



INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

L.40

(10/2000)

SERIES L: CONSTRUCTION, INSTALLATION AND
PROTECTION OF CABLES AND OTHER ELEMENTS OF
OUTSIDE PLANT

Optical fibre outside plant maintenance support, monitoring and testing system

ITU-T Recommendation L.40

(Formerly CCITT Recommendation)

Optical fibre outside plant maintenance support, monitoring and testing system

Summary

Outdoor optical fibre maintenance is important to create networks and to maintain their reliability. As traffic increases, higher capacity fibre cables are installed. Recently, optical fibre cables with over 100 cores have become common, so many transmission systems use the same optical fibre cable. Minimal levels of maintenance and testing are required to provide high reliability and quick response.

After a cable is installed, functions like fibre monitoring and control have to be done without interfering with the data transmission signals. By monitoring dark fibres (that is, without signal traffic) an indication is given of the performance of the in-service fibres as the degradation and breaks that a cable undergoes affects all fibres in the same way. Nevertheless greater reliability is achieved by monitoring the fibres with traffic. Also fibre identification is important to control fibre networks because several fibres may have to be chosen from within a cable, even if the cable has many fibres in-service.

Source

ITU-T Recommendation L.40 was prepared by ITU-T Study Group 6 (1997-2000) and approved by the World Telecommunication Standardization Assembly (Montreal, 27 September – 6 October 2000).

This Recommendation includes Appendices I to V approved on 9 March 2001.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

© ITU 2001

All rights reserved. No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from ITU.

CONTENTS

	Page
1 Scope.....	1
2 Fundamental requirements.....	1
2.1 Functions.....	1
2.2 Interface	1
3 Testing and maintaining principle	2
3.1 Methods	2
3.2 Wavelength	2
4 Fundamental architecture.....	3
4.1 General system architecture.....	3
4.2 Optical testing module (OTM)	5
Appendix I – United States experience regarding remote fibre monitoring and testing	6
I.1 Introduction.....	6
I.2 Remote fibre testing and monitoring architectures.....	6
I.2.1 Basic dark fibre remote test systems (RFTSs).....	6
I.2.2 Remote fibre test systems with active fibre monitoring and testing.....	7
I.2.3 RFTS manager	8
I.2.4 Alarms	8
I.3 Conclusions.....	9
I.4 References.....	10
Appendix II – Optical fibre outside plant maintenance support and testing system	10
II.1 Abstract	10
II.1.1 Fundamental requirements	10
II.1.2 Testing and maintaining principle	11
II.1.3 Fundamental architecture	12
II.2 Detail of the system	13
II.2.1 Purposes.....	13
II.2.2 System functions.....	13
II.2.3 System configuration.....	14
II.2.4 Control system overview	15
II.2.5 Testing and measurement principles	16
II.3 Mandatory conditions	18
II.3.1 Network topologies.....	18
II.3.2 Capacities.....	18
II.3.3 Test wavelength.....	18

	Page
II.3.4 System data management	18
II.3.5 Interface	19
Appendix III – Optical fibre outside plant maintenance support and testing system	19
III.1 Introduction.....	19
III.2 Scenario	20
III.3 Benefits of attenuation continuous monitoring.....	20
III.4 Basic principles of the optical cable supervisory system	22
III.5 Requirements of the optical cable supervisory system.....	22
III.6 Conclusions.....	26
Appendix IV – The Indonesian experience on optical fibre cable operation and maintenance support system	26
IV.1 Introduction.....	26
IV.2 Fundamental requirements.....	27
IV.3 System's basic configuration.....	27
IV.4 Functions of main units.....	28
IV.5 System's hardware configuration.....	29
IV.6 General specification of optical fibre cable O&M support system	30
IV.6.1 Test scope	30
IV.6.2 Capacities.....	31
IV.6.3 Test wavelength.....	31
IV.6.4 Test distance restrictions	31
IV.6.5 System data management	31
IV.6.6 Coupling loss and reflection measurement.....	31
IV.6.7 Transmission conditions.....	32
IV.6.8 System use conditions	32
IV.7 Application software.....	32
Appendix V – Spain's experience of an optical fibre monitoring system (OFMS)	33
V.1 Introduction.....	33
V.2 General.....	34
V.3 Optical fibre monitoring system (OFMS) – General description	34
V.4 System performance	34
V.5 System.....	35
V.6 Incorporation of the system in the centralized monitoring structure	36

ITU-T Recommendation L.40

Optical fibre outside plant maintenance support, monitoring and testing system

1 Scope

This Recommendation deals with outdoor optical fibre maintenance support, monitoring and testing systems for both trunk and access optical fibre cable networks. It describes fundamental requirements, principles, and architecture to develop a suitable guide to design systems.

