



INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

I.731

(03/96)

SERIES I: INTEGRATED SERVICES DIGITAL
NETWORK

B-ISDN equipment aspects - ATM equipment

**Types and general characteristics
of ATM equipment**

ITU-T Recommendation I.731

(Previously «CCITT Recommendation»)

FOREWORD

The ITU-T (Telecommunication Standardization Sector) is a permanent organ of the International Telecommunication Union (ITU). The 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 Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1 (Helsinki, March 1-12, 1993).

ITU-T Recommendation I.731 was prepared by ITU-T Study Group 15 (1993-1996) and was approved under the WTSC Resolution No. 1 procedure on the 19th of March 1996.

NOTE

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

© ITU 1996

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 the ITU.

CONTENTS

	<i>Page</i>
0 Introduction	1
1 Scope	1
2 References	1
3 Abbreviations, Terms and Definitions.....	3
3.1 Abbreviations	3
3.2 Definitions.....	4
4 General functional architecture and relationship to ATM network models.....	4
5 Overview of equipment functions	5
5.1 Transfer functions	5
5.2 Layer Management functions.....	9
5.3 ATM Equipment Management Function (AEMF).....	9
5.4 Message Communications Function	10
5.5 Coordination function	10
5.6 Signalling Application	10
5.7 Timing function.....	10
5.8 Interworking functions	10
5.9 Protection switching and restoration	10
6 Equipment types	11
7 Generic performance requirements.....	12
7.1 Reference connections	12
7.2 Quality of Service Aspects.....	12
7.3 ATM Network Element performance objectives	13
8 Timing and synchronization requirements	14
9 Other requirements	14
9.1 Availability.....	14
9.2 Reliability.....	14
Annex A – Examples of ATM equipment	14

SUMMARY

This Recommendation describes the general functional architecture and characteristics of ATM Network Elements (NE) in terms of specific functional blocks derived from the B-ISDN Protocol Reference Model (PRM) described in Recommendation I.321 and the modelling methodology in Recommendations G.805 and I.326.

The intent of this Recommendation is to enable interoperability between ATM equipment based on the specific requirements described for the functional blocks. The more detailed description of the individual functional elements is given in the companion Recommendation I.732.

Clause 5 provides an overview description of the ATM NE functional blocks in terms of the User Plane, Layer Management and Plane Management functions. The Transfer Functions common to both User and Control Planes are described. The Physical Interfaces required for interoperability between the ATM NEs are defined, with references to the appropriate Recommendations which describe these interfaces in detail.

Clause 6 defines the criteria for the classification of the ATM Equipment Types. Examples of ATM equipment network applications are illustrated in Annex A.

Clause 7 describes the generic performance requirements and Quality of Service (QOS) aspects applicable to ATM Equipment, with reference to the relevant I-Series Recommendations.

Clause 8 outlines timing and synchronization requirements for ATM equipment.

TYPES AND GENERAL CHARACTERISTICS OF ATM EQUIPMENT

(Geneva, 1996)

0 Introduction

This Recommendation gives an overview of the functions of ATM equipment, example of equipment types and performance objectives for ATM network elements.

The general characteristics of ATM equipment may be described by using the functional partitioning of the network element into logical blocks linked by internal communications between the blocks. A general methodology which may be used to clarify the different types of ATM equipment is also given.

The grouping of functional blocks in accordance with the B-ISDN Protocol Reference Model and the detailed modelling methodology of Recommendation I.326 enables the description of any ATM equipment to the required level of detail.

1 Scope

This Recommendation gives an overview of the functions of ATM equipment, examples of equipment types and overall performance requirements for ATM network elements.

The flexibility of ATM equipment implies the need to provide a Recommendation which enables interoperability while remaining generic so as not to constrain implementation. The approach adopted in this Recommendation, and extended in Recommendation I.732, is to specify the functional requirements based on a description of ATM equipment in terms of functional blocks. The description of equipment provided is compliant with both the B-ISDN Protocol Reference Model of Recommendation I.321 and the functional model of Recommendations G.805 and I.326.

Physical interface requirements are specified as distinct functional blocks. These will conform to either SDH or PDH standards. The interface to the Telecommunications Management Network (TMN) is defined in Recommendation I.751. The points between functional blocks exist only as logical reference points and not as internal interfaces; consequently there is no interface description or interface specification associated with these points.

2 References

The following Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision: all users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published.

- [1] CCITT Recommendation G.703 (1991), *Physical/electrical characteristics of hierarchical digital interfaces*.
- [2] ITU-T Recommendation G.704 (1995), *Synchronous frame structures used at 1544, 6312, 2048, 8488 and 44 736 kbit/s hierarchical levels*.
- [3] ITU-T Recommendation G.707 (1996), *Network node interface for the Synchronous Digital Hierarchy (SDH)*.
- [4] ITU-T Recommendation G.773 (1993), *Protocol suites for Q-interfaces for management of transmission systems*.
- [5] ITU-T Recommendation G.783 (1994), *Characteristics of Synchronous Digital Hierarchy (SDH) equipment functional blocks*.
- [6] ITU-T Recommendation G.784 (1994), *Synchronous Digital Hierarchy (SDH) management*.
- [7] ITU-T Recommendation G.804 (1993), *ATM cell mapping into Plesiochronous Digital Hierarchy (PDH)*.

