**Superseded by a more recent version**

INTERNATIONAL TELECOMMUNICATION UNION

# ITU-T

# I.610

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

(11/95)

## INTEGRATED SERVICES DIGITAL NETWORK (ISDN)

## MAINTENANCE PRINCIPLES

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# B-ISDN OPERATION AND MAINTENANCE PRINCIPLES AND FUNCTIONS

**ITU-T Recommendation I.610**

Superseded by a more recent version

(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.610 was revised by ITU-T Study Group 13 (1993-1996) and was approved under the WTSC Resolution No. 1 procedure on the 2nd of November 1995.

NOTE

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

## CONTENTS

## ABSTRACTS

Recommendation 1.610 "B-ISDN operation and maintenance principles and functions" describes the set of functions required to operate and maintain the physical layer and ATM layer aspects of the B-ISDN for permanent, semi-permanent, reserved and on-demand virtual connections.

The functions of the layers above the ATM layer are not considered.

For a detailed description of the maintenance mechanisms and functions at the physical layer, the appropriate ITU-T Recommendations need to be considered depending on the transmission system in use (e.g. SDH, PDH).

For maintenance purposes an F4 and an F5 flow is defined at the ATM layer covering the VP and VC level, respectively. Both flows are bidirectional and follow the same physical route as the user-data cells, thus constituting an in-band maintenance flow.

Besides the vertical subdivision into F4 and F5 level a "horizontal" partition also exists: both flows can either cover the entire virtual connection (end-to-end flow) or only parts of the virtual connection (segment flow).

Dedicated OAM cells with pre-assigned VCI and PTI values are used to implement the F4 and F5 flows at segment level or end-to-end.

This Recommendation specifies the purpose and the realization (using different OAM cell types) of the following functions:

1) Fault management, using AIS, RDI, continuity check and loopback OAM cells.
2) Performance management, using forward monitoring and backward reporting OAM cells.
3) Activation/deactivation of performance monitoring and/or continuity check, using activation/deactivation OAM cells.
4) System management OAM cells for use by end-systems only.

# B-ISDN OPERATION AND MAINTENANCE PRINCIPLES AND FUNCTIONS

*(Geneva, 1991; revised Helsinki, 1993 and Geneva, 1995)*

## 1 Introduction

### 1.1 General

Considerations on Operations and Maintenance (OAM) functions take into account the following Recommendations:

- CCITT Recommendation M.20 (1992), *Maintenance philosophy for telecommunications networks*.
- CCITT Recommendation M.3010 (1992), *Principles for a telecommunications management network*.
- CCITT Recommendation M.3600 (1992), *Principles for the management of ISDNs*.
- ITU-T Recommendation I.113 (1993), *Vocabulary of terms for broadband aspects of ISDN*.
- ITU-T Recommendation I.150 (1993), *B-ISDN asynchronous transfer mode functional characteristics*.
- ITU-T Recommendation I.311 (1993), *B-ISDN general network aspects*.
- CCITT Recommendation I.321 (1991), *B-ISDN protocol reference model and its application*.
- ITU-T Recommendation I.356 (1993), *B-ISDN ATM layer cell transfer performance*.
- ITU-T Recommendation I.371 (1993), *Traffic control and congestion control in B-ISDN*.
- ITU-T Recommendation I.361 (1993), *B-ISDN ATM layer specification*.
- ITU-T Recommendation I.413 (1993), *B-ISDN user-network interface*.
- ITU-T Recommendation I.432 (1993) *B-ISDN user-network interface – Physical layer specification*.
- CCITT Recommendation I.601 (1988) *General maintenence principles of ISDN subscriber access and subscriber installation*.
- CCITT Recommendation G.702 (1988), *Digital hierarchy bit rates*.
- ITU-T Recommendation G.707 (1993), *Synchronous digital hierarchy bit rates*.
- ITU-T Recommendation G.708 (1993), *Network node interface for the synchronous digital hierarchy*.
- ITU-T Recommendation G.709 (1993), *Synchronous multiplexing structure*.
- ITU-T Recommendation G.782 (1994), *Types and general characteristics of synchronous Digital Hierarchy (SDH) equipment*.
- ITU-T Recommendation G.783 (1994), *Characteristics of Synchronous Digital Hierarchy (SDH) equipment functional blocks*.
- ITU-T Recommendation G.784 (1994), *Synchronous Digital Hierarchy (SDH) management*.
- ITU-T Recommendation G.803 (1993), *Architectures of transport networks based on the Synchronous Digital Hierarchy (SDH)*.
- ITU-T Recommendation G.804 (1993), *ATM cell mapping into Plesiochronous Digital Hierarchy (PDH)*.
- ITU-T Recommendation G.832 (1993), *Transport of SDH elements on PDH networks: Frame and multiplexing structures*.

The terms anomaly, defect and failure as used in this Recommendation are defined in Recommendation M.20.

### 1.2 Scope

The scope of this Recommendation is to identify functions required to operate and maintain the physical layer and ATM layer aspects of the B-ISDN. The functions apply to the Virtual Path (VP) and Virtual Channel (VC) connections that may be routed through the B-ISDN. The mechanisms, functions and protocols as described in this Recommendation apply to all types of ATM connections, i.e. permanent, semi-permanent, reserved and switched virtual connections unless otherwise stated. However, the need for reduced and/or additional OAM functionality for switched virtual connections is for further study. Whenever the term "customer access" is referred to in this Recommendation, it includes the UNI.

The functions of the layers above the ATM layer are not considered but are for further study.

## 2 OAM principles

The following principles have to be considered in specifying the OAM functions of the B-ISDN.

a) *Performance monitoring*

   Performance monitoring is a function which processes user information to produce maintenance information specific to the user information. This maintenance information is added to the user information at the source of a connection/link and extracted at the sink of a connection/link. Analysis of the maintenance event information at the sink of the connection allows estimation of the transport integrity to be analysed.

b) *Defect and failure detection*

   Defect/failures affecting the transport of user information are detected by continuous or periodic checking. As a result, maintenance event information or various alarms will be produced.

c) *System protection*

   The effect of a defect on the transport of user information is minimized by blocking or changeover to other entities. As a result the failed entity is excluded from operation.

d) *Defect information*

   Defect information is given to other management entities. As a result, alarm indications are given to other management planes. Response to a status report request will also be given.

e) *Fault localization*

   Determination by internal or external test systems of a failed entity if defect information is insufficient.

NOTE – Some aspects of these functions are, at present, not subject to the description in this Recommendation.

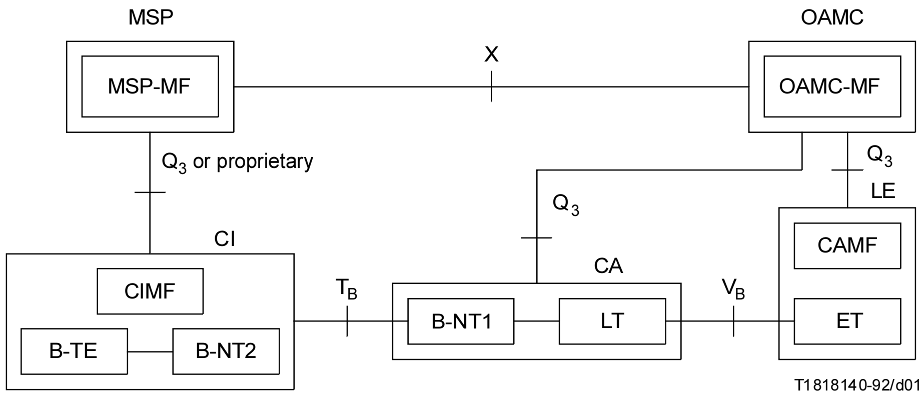
### 2.1 Network configuration for maintenance activities

The network configuration for maintenance activities is described in Recommendation M.3600. This configuration is also applicable for the B-ISDN.

### 2.2 Relation with the Telecommunication Management Network (TMN)

An example of a customer access network architecture describing the relation with the TMN is given in Figure 1. The protocols used for the TMN are specified through Q-interfaces and may include the transmission section between B-NT2 and B-NT1.

Network element internal monitoring functions are not subject to standardization. The results of that monitoring will be delivered to the TMN via Q-interfaces. Figure 1 illustrates management related systems and their relationship for the B-ISDN customer access.




| | |
|---|---|
| CIMF | Customer Installation Management Function |
| CAMF | Customer Access Management Function |
| MSP | Management Service Provider |
| LE | Local Exchange |
| MF | Management Function |
| OAMC | Operation Administration Maintenance Center |
| CI | Customer Installation |
| CA | Customer Access |
| X | Interface between two management systems |
| $Q_3$ | TMN Interface |
| ET | Exchange Termination |
| LT | Line Termination |
| NT | Network Termination |
| TE | Terminal Equipment |
| $V_B$ | Reference Point |
| $T_B$ | Reference Point |

NOTE – Mediation/adaptation functions with $Q_2$ interfaces may be distributed in different equipment.

FIGURE 1/I.610

**Example of TMN architecture for the customer access**

## 3 OAM levels and flows

### 3.1 OAM levels in the B-ISDN

OAM functions in the network are performed on five OAM hierarchical levels associated with the ATM and physical layers of the protocol reference model. The functions result in corresponding bidirectional information flows F1, F2, F3, F4 and F5 referred to as OAM flows (see Figure 2). Not all of these flows need to be present. The OAM functions of a missing level are performed at the next higher level. The levels are as follows:

– *Virtual channel level* – Extends between network elements performing virtual channel connection termination functions and is shown extending through one or more path connections (see also 2.3.1/I.311).

– *Virtual path level* – Extends between network elements performing virtual path connection termination functions (see 2.3.2/I.311) and is shown extending through one or more transmission paths.

– *Transmission path level* – Extends between network elements assembling/disassembling the payload of a transmission system and associating it with its OAM functions. Cell delineation and Header Error Control (HEC) functions are required at the end points of each transmission path. The transmission path is connected through one or more digital sections.

– *Digital section level* – Extends between section end points and comprises a maintenance entity according to the definition of Clause 3/M.20.

– *Regenerator section level* – A regenerator section is a portion of a digital section and as such is a maintenance subentity.

### 3.2 Relationship of OAM functions with the B-ISDN models

#### 3.2.1 B-ISDN Protocol Reference Model (PRM)

OAM functions are allocated to the layer management of the B-ISDN protocol reference model (see Recommendation I.321).

This layered concept and the requirements of independence of the layers from each other lead to the following principles:

1) OAM functions related to OAM levels are independent from the OAM functions of other layers and have to be provided at each layer.

2) Each layer, where OAM functions are required, is able to carry out its own processing to obtain quality and status information. OAM functions are performed by the layer management. These results may be provided to the plane management or to the adjacent higher layer. Higher layer functions are not necessary to support the OAM of the lower layer.

The functions of the layers above the ATM layer are not considered in this Recommendation.

#### 3.2.2 ATM transport network model

An alternative ATM transport network model has been developed using modelling techniques given in Recommendation G.803. It is possible to model the B-ISDN functions using this model. Given that OAM functions operate within a layer as described in the PRM, each layer contains a "Trail Termination Function" (TTF); in this Recommendation a VP/VC segment end-point or connection end-point performs trail termination functionality. The TTF is responsible for the generation and termination of the OAM flows. The TTF interacts with layer management functionality and exchanges appropriate layer management information (e.g. defect indications, performance data, etc.) with the plane management entity.

Description of ATM layer OAM functions in terms of Recommendation G.803 principles is for further study.

## 4 Mechanisms to provide OAM flows

### 4.1 Physical layer mechanisms

The physical layer contains the three lowest OAM levels as outlined in Figure 2. The allocation of the OAM flows is as follows:

– F1: regenerator section level;

– F2: digital section level;

– F3: transmission path level.

The mechanisms to provide OAM functions and to generate OAM flows F1, F2 and F3 will depend on the transport mechanism of the transmission system as well as on the supervision functions contained within the physical layer termination functions of equipments. Three types of transmission can be provided in ATM networks.

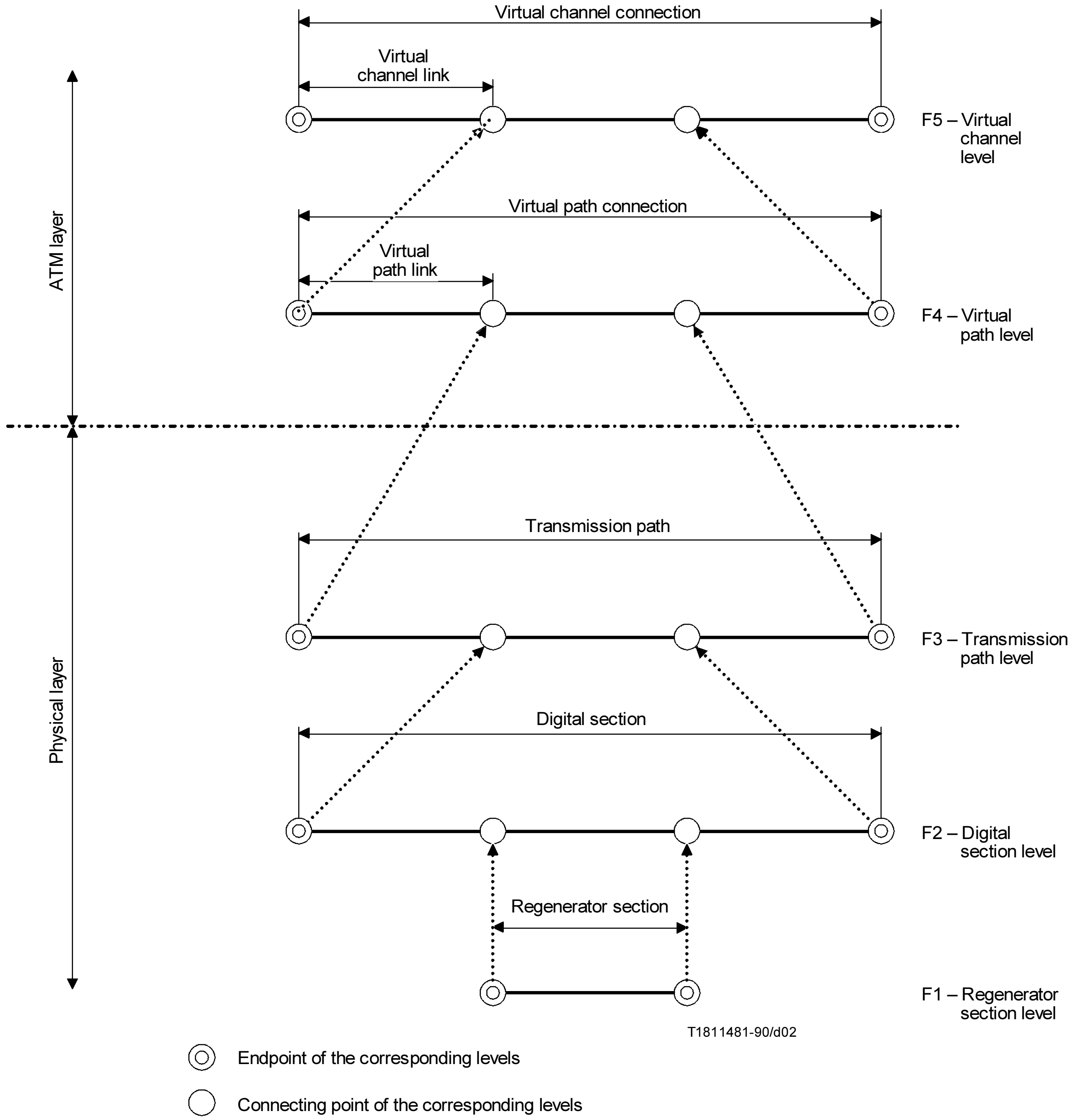



FIGURE 2/I.610

**OAM hierarchical levels and their relationship with the ATM layer and physical layer**

#### 4.1.1 SDH-based transmission systems (Recommendations G.707 to 709, G.782, G.783)

Flows F1 and F2 are carried on bytes in the Section Overhead (SOH), flow F3 is carried in the higher order Path Overhead (POH) of the transmission frame. ATM transport may also be supported on lower order paths which support path overheads. These lower order path OAM flows are subsets of the F3 flow.

#### 4.1.2 Cell-based transmission systems

Such transmission systems may use an interface structure as specified in 4.2.1/I.432. OAM flows F1 and F3 are carried through maintenance cells at the physical layer using a specific pattern in the header for F1 and F3. F2 flows are not provided, but the associated functions are supported by F3 flows. These cells are not passed to the ATM layer. The occurrence of a PL-OAM cell is determined by the requirements of the supported OAM functions. For each type (F1 and F3) of PL-OAM cell, maximum spacing is applied. If maximum spacing is exceeded, Loss of Maintenance Flow (LMF) event will occur.

When transmission path-RDI is sent, the cause of this defect (LOC, LMF, AIS) is indicated in the layer management message.

#### 4.1.3 PDH-rate frame-based transmission systems (Recommendations G.702, G.804, G.832)

Specific means to monitor the section performance (e.g. violation code counting CRC, etc.) are defined within the Recommendations G.702, G.804, G.832. If the ATM layer is supported only on a PDH section then the G.804 overhead constitutes both F1 and F3 flows (but not F2).

NOTE – F1 is supported by frame alignment bytes and the remainder of the overhead constitutes the F3 flow. If the PDH bitrate frame structure is consequently transported across SDH then the G.804 overhead minus the frame alignment word then constitutes the F3 flow with the SDH higher order path overhead forming a subset of the F3 flow.

