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SERIES E: OVERALL NETWORK OPERATION, TELEPHONE SERVICE, SERVICE OPERATION AND HUMAN FACTORS

Quality of service, network management and traffic engineering – Traffic engineering – ISDN traffic engineering

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# Cell level measurement requirements for the B-ISDN

ITU-T Recommendation E.745

(Formerly CCITT Recommendation)

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**ITU-T RECOMMENDATION E.745**

# CELL LEVEL MEASUREMENT REQUIREMENTS FOR THE B-ISDN


## Summary

This Recommendation provides the requirements to measurements needed at the cell level for an ATM (Asynchronous Transfer Mode)-based B-ISDN (Broadband Integrated Services Digital Network) network. Measurements may be both for real time and for record. The first release of this Recommendation focuses on the latter. This Recommendation is not restricted to point-to-point connections, but covers point-to-multipoint connections as well.



## Source

ITU-T Recommendation E.745 was prepared by ITU-T Study Group 2 (1997-2000) and was approved under the WTSC Resolution No. 1 procedure on 13 March 2000.

## FOREWORD

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The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1.

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

## NOTE

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

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

## CONTENTS

**Recommendation E.745**

# CELL LEVEL MEASUREMENT REQUIREMENTS FOR THE B-ISDN

*(Geneva, 2000)*

## 1 Scope

This Recommendation provides the requirements to measurements needed at the cell level for an ATM (Asynchronous Transfer Mode)-based B-ISDN (Broadband Integrated Services Digital Network) network. Measurements may be both for real time and for record. The first release of this Recommendation focuses on the latter. This Recommendation is not restricted to point-to-point connections, but covers point-to-multipoint connections as well.

## 2 References

This Recommendation is based on and/or supplements the following Recommendations:

– ITU-T Recommendation E.492 (1996), *Traffic reference period*.

– CCITT Recommendation E.502 (1992), *Traffic measurement requirements for digital telecommunication exchanges*.

– CCITT Recommendation E.505 (1992), *Measurements of the performance of common channel signalling network*.

– ITU-T Recommendation E.600 (1993), *Terms and definitions of traffic engineering*.

– ITU-T Recommendation E.716 (1996), *User demand modelling in Broadband-ISDN*.

– ITU-T Recommendation E.726 (2000), *Network grade of service parameters and target values for B-ISDN*.

– ITU-T Recommendation E.736 (2000), *Methods for cell level traffic control in B-ISDN*.

– ITU-T Recommendation E.737 (1997), *Dimensioning methods for B-ISDN*.

– ITU-T Recommendation E.743 (1995), *Traffic measurements for SS No. 7 dimensioning and planning*.

– ITU-T Recommendation E.800 (1994), *Terms and definitions related to quality of service and network performance including dependability*.

– ITU-T Recommendation G.826 (1999), *Error performance parameters and objectives for international constant bit rate digital paths at or above the primary rate*.

– ITU-T Recommendation I.150 (1999), *B-ISDN asynchronous transfer mode functional characteristics*.

– CCITT Recommendation I.321 (1991), *B-ISDN protocol reference model and its application*.

– ITU-T Recommendation I.350 (1993), *General aspects of quality of service and network performance in digital networks, including ISDNs*.

– ITU-T Recommendation I.353 (1996), *Reference events for defining ISDN and B-ISDN performance parameters*.

– ITU-T Recommendation I.356 (2000), *B-ISDN ATM layer cell transfer performance*.

– ITU-T Recommendation I.358 (1998), *Call processing performance for switched virtual channel connections (VCCs) in a B-ISDN*.

– ITU-T Recommendation I.361 (1999), *B-ISDN ATM layer specification*.

– ITU-T Recommendation I.371 (2000), *Traffic control and congestion control in B-ISDN*.

– ITU-T Recommendation I.610 (1999), *B-ISDN operation and maintenance principles and functions*.

– ITU-T Recommendation I.732 (1996), *Functional characteristics of ATM equipment*.

– ITU-T Recommendation M.3010 (2000), *Principles for a telecommunications management network*.

## 3 Terms and definitions

### 3.1 Reference events

Figure 1 provides the basis to define the reference events in this Recommendation.