- [8] ITU-T Recommendation G.805 (1995), *Generic functional architecture of transport networks*.
- [9] ITU-T Recommendation G.832 (1995), *Transport of SDH elements on PDH networks: Frame and multiplexing structures*.
- [10] ITU-T Recommendation G.957 (1995), *Optical interfaces for equipments and systems relating to the synchronous digital hierarchy*.
- [11] ITU-T Recommendation I.150 (1995), *B-ISDN asynchronous transfer mode functional characteristics*.
- [12] ITU-T Recommendation I.211 (1993), *B-ISDN service aspects*.
- [13] ITU-T Recommendation I.311 (1993), *B-ISDN general network aspects*.
- [14] CCITT Recommendation I.321 (1991), *B-ISDN protocol reference model and its application*.
- [15] ITU-T Recommendation I.326 (1995), *Functional architecture of transport networks based on ATM*.
- [16] ITU-T Recommendation I.327 (1993), *B-ISDN functional architectures*.
- [17] ITU-T Recommendation I.353 (1993), *Reference events for defining ISDN performance parameters*.
- [18] ITU-T Recommendation I.356 (1993), *B-ISDN ATM layer cell transfer performance*.
- [19] ITU-T Recommendation I.361 (1995), *B-ISDN ATM layer specification*.
- [20] ITU-T Recommendation I.363 (1993), *B-ISDN ATM adaptation layer (AAL) specification*.
- [21] ITU-T Recommendation I.371 (1993), *Traffic control and congestion control in B-ISDN*.
- [22] ITU-T Recommendation I.413 (1993), *B-ISDN user-network interface*.
- [23] ITU-T Recommendation I.432 (1993), *B-ISDN user-network interface – Physical layer specification*.
- [24] ITU-T Recommendation I.555 (1993), *Frame relaying bearer service interworking*.
- [25] ITU-T Recommendation I.580 (1993), *General arrangements for interworking between B-ISDN and 64 kbit/s based ISDN*.
- [26] ITU-T Recommendation I.610 (1995), *B-ISDN operation and maintenance principles and functions*.
- [27] ITU-T Recommendation I.732 (1996), *Functional characteristics of ATM equipment*.
- [28] ITU-T Recommendation I.751 (1996), *Asynchronous Transfer Mode (ATM) management of the network element view*.
- [29] CCITT Recommendation M.3010 (1992), *Principles for a telecommunications management network*.
- [30] ITU-T Recommendation Q.811 (1993), *Lower layer protocol profiles for the Q3 interface*.
- [31] ITU-T Recommendation Q.812 (1993), *Upper layer protocol profiles for the Q3 interface*.
- [32] ITU-T Recommendation Q.2100 (1994), *B-ISDN signalling ATM adaptation layer (SAAL) overview description*.
- [33] ITU-T Recommendation Q.2144 (1995), *B-ISDN signalling ATM adaptation layer (SAAL) – Layer management for the SAAL at the Network Node Interface (NNI)*.

- [34] ITU-T Recommendation Q.2761 (1995), *Broadband Integrated Services Digital Network (B-ISDN) – Functional description of the B-ISDN User Part (B-ISUP) of Signalling System No. 7.*
- [35] ITU-T Recommendation Q.2762 (1995), *Broadband Integrated Services Digital Network (B-ISDN) – General functions of messages and signals of the B-ISDN User Part (B-ISUP) of Signalling System No. 7.*
- [36] ITU-T Recommendation Q.2763 (1995), *Broadband Integrated Services Digital Network (B-ISDN) – Signalling System No. 7 B-ISDN User Part (B-ISUP) – Formats and codes.*
- [37] ITU-T Recommendation Q.2764 (1995), *Broadband Integrated Services Digital Network (B-ISDN) – Signalling System No. 7 B-ISDN User Part (B-ISUP) – Basic call procedures.*
- [38] ITU-T Recommendation Q.2931 (1995), *Broadband Integrated Services Digital Network (B-ISDN) – Digital Subscriber Signalling System No. 2 (DSS 2) – User-Network Interface (UNI) layer 3 specification for basic call/connection control.*
- [39] ITU-T Recommendation X.25 (1993), *Interface between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for terminals operating in the packet mode and connected to public data networks by dedicated circuit.*

3 Abbreviations, Terms and Definitions

3.1 Abbreviations

For the purposes of this Recommendation the following abbreviations are used:

AAL	ATM Adaptation Layer
ABR	Available Bit Rate
ACC	Accounting Management
AEMF	ATM Equipment Management Function
AIS	Alarm Indication Signal
ATM	Asynchronous Transfer Mode
B-ISDN	Broadband Integrated Services Digital Network
B-UNI	Broadband User Network Interface
CAC	Connection Admission Control
CBR	Constant Bit Rate
CDV	Cell Delay Variation
CLR	Cell Loss Ratio
CoF	Coordination Function
CONFIG	Configuration
CTD	Cell Transfer Delay
DBR	Deterministic Bit Rate
ETS	Equipment Timing Source
ETPI	Equipment Timing Physical Interface
FMBS	Frame Mode Bearer Services
FM	Fault Management
HEC	Header Error Control
ISDN	Integrated Services Digital Network
IWF	Interworking Function
LMI	Layer Management Indications
NE	Network Element
NNI	Network Node Interface
NPC	Network Parameter Control

MCF	Message Communications Function
OAM	Operations and Maintenance
PDH	Plesiochronous Digital Hierarchy
PDU	Protocol Data Unit
PM	Performance Management
QOS	Quality of Service
RM	Resource Management
SAAL	B-ISDN signalling ATM adaptation layer
SAP	Service Access Point
SBR	Statistical Bit Rate
SDH	Synchronous Digital Hierarchy
SDU	Service Data Unit
TM	Transmission Media
TMN	Telecommunications Management Network
TP	Transmission Path
UBR	Unspecified Bit Rate
UNI	User Network Interface
UPC	Usage Parameter Control
VBR	Variable Bit Rate
VC	Virtual Channel
VP	Virtual Path

3.2 Definitions

This Recommendation uses definitions and terms defined in other ITU-T Recommendations.

4 General functional architecture and relationship to ATM network models

The general functional architecture of a B-ISDN Network Element is given in Figure 4-1. This description is based on the B-ISDN Protocol Reference Model (PRM) described in Recommendation I.321.

The relationship between the description of equipment based on the PRM and the I.326 functional model is defined in Annex A/I.732.

The transfer functions are related to the flow of ATM cells on at least one interface (UNI or NNI) for:

- 1) user information;
- 2) signalling information;
- 3) Operations and Maintenance (OAM) information;
- 4) Resource Management (RM) information.

