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**Transmission and Multiplexing (TM);  
Requirements of passive Optical Access Networks (OANs) to  
provide services up to 2 Mbit/s bearer capacity**

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## Foreword

This final draft European Telecommunication Standard (ETS) has been produced by the Transmission and Multiplexing (TM) Technical Committee of the European Telecommunications Standards Institute (ETSI), and is now submitted for the Voting phase of the ETSI standards approval procedure.

This ETS describes cost effective and flexible access networks using optical fibre technology and is designed to provide both services to meet the current demands and an infrastructure which is able to satisfy the requirements of the future.

<b>Proposed transposition dates</b>	
Date of latest announcement of this ETS (doa):	3 months after ETSI publication
Date of latest publication of new National Standard or endorsement of this ETS (dop/e):	6 months after doa
Date of withdrawal of any conflicting National Standard (dow):	6 months after doa

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## 1 Scope

This final draft European Telecommunication Standard (ETS) describes cost effective and flexible access networks using optical fibre technology. This ETS is designed to provide both services to meet the current demands and an infrastructure which is able to satisfy the requirements of the future.

This ETS describes the characteristics of an Optical Access Network (OAN) with the capability of transporting interactive services, based on 64 kbit/s bearer capabilities, between the User Network Interface (UNI) and the local exchange. The ETS considers an OAN capable of providing business and residential customers with a range of services (up to 2 Mbit/s) over a passive split optical network. Distributive services (e.g. cable television) are outside the scope of this ETS.

The OAN described in this standard has considered the requirement for the access network to adapt to the changing requirements of individual customers in terms of capacity, flexibility and types of services offered without the need for network operators to provide service specific overlay networks.

The considered systems within this ETS are based on Time Division Multiple Access (TDMA) and/or Subcarrier Multiple Access (SCMA) methods. One and two fibre systems are described.

This ETS considers OANs where the Optical Distribution Network (ODN) is based on point-to-multipoint tree and branch options as described in prETS 300 681 [5].

This ETS is not a complete system definition. It identifies aspects that can be defined without preventing transmission innovation.

## 2 Normative references

This ETS incorporates by dated and undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this ETS only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

- [1] EC SYN 287 (1990): "Proposal for the council directive concerning the protection of individuals in relation to the processing of personal data".
- [2] EC SYN 288 (1990): "Proposal for the directive concerning the protection of personal data and privacy in the context of public digital telecommunication networks, in particular the integrated services digital network (ISDN) and public digital mobile networks".
- [3] EN 41 003: "Particular safety requirements for equipment to be connected to telecommunication networks".
- [4] EN 60 950: "Safety of information technology equipment, including electrical business equipment".
- [5] prETS 300 681 (1996): "Transmission and Multiplexing (TM); Optical distribution network for Optical Access Networks (OANs)".
- [6] prETS 300 736: "Transmission and Multiplexing (TM); Operation and maintenance of Optical Access Networks (OANs)".
- [7] ETR 080: "Transmission and Multiplexing (TM); Integrated Services Digital Network (ISDN) basic rate access; Digital transmission system on metallic local lines".
- [8] ETS 300 011: "Integrated Services Digital Network (ISDN); Primary rate user-network interface; Layer 1 specification and test principles".
- [9] ETS 300 012: "Integrated Services Digital Network (ISDN); Basic user-network interface; Layer 1 specification and test principles".

- [10] ETS 300 019: "Equipment Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment".
- [11] ETS 300 233: "Integrated Services Digital Network (ISDN); Access digital section for ISDN primary rate".
- [12] ETS 300 288: "Business TeleCommunications (BTC); 64 kbit/s digital unrestricted leased line with octet integrity (D64U); Network interface presentation".
- [13] ETS 300 324: "Signalling Protocols and Switching (SPS); V interfaces at the digital Local Exchange (LE); V5.1 interface for the support of Access Network (AN)".
- [14] ETS 300 347: "Signalling Protocols and Switching (SPS); V interfaces at the digital Local Exchange (LE); V5.2 interface for the support of Access Network (AN)".
- [15] ETS 300 376-1: "Signalling Protocols and Switching (SPS); Q3 interface at the Access Network (AN) for configuration management of V5 interfaces and associated user ports; Part 1: Q3 interface specification".
- [16] ETS 300 378-1: "Signalling Protocols and Switching (SPS); Q3 interface at the Access Network (AN) for fault and performance management of V5 interfaces and associated user ports; Part 1: Q3 interface specification".
- [17] prETS 300 462-2: "Transmission and Multiplexing (TM); Generic requirements for synchronization networks; Part 2: Synchronization network architecture".
- [18] prETS 300 462-5: "Transmission and Multiplexing (TM); Generic requirements for synchronization networks; Part 5: Timing characteristics of slave clocks suitable for operation in Synchronous Digital Hierarchy (SDH) equipment".
- [19] ETS 300 418: "Business TeleCommunications (BTC); 2 048 kbit/s digital unstructured and structured leased lines (D2048U and D2048S); Network interface presentation".
- [20] ITU-T Recommendation G.703: "Physical/electrical characteristics of hierarchical digital interfaces".
- [21] ITU-T Recommendation G.704: "Synchronous frame structures used at 1544, 6312, 2048, 8488 and 44 736 kbit/s hierarchical levels".
- [22] ITU-T Recommendation G.803: "Architectures of transport networks based on the synchronous digital hierarchy (SDH)".
- [23] ITU-T Recommendation G.823: "The control of jitter and wander within digital networks which are based on the 2048 kbit/s hierarchy".
- [24] ITU-T Recommendation G.832: "Transport of SDH elements on PDH networks: Frame and multiplexing structures".
- [25] ITU-T Recommendation I.430: "Basic user-network interface - Layer 1 specification".
- [26] ITU-T Recommendation M.3010: "Principles for a telecommunications management network".
- [27] EC ITSEC: "Information Technology Security Criteria (ITSEC)".



## 3 Definitions and abbreviations

### 3.1 Definitions

For the purposes of this ETS, the following definitions apply:

**access link:** The whole of transmission means between a given network interface and a single user interface. The concept of access link is used in order to allow a functional and procedural description and a definition of the network requirements.

NOTE 1: The user-side and the network-side of the access link are not identical and therefore the access link is not symmetrical.

**Adaptation Unit (AU):** An AU provides adaptation functions between the Optical Network Unit (ONU) and the user side.

**diplex working:** Bidirectional communication using a different wavelength for each direction of transmission over a single fibre.

**duplex working:** Bidirectional communication using the same wavelength for both directions of transmission over a single fibre.

**Field Replaceable Unit (FRU):** A FRU is the lowest level of maintenance spare and will typically be a plug-in card. The modules of an Optical Line (OLT) and ONU should be FRUs.

**full access:** Given no other connections, any slot on one side of the concentrator may be connected to any slot on the other side of the concentrator.

**multiplexing; static:** A system of multiplexing where the relationship between the position of the tributaries to the multiplexed format (channels) is predetermined and fixed.

**multiplexing; dynamic:** A system of multiplexing where the relationship between the position of the tributaries to the multiplexed format (channels) is flexible. It also allows for tributaries to be aggregated where there are more tributaries than available channels and the possibility to vary the bandwidth to  $n$  times the capacity of the channels.

**non-blocking:** Any allowable connection may be made at any time, regardless of the order in which connections are established or removed. (An allowable connection assumes that the respective slots are free).

**Optical Access Network (OAN):** The set of access links sharing the same network-side interfaces and supported by optical access transmission systems.

NOTE 2: The OAN may include a number of ODNs connected to the same OLT.

**Optical Distribution Network (ODN):** An ODN provides the optical transmission means from the OLT towards the users, and vice versa.

**Optical Line Termination (OLT):** An OLT provides the network-side interface of the OAN and is connected to one or more ODNs.

**Optical Network Unit (ONU):** An ONU provides (directly or remotely) the user-side interface of the OAN and is connected to the ODN.

**optical filter:** A device for the selection of optical signals at optical specific wavelengths.

**optical power splitter:** A device that has  $n$  inputs with  $k$  outputs, where  $n = 1$  to  $k$  and  $k = 2$  to infinity.

**passive component:** A component part of the ODN that does not require external power, i.e. fibre, splitter, filter.

**point-to-multipoint:** A transmission system which can have one input or output at one end with multiple inputs or outputs at the other end.

**Passive Optical Network (PON):** A PON is a subset of an ODN and refers to a point-to-multipoint option.

**Space Division Multiplexing (SDM):** Bi-directional multiplexing using different fibres for up and downstream signals.

**Sub Carrier Multiplexing (SCM):** Multiplexing multiple electrical frequencies onto a single fibre at a single wavelength to provide an individual frequency to each multipoint to point path.

**serial number:** A reference number assigned to an object, component, etc.

**service channel:** Each bearer service is allocated a service channel in the PON systems. e.g. a 64 kbit/s channel to support the Public Switched Telephone Network (PSTN).

**Service Unit (SU):** A FRU that supports service interface (Service Unit (SU)) function(s).

**simplex working:** Communication which uses a different fibre for each direction of transmission.

**Time Compression Multiplexing (TCM):** Bi-directional multiplexing using different time slots for up and downstream signals.

**Time Division Multiplexing (TDM):** Multiplexing information onto fixed time ranges.

**Tributary Unit (TU):** A TU is a FRU with one or more tributary interface functions.

**Wavelength Division Multiplexing (WDM):** Bi-directional multiplexing using different optical wavelength for up and downstream signals.