2 Fundamental requirements

2.1 Functions

The system has functions shown in Table 1.

Table 1/L.40 – Functions and status

Category	Activity	Functions	Status
Preventative maintenance	Surveillance (e.g. Periodic testing, Continuous testing)	• Detection of fibre loss increase • Detection of signal power loss increase • Detection of water penetration	Optional Optional Optional
	Testing (e.g. Fibre degradation testing)	• Measurement of fibre fault location • Measurement of fibre strain distribution • Measurement of water location	Optional Optional Optional
	Control (e.g. Network element control)	• Fibre identification • Fibre transfer	Optional Optional
After installation before service or post-fault maintenance	Surveillance (e.g. Reception of transmission system alarm or customer trouble report)	• Interface with path operation system • Interface with customer service operation system	Optional Optional
	Testing (e.g. After installation testing, Fibre fault testing)	• Confirmation of fibre condition • Fault distinction between transmission equipment and fibre network • Measurement of fibre fault location	Required Required Required
	Control (e.g. Cable install/repair/replacement)	• Fibre identification • Fibre transfer • Interface with outside plant database • Interface with mapping system	Required Optional Required Optional

2.2 Interface

The system can be controlled by human or by other systems. The system shall be able to be remotely controlled. So operation terminals with HMI (human-machine interface) should be included in the system.

The system shall be able to gather data about outdoor fibres from the outside plant database and it should have interface with path operation and customer service system.

- 1) standard on-line interface;
- 2) proprietary on-line interface;
- 3) an external storage medium such as magnetic optical disc or floppy disc.

3.1 Methods

Table 2/L.40 – Suitable test methods

3.2 Wavelength

Table 3/L.40 – Wavelength selection

Category	Activity	Functions	Wavelength
Preventative maintenance	Surveillance	• Detection of fibre loss increase • Detection of signal power loss increase • Detection of water penetration	Maintenance wavelength ^{a)} Signal wavelength Any wavelength on fibres not carrying signals
	Testing	• Measurement of fibre fault location • Measurement of fibre strain distribution • Measurement of water location	Any wavelength on fibres not carrying signals Any wavelength on fibres not carrying signals Any wavelength on fibres not carrying signals
	Control	• Fibre identification • Fibre transfer	Maintenance wavelength ^{a)} None
After installation before service or post-fault maintenance	Surveillance	• Interface with path operation system • Interface with customer service operation system	None None
	Testing	• Confirmation of fibre condition • Fault distinction between transmission equipment and fibre network • Measurement of fibre fault location	Any wavelength Any wavelength Any wavelength
	Control	• Fibre identification • Fibre transfer • Interface with outside plant database • Interface with mapping system	Any wavelength None None None
^{a)} Refer to "Recommendation of Maintenance wavelength on fibres carrying signals (ITU-T L.41)".			

4 Fundamental architecture

4.1 General system architecture

Systems (see Figure 1) must have at least an operation terminal and optical testing module (OTM). The minimum system consists of only these two items. This type of system is convenient for initial installation. A server can improve performance by keeping outside plant, test results, and interfaces with other systems. The server can also control OTMs.

There are several choices for Data Communication Network (DCN), including POTS, ISDN and X.25. Traffic analysis is important for an economical high-performance system.

