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(Part A)

DWDM Interconnect between UK Licensed Operators

OVERVIEW

Issue 1

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1.1Document History

Revision	Date of issue	Updated By	Description
Draft 1A	September 2000		First draft for comments
Draft 1B	September 2000	P. Kidd	2nd draft following review on 11.09.00
Draft 1C	September		3rd draft following review by correspondence
Issue 1.0	September		As agreed by correspondence

1.2 References

1. ITU-T G.911 – Parameters and calculation methodologies for reliability and availability of optical fibre.
2. ITU-T G.912 – Methodology for deriving fibre optic system reliability
3. NICC Document 98/050 – Rules and procedures of NICC Study Groups.

1.3 Abbreviations and definitions

Abbreviations

ETSI	European Telecommunications Standards Institute
ISI	In-Span Interconnect
NICC	Network Interfaces Co-ordination Committee
PNO-CSI	Public Network Operators Committee for SDH Interconnect
PNO-IG	Public Network Operators Interest Group
PNO-TIG	Public Network Operators Transmission Interconnect Group
POI	Point Of Interconnect
SDH	Synchronous Digital Hierarchy
WDM	Wavelength Division Multiplexing
DWDM	Dense Wavelength Division Multiplexing
OIF	Optical Internetworking Forum

Definitions

Native	Terminal equipment (e.g SDH incorporating embedded ITU optical λs).
Transponder	Translation 'Stand-alone' equipment converts inputs to ITU optical λs
Post Amplifier	Optical booster amplifier normally associated at Transmit end
Pre- Amplifier	Optical booster amplifier normally associated at Receiver end
Optical amp	In line optical amplifier

1.4 Scope

The number of DWDM systems being deployed throughout the world is growing rapidly. What began as simple point-to-point links is now entering a new era of complex optical networking functionality. To address this complexity, industry bodies and the various standards committees are actively addressing DWDM interoperability. An example of this work is the ITU-T G.872 -Architecture of Optical Transport Networks. This document also identifies interconnection scenarios for interworking optical systems and networks between different domains.

With such developments there is an urgent need to maintain interoperability between various operator deployment schemes. This situation will enable Operators to deliver seamless services across multiple networks, whilst operating in a multi-vendor DWDM environment.

Increasing opportunities for DWDM interconnect between licensed telecommunications operators both within the United Kingdom and between the United Kingdom and overseas, together with advances in technology and developments in international standards have necessitated the creation of a set of UK DWDM Interconnect Recommendations. This particular document represents the “Overview” part of the new set.

It is assumed that international interconnect activity will still be covered at international level in such fora as the ITU-T and ETSI.

Broadly speaking national interconnect can take one of the following forms:-

Source to destination interconnect - in this form of interconnect traffic flows direct from one operator to another . The traffic may be switched or point to point leased, telephony, data or video, and may be carried in a number of ways ie using particular transmission techniques, such as synchronous or asynchronous transfer mode, via a photonic, copper or wireless medium.

Transit interconnect - this form of interconnect is where traffic from one operator to another (or in some cases the same operator) is carried over the network of a third (different) operator or operators. The type of traffic carried is identical to that in the first example of interconnect.

Shared restoration interconnect - in this case two or more operators may agree to share spare capacity within each others’ transmission systems for restoration purposes in the event of a major system failure within their own network.

This document is applicable exclusively to DWDM interconnect between operators as defined above.

1.5 Purpose

The PNO-IG is mandated to follow ETSI and other international standards such as the ITU-T where available. Documents that are produced are not in themselves mandatory but aim to represent the consensus views of UK operators.

The PNO-TIG (Transport Interconnect Group), is a sub-group of the PNO-IG (Public Network Operators Interest Group. This group sits within the umbrella of the UK NICC (Network Interoperability Consultative Committee), founded by OFTEL in 1993, to establish interoperability between UK network operators and for customer terminal access.

The continuing aim of these documents is to facilitate interconnection between different operators' networks , by providing a common set of recommendations to which operators can work. The recommendations are not mandatory, although operators may choose to use the recommendations as a basis for contractual agreements. It is hoped that the voluntary adoption of a common set of recommendations will help to ensure consistency between operators, and will simplify the task of offering services across multiple interconnected networks.

Ultimately in order that successful interconnection may be achieved in the most cost-effective manner, it is expected that equipment from different vendors will become fully interoperable.