### 4.2 ATM layer mechanism

The ATM layer contains the two highest OAM levels as outlined in Figure 2. The allocation of the OAM flows is as follows:

– F4: virtual path level;

– F5: virtual channel level.

These OAM flows are provided by cells dedicated to ATM layer OAM functions for both Virtual Channel Connections (VCC) and Virtual Path Connections (VPC). In addition, such cells are usable for communication within the same layers of the management plane.

#### 4.2.1 F4 flow mechanism

The F4 flow is bidirectional. OAM cells for the F4 flow have the same VPI value as the user cells of the VPC and are identified by one or more pre-assigned VCI values. The same pre-assigned VCI value shall be used for both directions of the F4 flow. The OAM cells for both directions of the F4 flow must follow the same physical route so that any connecting points supporting that connection can correlate the fault and performance information from both directions.

For the purpose of this Recommendation at F4 level, the term "user cell" is used for OAM according to the VCI values as shown in Table 1.

There are two kinds of F4 flows, which can simultaneously exist in a VPC. These are:

– *End-to-end F4 flow* – This flow, identified by a standardized VCI (see Recommendation I.361), is used for end-to-end VPC operations communications.

– *Segment F4 flow* – This flow, identified by a standardized VCI (see Recommendation I.361), is used for communicating operations information within the bounds of one VPC link or multiple inter-connected VPC links. Such a concatenation of VPC links is called a VPC segment.

  One or more OAM segments may be defined along a VPC. Nevertheless neither overlapped nor embedded segments can be defined. For that purpose it must be ensured that all intermediate Connecting Points (CP) in between the source/sink CP of a segment shall not be a source or sink CP of another segment.

The definition of the span of a managed segment is not necessarily fixed for the duration of a connection, i.e. the managed segment may be re-configured as required.

NOTE – A VPC segment is typically under the control of one Administration or organization; however, it can be extended beyond the control of one Administration/organization by mutual agreement.

End-to-end F4 flows must be terminated at the end-points of a VPC and segment F4 flows at the connecting points terminating a VPC segment. Intermediate points (i.e. connecting points) along the VPC or along the VPC segment may monitor OAM cells passing through them and insert new OAM cells, but they cannot terminate the OAM flow, except when loopbacks are performed. In this case the loopback cell (see 6.2.1.1.3) may be extracted from the OAM flow by the intermediate point where the loopback has to be performed and the looped cell may be extracted by the loopback originator upon reception. The F4 flow will be initiated at or after connection set-up either by the TMN or by OAM function dependent activation procedures.

A source point of a VPC segment acting in a dowstream direction should discard unexpected VPC segment OAM cells coming from the upstream side of the connection.

It shall be possible for any intermediate connecting point to be configured as a source/sink of a VPC segment.

TABLE 1/I.610

**"User cells" at F4 level**

| VCI | Interpretation | Category |
|---|---|---|
| 0 | Unassigned cell (VPI = 0) | Non-user cell |
| 0 | Unused (VPI > 0) | |
| 1 | Meta-signalling cell (UNI) | User cell |
| 2 | General broadcast signalling cell (UNI) | |
| 3 | Segment OAM F4 flow cell | Non-user cell |
| 4 | End-to-end OAM F4 flow cell | |
| 5 | Point-to-point signalling cell | User cell |
| 6 | Resource management cell | Non-user cell |
| 7-15 | Reserved for future standardized functions | |
| 16-31 | Reserved for future standardized functions | User cell |
| VCI > 31 | Available for user data transmission | |

### 4.2.2 F5 flow mechanism

The F5 flow is bidirectional. OAM cells for the F5 flow have the same VCI/VPI values as the user cells of the VCC and are identified by the Payload Type Identifier (PTI). The same PTI value shall be used for both directions of the F5 flow. The OAM cells for both directions of the F5 flow must follow the same physical route so that any connecting points supporting that connection can correlate the fault and performance information from both directions.

For the purpose of this Recommendation at F5 level, the term "user cell" is used for OAM according to the PTI values as shown in Table 2.

There are two kinds of F5 flows, which can simultaneously exist in a VCC. These are:

– *End-to-end F5 flow* – This flow, identified by a standardized PTI (see Recommendation I.361), is used for end-to-end VCC operations communications.

– *Segment F5 flow* – This flow, identified by a standardized PTI (see Recommendation I.361), is used for communicating operations information within the bounds of one VCC link or multiple inter-connected VCC links. Such a concatenation of VCC links is called a VCC segment.

One or more OAM segments may be defined along a VCC. Nevertheless neither overlapped nor embedded segments can be defined. For that purpose it must be ensured that all intermediate CPs in between the source/sink CP of a segment shall not be a source or sink CP of another segment.

The definition of the span of a managed segment is not necessarily fixed for the duration of a connection, i.e. the managed segment may be re-configured as required.

NOTE – A VCC segment is typically under the control of one Administration or organization, however, it can be extended beyond the control of one Administration/organization by mutual agreement.

End-to-end F5 flows must be terminated at the end-points of a VCC and segment F5 flows at the connecting points terminating a VCC segment. Intermediate points (i.e. connecting points) along the VCC or along the VCC segment may monitor OAM cells passing through them and insert new OAM cells, but they cannot terminate the OAM flow, except when loopbacks are performed. In this case the loopback cell (see 6.2.2.1.3) may be extracted from the OAM flow by the intermediate point where the loopback has to be performed and the looped cell may be extracted by the loopback originator upon reception. The F5 flow will be initiated at or after connection set-up either by the TMN or by OAM function dependent activation procedures.

A source point of a VCC segment acting in a downstream direction should discard unexpected VCC segment OAM cells coming from the upstream side of the connection.

It shall be possible for any intermediate connecting-point to be configured as a source/sink of a VCC segment.

TABLE 2/I.610

**“User cells” at F5 level**

| PTI code | Interpretation | Category |
|---|---|---|
| 000 | User data cell, congestion not experienced | User cells |
| 001 | | |
| 010 | User data cell, congestion experienced | |
| 011 | | |
| 100 | Segment OAM F5 flow cell | Non-user cells |
| 101 | End-to-end OAM F5 flow cell | |
| 110 | Resource management cell | |
| 111 | Reserved for future standardized functions | |

## 4.3 Association of the OAM mechanisms with the transport functions

Figure 3 gives an example of a virtual channel connection supported by all lower network levels according to the techniques described in clause 2/I.311. The associated OAM mechanisms for each level are also shown. The digital section and the regenerator section levels are shown combined under the term “section”.

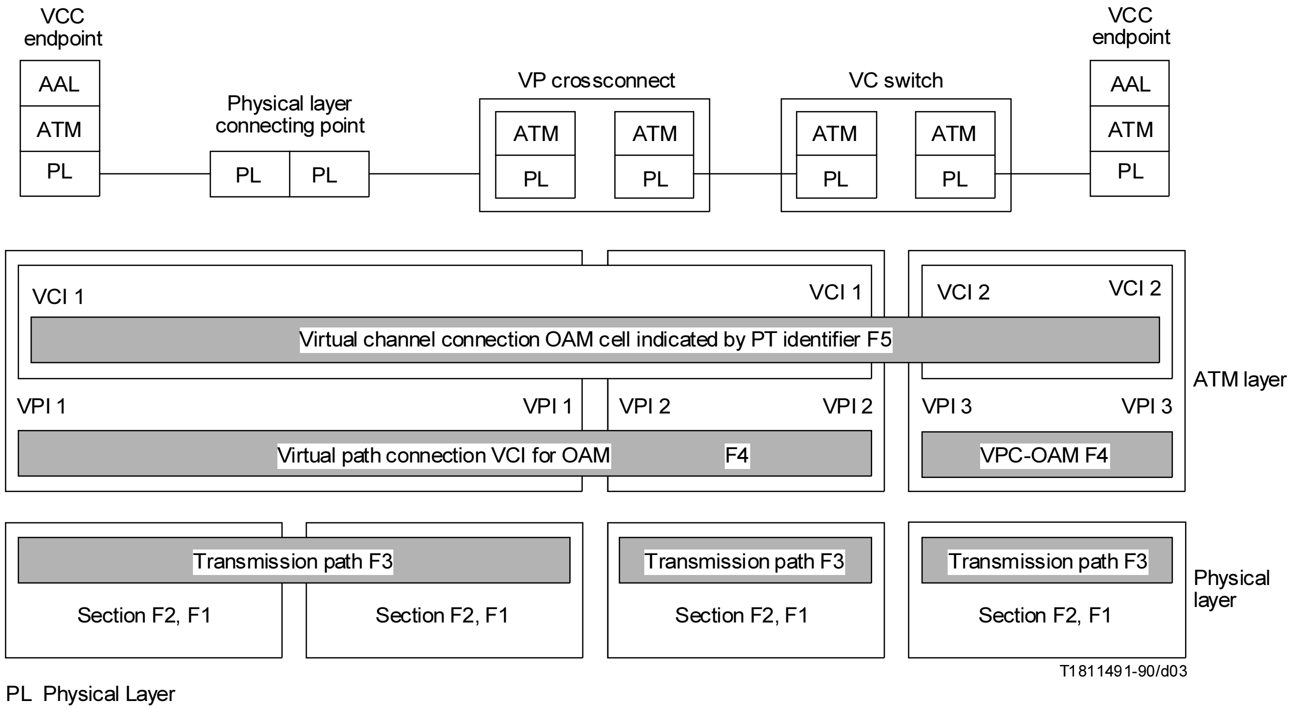



FIGURE 3/I.610

**Example of mechanisms for OAM flows**

## 5 OAM functions of the physical layer

This clause provides additional information on the OAM flows (F1, F2 and F3) within the physical layer. It is not intended to replace the in-depth physical layer OAM functionality defined in the G-Series Recommendations, e.g. for PDH rate interfaces refer to Recommendation G.832/G.804 and for SDH interfaces refer to Recommendation G.782/G.783/G.784.

A more detailed description of the physical layer to ATM layer adaptation function will be provided in the G-Series Recommendations.

### 5.1 OAM flows in some physical configurations

Figure 4 illustrates examples of the OAM flows in some physical configurations for the B-ISDN customer access.

### 5.2 OAM Functions

Two types of OAM functions are distinguished:

1) *OAM functions supported solely by the flows F1, F2, and F3*

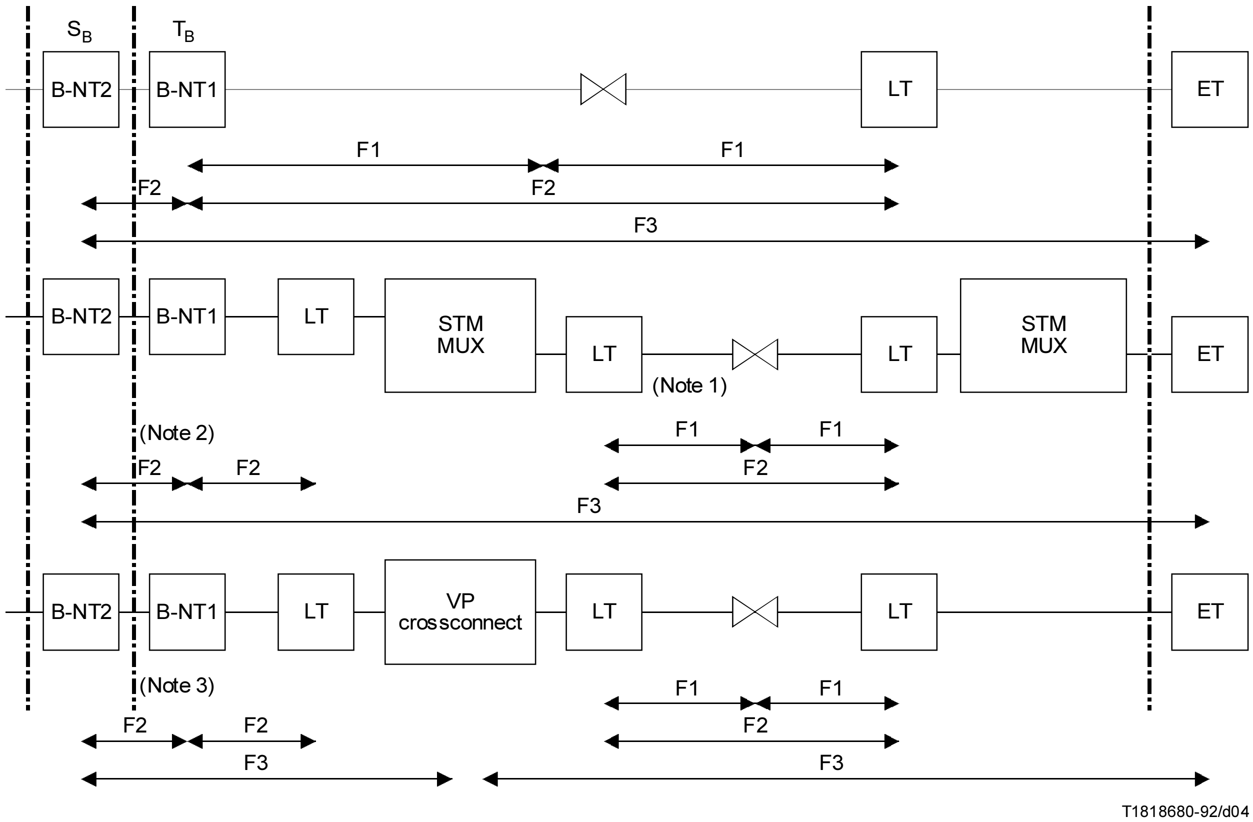
   – Dedicated to detection and indication of unavailability state.

   – Requiring "real time", defect information transport towards the affected end points for system protection.

2) *OAM functions with regard to the system management*

   – Dedicated to performance monitoring and reporting, or for localization of failed equipment.

   – May be supported by the flows F1 to F3 or by other means, e.g., TMN via the Q-interfaces.




ET Exchange Termination
LT Line Termination
STM Synchronous Transfer Mode

NOTES

1 Depending on the transmission system used (e.g. PDH, SDH, etc.) and its funcional implementation (e.g. LT integrated in STM MUX) the related OAM flows may be implemented but not shown.

2 In case of cell-based transmission systems, F2 functions are supported by F3 flow.

3 In case of cell-based transmission system, a F1 flow is provided.

FIGURE 4/I.610

**Examples of physical configurations and OAM flows at the physical layer**

### 5.2.1 OAM functions supported solely by the flows F1 to F3

Table 3 gives an overview of the OAM functions at the SDH-based physical layer. Table 4 illustrates the same aspects for the cell-based physical layer.

Tables 3 and 4 cover defects occurring on the B-NT2 <–> B-NT1 section and on the B-NT2 <–> transmission path termination. The B-NT1 <–> LT section has to provide some capability to report defects from the $T_B$ reference point to the relevant Q-interface.

#### 5.2.2 OAM functions with regard to the system management

For the SDH-based option, examples of these functions are:

- error monitoring at the regenerator section level, allowing the detection of a degraded error performance (optional);
- error monitoring/reporting at the multiplex section level, allowing the detection of a degraded error performance;
- error monitoring/reporting at the transmission path level, allowing the detection of a degraded error performance.

For the cell-based option, examples of these functions are:

- error monitoring/reporting at the regenerator section level, allowing the detection of a degraded error performance;
- error monitoring/reporting at the transmission path level, allowing the detection of a degraded error performance.

For both options, examples of these functions are:

- uncorrectable headers count;
- header error performance monitoring (degraded or not).

## 6 OAM functions of the ATM layer

### 6.1 OAM flows in some physical configurations

Figure 5 illustrates the implementation of the above-mentioned OAM flows in some physical configurations for the B-ISDN customer access. The arrow heads show possible flow termination points.

### 6.2 OAM functions

Table 5 gives an overview of the OAM functions of the ATM layer. Additional functions for testing, fault localization and performance measurement are for further study. Means to detect OAM procedure failures are for further study.

The use of the OAM mechanisms for VP/VC status monitoring (i.e. available or unavailable) is outlined in Annex A.

When allocating bandwidth to a connection, it is necessary to allocate sufficient bandwidth for the OAM cells in that connection as described in Recommendation I.371.

#### 6.2.1 OAM functions for VPC (F4 flow)

This subclause addresses VP-level fault management and performance management functions.

##### 6.2.1.1 Virtual path fault management functions

The following fault management functions shall be used.

###### 6.2.1.1.1 VP-AIS and VP-RDI defect indications

VP-AIS and VP-RDI defect indications shall be used for identifying and reporting VPC defects end-to-end. Segment VP-AIS and VP-RDI cells are for further study.

TABLE 3/I.610

**OAM functions of the SDH-based Physical Layer**
(Defect occurring on the B-NT2 <–> B-NT1 section)

| Level | Function | Defect detection | System protection and defect information transmitted in the flow | | |
|---|---|---|---|---|---|
| | | | F2 on the B-NT2 <–> B-NT1 section | B-NT1 <–> LT section (Note 2) | F3 on the B-NT2 <–> transmission path termination |
| Physical Interface/ Regenerator Section | Signal detection frame alignment | Loss of Signal or Loss of Frame into B-NT1 (from B-NT2) | MS-RDI towards the B-NT2 (Note 3) | (Note 1) | Path-AIS towards the transmission path termination (generated by the B-NT1) |
| | | Loss of Signal or Loss of Frame into B-NT2 (from B-NT1) | MS-RDI towards the B-NT1 (Note 3) | | Path-RDI towards the transmission path termination (generated by the B-NT2) |
| Multiplex Section (MS) | Section error monitoring (B2) | Unacceptable error performance outcome into B-NT1 | MS-RDI towards the B-NT2 (Notes 3, 4) | (Note 1) | Path-AIS towards the transmission path termination (generated by the B-NT1) (Note 4) |
| | | Unacceptable error performance outcome into B-NT2 | MS-RDI towards the B-NT1 (Notes 3, 4) | | – |
| Multiplex Section Adaptation (MSA) | AU Pointer operation | Loss of AU pointer or Path-AIS into B-NT2 | – | | Path-RDI towards the transmission path termination |
| Transmission path adaptation | Cell rate decoupling | Defect of insertion/ suppression of idle cells in B-NT2 | – | (Note 1) | (Note 5) |
| | Cell delineation | Loss of Cell Delineation defect into B-NT2 | – | | Path-RDI |

NOTES

1 Capabilities for reporting faults from the $T_B$ reference point to the relevant Q-interface must be accommodated by the transmission equipment specification.