The transfer functions are layered as follows:

- 1) the Transmission Media Layer;
- 2) the Transmission Path Layer;
- 3) the ATM VP Layer;
- 4) the ATM VC Layer; and
- 5) the AAL.

The ATM equipment transfer functions described in Recommendations I.731 and I.732 are consistent with both the transport network architecture model given in Recommendation I.326 and the B-ISDN PRM described in Recommendation I.321.

Layer Management and Plane Management include the following functions:

- Configuration Management.
- Fault Management.
- Performance Management.
- Accounting Management.
- Security Management.

These functions are distributed in the ATM network element in the ATM Equipment Management Function (AEMF), the Coordination Function (CoF), and Layer Management (LM) functional blocks.

The Plane Management deals with the set of functions applicable to management of the network element as a whole or those functions related to the relationships with management systems external to the ATM network element.

Functions necessary for providing synchronization to network timing are provided in the Timing functional block.

Signalling Applications constitute those control plane functions required for on-demand call/connection control (i.e. mainly related to the higher layers of the B-ISDN Protocol Reference Model). The signalling functions are subdivided into user access signalling and network signalling.

5 Overview of equipment functions

For the purposes of this Recommendation, ATM equipment is described in terms of the functions of the user plane, control plane, layer management plane and plane management. The transfer functions are common to user plane and control plane.

5.1 Transfer functions

Transfer functions include all functions required for the transport of user, signalling, OAM, and RM information. In accordance with the B-ISDN Protocol Reference Model described in Recommendation I.321, the User Plane functions are layered into those for Physical Layer processing and those for ATM Layer processing.

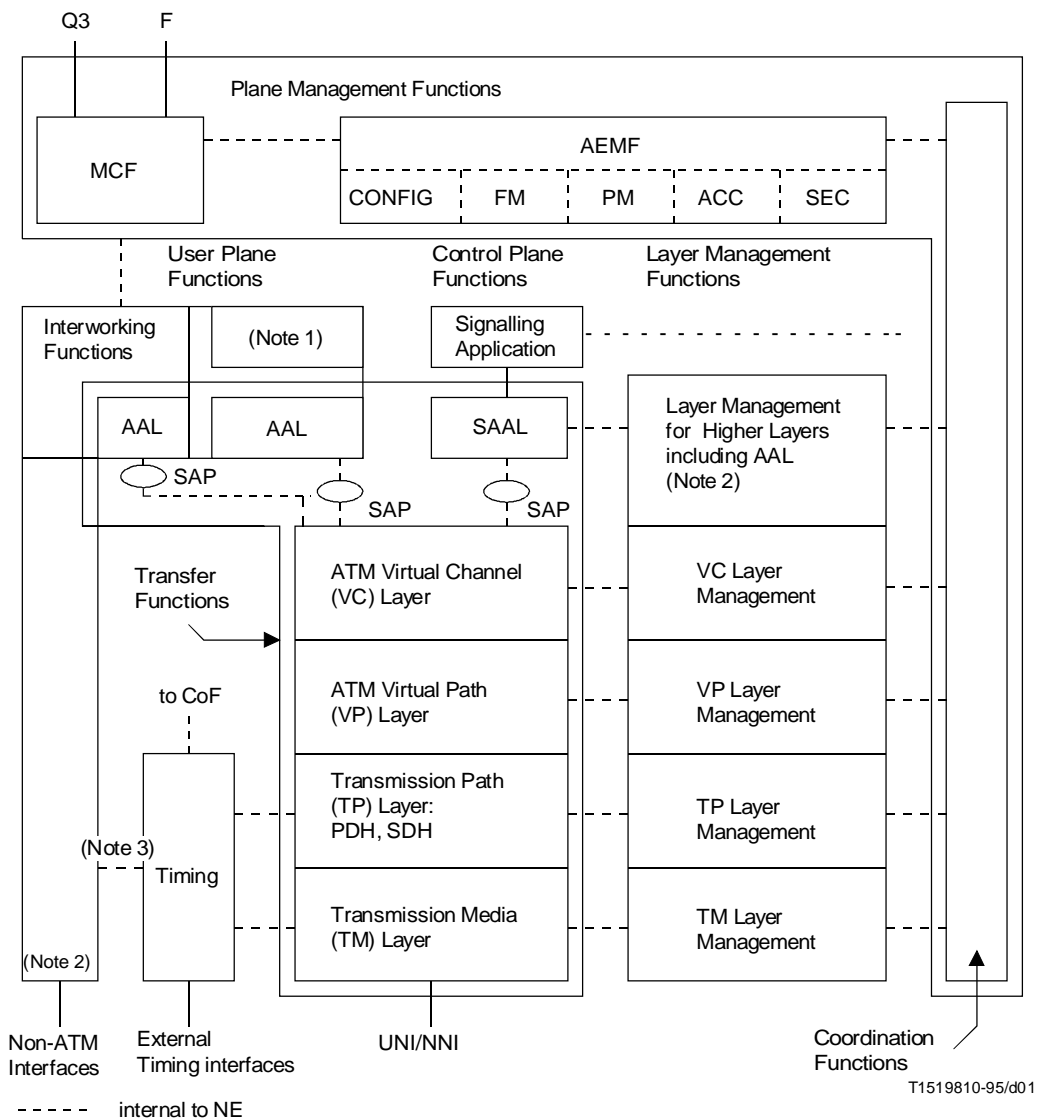
The transfer functions are common for all higher layer services in B-ISDN. The service specific requirements for user information transfer only manifest themselves in the ATM Adaptation Layer (AAL) and higher layers. Descriptions of the higher layers are outside the scope of this Recommendation.

The transfer functions are also common for network related information such as signalling and management communications. The B-ISDN Protocol Reference Model makes a clear separation between User Plane (U-Plane), C-Plane and M-Plane functions. Consequently, the information flows between peer entities of the User Plane, Control Plane and Management Plane should be distinguished by the ATM NE in accordance with the procedures described in Recommendation I.361.