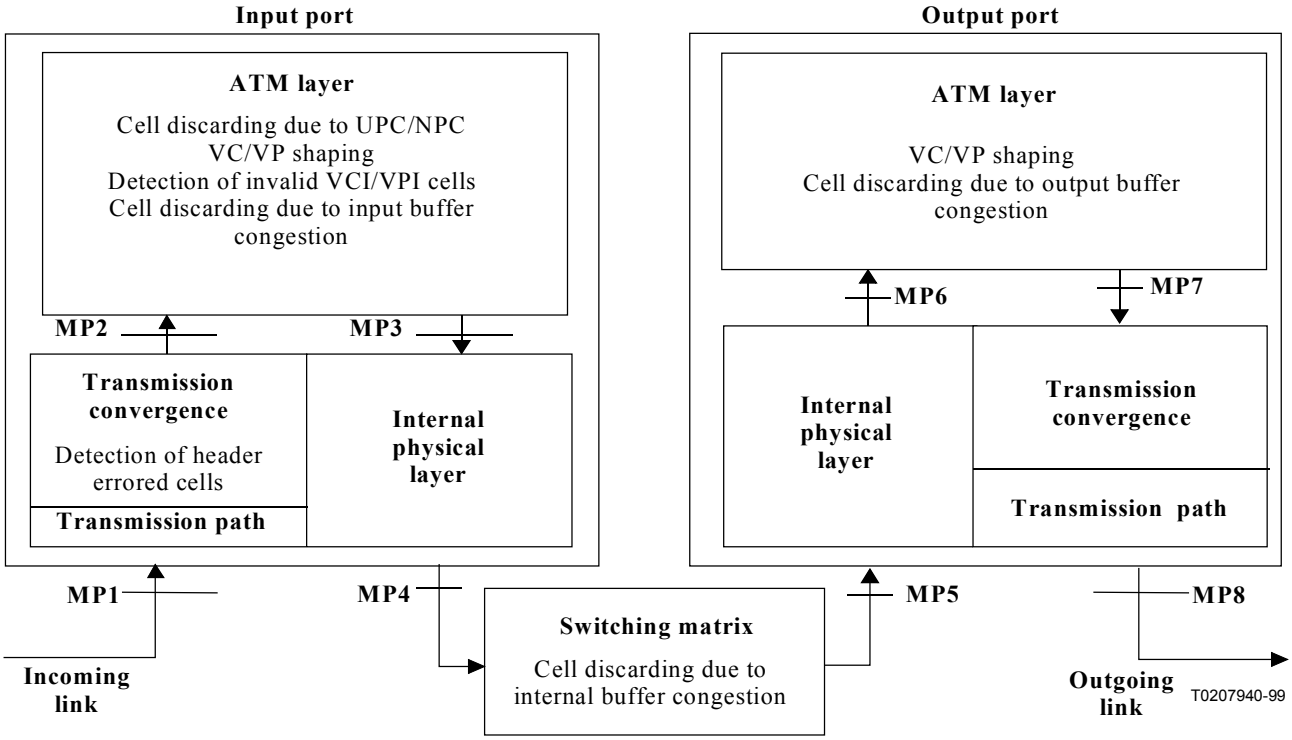



**Figure 1/E.745 – Measurement points (MPs) inside the network element**

**3.1.1 incoming cell**: A cell entering a generic MP (I.356 cell entry).

**3.1.2 outgoing cell**: A cell exiting a generic MP (I.356 cell exit).

**3.1.3 UPC/NPC non-conforming cell**: A cell which, according to the UPC/NPC device, violates the traffic contract.

**3.1.4 UPC/NPC discarded cell**: A cell discarded by the UPC/NPC device.

**3.1.5 lost cell**: A cell lost between two different MPs is a cell received at the first MP but not at the second one, within a time $T_{max}$ (this definition is the same as reported in Recommendation I.356). The choice of the two MPs has to be consistent with the observed cell stream.

**3.1.6 cell transfer delay across a node**: It is defined as the difference between the time at which the first bit of a given cell has completed transmission across MP8 and the time at which the last bit of the same cell had completed transmission across MP1 (this definition is the same as reported in Recommendation I.356).

**3.1.7 one-point Cell Delay Variation (CDV)**: For each cell of a given connection the one-point CDV is the difference between the cell's reference arrival time at a given MP and its actual arrival time (this definition is the same reported in Recommendation I.356). The reference arrival time is defined in Recommendation I.356 and uses the peak cell rate value declared by the connection.

**3.1.8 buffer occupancy status**: Buffer occupancy is measured as the fraction of arriving cells finding the buffer above a given set of thresholds (in the simplest case a single threshold can be used). This measurement provides information useful to derive the cell loss probability due to buffer congestion, in addition to that obtained from the measurement of the cell loss ratio. As traffic engineering procedures aim at keeping cell losses as rare events, the information obtained from buffer occupancy, being derived from more frequent events, will be more reliable and could therefore be considered as the primary source of information on cell loss probability.

