BELLSOUTH

TR 73585
Issue E

ASYNCHRONOUS TRANSFER MODE (ATM) NETWORK INTERFACE AND PERFORMANCE SPECIFICATIONS

Technical
Reference

January, 2000

NOTICE

This Technical Reference is published by BellSouth Telecommunications, Inc. and describes the Network Interface specifications for BellSouth's Asynchronous Transfer Mode (ATM) network transport and ATM−based services.

BellSouth Telecommunications, Inc. reserves the right to revise this document for any reason, including but not limited to, conformity with standards promulgated by various governmental or regulatory agencies, utilization of advances in the state of the technical arts, or the reflection of changes in the design of any equipment, techniques, or procedures described or referred to herein. Liability to anyone arising out of use or reliance upon any information set forth herein is expressly disclaimed, and no representations of warranties, expressed or implied, are made with respect to the accuracy or utility of any information set forth herein.

This document is not to be construed as a suggestion to any manufacturer to modify or change any of its products, nor does this document represent any commitment by BellSouth Telecommunications, Inc. to purchase any product whether or not it provides the described characteristics.

Nothing contained herein shall be construed as conferring by implication, estoppel or otherwise, any license or right under any patent, whether or not the use of any information herein necessarily employs an invention of any existing or later issued patent.

If further information is required, please contact:

Research Director − Transport Systems Engineering
BellSouth Telecommunications, Inc.
1884 Data Drive
Birmingham, Alabama 35244

ASYNCHRONOUS TRANSFER MODE (ATM) NETWORK INTERFACE AND PERFORMANCE SPECIFICATIONS

CONTENTS

ASYNCHRONOUS TRANSFER MODE (ATM) NETWORK INTERFACE AND PERFORMANCE SPECIFICATIONS

1. General

This Technical Reference (TR) describes the Network Interface (NI) specifications for BellSouth's Asynchronous Transfer Mode (ATM) network transport and ATM−based services. The requirements in this document were developed to establish a functional and practical interface. Compliance with these requirements should provide a satisfactory interface in a high percentage of installations. If cases arise that have not been adequately addressed in this document, any resulting problems should be resolved through the cooperation of the customer, BST and the equipment suppliers.

ATM enables efficient transport and switching to support deployment of the Broadband Integrated Services Digital Network (B−ISDN). B−ISDN deployment requires reliable high−speed switching and transport for voice, data and video services. The ATM protocol provides the transport functionality for the B−IDSN. The ATM−based B−ISDN provides efficient and cost−effective broadband services with high data throughput rates and low end−to−end delays.

The ATM transport facilities utilize a packet−like protocol, which allows many customers access to near the full bandwidth of the underlying transport facilities, as needed. The ATM protocol specifies the use of fixed−length (53 octets) packets, referred to as "cells". An ATM network facility may be shared by many customers, although any individual customer has exclusive use of the entire bandwidth of the facility during the time it takes to transmit an ATM cell. ATM utilizes the concept of virtual circuits, such that each customer is assigned a unique virtual circuit number, allowing the facility to appear as a dedicated private line.

This Technical Reference is being reissued to revise the ATM−based services descriptions and to provide more comprehensive information regarding BellSouth's tariffed ATM service offerings.

1.1 BellSouth ATM

The BellSouth Telecommunication broadband services differ significantly from BellSouth's other traditional switched data services, both in higher transmission speeds and in network error correction philosophy. Typical transmission speeds for ATM−based services are generally higher than those for other data services, but do not provide error correction capability. Since ATM−based services include no network error correction capability, it is the responsibility of the customer and customer applications to detect and correct transmission errors, including those caused by the network.

BellSouth's high−speed broadband digital data network utilizes ATM protocol and is comprised of ATM switches and Synchronous Optical Network (SONET) transport facilities. BellSouth currently supports point−to−point. Permanent Virtual Connection (PVC) service as well as Switched Virtual Connection (SVC) service. BellSouth ATM−based service categories include Constant Bit Rate (CBR), Variable Bit Rate − Real Time (VBR−rt), Variable Bit Rate − Non−Real Time (VBR−nrt) and Unspecified Bit Rate (UBR).

1.1.1 Permanent Virtual Connections (PVC)

Permanent Virtual Connections (PVC) are established at the time of subscription and remain active with the traffic parameters established at subscription until the customer disconnects the service. Bandwidth requirements as well as traffic parameters are established at subscription for each PVC. In that sense PVCs are similar to leased private line connections. PVCs are identified by Virtual Path Identifiers (VPIs) and Virtual Channel Identifiers (VCIs) as their addresses.

1.1.2 Switched Virtual Connections (SVC)

Switched Virtual Connections (SVC) are connections that are established and subsequently disconnected through the use of signaling messages as defined in the ATM Forum's UNI Specifications. SVCs are identified by ICD AESA (International Code Designator form of an ATM End System Address). The format of this address is shown in the following example.

47.0109.00.840.13.01.002.0195.01B5.0123456789AB.00
BellSouth Administered Cust MAC Addr SL

As is shown in the above example, the first 22 characters are administered and assigned by BellSouth. Of the remaining 18 characters, the last two are the Selector (SL) field and are only used by applications within end systems. The 12 characters preceding the Selector field usually contain the Media Access Control (MAC) address of the terminating device. The other 4 characters are left to the customer to administer. The 22 character (11 byte) prefix assigned by BellSouth, with the four character (2 byte) Cust field, is a block of 65,536 (possible values of the Cust field) 13 byte prefixes; giving the customer the ability to support a large number of ATM end systems behind one UNI.

At the time of subscription, customers will set up the SVC capability on their interface with a bandwidth value to accommodate the total bandwidth needed for their maximum number of simultaneous SVC calls. Customers may signal SVC service categories and traffic descriptors that are the same as those offered for PVC connections. The bandwidth required for each SVC call can be determined using the same formulas as those for PVCs. It is the customer's responsibility to ensure that the negotiated total bandwidth is not exceeded by the cumulative bandwidth needs of the simultaneous SVC calls.

1.2 BellSouth ATM Service Categories

The BellSouth service categories listed in this section are those which currently utilize the ATM protocol across the NI. The categories of BellSouth services utilizing ATM transport are Constant Bit Rate (CBR), Variable Bit Rate – Real Time (VBR–rt), Variable Bit Rate – Non–Real Time (VBR–nrt) and Unspecified Bit Rate (UBR).

1.2.1 CBR (Constant Bit Rate)

CBR service provides a private line like service over ATM. The user chooses the required bandwidth or traffic parameters, at subscription, for PVCs and through signaling messages for SVCs. CBR service could be utilized for Circuit Emulation Services over ATM (e.g., DS1 and DS3).

1.2.1.1 DS1 Circuit Emulation

ATM DS1 Circuit Emulation (CE) service provides for the transport of DS1 (1.544 Mbps) circuits over ATM facilities. ATM CE service requires that the DS1 signal be mapped into the ATM protocol using AAL1. ATM DS1 CE can be provided for either unstructured or structured DS1 signals.

