as being able to request individual records the MV36 operator is able to regularly poll for card level reports.

- Suitable display of the analogue values (preferably graphical) over appropriate periods e.g. days, weeks or months

- Trend analysis

11.10 Client Ingress/Egress 8B/10B code violation monitoring and logging

8B/10B code violation error counters are provided for all client signals that are 8B/10B coded, in accordance to IEEE 802.3 section 36.2. This feature applies to any unit that is able to carry such data traffics (Ethernet, DVB-ASI, Fibre Channel - Payload types 32, 31, 30, 25, 24 and a payload type 33 (Renamed - 270Mbit/s (DVB-ASI))

Performance error monitoring based on 8B/10B violations is required for both client incoming (Ingress) and client outgoing signals (Egress).

Two types of error monitoring based on 8B/10B code violations are provided:

- Raw 8B/10B violation counters
- ITU error counters (SES, BBE, ES).

11.10.1 Raw 8B/10B Violation Counters

The system provides the following error parameters:

- **8B/10B code violation counter**: number of 8B/10B code violations that are detected during the observation period.
- **8B/10B code violation rate**: the ratio between 8B/10B code violations detected over the observation period and the total number of bits received in the same observation period. The ratio to be presented in the format x.y x10^{-z}.

$$\text{BER}=\frac{\text{Code\_Violation\_count}}{\text{Period\_in \_secs} * \text{Bit\_rate\_in\_bits\_per\_sec}}$$

Where: -

Payload Type	Bit Rate [bits/sec]
GbE	1.25E9
2G FC	2.125E9
1G FC	1.0625E9
DVB-ASI	270E6

The observation period is a time frame that elapses between the start of the granularity period and the time in which the counter value is retrieved.

The granularity period is selectable by the operator among 15minutes, 1 hour or 24hours options.

This choice impacts not only the reset period of the current registers, but also the retention period. Assumed that 24 recent registers are requested, the following historical collection is provided:

- 15Min Registers 24 x 15min Recent Register (6 hours monitoring)
- 1Hr Registers -> 24 x 1 Hr Recent Register (1 Day monitoring)
- 24Hr Registers-> 24 x 24Hr Recent Register (24 days monitoring)

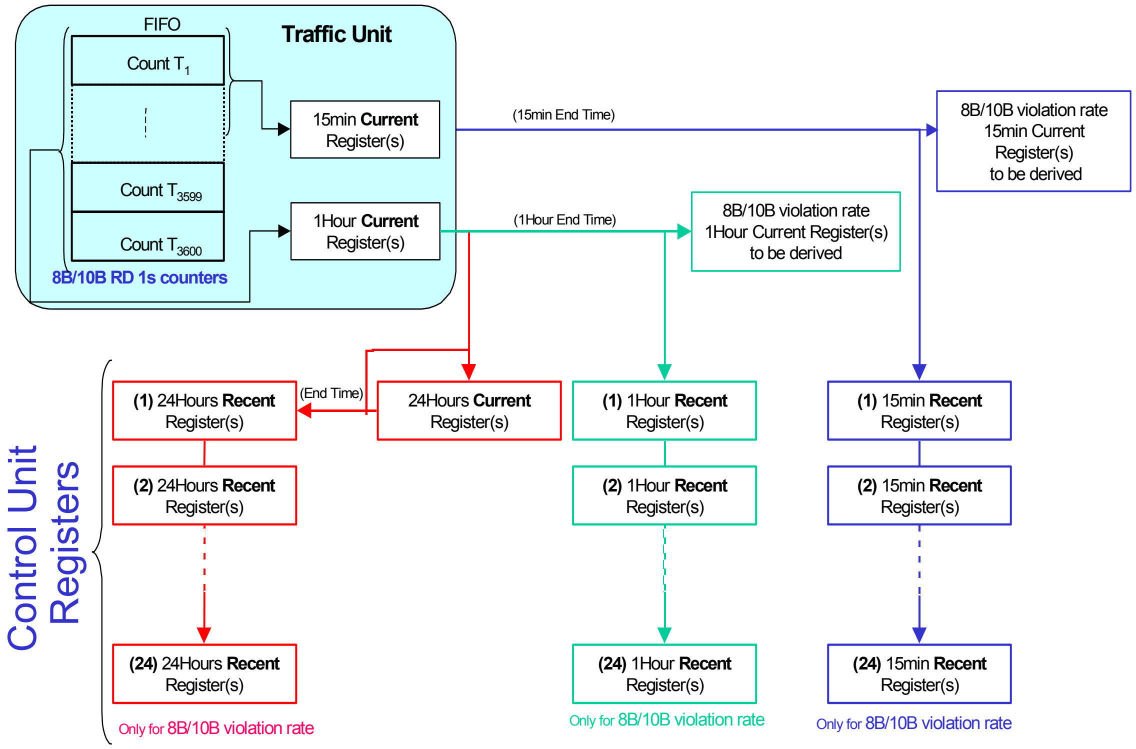
Register set periods are configurable on a per port basis. If the operator modifies the register set at run-time, the old historic counters are reset and LCT displays a warning box to the operator. In particular, for each monitor point (ingress and egress of each) client port the NE maintains:

- 1 current register (Stored on card) for 8B/10B code violation counter.
- 1 current register (derived from raw 8B/10B RD error counts) and 24 recent registers (Stored on NEC) for performance monitoring of 8B/10B code violation rate.

No tidemarks are foreseen for 8B/10B violation error parameters. It is tolerated that the 32-bit registers holding the raw counters within NEC may saturate for high BER values. It would be desirable that a suspect indication is provided when overflow occurs.

Figure 11-1below shows some implementation aspects for the provision of the 8B/10B RD violation counters and derived rate. It shows that a FIFO with 3600 entries it stored within the units, providing the 8B/10B RD error counts over selectable time frames. Error rates current values and recent records are derived from these entries and stored on NEC.

Figure 11-1: B/10B Historic Logging



11.11 WDM/Aggregate Input Power Thresholds

The optical power received by the following units at the WDM input port interfaces continually monitored by hardware:

- 2.5Gbit/s ER Transponding Channel Unit (Single Path) Termination or Link (Bi-directional)
- 2.5Gbit/s SR Transponding Channel Unit (Single Path) Termination or Link (Bi-directional) (Card Type 15)
- 10Gbit/s NRZ Transponding Channel Unit (Single Path) Termination or Link (Bi-directional)
- 10Gbit/s RZ Transponding Channel Unit (Single Path) Termination or Link (Bi-directional)

A value allocated to the on-card microprocessor and the unit firmware compares this value against either operator configurable threshold (For Card Type 15 Variant 3) or a non-operator configurable threshold for all other units. If the Input power falls below or exceeds the configured threshold, then a ‘Power Low’ fault is indicated to the Event Handling Subsystem for the affected WDM/Aggregate input.

The WDM Input thresholds are defined in Table 11-18 below on a per-WDM/Aggregate input port basis.

Table 11-18: WDM Input Power Low Threshold Configuration for Transponding Channel Units

Primitive	Units	Threshold value	Failure Criterion
WDM Input Power Low	dBm	-16 dBm	<Threshold
WDM Input Power Low	dBm	-24dBm	<Threshold
WDM Input Power Low	dBm	-24dBm	<Threshold
WDM Input Power Low	dBm	-22dBm	<Threshold
WDM Input Power Low	dBm	-19dBm	<Threshold
WDM Input Power Low	dBm		<Threshold

11.12 G709 Transponder Monitoring

The following Figures detail the monitoring required on the different transponder options in Multihaul 3000. For full details of the use of each of the bytes see ITU-T G709.