### 3.2 Abbreviations

For the purposes of this ETS, the following abbreviations apply:

AC	Alternating Current
A/D	Analogue to Digital (conversion)
AN	Access Network
ATM	Asynchronous Transfer Mode
AU	Adaptation Unit
BA	Basic Access
B-ISDN	Broadband Integrated Services Digital Network
DC	Direct Current
D/A	Digital to Analogue (conversion)
D2048S	2 048 kbit/s digital structured ONP leased line
D2048U	2 048 kbit/s digital unstructured ONP leased line
FDM	Frequency Division Multiplexing
FITL	Fibre In The Loop
FRU	Field Replaceable Unit
ISDN	Integrated Services Digital Network
ISDN	ISDN Basic Access
ITSEC	Information Technology Security Criteria
MTBF	Mean Time Between Failures
MTTR	Mean Time To Repair
NNI	Network to Network Interface
NT	Network Termination
NTI	Network Termination 1
OAM	Operations Administration and Maintenance
OAN	Optical Access Network
ODN	Optical Distribution Network
OLT	Optical Line Termination
ONP	Open Network Provision
ONU	Optical Network Unit

OS	Operations System
OSI	Open Systems Interconnection
OTDR	Optical Time Domain Reflectometer
PON	Passive Optical Network
POTS	Plain Old Telephony Services
ppm	parts per million
PRA	Primary Rate Access
PRC	Primary Reference Clock
PSTN	Public Switched Telephone Network
QAN	Q interface for the Access Network
SCM	Sub Carrier Multiplexing
SCMA	Sub Carrier Multiple Access
SDH	Synchronous Digital Hierarchy
SDM	Space Division Multiplexing
SELV	Subscriber Extra Low Voltage
SNI	Service Node Interface
SPF	Signalling Processing Function
SSU	Synchronization Supply Unit
SU	Service Unit
TCM	Time Compression Multiplexing
TDM	Time Division Multiplexing
TDMA	Time Division Multiple Access
TNV	Telecom Network Voltage
TU	Tributary Unit
Ulpp	Unit Intervals peak to peak
UNI	User Network Interface
VC	Virtual Container
VF	Voice Frequency
WDM	Wavelength Division Multiplexing

## 4 Configuration of an OAN

The configuration of an OAN is considered in this clause. It provides an introduction to the detailed requirements of an OAN.

NOTE: The functional architecture issues are under study in ETSI Sub Technical Committee (STC) TM3.

### 4.1 Topological and functional issues

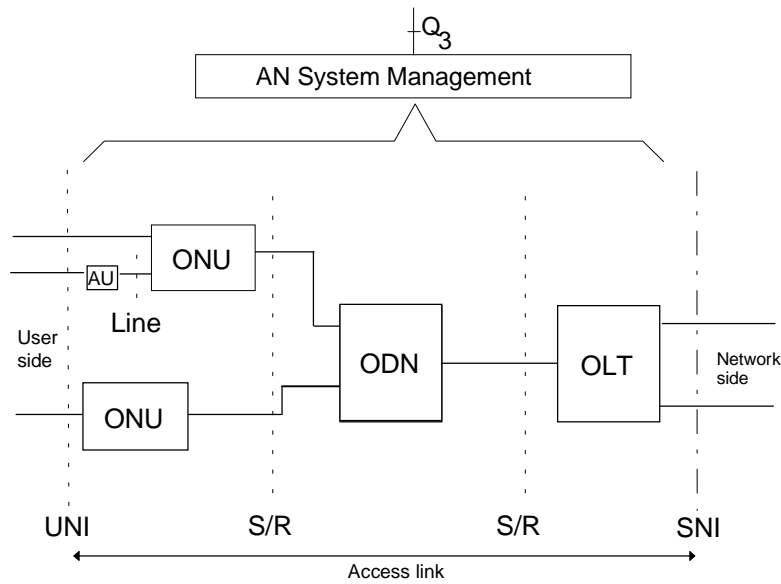
A configuration for an OAN is shown in figure 1. An OAN consists of:

- a) one OLT;
- b) at least one ODN;
- c) at least one ONU;
- d) AUs.

The ODN provides the optical transmission means from the OLT towards the users and vice versa. ONUs provide the user-side interface of the OAN and are connected to the ODN. The functions comprised by the AU include adaptation of the service interfacing between ONU and user (e.g. conversion of data communication protocols and rates) as well as transportation of the service over the last drop between the ONU and user when these interfaces do not coincide (e.g. Network Termination 1 (NT1) for Integrated Services Digital Network, Basic Access (ISDN-BA)).

The reference points User Network Interface (UNI) and Service Node Interface (SNI) as well as the Q3 interface shown in figure 1. The R and S reference points are described in prETS 300 681 [5].

NOTE: Standardization work related to such an AU is outside the scope of this ETS.



**Figure 1: Example configuration for an OAN**

A functional architecture of the OAN in accordance with the principles of ITU-T Recommendation G.803 [22] is shown in figure 2. ISDN-BA is the adapted service shown in this architecture. The Service Node Interface (SNI) is according to V5.1, see ETS 300 324 [13]. The multiplexing of the user individual D-channels is performed on a higher layer and not shown in this structure. The structure of D and D\* are not identical. Although a number of other options exist (e.g. leased lines, V5.2, etc.) they are not shown on this diagram.

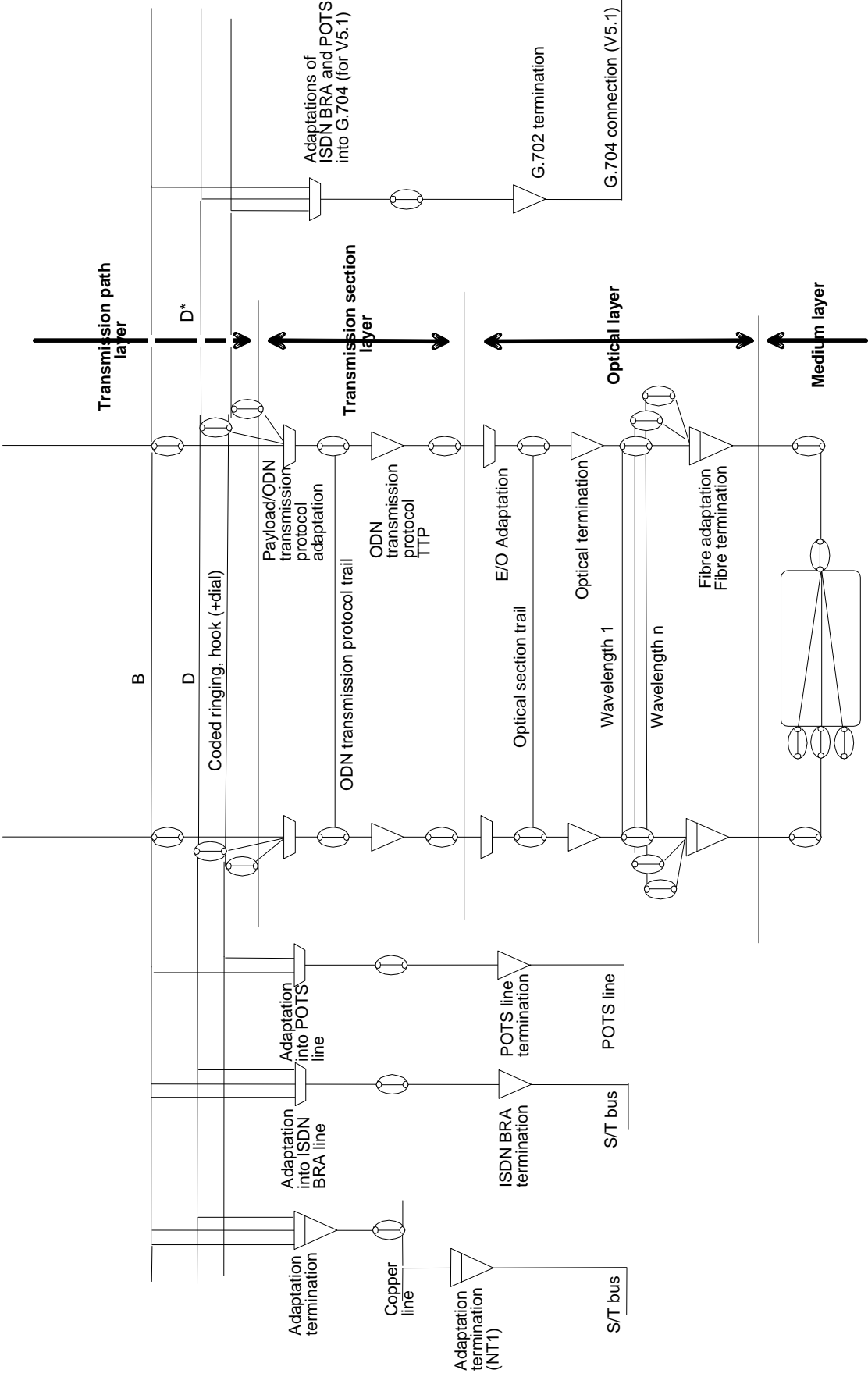


Figure 2: Example architecture configuration for the OAN

## 4.2 Service capability

The OAN shall be capable of supporting the following services:

- a) POTS;
- b) leased lines;
- c) packet data;
- d) ISDN-BA;
- e) ISDN Primary Rate Access (ISDN-PRA);
- f)  $n \times 64$  kbit/s;
- g) 2 Mbit/s (structured or unstructured).

## 5 ONU

The ONU provides an optical interface towards the ODN and implements the interfaces at the customer side of the OAN. ONUs shall be located on the customer's premises (fibre to the home, fibre to the office, fibre to the building) or in the field as part of the optical access section (fibre to the kerb). The ONU provides the means necessary for delivering the different services that are to be handled by the system.

