BBA
A.Nylund

Original Date: 16.3.2004

Nokia D500 DSLAM
Public Interface Specification

Interface Specification
For the D500 R. 3.2.x, R2.4 onwards
Updated: May 19, 2005

BBA
A.Nylund Original Date: 16.3.2004

Contents

BBA
A.Nylund Original Date: 16.3.2004

BBA
A.Nylund Original Date: 16.3.2004

1. PREFACE

The Nokia D500 DSLAM is an access system for ATM based and Ethernet based networks.

This document specifies the DSL physical layer interface based on:

• ANSI Standard T1.413 [1];
• ETSI Technical Specification TS 101 388 [2];
• ITU-T Recommendation G.992.1 [3];
• ITU-T Recommendation G.992.2 [4];
• ITU-T Recommendation G.992.3 [5];
• ITU-T Recommendation G.992.5 [7];
• ITU-T Recommendation G.994.1 [8];
• ITU-T Recommendation G.991.2 [6];
• ETSI Technical Specification TS 101 524 [10].
• ITU-T Recommendation G.993.1 [11];

Also annexes are added, describing:
• Annex A: ATM layer interface specification;
• Annex B: IP layer interface specification;
• Annex C: VoDSL interface specification.

This document provides the specification of the digital subscriber line interface. It refers to publicly available standards wherever possible. The XTU–C transmitter characteristics are described as they apply to the D500 central office and D500 remote access multiplexer (or RAM) equipment.
The xTU–R transmitter requirements are specified with respect to interoperability with the D500 xTU–C. xTU–R requirements that may affect interoperability of the D500l xTU–C are highlighted in this document.

1.1 Referenced Documents

The following documents are referenced:
[1] ANSI Standard T1.413-1998, “Network and Customer Installation Interfaces – Asymmetrical Digital Subscriber Line (ADSL) Metallic Interface”, publication by the ANSI.
[2] ETSI Technical Specification TS 101 388, “Access transmission systems on metallic access cables; Asymetric Digital Subscriber Line (ADSL) - Coexistence of ADSL and ISDN-BA on the same pair [ANSI T1.413-1998, modified]”, November 1998.
[3] ITU-T Recommendation G.992.1, *“Asymmetrical Digital Subscriber Line (ADSL) Transceivers”*, publication by the ITU-T, 1999.
[4] ITU-T Recommendation G.992.2, “*Splitterless Asymmetrical Digital Subscriber Line (ADSL) Transceivers*”, publication by the ITU-T, 1999.
[5] ITU-T Recommendation G.992.3, “Asymmetric digital subscriber line transceivers - 2 (ADSL2)”
[6] ITU-T Recommendation G.991.2, *“Single-Pair High Speed Digital Subscriber Line (SHDSL) Transceivers“*, publication by the ITU-T, 2001.
[7] ITU-T Recommendation G.992.5, “Asymmetrical Digital Subscriber Line (ADSL) transceivers - Extended bandwidth ADSL2 (ADSL2+)”
[8] ITU-T Recommendation G.994.1, “*Handshake Procedures for Asymmetrical Digital Subscriber Line (ADSL) Transceivers*”, publication by the ITU-T 05/2003.
[10] ETSI Technical Specification TS 101 524, “*Symmetric single pair high bit rate digital subscriber line (SDSL) transmission system on metallic local lines*”, version 1.1.2, August 2001.
[11] ITU-T Recommendation G.993.1, “*Very high speed digital subscriber line foundation*”

BBA
A.Nylund Original Date: 16.3.2004

2. OVERVIEW

The D500 implements transport methods for delivery of broadband services on ordinary subscriber loops. It uses the latest techniques to allow high–speed digital communications between the D500 and a DSL modem at the customer's premises (residential, SOHO or business). Both asymmetric (ADSL) and symmetric (SHDSL) interfaces are available.
Figure 1 and Figure 2 show the general ADSL architectures and their interfaces (depending on the usage of a SPLITTER or micro filter at subscriber premises). The following main building blocks can be distinguished:

• D500 with ADSL interface and splitters at the network side.
• ADSL Customer Premises Equipment (CPE) at the subscriber side with splitter or microfilters.

In the case of Figure 1, a POTS or ISDN splitter is located at the entrance of the customer premises. A splitter is used for operation of ADSL above POTS and a ISDN splitter (universal splitter) is used for operation of ADSL above ISDN or POTS.

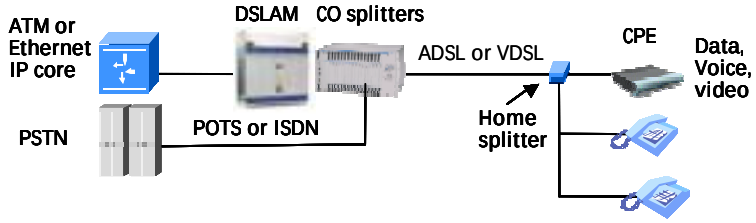

Figure 1 ADSL access with ISDN or POTS splitters at CO and CPE side

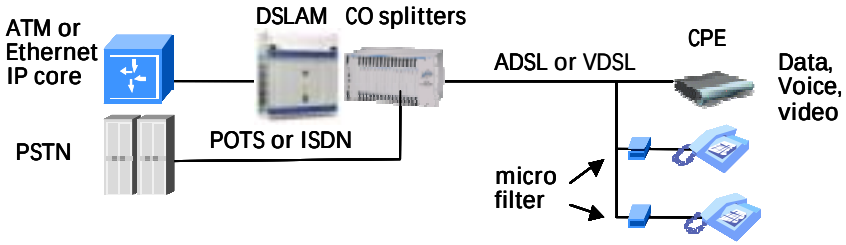

Figure 2 ADSL access with ISDN or POTS micro filters at CO side and splitters at subscriber side

In the case of Figure 2, no SPLITTER is used at the entrance of the subscriber premises. Micro filters (Low Pass Filters (LPF)) are used to protect phone sets (or other voice band appliances) from interfering with the ADSL signal. Depending on the phone set characteristics, the absence of such LPF may have a severe impact on ADSL performance and/or the voice connection may be severely disturbed by the ADSL signal.