CAUTION!

In this release the ODU LCK signal is not supported by the Multihaul product. If this signal is received from a third party equipment the following consequences are observed.

ODU LCK Received on CTP Transponder client side.

On receiving ODU LCK a CTP Transponder will raise the following alarms:

- FCIF ODU Ingress monitor

On far end TTP Transponder the following alarms are raised:

- DEG, FCIF, PLM ODU Egress
- SSF RS Egress Mon

ODU LCK Received on CTP Transponder WDM side.

On receiving ODU LCK a CTP Transponder will raise the following alarms:

- DEG, FCIF, PLM ODU Ingress monitor

On far end TTP Transponder the following alarms are raised:

- DEG, FCIF, PLM ODU Egress
- SSF RS Egress Mon

Figure 11-3: Monitoring Required on Different Transponder Options

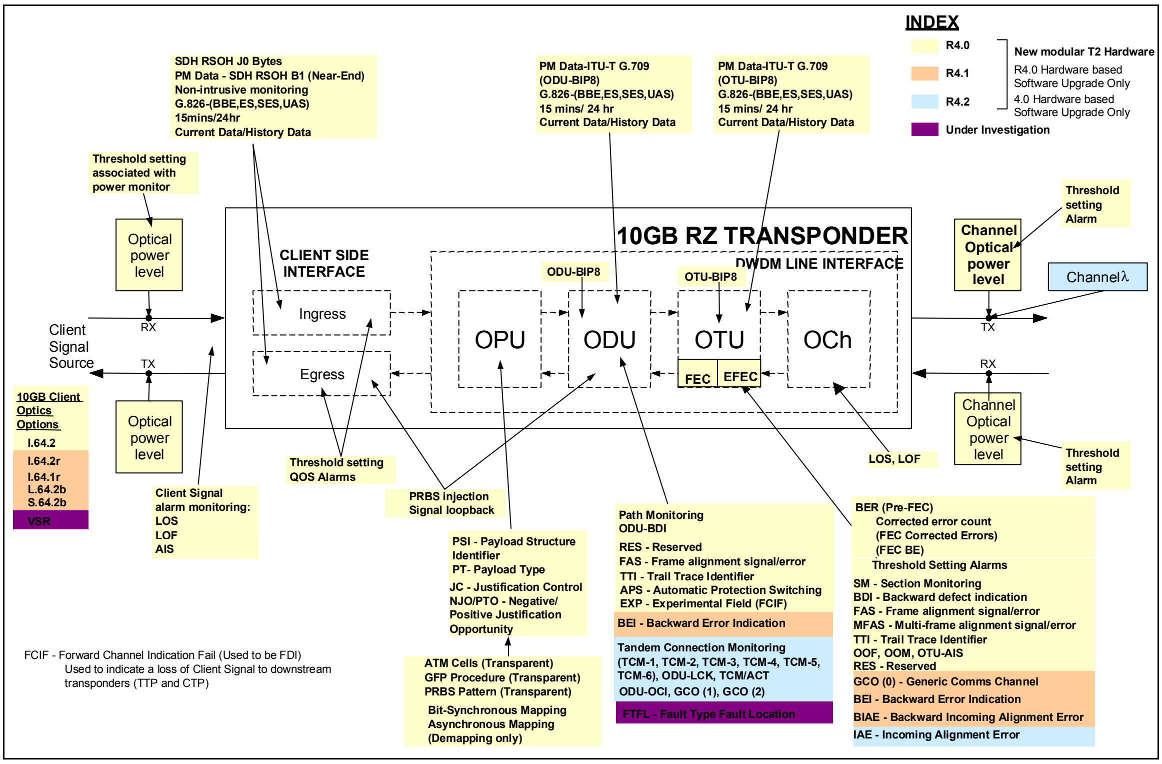


Figure 11-5: Monitoring Required on Different Transponder Options (Continued)

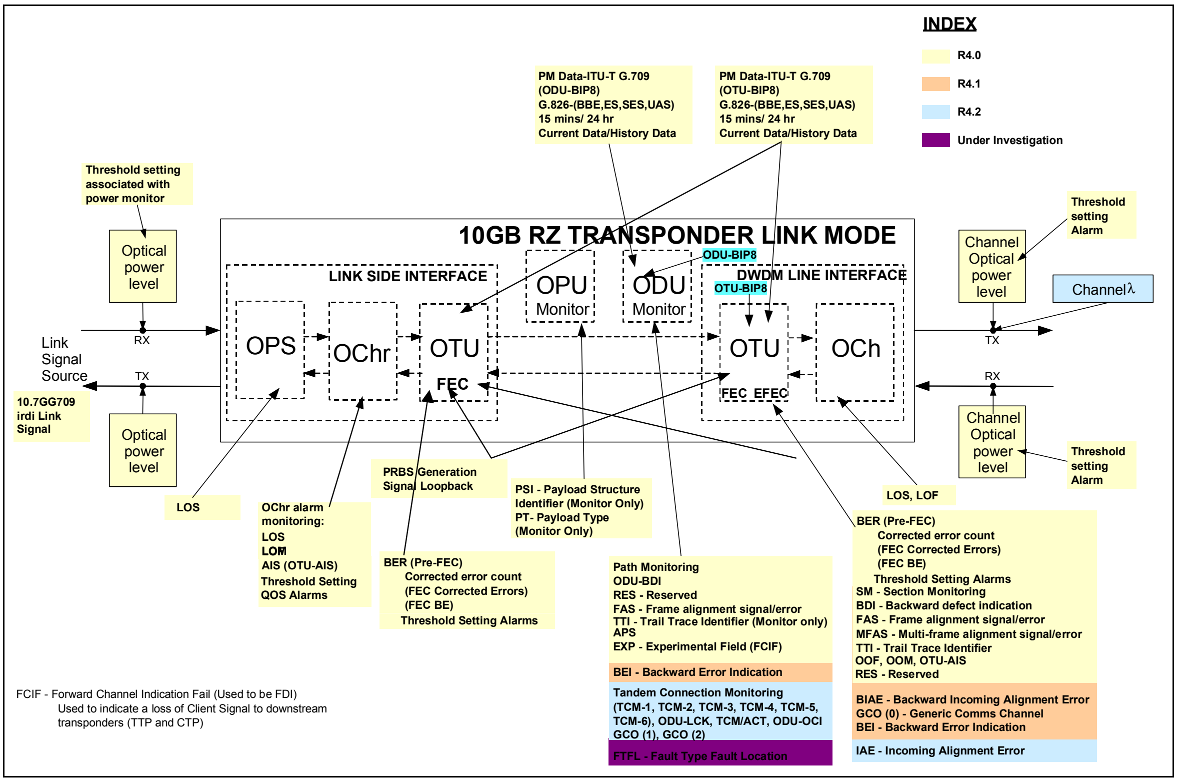


Figure 11-7: Monitoring Required on Different Transponder Options (Continued)

