CEC TEN-T ATM Task UK/96/94

ACCESS

ATN Compliant Communications

European Strategy Study

Definition of ATN Air-Ground Subnetworks

Document Reference	: ACCESS/NATS/205/WPR/024
Author	: NATS Ltd
Revision Number	: 3.1
Date	: 19/11/98
Filename	: N024I3-1.DOC

DOCUMENT CONTROL LOG

Revision Number	Date	Description of Change
0.1	23-6-97	Document Creation - Development of Deliverable Outline
0.2	17-8-97	First Complete Internal Draft
0.3	25-8-97	General update to internal draft
0.4	31-8-97	Updated following internal NATS review - Issued to partners for review
0.5	7-10-97	Updated following partner review
0.6	22-12-97	Updated following EUROCONTROL and further partner review.
0.7	7-2-98	Updated following further STNA Review (8/1/98)
1.0	07-04-98	Updated following STNA comments and updates from ST15 work and FAA 'Performance Paper'
2.0	27-04-98	Updated following STNA comments and updates from COMT 11.
3.0	19-08-98	Updated following DFS comments (Amendment to chapter 2.4.4. - Ref: ACCESS/NATS/208/WPR/083)
3.1	19-11-98	Updated following DFS comments.

EXECUTIVE SUMMARY

One of the key decisions that any region must make as a part of the deployment of the ATN is the selection of air/ground subnetwork(s) that are to be deployed in that region to provide primary and/or back-up air/ground datalink services.

The objective of this Work Package was to identify the preferred choice of air/ground technology to be integrated into the European ATN infrastructure. Such a selection was to be made based upon an analysis of existing trials and studies that have addressed the subject of air/ground subnetworks and to take into account the policies and plans of European and non-European ATS providers, aircraft operators, communications service providers and finally ICAO. The final selection must be based on a number of criteria including ability of the selected technology to fulfil performance , reliability and coverage requirements whilst taking into consideration issues related to costs, ownership, service availability, service provision. etc.

Currently there are four candidate technologies that have been or are in the process of international standardisation through ICAO, these being:

- Mode S Data Link
- AMSS
- VHF Data Link (VDL)
- HF Data Link

Whilst there are other possible satellite technologies (e.g Low Earth Orbit, Medium Earth Orbit) that are potential providers of ATN compatible air/ground datalink services it has been assumed in this report that such technologies are unlikely to be standardised, validated and commercially available to support air traffic services within the time-frame of the initial European ATN implementation. However, noting that the ICAO AMCP has been reviewing the potential of these new satellite technologies with respect top their applicability to ATS it is recommended that this assumption be reviewed and this report be updated accordingly once the final AMCP recommendations on this subject are concluded.

The EATCHIP ST.15 study (Analysis Options for Initial Air/Ground Data Networks) has been found to be of particular relevance to this WP since it has conducted an extensive and detailed analysis of the various air/ground technologies and assessed their abilities to comply with the types of datalink air/ground communication services that have been envisaged for use in the European Region by the EATCHIP ODIAC SG, such services also being those upon which the ACCESS WP202 services have been defined. Phase 1 of the ST.15 study was to inventorise the potential air/ground technologies and air/ground services that were foreseen to be available in the coming decade. That Phase resulted in a number of possible options for deployment within the time-frame of the study, i.e. 1995 to 2005. Phase 2 subsequently applied a set of user defined criteria to the inventory produced in Phase 1 and concluded that:

- in the 1995 to 2000 time-frame an ACARS based service should be provided as a interim step and

- for the 2000 to 2005 time-frame a VDL (Mode 2) service to be provided as the main subnetwork. A combination of Mode S and SATCOM systems will be used as a secondary back-up. The VDL Mode 4 (STDMA) subnetwork to be examined as a candidate for a main subnetwork.

Phase 3 subsequently studied the air/ground data subnetwork options selected in Phase 2 considering their technical feasibility, cost and the implementation programme. The results of the ST15 Phase 3 study were presented at the COMT-11 meeting held in Brussels (10-11/2/98). COMT endorsed the ST15 report and recommended " *to implement in the ECAC States the VDL Mode 2 system, as the first*

ATN air-ground subnetwork, to support initial ATS and Airline data link services". The COMT also made recommendations regarding the use of other air-ground subnetworks e.g. Mode-S, SATCOM and VDL Mode 4.

Another key activity of relevance to the conclusions of this Work Package is the work of WG-D of the ICAO AMCP which is currently in the process of developing two reports:

- - an **assessment** of the various air/ground digital links providing for voice and/or data communications against their operational requirements and an overview of the performance characteristics of these systems (study called "AMCP study report for the evaluation of CNS systems") and

- - a **comparative** analysis of the candidate data links for navigation and surveillance applications (study called "AMCP study report for the development of datalinks for Navigation and Surveillance").