2 In accordance with the OAM Recommendation of the transmission system.

3 In conformance with the SDH Recommendations the term MS (Multiplex Section) is used.

4 Can be disabled (see Recommendation G.783).

5 Creates no defect indication.

TABLE 4/I.610

**OAM functions of the cell-based Physical Layer**
(Defect occurring on the B-NT2 <–> B-NT1 section)

| Level | Function | Defect detection | System protection and defect information transmitted in the flow | | |
|---|---|---|---|---|---|
| | | | F1 on the B-NT2 <–> B-NT1 section | B-NT1 <–> LT section (Note 2) | F3 on the B-NT2 <–> Transmission path termination |
| Physical Interface/ Regenerator Section | Signal detection PL-OAM cell recognition | Loss of Signal or Loss of F1 PL-OAM cell recognition into B-NT1 (from B-NT2) | Section-RDI towards the B-NT2 | (Note 1) | Path-AIS towards the transmission path termination (generated by the B-NT1) (Note 3) |
| | | Loss of Signal or Loss of F1 PL-OAM cell recognition into B-NT2 (from B-NT1) | Section-RDI towards the B-NT1 | | Path-RDI towards the transmission path termination (generated by the B-NT2) |
| | Error monitoring | Unacceptable error performance outcome into B-NT1 | Section-RDI towards the B-NT2 | | Path-AIS towards the transmission path termination (generated by the B-NT1) |
| | | Unacceptable error performance outcome into B-NT2 | Section-RDI towards the B-NT1 | | – |
| Transmission Path | Cell rate decoupling | Defect of insertion/ suppression of idle cells in B-NT2 | – | (Note 1) | (Note 4) |
| | PL-OAM cell recognition | Loss of F3 PL-OAM cell recognition into B-NT2 | – | | Path-RDI |
| | Cell delineation | Loss of Cell Delineation defect into B-NT2 | – | | Path-RDI |

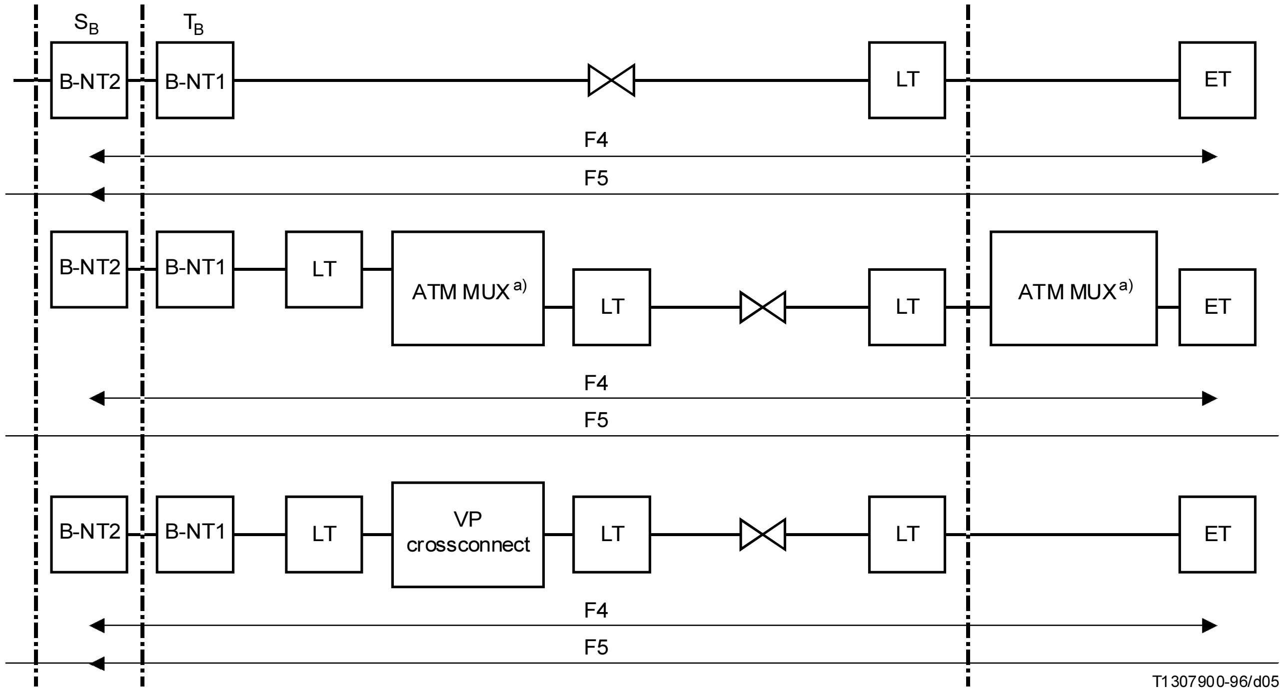
NOTES

1 Capabilities for reporting maintenance information from the $T_B$ reference point to the relevant Q-interface must be accommodated by the transmission equipment specification.

2 In accordance with the OAM Recommendation of the transmission system.

3 The B-NT1 as a connecting point can insert a Path-AIS at the F3 level.

4 Creates no defect indication.




a) ATM MUX without VP termination.

FIGURE 5/I.610

**Examples of physical configurations and OAM flows at the ATM layer**

TABLE 5/I.610

**OAM functions of the ATM layer**

| OAM function | Main application |
|---|---|
| AIS | For reporting defect indications in the forward direction |
| RDI | For reporting remote defect indications in the backward direction |
| Continuity check | For continously monitoring continuity |
| Loopback | For on-demand connectivity monitoring<br>For fault localization<br>For pre-service connectivity verification |
| Forward performance monitoring | For estimating performance |
| Backward performance monitoring | For reporting performance estimations in the backward direction |
| Activation/deactivation | For activating/deactivating performance monitoring and continuity check |
| System management | For use by end-systems only |

#### 6.2.1.1.1.1 VP-AIS

VP-AIS cells shall be generated and sent downstream on all affected active VPCs from the VP connecting point (e.g. at an ATM crossconnect) which detects the VPC defect at VP level. VP-AIS will be sent when receiving transmission path-AIS defect indications from the physical layer or detecting loss of continuity at the VP layer. Transmission path-AIS defect indications result from defects observed at the regenerator section, multiplex section or transmission path levels as shown in Tables 3 and 4.

*VP-AIS cell generation condition* – VP-AIS cells are generated and transmitted as soon as possible after observing a defect indication, and transmitted periodically during the defect condition in order to indicate an interruption of the cell transfer capability at the VP level. The generation frequency of VP-AIS cells is nominally one cell per second and shall be the same for each VPC concerned.

VP-AIS cell generation shall be stopped as soon as the defect indications (e.g. transmission path-AIS defect) are removed.

*VP-AIS cell detection* – VP-AIS cells are detected at the VPC sink-point. VP connecting points may non intrusively monitor the VP-AIS cells.

*VP-AIS state declaration and release conditions* – VP-AIS state is declared at the VPC end-point as soon as a VP-AIS cell is received, a transmission path-AIS defect or a VPC defect (e.g. loss of VPC continuity) is detected at this endpoint. The VP-AIS state is released when a user cell (see Table 1) or continuity check cell is received. If continuity check is not activated the VP-AIS state is also released if VP-AIS cells are absent for nominally 2.5 seconds, with a margin of ± 0.5 seconds.

#### 6.2.1.1.1.2 VP-RDI

VP-RDI is sent to the far-end from a VPC endpoint as soon as it has declared a VP-AIS state.

*VP-RDI cell generation condition* – VP-RDI cells are generated and transmitted periodically while the VP-AIS state persists in order to indicate in the backward direction an interruption of the cell transfer capability at the VP level in the forward direction. Generation frequency of VP-RDI cells is nominally one cell per second and shall be the same for all VPCs concerned.

VP-RDI cell generation shall be stopped as soon as the VP-AIS state is released.

*VP-RDI cell detection* – VP-RDI cells are detected at the VPC endpoint and VP-RDI state is declared after the reception of one VP-RDI cell. VP connecting points may monitor the VP-RDI cells.

*VP-RDI state declaration and release conditions* – VP-RDI state is declared at the VPC endpoint as soon as a VP-RDI cell is received at this point. The VP-RDI state is released at the VPC endpoint when no VP-RDI cell is received during a nominally 2.5 seconds period, with a margin of ± 0.5 seconds.

#### 6.2.1.1.2 VPC continuity check

Continuity Check (CC) can be simultaneously carried out end-to-end or at segment level on a certain number of selected active VPCs per interface (UNI, NNI) in each direction. The value of this number is outside the scope of this Recommendation.

Continuity check can be activated either during connection establishment or at any time after the connection has been established.

Procedures for activation (and associated deactivation) are described in 6.2.3. The possibility to activate the continuity check on all active VPCs and VPC segments remains as an option.

NOTE – Although use of the continuity check is a network operator option, some Administrations considered the ability to activate continuity check on some or all of the VPCs or VPC segments to be important. This is due to the fact that the continuity check is the only in-service mechanism able to continuously detect for ATM layer defects (as opposed to physical layer defects) in real-time. Also activation of the continuity check mechanism together with the performance management process allows the performance to be assessed only during the available time of the VPC/VPC segment according to Recommendation I.356.

Two alternative mechanisms exist for the insertion of continuity check cells after the activation of the continuity check function:

1) continuity check cell is sent downstream by a VPC source-point or a VPC segment source-point when no user cell has been sent for a period of nominally 1 second.
2) Continuity check cells can also be sent repetitively with a periodicity of nominally 1 cell per second independent of the user cell flow.

When the VPC sink-point with continuity check activated does not receive any user cell or continuity check cell within a time interval of 3.5 seconds, with a margin of ± 0.5 seconds, it will declare the VP-AIS state due to a Loss of Continuity (LOC) defect.

When the VPC segment sink-point does not receive any user cell or continuity check cell within a time interval of 3.5 seconds, with a margin of ± 0.5 seconds, it will declare a Loss of Continuity (LOC) defect and start transmitting VP-AIS cells downstream. However, during a LOC defect, to avoid a duplication of VP-AIS cell flows this segment sink-point shall not insert additional VP-AIS cells if it already is receiving and forwarding VP-AIS cells.

#### 6.2.1.1.3 VP loopback capability

##### 6.2.1.1.3.1 General description

The ATM layer loopback capability allows for operations related information to be inserted at one location along a virtual path connection and returned (or looped back) at a different location, without having to take the connection out-of-service. This capability is performed by non-intrusively inserting a loopback OAM cell at an accessible point along the virtual path connection (i.e. at an endpoint or any connecting point). This cell is looped back at a downstream point following either an instruction from the system management, or the information contained in its information field.

##### 6.2.1.1.3.2 Principles of operation

1) Loopback cells can be inserted at connecting as well as segment and connection endpoints. The VP connecting point that originated the looped cell may optionally remove it, after matching the correlation tag and the source identifier.
2) Segment loopback cells can be looped back at connecting as well as segment and connection endpoints. The VP connecting point may optionally remove the segment loopback OAM cell, after looping it back[1]. The use of the loopback location identifier (i.e. an identifier to address the particular node where the loopback is to occur) for the case of loopback at a connecting point, is a network operator option for segment loopback cells.
3) The waiting time between the transmission of successive loopbacks on a connection shall be 5 seconds. The loopback shall be considered unsuccessful if the loopback cell is not returned to the originating point within 5 seconds.
4) It shall be possible to initiate a loopback without a command from the TMN, e.g. a customer may initiate an end-to-end loopback. This does not preclude the reporting of loopback results to the TMN.
5) A means to confirm that loopback is performed at the ATM layer, rather than at the physical layer, is provided by requiring the loopback point to change a field (the loopback indication field – described in 7.2.4) within the loopback cell payload. This principle is illustrated in Figure 6. The requirement for the loopback point to change the loopback indication, also overcomes the problem of infinite loopback that would otherwise occur with the use of the default (all 1's) loopback location identifier.
6) End-to-end loopback cells shall not be looped back at intermediate connecting points.
7) Annex C shows the detailed procedures which should be performed when a loopback cell is received by a network element.

[1] Additional functions associated with the Loopback mechanism are for further study. These functions may require that the removal of Segment Loopack cells (after being looped back at an intermediate CP) be disabled.

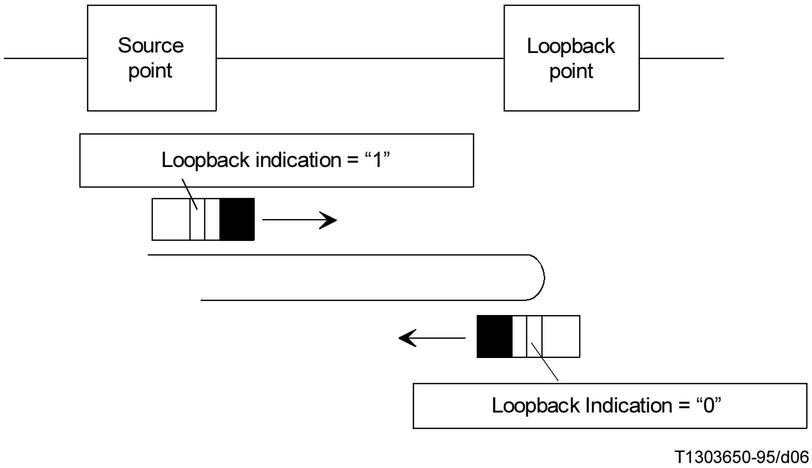



FIGURE 6/I.610
**The loopback indication function**

#### 6.2.1.1.3.3 Loopback applications

The loopback capability supports the applications shown in Figure 7. The applications are limited to the five following cases:

a) *End-to-end loopback* – A VP end-to-end loopback cell is inserted by a VP endpoint and looped back by the corresponding far-end VP endpoint.

b) *Access line loopback* – A VP segment loopback cell is inserted by the customer or the network and looped back by the first ATM node in the network or customer equipment respectively. For this application, the segment is defined by mutual agreement.

c) *Inter-domain loopback* – A VP segment loopback cell is inserted by one network operator and looped back by the first ATM node in an adjacent network operator domain. For this application, the segment is defined by mutual agreement.

d) *Network-to-endpoint loopback* – A VP end-to-end loopback cell is inserted by one network operator and looped back by the VP endpoint in another domain.

e) *Intra-domain loopback* – A VP segment loopback cell is inserted by a VP connection/segment endpoint or a VP connecting point and looped back by a VP segment or a VP connecting point. For this application, the use of the loopback location identifier is a network operator option.

#### 6.2.1.2 VP performance management functions

Performance monitoring of a VPC or VPC segment is performed by inserting monitoring cells at the ends of the VPC or VPC segment, respectively. In the procedure supporting this function, forward error detection information (e.g. the error detection code) is communicated by the end points using the forward (outgoing) F4 flow. The performance monitoring results, on the other hand, are received on the reverse (incoming) F4 flow. Note that when monitoring VPCs that are entirely within one span of control or when monitoring VPC segments, the monitoring result may be reported using the reverse F4 flow or via some other means (e.g. TMN).

Performance monitoring shall be done by monitoring blocks of user cells. Table 1 gives the list of cell types which should be considered as "user cell" for VP performance monitoring (i.e. cells which should form part of the monitored cell block at the VP level).