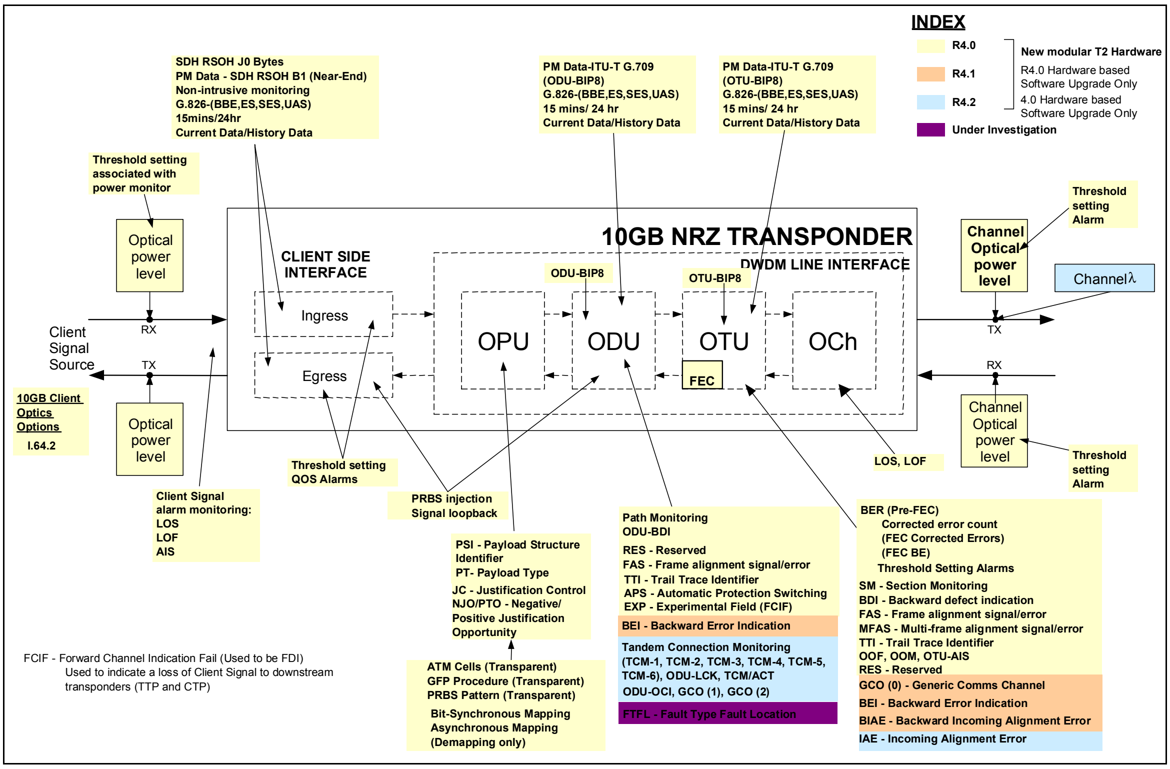


Figure 11-9: Monitoring Required on Different Transponder Options (Continued)

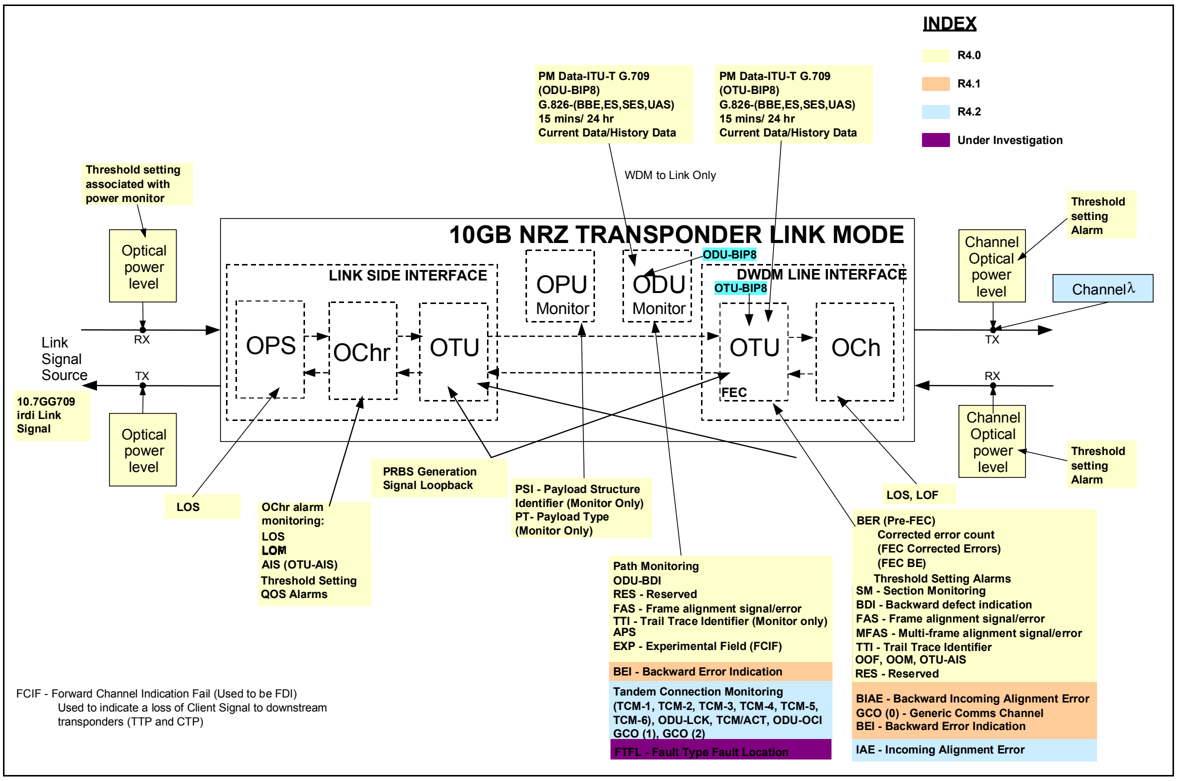


Figure 11-11: Monitoring Required on Different Transponder Options (Continued)