5.1.1 Physical layer

The functions and related requirements associated with the Physical Layer, e.g. electro-optical conversion, line coding, timing recovery, frame generation, synchronization, and transmission overheads processing, are subdivided into Transmission Media Layer (including the digital or multiplex section, the regenerator section and the transmission media) and Transmission Path layers.

Possible physical interfaces for ATM Network Elements are listed below.



NOTES

- 1 Service specific and higher layers. Not addressed in this Recommendation.
- 2 Not addressed in this Recommendation.
- 3 Optional.

FIGURE 4-1/I.731

General functional architecture of a B-ISDN network element

5.1.1.1 Transmission media layers for user and network interfaces

The Transmission media layer should be in accordance with Table 5-1.

TABLE 5-1/I.731

Possible transmission media layers

Interface	SDH STM-N		PDH		Cell Based	
	Rates (kbit/s)	Recommendations	Rates (kbit/s)	Recommendations	Rates (kbit/s)	Recommendations
UNI	155 520 622 080	I.432, G.957, G.703	1 544 2 048 6 312 34 368 44 736 97 728 139 264	G.703	155 520 622 080	I.432
NNI	155 520 622 080 2 488 320 9 953 280	G.707 (1995), G.957, G.703	1 544 2 048 6 312 34 368 44 736 97 728 139 264	G.703		

5.1.1.2 Transmission path layers for user and network interfaces

The transmission path layers available to map ATM cells should be in accordance with Table 5-2.

TABLE 5-2/I.731

Possible transmission path layers

SDH paths		PDH paths	
Rates	Recommendations	Rates	Recommendations
VC-11 VC-12 VC-2 VC-2-mc VC-3 VC-4 VC-4-Xc	G.707 (1996)	1 544 2 048 6 312 34 368 44 736 97 728 139 264	G.804, G.832

5.1.1.3 Other interfaces

- 1) TMN interface (e.g. Q interface in accordance with Recommendations G.773, Q.811 and Q.812).
- 2) Local craft interface (e.g. F interface).
- 3) External Timing interfaces (see clause 8/I.731).
- 4) Non-ATM interfaces (e.g. 64 kbit/s, FMBS, Recommendation X.25, etc. Not described in this Recommendation).

5.1.2 ATM Layer

ATM Layer functions and related requirements are associated with multiplexing/demultiplexing and cross-connecting or switching of ATM cells. They are subdivided into two functional blocks respectively processing Virtual Paths and Virtual Channels. Each of these blocks consists of four entities (further details are provided in Recommendation I.732):

- 1) a *Multiplexing Entity* (VPME/VCME) includes functions that are common to all VP links (e.g. cell rate decoupling, HEC processing, cell delineation, scrambling/descrambling, multiplexing/demultiplexing of VPs) or to all VC links (multiplexing/demultiplexing of VCs);
- 2) a *VP/VC Entity* (VPE/VCE) includes all functions that are performed per individual VP/VC link. These include: (e.g. VP/VC UPC/NPC, processing of segment F4/F5 OAM flows); there is one instance of these blocks per VP/VC links;
- 3) a *VP/VC Connection Entity* (VP_C/VC_C) performs connections of VP/VC links between VP/VC link End Points within the same Network Element according to established ATM connections;
- 4) a *VP/VC Connection Termination* (VPCT/VCCT) that perform functions devoted to ATM Connection Endpoints. (e.g. processing of end-to-end F4/F5 OAM flows); there is one instance of these blocks per terminated VP/VC links.

According to Recommendation I.150, cell sequence integrity shall be maintained between endpoints of a VP Connection for all cells belonging to this VP and between endpoints of a VC Connection for all cells belonging to this VC.

5.1.3 ATM Adaptation Layer (AAL)

The AAL functions enhance the service provided by the ATM Layer functions to enable the service-specific higher layers to use the service-independent ATM layer.

When AAL processing is required in the ATM NE, the AAL functional requirements should be in accordance with the AAL protocols described in Recommendations I.363.

The AAL types described in Recommendations I.363 are:

- 1) AAL Type 1;
- 2) AAL Type 3/4;
- 3) AAL Type 5;
- 4) AAL Type 2, for further study.

Typical AAL functions include:

- 1) Segmentation and Reassembly (SAR).
- 2) Error detection/correction.
- 3) Length indication.
- 4) Timing Recovery.
- 5) Other service specific functions.

These protocols are service specific and are consequently Network/Service Provider Option(s). In general AAL protocols are end-to-end and therefore not processed by intermediate ATM network elements. However, network providers may choose to offer specific services which may require AAL processing in ATM network elements.

5.1.4 Signalling ATM Adaptation Layer (SAAL)

One particular type of AAL service user is the signalling entity wishing to communicate with a peer entity. Each of these entities would require that functions are provided above the common part of the AAL specifically designed to facilitate this task. The AAL functions necessary to support signalling should be in accordance with Recommendation Q.2100, B-ISDN signalling ATM adaptation layer (SAAL). Recommendation Q.2100 also serves as a guide to all other Recommendations required by a user for the implementation of an AAL for the purpose of signalling.

5.2 Layer Management functions

Management information associated with a given transfer layer function is passed to (or received from) the corresponding Layer Management function, e.g. for processing of configuration, fault monitoring, performance monitoring, UPC/NPC. Configuration, performance, fault, and accounting information relating to the corresponding functions may be passed to the AEMF for further processing and/or communication to external network management entities and/or Operating Systems.

Layer Management functional blocks correspond one-to-one with transfer functional blocks.

5.2.1 Physical Layer Management

This functional block includes Transmission Path and Transmission Media layer management functions such as:

- 1) Processing of F1, F2 and F3 OAM flows and transmission overheads information.
- 2) Activation-deactivation functions (if present).
- 3) Error processing.