It is also envisaged that any agreements reached, and principles adopted within this forum, in the quest for full interoperability of equipments, should be used to influence developments in international standards groups such as ITU-T and ETSI TM through the medium of the UK Standards Coordination Committees.

2. DOCUMENTATION STRUCTURE

The objective of the PNO-TIG is to produce a set of documents relating to DWDM transmission interconnection between different operators networks. The set of documents in this (release 1) package comprises the following:-

Overview - (this document).

Technical recommendation - This document covers the technical aspects of DWDM interconnect considering issues such as physical interfaces, end-to-end performance monitoring, service protection and optical safety. The document also considers standardisation issues raised by multi-vendor networks.

Interconnect commissioning recommendation - This document describes the test procedures to be used to establish that the interconnection between the networks is operating correctly.

The aim of the Overview document is to facilitate DWDM Interoperability by providing a basis for a common set of recommendations to which operators can work. The recommendations are not mandatory, although operators may choose to use the recommendations as the basis for contractual agreements. It is hoped that the voluntary adoption of a common set of recommendations will help to ensure consistency between operators, and ultimately simplify the task of offering services over DWDM networks.

3.0 PRINCIPLES OF DWDM INTEROPERABILITY

The following issues need to be recognised when planning DWDM transmission interoperability between two or more networks. For illustration purposes only single direction links are shown. Figure 1 illustrates the key functional elements of a DWDM system. Note that the following definitions will need to be reviewed if more complex optical DWDM links are considered in the future.

-Transmitter end

The optical transmitter end includes a wavelength specific optical output for embedded or transponder system meeting ITU-T/G.692 grid standards and may include a optical post amplifier. Transmission beyond STM-16 bit rates is not considered here.

- Transmission Media

The transmission media is optical fibre cable. The use of dispersion compensation modules is outside of scope of this work since it’s application is not required for STM-16 systems on short haul links.

-Receiver end

The optical receiver end includes the optical demultiplexer (normally passive) and a optical pre-amplifier where necessary.

The above definitions apply to both an embedded system (DWDM native SDH) and a transponder based system (stand-alone). The intent is to develop an understanding of the issues for DWDM and the consequences for any future requirements for interoperability within and between different manufacturer's equipment. Throughout his work a client/server architecture is assumed, for example SDH over DWDM.

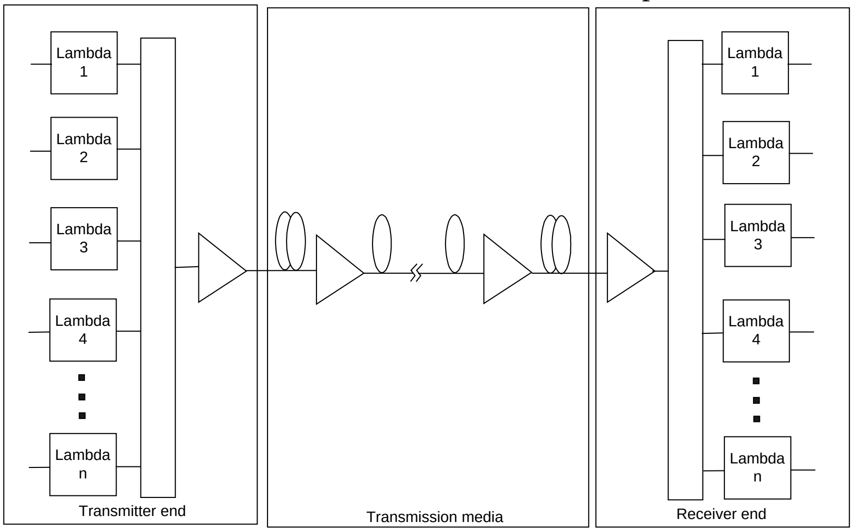

Fig.1 - Functional elements of a WDM link
(Note this figure illustrates all functional elements of a DWDM system. The first version of this standard only addresses scenarios with or without pre and booster amplifiers. It does not address line amplifiers.

3.1 Interoperability Topologies

The following scenarios have been identified for point to point DWDM Interoperability, for illustration purposes only a single direction transmission is shown.

- Un-amplified span.
- Post amplifier span.
- Post and Pre-amplifier span.

Additional issues such as power levels, modulation formats, line management and complex functionality for each scenario will form additional sections of this document.

3.1.1 Scenario 1

Figure 2 refers. An unamplified span would be implemented over a short haul link (up to 40km as a guideline) where nodes A and B could be different operator domains and DWDM equipment. A mid-span meet would therefore represent the boundary between operators.