**3.1.9 number of cell lost due to congestion at input-port, internal, or output-port buffers**: The number of cells lost due to congestion at the network element (NE) either at the input, internally or at the output. The congestion is assumed to take place at input-, internal- or output buffers respectively. The location where cells might be discarded due to buffer congestion is dependent on the node architecture. For example, the architecture could be such that discards due to congestion will occur only at output-line cards. Logically, the measurements of cell discards due to congestion need only to be done at locations where such events are designed to occur.

**3.1.10 incoming traffic volume**: It is defined as the number of incoming cells across MP2 over a fixed time interval T. In this way, we do not consider cells that are discarded due to header error.

**3.1.11 outgoing traffic volume**: It is the number of outgoing cells across MP7, counted over a period of fixed length T.

## 4 Abbreviations

This Recommendation uses the following abbreviations:

AAL ATM Adaptation Layer

ABR Available Bit Rate

ATC ATM Transfer Capability

ATM Asynchronous Transfer Mode

B-ISDN Broadband Integrated Digital Services Network

CDV Cell Delay Variation

CLP Cell Loss Priority

GFC Generic Flow Control

GOS Grade of Service

HEC Header Error Control

MP Measurement Point

NE Network Element

NP Network Performance

NPC Network Parameter Control

OAM Operation and Maintenance

PTI Payload Type Indicator

QOS Quality of Service

RM Resource Management

TM Traffic Measurements

TMN Telecommunications Management Network

UNI User-to-Network Interface

UPC Usage Parameter Control

VCC Virtual Channel Connection

VCI Virtual Channel Identifier

VPC Virtual Path Connection

VPI Virtual Path Identifier

# 5 Introduction

## 5.1 Objective of measurements

The objective of the measurement records defined in this Recommendation is to produce data for the following three main categories of purposes:

- *Traffic characterization*
  - Traffic type classification through cell traffic variables (see Recommendation E.716).
  - Load evaluation.
- *Performance monitoring*
  - Monitoring of the GOS provided at the cell level.
- *Traffic control behaviour*
  - Monitoring of UPC/NPC actions.
  - Support of ABR mechanisms.
  - Support of ABT mechanisms.
  - Support of adaptive CAC.

## 5.2 Restrictions to this Recommendation

This Recommendation does not specify any specific measurement methods. In Annex C/I.356 some methods are given, which can serve as a guideline for some of the measurement types given below. Annex C/I.356 describes both methods which can be in-service and out-of-service, but it is by no means comprehensive. For instance, passive measurement methods are not covered.

This Recommendation does not specify measurements for the physical layer, which are covered in Recommendation G.826.

Measurements for cells containing signalling information are for further study, but from a cell level measurement point of view they are merely cells with a special header (see Recommendation I.311).

The signalling measurements specified in this Recommendation provide only counts (or percentages) of signalling traffic.

Operation and maintenance (OAM) cell measurements are specified to a certain degree in Recommendation I.610.

The measurements described in this Recommendation neither analyse signalling, RM (Resource Management) nor OAM cells but can count them and send them on for further processing by the signalling or RM systems or the Telecommunications Management Network (TMN) system respectively for further processing.

Issues like dependability, retainability and integrity are outside the scope of this Recommendation.

## 6 Cell-level measurement

This clause follows the structure of that in Recommendation E.502 and its terminology is used as far as possible.

### 6.1 Cell-level measurement model

At the ATM-level measurements basically consist of a counting process. The counting may be based on specific bits in the ATM-header (see Recommendation I.361), or may consist of a count until the next cell of a given kind arrives at the measurement device as for instance between successive OAM cells. At the cell level a timing relation does not exist, so in order to get the time-stamp for a measurement, interaction with the TMN is needed. Note that the establishment of a new VPC and/or VCC differs from the establishment of a call (in the data processing argot frequently called a session), as a call can contain several VPC/VCCs and new VPC/VCCs may be established/terminated during a call. A given VPC/VCC is known to the measurement device by a unique VPI or VCI. It is for the cell level measurements only that the entities, objects and measurement types are defined for this Recommendation. Some examples of entities and objects are given below:

Entities:

- Number of CLP = 0 + 1 user-data cells.
- Number of CLP = 0 user-data cells.
- Number of OAM cells.
- Number of RM cells.
- Number of signalling cells.
- Number of CLP = 0 + 1 user-data cells discarded due to input buffer congestion.
- Number of CLP = 0 + 1 user-data cells discarded due to output buffer congestion.
- Number of CLP = 0 user-data cells discarded due to input buffer congestion.
- Number of CLP = 0 user-data cells discarded due to output buffer congestion.
- Number of UPC/NPC non-conforming CLP = 0 + 1 cells that are discarded.
- Number of UPC/NPC non-conforming CLP = 0 cells that are discarded.
- Number of UPC/NPC non-conforming cells that are tagged.