5.2.2 ATM Layer Management

ATM Layer Management functions are subdivided into VP and VC Layer Management functional blocks. For each layer (VP and VC layers) the following Layer Management blocks are identified (further details are provided in Recommendation I.732):

- 1) A block corresponding to the VPME/VCME block of the Transfer Plane. This block includes functions such as congestion control.
- 2) A block corresponding to the VPE/VCE block of the Transfer Plane. This block includes functions such as processing of segment F4/F5 OAM information, UPC/NPC management, VPI/VCI setting.
- 3) A block corresponding to the VP_C/VC_C block of the Transfer Plane. This block includes management of the associations between incoming links and outgoing links.
- 4) A block corresponding to the VPCT/VCCT block of the Transfer Plane. This block includes functions such as processing of end-to-end F4/F5 OAM information.

5.2.3 AAL Management

For further study.

5.2.4 SAAL Management

If present, SAAL management at NNI should be in accordance with Recommendation Q.2144 (B-ISDN signalling ATM LM for the SAAL at the NNI).

5.3 ATM Equipment Management Function (AEMF)

AEMF functions are classified into five areas:

- 1) configuration management;
- 2) fault management;
- 3) performance management;
- 4) accounting management;
- 5) security management.

Description of AEMF is found in Recommendation I.751. It is outside of the scope of this Recommendation which equipment management functions are actually performed in the Network Element and which functions are performed outside the Network Element.

5.4 Message Communications Function

The Message Communications Function (MCF) performs the exchange of AEMF messages with the TMN. It may be based on different protocol stacks. These include:

- 1) X.25 protocol;
- 2) ATM protocol.

5.5 Coordination function

Some management functions may require coordination between the relevant Layer Management functions at the different layers. This coordination function is part of the overall Plane Management.

The coordination function processes requests through the Control Plane (C-Plane) and the Management Plane (M-Plane) for network resources and messages between the layer management. It includes:

- 1) Connection Admission Control (CAC) function.
- 2) Internal communications between layers [Layer Management Indications (LMIs)].

5.6 Signalling Application

At the User Network Interface (UNI) the signalling procedures and messages shall be in accordance with Recommendation Q.2931. The basic set of UNI signalling procedures are defined in Recommendation Q.2931 (B-ISDN Digital Service Signalling System (DSS 2), User Network Interface Layer 3 specification for Basic Call/Connection control).

At the Network Node Interface (NNI) the signalling procedures and messages shall be in accordance with Recommendations Q.2761, Q.2762, Q.2763 and Q.2764, that as a set form the basis for the Broadband ISDN User Part (B-ISUP).

5.7 Timing function

The timing functions deal with the actions required to synchronize the equipment interfaces, either ATM interfaces or non-ATM interfaces, to a clock source (e.g. network, external or internal).

5.8 Interworking functions

Depending on Service Provider requirements, interworking between ATM based services and other network services may in some instances be supported by the ATM equipment.

For interworking between B-ISDN/ATM and ISDN network elements the Interworking Function (IWF) should be in accordance with Recommendation I.580.

For interworking between B-ISDN/ATM and Frame Mode Bearer Services (FMBS) the Interworking Function (IWF) should be in accordance with Recommendation I.555.

ATM equipment requirements for interworking between B-ISDN and other network services is for further study.

NOTE – Two general scenarios for interworking between B-ISDN/ATM and other networks have been identified.

In one scenario the B-ISDN/ATM network simply encapsulates the higher layer Service or Protocol Data Unit (SDU/PDU) for transparent transport through the B-ISDN.

In the more complex scenario, the services provided by the other (e.g. FMBS, ISDN, etc.) network is mapped wholly or partially into the B-ISDN/ATM services at the IWF (termed Service Interworking). This requires the IWF to partially or wholly terminate protocol functions.

It is a network option as to which interworking scenario may be supported.

Equipment functional requirements related to these different interworking scenarios are for further study.

5.9 Protection switching and restoration

ATM layer based protection switching and restoration capabilities ATM network elements is left for future study.

Physical layer protection switching capabilities may be provided, e.g. for SDH-based interfaces by STM-N Multiplex Section Linear Protection functionality (described in Recommendations G.707 and G.783) or STM-N Multiplex Section shared protection ring functionality (described in Recommendation G.841).

6 Equipment types

The high level functional description of the ATM Equipment types discussed are based on the definition of the Network Elements given in Recommendation I.311/I.327.

The basic criteria used for classification of equipment types are:

- 1) signalling capability, which refers to the presence of signalling applications inside the equipment;
- 2) connectivity.

Restricted connectivity implies that:

- a) the equipment has multiple transfer interfaces towards user side and only one transfer interface towards the network;
- b) there is no connectivity between the user side interfaces.

Unrestricted connectivity implies that a) and/or b) above may not apply.

Those basic criteria lead to the following equipment types (see Table 6-1):

TABLE 6-1/I.731
ATM equipment types

Basic equipment types	Signalling capability	
	No	Yes
Unrestricted connectivity	Cross-connect	Switch
Restricted connectivity	Multiplexer	On-demand multiplexer

Additional distinguishing characteristics are:

- 1) VPI based connectivity or (VPI, VCI) based connectivity;
- 2) presence of interworking functions for support of non-ATM interfaces.

Those additional distinguishing characteristics lead to the following derived equipment types (see Tables 6-2 to 6-5):

TABLE 6-2/I.731
Cross-connect types

Cross-connect types		VPI based connectivity	(VPI, VCI) based connectivity
Interworking Function for support of non-ATM interfaces	No	VP Cross-connect	VC Cross-connect
	Yes	Interworking VP Cross-connect	Interworking VC Cross-connect

TABLE 6-3/I.731

Switch types

Switch types		VPI based connectivity	(VPI, VCI) based connectivity
Interworking Function for support of non-ATM interfaces	No	VP Switch	VC Switch
	Yes	Interworking VP Switch	Interworking VC Switch

TABLE 6-4/I.731

Multiplexer types

Multiplexer types		VPI based connectivity	(VPI, VCI) based connectivity
Interworking Function for support of non-ATM interfaces	No	VP multiplexer	VC multiplexer
	Yes	Interworking VP multiplexer (Note)	Interworking VC multiplexer (Note)
NOTE – Interworking multiplexer is sometimes called “Services Multiplexer”.			