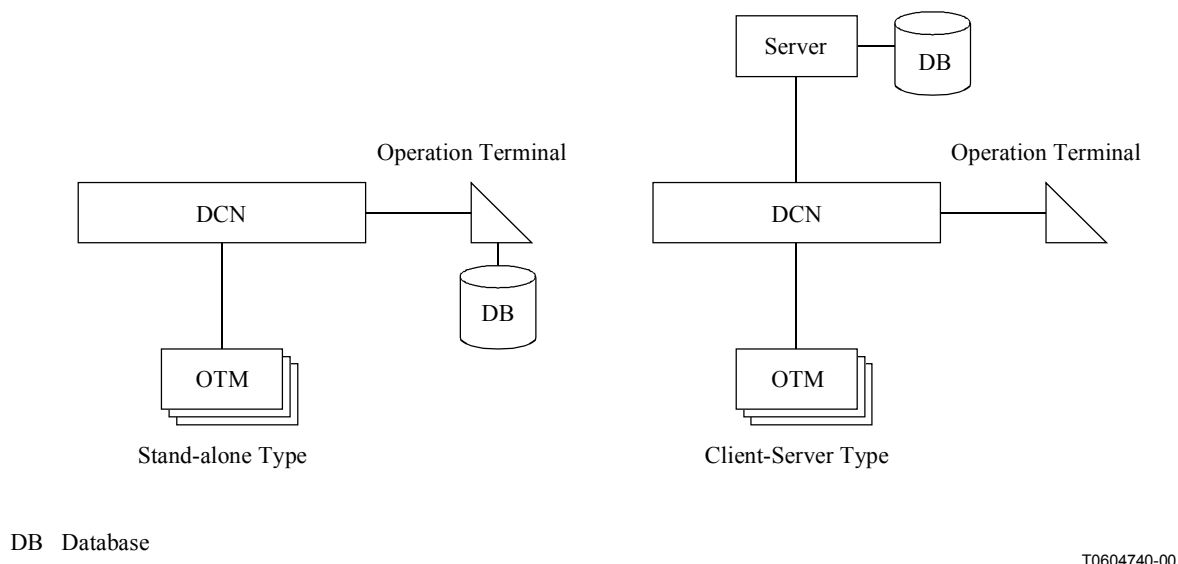
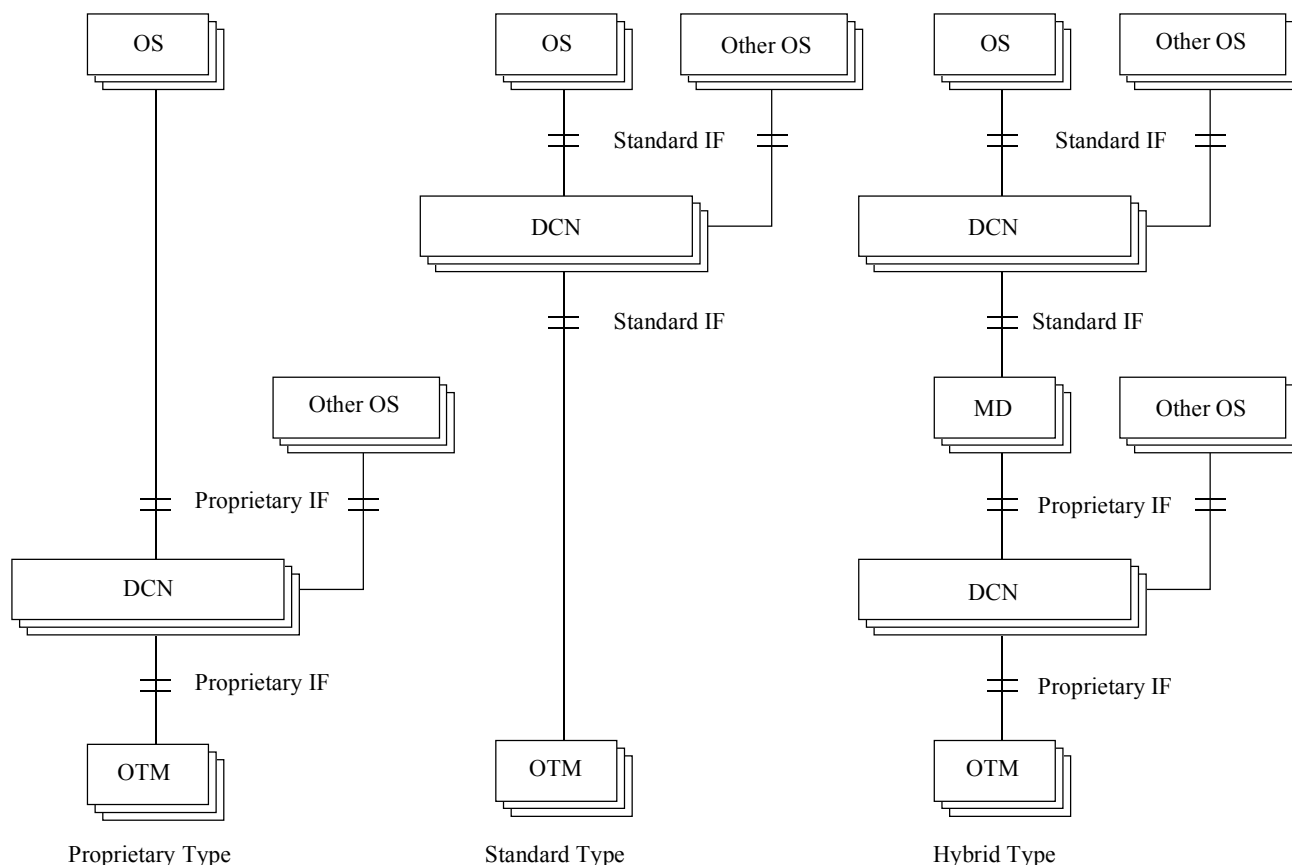