Objects:

- All incoming links.
- All outgoing links.
- Selected incoming ports.
- Selected outgoing ports.

- Selected incoming VPCs and/or VCCs.
- Selected outgoing VPCs and/or VCCs.

The measurements are classified into different measurement types on the basis of the measurement matrix defined in Annex A which is a copy of the one from E.502.

A measurement type is a particular combination of entities and objects corresponding to certain entries in the measurement matrix. Part of these measurement types may be standardized while the rest of them are system- and/or administration-dependent. It should be noted that not all of the entries in the measurement matrix can be used because some of them will be impossible and others may be meaningless. In all measurement types, the entities are fixed although some entities may not be measured for some applications. Selected objects form an object list. In some measurement types, the object list is fixed. In other types one can choose for the actual measurement some or all of the allowed objects. A measurement set is a collection of measurement types.

## 6.2 Cell-level measurement structure

A cell-level measurement consists of:

- measurement set information;
- time information;
- destination information of measurement output.

### 6.2.1 Measurement set information

Measurement set information consists of one or several selected measurement types with defined objects (object lists) and measurement-type-dependent parameters.

### 6.2.2 Time information

For time-stamping individual measurements, the necessary timing information is obtained via the TMN system.

### 6.2.3 Destination information of measurement output

The destination of the measurement output is normally a file for subsequent processing. Occasionally it can be routed to a video screen and (seldom) to a printer.

# 7 Traffic flows

Measurements may just concern a subset of the traffic flows in a switch. For example, it may be required to measure the traffic flows belonging to specific VPCs or VCCs, i.e. specified by a given combination of the VPI and VCI values in the cell headers. In addition to the VPI/VCI bits the choice of the traffic flows to measure can be based on other bits of the cell header, e.g. the PTI (Payload Type Indicator) or the CLP (Cell Loss Priority) bits, and at the UNI (User-to-Network Interface) also GFC bits.

Resource management cells (see I.371) are of interest especially for the ABR and ATM block transfer capabilities.

In the context of a given ATM transfer capability, it is of interest to monitor traffic flows characterized by a specific CLP bit value (i.e. CLP = 0 or CLP = 0 + 1). The traffic flows of interest are therefore defined in relation to the chosen ATM transfer capability, in accordance with Recommendation I.371.

From Figure 2 the following relation applies:

$$A = E + F + G + H + Z$$

where Z accounts for cells that cannot be identified and:

$$I = C + D + G + J - Y$$

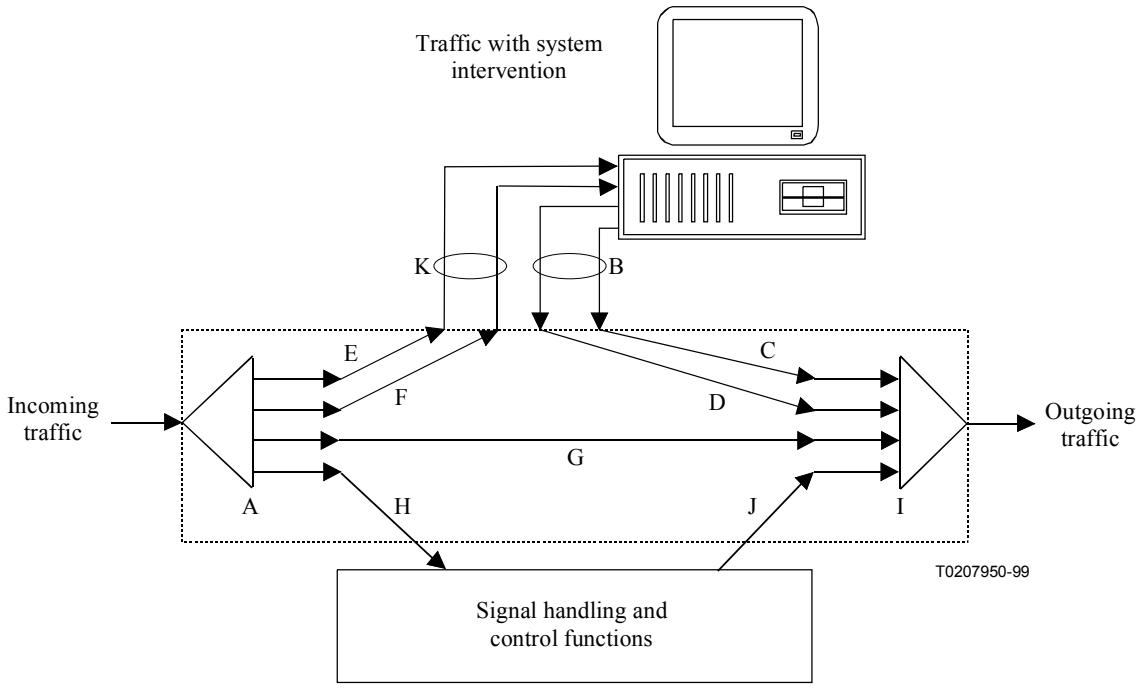
where Y accounts for cells that:

a) cannot be identified;

b) are subject to internal congestion;

c) experience a busy or unavailable outlet;

d) the arriving traffic has already been subject to UPC or NPC at the UNI or NNI respectively (depending on the switch location in the network).




A Incoming traffic
B Originating system stimuli
C OAM originating traffic
D RM originating traffic
E OAM terminating traffic
F RM terminating traffic
G User traffic
H Arriving signalling traffic
I Outgoing traffic
J Outgoing signalling traffic
K Traffic for local processing

**Figure 2/E.745 – Main traffic flow diagram at an B-ISDN switch**

## 8 Basic measurement types

### 8.1 General

Depending on the purpose of the measurement, different degrees of detail may be needed.

#### 8.1.1 Considerations on UPC/NPC

If the switch is at a location in the network where UPC or NPC is needed, it is assumed that the UPC or NPC takes place at the input. OAM or RM cells may be included or excluded from the user data and thus be policed jointly with or separate from it depending on the ATM bearer capability.

### 8.1.2 Considerations on special cells

OAM cells, RM cells and signalling cells (i.e. traffic flows C, D, E, F, H and J in Figure 2) can be recognized by the measurement device, but the information they contain will be processed by the TMN-, RM- and signalling-systems respectively. The measurements specified in this Recommendation only supply counts (or percentages) of such cells.

### 8.1.3 Traffic engineering

Information on how measurements can be used for planning and dimensioning purposes is given in Recommendation E.737, while traffic controls are given in Recommendation E.736. The GOS parameters to be assessed using the measurements are given in Recommendation E.726.

## 8.2 Measurements

Table 1 gives an overview of the usage of the measurement types defined in further detail in 8.2.1 to 8.2.4.

**Table 1/E.745 – Overview of the intended usage of the measurement types defined below**

| | Type 1 | Type 2 | Types 3-4-5 | Types 6-7 | Type 8 | Type 9 | Type 10 | Types 11-12 |
|---|---|---|---|---|---|---|---|---|
| Traffic characterization | √ | | √ | √ | √ | √ | | √ |
| Performance monitoring | | √ | | √ | √ | √ | | √ |
| Traffic control behaviour | | | | | √ | | √ | |

The different QOS classes and ATM Transfer Capabilities (ATCs) have different performance commitments, and thus need different measurement entities.

Measurements may be performed on a per-connection basis (e.g. for switched virtual connections according to the classification included in 8.2.2), in which case the values obtained refer to the duration of a connection, or on a time interval basis. In the latter case, measurements may be performed continuously throughout the day of the year or on selected portions of the day either on a periodic or aperiodic basis. The time interval over which measurements are taken is called the measurement interval. This measurement interval consists of a sequence of read-out periods. The values of the measured entities for each read-out period are temporarily stored in the switch to be transferred to external units for post-processing. The length of the read-out period is set by the network operator on the basis of the measurement purpose, e.g. 3-5 minutes for network management, and according to Recommendation E.492 for network planning. Recommendation E.492 states that the read-out period should be suitably chosen so that traffic variations and peaks within the read-out period can be determined using mathematical models and the measured average intensity. At the cell level this criterium may lead to very short read-out periods, in the order of 0.1 msec. Since the processing power required to perform all the measurements with such small read-out periods may be excessive, the combination of the following two lengths of read-out periods is recommended:

a) one minute or longer for all the measurements, in order to know the average traffic intensity over this period length;

b) down to 0.1 msec for selected measurements, in order to investigate on appropriate mathematical models to apply when read-out periods of length a) are used, i.e. in order to know how to derive the remaining traffic variables characterizing the traffic from the average intensity measured over periods of length a).