The Figure 3 shows the general SHDSL architectures and interfaces. The following main building blocks can be distinguished:
• D500 with SHDSL interface at the network side.
• SHDSL Customer Premises Equipment (CPE) at the subscriber side.

BBA
A.Nylund Original Date: 16.3.2004

Figure 3 SHDSL access, mainly used business customers and G2, G3 base station access

The connection mey run in two wire mode or in four-wire (two-pair) mode to increase BW or reach or both. In the case of Figure 3, the SHDSL CPE may provide data, voice and/or video conferencing services. Alternatively, more business oriented interfaces may be provided, e.g., PABX interconnect, FR interworking.

3. DSL INTERFACE CHARACTERISTICS

3.1 ADSL frequency spectrum usage

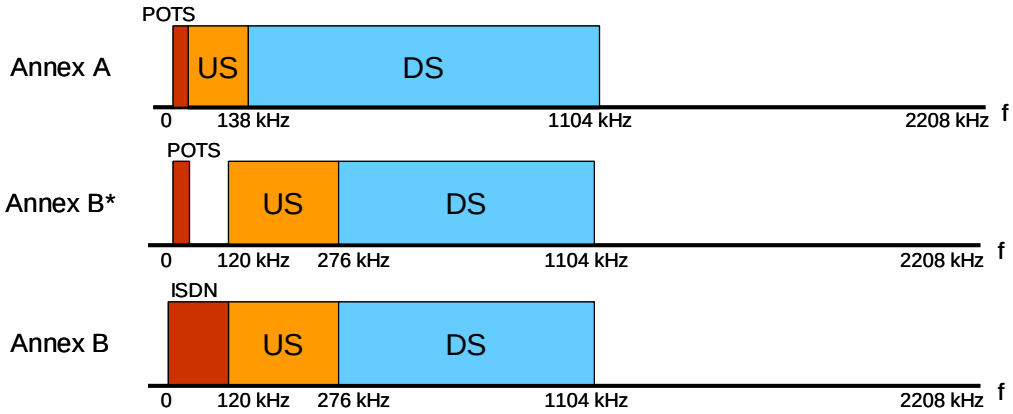

Figure 4 ADSL over POTS and over ISDN line spectrum. Annex B* means ADSL in ISDN mode over POTS

The Digital Subscriber Line (DSL) interface carries the normal Plain Old Telephone Service (POTS) frequencies multiplexed with the upstream and downstream ADSL signals. The interface connects the ATU–R (in the CPE) to the ATU-C in D500 via the standard subscriber cooper loop.

The upstream and downstream signals are DMT modulated. A view of spectrum usage with different modes of DMT ADSL is shown in Figures 4 to 6. It is not recommended to use different ADSL modes, where up- and down-stream spectra of the different modes overlap each other, withing the same subscriber cable.

BBA
A.Nylund Original Date: 16.3.2004

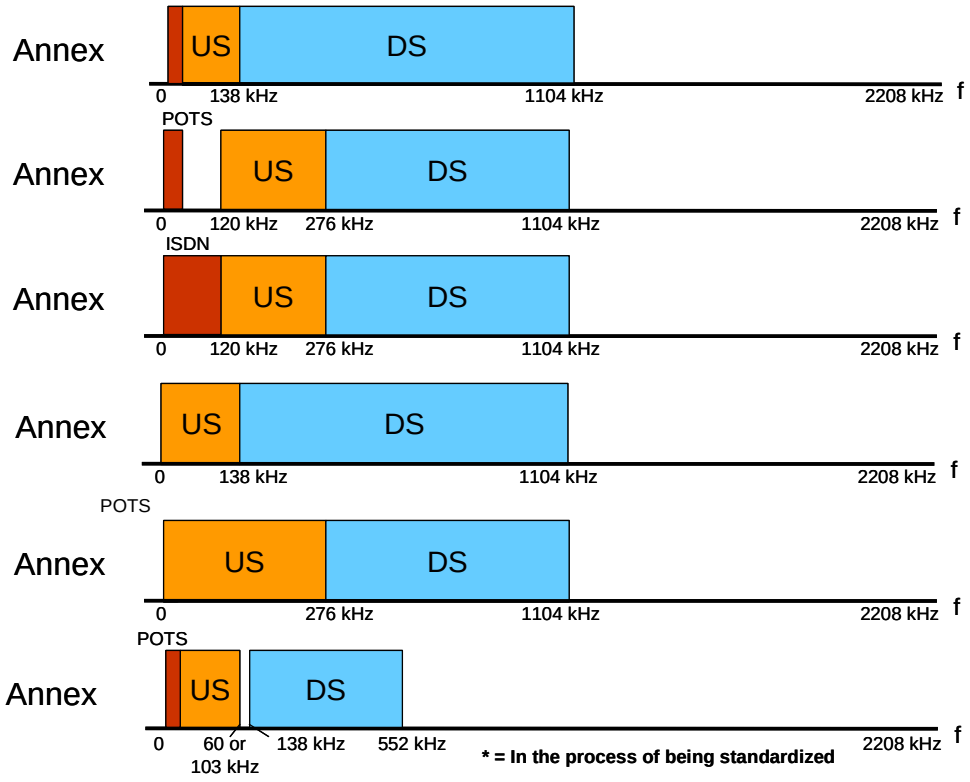

Figure 5 ADSL2 over POTS and ISDN line spectrum. Annexes I and J not yet supported