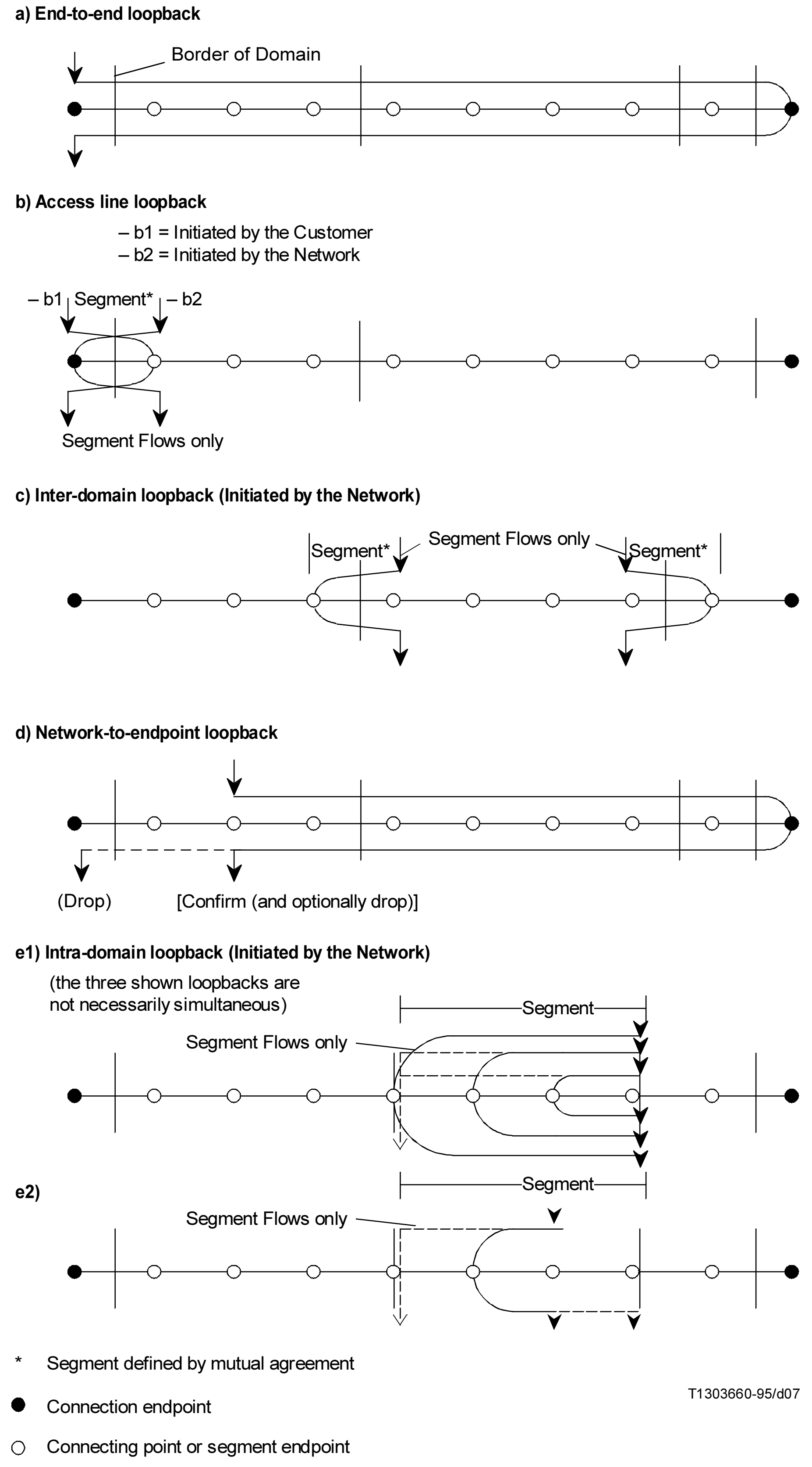



FIGURE 7/I.610

**Loopback applications**

Whenever performance monitoring is performed at the end-to-end or segment level, it is advisable to insure that the corresponding continuity check mechanism (end-to-end or segment continuity check, respectively) is activated during the overall performance assessment period. This allows a continuous monitoring of the availability of the VP connection or connection portion during that measurement period. Continuity check may be activated either before or when starting the performance monitoring process.

A performance monitoring cell insertion request is initiated after every N user cells. The monitoring cell is inserted at the first available cell location after the request.

The block size N may have the values 128, 256, 512, and 1024 (additional block sizes may be defined in the future). These are nominal block size values, and the actual size of the monitored cell block may vary. The cell block size may vary up to a maximum margin of 50% of the value of N for end-to-end performance monitoring. However, for end-to-end performance monitoring, the monitoring cell must be inserted into the user cell stream no more than N/2 user cells after an insertion request has been initiated. The actual monitoring block size averages out to approximately N cells.

To eliminate forced insertions when monitoring VPC segment performance, the actual monitoring block size may be extended until a cell location is available after the insertion request. However, in this case, the actual monitoring block size may not average out to N cells. Forced insertion at the segment level remains as an option.

The monitoring cell will detect:

– errored blocks;

– loss/mis-insertion of cells within a monitored block of cells;

– other functions (e.g. cell transfer delay) are for further study.

Performance monitoring can be simultaneously carried out on a certain number of selected VPCs per interface (UNI, NNI). The specification of this number is beyond the scope of this Recommendation.

Performance monitoring can be activated either during connection establishment or at any time after the connection has been established. Degradation of quality of service experienced by the user due to activation and deactivation should be negligible if resources are properly allocated.

Procedures for activation (and associated deactivation) are described in 6.2.3. Following performance monitoring activation, the first performance monitoring cell received is used for initialization only and is not used to update performance parameters.

There may be potential interference between performance monitoring and UPC/NPC actions. This requires further study.

#### 6.2.1.3 VP system management

The VP system management OAM cell type is defined for use by systems to control and maintain various functions at the VP layer. VP system management OAM cells are of the end-to-end type. These OAM cells are inserted/extracted and processed only within the end-user equipment (i.e. within the customer premises) which terminate the corresponding VPC; they are transparently conveyed on the VPC.

VP system management OAM cells are not defined either between network nodes or between an end-user equipment and a network node.

No segment flow for this function is defined, so that segment OAM cells with this cell type may be used by network element equipment for internal functions (i.e. this cell shall not cross any external interface). Thus no segment for the system management cell type shall be defined in the future.

End-user equipment implementation of the system management OAM cell is optional and is not recommended except for specific applications which are not satisfied by other mechanisms.

### 6.2.2 OAM functions for the VCC (F5 flow)

This subclause addresses VC-level fault management and performance management functions.

#### 6.2.2.1 Virtual channel fault management functions

The following fault management functions shall be used.

##### 6.2.2.1.1 VC-AIS and VC-RDI defect indications

VC-AIS and VC-RDI defect indications shall be used for identifying and reporting VCC defects end-to-end. Segment VC-AIS and VC-RDI cells are for further study.

###### 6.2.2.1.1.1 VC-AIS

VC-AIS cells shall be generated and sent downstream on all affected active VCCs from the VC connecting point (e.g. at an ATM switch) which detects the VCC defect at VC level. VC-AIS will be sent when receiving transmission path-AIS defect indications from the physical layer or defect indications from the VP level (e.g. VP-AIS or loss of VPC continuity) or detecting loss of continuity at the VC layer. Transmission path-AIS defect indications result from defects observed at the regenerator section, multiplex section or transmission path level as shown in Tables 3 and 4.

*VC-AIS Cell Generation Condition* – VC-AIS cells are generated and transmitted as soon as possible after observing a defect indication, and transmitted periodically during the defect condition in order to indicate an interruption of the cell transfer capability at the VC level. The generation frequency of VC-AIS cells is nominally one cell per second and shall be the same for each VCC concerned.

VC-AIS cell generation shall be stopped as soon as the defect indications (e.g. transmission path-AIS, VP-AIS and loss of VPC continuity) are removed.

*VC-AIS Cell Detection* – VC-AIS cells are detected at the VCC sink-point. VC connecting points may monitor the VC-AIS cells non-intrusively.

*VC-AIS state declaration and release conditions* – VC-AIS state is declared at the VCC endpoint as soon as a VC-AIS cell is received or a transmission path-AIS defect, a VPC defect (e.g. VP-AIS, loss of VPC continuity) or a VCC defect (e.g. loss of VCC continuity) is detected at this endpoint. The VC-AIS state is released when a valid user cell (see Table 2) or end-to-end continuity check cell is received. If continuity check is not activated, the VC-AIS state is also released if VC-AIS cells are absent for nominally 2.5 seconds with a margin of ± 0.5 seconds.

###### 6.2.2.1.1.2 VC-RDI

VC-RDI is sent to the far-end from a VCC endpoint as soon as it has declared a VC-AIS state.

*VC-RDI Cell Generation Condition* – VC-RDI cells are generated and transmitted periodically while the VC-AIS state persists in order to indicate in the backward direction an interruption of the cell transfer capability at the VC level in the forward direction. Generation frequency of VC-RDI cells is nominally one cell per second and shall be the same for all VCCs concerned.

VC-RDI cell generation shall be stopped as soon as the VC-AIS state is released.

*VC-RDI Cell Detection* – VC-RDI cells are detected at the VCC endpoint. VC connecting points may monitor the VC-RDI cells.

*VC-RDI state declaration and release condition* – VC-RDI state is declared at the VCC endpoint as soon as a VC-RDI cell is received at this endpoint. The VC-RDI state is released at the VCC endpoint when no VC-RDI cell is received during a nominally 2.5 seconds period, with a margin of ± 0.5 seconds.

##### 6.2.2.1.2 VCC continuity check

Continuity Check (CC) can be simultaneously carried out end-to-end or at segment level on a certain number of selected active VCCs per interface (UNI, NNI) in each direction. The value of this number is outside the scope of this Recommendation.

Continuity check can be activated either during connection establishment or at any time after the connection has been established.

Procedures for activation (and associated deactivation) are described in 6.2.3.

The possibility to activate the continuity check on all active VCCs and VCC segments remains as an option.

NOTE – The same note as for the VPC case in 6.2.1.1.2 applies here too.

Two alternative mechanisms exist for the insertion of continuity check cells after the activation of the continuity check function:

1) A continuity check cell is sent downstream by a VCC source-point or a VCC segment source-point when no user cell has been sent for a period of nominally 1 second.

2) Continuity check cells can also be sent repetitively with a periodicity of nominally 1 cell per second independent of the user cell flow.

When the VCC sink-point with continuity check activated does not receive any user cell or continuity check cell within a time interval of 3.5 seconds, with a margin of ± 0.5 seconds, it will declare the VC-AIS state due to a Loss of Continuity (LOC) defect.

When the VCC segment sink-point does not receive any user cell or continuity check cell within a time interval of 3.5 seconds, with a margin of ± 0.5 seconds, it will declare a Loss of Continuity (LOC) defect and start transmitting VC-AIS cells downstream. However, during an LOC defect, to avoid a duplication of VC-AIS cell flows this segment sink-point shall not insert additional VC-AIS cells if it already is receiving and forwarding VC-AIS cells.

**6.2.2.1.3 VC loopback capability**

**6.2.2.1.3.1 General description**

The ATM layer loopback capability allows for operations related information to be inserted at one location along a virtual channel connection and returned (or looped back) at a different location, without having to take the connection out-of-service. This capability is performed by non-intrusively inserting a loopback OAM cell at an accessible point along the virtual channel connection (i.e. at an end-point or any connecting point). This cell is looped back at a downstream point following an instruction either from the system management, or the information contained in its information field.

**6.2.2.1.3.2 Principles of operation**

1) Loopback cells can be inserted at connecting as well as segment and connection endpoints. The VC connecting point that originated the looped cell may optionally remove it, after matching the correlation tag and the source identifier.

2) Segment loopback cells can be looped back at connecting as well as segment and connection endpoints. The VC connecting point may optionally remove the segment loopback OAM cell, after looping it back[2]. The use of the loopback location identifier (i.e. an identifier to address the particular node where the loopback is to occur) for the case of loopback at a connecting point, is a network operator option for segment loopback cells.

3) The waiting time between the transmission of successive loopbacks on a connection shall be 5 seconds. The loopback shall be considered unsuccessful if the loopback cell is not returned to the originating point within 5 seconds.

4) It shall be possible to initiate a loopback without a command from the TMN, e.g. a customer may initiate an end-to-end loopback. This does not preclude the reporting of loopback results to the TMN.

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[2] Additional functions associated with the Loopback mechanism are for further study. These functions may require that the removal of Segment Loopack cells (after being looped back at an intermediate CP) be disabled.

5) A means to confirm that loopback is performed at the ATM layer, rather than at the physical layer, is provided by requiring the loopback point to change a field (the loopback indication field – described later) within the loopback cell payload. This principle is illustrated in Figure 6. As discussed in 7.2.4, the requirement for the loopback point to change the loopback indication, also overcomes the problem of infinite loopback that would otherwise occur with the use of the default (all 1's) loopback location identifier.

6) End-to-end loopback cells shall not be looped back at intermediate connecting points.

7) Annex C shows the detailed procedures which should be performed when a loopback cell is received by a network element.

#### 6.2.2.1.3.3 Loopback applications

The loopback capability supports the applications shown in Figure 7. The applications are:

a) *End-to-end loopback* – A VC end-to-end loopback cell is inserted by a VC endpoint, and looped back by the corresponding far-end VC endpoint.

b) *Access line loopback* – A VC segment loopback cell is inserted by the customer or the network, and looped back by the first ATM node (at the VC level) in the network or customer equipment respectively. For this application, the segment is defined by mutual agreement.

c) *Inter-domain loopback* – A VC segment loopback cell is inserted by one network operator, and looped back by the first ATM node (at the VC level) in an adjacent network operator domain. For this application, the segment is defined by mutual agreement.

d) *Network-to-endpoint loopback* – A VC end-to-end loopback cell is inserted by one network operator, and looped back by the VC endpoint in another domain.

e) *Intra-domain loopback* – A VC segment loopback is inserted by a VC connection/segment endpoint or a VC connecting point, and looped back by a VC segment or a VC connecting point. For this application, the use of the loopback location identifier is a network operator option.

#### 6.2.2.2 VC performance management functions

Performance monitoring of a VCC or VCC segment is performed by inserting monitoring cells at the ends of the VCC or VCC segment, respectively. In the procedure supporting this function, forward error detection information (e.g. the error detection code) is communicated by the endpoints using the forward (outgoing) F5 flow. The performance monitoring results, on the other hand, are received on the reverse (incoming) F5 flow. Note that when monitoring VCCs that are entirely within one span of control or when monitoring VCC segments, the monitoring result may be reported using the reverse F5 flow or via some other means (e.g. TMN).

Performance monitoring shall be done by monitoring blocks of user cells. Table 2 gives the list of cell types which should be considered as "user cell" for VC performance monitoring (i.e. cells which should form part of the monitored cell block at the VC level).

Whenever performance monitoring is performed at the end-to-end or segment level, it is advisable to insure that the corresponding continuity check mechanism (end-to-end or segment continuity check, respectively) is activated during the overall performance assessment period. This allows a continuous monitoring of the availability of the VC connection or connection portion during that measurement period. Continuity check may be activated either before or when starting the performance monitoring process.

A performance monitoring cell insertion request is initiated after every N user cells. The monitoring cell is inserted at the first available cell location after the request.

The block size N may have the values 128, 256, 512, and 1024 (additional block sizes may be defined in the future). These are nominal block size values, and the actual size of the monitored cell block may vary. The cell block size may vary up to a maximum margin of 50% of the value of N for end-to-end performance monitoring. However, for end-to-end performance monitoring, the monitoring cell must be inserted into the user cell stream no more than N/2 user cells after an insertion request has been initiated. The actual monitoring block size averages out to approximately N cells.

To eliminate forced insertions when monitoring VCC segment performance, the actual monitoring block size may be extended until a cell location is available after the insertion request. However, in this case, the actual monitoring block size may not average out to N cells. Forced insertion at the segment level remains an option.

The monitoring cell will detect:

- errored blocks;
- loss/mis-insertion of cells within a monitored block of cells;
- other functions (e.g. cell transfer delay) are for further study.

Performance monitoring can be simultaneously carried out on a certain number of selected VCCs per interface. The specification of this number is beyond the scope of this Recommendation.

Performance monitoring can be activated either during connection establishment or at any time after the connection has been established. Degradation of quality of service experienced by the user due to activation and deactivation should be negligible if resources are properly allocated.

Procedures for activation (and associated deactivation) are described in 6.2.3. Following performance monitoring activation, the first performance monitoring cell received is used for initialization only and is not used to update performance parameters.

There may be potential interference between performance monitoring and UPC/NPC actions. This requires further study.

#### 6.2.2.3 VC system management

The VC system management OAM cell type is defined for use by systems to control and maintain various functions at the VC layer. VC system management OAM cells are of the end-to-end type. These OAM cells are inserted/extracted and processed only within the end-user equipment (i.e. within the customer premises) which terminate the corresponding VCC; they are transparently conveyed on the VCC.

VC system management OAM cells are not defined either between network nodes or between an end-user equipment and a network node.

No segment flow for this function is defined, so that segment OAM cells with this cell type may be used by network element equipment for internal functions (i.e. this cell shall not cross any external interface). Thus no segment for the system management cell type shall be defined in the future.

End-user equipment implementation of the system management OAM cell is optional and is not recommended except for specific applications which are not satisfied by other mechanisms.

### 6.2.3 Activation/deactivation procedures

The following procedures are identical at both the VP and VC level.

Performance monitoring and continuity check can be activated either during connection/segment establishment or at any time after the connection/segment has been established. Such activation (and associated deactivation) is initiated by the TMN or by the end-user. After the TMN or the end-user has requested activation/deactivation of performance monitoring or continuity check, an initialization procedure is needed between the two endpoints of the connection (or connection segment) to properly initialize the OAM process. Specifically, this initialization procedure serves the following purposes:

- To coordinate the beginning or end of the transmission and downstream reception of OAM cells used to monitor performance or check continuity.
- To establish agreement on the block size and the direction of transmission to start or stop monitoring in the case of performance monitoring.

The initialization procedure is performed by either:

a) using activation/deactivation OAM cells as illustrated in Figures 8 and 9 for activation and deactivation, respectively; or

b) entirely via TMN as described below.

The detailed specification of the activation/deactivation OAM procedure a) is given in Annex B.

For the case where performance monitoring or continuity check is to be established on a connection or connection segment with endpoints contained in a single administrative domain, the OAM function activation and deactivation may be also entirely carried out by the TMN. In this case, the following information is necessary from the TMN:

1) Identification of the specific connection or connection segment on which performance monitoring or continuity check activation/deactivation is desired.

2) The direction of action.

3) For performance monitoring activation requests, one (and only one) block size must be specified for the forward monitoring direction. No block size is reported for the backward reporting direction.

For the case where the connection or connection segment crosses an administrative boundary, performance monitoring or continuity check activation and deactivation may in special cases be also entirely carried out by the TMN. This, however, requires mutual agreement and TMN coordination among network providers and end-users as applicable.

In both cases above, the TMN is responsible for coordinating the connection or connection segment end-points' activities. Therefore, it is necessary that actions be completed one direction at a time.