The processing power of the system must allow to perform all the specified measurements with a read-out period of length a) and at least measurements of one selectable entity of one selectable object with a read-out period of length b).

The accuracy required for the individual measurements is for further study. In the case where a measurement consists of a count, this accuracy is measured by a certain maximum variability.

For all the entities below, the cell count pertains to cells with a correct header, as detected or corrected by the Header Error Control (HEC) function.

### 8.2.1 Overall measurements

*Type 1*: Overall measurements on incoming traffic (Figure 2 type A).

Object: All cells on all incoming links.

Entities:

1) Total number of CLP = 0 + 1 user-data cells.
2) Total number of CLP = 0 user-data cells.
3) Total number of OAM cells.
4) Total number of RM cells.
5) Total number of signalling cells.

*Type 2*: Overall measurements on internal traffic (Figure 2 type A).

Object: All cells traversing the switch.

Entities:

1) Number of CLP = 0 + 1 user-data cells discarded due to internal buffer congestion.
2) Number of CLP = 0 user-data cells discarded due to internal buffer congestion.

*Type 3*: Overall measurements on total outgoing traffic (Figure 2 type I).

Object: All cells on all outgoing links.

Entities:

1) Total number of CLP = 0 + 1 user-data cells.
2) Total number of CLP = 0 user-data cells.
3) Total number of OAM cells.
4) Total number of RM cells.
5) Total number of signalling cells.

*Type 4*: Overall measurements for incoming ports.

Object: Selected incoming ports.

Note that an important special case of selected incoming ports is the set of ports terminating an ATM link set. An ATM link set is the set of all ATM links with the same direction of transmission interconnecting two ATM nodes without any intermediate ATM node (see Recommendation E.735).

Entities:

1) Total number of CLP = 0 + 1 user-data cells.
2) Total number of CLP = 0 user-data cells.
3) Total number of OAM cells.
4) Total number of RM cells.
5) Total number of signalling cells.

*Type 5*: Overall measurements for outgoing ports.

Object: Selected outgoing ports.

Note that an important special case of selected outgoing ports is the set of ports originating an ATM link set.

Entities:

1) Total number of CLP = 0 + 1 user-data cells.
2) Total number of CLP = 0 user-data cells.
3) Total number of OAM cells.
4) Total number of RM cells.
5) Total number of signalling cells.

### 8.2.2 Measurements on selectable objects

*Type 6*: Incoming ATM transfer capability monitoring.

Object: All cells on an incoming port belonging to one or more specified ATM transfer capabilities. ATM transfer capabilities are defined in Recommendation I.371.

Entities:

1) Number of CLP = 0 + 1 user-data cells.
2) Number of CLP = 0 user-data cells.
3) Number of CLP = 0 + 1 user-data cells discarded due to input buffer congestion.
4) Number of CLP = 0 user-data cells discarded due to input buffer congestion.

For a given ATC, only a subset of the above entities may be pertinent.

*Type 7*: Outgoing ATM transfer capability monitoring.

Object: All cells on an outgoing port belonging to one or more specified ATM transfer capabilities.

Entities:

1) Number of CLP = 0 + 1 user-data cells.
2) Number of CLP = 0 user-data cells.
3) Number of CLP = 0 + 1 user-data cells discarded due to output buffer congestion.
4) Number of CLP = 0 user-data cells discarded due to output buffer congestion.

For a given ATC, only a subset of the above entities may be pertinent.

*Type 8*: Measurements on incoming user traffic (Figure 2 type G).

Object: Selected incoming VPCs and/or VCCs.

For switched virtual connections (VPCs or VCCs), a count is made over the duration of the connection. For permanent virtual connections (VPCs or VCCs), counts are reported within the measurement interval defined by the network operator (see 8.2).

Note that an important special case of selected incoming VPCs is the set of VPCs terminating a VPC set. A VPC set is the set of all VPCs with the same direction of transmission interconnecting two VC nodes without any intermediate VC node (see Recommendation E.735)[1].

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[1] The term "VC node" here refers either to a VC node or to a VP/VC node performing VC functions for the considered VPC.