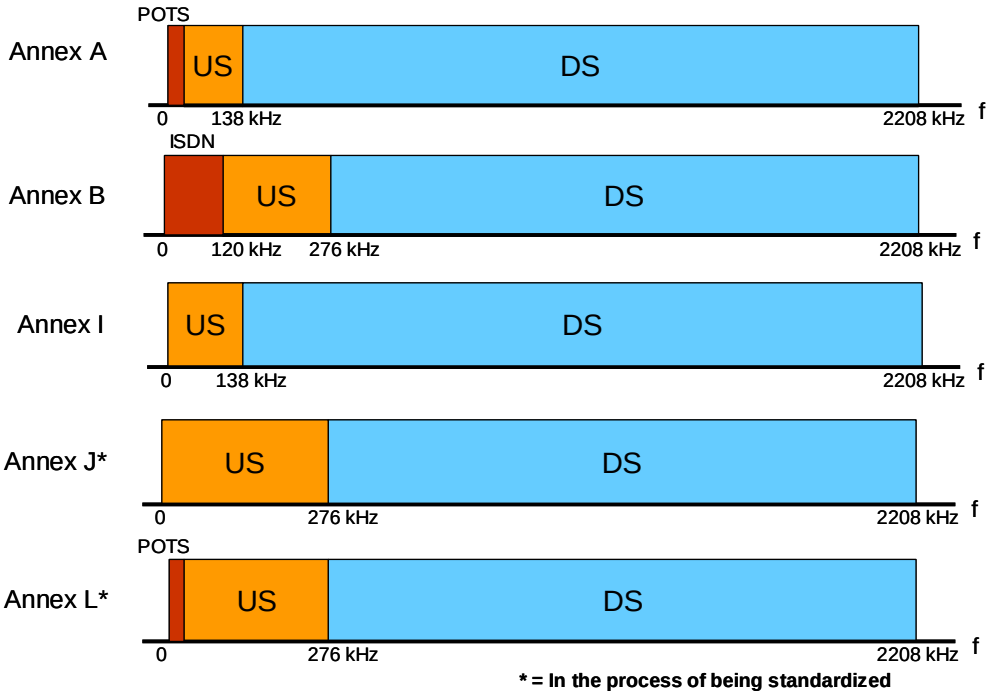

Figure 6 ADSL2+ line spectrum in ISDN and POTS modes . Annexes I and J not yet supported.

BBA
A.Nylund Original Date: 16.3.2004

3.2 VDSL frequency spectrum usage

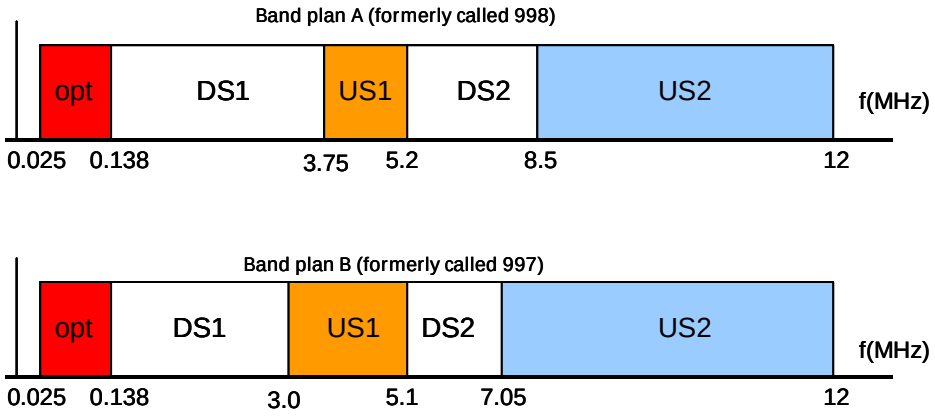

Figure 7 VDSL. Frequency plans A (998) and B (997)

The optionl band is not supported and the Digital Subscriber Line (DSL) interface can carry the normal Plain Old Telephone Service (POTS) frequencies or ISDN frequencies multiplexed with the upstream and downstream VDSL signals. The interface connects the ATU–R (in the CPE) to the ATU-C in D500 via the standard subscriber cooper loop.

The upstream and downstream signals are DMT modulated. A view of spectrum usage with different frequency plans of DMT VDSL is shown in Figures 7. The current unit supports 2 or 3 band operation with band plans A and B. It is not recommended to use different VDSL frequency plans withing the same subscriber cable, because crosstalk between overlapping up- and downstream bands will deteriorate connection performance.

3.3 SHDSL frequency spectrum usage

The Digital Subscriber Line (DSL) interface carries the upstream and downstream SHDSL signals. The downstream and upstream signals use the same frequency band. The frequency bandwidth depends on the data rate provided. Typically, the (3 dB down) bandwidth is the data rate devided by 6 (e.g., 384 kHz at 2.304 Mbit/s). The interface connects the STU–R (in the CPE) to the STU-C (in the DSLAM) via the copper access network. Normal subscriber line wire is used for the connection.
The upstream and downstream signals are 16-TCPAM modulated. A view of the PAM power spectrum density (PSD) used in the SHDSL modem is shown in Figure 6. It shows how the bandwidth used by the SHDSL signal scales with the data rate.

BBA
A.Nylund Original Date: 16.3.2004

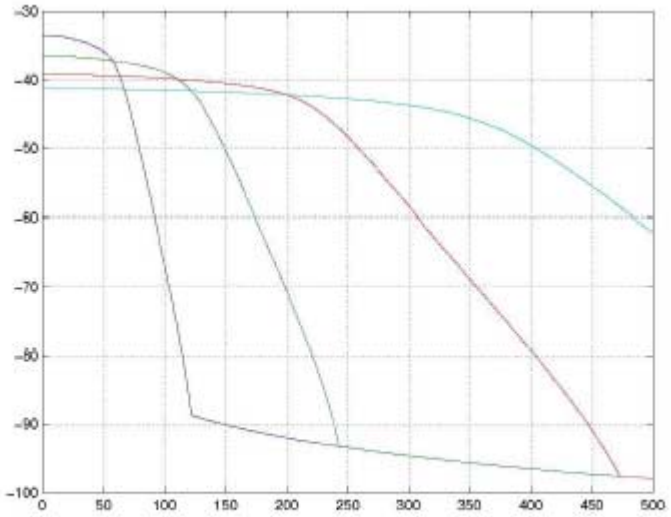

Figure 6 – SHDSL Spectrum for data rates 384, 768, 1536 and 2304 kbit/s.