Unstructured DS1 CE provides transparent transmission of the 1.544 Mbps DS1 data stream mapped into the AAL1 layer via the CBR service category. Structured DS1 CE allows for the transport of Nx64 kbps services in either a basic format or with Channel Associated Signaling (CAS). The Nx64 kbps service with CAS collects the signaling information for the associated channels into a specific location in an AAL1 block before it is transmitted via a CBR service category. The basic format does not accommodate any signaling information.

Detailed specifications of ATM CE service are contained in ATM Forum Circuit Emulation Service Interoperability Specification.

1.2.2 VBR (Variable Bit Rate)

VBR service provides for the transport of information that is “bursty” and does not flow at a constant rate. BellSouth supports two categories of VBR traffic; Real Time (VBR−rt) and Non−Real Time (VBR−nrt).

1.2.2.1 VBR−rt (Variable Bit Rate − Real Time)

This category of VBR service is defined for applications which require low cell delay variation, but not as stringent as would be needed for CBR traffic. The user chooses the required bandwidth and/or traffic parameters, at subscription for PVCs and through signaling messages for SVCs. VBR−rt service is typically used to support applications such as variable bit rate video compression and packetized voice.

1.2.2.2 VBR−nrt (Variable Bit Rate − Non−Real Time)

This category of VBR service is defined for applications which can tolerate larger cell delay variations than VBR−rt. The user chooses the required bandwidth and/or traffic parameters, at subscription for PVCs and through signaling messages for SVCs. VBR−nrt service is typically used to support applications such as LAN traffic and Frame Relay interworking.

1.2.3 UBR (Unspecified Bit Rate)

UBR service is considered to be a “best effort” service where the user does not specify a bandwidth requirement (or any other traffic parameters) and no performance objectives are supported. UBR service is typically used to support applications such as file transfers and E−mail. At start−up, UBR services may receive a temporary burst of traffic management cells normally associated with ABR flow control as described in ATM Forum Traffic Management Specifications Version 4.0.

1.2.4 Frame Relay – ATM Network Interworking

Frame Relay is a high–speed packet switched service that can be used to connect customer networks and equipment across metropolitan or wide areas. A feature of the BellSouth Frame Relay service offering is the mapping of Frame Relay traffic into ATM cells in the BellSouth network. BellSouth's Frame Relay NI specifications are contained in TR 73587. Frame Relay over ATM requires that the Frame Relay protocol be mapped into the ATM protocol at the NI, using ATM Adaptation Layer 5 (AAL5) in accordance with Frame Relay Forum Document FRF.5.

1.3 ATM Traffic Parameters

In addition to a Service Category, each ATM connection will have a set of Traffic Parameters associated with it to describe the characteristics of the information being transmitted. Section 3 provides a more detailed description of the traffic parameters and the traffic contract.

1.3.1 Peak Cell Rate (PCR)

The Peak Cell Rate is the upper bound specified on the traffic that can be submitted on an ATM connection. The PCR is expressed in cells per second. The PCR cannot exceed the data–carrying capability of the access facility.

1.3.2 Sustainable Cell Rate (SCR)

The Sustainable Cell Rate is an upper bound on the possible conforming "average rate" of an ATM connection, where "average rate" is the number of cells transmitted divided by a closed interval of time. The SCR is expressed in cells per second

1.3.3 Maximum Burst Size (MBS)

The Maximum Burst Size is the maximum number of cells that may be transmitted at the PCR and still be in conformance with the information transfer limits established by the service. The MBS is expressed in number of cells.

1.3.4 BellSouth ATM Service Bandwidth Parameter

The BellSouth ATM Service Bandwidth (BW) parameter is a derived parameter which represents the ATM network resources required to provide the desired service. For a connection, the values of the SCR, PCR and MBS traffic parameters described above for a given service category are specified at subscription or signaled at call setup. The calculation methods to derive the BW parameter for the specified traffic parameters for each service category are described in the following Sections.

When the resulting Bandwidth parameter value is greater than 1 Mbps, the value is expressed in units of Mbps with any fractional values rounded up to the next whole Mbps increment. When the resulting value is less than 1.536 Mbps, the value is divided by 0.064 to arrive at a quantity of 64 kbps increments. Again, fractional values are rounded up to the next whole number. The actual values of the SCR and PCR provided by the network will be determined by the calculations given in the following Sections using the rounded Bandwidth parameter value as their source.

1.3.4.1 CBR Service

For CBR service, the only traffic parameter used is the PCR. Once the PCR is determined, the corresponding Bandwidth parameter will be equal to the PCR times 0.000424.

$$BW_{CBR} = PCR * 0.000424$$

or

$$PCR = BW_{CBR} / 0.000424$$

1.3.4.2 DS1 Circuit Emulation (CE) Service

For DS1 CE service the formula for determining the Bandwidth parameter value is identical to CBR Service. The PCR value for Unstructured DS1 and Structured DS1 (N x 64 kbps) CE Service is determined as follows:

Unstructured DS1	PCR = 4107 (cells per second)
Structured DS1 (Basic) PCR =	(8000*N) / 46.875
Structured DS1 (with CAS)	PCR = 8000 *[(1 + N*49) /48] / 46.875

1.3.4.3 VBR−rt Service

For VBR−rt service, the traffic parameters used are the PCR, SCR and the MBS. The MBS is fixed in BellSouth at 32 cells and a PCR−to−SCR ratio of 200% is recommended. Once these parameters are determined, the corresponding Bandwidth parameter will be equal to the SCR times 0.000512.

$$BW_{VBR-rt} = SCR * 0.000512$$

or

$$SCR = BW_{VBR-rt} / 0.000512$$

For PCR−to−SCR ratios other than the recommended value, see Section 1.3.4.7.

1.3.4.4 VBR−nrt Service

For VBR−nrt service, the traffic parameters used are the PCR, SCR and the MBS. The MBS is fixed in BellSouth at 100 cells and a PCR−to−SCR ratio of 400% is recommended. Once these parameters are determined, the corresponding Bandwidth parameter will be equal to the SCR times 0.000804.

$$BW_{VBR-nrt} = SCR * 0.000804$$

or

$$SCR = BW_{VBR-nrt} / 0.000804$$

For PCR−to−SCR ratios other than the recommended value, see Section 1.3.4.7.

1.3.4.5 UBR Service

Because UBR is a “best effort” service and no traffic parameters are used, there is no Bandwidth parameter associated with UBR service

1.3.4.6 Frame Relay – ATM Network Interworking

Frame Relay service has service parameters that are significantly different from those used for ATM, and successful interworking requires a mapping of service parameters and values. For a more detailed description of the Frame Relay service and its parameters, see BellSouth Technical Reference, TR73587, *Frame Relay Service Interface and Performance Specifications.*

The pertinent Frame Relay service parameters are:

CIR – . The Committed Information Rate (CIR) describes the average rate at which the network will admit committed information frames.

EIR – The Excess Information rate (EIR) describes the rate at which the network will admit and transfer excess information frames. This is usually the difference between the Frame Relay access rate and the CIR.