As an example of this procedure, activation of a bidirectional performance monitoring on connection A-B may be carried out by the following four steps:

In the A to B direction:

- Endpoint B is commanded to activate the sink-process of the performance monitoring function.

- Endpoint A is commanded to activate the source-process of the performance monitoring function.

In the B to A direction:

- Endpoint A is commanded to activate the sink-process of the performance monitoring function.

- Endpoint B is commanded to activate the source-process of the performance monitoring function.

Deactivation of the performance monitoring function for connection A-B would follow these steps in reverse order.

As another example of this procedure, activation of a bidirectional continuity check on connection A-B may be carried out by the following four steps:

In the A to B direction:

- Endpoint A is commanded to activate the source-process of the continuity check function.

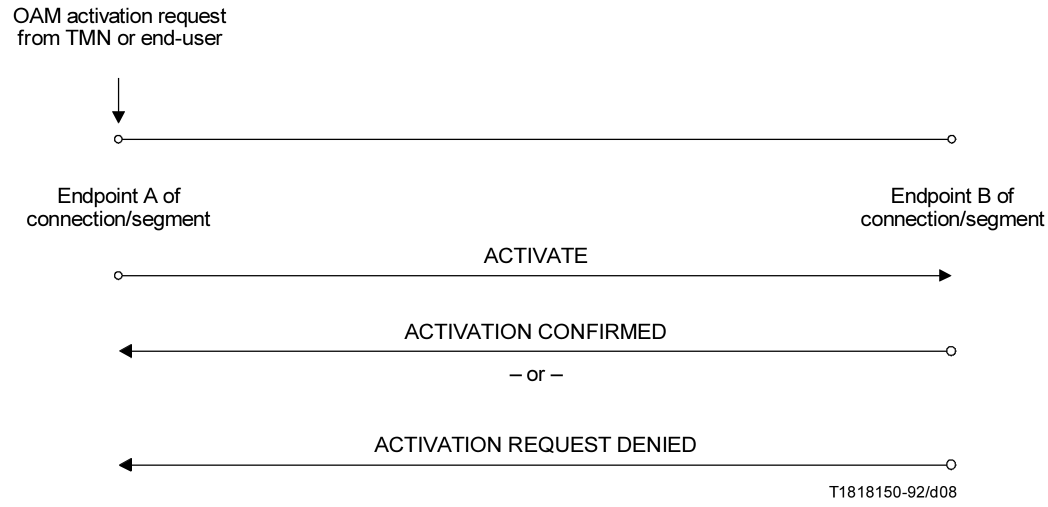
- Endpoint B is commanded to activate the sink-process of the continuity check function.

In the B to A direction:

- Endpoint B is commanded to activate the source-process of the continuity check function.

- Endpoint A is commanded to activate the sink-process of the continuity check function.

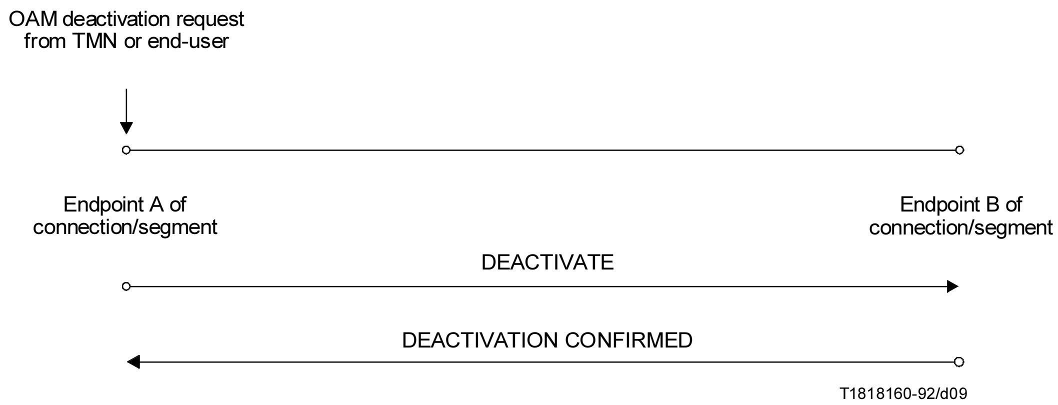
Deactivation of the continuity check function for connection A-B would follow these steps in reverse order.




OAM Performance Monitoring or Continuity Check function

FIGURE 8/I.610

**Initialization procedure for PM or CC activation via activation OAM cells**




OAM Performance Monitoring or Continuity Check OAM function.

FIGURE 9/I.610

**Initialization procedure for PM or CC deactivation via deactivation OAM cells**

## 7 ATM layer OAM cell format

The ATM layer OAM cells contain fields common to all types of OAM cells (see Table 6) as well as specific fields for each type of OAM cell. The coding principles for unused common and specific fields are:

- Unused OAM cell information field octets are coded 0110 1010 (6AH);
- Unused OAM cell information field bits (incomplete octets) are coded all zero.

The unused octets and unused bits are not to be checked by the receiver for conformance to this coding rule. A connecting point (which is not also a segment endpoint) shall transparently transfer all OAM cells regardless of the encoding within a given field (except possibly for the case of loopback cells, see 6.2.1.1.3.2 and 6.2.2.1.3.2).

Further enhancements to this Recommendation should ensure that equipment supporting lower versions has no compatibility problems related to the content of OAM cells. That is, functions and encodings of defined fields shall not be redefined in the future.

However, unused fields and unused code-points may be defined in future releases of this Recommendation and are therefore reserved.

For the purpose of this Recommendation the leftmost bit is the most significant bit and transmitted first.

TABLE 6/I.610

**OAM Type and function type identifiers**

| OAM type | Coding | Function type | Coding |
|---|---|---|---|
| Fault management | 0001<br>0001<br>0001<br>0001 | AIS<br>RDI<br>Continuity check<br>Loopback | 0000<br>0001<br>0100<br>1000 |
| Performance management | 0010<br>0010 | Forward monitoring<br>Backward reporting | 0000<br>0001 |
| Activation/deactivation | 1000<br>1000 | Performance monitoring<br>Continuity check | 0000<br>0001 |
| System management | 1111 | (Note) | (Note) |
| NOTE – Not to be standardized by this Recommendation. | | | |

### 7.1 Common OAM cell fields

All ATM layer OAM cells will have the following common fields (see Figure 10):

1) *Header* – Details of this field are in Recommendation I.361. For F4 flow identification, two pre-assigned VCIs are used to distinguish OAM cells for VPCs and VPC segments. These two values are defined in Recommendation I.361. For F5 flow identification, two PTI values are used to distinguish OAM cells for VCCs and VCC segments. These two values are defined in Recommendation I.361.

2) *OAM Cell Type (4 bits)* – This field indicates the type of management function performed by this cell, e.g. fault management, performance management, and activation/deactivation.

3) *OAM Function Type (4 bits)* – This field indicates the actual function performed by this cell within the management type indicated by the OAM cell type field.

4) *Reserved field for future use (6 bits)* – Default value coded all zero. One possible use of these bits is an OAM protocol version indication.

5) *Error Detection Code (10 bits)* – This field carries a CRC-10 error detection code computed over the OAM cell information field excluding the EDC field. It shall be the remainder of the division (modulo 2) by the generator polynomial of the product of $x^{10}$ and the content of the OAM cell information field (namely OAM type, function type, function specific field, reserved field, excluding the EDC field) (374 bits). Each bit of the concatenated field mentioned above is considered as a coefficient (modulo 2) of a polynomial of degree 373 using the first bit as coefficient of the highest order term. The CRC-10 generating polynomial is:

$$G(x) = 1 + x + x^4 + x^5 + x^9 + x^{10}$$

The result of the CRC calculation is placed with the least significant bit right justified in the CRC field. See Appendix I for examples of CRC-10 values.

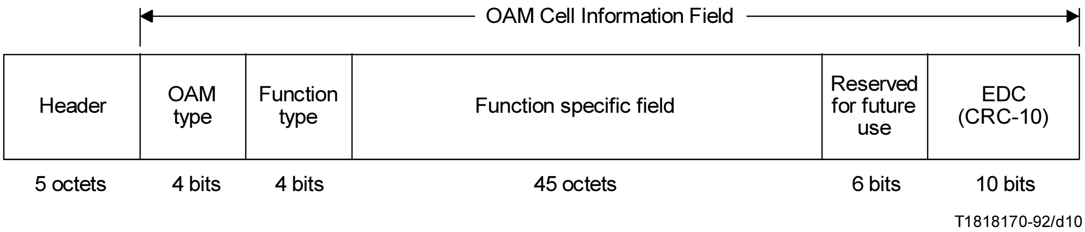



FIGURE 10/I.610

**Common OAM Cell Format**

## 7.2 Specific fields for fault management cell

The function type field for fault management applications will be used to identify the following possible functions: AIS, RDI, continuity check, and loopback. Further specifications of cells carrying these functions are provided in the subclauses that follow.

### 7.2.1 AIS/RDI fault management cell

The AIS/RDI fault management cell will have the following function specific fields:

1) *Defect Type (8 bits)* – As an option, this field may be used to indicate the nature of the reported defect.

   Examples for these defect types are:

   – defect not specified;

   – defect in the VP/VC layer in which the OAM flow is transmitted;

   – defect in the layer which supports the layer in which the OAM flow is transmitted (lower layer defect).

   An additional distinction can be made to indicate whether the defect occurs in-service or out-of-service. Additional detailed defect information and the coding of the defect type field is for further study.

If this field is not used it shall be encoded 6AH.

2) *Defect Location (16 octets)* – As an option, this field may be used to carry information about the defect location. For an AIS cell this field indicates the location which generates the AIS cell. For an RDI cell this field contains the same location identifier as which was received in the corresponding AIS cell.

If this optional field is not used it shall be encoded 6AH. See Figure 11.

| Defect type (Optional) | Defect location (Optional) | Unused octets (6AH) |
|---|---|---|
| 1 octet | 16 octets | 28 octets |

FIGURE 11/I.610

**Specific fields for AIS/RDI fault management cell**

#### 7.2.3 Continuity check fault management cell

There are currently no fields that are specific to the continuity check function, and hence the function specific field is encoded 6AH.

#### 7.2.4 Loopback cell

The OAM cell format for VP/VC end-to-end and segment level loopback is provided in Figure 12. The function specific fields consist of:

– *Loopback indication field* (1 octet) – The least significant bit of this field provides a boolean indication as to whether or not the cell has already been looped back. The field confirms that the loopback has occured at the ATM layer and avoids the problem of infinite loopback that would otherwise occur when the default (all 1's) loopback location ID field is used. The source point encodes this field as 00000001. The loopback point changes the encoding to 00000000.

– *Correlation tag field* (4 octets) – This field is used to correlate the transmitted OAM cell with the received OAM cell.

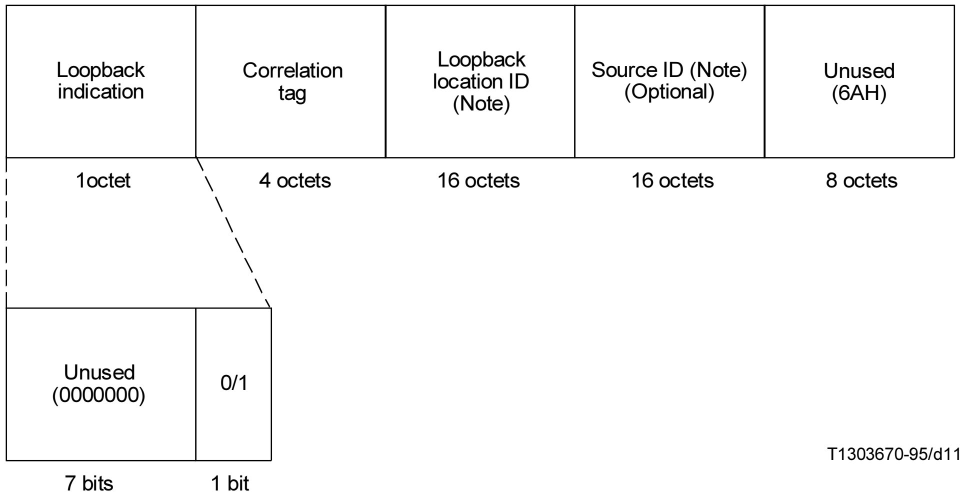
– *Loopback location ID field* (16 octets) – This field identifies as an option the connecting point along the virtual connection or connection segment where the loopback is to occur. The value of this field is not subject to standardization. Default is all 1's, and represents the end-point of the connection or connection segment, depending on the flow.

– *Source ID field* (16 octets) – The use of this field is optional and identifies the source originating the loopback cell. The value of this field is not subject to standardization. Default is all 1's.

Annex C shows the detailed procedures which should be performed when a loopback cell is received by a network element.

### 7.3 Specific fields for performance management cell (see Figure 13)

The function type field for performance management applications will be used to identify the following possible functions: forward monitoring and backward reporting. When forward monitoring and backward reporting functions are both activated, for a given connection, OAM information related to a given cell block – which is transmitted in the forward direction – has to be carried in both directions by corresponding forward monitoring and backward reporting OAM cells referred to as "paired" OAM cells, i.e. for each received forward monitoring OAM cell a corresponding backward reporting cell shall be issued.




NOTE – values (except for default all 1's) are not subject to standardization and encoding of non-default values is optional.

FIGURE 12/I.610

**Specific fields for loopback cell**

The performance management cell will have the following function specific fields:

| MCSN | $TUC_{0+1}$ | $BEDC_{0+1}$ | $TUC_{0}$ | TSTP (Optional) | Unused | $TRCC_{0}$ | $BLER_{0+1}$ | $TRCC_{0+1}$ |
|---|---|---|---|---|---|---|---|---|
| 8 bits | 16 bits | 16 bits | 16 bits | 32 bits | 29 octets | 16 bits | 8 bits | 16 bits |

$BEDC_{0+1}$ is only used for forward monitoring cells.

$TRCC_{0}$, $BLER_{0+1}$ and $TRCC_{0+1}$ are only used for backward reporting cells.

MCSN, $TUC_{0}$ , TSTP and $TUC_{0+1}$ fields are used for both types of PM-OAM cells.

FIGURE 13/I.610

**Specific fields for the forward monitoring and the backward reporting performance management cell**

1) *Monitoring Cell Sequence Number (MCSN) (8 bits)* – This sequence number field indicates the current value of a running counter modulo 256 of the forward monitoring and of the backward reporting OAM cell sequence. Independent counters are used at both ends of the connection/segment for the paired forward monitoring and backward reporting cells.

2) *Total user cell number related to the CLP-$_{0+1}$ user cell flow (TUC-$_{0+1}$) (16 bits)* – This field indicates the current value of a running counter related to the total number (modulo 65536) of transmitted user cells (i.e. CLP = 0+1), when the forward monitoring cell is inserted. In case of backward reporting OAM cell, this field contains the TUC–$_{0+1}$ value copied from the paired forward monitoring OAM cell.

NOTE 1 – In case of forward monitoring OAM cells, at the transmitting side (where OAM cells are inserted), the difference between two consecutive TUC values represents then the number of user cells included between two forward monitoring OAM cells sent consecutively. This corresponds to the size of the block of user cells on which performance is estimated. In case of backward reporting OAM cells, at the transmitting side, the difference between two consecutively transmitted TUC values represents then the number of user cells included between two consecutively received forward monitoring OAM cells. This set of cells corresponds to one block of user cells if forward monitoring OAM cells are received in sequence (MCSN values are consecutive) or to several blocks in case of lost forward monitoring OAM cells.

3) *Total user cell number related to the CLP-$_0$ user cell flow (TUC-$_0$) (16 bits)* – The use of this field is similar to the use of the TUC-$_{0+1}$ field. It is related to the transmitted user cells with a CLP value equal to "0".

4) *Block error detection code related to the CLP-$_{0+1}$ user cell flow (BEDC-$_{0+1}$) (16 bits)* – This field is used for forward monitoring OAM cells only. It carries the even parity BIP-16 (see Note 2) error detection code computed over the information fields of the block of user cells (i.e. CLP = 0+1) after the transmission of the last forward monitoring cell. In the case of backward reporting OAM cells, this field is unused and all octets are encoded as 6AH.

NOTE 2 – Bit interleaved parity-X (BIP-X) code is defined as a method of error monitoring. With even parity an X-bit code is generated by the transmitting equipment over a specific portion of the signal in such a manner that the first bit of the code provides even parity over the first bit of all X-bit sequences in the covered portion of the signal, the second bit provides even parity over the second bit of all X-bit sequences within the specific portion, etc. Even parity is generated by setting the BIP-X bits so that there is an even number of 1's in each of all monitored partitions of the signal including the BIP-X (a monitor partition of the signal is built by all bits which are in the same bit position within the X-bit sequences in the covered portion of the signal).

5) *Time Stamp (TSTP) (32 bits)* – As an option this field may be used to represent the time at which the performance monitoring OAM cell was inserted. Default value for this field shall be all 1's since 6AH might be a valid time stamp value. Use of this field requires further study.

6) *Total received cell count related to the CLP-$_{0+1}$ user cell flow (TRCC-$_{0+1}$) (16 bits)* – This field is used for backward reporting OAM cells only. All user cells are considered (i.e. CLP = 0+1). This field carries the current value of a running counter related to the total number (modulo 65536) of received user cells (CLP = 0+1), read when a forward monitoring OAM cell is received.

NOTE 3 – At the transmitting point (where backward reporting OAM cells are inserted), the difference between two consecutively transmitted TRCC-$_{0+1}$ values represents then the number of user cells received between the two last received forward monitoring OAM cells. At the receiving side where backward reporting OAM cells are evaluated, the following calculations can be performed on two consecutively received backward reporting OAM cells:

a) Calculate the difference (modulo 65536) between two consecutively received TRCC-$_{0+1}$ fields;

b) Calculate the difference (modulo 65536) between two consecutively received TUC-$_{0+1}$ fields.