Note: Scenario 1 is the situation now. Scenarios 2 and 3 will be for further study.

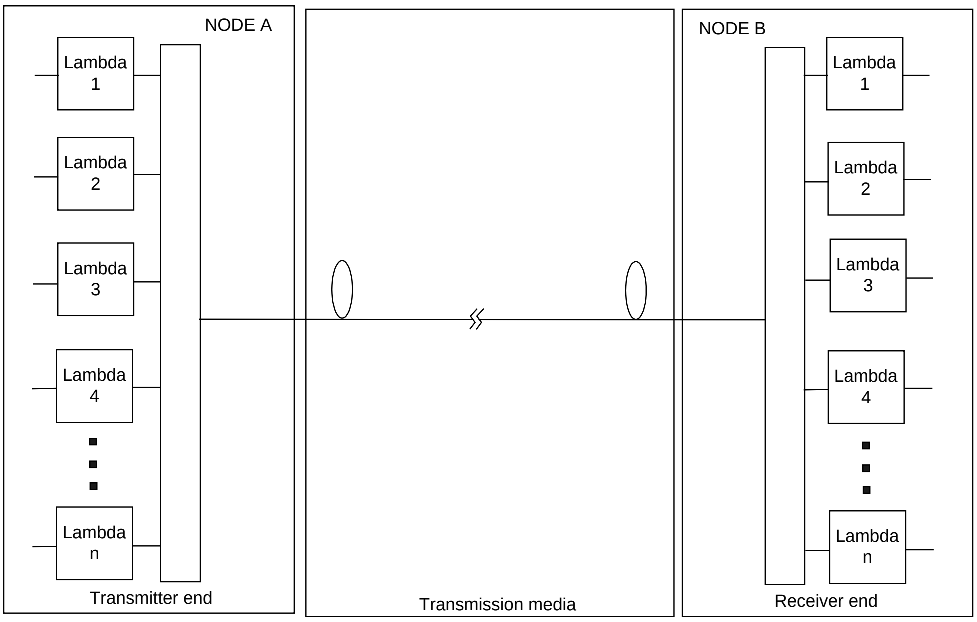

Fig. 2 - Scenario 1 Unamplified short haul span

3.1.2 Scenario 2

An extension to scenario 1 is represented in Figure 3 for an application which requires the use of a post amplifier to obtain additional reach. The mid-span meet represents the boundary between the different operator domains. In this configuration typical transmission distance up to ≈80km as a guideline should be feasible. Transmission equipment could be sourced from different suppliers thus the post amplifier would need to be managed locally via node A.

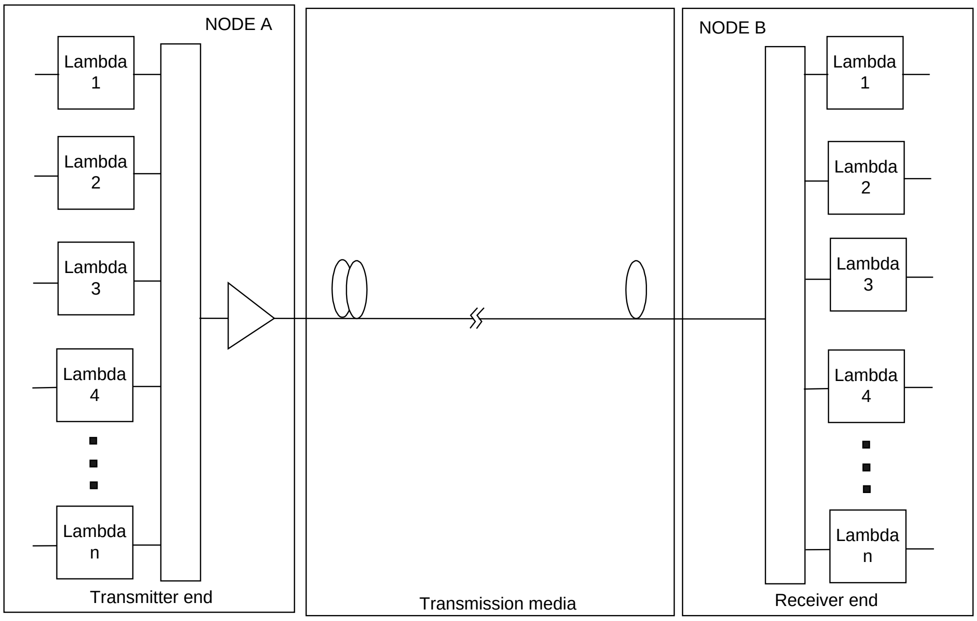

Fig. 3 - Scenario 2 Post amplifier at source

3.1.3 Scenario 3

Figure 4 refers. Scenario 3 addresses medium span amplified DWDM applications where a post amplifier and pre-amplifier are both used in the link to enhance the transmission distance. In this configuration typical transmission distance up to ≈120km as a guideline should be feasible. The mid-span meet represents the boundary between the different operator domains.