Bc – The Committed Burst Size (Bc) specifies the number of user bits that can be sent by the user to the network within time T (one second in BellSouth).

The pertinent ATM Parameters PCR, SCR and MBS are described in Section 1.3.

The relationship between the two sets of parameters are described by the following formulas taken from Appendix A of the ATM Forum document af–bici–0013.003, *B–ICI Specification, V 2.0:*

$$PCR = (CIR + EIR) * OHB / 8$$
$$SCR = (CIR * OHB) / 8$$
$$MBS = Bc * OHB / 8$$ (BellSouth uses 100 cells as the MBS for this IWF)

The OHB (Overhead Factor for Committed/Excess Rate) is specified in cells/octet and accounts for extra bytes needed to encapsulate a frame into equally sized cells. OHB is equal to the number of cells needed to transport the frame divided by the number of octets in the frame. For example, a 256 octet frame which requires 6 cells for ATM transport has an OHB = 0.0234375 cells/octet. This value of 0.0234375 is currently the BellSouth default value for the OHB.

Frame Relay service with a zero Committed Information Rate (CIR) will be mapped into ATM utilizing the UBR service category. Frame Relay service with a non–zero CIR will be mapped into ATM utilizing the VBR service category.

Appropriate rounding of the Bandwidth parameter value, as described in Section 1.3.4, will be applied.

1.3.4.7 Summary of Relationships of Traffic Parameter to Bandwidth Parameter

	CBR	VBR–rt	VBR–nrt
PCR	*BW / 0.000424*	*SCR * 2*	*SCR * 4*
SCR	–	*BW / 0.000512*	*BW / 0.000804*
MBS	–	*32*	*100*

For VBR service with PCR−to−SCR ratios different than the recommend values, the following will apply in determining the BellSouth ATM Service Bandwidth:

BW_{VBR} = SCR * 0.000286 + PCR * 0.000133
MBS = 100 cells

Appropriate rounding of the Bandwidth parameter value, as described in Section 1.3.4, will be applied.

2. ATM Protocols

Each of the of ATM services offered by BellSouth requires that Customer Premises Equipment (CPE) be compatible with the ATM transport layer protocol supported by BellSouth. Figure 1 illustrates the relationship of the protocols described in this section.

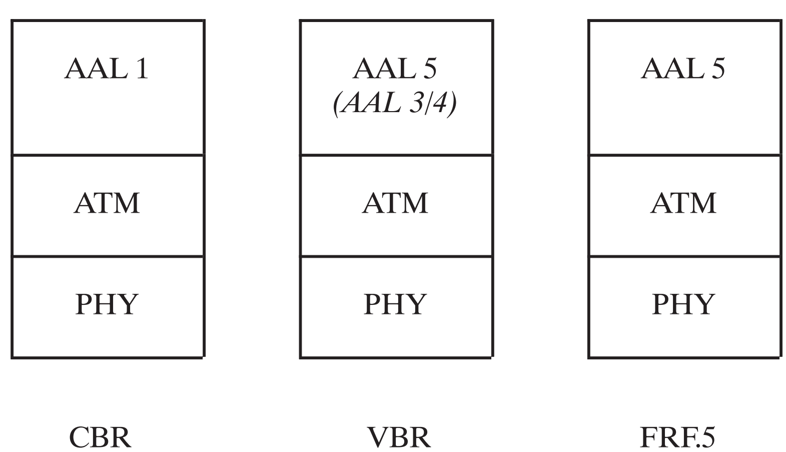

Figure 1 − ATM End User Services Protocol Layers

The NI for an ATM end user is located at the customer's location and the NI for an Interexchange Carrier (IC) is the IC's Point of Presence. NI specification for the BellSouth ATM services described in this document at the End User (UNI) are based upon the ATM Forum's *ATM UNI Specification*, Version 3.0, 3.1 and/or 4.0. NI specification for the BellSouth ATM services described in this document at the Network−to−Network Interface (NNI) are based upon the ATM Forum's *Interim Inter−switch Signaling Protocol (IISP) Specification*, Version 1.0, which is based on UNI 3.1.

Three "planes" are defined for the B−ISDN Reference Model. These planes are the User plane (U−plane), the Control plane (C−plane) and the Management plane (M−plane). The three planes are a categorization of B−ISDN functions and involve multiple protocol levels. The U−plane provides for the transfer of user data and involves the Physical, ATM and AAL layers. The C−plane deals with ATM SVC service only and is therefore not relevant to the NI specifications described in this document. The M−plane function includes layer management functions for ATM PVC services.

2.1 Physical Specifications

Sections 2.1.1 − 2.1.4 describe the physical characteristics of the facilities BellSouth currently supports for ATM intraLATA access. These facilities include SONET OC−12 and OC−3, as well as DS3, DS1 and IMA. Additional information is also contained in BellSouth TR 73590.

The physical layer is partitioned functionally into two parts − the Physical Media Dependent (PMD) sublayer, and the Transmission Convergence (TC) sublayer. The PMD sublayer is the lower of the two sublayers and defines the physical medium and transmission characteristics, but does not specify framing or overhead information. The TC sublayer deals with the physical layer characteristics which are not medium−specific, such as specifications for use of the SONET overhead bits.

2.1.1 OC−12 Physical Layer Specifications

ATM interconnection is available over single mode SONET OC−12 fiber optic cable facilities utilizing STS−12c framing. The nominal bit rate for this access is 622.080 Mb/s, including STS−12c overhead bytes. The nominal bit rate available for ATM cell transport is 599.040 Mb/s. The network interface jack is a duplex SC optical connector with receptacle (SJASC).

2.1.1.1 OC−12 PMD Sublayer Specifications

The physical medium characteristics at the NI shall be compliant with the PMD sublayer specifications contained in ATM Forum 622.08 Mbps Interface Specification and TR−NWT−00253 for intermediate−reach and long−reach OC−12 signals.

2.1.1.2 OC−12 TC Sublayer Specifications

All mandatory active SONET overhead bytes shall be processed and generated in accordance with the ATM Forum 622.08 Mbps Interface Specification and Bellcore TR−NWT−000253. SONET procedures related to signal concatenation, frame scrambling, timing and framing as defined in the ATM Forum 622.08 Mbps Interface Specification shall be supported.

ATM Header Error Control (HEC) error detection and cell delineation, ATM cell scrambling/descrambling, and ATM cell mapping into the SONET STS−12c Synchronous Payload Envelope shall be supported, as per the ATM Specification. STS−12c specifications are consistent with TR−NWT−000253.

2.1.2 OC−3 Physical Layer Specifications

ATM interconnection is available over single mode SONET OC−3 fiber optic cable facilities utilizing STS−3c framing. The nominal bit rate of an OC−3 signal is 155.520 Mb/s, including STS−3c overhead bytes. The nominal bit rate available for ATM cell transmission is 149.760 Mb/s. It is expected that a mix of CBR, VBR and UBR traffic will be present on an OC−3 interface. If an OC−3 interface is used exclusively for CBR traffic, the Service Bandwidth may be limited to 146 Mb/s. The NI jack is a duplex SC optical connector with receptacle (SJASC).