3.4 DSL Interfaces available at D500

Nokia D500 supports the following ADSL line cards:
• ADSL above POTS per ITU-T Rec. G.992.1 Annex A [3];
• ADSL above POTS per ITU-T Rec. G.992.2 Annex A/B [4];
• ADSL in TCM noise enviroment per ITU-T Rec. G.992.2 Annex C [4].
• ADSL above POTS per ANSI Standard T1.413 [1];
• ADSL above ISDN per ITU-T Rec. G.992.1 Annex B [3];
• ADSL above ISDN per ETSI Technical Spec. TS 101 388 [2].
• ADSL2 above POTS per ITU-T Rec. G.992.3 Annex A [5]
• ADSL2 above ISDN per ITU-T Rec. G.992.3 Annex B [5]
• ADSL2+ above POTS per ITU-T Rec. G.992.5 Annex A [7]
• ADSL2+ above ISDN per ITU-T Rec. G.992.5 Annex B [7]

Nokia D500 supports the following SHDSL operating modes:
• SHDSL for North America per ITU-T Rec. G.991.2 Annex A [6].
• SHDSL for Europe per ITU-T Rec. G.991.2 Annex B [6].
• SHDSL ITU-T Rec. G.991.2, E9.2 four wire mode [6].

Nokia D500 supports the following VDSL line card
• VDSL above POTS or ISDN: G.993.1

The ATU-C characteristics and the ATU-R requirements to interoperate with the ATU-C are described in separate sections for each of these operating modes.

4. ADSL ABOVE POTS: G.992.1 ANNEX A

The ITU-T Recommendation G.992.1 is also known as G.dmt.
The ATU-C startup procedure supports both the G.994.1 Handshake Procedures [5] and the T1.413-1998 Initialization Procedure [1].

BBA
A.Nylund Original Date: 16.3.2004

In case the ATU-R alternates [5] and [1] according to G.994.1 Annex A, the ATU-C gives priority to G.994.1 Handshake Procedures and a subsequent G.992.x operating mode.
In case both the ATU-C and the ATU-R support the G.992.1 and G.992.2 operating modes, the ATU-C (when selecting the operating mode) gives priority to the G.992.1 operating mode.

4.1 General

The U-C interface is compliant with G.992.1 Annex A [3] (including G.994.1 [5]), unless explicitly stated in this section.
The U-R interface shall be compliant with G.992.1 Annex A [3] (including G.994.1 [5]).
The U–C interface is an ATM cell–based interface. The ATU–C is configured for ATM transport and complies with sections 5.1.2, 6.2, and 7.2 of G.992.1 [3].
The U–R interface shall be an ATM cell–based interface. The ATU–R shall be configured for ATM transport and shall comply with sections 5.2.2, 6.2, and 8.2 of G.992.1 [3].

4.2 Transport capacity

The transport capacity of the ATU–C complies with section 6.2 of G.992.1 [3]. It supports downstream transmission at all multiples of 32 kb/s up to a net data rate of 8128 kb/s, and upstream reception at all multiples of 32 kb/s up to a net data rate of 1024kb/s upstream.
The maximum downstream transport capacity of the ATU–C implementation is 10816 kb/s (total data rate). The actual downstream transport capacity depends upon the line characteristics measured at modem initialization and the implementation limitations of the ATU-R. The ADSL system overhead depends on the modem configuration and can be as low as 32 kb/s.

4.3 Framing Modes

ATU-C supports interleaved and fast path modes (framing modes 1 and 3). Dual latency mode is not supported.

4.4 Network Timing Reference

The NTR bit in C-MSG1 is always coded “0”. The downstream indicator bits 23–20 are always coded “1111”.

5. ADSL ABOVE POTS: G.992.2 ANNEX A/B

The ITU-T Recommendation G.992.2 is also known as G.lite.
The ATU-C startup procedure supports both the G.994.1 Handshake Procedures [5] and the T1.413-1998 Initialization Procedure [1].
In case the ATU-R alternates [5] and [1] according to G.994.1 Annex A, the ATU-C gives priority to G.994.1 Handshake Procedures and a subsequent G.992.x operating mode.
In case both the ATU-C and the ATU-R support the G.992.1 and G.992.2 operating modes, the ATU-C (when selecting the operating mode) gives priority to the G.992.1 operating mode.

5.1 General

The U-C interface is compliant with G.992.2 Annex A/B [4] (including G.994.1 [5]).
The U-R interface shall be compliant with G.992.2 Annex A/B [4] (including G.994.1 [5]).

5.2 Transport capacity

The transport capacity of the ATU–C complies with section 5 of G.992.2 [4]. It supports downstream transmission at all multiples of 32 kb/s up to a net data rate of 1.536 Mb/s, and upstream reception at all multiples of 32 kb/s up to a net data rate of 512 kb/s upstream.

BBA
A.Nylund Original Date: 16.3.2004

5.3 Network Timing Reference

The NTR bit in C-MSG1 is always coded “0”. The downstream indicator bits 23–20 are always coded “1111”.

6. ADSL ABOVE POTS: T1.413

The ANSI Standard T1.413-1998 is also known as T1.413 Issue 2.
The ATU-C startup procedure supports both the G.994.1 Handshake Procedures [5] and the T1.413-1998 Initialization Procedure [1].
In case the ATU-R alternates [5] and [1] according to G.994.1 Annex A, the ATU-C gives priority to G.994.1 Handshake Procedures and a subsequent G.992.x operating mode.
In case both the ATU-C and the ATU-R support the G.992.1 and G.992.2 operating modes, the ATU-C (when selecting the operating mode) gives priority to the G.992.1 operating mode.

6.1 General

The U-C interface is compliant with T1.413 [1], unless explicitly stated in this section.
The U-R interface shall be compliant with T1.413 [1].
The U–C interface is an ATM cell–based interface. The ATU–C is configured for ATM transport and complies with sections 4.2.2, 5.2, and 6.2 of T1.413 [1].
The U–R interface shall be an ATM cell–based interface. The ATU–R shall be configured for ATM transport and shall comply with sections 4.3.2, 5.2, and 7.2 of T1.413 [1].