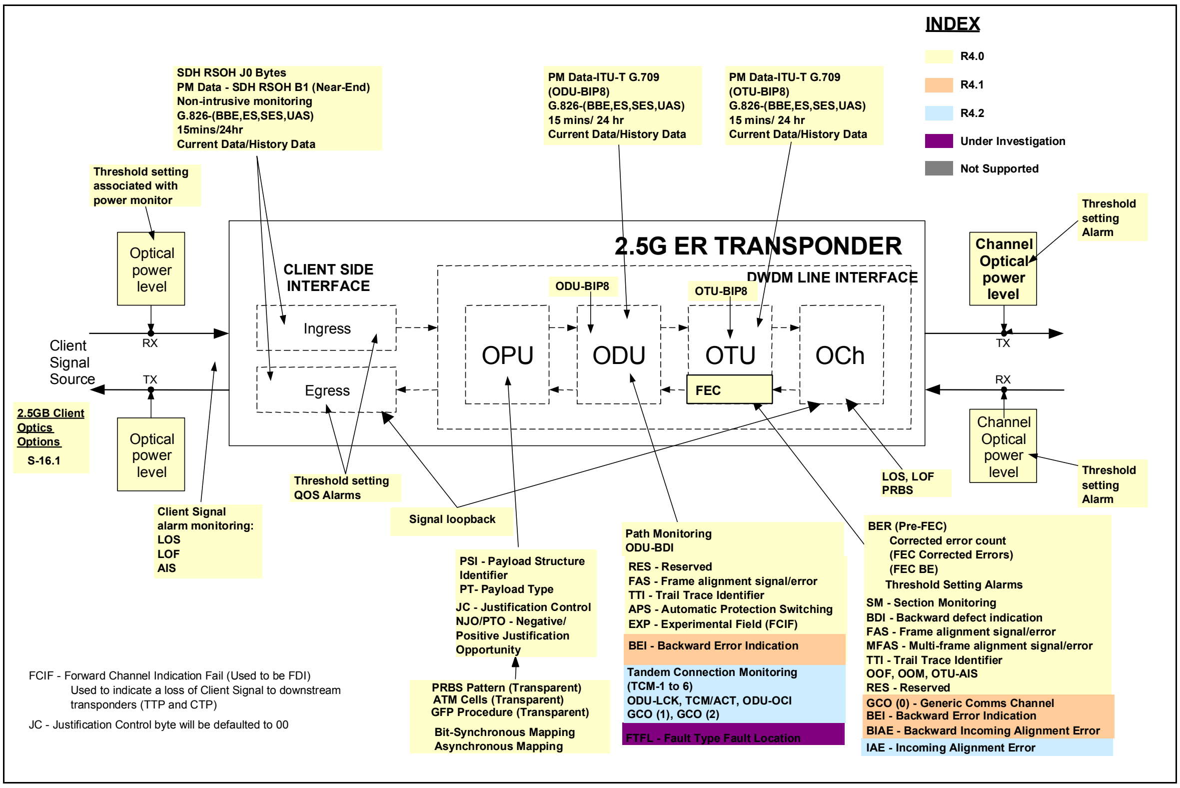


Figure 11-13: Monitoring Required on Different Transponder Options (Continued)

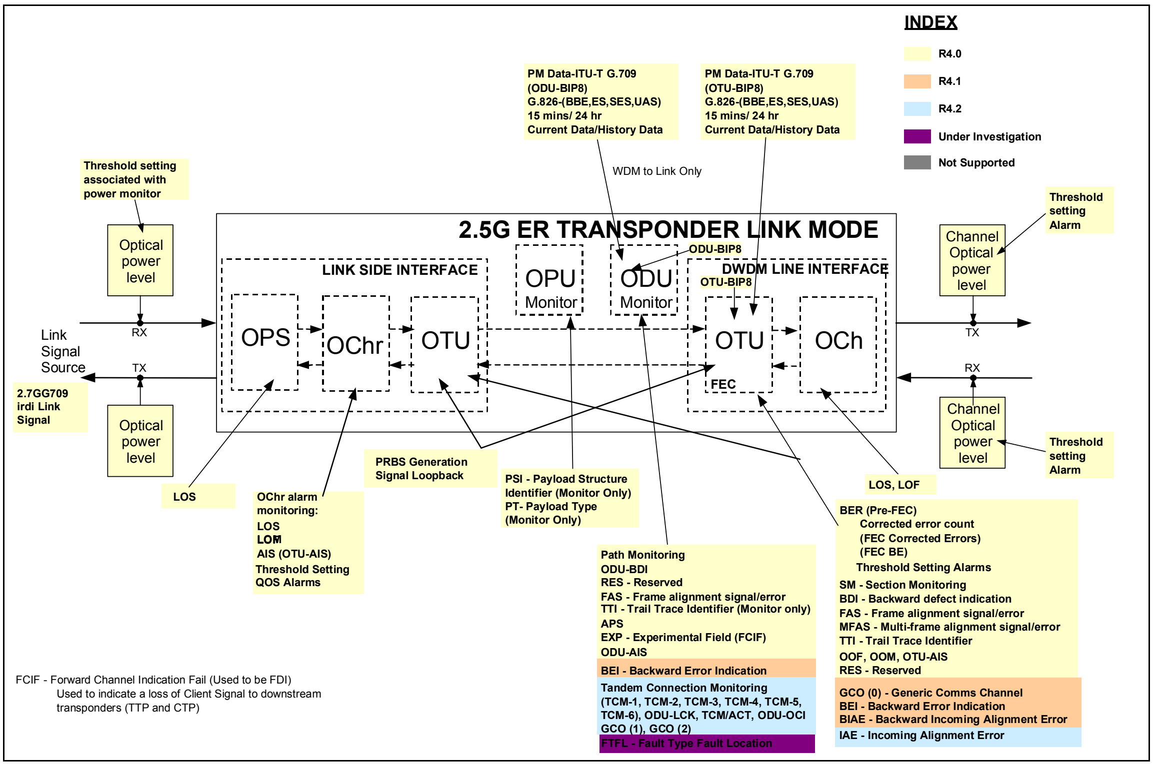


Figure 11-15: Monitoring Required on Different Transponder Options (Continued)

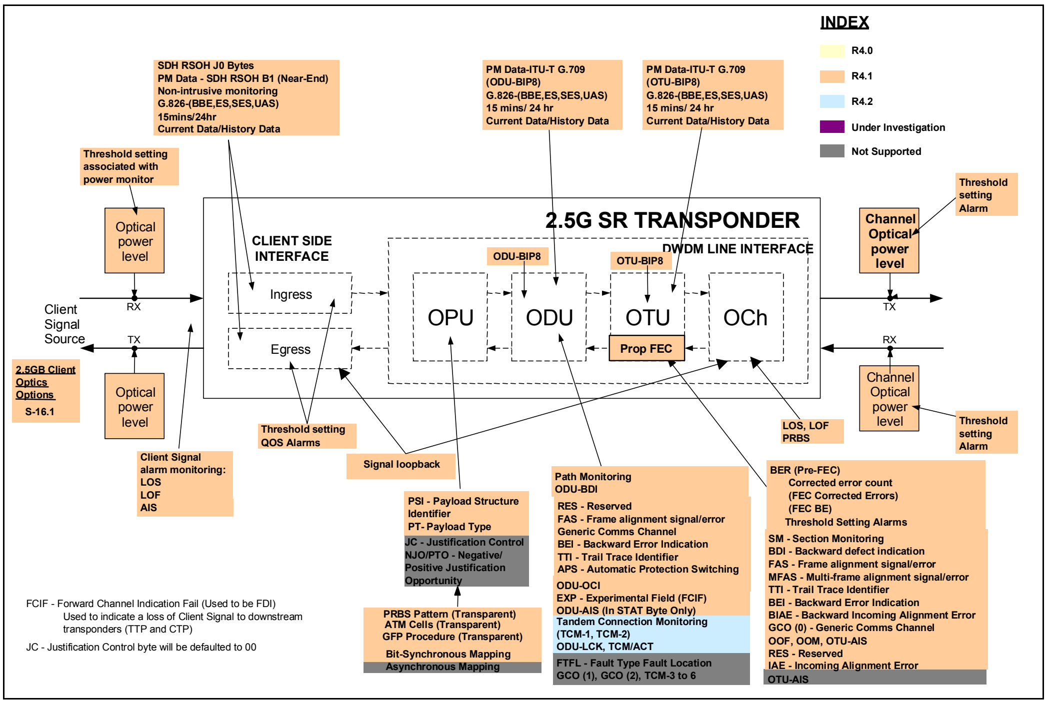


Figure 11-17: Monitoring Required on Different Transponder Options (Continued)