TABLE 6-5/I.731

On-demand multiplexer types

On-demand multiplexer types		VPI based connectivity	(VPI, VCI) based connectivity
Interworking Function for support of non-ATM interfaces	No	VP On-demand multiplexer	VC On-demand multiplexer
	Yes	Interworking On-demand VP multiplexer (Note)	Interworking On-demand VC multiplexer (Note)
NOTE – Interworking multiplexer is sometimes called “Services Multiplexer”.			

Some examples of generic ATM Network Element architectures are shown in Annex A. Other equipment types may be possible.

7 Generic performance requirements

7.1 Reference connections

For further study.

7.2 Quality of Service Aspects

B-ISDNs are envisaged to support a range of bearers/Network Services which may require different QOS categories, depending on Network Operator/Service Providers choice.

The ATM Equipment should be capable, by means of appropriate traffic engineering and resource allocation of both bandwidth and buffer capacity, of providing sufficient performance in terms of the selected parameters such as Cell Loss Ratio (CLR), Cell Transfer Delay (CTD) and Cell Delay Variation (CDV), to meet the QOS requirements specified by the Service Provider.

The functions required as a basis for ATM resource management shall be in accordance with Recommendation I.371. These include:

- 1) Usage Parameter Control (UPC)/Network Parameter Control (NPC);
- 2) Connection Admission Control (CAC);
- 3) Congestion Control;
- 4) Network Resource Management.

The ATM Equipment should provide these functions to support the Network Performance QOS requirements of Recommendations I.356 and I.211. ATM Networks are envisaged as capable of providing end-to-end cell loss and delay performance sufficient to support stringent services such as circuit emulation and high quality video transmission. Consequently, the ATM NEs should be capable of providing low cell loss ratio, low delay and low CDV to those connections requiring them, as specified by the Service Provider.

7.3 ATM Network Element performance objectives

The definitions, measurement methods and values of the ATM network performance parameters should be in accordance with Recommendations I.353 and I.356.

The following subclauses provide performance objectives for a network element to be used as provisional values. These objectives may have to be revised to be consistent with Recommendation I.356.

Test methods have to be defined for the verification of these objectives. Different methods may be required to suit different operational states for the equipment and the connections. A full description of the test methods is out of the scope of this Recommendation.

The objective values should be measured with a physical interface load of 80% and for 155.52 Mbit/s interface. Other values of link load and interface rates are for further study.

7.3.1 Cell Loss objectives

A CLR objective of $< 2 \times 10^{-10}$ per ATM NE should be provided for a specified number of connections for the selected demanding applications. In addition, a lower engineered CLR objective of $< 10^{-7}$ per ATM NE may be supported for applications requiring less demanding cell loss.

7.3.2 Cell Transfer Delay objectives

Although Cell Transfer Delay (CTD) requirements may vary widely for different applications, some service capabilities (e.g. DBR) are sensitive to cell delay and particularly Cell Delay Variation (CDV), as specified in Recommendation I.356.

The ATM NE should be capable of providing low cell transfer delay and cell delay variation to those selected connections requiring them, as specified by the Service Provider.

The ATM NE should be capable of providing a cell transfer delay for DBR ATM layer bearer capability (Recommendation I.371) according to the following values:

- maximum CTD (10^{-10} quantile): 300 microsec.
- CTD (99 percentile): 150 microsec.
- mean CTD: 100 microsec.

A set of CTD parameters for ABR ATM layer bearer capability and SBR ATM layer bearer capability are for further study.

7.3.3 CDV Objectives

The cell delay variation for DBR ATM layer bearer capability within an ATM NE should not exceed the following value:

- maximum CDV (10^{-10} quantile): 250 microsec

Thereby, CDV is defined as the variable part of the cell delay, i.e. the cell delay minus the constant part of the cell delay.

The CDV objectives for ABR and SBR ATM layer bearer capability are for further study.

8 Timing and synchronization requirements

Timing functional blocks include all the functions required to provide synchronization to the network timing. The timing is subdivided into two parts: the Equipment Timing Source (ETS) and the Equipment Timing Physical Interface (ETPI). The ETPI function provides the interface between the external synchronization signal and the equipment timing source and shall have, at the interface port, the physical characteristics of one of the G.703 synchronization interfaces. The 2048 kHz synchronization interface port shall be according to clause 10/G.703. The case of 1544 kHz is for further study. If required, the ETS function provides the timing reference to the Transmission Media Layer or the Interworking Functions. The ETS function is described in Recommendation G.782.

9 Other requirements

9.1 Availability

For further study.

9.2 Reliability

For further study.

Annex A

Examples of ATM equipment

(This annex forms an integral part of this Recommendation)

This annex intends to provide examples of ATM equipment, and is not intended to be exhaustive. Other combinations may be possible.

Five examples of ATM equipments are given (see also Recommendation I.732 for more detailed representation of these examples):

- 1) VP Cross-connect (Figure A.1).
- 2) VC switch (Figure A.2).
- 3) VP multiplexer (Figure A.3).
- 4) On-Demand VC multiplexer (Figure A.4).
- 5) Interworking On-Demand VC multiplexer (Figure A.5).

The external interfaces appear at the bottom of each figure.