6.2 Transport capacity

The transport capacity of the ATU–C complies with section 5.2 of T1.413 [1]. It supports downstream transmission at all multiples of 32 kb/s up to a net data rate of 8128 kb/s, and upstream reception at all multiples of 32 kb/s up to a net data rate of 1024 kb/s upstream.

The maximum downstream transport capacity of the ATU–C implementation is 10816 kb/s (total data rate). The actual downstream transport capacity depends upon the line characteristics measured at modem initialization and the implementation limitations of the ATU-R. The ADSL system overhead depends on the modem configuration and can be as low as 32 kb/s.

6.3 Framing Modes

ATU-C supports interleaved and fast path modes (framing modes 1 and 3). Dual latency mode is not supported.

6.4 Network Timing Reference

The NTR bit in C-MSG1 is always coded “0”. The downstream indicator bits 23–20 are always coded “1111”.

7. ADSL ABOVE ISDN: G.992.1 ANNEX B

The ITU-T Recommendation G.992.1 is also known as G.dmt.
The ATU-C startup procedure supports both the G.994.1 Handshake Procedures [5] and the TS 101 388 Initialization Procedure [2].
In case the ATU-R alternates [5] and [2] according to G.994.1 Annex A, the ATU-C gives priority to G.994.1 Handshake Procedures and a subsequent G.992.x operating mode.

BBA
A.Nylund Original Date: 16.3.2004

7.1 General

The U-C interface is compliant with G.992.1 Annex B [3] (including G.994.1 [5]), unless explicitly stated in this section.
The U-R interface shall be compliant with G.992.1 Annex B [3] (including G.994.1 [5]).
The U–C interface is an ATM cell–based interface. The ATU–C is configured for ATM transport and complies with sections 5.1.2, 6.2, and 7.2 of G.992.1 [3].
The U–R interface shall be an ATM cell–based interface. The ATU–R shall be configured for ATM transport and shall comply with sections 5.2.2, 6.2, and 8.2 of G.992.1 [3].

7.2 Transport capacity

The transport capacity of the ATU–C complies with section 6.2 of G.992.1 [3]. It supports downstream transmission at all multiples of 32 kb/s up to a net data rate of 8128 kb/s, and upstream reception at all multiples of 32 kb/s up to a net data rate of 1024 kb/s upstream.
.
The maximum downstream transport capacity of the ATU–C implementation is 10816 kb/s (total data rate). The actual downstream transport capacity depends upon the line characteristics measured at modem initialization and the implementation limitations of the ATU-R. The ADSL system overhead depends on the modem configuration and can be as low as 32 kb/s.

7.3 Framing Modes

ATU-C supports interleaved and fast path modes (framing modes 1 and 3). Dual latency mode is not supported.

7.4 Network Timing Reference

The NTR bit in C-MSG1 is always coded “0”. The downstream indicator bits 23–20 are always coded “1111”.

8. ADSL ABOVE ISDN: TS 101 388

The TS 101 388 Technical Specification is an adaptation of the ANSI ADSL over POTS Standard T1.413-1998 [1] for the transport of ADSL over ISDN.
The ATU-C startup procedure supports both the G.994.1 Handshake Procedures [5] and the T1.413-1998 Initialization Procedure [1].
In case the ATU-R alternates [5] and [1] according to G.994.1 Annex A, the ATU-C gives priority to G.994.1 Handshake Procedures and a subsequent G.992.x operating mode.

8.1 General

The U-C interface is compliant with TS 101 388 [2], unless explicitly stated in this section.
The U-R interface shall be compliant with TS 101 388 [2].
The U–C interface is an ATM cell–based interface. The ATU–C is configured for ATM transport and complies with TS 101 388 [2], which references sections 4.2.2, 5.2, and 6.2 of T1.413 [1].
The U–R interface shall be an ATM cell–based interface. The ATU–R shall be configured for ATM transport and shall comply with TS 101 388 [2], which references sections 4.3.2, 5.2, and 7.2 of T1.413 [1].

8.2 Transport capacity

The transport capacity of the ATU–C complies with TS 101 388 [2], which references section 5.2 of T1.413 [1]. It supports downstream transmission at all multiples of 32 kb/s up to a net data rate of 8128 kb/s, and upstream reception at all multiples of 32 kb/s up to a net data rate of 1024 kb/s upstream.

BBA
A.Nylund Original Date: 16.3.2004

The maximum downstream transport capacity of the ATU–C implementation is 10816 kb/s (total data rate). The actual downstream transport capacity depends upon the line characteristics measured at modem initialization and the implementation limitations of the ATU-R. The ADSL system overhead depends on the modem configuration and can be as low as 32 kb/s.

8.3 Framing Modes

ATU-C supports interleaved and fast path modes (framing modes 1 and 3). Dual latency mode is not supported.

8.4 Network Timing Reference

The NTR bit in C-MSG1 is always coded “0”. The downstream indicator bits 23–20 are always coded “1111”.

9. ADSL2 ABOVE POTS: G.992.3 ANNEX A

The ITU-T Recommendation G.992.3 is also known as ADSL2
The ATU-C startup procedure supports both the G.994.1 Handshake Procedures [8] and the T1.413-1998 Initialization Procedure [1].
In case the ATU-R alternates [8] and [1] according to G.994.1 Annex A, the ATU-C gives priority to G.994.1 Handshake Procedures and a subsequent G.992.x operating mode.

9.1 General

The U-C interface is compliant with G.992.3 Annex A [5] (including G.994.1 [8]), unless explicitly stated in this section.
The U-R interface shall be compliant with G.992.3 Annex A [5] (including G.994.1 [8]).
The U–C interface is an ATM cell–based interface. The ATU–C is configured for ATM transport and complies with Annex K.2 of G.992.3 [5].
The U–R interface shall be an ATM cell–based interface. The ATU–R shall be configured for ATM transport and shall comply with annex K.2 of G.992.3 [5].