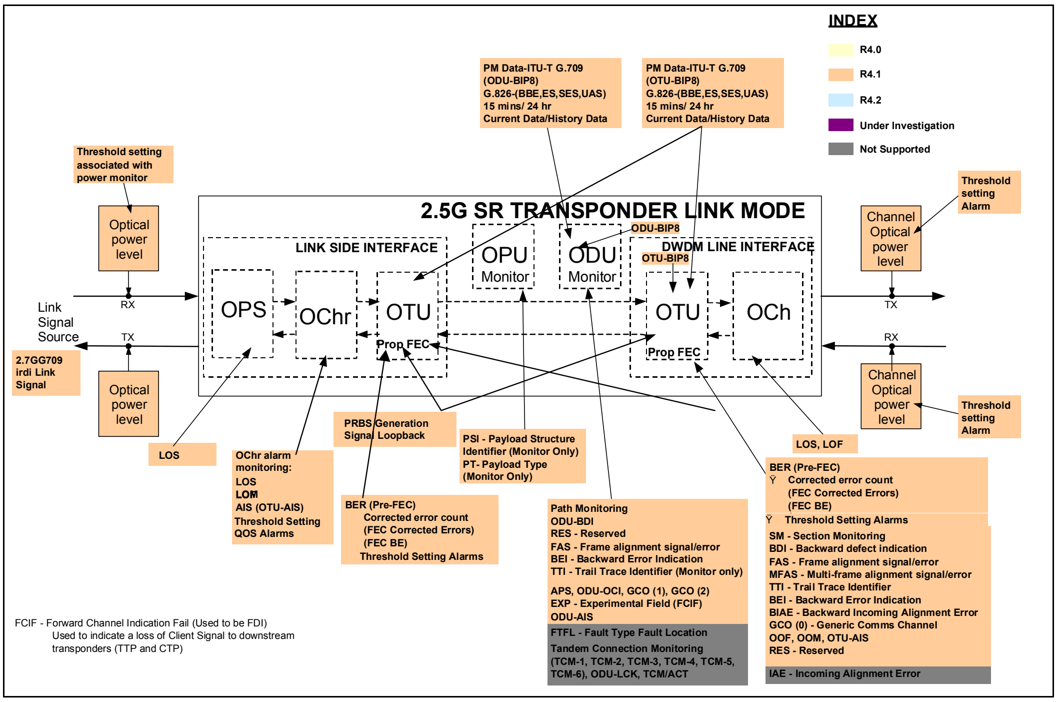


Figure 11-19: Monitoring Required on Different Transponder Options (Continued)

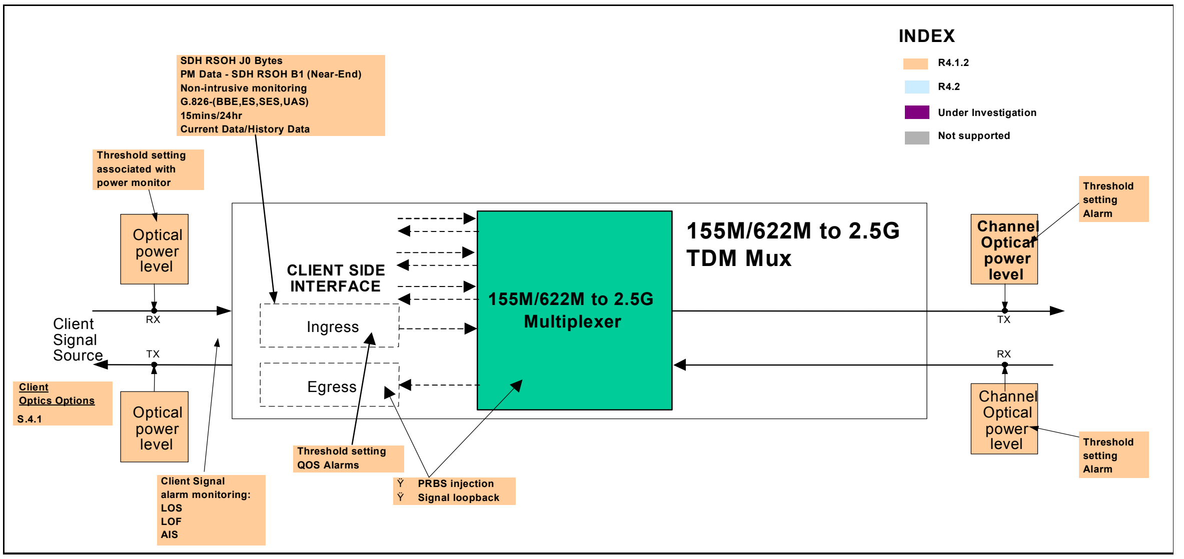
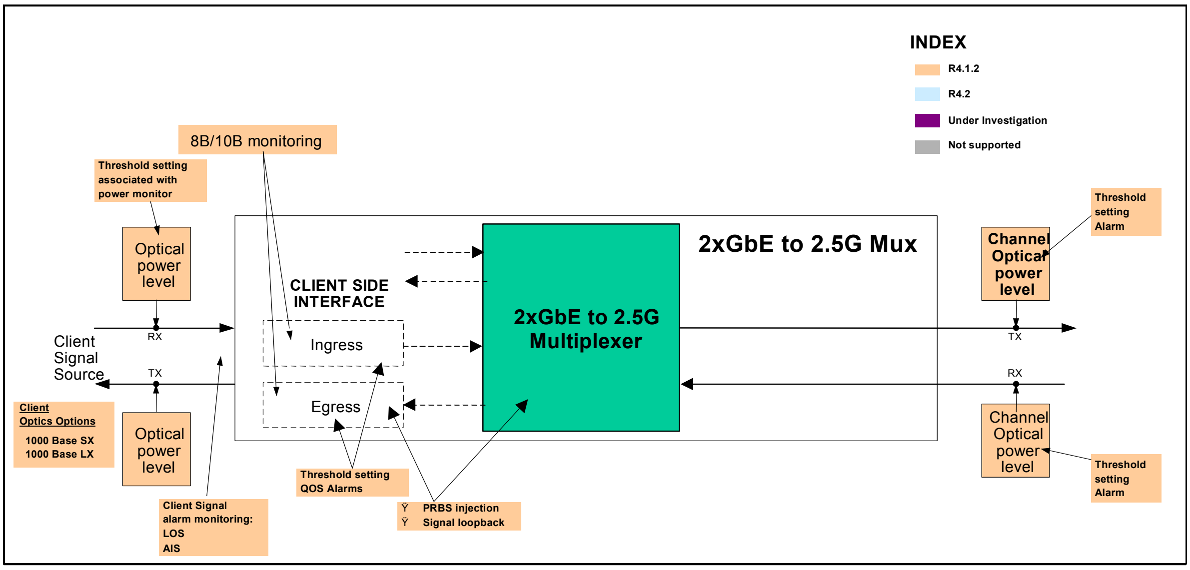


Figure 11-21: Monitoring Required on Different Transponder Options (Continued)



11.13 Manual Diagnostic Facilities

Manual diagnostic facilities are provided to assist in diagnosing equipment and network faults.

Manual diagnostic facilities refer to commands from LT/EM, which cause stimuli to be artificially generated by the Multihaul 3000, in order to provoke responses from other NEs for validation of the Photonics network. In general, these facilities are invoked whilst the Multihaul 3000 is operating normally i.e. correctly equipped, correctly powered and suitably configured.

The following manual diagnostic facilities are provided:

- Pattern Analyser/Generator
- Loop backs
- Remote Failure Injection using BDI.

Each diagnostic facility is independently operator-controlled (Enabled/Disabled) as detailed in the following sub-sections. Additionally, all manual diagnostics facilities are subject to an automatic diagnostics clear feature (providing that this feature is enabled).