Figure 1/L.40 – System architectures

Figure 2 shows these system interfaces. There are several kinds of interface between an operating system (OS), which runs on an operation terminal or server, and OTM. A proprietary interface is convenient for closed systems. Standard interfaces are useful for open systems. A hybrid type is also possible.

The system has to have interfaces with other systems. This may be done in a variety of ways, for example:

- 1) standard on-line interface;
- 2) proprietary on-line interface;
- 3) an external storage medium such as magnetic optical disc or floppy disc.



T0604750-00

Figure 2/L.40 – System interfaces

4.2 Optical testing module (OTM)

The optical testing module (OTM) consists of a controller, an optical testing unit (OTU), fibre selectors (FS), optical couplers, filters, water sensors and by path units.

- 1) The controller controls the OTU, communicates with the server or the operation terminal, and analyses test results, along with performing several other functions.
- 2) The OTU is used for the actual testing. It comprises an Optical Time Domain Reflection meter (OTDR) and other instruments, light sources, power meters and a controller for these devices.
- 3) Fibre selectors (FS) are installed within a fibre termination frame and/or an OTU frame. Their function is to select the fibre to be tested under instruction from the OTU.
- 4) An optical coupler is installed within a fibre termination frame. Its function is to inject and detect a test light in the optical fibre or to detect a proportion of the signal for monitoring proposes.
- 5) A filter is installed to protect transmission equipment from being affected by the test light.
- 6) A water sensor is installed at the optical fibre cable joints to detect the water penetration.
- 7) A bypath unit is used to make a roundabout route to avoid a transmission device.

APPENDIX I

United States experience regarding remote fibre monitoring and testing

I.1 Introduction

Based on our experience with customers in the United States, many of the larger network providers that predominantly provide local telephony services do not use Remote Fibre Test Systems (RFTSs). These companies rely on transmission system equipment alarms, ring topology and protection switching. In response to an alarm, traffic is switched to an alternate fibre, and after applying proprietary maintenance analyses an OTDR is used to determine the location of a cable break. These companies have historical and landmark data available for fault location. Network providers that are predominantly long-distance providers do use some level of remote fibre testing systems in their networks.

The RFTSs range from the basic dark fibre systems to identify and roughly locate fibre breaks to more sophisticated systems that can monitor working systems, detect degradation of the network before it fails and accurately locates fibre faults. RFTSs may be controlled locally, regionally or at a central maintenance centre of a network provider. In the case of the dark fibre system, the main purpose is to reduce the time to locate faults and thus reduce the time of circuit outages. The sophisticated systems are integrated into the network surveillance operational system that monitors the transmission, switching equipment and the RFTS. These systems can also determine degradation of the fibre network and sound alarms before the network is out of service.

I.2 Remote fibre testing and monitoring architectures

I.2.1 Basic dark fibre remote test systems (RFTSs)

The basic dark fibre Remote Fibre Test System (RFTS), shown in Figure I.1, consists of three elements. The first is an Optical Test Access Unit (OTAU), which is essentially a remotely controlled optical switch. The size of the switch depends on the number of fibres under test, a common size is 72 fibres, but larger switches are used. The switch connects the test fibres to the second element, the Remote Test Unit (RTU), which is a remotely controlled OTDR that provides the test signal and makes the OTDR measurements. The third element is the Test System Controller (TSC), which selects the test fibre and operates the RTU. This architecture is typical of the dark fibre monitoring in use today in the United States. The test operating system may be integrated into a surveillance operational system using proprietary software.