9.2 Transport capacity

The transport capacity of the ATU–C complies with section K.2.5 of G.992.3 [5]. It supports downstream transmission at all multiples of 32 kb/s up to a net data rate of 12 Mb/s, and upstream reception at all multiples of 32 kb/s up to a net data rate of 1024 kb/s upstream.

The maximum downstream transport capacity of the ATU–C implementation is 12Mb/s (total data rate). The actual downstream transport capacity depends upon the line characteristics measured at modem initialization and the implementation limitations of the ATU-R. The ADSL system overhead depends on the modem configuration and can be as low as 32 kb/s.

9.3 Framing Modes

ATU-C supports interleaved and fast path modes.

9.4 Network Timing Reference

The ATU-C inserts the Network Timing Reference in the ADSL frame, as specified in G.992.3 [5]. The ATU-R may recover the Network Timing Reference from that information.

BBA
A.Nylund Original Date: 16.3.2004

9.5 Data on pilot subcarrier 64

The ITU-T Recommendation G.992.3 specifies that no data shall be carried on the downstream pilot subcarrier 64. However, the ATU-C may indicate in the G.994.1 non-standard information field (NSIF) that it supports modulation of data on the downstream pilot subcarrier 64. If the ATU-R indicates the same, then data modulation on the downstream pilot subcarrier 64 is enabled. The G.994.1 NSIF syntax is defined in Annex A.

10. ADSL2 ABOVE ISDN: G.992.3 ANNEX B

The ITU-T Recommendation G.992.3 is also known as ADSL2.
The ATU-C startup procedure supports both the G.994.1 Handshake Procedures [8] and the TS 101 388 Initialization Procedure [2].
In case the ATU-R alternates [8] and [2] according to G.994.1 Annex A, the ATU-C gives priority to G.994.1 Handshake Procedures and a subsequent G.992.x operating mode.

10.1 General

The U-C interface is compliant with G.992.3 Annex B [5] (including G.994.1 [8]), unless explicitly stated in this section.
The U-R interface shall be compliant with G.992.3 Annex B [5] (including G.994.1 [8]).
The U–C interface is an ATM cell–based interface. The ATU–C is configured for ATM transport and complies with K.2 of G.992.3 [5].
The U–R interface shall be an ATM cell–based interface. The ATU–R shall be configured for ATM transport and shall comply with annex K.2 of G.992.3 [5].

10.2 Transport capacity

The transport capacity of the ATU–C complies with section K.2.5 of G.992.3 [5]. It supports downstream transmission at all multiples of 32 kb/s up to a net data rate of 12 Mb/s, and upstream reception at all multiples of 32 kb/s up to a net data rate of 1024 kb/s upstream.

The maximum downstream transport capacity of the ATU–C implementation is 12Mb/s (total data rate). The actual downstream transport capacity depends upon the line characteristics measured at modem initialization and the implementation limitations of the ATU-R. The ADSL system overhead depends on the modem configuration and can be as low as 32 kb/s.

10.3 Framing Modes

ATU-C supports interleaved and fast framing modes.

10.4 Network Timing Reference

The ATU-C inserts the Network Timing Reference in the ADSL frame, as specified in G.992.3 [5]. The ATU-R may recover the Network Timing Reference from that information.

11. ADSL2+ ABOVE POTS: G.992.5 ANNEX A

The ITU-T Recommendation G.992.5 is also known as ADSL2+
The ATU-C startup procedure supports both the G.994.1 Handshake Procedures [8] and the T1.413-1998 Initialization Procedure [1].
In case the ATU-R alternates [8] and [1] according to G.994.1 Annex A, the ATU-C gives priority to G.994.1 Handshake Procedures and a subsequent G.992.x operating mode.

BBA
A.Nylund Original Date: 16.3.2004

11.1 General

The U-C interface is compliant with G.992.5 Annex A [7] (including G.994.1 [8]), unless explicitly stated in this section.
The U-R interface shall be compliant with G.992.5 Annex A [7] (including G.994.1 [8]).
The U–C interface is an ATM cell–based interface. The ATU–C is configured for ATM transport and complies with annex K.2 of G.992.3 [5].
The U–R interface shall be an ATM cell–based interface. The ATU–R shall be configured for ATM transport and shall comply with annex K.2 of G.992.3 [5].

11.2 Transport capacity

The transport capacity of the ATU–C complies with section K.2.5 of G.992.3 [5]. It supports downstream transmission at all multiples of 32 kb/s up to a net data rate of 24 Mb/s, and upstream reception at all multiples of 32 kb/s up to a net data rate of 1024 kb/s upstream.

The maximum downstream transport capacity of the ATU–C implementation is 24 Mb/s (total data rate). The actual downstream transport capacity depends upon the line characteristics measured at modem initialization and the implementation limitations of the ATU-R. The ADSL system overhead depends on the modem configuration and can be as low as 32 kb/s.

11.3 Framing Modes

ATU-C supports interleaved and fast framing modes.

11.4 Network Timing Reference

The ATU-C inserts the Network Timing Reference in the ADSL frame, as specified in G.992.5 [7]. The ATU-R may recover the Network Timing Reference from that information.

11.5 Data on pilot subcarrier 64

The ITU-T Recommendation G.992.5 specifies that no data shall be carried on the downstream pilot subcarrier 64. However, the ATU-C may indicate in the G.994.1 non-standard information field (NSIF) that it supports modulation of data on the downstream pilot subcarrier 64. If the ATU-R indicates the same, then data modulation on the downstream pilot subcarrier 64 is enabled. The G.994.1 NSIF syntax is defined in Annex A.

12. ADSL2+ ABOVE ISDN: G.992.5 ANNEX B

The ITU-T Recommendation G.992.5 is also known as ADSL2+
The ATU-C startup procedure supports both the G.994.1 Handshake Procedures [8] and the T1.413-1998 Initialization Procedure [1].
In case the ATU-R alternates [8] and [1] according to G.994.1 Annex B, the ATU-C gives priority to G.994.1 Handshake Procedures and a subsequent G.992.x operating mode.