### 5.1 Description of functions

Figure 3 shows a functional description of the ONU. It is useful for standardization purposes to consider the ONU in terms of three parts, these are defined as:

- a) core shell;
- b) service shell;
- c) common shell.

The functionality of these shells is described in subclauses 5.1.1 to 5.1.3.

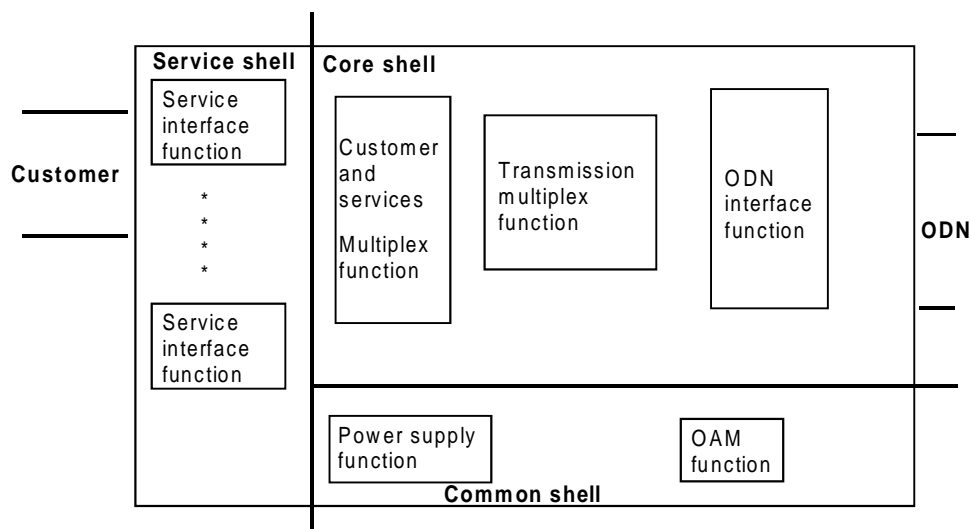


Figure 3: ONU functional blocks

### 5.1.1 ONU core shell

The ONU core shell includes:

- a) ODN interface;
- b) transmission multiplexing;
- c) customer and service multiplexing functions.

The ODN interface function provides a set of optical physical interface functions terminating the relevant set of optical fibres of the ODN, and includes optical/electrical and electrical/optical conversion.

The transmission multiplexing function provides the necessary functions for evaluation and allocation of the incoming and outgoing signals from and to the ODN Interface Function extracting and inputting the information relevant to this ONU.

The customer and service multiplexer function assembles/disassembles the information from/to the different subscribers and connects the individual service interface functions.

### 5.1.2 ONU service shell

The ONU service shell provides the service interface functions.

The service interface functions provide the customer service interfaces and their adaptation into 64 kbit/s or  $n \times 64$  kbit/s. The function can be provided for a single customer or a group of customers. It also provides signalling conversion functions according to the physical interface (e.g. ringing, signalling, Analogue to Digital (A/D) and Digital to Analogue (D/A) conversions).

### 5.1.3 ONU common shell

The ONU common shell includes power supply and Operations Administration and Maintenance (OAM) functions.

The power supply function provides the powering to the ONU (e.g. Alternating Current (AC) to Direct Current (DC) or DC to DC conversion).

Power shall be provided locally (from mains) or remotely. The power supply may be shared by several ONUs. The ONU shall be capable of operating via a battery back-up source.

The OAM function provides the means to handle the OAM functionality to all blocks of the ONU (e.g. control of loop backs in the different blocks).

NOTE: For local control an interface may be provided for testing purposes.

## 5.2 ONU dimensions

The ONU dimensions considered in this subclause refer to issues relating to the service capacity.

An ONU is defined as being of a specific type and belonging to a specific class.

Five types and three classes are described. The types are described in terms of number of POTS circuits which can be provided and are shown in table 1:

**Table 1: ONU type description**

	<b>Maximum number of POTS circuits that can be equipped</b>
Type I	4 POTS
Type II	12 POTS
Type III	30 POTS
Type IV	60 POTS
Type V	120 POTS

The classes of ONU are defined by the maximum throughput required at the customer side of the ONU. This is defined in terms of the usable B channels (where B is a 64 kbit/s bearer channel). Control and signalling channels are not generally included except where carried within the bearer channels (e.g. ISDN Primary Rate Access (ISDN PRA)).

Three classes are defined as shown in table 2:

**Table 2: ONU Class description**

	<b>Maximum number of B channels</b>
Class 1	4B
Class 2	32B
Class 3	64B

ONU types and classes above and below the values described in tables 1 and 2 have not been defined and are for further study.

It shall be possible to reallocate unused B channels from one ONU to any other ONU up to their maximum capacity. For example: a class 3 ONU has a maximum throughput of 64 B. If only 30 POTS lines are required then 34 B can be reallocated to other ONUs.

It shall be possible to mix different ONU types and classes on the same ODN.

The relationships between types and classes are described in annex A.

To calculate the above service capacities the following equivalents shall be used:

- 1 x 64 kbit/s:
- = 1 analogue telephone access (POTS);
- = 1 analogue customer access for fixed connections (leased line);
- = 1 digital customer access for fixed connections 64 kbit/s (leased line);
- = 1 data access  $\leq$  64 kbit/s;
- = 1/2 ISDN-BA;
- = 1/32 ISDN-PRA;
- = 1/32 digital customer access for fixed connections 1,984 Mbit/s (leased line);
- = 1/32 digital customer access for fixed connections 2,048 Mbit/s (unstructured leased line).



The SUs of the ONUs as an example may be equipped as follows: 2 analogue telephone accesses (POTS) per card; 2 analogue fixed accesses (leased lines) per card; 2 digital fixed accesses 64 kbit/s (leased lines) per card; 1 ISDN-BA (T interface) per card; 1 ISDN-BA (Line interface) per card; 1 ISDN-PRA per card and 1 digital fixed access 2 Mbit/s (leased line) per card.

### 5.3 User to Network Interfaces (UNIs)

The narrow band ISDN and POTS interfaces have been identified and the existing UNIs shall be used:

analogue telephony services:	national;
analogue leased line services:	national;
ISDN-BA:	ETS 300 012 [9]; for ISDN BA, this also could be a line interface, where the NT is connected to the ONU using a transmission system according to ETR 080 [7];
ISDN-PRA:	ETS 300 011 [8];
circuit switched and packet data services:	the customer interface for data services should be 64 kbit/s according to ITU-T Recommendation G.703 [20]; or 2 Mbit/s according to ITU-T Recommendations G.703 [20] and G.704 [21];

NOTE 1: The conversion to the appropriate data network interface may be provided by an AU which is not part of the OAN. In case the ONU is not located at the customers premises, an AU as part of the OAN is also needed to facilitate the transport of this 64 kbit/s bearer channel made available at the interface of the SU concerned.

digital leased line services:

64 kbit/s ITU-T Recommendation G.703 [20]:	ETS 300 288 [12];
64 kbit/s ITU-T Recommendation I.430 [25]:	similar to ETS 300 012 [9];
1 984 kbit/s:	ETS 300 418 [19] (D2048S);
2 048 kbit/s:	ETS 300 418 [19] (D2048U);
n x 64 kbit/s ( $n \leq 30$ ):	ETS 300 418 [19] (D2048U).

For the unstructured 2,048 Mbit/s:

In the case when a Synchronous Digital Hierarchy Virtual Container 12 (SDH VC12) path is used this shall be terminated in the ONU. A justification mechanism has to be used to provide the possibility of third party timing.

NOTE 2: The transport of the SDH VC12 and the related timing does not require standardization.

A method similar to the ITU-T Recommendation G.832 [24] can be used in 2,048 Mbit/s oriented networks. Another possibility is the transport of the complete SDH TU12 including pointers in a OAN providing a flexible transmission frame.

### 5.4 ONU power considerations

For each ONU type the minimum, maximum and typical power requirements and the conditions used to calculate them shall be provided. The specific powering requirements of the different interfaces (as defined in subclause 5.3) shall be considered.

Power used for battery charging should not be included in the core power consumption values, however, this power parameter shall be provided.

The loop resistance up to the network termination point is dependant on the national implementation, 300  $\Omega$  should be used for calculation purposes.

The powering requirements calculation for an ONU shall take into account the environmental class described in ETS 300 019 [10].

A detailed description of the powering aspects of ONUs and examples of power consumption values are shown in annex B.

## 6 ODN

The detailed specification of the ODN is considered in prETS 300 681 [5].

### 6.1 General ODN requirements

The ODN is based on point-to-multipoint tree and branch options as described in prETS 300 681 [5].

The ODN includes no optical to electrical conversion.

ODN optical elements may be co-located with the ONU and/or OLT.

The ODN shall support operation in the second and third wavelength regions as described in prETS 300 681 [5].

### 6.2 Reach limitations and split ratios of the ODN

In this subclause all distances quoted refer to fibre kilometres. The OAN system shall be able to operate over a distance up to 20 km.

Two OAN system types are described which are based on the transmission methods considered in clause 8. OAN systems type 2 have restricted ODN requirements e.g. Time Compression Multiplexing (TCM).

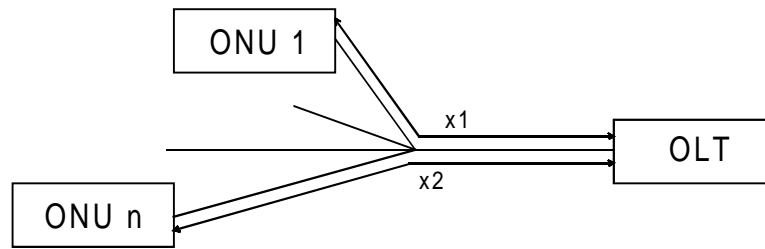
At the given distances in table 3 the split ratios shown are required.