2.1.2.1 OC−3 PMD Sublayer Specifications

The physical medium characteristics at the NI shall be compliant with the PMD sublayer specifications contained in the ATM Forum UNI Specification document and TR−NWT−00253 for intermediate−reach and long−reach OC−3 signals.

2.1.2.2 OC−3 TC Sublayer Specifications

All mandatory active SONET overhead bytes shall be processed and generated in accordance with the ATM Forum UNI Specification and Bellcore TR−NWT−000253. SONET procedures related to STS−1 signal concatenation, STS−3c frame scrambling, timing and framing as defined in the ATM Forum UNI Specification shall be supported.

ATM Header Error Control (HEC) error detection and cell delineation, ATM cell scrambling/descrambling, and ATM cell mapping into the SONET STS−3c Synchronous Payload Envelope shall be supported, as per the ATM UNI Specification. STS−3c specifications are consistent with TR−NWT−000253.

2.1.3 DS3 Physical Layer Specifications

This section specifies the physical layer requirements at the NI for the DS3 (44.736 Mbps) format. The DS3/ATM physical layer is described in the ATM Forum document af−phy−0054.000, *DS3 Physical Layer Interface Specification,* which supersedes the DS3 Physical Layer Sections of the ATM UNI Specification.

2.1.3.1 DS3 PMD Sublayer Specifications

DS3 PMD sublayer NI specifications are contained in BellSouth TR 73590. The NI connector comprises two 75 ohm, threaded, N−type, coaxial, TNC jack and plug connectors. The USOC designation for this configuration is SJA 44.

2.1.3.2 DS3 TC Sublayer Specifications

There are two methods for mapping ATM cells into the payload of the DS3 transport facility − Direct Mapping and Physical Layer Convergence Protocol (PLCP). Direct Mapping is preferred, however BellSouth will support PLCP, depending upon available network facilities and the geographical location of the NI. Direct Mapping specifications are described in ANSI T1.646−1995. DS3 PLCP specifications are described in the ATM Forum DS3 Physical Layer Interface Specification. Direct Mapping will allow for a usable bandwidth of 44.210 Mbps. The use of PLCP mapping will restrict the usable bandwidth of the DS3 to 40.704 Mbps.

Both of the mapping methods are based upon the C−bit Parity format described in ANSI T1.107 and Bellcore TR−TSY−000499. The C−bit parity format is preferred, however other farming formats may be negotiated with BellSouth and are subject to the availability of network facilities and the geographical location of the NI.

2.1.4 DS1 Physical Layer Specifications

The DS1 must conform to the electrical specifications and framing format contained in BellSouth TR 73590. For the transport of ATM protocol over a DS1, Extended Superframe format and B8ZS line code is required. DS1 NI connection is made through one of the four following USOC connectors: RJ48C, RJ48X, RJ48M, or RF48H.

The DS1 Direct Mapping method is used to carry ATM cells over DS1 facilities, and is described in ANSI T1.646−1995. This method allows for a usable bandwidth of 1.536 Mbps.

2.1.4.1 Inverse Multiplexing for ATM (IMA) Specifications

Inverse Multiplexing for ATM (IMA) allows for the multiplexing and de−multiplexing of ATM cells in a cyclical manner among two to eight DS1 facilities grouped together to form a higher bandwidth logical facility. The rate of the logical facility will be approximately equal to the sum of the link rates. The usable bandwidth of the facility will be approximately 1.524 Mbps per DS1 facility used. IMA is described in ATM Forum Document af−phy−0086.000, *Inverse Multiplexing for ATM (IMA) Specification (Version1.0)*.

2.2 ATM Layer Protocol

The ATM layer provides transport of ATM Service Data Units (ATM_SDUs) between ATM layer endpoints. These 48−octet ATM_SDUs are encapsulated as payload within 53−octet ATM Protocol Data Units (ATM_PDUs, or “cells”) by the sending entity for ATM layer transport.

Each ATM cell consists of a 5–octet cell header and 48–octet payload, as shown in Figure 2.

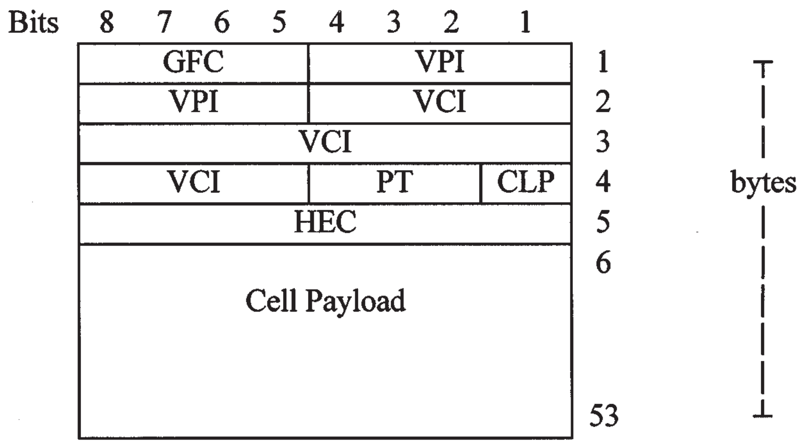

Figure 2 – ATM Layer Protocol Cell Structure

2.2.1 ATM Cell Structure

This section describes the ATM cell structure and encoding requirements necessary to interface with the BellSouth ATM–based services across the NI. These requirements are based upon the ATM UNI Specification.

2.2.1.1 Generic Flow Control (GFC) Field

The four–bit GFC field shall be set to all zeros by both the CPE and the network. This field has local significance only, and has no function across the NI.

2.2.1.2 Virtual Path Identifier (VPI) and Virtual Channel Identifier (VCI) Fields

The VPI and VCI fields are used to route cells through the network. The VPI field comprises eight bits and the VCI field 16 bits. The number of VPI and VCI bits used by the network for routing is negotiated between BellSouth and the customer at service subscription.

The bits in the VPI and VCI fields allocated for routing shall be contiguous, and shall be the least significant bits of the respective fields. The least significant bit in the VPI field is bit position 5 of octet 2 of each ATM cell. The least significant bit of the VCI field is bit position 5 of octet 4. All unallocated bits in both the VPI and VCI fields shall be set to zero.

The combination of VPI and VCI values are used to define the PVC or SVC addresses. Due to limitations in switch software, there may be boundaries placed on the number of VC addresses allowed per connection. The following chart lists the current maximum number of PVC and simultaneous SVC identifiers allowed per customer connection.

Rate of Connection	Number of VC Identifiers
1.536 Mbps (DS1)	2000
IMA (n X DS1)	512
44.210 Mbps (DS3)	2000
149.760 Mbps (OC–3)	4000
599.040 Mbps (OC–12)	6000

There may also be additional limitations on the maximum number of possible VC addresses if access concentrator technology is used in the network. A mutual understanding between BellSouth and the customer on the address limitations should be established at the time of subscription.