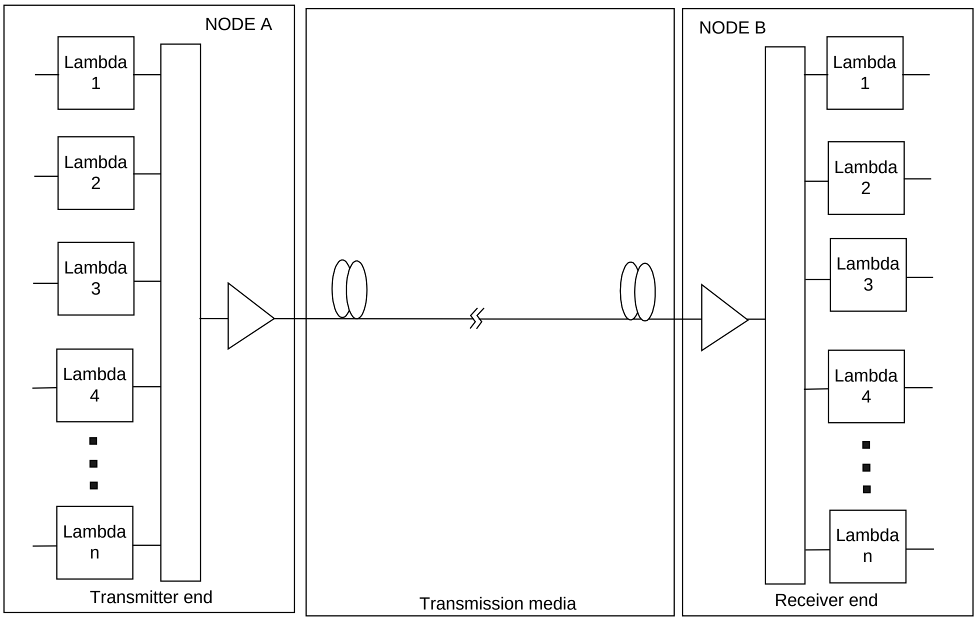

Fig. 4 - Scenario 3 Post and pre-amplification

4.0 APPLICATIONS

The following section serves to outline key applications which apply to the scenarios used in this document.

a) Source to Destination interconnection, between operator A and Operator B with the POI in the middle as shown in figure 7.

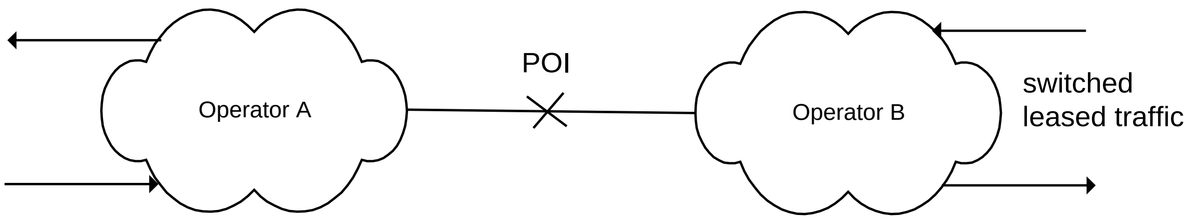

Fig. 7 - Source to destination application

b) Transit interconnection, used where a third party is required to provide transport, with the POI located between each Operator, as shown in figure 8.