**Table 3: OAN system types**

Distance	OAN system type 1 (e.g. SDM, WDM, FDM)	OAN system type 2 (e.g. TCM)
20 km	A split ratio of at least 16 way shall be supported	A split ratio of at least 8 way shall be supported
10 km	A split ratio of at least 32 way shall be supported	A split ratio of at least 16 way shall be supported
SDM: Space Division Multiplexing WDM: Wavelength Division Multiplexing FDM: Frequency Division Multiplexing		

The path losses for the above requirements are calculated in prETS 300 681 [5].

There is a OAN system requirement to operate with a differential fibre distance ( $\Delta$ ) between the nearest and furthest ONU from the OLT as defined in figure 4.



- x1: Shortest distance between OLT and ONU of an ODN.  
x2: Longest distance between OLT and ONU of an ODN.

**Figure 4: Reach limitations of PONs**

The differential fibre distance ( $\Delta$ ) =  $x2 - x1$

The OAN system must be capable of operating over an ODN such that the differential fibre distance ( $\Delta$ ) between the nearest and furthest ONU from the OLT is anywhere between 0 km and at least 5 km.

NOTE: If the OAN system will not provide service to ONUs when the distance between the nearest and furthest ONU from the OLT is 4,5 km then the system does not meet this requirement. However if the OAN system will provide service to ONUs when the distance between the OLT and the nearest and furthest ONU is 5,1 km, 10 km or 20 km (i.e. greater than or equal to 5 km) then the system meets the requirement).

## 7 OLT

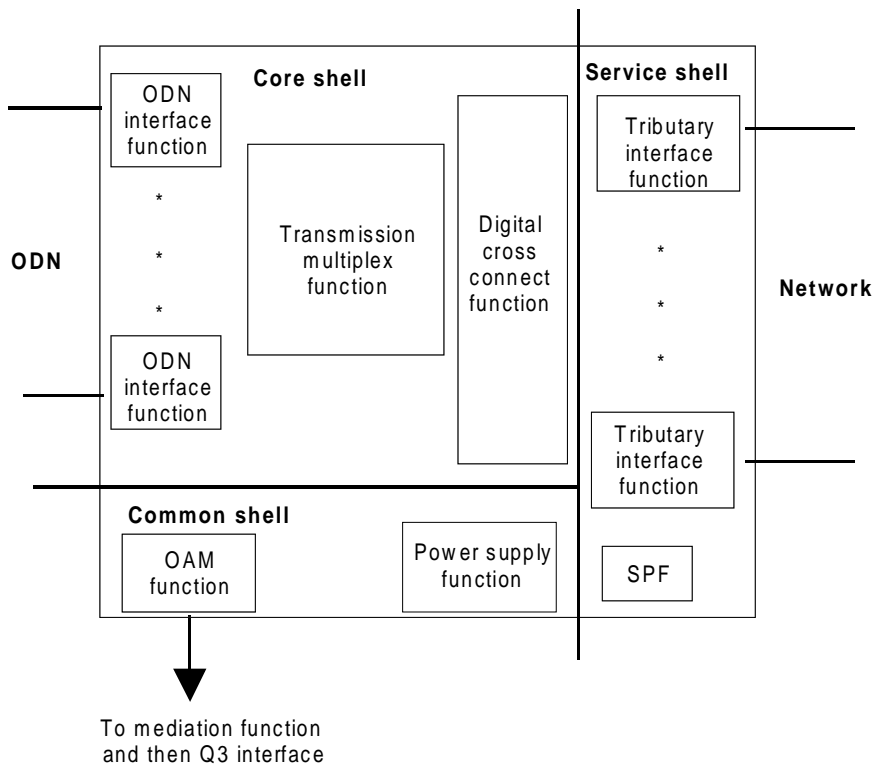
The OLT provides at least one optical interface towards the ODN and provides at least one network interface on the network side of the OAN. The OLT can be co-located within a local exchange or at a remote location. It comprises the means necessary for delivering different services to the required ONUs.

### 7.1 Description of functions

Figure 5 shows a functional description of the OLT. It is useful for standardization purposes to consider the OLT in terms of three parts, these are defined as:

- a) core shell;
- b) service shell;
- c) common shell.

The functionality of these shells is described in subclauses 7.1.1 to 7.1.3.



SPF:        Signalling Processing Function

**Figure 5: OLT functional blocks**

**7.1.1        OLT core shell**

The OLT core shell includes:

- a)    ODN interface;
- b)    transmission multiplexing;
- c)    customer and service cross connect functions.

The ODN interface function provides a set of physical optical interface functions terminating the relevant set(s) of optical fibres of the ODN(s), and includes optical/electrical and electrical/optical conversion.

In order to enable implementation of protection switching between geographically redundant routes up to a flexibility point in the ODN where optical fibre splitting occurs, the OAN system should provide the possibility of optionally equipping the OLT with a duplicate ODN interface. This is in addition to the maximum number of ODNs that the OLT is designed for normal operation.

Detailed characteristics of possible protection mechanisms are not considered in this ETS.

The transmission multiplexing function provides the necessary functions for transmitting or receiving service channels over the ODN.

The customer and service cross connect function provides connectivity between the available bandwidth at the ODN side and the network parts at the network side.

Full access shall be provided.

### 7.1.2 OLT service shell

The OLT service shell can include NT interface and signal processing functions.

A TU is an FRU with one or more tributary interface functions.

A network tributary interface function is a 2 Mbit/s port (described in subclause 7.3) on a TU, it provides the interface between the OLT and the main network. They shall be specific to a single service, configurable to one of a number of services, or capable of simultaneously supporting two or more different services.

Any TU that provides two or more 2 Mbit/s ports shall be independently configurable on a per port basis. For this type of multi-port TU, it shall be possible to configure each port to a different service.

Each TU position in the OLT equipment shall be capable of accepting a TU of any type.

The OLT shall be able to support any number of TUs up to the designed maximum number in any combination of services.

The signal processing functions provide the means for handling signalling information through the OLT.

### 7.1.3 OLT common shell

The OLT common shell can include power supply and OAM functions.

The power supply function converts an external power source to the required level.

The OAM function provides the means to handle the OAM functionality to all blocks of the OLT.

It also provides an interface function both for local control for testing purposes and for the Q interface for the Access Network ( $Q_{AN}$ ) interface towards the Operations System (OS) via a mediation function.

## 7.2 OLT dimensions

The OLT dimensions considered in this subclause refer to issues relating to the service capacity.

The OLT dimensions are described in table 4. Two OAN system types are described which are based on the transmission methods considered in clause 8. OAN systems type 2 have restricted ODN requirements e.g. TCM.

**Table 4: OLT dimensions**

Reference	OAN system type 1 (e.g. SDM, WDM, FDM)	OAN system type 2 (e.g. TCM)
Number of tributary interface functions	at least 32	at least 32
Number of ODN Interfaces	at least 4	at least 4
Total OLT cross-connect function capability	at least 800B	at least 800B
ODN interface capacity	at least 200B	at least 100B

### 7.3 SNIs

The SNIs used should be as described in table 5.

**Table 5**

<b>POTS:</b>	<b>V5.1 (ETS 300 324 [13]) / V5.2 (ETS 300 347 [14])</b>
ISDN-BA:	V5.1 (ETS 300 324 [13]) / V5.2 (ETS 300 347 [14])
ISDN-PRA:	V3 (ETS 300 233 [11])
ISDN-PRA(sub filled):	V5.2 (ETS 300 347 [14])
Data services:	2 Mbit/s according to G.703 and G.704
Analogue leased lines:	
with inband signalling:	2 Mbit/s according to G.703 and G.704
with outband signalling:	2 Mbit/s according to G.703 and G.704 plus national signalling
Digital leased line services:	2 Mbit/s according to G.703 and G.704
64 kbit/s G.703:	2 Mbit/s according to G.703 and G.704
64 kbit/s I.430:	2 Mbit/s according to G.703 and G.704
1 984 kbit/s:	2 Mbit/s according to G.703 and G.704
2 048 kbit/s unstructured:	2 Mbit/s according to G.703
G.703:	ITU-T Recommendation G.703 [20].
G.704:	ITU-T Recommendation G.704 [21].
I.430:	ITU-T Recommendation I.430 [25].

There is a possibility that these interfaces could be mapped on to SDH transport mechanism as an alternative method.

## 8 Specific attributes of OANs

In this clause the key features of OANs to meet the requirements of the network operators are described.

### 8.1 Transmission method

The transmission method shall allow the OLT-ONU connection to be point-to-multipoint.

The transmission method shall also allow point-to-point inter working between the OLT and the ONU, however, this should be considered as a subset of the transmission mechanism capabilities. Specific optimized point-to-point systems are outside the scope of this ETS.

The multiple access method shall be based on the TDMA and/or SCMA transmission method.

The bi-directional transmission scheme shall be based on one of the following procedures:

- SDM (2 fibres, simplex);
- TCM (1 fibre, half-duplex);
- WDM (1 fibre, diplex).
- FDM (1 fibre, duplex).

### 8.2 Operating wavelength range for an OAN

The operating wavelength range described in this subclause refers to the system wavelength for providing narrowband services. It is possible that wavelengths outside these regions may be simultaneously present on the same ODN (e.g. for testing purposes), these could be considered as interfering signals. The OAN should continue to operate normally in the presence of interfering signals.

It is important to consider the operating wavelength range in two directions as the possible use of wavelength may be different in each direction.