2.2.1.3 Payload Type (PT) Field

The three−bit PT field indicates whether the ATM cell is a user cell, or is an Operations, Administration and Maintenance (OAM) cell. The PT codes are shown in Table 1.

Table 1 − Payload Type Field Encoding

PT Coding (MSB First)	Interpretation
000	User data cell, no congestion experienced, SDU type = 0
001	User data cell, no congestion experienced, SDU type = 1
010	User data cell, congestion experienced, SDU type = 0
011	User data cell, congestion experienced, SDU type = 1
100	Segment OAM F5 flow related cell
101	End−to−End OAM F5 flow related cell
110	Reserved for future traffic control and resource management
111	Reserved for future functions

2.2.1.4 Cell Loss Priority (CLP) Field

The CLP field comprises one bit and is used for selective cell discarding in the network, and may be used for loss priority indication by end points (customer CPE).

A CLP bit of zero (0) indicates a cell of higher priority than one in which the CLP bit is set to one (1). The network, under certain traffic conditions may discard customer cells. Under these circumstances, those cells with a CLP bit set to one will be discarded before those cells with a CLP bit set to zero.

BellSouth may utilize the CLP field to control network congestion and for Peak Cell Rate enforcement.

2.2.1.5 Header Error Control (HEC) Field

The HEC field is used to detect errors in the cell header and may also be used for cell delineation. Cells with errors in the cell header are discarded by the network.

The HEC function utilizes the fifth octet of the five−octet ATM cell header to detect header errors. The HEC function is implemented as defined in ITU I.432, and described in the ATM Forum Specification. The ATM transmitter calculates an eight−bit polynomial based upon the contents of the first four octets in each cell header and populates the HEC field with the result of this calculation. Each ATM receiver in the network makes a similar calculation on the first four octets of each cell and compares the result to the value received in the fifth octet position of the cell. If the values are not the same, the cell is discarded by the network. BellSouth does not attempt cell header error correction.

2.2.1.6 Cell Payload

The 48−octet Cell Payload field contains user data, and/or higher layer protocol overhead bits. The network requires and implements the self synchronizing scrambling and descrambling procedures defined in ITU I.432 and described in the ATM Forum UNI Specification. The procedures apply to the cell payload only and do not apply to the cell header. This field is the ATM Service Data Unit (ATM_SDU).

2.2.2 U−Plane Functions

ATM layer U−plane functions are categorized in this section.

2.2.2.1 Multiplexing of ATM Connections

This function involves the multiplexing of ATM connections with different Quality of Service (QoS) classes. QoS is discussed in Section 4.2 of this document. The QoS is the same for all cells belonging to the same connection, and remains unchanged for the duration of the connection.

2.2.2.2 Cell Rate Decoupling

The Cell Rate Decoupling function requires that the transmitting entity add unassigned cells to the assigned cell bit stream, transforming a non−continuous assigned cell bit stream into a continuous bit stream of assigned and unassigned cells. The opposite operation is required at the receiving entity. Unassigned cells are recognized by a pre−defined header code, defined in Section 2.2.2.3.

2.2.2.3 Cell Discrimination Based on Pre−Defined Header Field Values

This function provides for cell discrimination based on certain pre−defined header field values. The current industry−defined values are shown in Table 2 below.

Table 2 − Pre−Defined Header Field Values

Use	Value of the First Four ATM Header Bytes [1,2,3,4]			
Unassigned Cell Indication	00000000	00000000	00000000	0000xxx0
Meta−signaling (default) [5, 7]	00000000	00000000	00000000	00010a0c
Meta−signaling [6, 7]	0000yyyy	yyyy0000	00000000	00100a0c
General Broad−cast signaling (Default) [5]	00000000	00000000	00000000	00100aac
General Broad−cast signaling [6]	0000yyyy	yyyy0000	00000000	00100aac
Point−to−point signaling (Default) [5]	00000000	00000000	00000000	01010aac
Point−to−point signaling [6]	0000yyyy	yyyy0000	00000000	01010aac
Invalid Pattern	xxxx0000	00000000	00000000	0000xxx1
Segment OAM F4 flow cell [7]	0000aaaa	aaaa0000	00000000	00110a0a
End−to−End OAM F4 flow cell [7]	0000aaaa	aaaa0000	00000000	01000a0a
ILMI message	00000000	00000000	00000001	0000aaa0

Note 1 **"a" indicates the bit is available for use by the appropriate ATM layer function**

Note 2 **"x" indicates "don't care" bit**

Note 3 **"y" indicates any VPI value other than 00000000**

Note 4 **"c" indicates the originating signaling entity shall set the CLP bit to 0. The network may change the value of the CLP bit**

Note 5 **Reserved for user signaling with the local exchange (BellSouth)**

Note 6 **Reserved for use with other signaling entities**

Note 7 **The transmitting ATM entity shall set bit 2 of octet 4 to zero. The receiving ATM entity shall ignore bit 2 of octet 4.**

The Meta−signaling values are associated with ATM SVC service and are not currently valid for BellSouth services. BellSouth currently does not support end−to−end OAM flow controls.

2.2.2.4 Cell Discrimination Based on PT Identifier Field Values

The PTI field is used to discriminate between user cells and non−user cells and to indicate whether user cells have experienced congestion in the network. The valid PTI values are shown in Table 1 in Section 2.2.1.3.

2.2.2.5 Loss Priority Indication and Selective Cell Discarding

The CLP field provides loss priority indication, as described in Section 2.2.1.4. The CLP field may be used by the network for traffic management and Traffic Contract enforcement.

2.2.3 M−Plane Functions

ATM layer M−plane functions across the UNI include alarm surveillance, connectivity verification and invalid VPI/VCI detection. Non−user ATM cells, referred to as OAM cells, have been defined to provide alarm surveillance and connectivity verification across the NI. This OAM functionality is defined using F4 and F5 cell flows. The F4 flow is used for segment or end−to−end VP level management, using VCI values 3 or 4 and the F5 flow is used for segment or end−to−end VC level management.

2.2.3.1 Interim Local Management Interface (ILMI)

The ATM Forum UNI Specification provides ILMI protocol specifications, as a method of passing status and provisioning information across the NI. ILMI utilizes Simple Network Management Protocol (SNMP) and an ATM UNI Management Information Base (MIB) to provide these functions.

2.2.4 Interim Inter−switch Signaling Protocol (IISP)

The Interim Inter−switch Signaling Protocol (IISP) was developed to allow for some base level capability between network. IISP is built upon the ATM Forum UNI 3.1 and its specification is contained in the ATM Forum Document af−pnni−0026.000.

2.3 ATM Adaptation Layer

The ATM Adaptation Layer (AAL) is a user−initiated process which performs functions required by the user, control and management planes and supports the mapping between the ATM layer and the next higher layer. It is assumed that the most common AALs used will be AAL 1 for CBR and AAL 5 for the VBR categories, with some VBR applications utilizing AAL 3/4. The two most common AALs (1 and 5) are discussed below. More detail concerning AALs is contained in ITU Recommendation I.363.