Entities:

1) Number of CLP = 0 + 1 user-data cells.
2) Number of CLP = 0 user-data cells.
3) Number of UPC/NPC non-conforming CLP = 0 + 1 cells that are discarded.
4) Number of UPC/NPC non-conforming CLP = 0 cells that are discarded.
5) Number of UPC/NPC non-conforming cells that are tagged (the CLP bit is changed from 0 to 1).
6) Number of CLP = 0 + 1 user-data cells discarded due to input buffer congestion.
7) Number of CLP = 0 user-data cells discarded due to input buffer congestion.

Note that for a given connection (depending on the ATC and QOS class) only a subset of the above entities may be pertinent.

*Type 9*: Measurements on outgoing user traffic (Figure 2 type G)

Object: Selected outgoing VPCs and/or VCCs.

For switched virtual connections (VPCs or VCCs), a count is made over the duration of the connection. For permanent virtual connections (VPCs or VCCs) counts are reported within the measurement interval defined by the network operator (see 8.2).

Note that an important special case of selected outgoing VPCs is the set of VPCs originating a VPC set.

Entities:

1) Number of CLP = 0 + 1 user-data cells.
2) Number of CLP = 0 user-data cells.
3) Number of CLP = 0 + 1 user-data cells discarded due to output buffer congestion.
4) Number of CLP = 0 user-data cells discarded due to output buffer congestion.

Note that for a given connection (depending on the ATC and QOS class), only a subset of the above entities may be pertinent.

### 8.2.3 Measurements on control units

This Recommendation only considers UPC/NPC as control units. Measurement for controls exercised by the signalling system and OAM are not considered in this Recommendation.

*Type 10*: Measurement on control units.

Object: Selected UNI or NNI incoming ports.

Entities:

1) Total number of CLP = 0 + 1 cells discarded due to UPC/NPC.
2) Total number of CLP = 0 cells discarded due to UPC/NPC.
3) Number of CLP = 0 cells tagged (the CLP bit is changed from 0 to 1).

### 8.2.4 QOS monitoring

In order to assess the QOS delivered, it is essential to measure delay values as well as cell losses. Delay measurements, which can only be performed by interaction with the OAM system and the TMN system, are left for further study.

*Type 11*: QOS monitoring (incoming).

Object: All cells on an incoming port belonging to a specified QOS class.

Entities:

1) Number of CLP = 0 + 1 user-data cells.
2) Number of CLP = 0 user-data cells.
3) Number of CLP = 0 + 1 user-data cells discarded due to input buffer congestion.
4) Number of CLP = 0 user-data cells discarded due to input buffer congestion.

For a given QOS class, only a subset of the above entities may be pertinent.

*Type 12*: QOS monitoring (outgoing).

Object: All cells on an outgoing port belonging to a specified QOS class.

Entities:

1) Number of CLP = 0 + 1 user-data cells.
2) Number of CLP = 0 user-data cells.
3) Number of CLP = 0 + 1 user-data cells discarded due to output buffer congestion.
4) Number of CLP = 0 user-data cells discarded due to output buffer congestion.

For a given QOS class, only a subset of the above entities may be pertinent.

NOTE – Whenever measurements of cell discarding due to congestion are specified, they should be complemented by measurements on buffer occupancy status.

## 9 Recommendation history

This is the first issue of this Recommendation.

ANNEX A

## Measurement matrix

Figure A.1 is a copy of Figure 1/E.502. It is included to clarify the discussions on what the required measurement entities and objects mean.