**8.2.1 SDM**

The operating wavelength range shall be within the 1 310 nm region as defined in prETS 300 681 [5].

**8.2.2 TCM**

The operating wavelength range shall be within the 1 310 nm region as defined in prETS 300 681 [5].

**8.2.3 WDM**

The operating wavelength range shall be within the 1 310 nm region as defined in prETS 300 681 [5].

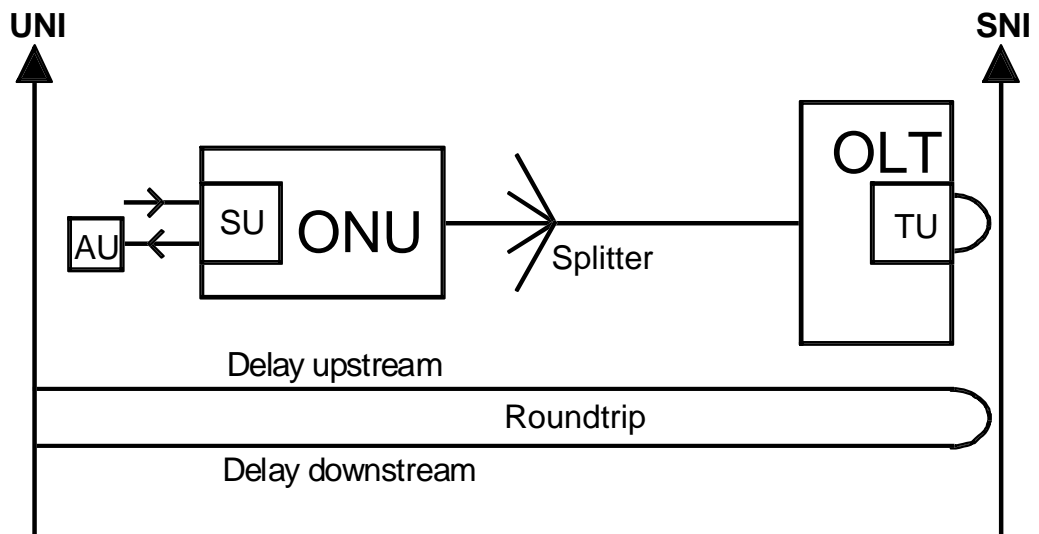
As an interim solution, due to economical and technical issues, the operating wavelength range for downstream direction (OLT to ONU) could be within the 1 550 nm region as defined in prETS 300 681 [5].

**8.2.4 FDM**

The operating wavelength range shall be within the 1 310 nm region as defined in prETS 300 681 [5].

**8.3 Signal transfer delay**

The figures below define the mean signal transfer delay as the average of the upstream and the downstream values. The mean signal transfer delay time is the measured round trip delay time divided by two, as shown in figure 6. All the defined values assume a 10 km distance of the ODN. The length of the metallic drop shall be neglected.



$$\text{mean signal transfer delay} = \frac{\text{delay downstream} + \text{delay upstream}}{2}$$

**Figure 6: Signal transfer delay calculations**

In the case of an OAN two applications shall be considered (see figure 1):

- a) provision of an ISDN-BA where the NT1 function is remote from the ONU. In figure 1 this application is bounded by the reference points SNI and UNI. The AU represents the NT1. The mean signal transfer delay between SNI and UNI shall be less than 2 ms;
- b) provision of an ISDN-BA where the NT1 function is an integral part of the ONU. In the figure this application is bounded by the reference points SNI and UNI. The mean signal transfer delay between SNI and UNI shall be less than 1,5 ms.

For other services (considered in subclause 5.3) which do not require an AU, the mean signal transfer delay value shall be less than 1,5 ms.

NOTE: The mean signal transfer delay could be measured as shown in annex C.

## 9 Timing and synchronization

### 9.1 Synchronization architecture

An OAN system will in general carry 64 kbit/s switched services. To minimize octet slip on these services the timing of the OAN system has to be traceable to the same Primary Reference Clock (PRC) as the PSTN switches within an operator's domain.

ETS 300 462-2 [17] (synchronization network architecture) describes the recommended method for distribution of synchronization to synchronous equipment.

If the OLT of an OAN system is located in a station with a clock of Synchronization Supply Unit (SSU) quality, the OAN system clock shall be synchronized to this SSU.

The operating clock of the OAN shall be derived from one of the following three options:

- a) option 1: Tributary interface function source (e.g. V5 interface source);
- b) option 2: An external source.

In the case of a failure mechanism precluding the above options a clock derived from an internal oscillator within the OLT shall be used. This is considered as option 3:

- c) option 3: An internal oscillator source.

Each of these options are now considered.

For option 1: If the SSU is contained within the PSTN switch to which the OAN system is connected, the OAN should take its timing reference from 2 048 kbit/s traffic carrying interfaces via which it is connected to the switch (e.g. V5.1 interface or a link of a V5.2 interface). If the SSU is not contained within the PSTN switch the OLT timing can be derived from other SSU timing carrying tributary interface functions.

If the OLT of an OAN system is remotely located synchronization should be derived from 2 048 kbit/s traffic carrying interfaces as long as the jitter and wander at the interface is within the network limits.

For option 2: If the SSU is implemented as a stand alone synchronous equipment the OAN system could take its timing directly from this equipment via 2 048 kbit/s external synchronization interfaces.

NOTE: The use of 2 048 kbit/s external synchronization interfaces is for further study.

For option 3: The frequency and accuracy of the internal reference must be at least 2 048 kHz  $\pm$  50 ppm. In general for this option the OAN will continue to operate but with some degradation to the quality of service.



## 9.2 Protection and ONU timing

To provide resilience against single failures the OLT shall be provided with at least two synchronization interfaces and shall support automatic reference switching in case of a reference failure.

Within an OAN system, timing will be distributed from the OLT to the ONUs connected to it via the optical bearer. This implies that 64 kbit/s services will be retimed in the ONU with the synchronization reference supplied from the OLT.

Services such as 2 Mbit/s unstructured cannot be treated in the same fashion. These services are intended to support the transport of third party timing and therefore require the OAN to be clock transparent. The mechanism used to support clock transparency shall be independent of the synchronous clock of the OAN system.

## 9.3 Synchronization interfaces

### 9.3.1 Jitter and wander tolerance

Jitter and wander acceptance at a 2 048 kHz synchronization interface shall comply with the limits stated in ETS 300 462-5 [18] for an SDH equipment clock. This will also satisfy the PDH requirements

## 9.4 Network side interfaces for synchronous services

### 9.4.1 Jitter and wander tolerance

Jitter acceptance at 2 048 kbit/s interfaces shall be according to ITU-T Recommendation G.823 [23] for low-Q. More detail is described in ETS 300 324-1 Amendment 1 [13]. Acceptance of phase variations in the wander region of the ITU-T Recommendation G.823 [23] mask is the minimum requirement for OLTs that are co-located with an SSU. To allow for remote location of OLTs the maximum acceptable differential wander between any two inputs shall be 26  $\mu$ s. The timing configuration is shown in figure 7 with:

- the network nodes (i.e. the NNI) synchronized from a PRC;
- a 4  $\mu$ s maximum wander between network nodes;
- an additional 8  $\mu$ s wander introduced when using an additional trunk SDH transport between a network node and the OLT.

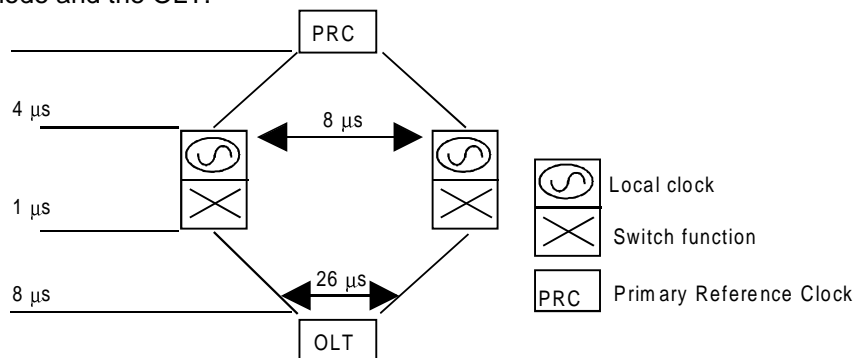


Figure 7: Differential wander calculation

### 9.4.2 Jitter and wander generation

The output jitter at a 2 048 kbit/s interface shall be less than 0,1 Ulpp when measured through a 20 Hz to 100 kHz bandpass filter and less than 0,075 Ulpp when measured through a 18 kHz to 100 kHz filter.

The OLT shall not add any noticeable wander to the wander offered at the synchronization interface, i.e. the wander amplification at any frequency shall be less than 0,1 dB.

NOTE: When a standard describing the jitter and wander generation is available these values shall be reviewed to comply with the standard.

## **9.5 User side interfaces for synchronous services**

### **9.5.1 Jitter and wander tolerance**

At the UNI the jitter and wander tolerance limits for the service that the OAN system is carrying shall apply. These can be found in ETS 300 012 [9] for ISDN BA and ETS 300 011 [8] for ISDN PRA.

### **9.5.2 Jitter and wander generation**

At the UNI the jitter and wander generation limits for the service that the OAN system is carrying shall apply. These can be found in ETS 300 012 [9] for ISDN BA and ETS 300 011 [8] for ISDN PRA.

## **9.6 Timing requirements for asynchronous services**

The timing requirements for asynchronous services require further study.

# **10 OAM**

## **10.1 General OAM requirements**

The general OAM requirements shall be defined according to ITU-T Recommendation M.3010 [26]. More specific OAM requirements are considered in prETS 300 736 [6].