12.1 General

The U-C interface is compliant with G.992.5 Annex B [7] (including G.994.1 [8]), unless explicitly stated in this section.
The U-R interface shall be compliant with G.992.5 Annex B [7] (including G.994.1 [8]).
The U–C interface is an ATM cell–based interface. The ATU–C is configured for ATM transport and complies with annex K.2 of G.992.3.

BBA
A.Nylund Original Date: 16.3.2004

The U–R interface shall be an ATM cell–based interface. The ATU–R shall be configured for ATM transport and shall comply with annex K.2 of G.992.3 [5].

12.2 Transport capacity

The transport capacity of the ATU–C complies with section K.2.5 of G.992.3]. It supports downstream transmission at all multiples of 32 kb/s up to a net data rate of 24 Mb/s, and upstream reception at all multiples of 32 kb/s up to a net data rate of 1024 kb/s upstream.

The maximum downstream transport capacity of the ATU–C implementation is 24 Mb/s (total data rate). The actual downstream transport capacity depends upon the line characteristics measured at modem initialization and the implementation limitations of the ATU-R. The ADSL system overhead depends on the modem configuration and can be as low as 32 kb/s.

12.3 Framing Modes

ATU-C supports interleaved and fast framing modes.

12.4 Network Timing Reference

The ATU-C inserts the Network Timing Reference in the ADSL frame, as specified in G.992.5 [7]. The ATU-R may recover the Network Timing Reference from that information.

13. VDSL ABOVE POTS OR ISDN: G.993.1

The ITU-T Recommendation G.993.1 is also known as VDSL fundation document.
The ATU-C startup procedure supports both the G.994.1 Handshake Procedures [8]

13.1 General

The U-C interface is compliant with G.993.1 Annex A [7] (including G.994.1 [8]), unless explicitly stated in this section.
The U-R interface shall be compliant with G.993.1 Annex A [7] (including G.994.1 [8]).
The U–C interface is an ATM cell–based interface.
Both the asymmetric frequency plan A (previously known as 998) and symmetric frequency plan B (previously known as 997) are supported.

13.2 Transport capacity

The minimum and maximum transport capacities of ATU–C and ATU-R are listed in the table below. The bit rate can be incremented from min to max value in steps of 64 kb/s.

Band plan		B (997)	B (997)	A (998)	A (998)
		2 band	3 band	2 band	3 band
Upstream direction	min	64	64	64	64
	max	10048	25024	3008	10048
Downstream direction	min	64	64	64	64
	max	10048	25024	22016	45056

BBA
A.Nylund Original Date: 16.3.2004

13.3 Framing Modes

ATU-C supports interleaved and fast framing modes.

13.4 Pilot tone

Use of dedicated pilot tone is optional. If the VTU-R requires a dedicated pilot tone it indicates its choice of pilot tone to the VTU-C during initialization.

14. SHDSL: G.991.2 ANNEX A

14.1 General

The U-C interface is compliant with G.991.2 Annex A [6], unless explicitly stated in this section. The G.991.2 Annex A operating mode is activated through the G.994.1 Handshake Procedure [5].
The U-R interface shall be compliant with G.991.2 Annex A [6].
The U–C interface is an ATM cell–based interface. The STU–C is configured for ATM transport and complies with section E.9 of G.991.2 [6].
The U–R interface shall be an ATM cell–based interface. The STU–R shall be configured for ATM transport and shall comply with section E.9 of G.991.2 [6].

14.2 Transport capacity

The transport capacity of the STU–C complies with section 5 of G.991.2 [6]. It supports symmetric data rates at all multiples of 64 kbit/s, from 192 kbit/s up to a net data rate of 2.304 Mbit/s. In four-wire mode, data rates at multiples of 128 kb/s from 384 kbit/s to 4.608 Mbit/s are supported. The data rate may be fixed or limited to within a range of data rates through the Central Office MIB.

14.3 Network Timing Reference

NTR will be supported.

15. SHDSL: G.991.2 ANNEX B

Operation according to G.992.1 Annex B [6] is identical to operation according to ETSI SDSL TS 101 524 [7]. Both operating modes are activated in exactly the same way through G.994.1 Handshake Procedures [5]. Therefore, the STU-R cannot distinguish the two operating modes. The STU-R interface requirements are identical for both operating modes and desceibed from G.992.1 Annex B perspective below.

15.1 General

The U-C interface is compliant with G.991.2 Annex B [6], unless explicitly stated in this section. The G.991.2 Annex B operating mode is activated through the G.994.1 Handshake Procedure [5].
The U-R interface shall be compliant with G.991.2 Annex B [6].
The U–C interface is an ATM cell–based interface. The STU–C is configured for ATM transport and complies with section E.9 of G.991.2 [6].
The U–R interface shall be an ATM cell–based interface. The STU–R shall be configured for ATM transport and shall comply with section E.9 of G.991.2 [6].

15.2 Transport capacity

The transport capacity of the STU–C complies with section 5 of G.991.2 [6]. It supports symmetric data rates at all multiples of 64 kbit/s, from 192 kbit/s up to a net data rate of 2.304 Mbit/s. In four-wore mode, data rates at

BBA
A.Nylund Original Date: 16.3.2004

multiples of 128 kb/s from 384 kbit/s to 4.608 Mbit/s are supported. The data rate may be fixed or limited to within a range of data rates through the Central Office MIB.
The STU-C is also planned to support the symmetric data rate of 2.312 Mbit/s for transport of the 2048 kbit/s E1 service over AAL1 ATM. When configured in this mode, the STU-C advertises a single data rate in the G.994.1 handshake [5], indicating ATM mode with n=36 and i=1. This mode is not supported in four-wire operation.