2.3.1 AAL 1

With the AAL 1 structure, user data in separated into 47 octet pieces (SAR−PDUs) and another octet containing a Segmentation and Reassembly (SAR) Header is added to created a payload of 48 octets. The SAR Header octet contains one bit for clock recovery (Convergence Sublayer Indication − CSI), three bits for a sequence count (Sequence Number − SN) and four bits to provide error detection and correction for the SAR Header (Sequence Number Protection − SNP). The resulting 48 octet units are then placed into ATM cells with the appropriate 5 octet header.

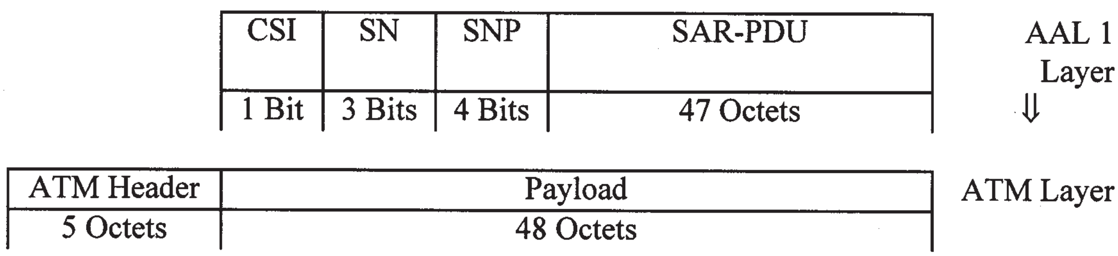

Figure 3 − AAL 1 Structure

2.3.2 AAL 5

With the AAL 5 structure, a pad is added to bring the total number of octets of user data plus pad plus trailer to a total number of octets that is an integer multiple of 48. The Trailer consists of one octet to transparently transfer user−to−user information (UU), one octet to align the trailer to 64 bits (Common Part Indicator − CPI), two octets to encode the length of the User Data (Length) and two octets to detect errors (CRC). The Common Part Convergence Sublayer − Protocol Data Unit (CPCS−PDU) is then divided into 48 octet pieces and placed into ATM cells with the appropriate 5 octet header.

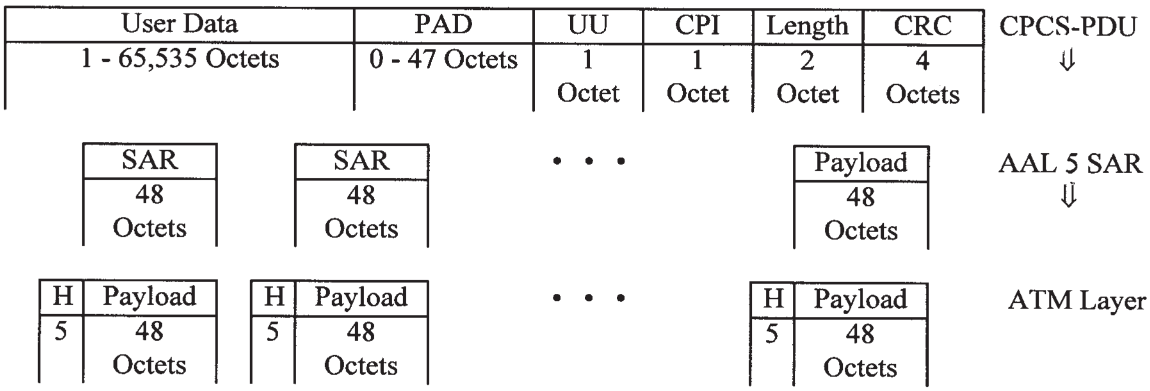

Figure 4 − AAL 5 Structure

3. Traffic Control and the Traffic Contract

For ATM services, a concept of a traffic contract between BellSouth and the customer is used to specify the negotiated traffic characteristics of the connection. Certain traffic parameters, grouped into "traffic descriptor" categories, must be specified. The traffic contract includes the Connection Traffic Descriptor, the QoS class (described in Section 4.2), and the compliance definition for the connection.

The Connection Traffic Descriptor comprises the Source Traffic Descriptor and the Conformance Definition for the individual ATM connections. The Source Traffic Descriptor is a subset of the traffic parameters (e.g., Peak Cell Rate, Sustainable Cell Rate, Maximum Burst Size). The set of traffic parameters associated with VBR connections will differ from those associated with CBR connections. The traffic contract may allow the customer to specify values for the traffic parameters associated with the particular type of ATM connection requested.

Essential to the traffic contract is the definition of a conforming cell and a compliant ATM connection. The definition of a conforming cell is based upon the Generic Cell Rate Algorithm (GCRA) described in the ATM Forum UNI specification. A compliant connection is defined by the network provider, and could allow a certain percentage of non−conforming cells to be included in a compliant connection.

All non−conforming cells may be discarded by the BellSouth network. In some cases, BellSouth may implement cell "tagging" on individual connections. When cell tagging is performed, the non−conforming cell's CLP bit (see Section 2.2.1.4) in the cell header will be set to a value of "1". These "tagged" cells (CLP = 1) will then have a lower priority than the non−tagged cells, and would be more likely to be discarded due to network traffic conditions.

3.1 Connection Admission Control

Connection Admission Control (CAC) is the procedure performed by ATM network providers to determine whether a request to establish a new ATM connection will be accepted or rejected. For ATM Permanent Virtual Connection service, the CAC function is performed by network administration procedures during the circuit provisioning process. When ATM Switched Virtual Connection services become available from BellSouth, the CAC will be provided via real−time signaling using an automatic algorithm within ATM network switches.

3.2 Usage Parameter Control

Usage Parameter Control (UPC) is the set of actions taken by BellSouth to monitor and control traffic over an established ATM connection, sometimes known as policing.

The UPC enforces the traffic contract by monitoring the agreed−to traffic parameters associated with each circuit, and possibly discarding all non−conforming or errored/invalid cells on the connection. The source traffic parameters of Peak Cell Rate (PCR), Sustainable Cell Rate (SCR), Maximum Burst Size (MBS) and the Cell Delay Variation Tolerance (CDVT) may be utilized by the UPC for traffic contract enforcement. BellSouth does not currently police for CDVT.

3.3 Source Traffic Descriptor

As previously stated, the subset of traffic parameters will differ between CBR connections and VBR connections. For CBR connections, Peak Cell Rate is currently the only Source Traffic Descriptor parameter associated with the BellSouth traffic contract. VBR connections, however, include the Peak Cell Rate, Sustainable Cell Rate and Maximum Burst Size as Source Traffic Descriptor parameters.

3.3.1 Peak Cell Rate

The Peak Cell Rate (PCR) is the upper bound specified on the traffic that can be submitted on an ATM connection, expressed in cells per second. The following Table 3 gives the correlation of some common data rates and the PCR values used to support them. These data rates include both user information and Operations, Administration and Maintenance (OAM) cells normally needed to support the ATM connection. This table is contained in Bellcore document GR−1110−CORE. Note that not all ATM switches in the BellSouth network can currently support all of these rates.