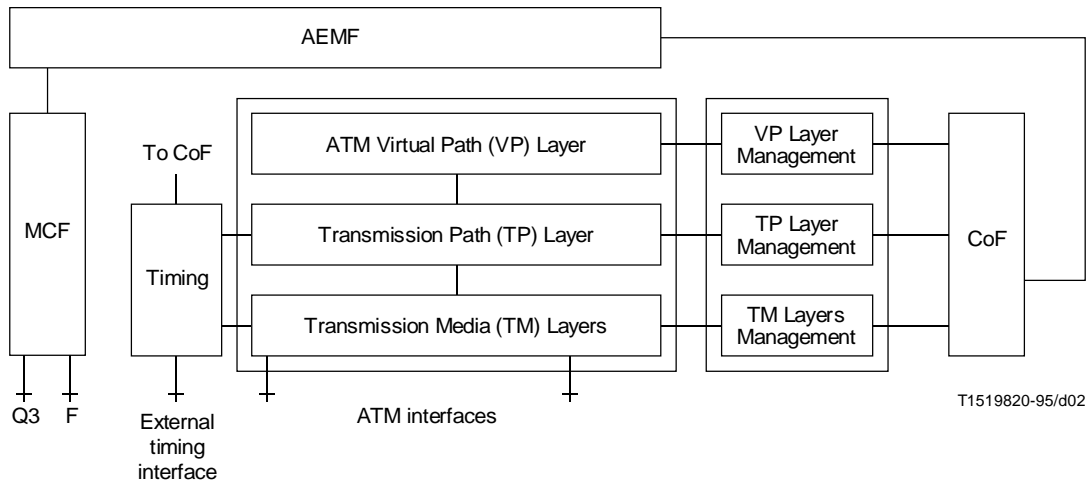
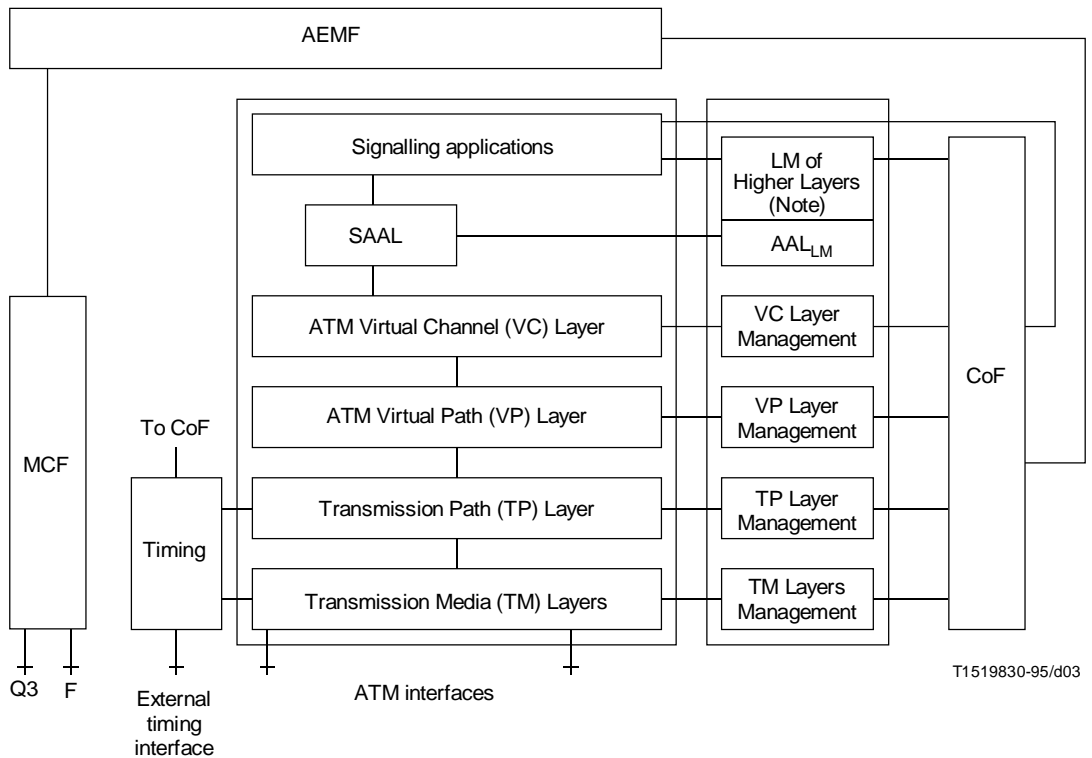


FIGURE A.1/I.731
VP cross-connect



NOTE – Layer Management of higher layers and AAL is not described in this Recommendation.