The difference b) – a) estimates the number of lost cells (positive result), or the number of misinserted cells (negative result); a zero result is interpreted as no lost/misinserted cells.

7) *Total Received Cell Count related to the CLP-$_0$ user cell flow (TRCC-$_0$) (16 bits)* – This field is used for backward reporting OAM cells only. The use of this field is similar to the use of the TRCC-$_{0+1}$ field. It is related to the total number of received user cells with a CLP value equal to "0".

NOTE 4 – If CLP = 0 cells are "tagged" (i.e. changed to CLP = 1, see Recommendation I.371) the computed number for CLP = 0 lost/misinserted cells may be misleading.

8) *Block error result (BLER-$_{0+1}$) (8 bits)* – This field is used for backward reporting OAM cells only. It carries the number of errored parity bits detected by the BIP-16 code of the paired forward monitoring cell. This number is only inserted in the corresponding backward reporting cell if the following two conditions are met:

   – The number of user data cells (i.e. CLP = 0+1) between the last two forward monitoring OAM cells equals the difference between the TUC of the last two forward monitoring OAM cells.

   – The MCSN of the last two PM OAM cells used for forward monitoring are sequential.

   Otherwise the field shall be encoded as all 1's. In the case of forward monitoring OAM cells, this field is unused and coded as 6AH.

### 7.4 Specific fields for activation/deactivation cell (see Figure 14)

The function type field for activation/deactivation applications will be used to identify the following possible function:

– PM activation/deactivation; and

– Continuity check activation/deactivation.

The activation/deactivation cell will have the following specific fields:

| Message ID | Directions of action | Correlation tag | PM block size A-B | PM block size B-A | Unused octets (6AH) |
|---|---|---|---|---|---|
| 6 bits | 2 bits | 8 bits | 4 bits | 4 bits | 336 bits |

FIGURE 14/I.610

**Specific fields for activation/deactivation cell**

1) *Message ID* (6 bits) – This field indicates the message ID for activating or deactivating specific VPC/VCC OAM functions. Code values for this field are shown in Table 7.

2) *Correlation Tag* (8 bits) – A correlation tag is generated for each message so nodes can correlate commands with responses. That is, the correlation tag in a response must match the correlation tag in the associated command. Consecutively generated correlation tags should be different, in order to correctly correlate commands with responses.

3) *Direction(s) of Action* (2 bits) – This field identifies the direction(s) of transmission to activate/deactivate OAM function. The A-B and B-A notation is used to differentiate between the direction of transmission away or towards the activator/deactivator, respectively. This field value is used as a parameter for the ACTIVATE and DEACTIVATE messages. This field shall be encoded as 01 for B-A, 10 for A-B, 11 for two-way action, and 00 (default value) when not applicable.

4) *PM Block Size A-B* (4 bits) – This field specifies the A-B PM block size required by the activator for the Performance Monitoring function. Currently defined code values for this field are shown in Table 8. This field value is used as a parameter for the ACTIVATE and ACTIVATION CONFIRMED messages. The default value for this field shall be 0000 for all other messages and when activating/deactivating continuity check.

5) *PM Block Size B-A* (4 bits) – This field specifies the B-A block size required by the activator for the performance monitoring function. It is encoded and used in the same manner as the block size A-B field.

TABLE 7/I.610

**Message ID values**

| Message | Command/ response | Coding |
|---|---|---|
| Activate | Command | 000001 |
| Activation Confirmed | Response | 000010 |
| Activation request denied | Response | 000011 |
| Deactivate | Command | 000101 |
| Deactivation confirmed | Response | 000110 |
| Deactivation request denied | Response | 000111 |

TABLE 8/I.610

**PM block size encoding**

| Message type | PM block size | Coding |
|---|---|---|
| Other | Unused | 0000 |
| ACTIVATE and ACTIVATE CONFIRMED for performance monitoring | 1024 | 0001 |
| | 512 | 0010 |
| | 256 | 0100 |
| | 128 | 1000 |

### 7.5 Specific fields for system management cell

The use of the function specific fields is out of the scope of this Recommendation.

## Annex A

## Virtual channel/virtual path status monitoring

(This annex forms an integral part of this Recommendation)

Definition of VC/VP status (i.e. available/unavailable) is out of the scope of this Recommendation. Appropriate definitions and criteria can be obtained from the appropriate Recommendations in the I.300 Series.

For ATM networks the status (available or unavailable) of the ATM virtual channels and virtual paths is derived from the use of the ATM layer fault management and performance management procedures based on the F4/F5 flows.

Loopback procedures may be initiated on-demand by the management system of the network element to test the status of the Virtual Channel (VC)/Virtual Path (VP) in-service or out-of-service.

Continuity check may be used together with performance monitoring to continuously monitor the status of the VC/VP.

When a defect is detected by the ATM layer management entity, as inferred from AIS state, loss of continuity or degraded performance outcome, an indication is passed to system management for further processing in order to determine the VC/VP unavailability state.

The VC/VP status information may then be passed by the network element system management entity to the operations support function for appropriate action via the relevant management interface to the network element.

# Annex B

## SDLs for activation/deactivation using OAM cells

(This annex forms an integral part of this Recommendation)

**B.1** This annex provides a detailed specification for the activation/deactivation procedures of performance monitoring and continuity check functions using OAM cells. The following description is given for performance monitoring but is also applicable to the continuity check function.

Figure B.2 shows the state diagram for the activation/deactivation of performance monitoring. The states referenced in this figure are:

**Ready** state

The performance monitoring process is not activated on an ATM connection.

**Wait-activate-confirm** state (abbreviated as Wait_act_con)

Activation of the performance monitoring process on an ATM connection has been requested by the local system management, an activate_PM message has been sent, and the corresponding response from the peer layer management entity has not arrived yet. This state only exists in systems that originate the activation of the performance monitoring process.

**Wait-activate-response** state (abbreviated as Wait_act_res state)

An activate_PM message from a peer layer management entity has been received, the request to activate the performance monitoring process on an ATM connection has been indicated to the local system management, and the corresponding response from the system management has not been received yet. This state only exists in systems that receive requests from peer layer management entity to activate the performance monitoring process.

**Active** state

The performance monitoring process is activated on an ATM connection.

**Wait-deactivate-confirm** state (abbreviated as Wait_deact_con)

Deactivation of the performance monitoring process on an ATM connection has been requested by the local system management, a deactivate_PM message has been sent, and the corresponding response from the peer layer management entity has not arrived yet. This state only exists in systems that originate the deactivation of the performance monitoring process.

For the description of the procedure, a minimal set of internal signals exchanged between ATM layer management and plane management are required. For the activation case, a relation of these internal signals is:

- INT_SIG_ACT.Request (parameters) – The plane management requests for the activation of the performance monitoring functions. Parameters are left for further study.
- INT_SIG_ACT.Indication (parameters) – The ATM layer management indicates to the plane management the arrival of a request for the activation of performance monitoring functions. Parameters are left for further study.

- INT_SIG_ACT.Response (Response, other_parameters) – The plane management replies to the ATM layer management. The parameter response indicates the acceptance (if Response = OK) or rejection (if Response = KO) of the requested activation. Other parameters are for further study.

- INT_SIG_ACT.Confirm (Response, other_parameters) – The ATM layer management confirms to the plane management the acceptance (Response = OK) or rejection (Response = KO) by the peer entity of the requested activation. Other parameters are for further study.

For the deactivation case a similar set of internal signals is required, the names of these internal signals are :

- INT_SIG_DEACT.Request, INT_SIG_DEACT.Indication, INT_SIG_DEACT.Response and INT_SIG_DEACT.Confirm. The meaning of each one of these signals is similar to the meaning of the corresponding signals for the activation case.

Examples of protocol operation for the activation case are included in the time flow diagrams of Figure B.3. The first two diagrams [a) and b)] describe the error free protocol operation mode. The next three [c), d) and e)] describe the protocol operation when some errors are detected. Finally, the diagrams [f), g) and h)] describe the collision case.

Similar examples for the deactivation case are included in Figure B.4.

SDL diagrams concerned with the proposed procedures are included in Figure B.5. In the diagrams, a reference to some variables is made. The meaning of each of these variables is:

T1 This constant is used to initialize the timer_1 when it is started. T1 is the minimum waiting time for the response from the peer entity (in case of receiving a request to activate the performance monitoring process from system management). The value of T1 is ≥ 5 seconds. This value is greater than the round trip delay plus the processing time (whose maximum value is T2) at the peer entity to generate the corresponding response. In case of message loss, this constant also indicates the elapsed time between the generation of two consecutive activate_PM messages.

T2 This constant is used to initialize the timer_2 when it is started. T2 is the minimum waiting time for the response from the system management (in case of receiving an activate_PM message). The value of T2 is ≤ 2 seconds.

T3 This constant is used to initialize the timer_3 when it is started. T3 is the minimum waiting time for the response from the peer entity (in case of receiving a request to deactivate the performance monitoring process from system management). The value of T3 is ≥ 5 seconds. This value is greater than the round trip delay plus the processing time at the peer entity to generate the corresponding response. In case of message loss, this constant also indicates the elapsed time between the generation of two consecutive deactivate_PM messages.

CT1 This constant is used to initialize the counter_1 when it is started. CT1 is the maximum number of attempts to send activate_PM messages. CT1 ≥ 3.

CT2 This constant is used to initialize the counter_2 when it is started. CT2 is the maximum number of attempts to send deactivate_PM messages. CT2 ≥ 3.

Timer_1 This variable represents the remaining time of a T1 time interval. This timer is used when the activation/deactivation process is in wait-activate-confirm state.

Timer_2 This variable represents the remaining time of a T2 time interval. This timer is used when the activation/deactivation process is in wait-activate-response state.

Timer_3 This variable represents the remaining time of a T3 time interval. This timer is used when the activation/deactivation process is in wait-deactivate-confirm state.

Counter_1 This variable represents the number of attempts to send activate_PM when the activation/deactivation process is in wait-activate-confirm state.

Counter_2 This variable represents the number of attempts to send deactivate_PM when the activation/deactivation process is in wait-activate-confirm state.

Finally, the key symbols used for the SDL[3] diagrams are included in Figure B.1.

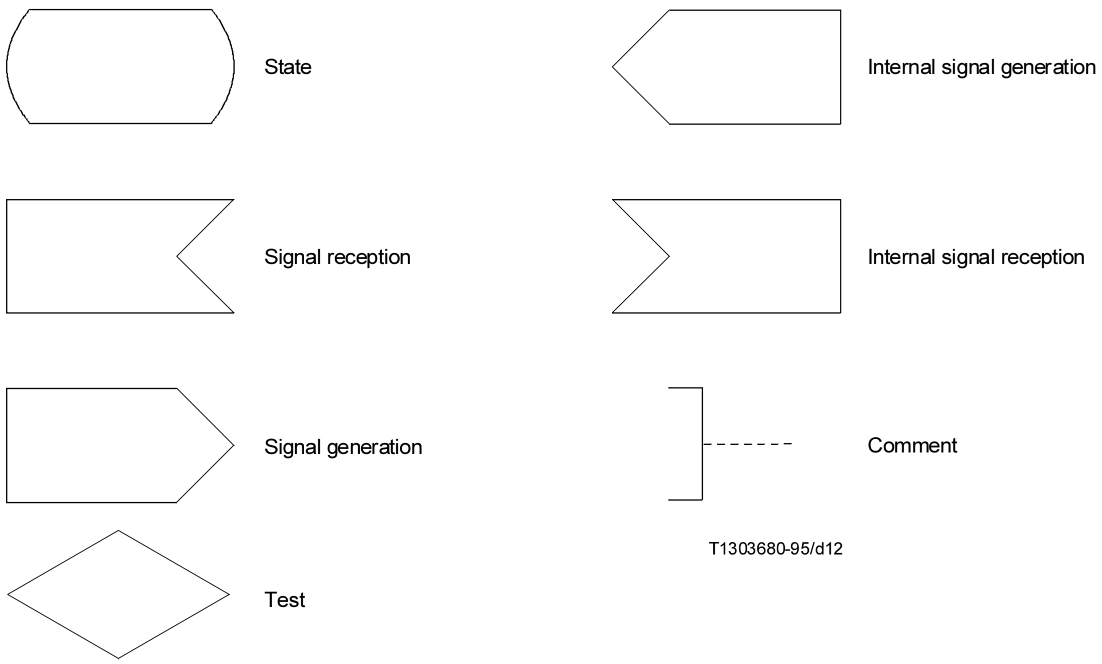



FIGURE B.1/I.610

**Keys used in the SDL diagrams**

While the activation/deactivation procedure is in ready state, the following operations take place [see Figure B.5 (sheet 1 of 5)]:

1) Upon receiving an activate_PM – Send a PM activation request indication to system management, start the timer_2, and go to wait-activate-response state.
2) Upon receiving a PM activation request from system management – Start the Timer_1, send to peer entity activate_PM with a correlation_tag, direction and block_size conveyed from system management, set counter_1 to 1, and go to wait-activate-confirm state.
3) Upon receiving a deactivate_PM – Send to peer entity PM_deactivation_confirmed, and stay in Ready state.

While the activation/deactivation procedure is in wait-activate-response state, the following operations take place [see Figure B.5 (sheet 2 of 5)]:

4) If system management rejects this request or the timer_2 expired – Stop timer_2, send to peer entity PM_activation_denied, and go to Ready state.
5) If system management accepts this request – Stop timer_2, send to peer entity PM_activation_confirmed; activate the performance monitoring process; and go to active state.

[3] In the internal signals are also included the timers previously referenced. Remainder signals are related with the peer entity communication.

While the activation/deactivation procedure is in wait-activate-confirm state, the following operations take place [see Figure B.5 (sheet 3 of 5)]:

6) Upon receiving a PM_activation_confirmed – Stop the timer_1; activate the performance monitoring process; send PM activation-success confirmation to system management, and go to active state.

7) Upon receiving a PM_activation_denied or an activate_PM, or upon expiration of timer_1 and counter_1 is greater than or equal to CT1 – Stop timer_1, send a PM activation-failure indication to system management, and go to ready state.

8) Upon expiration of the timer_1 (T1 time period) and counter_1 is less than CT1 – Increment counter_1 by 1, start the timer_1, send to peer entity activate_PM with a correlation_tag, direction and block_size conveyed from system management, and stay in wait-activate-confirm state.

While the activation/deactivation procedure is in active state, the following operations take place [see Figure B.5 (sheet 4 of 5)]:

9) Upon receiving a PM deactivation request from system management – Send deactivate_PM with a correlation_tag and direction conveyed from system management, start the timer_3, set counter_2 to 1 and go to wait-deactivate-confirm state.

10) Upon receiving a deactivate_PM – Send a PM deactivation request indication to system management, send to peer entity PM_deactivation_confirmed, and go to ready state.

11) Upon receiving an activate_PM – Send to peer entity PM_activation_confirmed; and stay in active state.

While the activation/deactivation procedure is in wait-deactivate-confirm state, the following operations take place [see Figure B.5 (sheet 5 of 5)]:

12) Upon receiving a PM_deactivation_confirmed, a deactivate_PM, or if timer_3 is expired and if counter_2 is greater than or equal to CT2 – Stop the timer_3; send PM deactivation-success confirmation to system management, deactivate the performance monitoring process; and go to ready state.

13) Upon expiration of the timer_3 (T3 time period) and counter_2 is less than CT2 – Increment counter_2 by 1, start the timer_3, send to peer entity deactivate_PM with a correlation_tag and direction conveyed from system management and stay in wait-activate-confirm state.