In a stand-alone system the TSC contains a database for the fibres under test that includes prior OTDR trace data and related geographic data of the fibre routes. In these systems only dark fibres are tested. The RFTS is capable of fault detection based on a process where the TSC cycles through each fibre connected to it. One TSC can control multiple RTUs. This means that a TSC may not discover a cable break for some time if the number of fibres connected to it is very large and if the fibres of that cable were tested shortly before the break occurred. The TSC may be connected to a Test Operating System (Test OS), which is located in a maintenance centre where other alarms from the network terminate. Operators there analyse the alarms coming from the TSC and other sources, such as transmission alarms, determine the root cause of the problem and obtain OTDR trace information from the TSC before dispatching a repair crew. If a transmission alarm is received first, the TOS can interrupt the test cycling, and direct the TSC to make a scan of the fibre with a transmission fault.

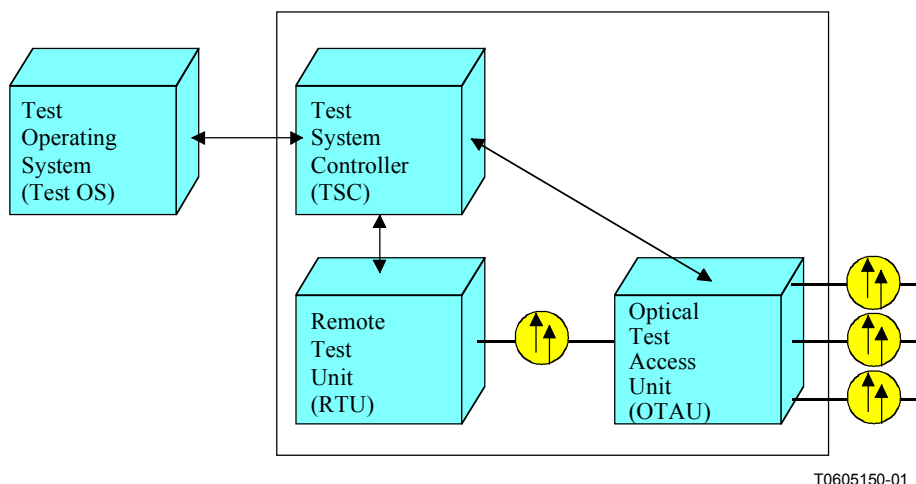


Figure I.1/L.40 – Basic dark fibre remote fibre test system (RFTS)

Many of the current systems in use today are vendor specific and not compatible with other vendor products on a system or component basis. Requirements for RFTSs that will overcome this problem in new systems put into use in the United States have been developed [1], [2] and [3].

Monitoring only the dark fibres cannot assure detection of faults that may occur with the working fibres. For example if water entered the cable and freezing occurred, some of the working fibres could experience high loss while the monitored dark fibres are unaffected. This problem can be overcome with monitoring of more fibres, including the active fibres. Of course, the number of fibres monitored increases the cost, which places a practical limit on how many fibres are monitored. Typically, only one or two fibres are monitored per cable.

I.2.2 Remote fibre test systems with active fibre monitoring and testing

The transmitted and/or received signal can be monitored full time and an OTDR test signal, which is out of the transmission band, can be injected into the OSP fibre without interference with the transmission by placing a WDM device between the transmission equipment and the OSP fibre. Figure I.2 illustrates this architecture and is representative of systems in use today [4]. The sophistication of the system depends upon the RFTS manager function that is discussed in I.2.3.

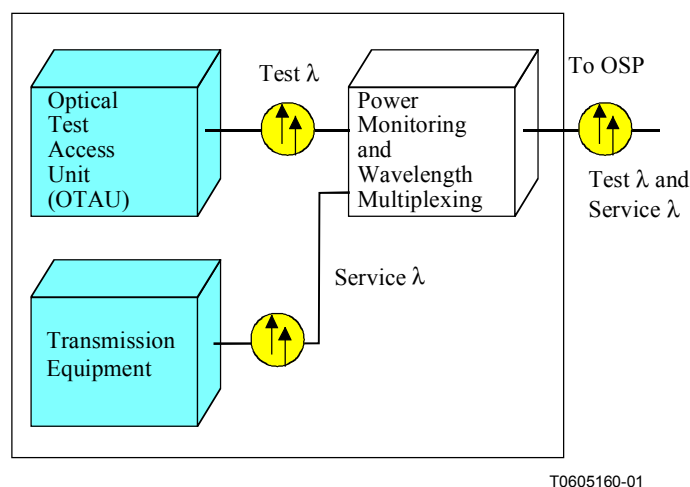


Figure I.2/L.40 – Power monitoring and wavelength division multiplexing an OTDR test signal with service transmission