A framework has been used which consists of two axes along which the OAM functions can be classified. The first axis consists of the functional subsystem of the OAN to which the OAM function relates. The second axis is the OAM functional category to which the OAM function belongs.

The following functional sub-systems shall fulfil the OAM requirements:

- a) enclosures;
- b) power;
- c) transmission;
- d) optical subsystem;
- e) service subsystem.

There are different ways in which OAM functions can be categorized. The categorization used here is derived from the Open Systems Interconnection (OSI) management information service definition architecture. In addition, testing has been included in the performance management category in accordance with the other aspects of OSI Fault Management category.

OAM requirements by functional category can be defined by the following five categories:

- a) access & security management;
- b) configuration & resource management;
- c) performance management;
- d) event (alarm) management;
- e) financial (accounting) management.

An example for these functional sub-systems and functional categories is shown in annex D.

For the OAM functionality the ability to address up to 128 logical fibre ends per ODN is required.

The management interface for the access network shall be at the OLT and shall be connected via a mediation function in cases where a full Q3 protocol interface is not supported by the OLT.

## 10.2 Line configuration and testing

Interworking via the management interface is required for the configuration of the OAN. The PSTN and ISDN configuration management is described in ETS 300 376-1 [15].

It may be necessary to select the function of line circuits. Different parameters have to be set in order to put the line circuit into the correct configuration e.g. Voice Frequency (VF)-relative input level, VF-relative output level, VF-impedance, metering pulse frequency, metering pulse level.

For line circuit operation there are different operational states to be performed by the line circuit.

In case of a digital test loop the digital data dedicated for the line circuit is looped through the line circuit. The terminal is disconnected.

In the case of the analogue test loop the analogue VF-output signal is connected to the VF-analogue input. The terminal has to be disconnected.

An exhaustive study of line testing requirements is described in ETS 300 378-1 [16].

During copper line testing the following measurements may be required (this list is not intended to be exhaustive):

- a) feeding current = [Within limit], [Out of limit];
- b) difference current = [Within limit], [Out of limit];
- c) loop impedance = [Within limit], [Out of limit];

NOTE: For the supervision of the feeding condition the following parameters may be required measurements:

- d) feeding voltage = [Within limit], [Out of limit];
- e) ringing generator voltage = [Within limit], [Out of limit];
- f) metering pulse signals = [Within limit], [Out of limit].

Examples of line configuration and testing are shown in annex D.

## 10.3 OAN operation

In this subclause the remainder of the requirements for the OAN operation are considered.

The system shall be designed for full access such that any service channel function on any ODN of one OLT can provide service via any service channel on any TU of the appropriate service type. This configuration shall be under the control of the OS.

The system should be designed to minimize interruption to customers as a result of common equipment replacement.

It shall be possible to connect and disconnect individual ONUs from an ODN without affecting service on any circuit on any other ONU operating on the same ODN.

Configuration of services on an ONU shall not affect the operation of any other service on that, or any other ONU.

It shall be possible to equip the ONUs of an ODN such that their combined potential service capacity exceeds the total service capacity of the OLT ODN interface.

Any fault occurring on any ONU shall not affect service on any other ONU.

All ONU traffic, call control, synchronization, system management and service management information shall be transmitted via the ODN using the core transmission system.

The system shall be designed such that a break in any of the fibres in the fibre network will not affect the operation of any ONU not served by those fibres.

The removal and insertion, or shutdown and restart, of any FRU shall not affect the operation of any circuits other than those directly supported by that FRU.

All FRUs should be easily accessible and replaceable.

## **11 Security of OANs**

The security aspects of both the equipment and data are considered in this ETS.

### **11.1 General information**

The council of the European Commission (EC) has issued a proposal for a council directive concerning the protection of personal data and privacy of public network. The titles of these directives are:

- SYN 287 [1].

Proposal for the council directive concerning the protection of individuals in relation to the processing of personal data:

- SYN 288 [2].

Proposal for the directive concerning the protection of personal data and privacy in the context of public digital telecommunication networks, in particular the ISDN and public digital mobile networks.

NOTE: Also the legal texts of some European countries demand security measures in public networks.

Due to the distribution characteristics of an OAN, data of one customer can reach in the downstream direction all ONUs on that OAN. Therefore it is very important to consider the security aspects on this network.

The terminology used here is consistent with that used in the EC document "Information Technology Security Criteria (ITSEC) [27]".

The splitter based ODN system should use appropriate mechanisms and procedures to be resistant to the following threats:

- malicious damage;
- malicious intrusion;
- eavesdropping;
- masquerading.

The minimum strength of mechanism rating should be "medium" as specified in ITSEC [27].

The assurance of correctness and effectiveness of the mechanisms and processes used to counter threats should be commensurate with ITSEC level E3 and, in addition, the aspect of "Start-up and Operations" covering "Secure Restart" should be included.

## 11.2 Identification and authentication

The OS should authenticate all FRUs on power up.

It should not be practical for an unauthorized person to determine the configuration status of any ONU.

The FRU is the smallest unit that can be identified, and the inventory information for each FRU should be unique.

An authentication process should be triggered by the power up of an OLT or ONU and also when a FRU is added to an existing OLT or ONU. This authentication process checks that the FRU types fitted match the OS database such that the OS reports any discrepancies to a user or a higher level OS.

It should not be possible for an unauthorized person to change the serial number of any FRU.

## 11.3 Access control

An FRU should not allow access to information and resources unless access to that information or resource is requested and authorized. Unauthorized reading, creation, amendment or deletion of information should be prevented. The ONU should be enclosed and physically locked such that unauthorized access to any ONU FRU is prevented. Opening the ONU enclosure should cause an event report to be sent to the OS.

Further measures, other than the locked ONU enclosure, should be provided at the ONU to restrict physical access to:

- a) data relating to other customers and other ONUs;
- b) electrical drive signals used to modulate the ONU optical transmitter.

If an ONU loses management communications with its OLT it should cease transmitting customer data. It should be possible to attempt to override this facility via the OS.

If an OLT loses management communications with an ONU it should attempt to cease the transmission of customer data by that ONU. It should be possible to attempt to override this facility via the OS.

If an OLT loses management communications with all dependent ONUs on any ODN interface, it should cease transmitting customer data from that ODN interface. It should be possible to override this facility via the OS.

## 11.4 Accountability and audit

Details of any change to the physical configuration of the system should be sent to the OS.

In the event of management communications failure between the OLT and the OS, event reports information should be stored at the relevant OLT until management communications has been restored, when this event report information should be sent to the OS.

## 11.5 Accuracy

The correctness of security related information should be preserved. Unauthorized modification of security related information or of the relationships between different items of security related information should be prevented.

## 11.6 Availability

Security related information and operational system resources and information should be provided to FRUs when they are needed.

## 11.7 Data exchange

The integrity and confidentiality of system management data should be preserved during transmission over the core transmission system.

The integrity of system management data should be verifiable during transmission over the core transmission system.

The confidentiality of customer data transmitted from the OLT to all dependent ONUs, and from the ONU to its dependent OLT should be preserved.

The unauthorized flow of information resulting from consecutive use of different FRUs should be prevented.

## 11.8 Layers of physical security

Security of OANs can be considered in three layers physical security, transmission system security and service security as shown in figure 8.

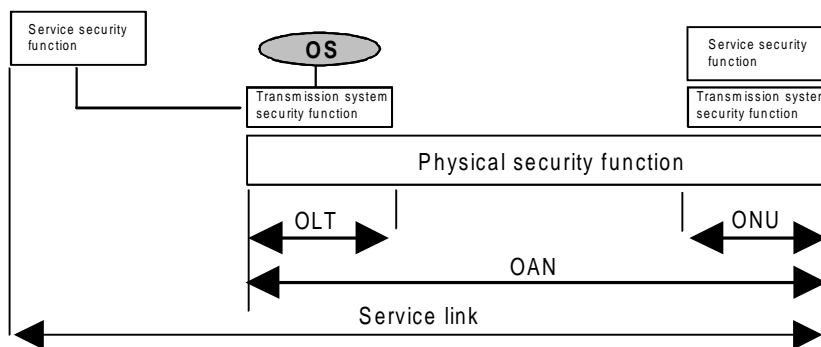


Figure 8: Layered approach to security of OANs

### 11.8.1 Physical security function

This first layer of security include the measures to provide security for the physical units:

- cables;
- shelves;
- splitter boxes;
- home ONU enclosures;
- kerb/ cabinet ONU enclosures.

Measures for this purpose can be:

- locks;
- supervision of optical attenuation;
- door contacts;
- lead marking.

### 11.8.2 Transmission system security function

This layer is providing the security for the core transmission system. The related security contains functions which are common for the core transmission system. This layer contains:

- the authentication processes for the FRUs;
- measures for access control of ONUs;
- measures for access control of data in the core transmission system.

These measures are provided centrally for the core transmission system. That means they are common for all ONUs. The following related messages have to be handed to the OS:

- inventory information;
- access control information;
- change of physical configuration.

The authentication process will also be controlled by the OS.

### 11.8.3 Service security function

This layer provides security of the service shell.

For special services where an extreme level of confidentiality has to be guaranteed, the security function has to be implemented related to this services on a link by link bases. This security is service specific and has to be implemented in the service shell.

## 12 Safety

The electrical safety aspects for the ONU equipment shall conform to the following European standards:

- EN 60 950 [4] for equipment fed from mains voltages. Also specifies the requirements for Subscriber Extra Low Voltage (SELV) circuits;
- EN 41 003 [3] for Telecom Network Voltage (TNV) circuits. Also specifies the isolation requirements between the TNV and SELV circuits.

## 13 Reliability and availability

Failure is defined as an event or combination of events which cause an interruption of a given service.