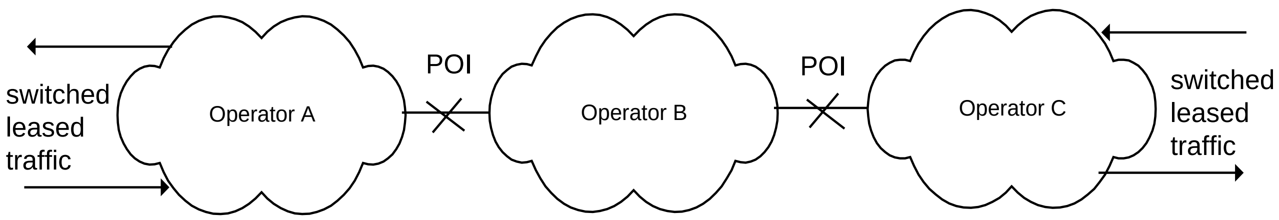

Fig. 8 - Transit application

c) Shared restoration interconnection, where two operators agree to provide shared capacity between network which in the event of a major disaster would form a means of recovery as shown in figure 9.

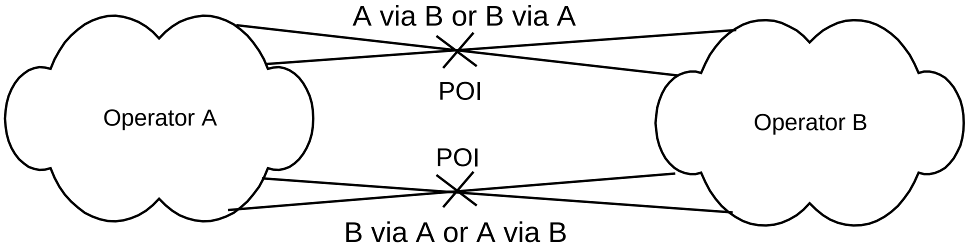

Fig. 9 - Shared restoration application

The initial focus will be on (a) representing a simple and manageable task.

5.0 PROTECTION

This is for further study.

ANNEX-1 ILLUSTRATIVE IMPLEMENTATIONS OF INTEROPERABILITY

Introduction

This annex describes a number of illustrative examples of how interoperability could be achieved. They are not intended to be a complete list of all possible combinations, rather they are intended to illustrate the main network management requirements.

Setting the Scene - SDH Interconnect

Figure 10 illustrates how SDH interoperability can be achieved using existing techniques. Each interface is a single optical wavelength that meets the requirements of ITU-T Recommendation G.957. SDH section overhead is passed between the network operators in order to allow for single ended maintenance. There is however no passing of data communications channel information (e.g. DCC) between operators except by mutual consent.

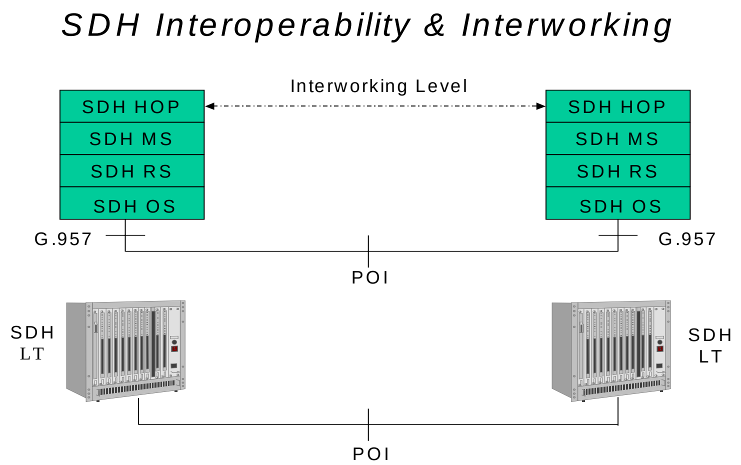

Fig. 10 - Existing solution for interworking

WDM Interoperability Scenarios

Scenario 1 - Passive Multiplexor

The first scenario illustrated in figure 10 is based upon the following components:

- Wavelength sources that comply with the ITU-T grid described in ITU-T Recommendation G.692 and an agreed channel plan are embedded into SDH equipment rather than sources associated with ITU-T Recommendation G.957. The SDH optical section (SDH OS) is replaced with the three optical layers of ITU-T Recommendation G.872.
- A passive multiplexer and demultiplexer

In this system it is necessary to define optical interfaces between the SDH, on a per channel basis, and the mux/demux, and between the mux and demux as an aggregate signal. It should be noted that the mux and demux in these circumstances could be purchased from someone other than the SDH supplier if necessary.