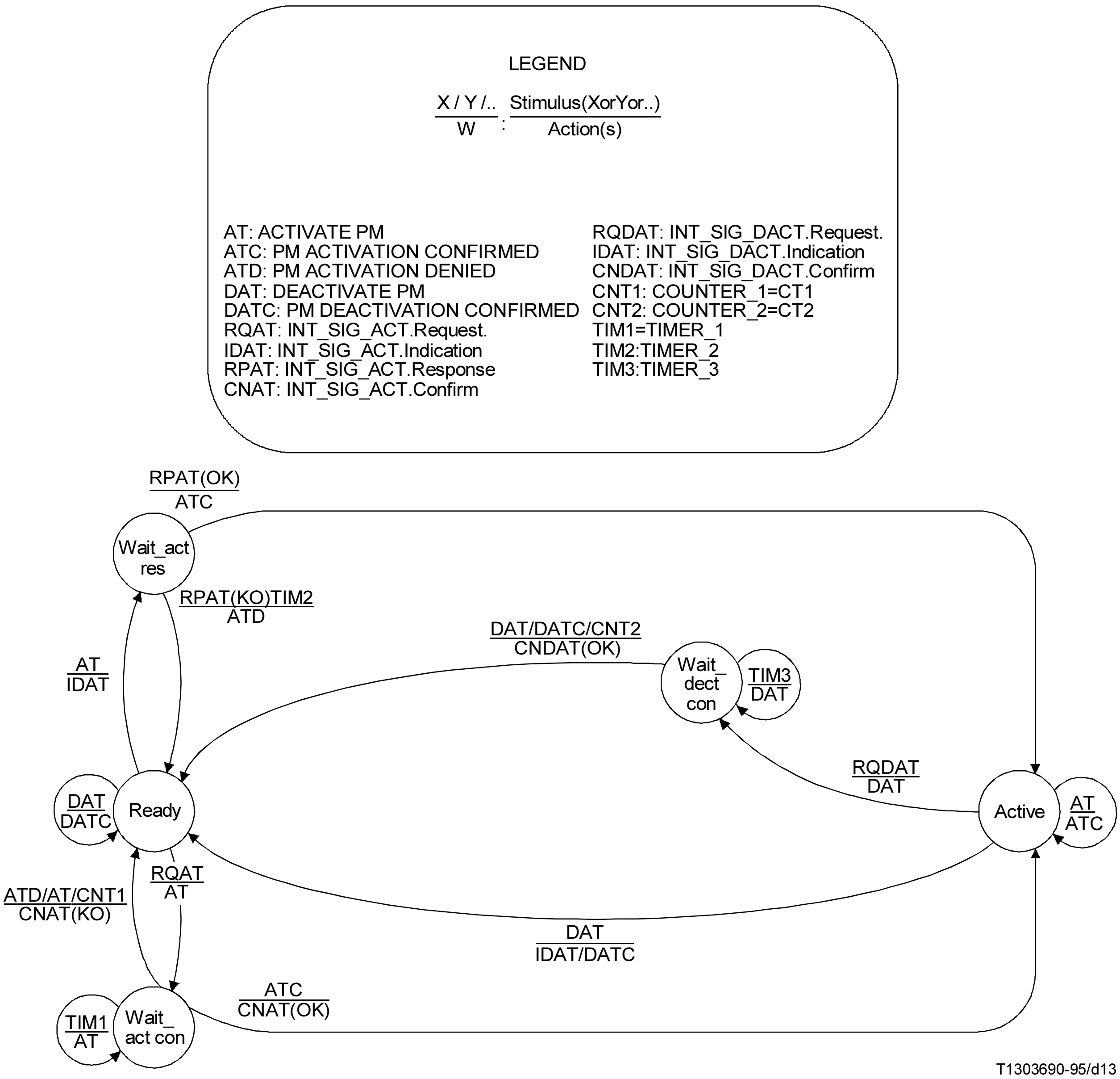



FIGURE B.2/I.610

**State diagrams**

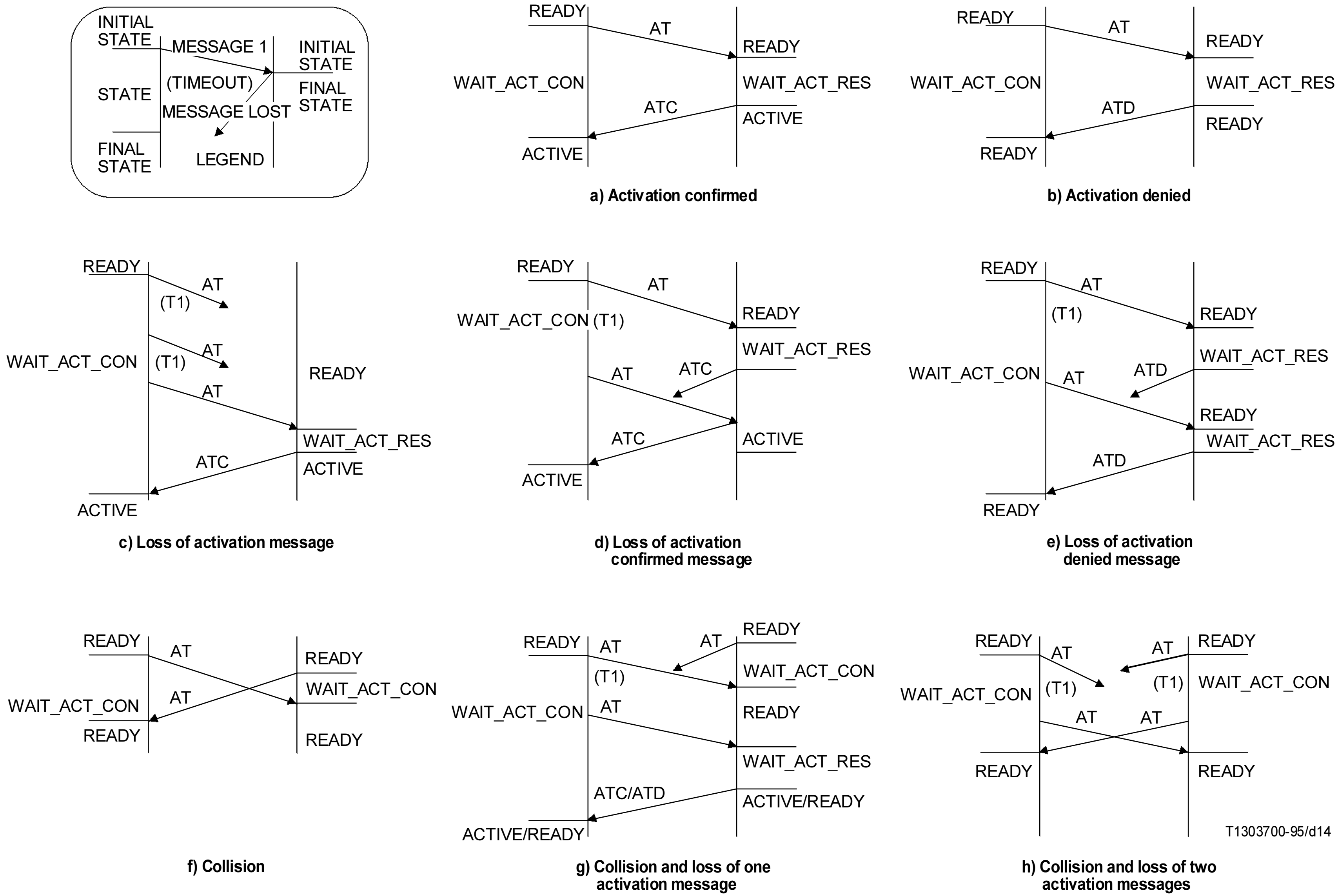



FIGURE B.3/I.610

**Activation: examples of protocol operation**

Superseded by a more recent version

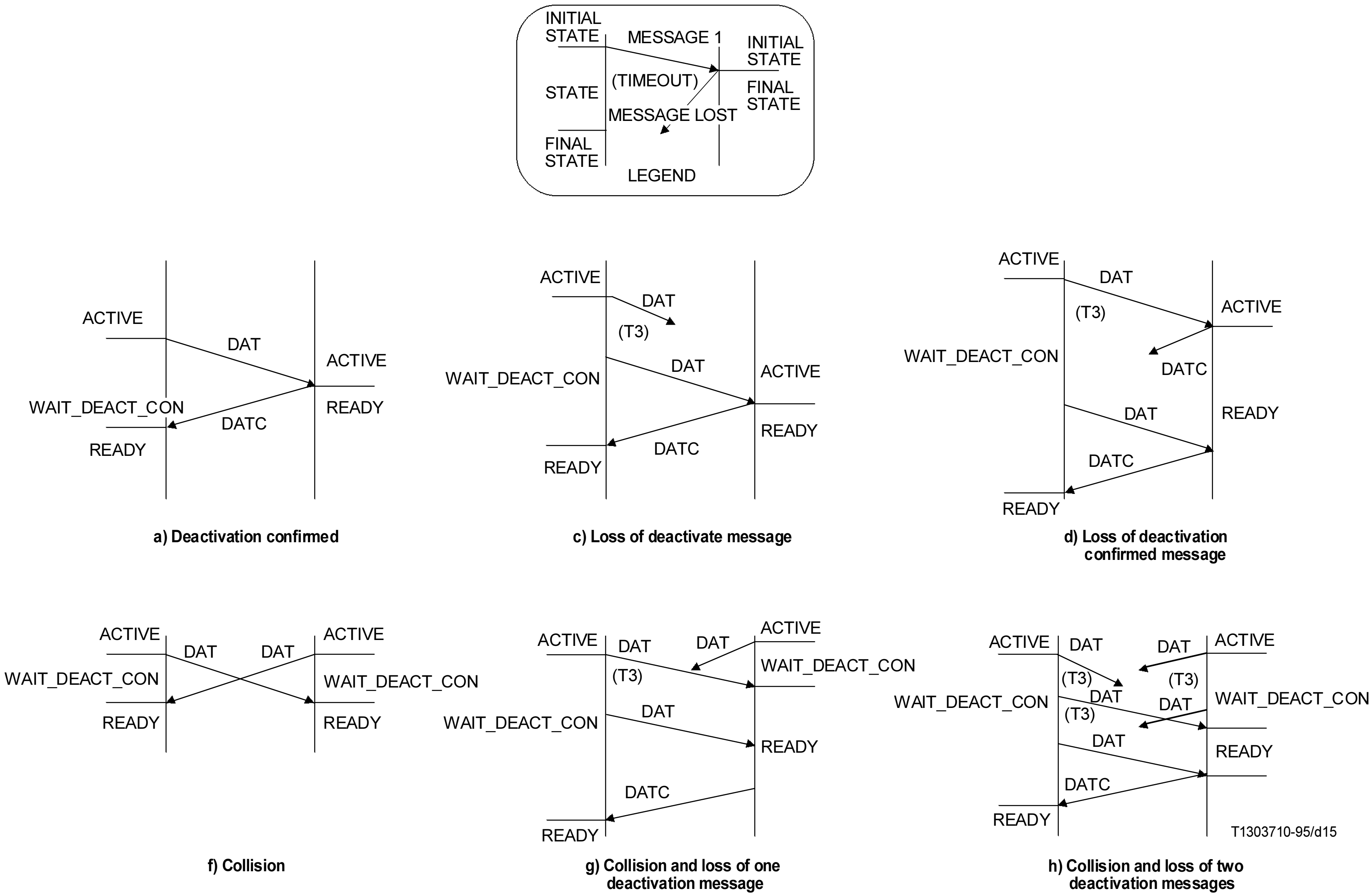



FIGURE B.4/I.610

**Deactivation: examples of protocol operation**

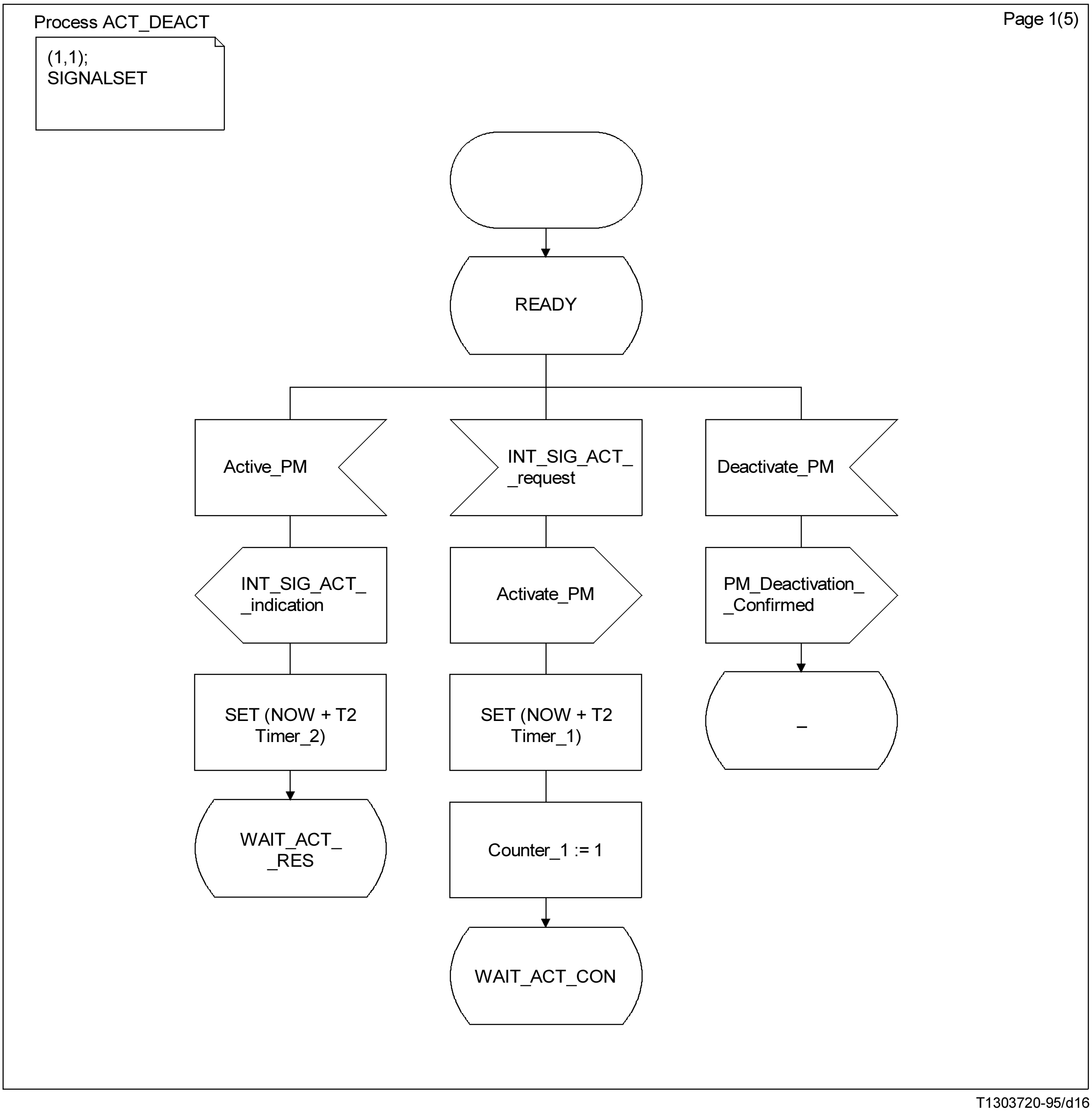



FIGURE B.5/I.610 (sheet 1 of 5)

**SDL diagrams**

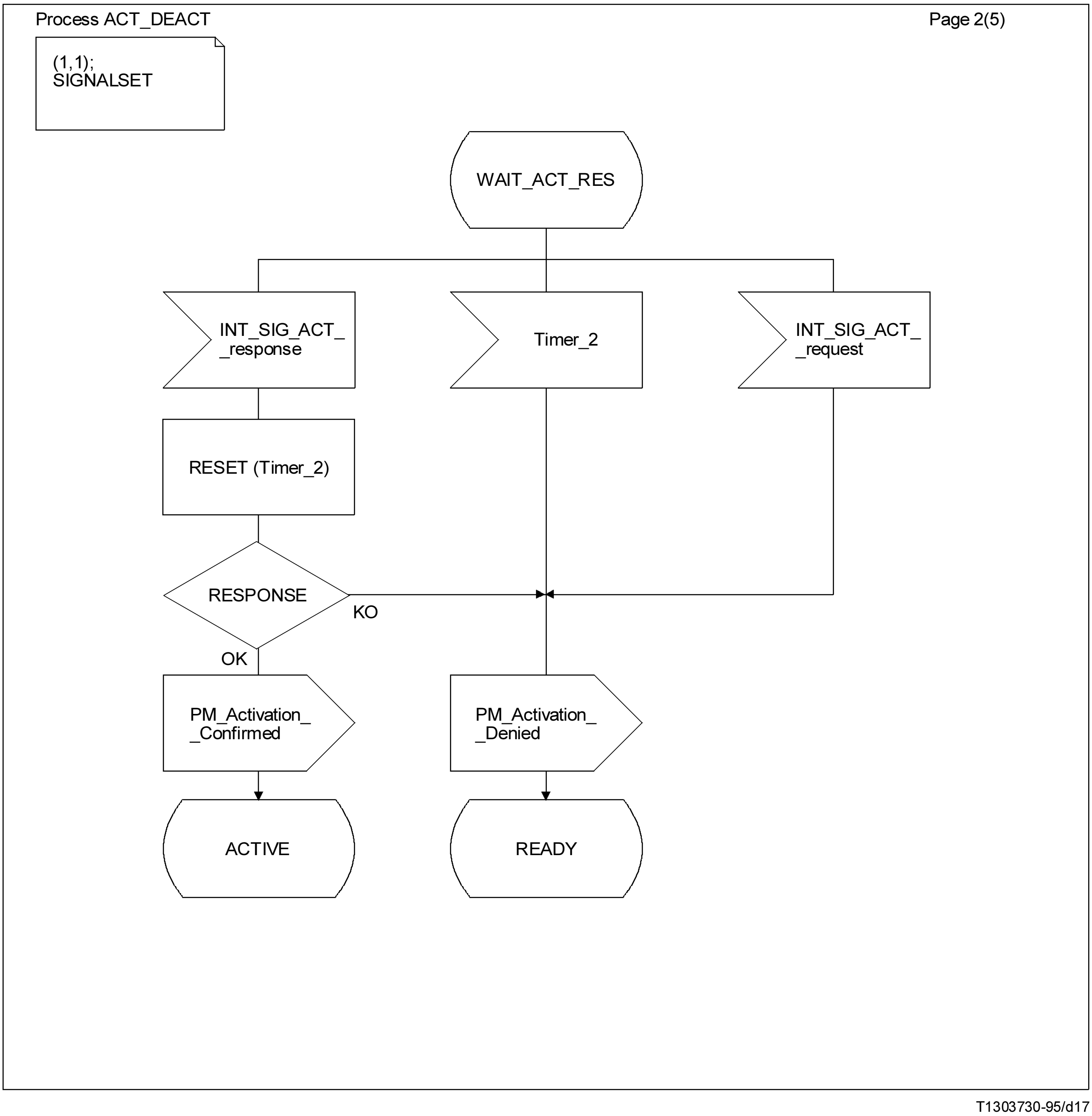



FIGURE B.5/I.610 (sheet 2 of 5)