A request to instigate monitoring or a test that would lead to traffic disruption causes the EM/LT to issue a suitably clear warning. The warning indicates the extent of the traffic disruption and requires operator confirmation that the selected action is in fact required.

11.13.1 Loop backs

In order to assist the operator in diagnosing faults within a Multihaul 3000, and in a network, a number of traffic path loopback facilities are available on the Transponding Channel Units. These loop backs can be used on their own or in conjunction with external test equipment to assist in the location of faults within the network.

The operator is able to configure the following loop backs on the ‘Transponding Channel Unit (Single Path) Termination (Bi-directional)’:

Client facing loopback (Near & Far): The ‘client input’ is looped back on itself at the electrical stage on the transponder. The operator will have one of the following options regarding the signal that is sent in the ‘WDM direction’:

- Payload Generic AIS (Near Only)
- Laser Off (WDM Tx)
- Transparent

Note: The affect on traffic of these options is none if the traffic is looped back, but on the other side of the loopback the traffic is replaced with either the incoming traffic, AIS or no signal.

Figure 11-23: Near End Client Loopback

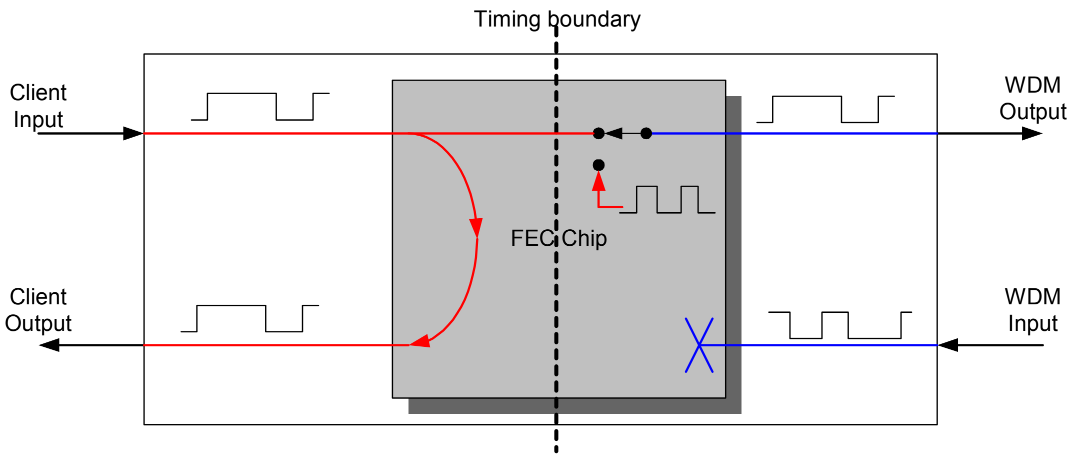
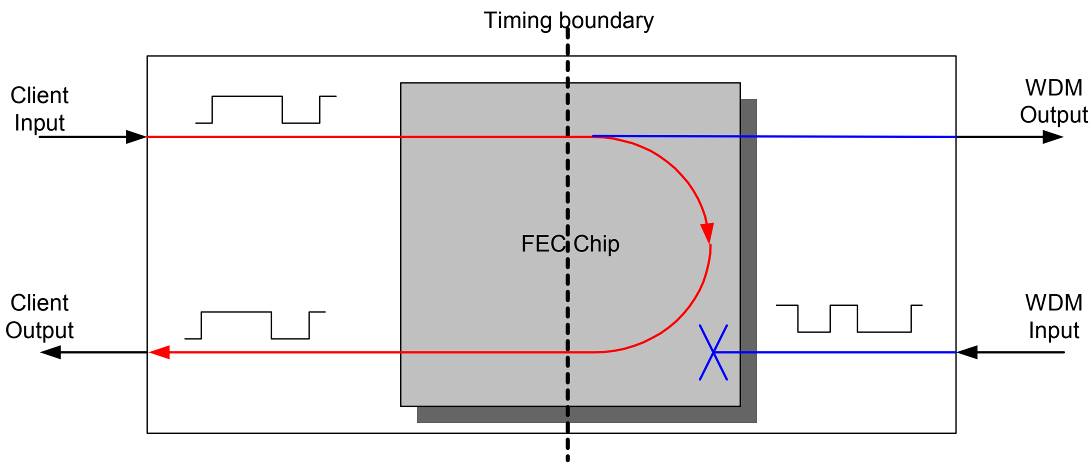


Figure 11-25: Far End Client Loopback



11.13.1.1 'WDM facing' loopback (Near & Far):

The 'WDM traffic' is looped back on itself at the electrical stage on the transponder. The operator has one of the following options regarding the signal that is sent in the 'client' direction:

- Generic AIS (Near Only)
- Transparent
- Laser Off (Client Tx)

Figure 11-27: Far End WDM Loopback

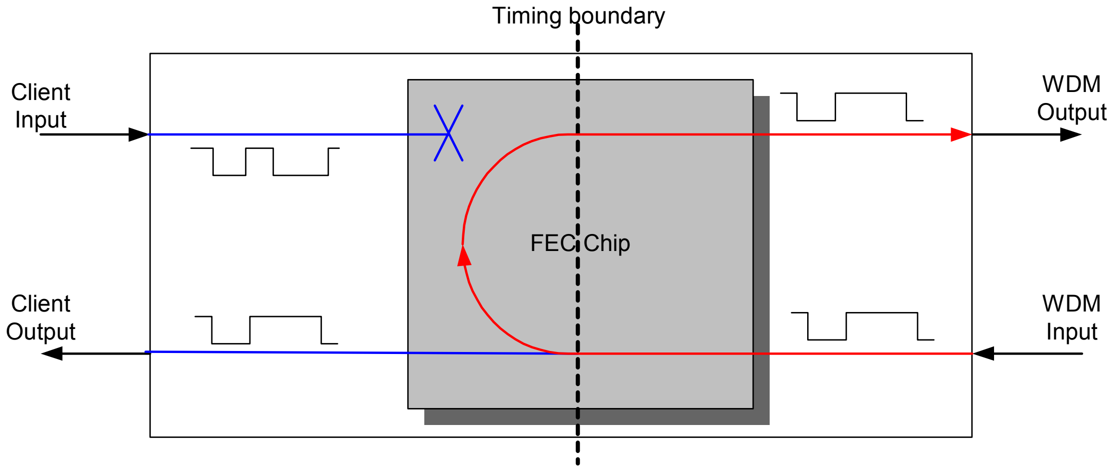
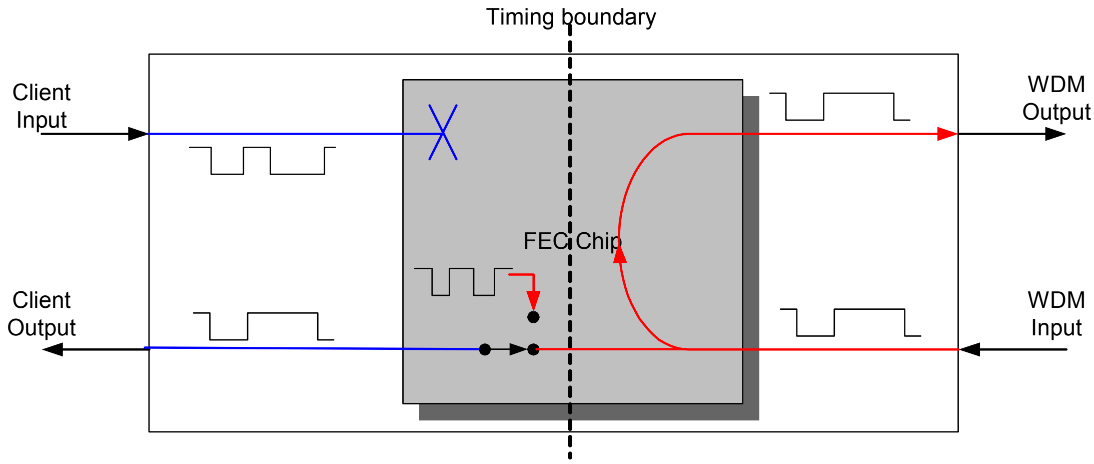