Reliability is the probability of a system operating satisfactorily for a period of time in an environment for which it is designed.

Maintainability is the probability that the maintenance action will restore a system to specified operational conditions within a desired period of time.

Unavailability is the probability that the system is not operating satisfactorily at a given time, it is also the percentage of time when a system is in the "down" condition.

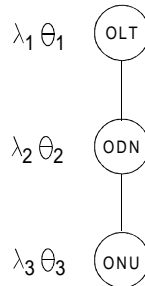
A target value for both the reliability and availability of a particular system scenario could be specific to national requirements although a target figure should be given within a standard in order to limit choices.

The Mean Time Between Failures (MTBF) should be calculated using a serial configuration of the identified sub-functions of an OLT and ONU.

In order to calculate the end to end unavailability of an OAN the following approach is recommended. Consider the following:

- $\lambda_i$  which is the failure rate of the sub system  $i$ ;
- $\theta_i$  which is the Mean Time To Repair (MTTR) of the sub system  $i$ .

The OAN is described as a serial configuration of three sub systems (OLT( $\lambda_1, \theta_1$ ), ODN ( $\lambda_2, \theta_2$ ) and ONU ( $\lambda_3, \theta_3$ )). The network unavailability ( $U_s$ ) can be calculated as indicated in figure 9.



**Figure 9: OAN unavailability calculation**

The OAN unavailability is defined by:  $U_s = \lambda_1 \theta_1 + \lambda_2 \theta_2 + \lambda_3 \theta_3$ .

$\lambda_3$  and  $\theta_3$  take into account the ONU, ONU powering (in the case of local powering) and a separate AU if used.

## 14 Upgrade of OANs

This clause of this ETS is provided for information only.

In order to support the evolution of service demand, OAN systems should include upgrade possibilities. It is anticipated that new services, which are currently not cost-effective or developed, will emerge, and should be supported by the OAN. The means for upgrading the OAN to transport these services should themselves be cost-effective and practical, and cause a minimum amount of disturbance to existing customers on the network, as they are implemented.

The Broadband ISDN (B-ISDN) UNI is under study in TM3, however there may be a requirement for customer interfaces at bit rates between 2 Mbit/s and 155 Mbit/s.

TM3 is studying an evolutionary path from 2 Mbit/s to 155 Mbit/s systems for the OLT taking into consideration the ability to include a concentrating function. Also the use of leased line requirements will have to be considered in this evolutionary path.

For a first upgrade of a PON using Asynchronous Transfer Mode (ATM) we may have to take account of a 155 Mbit/s or 622 Mbit/s interface at the network side but only a lower bit rate than 155 Mbit/s at the user interface side.

Possible mechanisms include the principles given in subclauses 14.1 and 14.2.

### 14.1 ODN considerations

The basic element of the Fibre In The Loop (FITL) system is the cable network. Therefore, initial installation of spare fibres (or providing ducts for later fibre provisioning) in the distribution part of the network between optical splitting point and ONU, and even in the drop section, provides the largest flexibility for later upgrade of new services and for utilising new technologies.



Upgrade will be possible:

- in the drop section:
  - by using the spare fibres or by installation of additional fibre cables in tubes/subducts or ducts;
- in the distribution/feeder section by:
  - adding further optical wavelengths to the existing fibres;
  - use of spare fibres;
  - installation of additional fibre cables in tubes/subducts or ducts.

#### **14.2 ONU considerations**

Several ways exist to upgrade an ONU and many including TDM and WDM are currently under study. TDM with a flexible frame allows an efficient upgrade with the ONU capacity matching with the service demand. The OAN could be prepared in advance for future upgrading by inclusion of optical filtering in front of the optical receivers in the ONUs at the time of installation of the network. This filtering has to block selectively the wavelength region that is not in use by the transmission system for narrow band services. The narrow band service signals being passed remain virtually unaffected.

## **Annex A (informative): Relationship between types and classes for ONUs**

a) For type I:

the ONU may have a fixed configuration and no FRUs are needed. Its capacity can be, for example:

- 4 POTS; or
- 2 POTS + 1 BA; or
- 2 BA.

The maximum bit rate available is always class 1 (4B).

b) For type II:

the maximum number of POTS for this type of ONU should be 12. The maximum throughput that will be required on the customer side of this type of ONU is 32 B (class 2). It is also possible at this ONU type to have for example 10 POTS circuits and one 2 Mbit/s service. For this configuration the maximum bit rate available should be 64 B (class 3);

c) For type III:

the maximum number of POTS for this type of ONU should be 30. The maximum throughput that will be required on the customer side of this type of ONU is 32 B (class 2). It is also possible at this ONU type to have for example 28 POTS circuits and one 2 Mbit/s service. For this configuration the maximum bit rate available should be 64 B (class 3);

d) For type IV:

the maximum number of POTS for this type of ONU should be 60. The maximum throughput that will be required on the customer side of this type of ONU is 64 B (class 3);

e) For type V:

this ONU has a maximum capacity of 120 POTS circuits. For type V no particular class is assigned or even defined, it is left for further study.

## Annex B (informative): An example power consumption for an OAN

An example of the power consumption of ONUs is shown in table B.1.

The inefficiencies of power conversion are not included in this annex.

**Table B.1: Example power consumption of ONUs**

ONU type	Core power consumption	
	Typical	Maximum
I	3 W	7 W
II	5 W	8 W
III	6 W	9 W
IV	8 W	11 W
V	for further study	for further study

**Table B.2: Linecard power consumption**

Condition	Per POTS power consumption	
	Typical	Maximum
on-hook	0,5 W	for further study
off-hook	1,5 W	2 W
ringing (note)	1,5 W	2 W
test head for line testing (if used)	2 W	
NOTE:	Ringing power consumption is additional to on-hook power consumption.	

Tables B.3 and B.4 use the values given in tables B.1 and B.2 to produce an overall summary calculation of the power required.

EXAMPLE 1:                   50 % of the lines are off-hook.  
                                  50 % of the lines are ringing.

**Table B.3**

ONU type	No. of POTS (lines)	Core		No. of lines			off-hook		on-hook		ringing		Sum		
		typ (W)	max (W)	off-hook (lines)	on-hook (lines)	ringing (lines)	typ (W)	max (W)	typ (W)	max (W)	typ (W)	max (W)	typ (W)	max (W)	
I	4	3	7	2	2	2	3	3,4	1	f.f.s	3	4	10	f.f.s.	
II	12	5	8	6	6	6	9	10,2	3	f.f.s	9	12	26	f.f.s.	
III	30	6	9	15	15	15	22,5	25,5	7,5	f.f.s	22,5	30	58,5	f.f.s.	
IV	60	8	11	30	30	30	45	51	15	f.f.s	45	60	113	f.f.s.	
V	120	f.f.s.	f.f.s.	60	60	60	90	102	30	f.f.s	90	120	f.f.s.	f.f.s.	
f.f.s:		for further study.													

EXAMPLE 2: 50 % of the lines are off-hook.  
Number of lines ringing is calculated with Poisson distribution method.

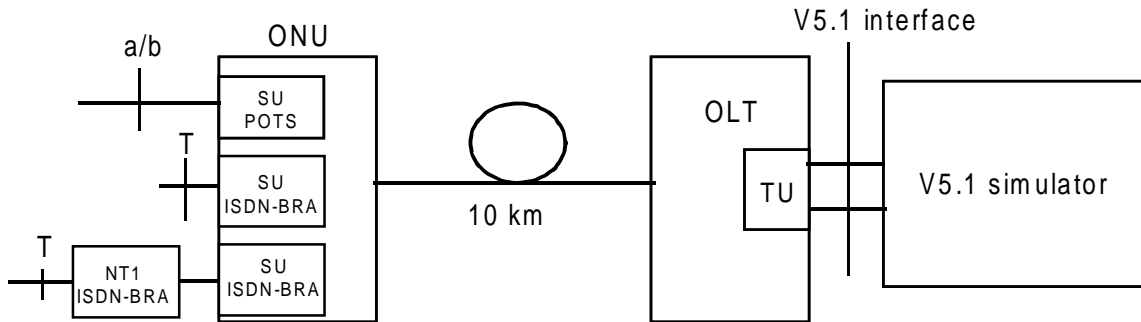
Table B.4

ONU type	No. of POTS (lines)	Core		No. of lines			off-hook		on-hook		ringing		Sum	
		typ (W)	max (W)	off-hook (lines)	on-hook (lines)	ringing (lines)	typ (W)	max (W)	typ (W)	max (W)	typ (W)	max (W)	typ (W)	max (W)
I	4	3	7	2	2	2	3	3,4	1	f.f.s	3	4	10	f.f.s
II	12	5	8	6	6	3	9	10,2	3	f.f.s	4,5	6	21,5	f.f.s
III	30	6	9	15	15	4	22,5	25,5	7,5	f.f.s	6	8	42	f.f.s
IV	60	8	11	30	30	6	45	51	15	f.f.s	9	12	77	f.f.s
V	120	f.f.s.	f.f.s.	60	60	f.f.s.	90	102	30	f.f.s	f.f.s.	f.f.s.	f.f.s.	f.f.s.

f.f.s: for further study.

NOTE: The given maximum values are for further study due to fact that the given on-hook values are also for further study.

**Annex C (informative): Signal transfer delay measurement technique**



**Figure C.1**

A signal is transmitted from the V5.1 Simulator via an OAN with a fibre length of 10 km and looped by the unterminated hybrid of an analogue PSTN port or by a digital loopback 2 at the T-Side of the NT1 function.

The length of the metallic drop should be ignored.