With regard to the management of such a system the following should be noted:

- A failure between the mux and demux will result in multiple SDH alarms being generated. Where the mux is partially (or fully, in certain circumstances) populated it will be necessary to correlate the number of alarms on the SDH by first checking that they are all on the same fibre and secondly that all channels associated with the fibre have failed.
- One element manager is required for each network operator. There are however 16 management interfaces and associated data communications network overheads with such as system. The mux and demux will, even though they are passive, need to be recorded in a database and related to fibre data.
- Such a system cannot support an optical supervisory channel between operators if the mux and demux are completely passive.
- If the mux or demux require active temperature control, etc. they cannot be considered as passive, even if the optics is, and need to be managed.
- Where the mux or demux is active (and therefore may also include an optical amplifier) an in-station LAN could be used to connect to the management system rather than an optical wavelength.

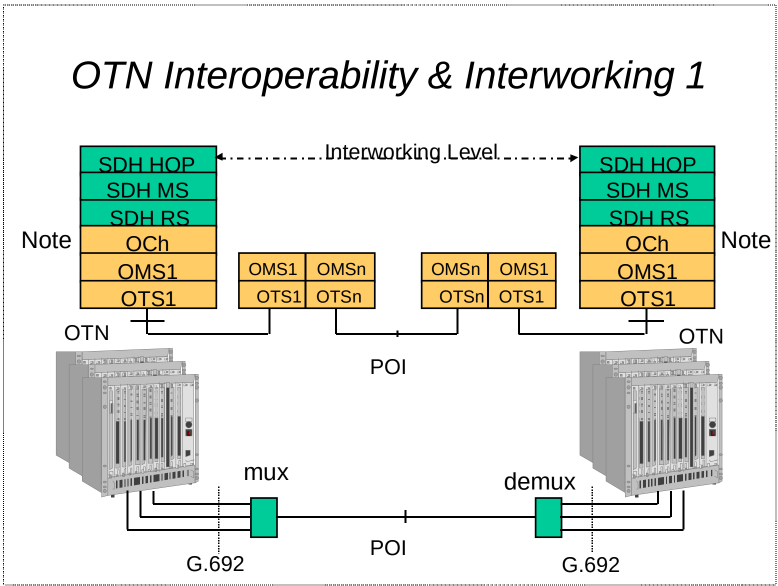

Fig. 11 - Interoperability via passive multiplexers and demultiplexers

Note. OCh is required for compliance with G.872, however for this scenario OCh layer is optional.

Scenario 2 - Transponder

Interoperability by means of transponders is illustrated in figure 12. In this scenario the SDH equipment retains the existing ITU-T Recommendation G.957 interfaces. The SDH outputs are converted into optical signals that can be multiplexed together by means of transponders and a multiplexer within an OLT. An optical supervisory channel may be used between OLT's or not as deemed necessary. Power and preamps may be used in the OLT if required. Receive end transponders may be used if necessary.

The use of two sets of transmitters and receivers results from using transponders, and this adds to the complexity and reliability issues. This scenario can be rather complex to manage for the following reasons:

- In each operators domain the OLT and SDH LT's are managed via separate element managers requiring more data communications infrastructure than if managed off one.
- There is no downstream suppression of consequential alarms from the multi-wavlength environment so both the SDH and WDM will alarm. Correlation is therefore required between element managers (to make sure all of the SDH signals are associated with the WDM line system) and databases.