Figure 11-29: Near End WDM Loopback



11.14 Transponding Channel Unit (Single Path) Link (Bi-directional), G.709

The operator is able to configure the following loop backs on the ‘Transponding Channel Unit (Single Path) Link (Bi-directional)’:

11.14.1 Link Interface, facing loopback (Near):

The ‘client input’ is looped back on itself at the electrical stage on the transponder. The operator has one of the following options regarding the signal that is sent in the ‘WDM direction’:

- ODUk AIS with Equipped OTUk.
- Laser off (WDM Tx)
- Transparent

(ODUk AIS with Equipped OTUk means that the ODU layer of the G709 payload will have AIS added to it, but the OTU will remain unchanged).

11.14.2 ‘WDM facing’ loopback (Near):

The ‘WDM traffic’ is looped back on itself at the electrical stage on the transponder. The operator has one of the following options regarding the signal that is sent in the ‘client’ direction:

- ODUk AIS with Equipped OTUk.
- Laser Off (Link Tx)
- Transparent

The operator is not able to simultaneously configure a ‘Link facing’ loopback and a ‘WDM facing’ loopback on the same transponder

11.14.3 Card Groups

The operator should be able to select individual cards on which to apply loop backs. This is because diagnostics is by its nature primarily equipment based.

11.15 Transponder mode

On a TTP transponder it is possible to configure the OPU source or OPU sink for async or sync mapping (default sync).

Where the TTP or CTP mode is configurable it is not possible to change this mode once a cross connection is applied to the transponder.

Where the FEC mode is configurable it can be switched between:

- WDM Side - G709 mode
- Enhanced FEC (Default = Enhanced FEC).

FEC mode can be set to No FEC.

- For Transponders this only disables the FEC error correction processing on the RX side, G709 encoded FEC algorithm is applied at the TX side.
- For the 2.5G SR Transponder this disables both the FEC error correction processing on the RX side, and FEC algorithm at the TX side. Instead the FEC is packed out with zeros.

Note: If a card does not support Enhanced FEC it defaults to G709 FEC.

- Link Side - G709 Mode (Default = G709)

11.15.1 Regen group

The operator is not be able to simultaneously configure a 'Link facing' loopback and a 'WDM facing' loopback on the same transponder. The operator is not able to apply loopbacks individually on the each of the link mode transponder cards within the Regen group.

11.15.2 Data Security

The application and removal (by manual request or auto restoration) of a loopback does not cause traffic interruption or errors to any traffic being carried by the equipment that is not directly involved in the looped path.

In the case of the application and removal of a transparent loopback. It is important that the application and removal of such a loopback will not cause traffic errors to be introduced into the data transmitted in the forward direction. However it is accepted that a glitch may occur when the loopback is enabled / disabled.

11.15.3 BDI Injection

In-service monitoring of error performance of WDM Sections and Optical Channels is provided using the SOH and OCh-OH respectively.

Note: Long-term performance records (i.e. 15min and 24hrs records) etc. are produced only for the optical channels, not for the sections.

In order to test the performance monitoring functionality of other NEs in the network, it is possible to set the BDI indication in the transmitted OCh-OH at the overhead generation point.

You can then verify the correct functioning of the Performance Monitoring Subsystem of the remote NE by examining the Performance Records it generates.

Note: The setting of BDI does not introduce errors into the payload data, however since the Alarm Records and Performance Records for the associated sections and optical channels are invalidated, these diagnostics are deemed to be traffic affecting.

You are suitably warned that usage of these features affects performance reporting on the remote NE by the raising of a BDI alarm.

11.15.4 Operation

BDI injection can be configured on the Transponding Channel Unit on a per OCh basis using operator-selectable configurations for each injection point within equipment.

11.15.5 Termination Mode Transponding Channel Units

In the Ingress direction it is possible for the operator to configure BDI Injection in both the OTUk source and the ODUk source.

11.15.6 Link Mode Transponding Channel Units

In the ingress direction it is possible for the operator to configure BDI Injection in both the OTUk source and the ODUk source at the line interface. In the egress direction it is possible for the operator to configure BDI Injection in the OTUk source at the link interface.

11.15.7 OPU PRBS Injection

For test purposes it is possible for the operator to configure PRBS injection on a G.709 TTP Transponding Channel Unit on a per OCh basis. The operator selectable configurations for each OCh within and equipment are as shown in Table 11-19: Operation of PRBS Injection

Table 11-19: Operation of PRBS Injection

PRBS Injection
NO (default)
YES

PRBS is a 2,147,483,647-bit Pseudo Random Bit Sequence, which is inserted into the OPUk payload of the Och. When PRBS injection is selected the Payload type is changed to 40, meaning the bit sequence 1111 1110 (FE) is inserted into the PT of the PSI. When PRBS injection is turned off the Payload type is set back to what was configured before PRBS was injected.

11.15.7.1 TSE Detection (Analyser)

When the Payload type 40 is detected the transponder informs the NEC that PRBS is being detected, and disable the raising of the Payload Type Mismatch alarm. The Transponder starts to calculate a Test sequence errors (TSE) rate using the following formula and pass it to the NEC on request: -

TSE Rate = TSE Count/1Second

Test sequence errors (TSE) count are bit errors in the PRBS data stream extracted from the OPUk payload area and is detected whenever the PRBS detector is in lock and the received data bit does not match the expected value.

The NEC on receipt of the transponder receiving PRBS message: -

- Reject requests for J0 client traces, and return a non-compliance message
- Mark the current 15-minute and 24-hour performance records for the RS B1 Egress primitives as suspect intervals. Note this affects the RS B1 monitors on grouped Muxs Client Outputs, and only impact the RS B1 Egress Delivered count if it is the worker transponder that is receiving PRBS.
- Every second request the TSE rate from the transponder.
- On receipt of the TSE rate from the transponder the NEC passes it up to the MT.

Note: No 15min/24hrs data collection is required for TSE counters/rates.

When the transponder stops detecting a payload type of 40 it informs the NEC that PRBS is not being detected, and enable the raising of the Payload type Mismatch alarm. The transponder stops calculating the TSE rate.

The NEC on receipt of the transponder not receiving PRBS message: -

- Restart the current 15 minute and 24 hour performance records for the RS B1 primitives.
- Report J0 Client traces when requested if applicable to payload type.