The time difference between the signals transmitted and signal received by the V5.1 simulator is equal to the round trip delay.

The supplier should also provide results of additional measurements with a digital loopback 1 at the ISDN LT-side of the ONU SU in the case of a discrete NT1.

## **Annex D (informative): Framework to capture the OAM requirements**

A brief framework to capture the OAM requirements is discussed in this annex.

### **D.1 Analysis of OAM requirements by functional sub-systems**

For the definition of OAM, a logical division into functional subsystems is provided. The subsystems and their requirements are listed below:

**a) enclosures:**

This subsystem includes the shelving and racking at the OLT and the ONUs. Enclosures also include any indicators (lights, bells, etc.) which are not contained on the cards, and any fibre management equipment. Also included are the field located housings for the optical splitters. The splitters themselves are not included as they are part of the optical subsystem;

**b) power:**

This subsystem includes the powering of the shelves and racks at the OLT and at the ONUs. The ONUs are likely to contain a power supply unit. At the OLT there is likely to be a power unit per shelf and / or a power unit per rack. Power supplies may be duplicated for security;

**c) transmission:**

This consists of transmit and receive electronics and opto-electronics at the OLT and at the ONUs. Fibre management equipment is deemed to be part of the enclosures subsystem, and the optics itself (fibre cabling, filters, splitters, etc.) is dealt with separately;

**d) optical subsystem:**

This subsystem transcends the OAN as it has the ability to support other systems. It consists of fibre in all its forms, the splitters, filters, and any Optical Time Domain Reflectometer (OTDR) equipment or clip-on optical power meters. Enclosures are treated separately, and components which are specific to the OAN are not included as part of the optical subsystem. Fibre management which is specific to the OAN is included under the enclosures subsystem;

**e) service subsystems:**

These consist of the subsystems which tailor the generic core of the OAN to support different services. Two examples of services are PSTN and ISDN.

The PSTN line unit related OAM functions can be separated into:

- 1) line circuit configuration;
- 2) line circuit operation;
- 3) line circuit supervision;
- 4) line terminal supervision.

## D.2 Examples for line circuit supervision

### a) supervision of a POTS line circuit.

The line circuits should be supervised during normal operation. In the case of the specified values being exceeded an alarm should be set.

Supervision of feeding current conditions:

$$\text{DC voltage} < 75 \% U_{\text{MIN.}}$$

Supervision of ringing generator:

$$\text{AC voltage} < 75 \% U_{\sim\text{MIN.}}$$

Supervision of metering pulse signal:

For further study.

Line and terminal supervision.

### b) supervision of a POTS a/b line + terminal.

The a/b wires will be supervised against faults. This may happen as an automatic test. In the case of exceeding the defined maximum and minimum levels an alarm will be set. External voltages at the line will be identified by invalid current values.

EXAMPLE 1: Idle feeding current:  
A fault will be detected if:  $0,1 \text{ mA} < I_{F_{\text{pas}}} < 5 \text{ mA}$   
Idle difference current:  
A fault will be detected if:  $0,5 \text{ mA} < I_{DIF_{\text{pas}}}$   
Active feeding current:  
A fault will be detected if:  $13 \text{ mA} < I_F < I_{\text{Constant}}$   
Active difference current:  
A fault will be detected if:  $I_{DIF} > 7 \text{ mA}$   
Passive line termination:  
A fault will be detected if the measured impedance exceeds:  
 $100 \text{ k}\Omega < R < 500 \text{ k}\Omega + \text{Diode impedance}$   
Idle terminal impedance:  
The ringer impedance will be measured and if the impedance exceeds the value given by:  $R < 10 \text{ k}\Omega$  and  $C > 330 \text{ nF}$  a fault will be detected.

NOTE: The values given above are one example and are for further study.

EXAMPLE 2: Feeding current:  
A fault will be detected if:  
POTS access:  $i_1 < I_{\text{feed}} < 5 \text{ mA}$ ; ( $i_1$  is a national requirement)  
ISDN access:  $I_{\text{feed}} < 1,6 \text{ mA}$  (or  $4,5 \text{ mA}$  if partial activation implemented)  
or if  
POTS and ISDN accesses:  $I_{\text{feed}} > 60 \text{ mA}$   
Difference current:  
A fault will be detected if:  
POTS and ISDN:  $i_x < I_{\text{diff}}$ ; ( $i_x$ : to be defined)  
Installation impedance:  
The purpose of the test is to detect an open line and consists typically in a capacitance measurement.

### D.3 Analysis of OAM requirements by functional category

#### D.3.1 Access and security

The access aspect of this category relates to who or what can gain access to the system and its resources. The security aspect relates to the integrity of the data in the system and the fall back arrangements, for instance in the event of loss of communication with higher level management. Functions in this category include:

- a) enclosures:
  - 1) prevention of unauthorized physical access to enclosures;
  - 2) security of enclosures against deliberate or accidental damage;
- b) power:
  - 1) possible duplication of power suppliers with transparent switch-over;
  - 2) backup in the event of a primary supply failure;
- c) transmission:
  - 1) detection of access to the system by unauthorized ONUs;
  - 2) security of transmission between the OLT and ONUs, including duplication where required;
  - 3) security of stored configuration data;
  - 4) fail-safe operation of lasers in remote ONUs to ensure these cannot transmit at random;
  - 5) security of any downloadable transmission software;
- d) optical subsystem:
  - 1) support of access by clip-on power meters if required;
  - 2) support of access by OTDRs if required;
  - 3) detection of unauthorized tapping of optical signals;
- e) service subsystems:
  - 1) security of service specific configuration data;
  - 2) security of any service specific downloadable software.

#### D.3.2 Configuration and resource management

Configuration management relates to the logical arrangement and topology of the resources within the OAN. Configuration management is responsible for the provision, modification and cessation of capabilities within the system. It also controls reconfiguration for traffic control and any reconfiguration which is required during and after testing.

Resource management relates to the physical organization and detailed structure of the system. It is responsible for keeping an inventory of the components which make up the system, including their version numbers. Resource management is highly implementation dependent.

Functions in configuration and resource management include:

- a) enclosures:
  - 1) support of simple and convenient working practices;
  - 2) simple indication, possibly visual, of configuration of internal components;
- b) power:
  - 1) configuration of duplicated power supplies;
  - 2) support of system auditing;
- c) transmission:
  - 1) configuration of bandwidth between the OLT and ONUs;
  - 2) initialization of ONUs;
  - 3) maintenance of an inventory and status of ONUs and general support of system auditing;



- d) optical subsystem:
  - 1) possible support of identification of OANs and their branches by clip-on power meters or OTDR through "fingerprinting";
  - 2) switching of OTDRs between OANs if required;
  - 3) support of system auditing;
- e) service subsystems:
  - 1) reconfiguration for line test;
  - 2) reconfiguration for loopback tests;
  - 3) configuration of line cards in ONUs;
  - 4) upgrading of line cards in ONUs and of exchange interface at the OLT;
  - 5) support of system auditing;
  - 6) re provisioning through the use of spare line circuits in ONUs.

### **D.3.3 Performance management**

There should be ongoing monitoring of the system. Since automatic routine testing of the system is included here, performance management is also taken to include testing which is initiated through human intervention or in response to an alarm. The passive monitoring of the system should supplement alarms by providing status information and should also initiate alarms.

The functions in performance management include:

- a) enclosures:
  - 1) support of visual monitoring of enclosed components;
  - 2) environmental monitoring of enclosures;
- b) power:
  - 1) operational status of power supplies;
  - 2) monitoring of degradation of power supplies;
  - 3) power supply testing;
- c) transmission:
  - 1) block error rate monitoring for measurable error rates;
  - 2) monitoring of signal to noise for very low errors;
  - 3) monitoring of ranging delays and received power level where applicable;
  - 4) diagnostic testing of transmission;
- d) optical subsystem:
  - 1) monitoring of OAN degradation;
  - 2) fault location on the OAN;
- e) service subsystems:
  - 1) monitoring of exchange interface at the OLT;
  - 2) monitoring of the lines at the ONUs;
  - 3) testing of the exchange interface at the OLT;
  - 4) testing of the line at the ONUs;
  - 5) loopback testing of service capability;
  - 6) installation testing of services.

### **D.3.4 Event (alarm) management**

Alarms are raised to give notice of events which can jeopardize service. There should be different degrees of priority and urgency of these alarms.

The most common response to an alarm will be an attempt to locate the fault through performance management functions. Alarms should be incorporated into a strategy of scheduled preventative maintenance which will reduce the need for the crisis management associated with high priority alarms.

The issues of the alarm priority and the masking of alarms to prevent the swamping of the network management layer are relevant to all functional subsystems. The other functions for discussion for event (alarm) management include:

- a) enclosures:
  - 1) environmental alarms at the ONUs;
  - 2) fault location alarms at the OLT;
- b) power:
  - 1) power unit failure;
  - 2) power source failure;
- c) transmission:
  - 1) loss of communication with an ONU;
  - 2) failure of transmission system at the OLT;
  - 3) excessive errors;
  - 4) excessive variation in received signals;
- d) optical subsystem:
  - 1) fault discovered by automatic testing;
- e) service subsystems:
  - 1) exchange interface alarms at the OLT;
  - 2) fault discovered by routine testing of lines at ONUs.

#### **D.3.5 Financial accounting management**

Financial accounting management is outside the scope of this ETS.

## **Annex E (informative): Bibliography**

- ITU-T Draft Recommendation G.902: "Framework recommendation on functional access networks".

## History

Document history			
March 1995	Public Enquiry	PE 80:	1995-03-06 to 1995-06-30
May 1996	Vote	V 102:	1996-05-06 to 1996-08-09