Table 3 − Peak Cell Rate to Data Rate Correlation

PCR value (cells/second)	Example Data Rates (bits/second)	Comment
152	56 kb/s + OAM cells	
n X 173, where n = 1 − 23	n X 64 kb/s + OAM cells	n X DS0
3,622	1.39 Mb/s, including OAM cells	DS1 direct mapping
n X 690, where n = 7−47, except n = 12, 18, 24, 30, 36 and 42	approximately n 256 kb/s	rates from 1.5 Mb/s to 12.3 Mb/s
n X 4,140, where n = 1 − 85	n X 1.544 + OAM cells	n X DS1
96,000	36.86 Mb/s, including OAM cells	DS3 PLCP
104,268	40.04 Mb/s, including OAM cells	DS3 direct mapping
n X 119,910	n X 44.736 Mb/s + OAM cells	n X DS3
353,207	135.63 Mb/s, including OAM cells	full STS−3c

3.3.2 Sustainable Cell Rate

Sustainable Cell Rate (SCR) is the upper limit for the average cell rate of a conforming ATM VBR connection, expressed in cells per second. SCR is not applicable to CBR connections. The same correlation between the PCR and data rates shown in Table 3 may also be used to derive example SCRs. In BellSouth the PCR is recommended to be 200% of the SCR value for VBR−rt Service and the PCR is recommended to be 400% of the SCR value for VBR−nrt Service.

3.3.3 Maximum Burst Size

Maximum Burst Size (MBS) is the maximum number of consecutive cells that can be transmitted at the PCR. It can be used by a network, in conjunction with SCR, to enforce the UPC on VBR connections. The supported MBS values for BellSouth ATM Service are 32 cells for VBR−rt Service and 100 cells for VBR−nrt Service.

3.3.4 Cell Delay Variation Tolerance

The Cell Delay Variation Tolerance (CDVT) is the amount of 2−point Cell Delay Variation (see Section 4.1.6) that the UPC will accommodate at the ingress of the network interface. Currently BellSouth does not police for CDVT.

3.4 Excessive Demand for Customer Resources

Subscribers to ATM PVC services should be aware that their behavior can adversely influence observed performance. Two important examples are given below. As this type of behavior is beyond the control of BellSouth, delivery of cells under these (or similar) circumstances cannot be guaranteed.

3.4.1 Unanticipated Simultaneous Access Line Bursting

There may be occasions where simultaneous bursts from the set of connections on an access circuit section exceed the physical capacity of the line. In accepting this set of connections the network and subscriber have anticipated a limited or negative time correlation among bursts of cells, but for unanticipated reasons this assumption may not hold true. During such events, the apparent performance of the network will be degraded and, in particular, this may result in increased CLR, CTD, CDV, or some combination of these effects.

3.4.2 Full Utilization of Over Subscribed Access

When multiple PVCs are involved, the network may allow a subscriber to establish multiple connections on an access circuit with a total BW greater than the access circuit's physical capacity. This allows the subscriber to take advantage of the fact that not all of these connections will be active simultaneously. However, the network's apparent performance will be degraded if the subscriber attempts to make use of this overbooked commitment beyond the physical capacity of the access circuit. In particular, attempts to fully utilize this overbooking may result in increased CLR, CTD, CDV, or some combination of these effects. In the worst case, attempts to fully utilize such overbooked commitments may appear as unavailability. BellSouth may limit the amount of over subscription available to the user.

4. ATM Performance

BellSouth has established provisional performance objectives for certain ATM−based services. These are only objectives, and their values may change as more performance data is collected from actual ATM network deployment.

4.1 ATM Performance Parameters

There are several ATM performance parameters that are currently defined, however not all parameters have specified objectives. This section provides a description of the ATM performance parameters.

4.1.1 Cell Error Ratio

Cell Error Ratio is defined as:

$$\frac{\text{Errored Cells}}{\text{Successfully Transferred Cells} + \text{Errored Cells}}$$

Cell blocks counted as Severely Errored Cell Blocks (see Section 4.1.2) are excluded from this calculation.

4.1.2 Severely Errored Cell Block Ratio

Severely Errored Cell Block Ratio is defined as:

$$\frac{\text{Severely Errored Cell Block Ratio}}{\text{Total Transmitted Cell Blocks}}$$

A cell block is a sequence of consecutively transmitted cells. A Severely Errored Cell Block occurs when a number of errored cells, or misinserted cells are observed in a cell block received.

The size of a cell block is yet to be specified. For measurement purposes, a cell block may generally be considered the group of user information cells transmitted between successive OAM cells.

4.1.3 Cell Loss Ratio

The Cell Loss Ratio (CLR) is defined as:

$$\frac{\text{Lost Cells}}{\text{Total Transmitted Cells}}$$

It should be noted that Lost Cells are those cells that are discarded by the network because of uncorrectable errors in the five−byte cell header. The CLR calculation does not include Errored Cells or Severely Errored Cell Blocks.

4.1.4 Cell Misinsertion Rate

Cell Misinsertion Rate is defined as:

$$\frac{\text{Misinserted Cells}}{\text{Time Interval}}$$

A misinserted cell occurs when there is a cell entry event at a receiving entity without a corresponding cell exit event at its source. Severely Errored Cell Blocks shall be excluded from this calculation.

4.1.5 Cell Transfer Delay

Cell Transfer Delay (CTD) is the elapsed time between a cell exit event measured at the source and the corresponding cell entry event measured at the receiving entity.

A cell exit event occurs when the first bit of an ATM cell crosses the NI towards the network. A cell entry event occurs when the last bit of an ATM cell has completed transmission across the NI in the network−to−customer direction.

CTD is the sum of the inter−ATM node transmission delay (propagation delay) and the ATM node processing delay (queuing, switching, and routing delays).

4.1.5.1 Mean Cell Transfer Delay

Mean Cell Delay is the arithmetic average of a specified number of Cell Transfer Delays.

4.1.6 Cell Delay Variation

Cell Delay Variation (CDV) describes the variability in the pattern of actual cell arrival times and the expected (reference) pattern of the cell arrival times. CDV is sometimes referred to as "cell jitter".

4.2 ATM Quality of Service Classes

QoS classes are being defined by the industry and standards bodies to support various types of services transported over the ATM network. Because these QoS classes are still evolving, the information in this Section is subject to change. The QoS classes in this Section correlate to the classes described in ITU–T Recommendation I.356.

There are two general categories of QoS classes – Specified QoS and Unspecified QoS. The Specified QoS category includes several QoS classes, each of which has specific performance parameter values. The Specified QoS classes are defined such that each class supports a particular ITU Service Class. The following QoS classes are currently defined in the ATM Forum UNI Specification:

QoS Class 1	Stringent Class; used for Constant Bit Rate (e.g., Circuit Emulation, CBR Video, etc.)
QoS Class 2	Tolerant Class; used for Variable Bit Rate Audio and Video
QoS Class 3	Bi–level Class; used for Connection–Oriented Data Transfer (e.g., Frame Relay, etc.)
QoS Class U	Unspecified Bit Rate (e.g., "best effort")

The Unspecified QoS class, QoS Class U, has no explicit or implied performance objectives on either the CLP = 0 or the CLP = 1 cell flows.