11.16 Lifecycle of Manually Applied Diagnostics

11.16.1 Specific Diagnostics Enable

The sequence for enabling any manual diagnostic facility is as follows:

The operator chooses the particular manual diagnostic, which he wishes to enable

The operator is suitably warned of the full implications of his chosen action and the option is given to either continue the operation or cancel

In the event that the operator chooses to continue the operation, the NE provides, and the LT / EM displays, a compliance or non-compliance as appropriate

11.16.2 Specific Diagnostics Disable

The sequence for manually disabling any manual diagnostic facility is as follows:

The operator chooses the particular manual diagnostic, which he wishes to disable

The option is given to either continue the operation or cancel

In the event that the operator chooses to continue the operation, the NE provides, and the LT / EM displays, a compliance or non-compliance as appropriate

11.17 Global Diagnostics Disable

It is possible for the operator to disable all manual diagnostic facilities of a particular type (or any combination of types) as part of a single 'Diagnostics Disable' command at the HCI as shown in Table 11-20: Global Diagnostics Disable. The equipment disables all enabled diagnostics of the specified type(s) and report appropriate compliance(s).

Table 11-20: Global Diagnostics Disable

OPTIONS
Remove all Loopbacks
Stop all BDI injection
Remove all Pattern Generation/Analyser

On receipt of one of the commands shown the equipment disables all enabled diagnostics of the specified type and report successful compliance. The equipment issues an appropriate compliance / non-compliance message in response to each reset command.

The 'Global Diagnostics Disable' command disables all enabled diagnostics of the specified type(s); the disabling takes place immediately, and independent of the current setting of the 'Automatic Diagnostics Clear' function.

11.18 Automatic Diagnostics Clear

In addition to the direct operator control, an option is available to the operator such that diagnostics is automatically stopped (and a Resource Status Event sent to the LT / EM) after a set period of time.

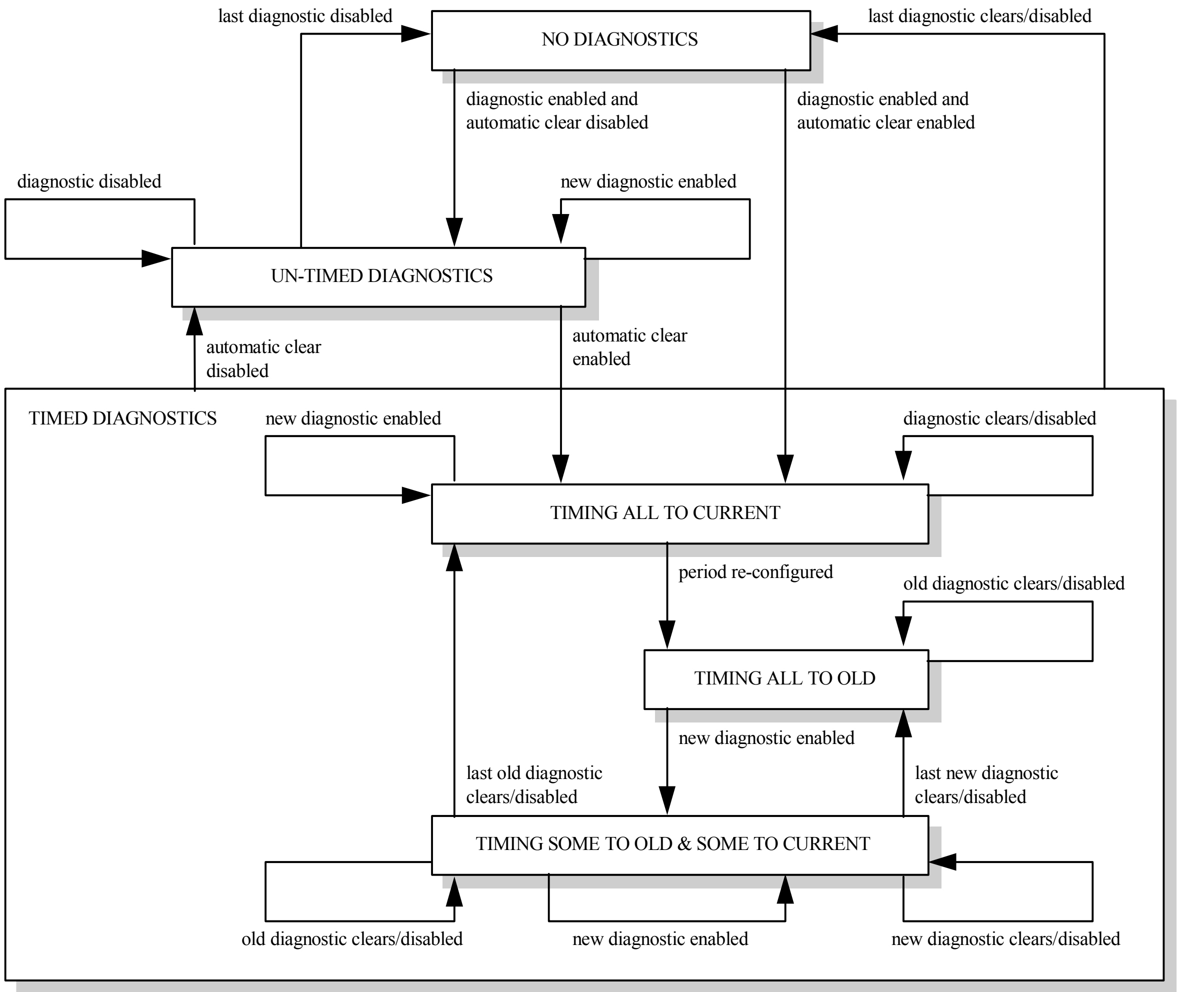
There is a single 'Automatic Diagnostics Clear' threshold applicable to all automatically clearing diagnostic functions within equipment. The 'clear' period applies to each diagnostic test separately; i.e. the period starts when the particular diagnostic is enabled.

It is possible for the operator to disable the 'Automatic Diagnostic Clear' to allow, for example, long-term diagnostics on optical channels without having to continually reconfigure them.

The 'Automatic Diagnostic Clear' function is configurable by the operator as follows:

- Automatic Diagnostics Clear:
- Enabled or Disabled (Default: Disabled)
- Clear Threshold:
- 5 minutes to 1 hour (Default: 10 minutes) in steps of 5 minutes
- When the 'Automatic Diagnostic Clear' is enabled, existing diagnostics clear after the currently configured clear period.
- When the 'Automatic Diagnostic Clear' is disabled, existing diagnostics will only clear when disabled manually by the operator.
- When the 'Automatic Diagnostic Clear' threshold is changed, existing diagnostics will continue to clear after the period, which was configured when they were enabled. Any diagnostics enabled following the change will clear after the newly configured period.

Figure 11-31: Lifecycle of manually applied diagnostics



11.19 Persistence of Diagnostic Configuration

Operator configured manual diagnostics is stored by the NE Controller. In the event of the power to the NE Controller being cycled, all manual diagnostics configuration are lost.

In the event of the power to any other type of unit being cycled, once re-initialisation of the particular unit has taken place then the NE Controller downloads the appropriate manual diagnostics configuration to the unit.

Note: During the period in which the unit is unavailable, the NE Controller continues to time-out any diagnostics which are supposed to be operative on that unit, only downloading those which have not timed-out.

In the event that a unit other than the NE Controller is manually reset then, on recovery, the unit exerts the same level of manual diagnostics that were in operation before the reset. The only exception to this is if a particular diagnostic has timed-out by the NE Controller during the period of the manual reset.

11.20 Unit Reset Command

It is possible to request the NE Controller to reset any unit other than itself (i.e. the NE Controller) or a PSU. Any unit receiving this command goes through a reset sequence and reconfiguration by the NE Controller including, if applicable, the reset of the comms.

The ‘Unit Reset’ command should only be used as a last resort in an attempt to clear a faulty unit. Loss of traffic data occurs during a card reset occurring in response to this command.