With this architecture there are a number of benefits:

- 1) The RTU need only be used to locate faults that are detected by loss of signal power.
- 2) The detection of signal loss would be essentially instantaneous; with the detection of loss of power, the monitoring circuitry can signal the TSC to direct the RTU and the OATU to make a test and locate the fault.
- 3) Both active and dark fibres can be batch tested.
- 4) Power monitoring as well as routine OTDR test data can be used to do proactive maintenance. It can support the detection of transmission quality degradation and observe the quality of the fibre over long periods of time for failure prediction.

I.2.3 RFTS manager

The RFTS manager, generally a PC with special fibre application software (FAS), communicates with the surveillance operations system (SOS), but it can also be accessed locally and directly from the field. The RFTS manager controls the RFTS equipment and stores data on the fibres monitored in its system, such as landmarks and other geographical information, OTDR traces, statistical data, alarm policy, and monitoring and test data. When an alarm is received, the manager directs the RFTS equipment (TSC, RTU and OTAU) to make a test. It processes the test data, and forwards to the SOS the location of the fault relative to landmark data for the repair crews. During a cable break, the SOS receives alarm information from the transmission equipment, from the protection switching equipment (if protection switching is used) and from the RFTS manager. With suitable correlation algorithms at both the RFTS manager and the SOS the several alarms can be sorted and only one alarm prevails. In the case of a cable break, it is the RFTS alarm with the necessary fault location information to dispatch a repair crew. Figure I.3 below illustrates this process.

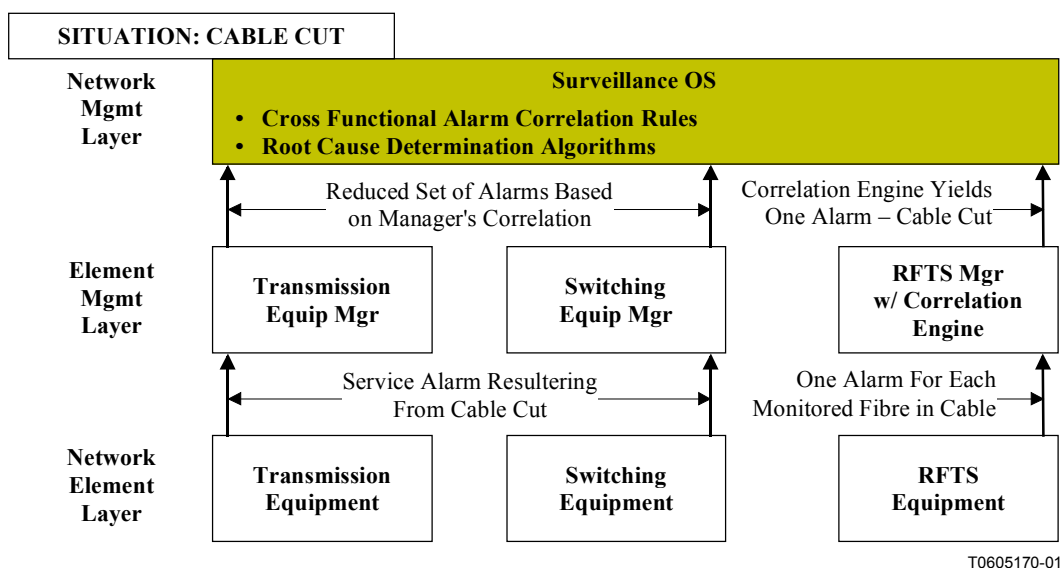


Figure I.3/L.40 – Telecommunications maintenance hierarchy with focus on alarm correlation

I.2.4 Alarms

For the most sophisticated systems, the FAS software provides an extensive set of alarm capabilities to alert maintenance personnel to fibre related issues. Fibres alarms are pre-set to detect changes in fibre path performance associated with comparative batch testing or power monitoring. The system also provides alarm information associated with equipment and other environmental fault conditions. All alarm information may be accessed via alarm lists maintained by the RFTS manager. A remote