**SDL diagrams**

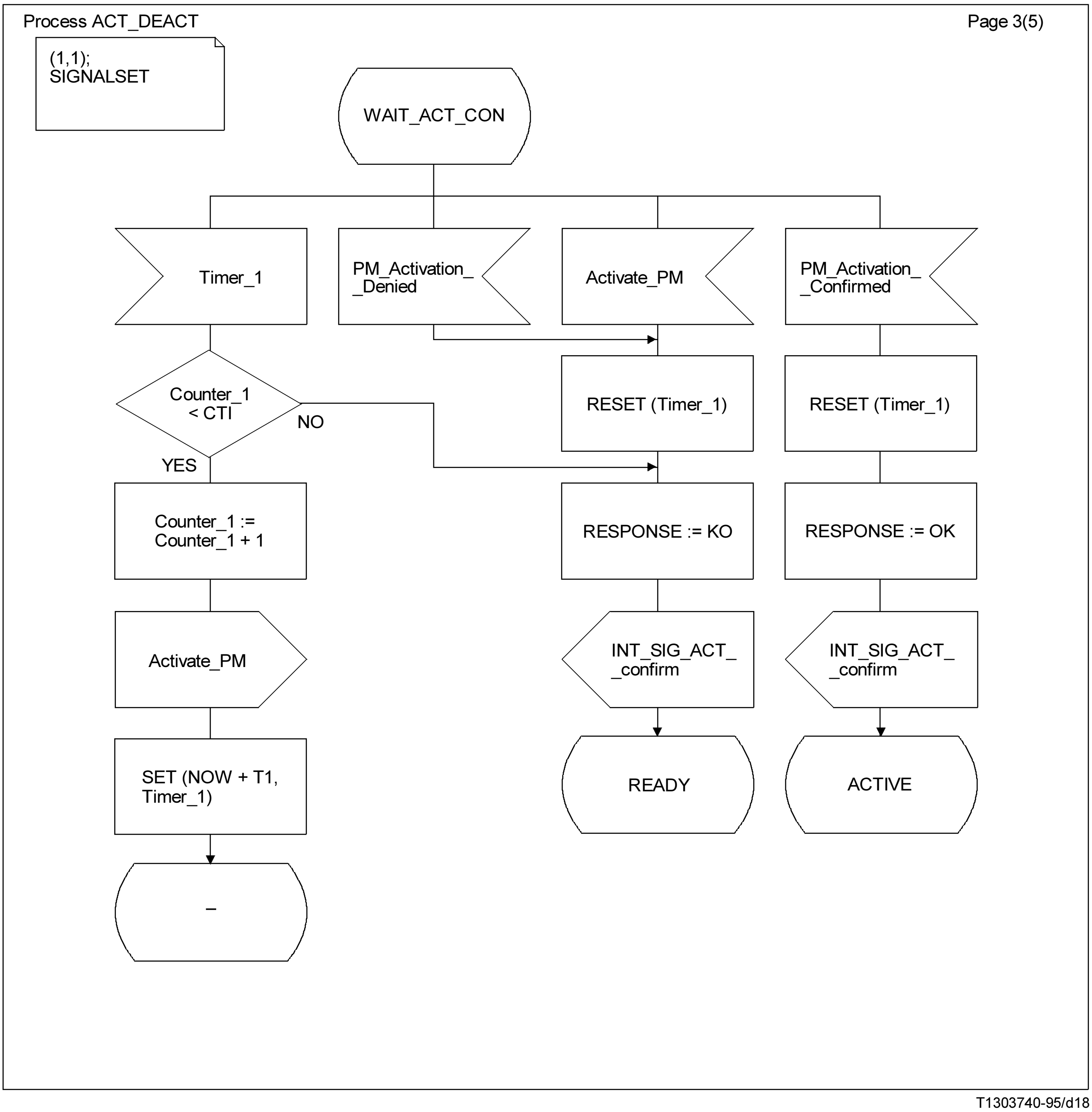



FIGURE B.5/I.610 (sheet 3 of 5)

**SDL diagrams**

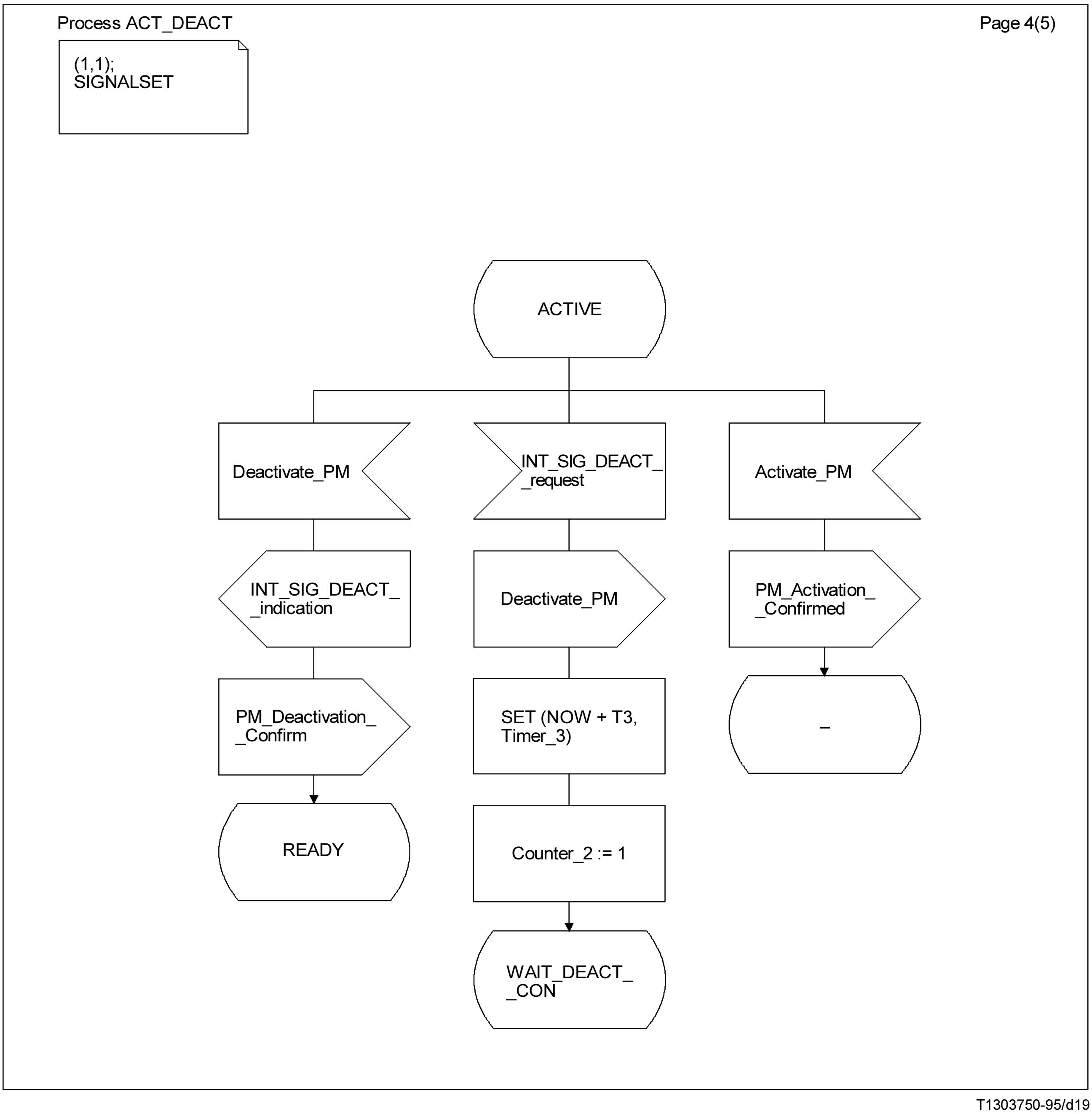



FIGURE B.5/I.610 (sheet 4 of 5)

**SDL diagrams**

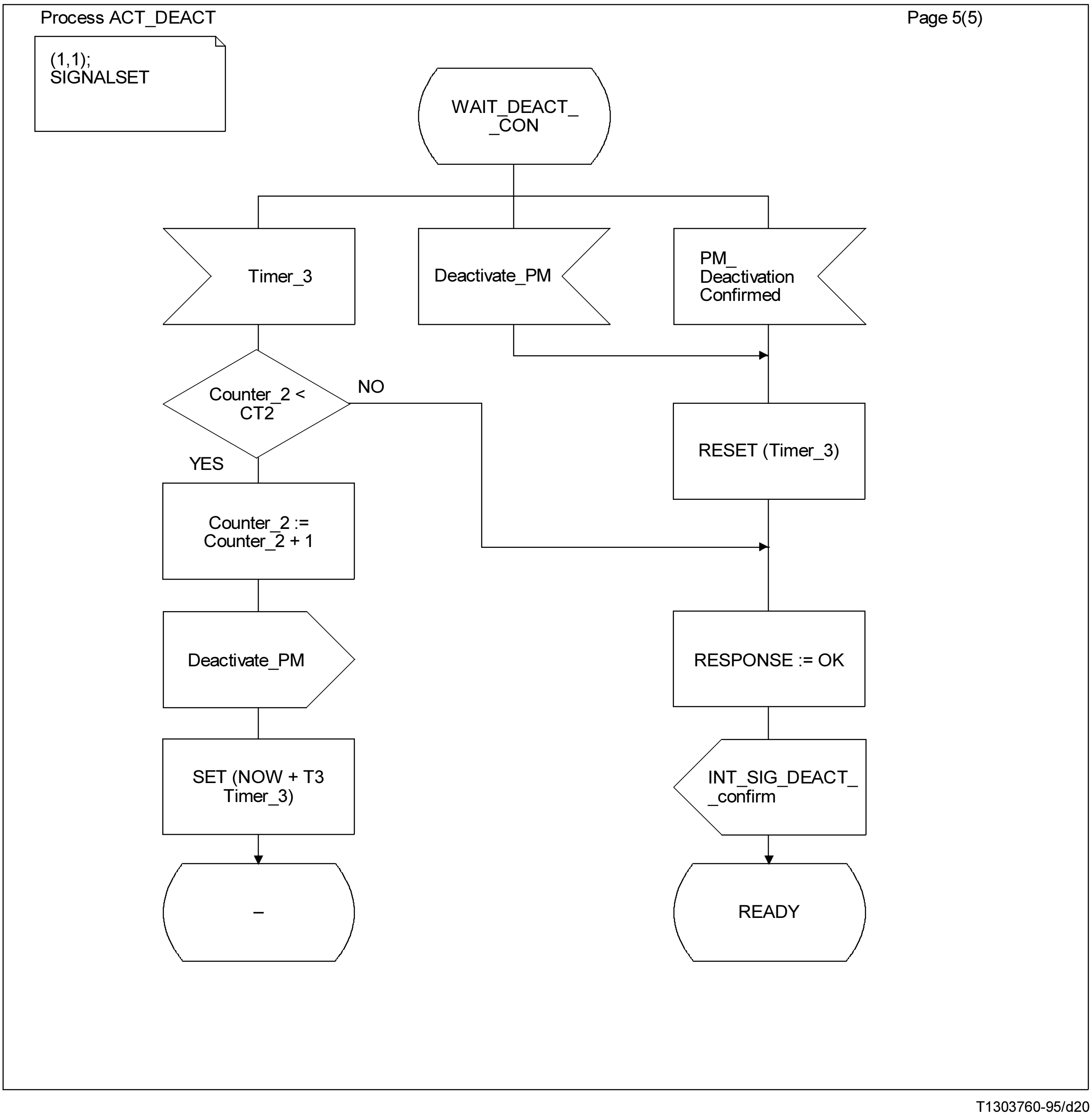


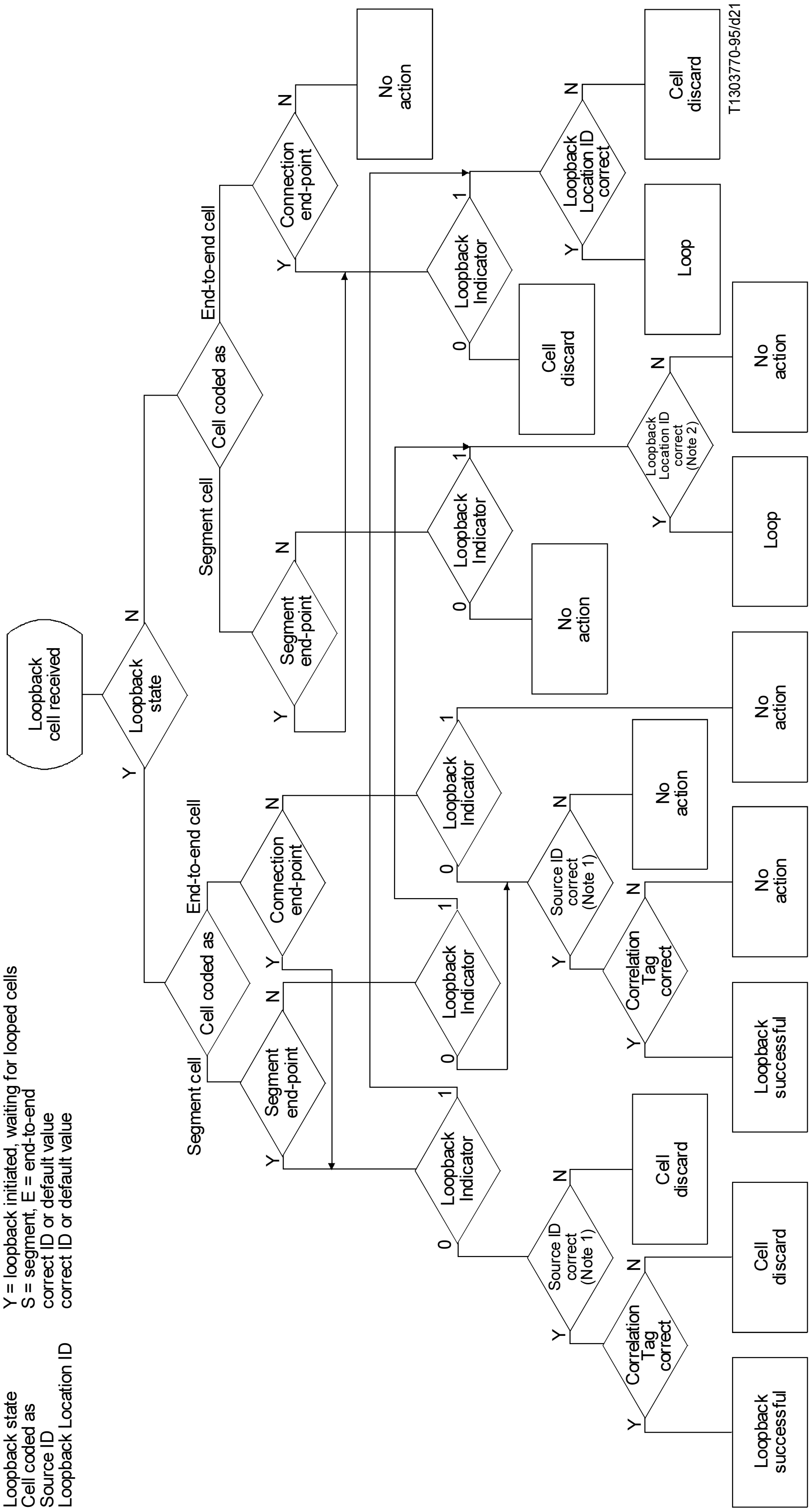

FIGURE B.5/I.610 (sheet 5 of 5)

**SDL diagrams**

# Annex C

## Procedures to be performed when receiving Loopback OAM cells

(This annex forms an integral part of this Recommendation)




NOTES

1 If the optional source ID field is not used, this decision should be skipped and continued direction “Y”.

2 In case the Loopback Location ID option is not used for an intermediate connecting point, this decision should be skipped and continued direction “N”.

# Appendix I

## Examples of OAM cell error detection codes

(This appendix does not form an integral part of this Recommendation)

**I.1** This appendix provides two examples of the 10-bit CRC Error Detection Field (EDC) calculated for an RDI cell and a loopback cell, respectively.

**Example 1 – RDI cell**

The cell type is "0001", the function type is "0001", and the next 45 octets are all coded as 6A hexadecimal. The reserved field consists of six "00" bits. The calculated CRC-10 is AF hexadecimal (i.e. "00 1010 1111"). The 48 octet information field is transmitted as:

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 6A | 6A | 6A | 6A | 6A | 6A | 6A | 6A | 6A | 6A | 6A |
| 6A | 6A | 6A | 6A | 6A | 6A | 6A | 6A | 6A | 6A | 6A | 6A |
| 6A | 6A | 6A | 6A | 6A | 6A | 6A | 6A | 6A | 6A | 6A | 6A |
| 6A | 6A | 6A | 6A | 6A | 6A | 6A | 6A | 6A | 6A | 00 | AF |

**Example 2 – Loopback cell**

The cell type is "0001", the function type is "1000", the loopback idication is "00000001" the correlation tag is AA hexadecimal, the loopback ID is all ones and the source ID is 6A hexadecimal. The calculated CRC-10 is 2AC hexadecimal (i.e. "10 1010 1100"). The 48 octet information field is transmitted as:

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 01 | AA | AA | AA | AA | FF | FF | FF | FF | FF | FF |
| FF | FF | FF | FF | FF | FF | FF | FF | FF | FF | 6A | 6A |
| 6A | 6A | 6A | 6A | 6A | 6A | 6A | 6A | 6A | 6A | 6A | 6A |
| 6A | 6A | 6A | 6A | 6A | 6A | 6A | 6A | 6A | 6A | 02 | AC |