The transport capacity of the STU–R shall comply with section 5 of G.991.2 [6]. It shall support one or more symmetric data rates at multiples of 64 kbit/s, from 192 kbit/s up to a net data rate of 2.312 Mbit/s.

15.3 Network Timing Reference

NTR is not supported.

Annex A: G.994.1 non-standard facilities

A.1 Vendor information
The ATU-C uses the following parameters in G.994.1:
COUNTRY CODE USA “181”
VENDOR CODE Texas Instruments “TSTC”

The vendor specific information is coded according to the NPAR/SPAR tree structure as defined in G.994.1 [4] for the Standard Information Field, with codepoints defined below.

A.2 Non-standard facilities

A.2.1 Data on pilot subcarrier 64

If the DPM codepoint is set in the CL message, the ATU-C supports modulation of data on the downstream pilot subcarrier 64 (transmitter function). Otherwise, the ATU-C does not.
The ATU-R may set the DPM codepoint in the CLR message to indicate it supports modulation of data on the downstream pilot subcarrier 64 (receiver function).
The DPM codepoint shall be set in the MS message if and only if it is set in both the CL and CLR message. If the DPM codepoint is set in the MS message, the ATU-R may request a bi>0 for downstream subcarrier 64 (during initialization or through bit swap). In that case, the ATU-C transmits subcarrier 64 as a data subcarrier.

Annex B: ATM Layer Interoperability

This annex is published to provide a technical description of the ATM layer of the user network interface. It is intended as a guideline for third–party ATM systems to successfully interoperate with D500.
For describing the ATM interoperability, the ATM reference model is used to specify the various aspects. It is assumed the reader is familiar with this model and its terminology.
All features are supported in both upstream and downstream directions unless otherwise stated.

B.1 Referenced Documents

BBA
A.Nylund Original Date: 16.3.2004

[ITU–T-I.361] ITU-T Recommendation I.361 ISDN Overall Network Aspects and Functions (11/95). B–ISDN ATM Layer Specification.
[ITU–T-I.371] ITU-T Recommendation I.371 ISDN Traffic Control and Congestion Control (08/96). B–ISDN ATM Layer Specification.
[ITU–T–I.432] ITU-T Recommendation I.432.1 - B–ISDN User-Network Interface - Physical Layer Specification: General Characteristics, August 1996.
[ITU–T–I.610] ITU-T Recommendation I.610 - B–ISDN Operation and Maintenance Principles and Functions (11/95).
[ATMF-3.1] ATM Forum AF–UNI–0010.002 - ATM User-Network Interface Specification V3.1.
[ATMF-Traffic] ATM Forum AF–TM–0056.000 - Traffic Management Specification Version 4.0.
The base documents for ATM layer specifications are [ITU–T-I.731], [ITU–T-I.732], [ITU-T-I.361] and [ATMF-3.1].

B.2 PMD & TC Layers

The functions listed below are typically Physical Medium Dependent and Transmission Convergence Sublayer functions:

- Cell Stream mapping/demapping
- Cell Delineation
- Payload Scrambling
- HEC Processing
- Cell Rate Decoupling

These functions interact directly with the underlying ADSL layer, which is almost independent of the processing of ATM cells. Therefore, this specific interoperability information is described in the documents referenced in the ADSL interface description.

B.3 ATM Cell Header Format

Cell Format

The ATM cell format is compliant with Recommendation [ITU-T-I.361].

This implies the cell structure complies with the generic ATM cell structure as defined in [ITU-T-I.361] Clause 2.1: Cell Structure.

The cell header coding scheme is of type ITU public **UNI** and complies to [ITU-T-I.361] Clause 2.2: Cell header format and encoding at UNI.

GFC Field

The GFC field coding is compliant with [ITU-T-I.361] Clause 2.2.2: Generic Flow Control field. Currently it is assumed that most CPE equipment connected to the D500 acts as "uncontrolled equipment". According to [ITU-T-I.361] this implies:

- downstream: cells sourced by the D500 will have their GFC bits set to 0;
- no action shall be taken by D500 on GFC field settings of received cells, moreover, non-zero GFC bits shall be forced to zero for cells "in transit".

Routing field (VPI & VCI field)

BBA
A.Nylund Original Date: 16.3.2004

The 24 bit routing field consists of 8 bits VPI and 16 bits VCI, which is compliant with [ITU-T-I.361] UNI format. 29 / 34

For PVC's VPI values can range from 0 to 255 and VCI values from 32 to 65535. The actual number of bits in the VPI and VCI fields used for routing, are configured compliant with the rules defined in [ITU-T-I.361] Clause 2.2.3: Routing field (VPI/VCI). VCI values from 0 to 31 can be used for signaling and OAM purposes.

VPI Field & VCI Field - Reserved VPI/VCI values

When processing cell headers, D500 takes the pre-assigned cell header values listed below into account:

• the pre-assigned cell header values for use by the physical layer at the UNI, [ITU-T-T.361] Table 1;
• the combinations of pre-assigned VPI, VCI, PTI and CLP values at the UNI [ITU-T-T.361] Table 2;

PTI Field

The PTI field encoding/decoding is compliant to [ITU-T-I.361].

B.4 Traffic Control & Congestion Control

The D500 implements VP/VC UPC at the UNI to detect violations of negotiated traffic parameters and reacts appropriately to protect the QoS of other VPC's/VCC's.

If D500 is configured as a VP cross-connect, VP UPC can be performed on each VP connection.

Via configuration management following service classes can be configured:

D500 Rel 3.x
• CBR
• VBR-rt
• VBR-nrt
• VBR-nrt with tagging
• UBR

D500 Rel 2.x
CBR
• VBR-rt
• VBR-nrt
• VBR-nrt with tagging
• UBR
• UBR +

Traffic descriptors of VBR-nrt with tagging include PCR, SCR. Excess traffic is CLP tagged without cell dropping. The class has the second lowest priority and can be used for same purpose as UBR+.

CLP Field

In downstream direction, the CLP bit setting is left untouched. In upstream, depending on the service class that is configured, the CLP bit is checked and modified according to the UPC rules.