FIGURE A.2/I.731
VC switch

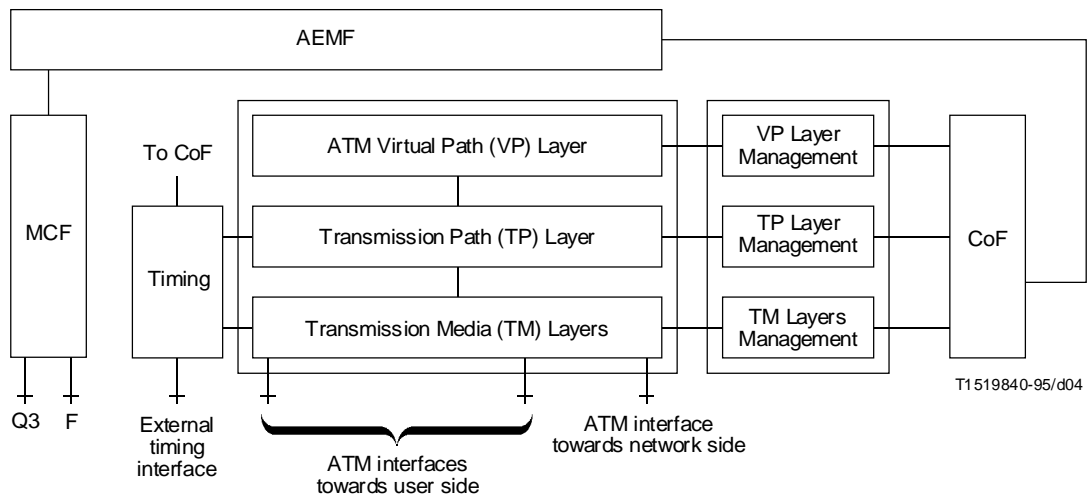
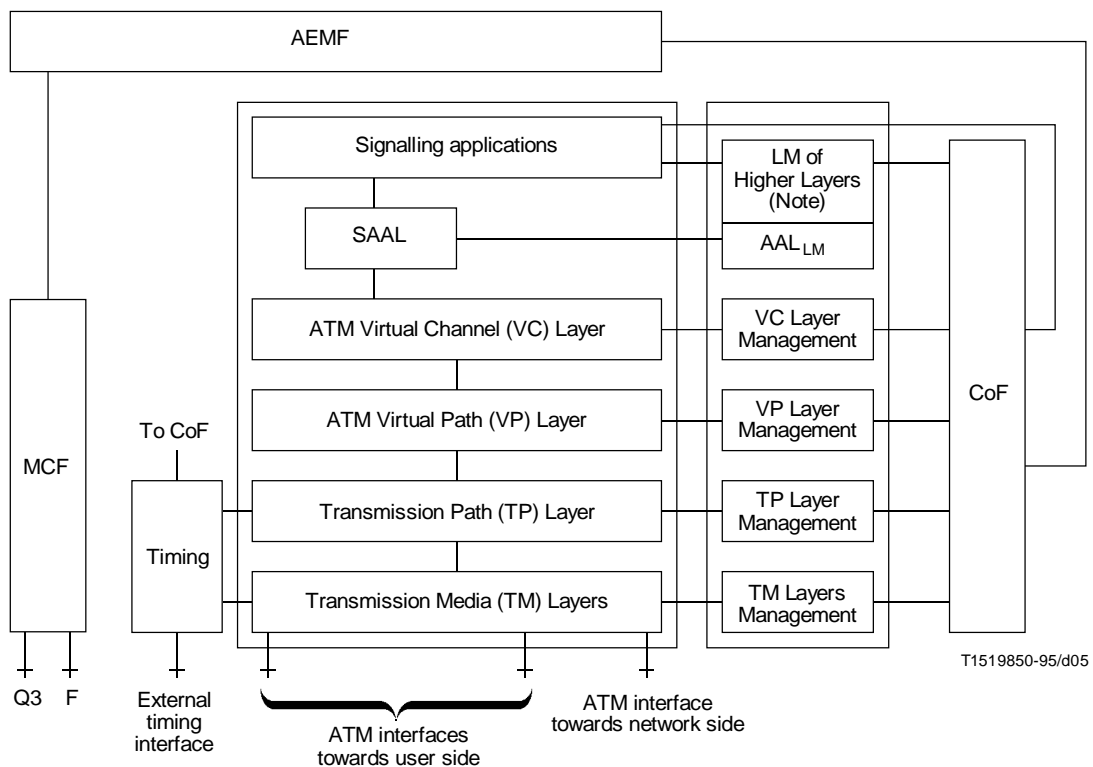
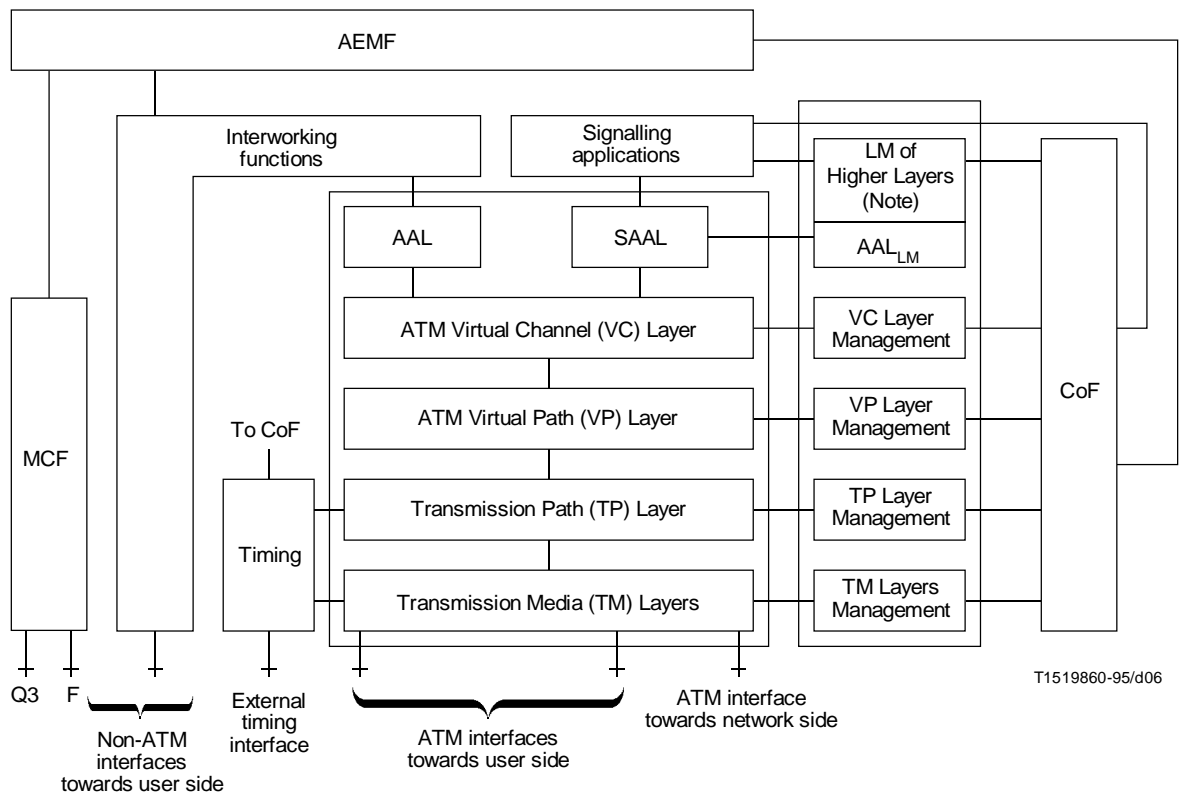


FIGURE A.3/I.731
VP multiplexer



NOTE – Layer Management of higher layers and AAL is not described in this Recommendation.

FIGURE A.4/I.731
On-Demand VC multiplexer



NOTE – Layer Management of higher layers and AAL is not described in this Recommendation.

FIGURE A.5/I.731
Interworking On-Demand VC multiplexer