4.2.1 BellSouth Performance

This section provides performance parameter objectives for the BellSouth–supported QoS classes. Again, it should be noted that these values are only objectives and are not negotiated. There are no performance guarantees associated with any BellSouth ATM–based service, and the performance objectives may be adjusted as experience with the ATM network warrants. Support of any particular QoS classes, or indeed any ATM–based service support, is dependent upon geographical availability.

The following Table 4 shows the current BellSouth Service Categories with the QoS class most closely associated with that Category and the expected performance objectives for intra−LATA service for that Category.

Table 4 − Performance Objectives

Service Categories	Equivalent QoS Class	CLR (max.).[1]	CDV [2]	CTD (max.) [3]
CBR	Class 1	$1 X 10^{-9}$	2 ms (DS3) 1 ms (STS−3c)	Connection Dependent
VBR−rt	Class 2	$1 X 10^{-7}$	Not Specified	Connection Dependent
VBR−nrt	Class 3	$1 X 10^{-7}$	Not Specified	Connection Dependent
UBR	Class U	Not Specified	Not Specified	Not Specified

Notes:

(1) Most BellSouth ATM switches are equipped with redundant switching processors for reliability. Either processor may be selected to be the active one, during which time the other would be in a standby mode. A normal operational procedure on some equipment is to periodically alternate the active and standby processors. During the associated switchover, a few ATM cells may be lost or duplicated. BellSouth does not include any cells lost during this routine switchover in the CLR objective calculation.

(2) The objective value shown is the maximum 2−point CDV parameter. The CDV objec tive applies to a quantile (percentile) of the total traffic between intraLATA UNI's on a connection. This objective is the upper bound on the difference between the upper and lower 10^{-8} quantiles of the CTD.

(3) While the CTD objective is dependent upon the connection and what equipment and facilities are used in that connection, it is anticipated that the maximum one−way CTD for a connection will not exceed 10 ms through the BellSouth network. This objective assumes that all facilities, both access and transport, are at DS3 or higher rates. It is expected that the CTD will increase as facility line rates decrease.

5. References

1.	ITU−T Rec. I.356	ITU−T Recommendation I.356, "B−ISDN ATM Layer Cell Transfer Performance", October, 1996. [1]
2.	ITU−T Rec. I.363	ITU−T Recommendation I.363, "Integrated Services Digital Network (ISDN) Overall Network Aspects and Functions − B−ISDN ATM Adaptation Layer (AAL) Specification", March, 1993. [1]
3.	ITU−T Rec. I.432	ITU−T Recommendation I.432, "B−ISDN User−Network Interface − Physical Layer Specification", Study Group XVIII, June, 1992.[1]
4.	TR 73587	BellSouth TR 73587, "Frame Relay Service Interface & Performance Specifications." [2]
5.	TR 73590	BellSouth TR 73590, "Broadband Exchange Line Service Interface & Performance Specifications." [2]
6.	ATM UNI Specifications	ATM Forum "ATM User−Network Interface Specification", Version 3.0, 3.1 and 4.0. [3]
7.	Circuit Emulation Service Interoperability	ATM Forum "Circuit Emulation Service Interoperability Specification", Version 2.0, af−vtoa−0078.000, January, 1997. [3]
8.	IISP Specification	ATM Forum "Interim Inter−switch Signaling Protocol (IISP) Specification", Version 1.0, af−pnni−0026.000, December, 1994. [3]
9.	DS3/ATM Physical Layer Interface Specification	ATM Forum "DS3/ATM Physical Layer Interface Specification", Version 4.0, af−phy−0054.000, January, 1996. [3]
10	622.08 Mbps Interface Specification	ATM Forum "622.08 Mbps Interface Specification", af−phy−0046.000, January, 1996.[3]
11	GR−1110−CORE	Telcordia GR−1110−CORE, "Broadband Switching System (BSS) Generic Requirements", Issue 3, December, 1999.[4]
12.	GR−253−CORE	Telcordia GR−253−CORE, "Synchronous Optical Network (SONET) Transport Systems: Common Generic Criteria", Issue 2, December, 1995. [4]
13.	GR−499−CORE	Telcordia GR−499−CORE, Issue 2, "Transport Systems Generic Requirements (TSGR): Common Requirements", December, 1998.[4]
14.	T1.107−1995	ANSI T1.107−1995, "Digital Hierarchy Formats Specifications ", July, 1995 [5]
15.	T1.646−1995	ANSI T1.646−1995, "Broadband ISDN − Physical Layer Specification for User−Network Interfaces" [5]
16.	FR−ATM Network Interworking	Frame Relay Forum "Frame Relay / ATM PVC Network Interworking Implementation Agreement", FRF.5, December, 1994. [6]

1. This document can be ordered from the International Telecommunication Union, General Secretariat, Sales Service, Place des Nations, CH−1211, Geneva 20, Switzerland.

2. This Technical Reference can be obtained from BellSouth Telecommunications, Inc., Documentation Operations, 20th Floor, 600 North 19th Street, Birmingham, AL, 35203.

3. This document can be ordered from the ATM Forum, Suite 304, 2570 West El Camino Real, Mountain View, CA, 94040−1313, Telephone 1−650−949−6700.

4. This document is available from Telcordia Technologies, Inc., 8 Corporate Place, PYA 3A−184 Piscataway, NJ, 08854−4156, Telephone 1−800−521−2673.

5. This document is available from the American National Standards Institute, Customer Services, 11 West 42nd Street, New York, NY, 10036, Telephone 1−212−302−1286.

6. This document can be ordered from the Frame Relay Forum, Suite 307, 39355 California Street, Fremont, CA, 94538−1447, Telephone 1−510−608−5920.

PLEASE HELP US

Please take a minute to provide us with feedback about this Technical Reference by completing the questions below. BellSouth is interested in receiving comments and suggestions to improve the quality of our publications. We will reply to your feedback individually, and appreciate your taking time to complete this form.

Technical Reference TR 73585 Issue E

Why did you order this document (please check appropriate box)?

General Reference __________

Product Development __________

Service Development __________

Other (please explain) ____

Did this document provide the technical information you needed? Yes _____ No _____

Was the information presented logically and clearly? Yes _____ No _____

How could this document be improved? ____

____

____

____

____

Your name: ____

Position: ____

Company: ____

Address: ____

____

____

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY MAIL

FIRST–CLASS MAIL PERMIT NO. 83 BIRMINGHAM, AL

Postage will be paid by addressee:

RESEARCH DIRECTOR – TRANSPORT
SYSTEMS ENGINEERING
BELLSOUTH TELECOMMUNICATIONS, INC.
1884 DATA DRIVE
BIRMINGHAM, AL. 35244

FOLD HERE