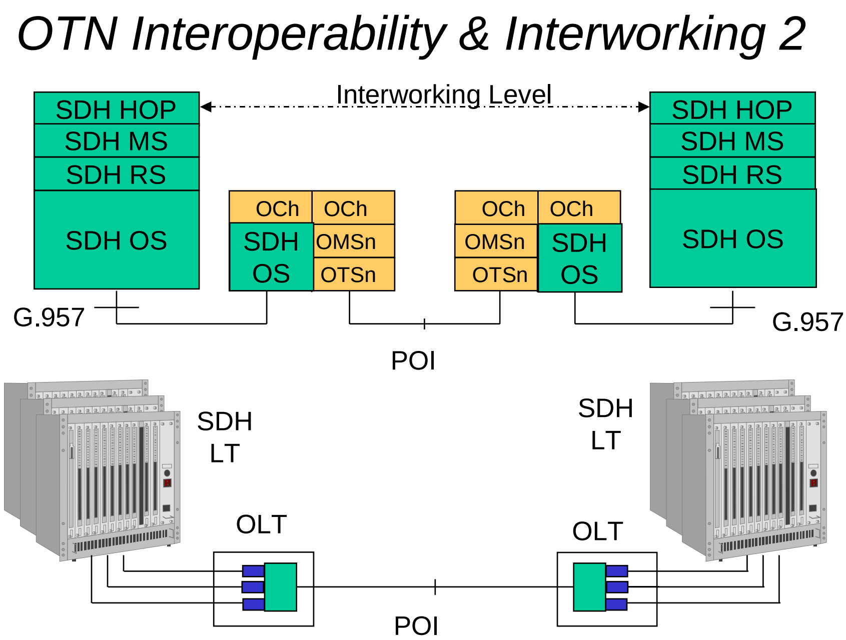

Fig. 12 - Interoperability using transponders

Scenario 3 - Integrated

In this scenario, shown in figure 13, the wavelength division multiplexing has been included within a single SDH equipment at each end. The advantages of this approach are as follows:

- Each operator has only one network element to manage. This results in less boxes, fewer network management interfaces and communications overhead.
- The optical transport network and SDH functions can be managed from a single element manager (per operator)
- Detection of loss of signal resulting from fibre failure can be used to generate one alarm and suppress SDH downstream consequential alarms.
- Only one physical interface needs to be defined at each end.
- One step network management for any faults.
- An optical supervisory channel may or may not be enabled between the network operators.
- Optical amplifiers may be embedded in the SDH terminals to increase range without resorting to inline amplifiers. As such they are easily managed.

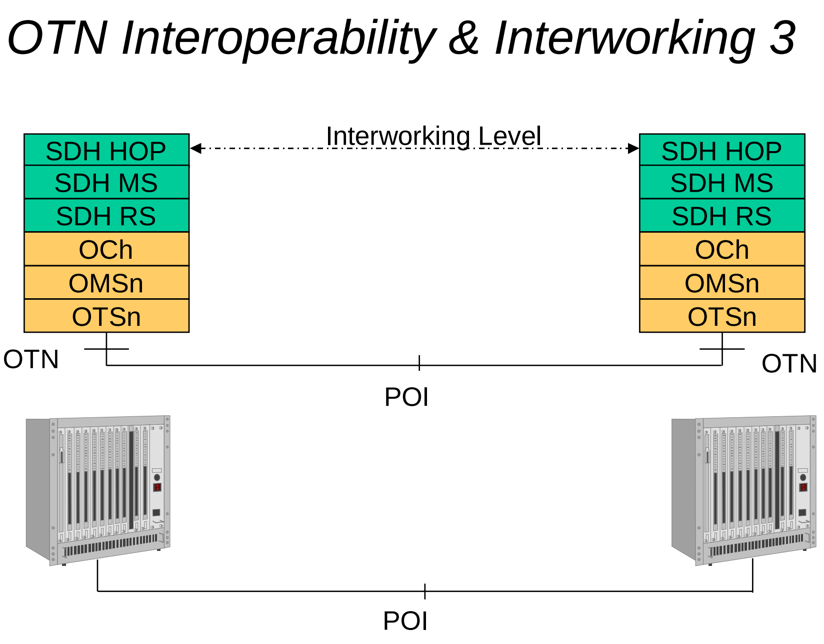

Fig. 13 - Interoperability via a single box solution

Conclusions

With regard to the scenarios described above it is possible to conclude the following:

- The transponder based solution is the most complex and has the following features
  - Duplication of lasers, clock functions etc,
  - It is the most complex network management solution of the options

  - It will require well defined interfaces
  - The optical supervisory channel may or may not be used.
- Coloured interfaces with passive optics is the simplest solution and has the following features
  - Requires well defined operational policies, but management is straightforward if manually intensive
  - Very limited range (no amplifiers, even post or pre-amp
  - The supervisory channel would be at the expense of a traffic wavelength.
- Integrated WDM within SDH (figure 13) is not currently available but has the following properties
  - Lowest number of interfaces and equipment count
  - Simple network management
  - Optical supervisory channel may or may not be used.
  - Amplifiers may or may not be embedded.
  - Single vendor per end.

From the above it is evident that the use of an optical supervisory channel is not completely necessary. Instead the SDH can be used for the purposes of first line network management to indicate that it has a problem with the underlying virtual fibre (which is what WDM is in effect as far as SDH is concerned) and then the WDM management to localise the fault further. Finally single ended maintenance can be achieved from the SDH overhead information. It should not be assumed that for clients other than SDH that these conclusions would still be valid and they are certainly no longer valid if optical line amplifiers are used.

End of document