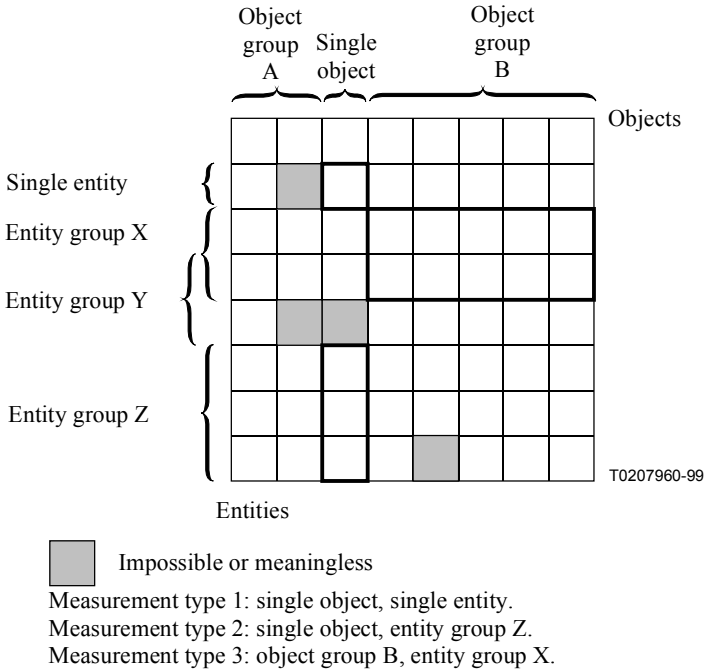
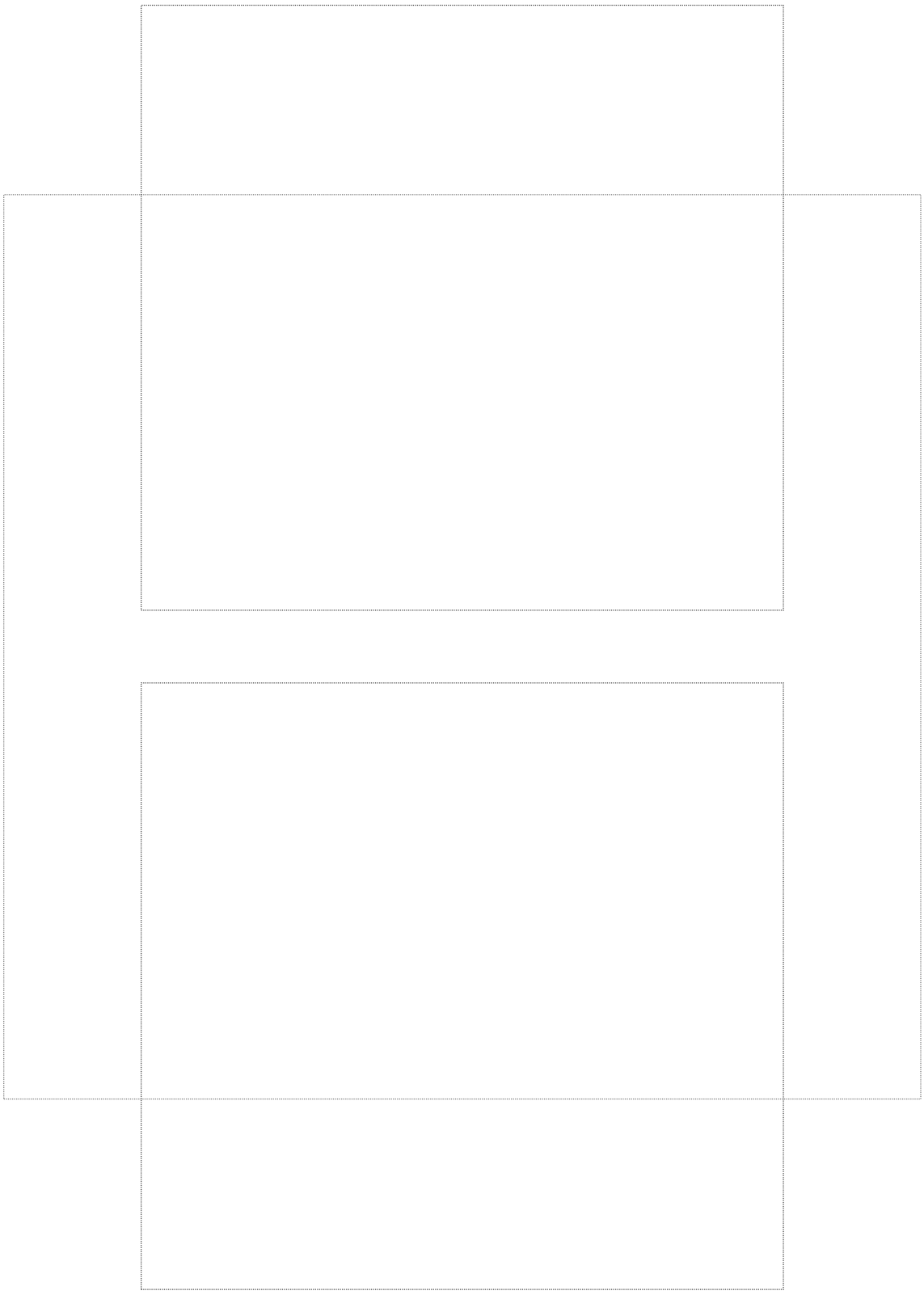



**Figure A.1/E.745 – Copy of measurement matrix from E.502**



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