The current drafts of these reports are insufficiently mature for any sound conclusions to be drawn. It is however recommended that the final recommendations of this WP are re-visited once the AMCP reports are finalised and endorsed by ICAO.

IATA recently established a Task Force to *"establish the airlines' requirements for the future data link infrastructure"*. Due to time-scale limitations and given the fact that the AMCP was conducting a detailed performance assessment of the candidate air/ground technologies the Task Force report, which was endorsed by the IATA Flight Operations Committee, did not conduct a performance assessment of the various air/ground technologies. However, the report did present a strong preference for a VDL based air/ground services. The report additionally highlighted a number of technical and economic reasons for implementing VDL rather than the Mode S subnetwork . Though not formally documented it is understood that IATA will encourage VDL Mode 2 implementation with a view to migrate to the integrated voice/data VDL Mode 3 system. There is currently no known formal IATA position on VDL Mode 4.

From a performance perspective and in the context of the validation of the ATN SARPs the FAA presented a validation report to the ICAO ATNP WG1 in Brazil in March 1998 and concluded that the range and value of ATSC classes/transit delay requirements defined in the SARPs were valid and that a VDL Mode 2 service would provide a Class B service (4.5 seconds one way transit delay) and Mode S a Class C service (7.2 seconds). These conclusions are based on the subnetworks supporting the optimum airborne configuration and being operated within the intended capacity.

There are currently a number of initiatives underway that are either utilising or developing air/ground technologies. The POEMS project is scheduled to deliver 3 SARPs compliant Mode S surveillance systems (with Mode S subnetwork interfaces, i.e. GDLP) by the end of 1999. Both the Pro-ATN and Euro VDL Mode 2 projects will result in the deployment of VDL Mode 2 services that will provide a combined coverage for a significant portion of European airspace in addition to developing the appropriate VDL Mode 2 avionics systems. The ADS Europe trial has acquired significant experience in the use of the AMSS ATN Data 3 compliant satellite service.

Given the current status, planned availability and performance characteristics of the various technologies UK NATS considers that VDL Mode 2, subject to confirmation through appropriate R&D initiatives (e.g. simulation) , will be capable of meeting its expected ATS communications demand for data link services. It is therefore the preferred choice for implementation for the time-frame in question, i.e. up to 2010 with a preference to migrate to the integrated voice/data VDL Mode 3 system as and when it becomes operationally deployed. UK NATS currently has no requirements for Mode S data link operation in domestic airspace. However, NATS is currently assessing requirements for the deployment of Mode S for basic surveillance. UK NATS plans to offer an ATN compliant AMSS based ATS service circa 2000 in the UK North Atlantic FIR. The use of HF data link as a back-up service in the NAT is currently under review.

Like NATS, STNA considers that VDL Mode 2 will be the appropriate and main ATN air/ground subnetwork in Europe for the next decade, i.e. up to 2010. Mode S and AMSS will be considered to be used as ATN back-up subnetworks.

As regards, the future of VHF technologies, STNA considers that, up to 2010 at least, the "8,33 kHz" solution will satisfy the requirements for voice telecommunications and that no clear requirements for data/voice integration exist today in Europe. In fact, STNA is not convinced that such a requirement will ever arise. If so, VDL Mode 3, as it is specified today, is not believed to be the appropriate technical solution. In fact, given the foreseen increase in ATC data telecommunications, a dedicated data subnetwork with better performance than VDL Mode 2 might be the answer to future ATC air/ground telecommunications requirements. Clearly, this means that STNA believes that the current proposed VHF technologies ("8.33 kHz" for voice and VDL Mode 2 for data) will satisfy the ATC air/ground telecommunications requirements up to 2010, and that none of the currently proposed technologies are believed to be satisfactory for longer terms solutions.

STNA further considers that VDL Mode 4 is only considered to be a possible complementary solution to Mode S for the support of ADS-B service, but the latter needs to be better defined in terms of operational objectives before the appropriate telecommunication supporting technology be precisely selected. VDL Mode 4 is not considered to be suitable for the support of point-to-point telecommunications in the context of ATN.

The DFS regard VDL Mode 2 becoming the primary link for non time critical ATS data link services in the medium time frame (from 2005 onwards). Therefore the VDL Mode 2 digital link will initially be used in parallel with ACARS (carrying initial data link applications) and will finally succeed ACARS. The necessity of the usage of a complementary data link (e.g. Mode S, SATCOM) will be the subject of further investigations to be concluded by 2001. The necessity of a data link for the provision of time critical ATS data link services (e.g. VDL Mode 3, VDL Mode 4) is a further subject of investigation to be concluded by 2002.

The US FAA is currently investigating, through OpNet based simulations with ARINC, the use of VDL Mode 2 to support the early introduction of ATS data link services. The FAA considers VDL Mode 3 remains as a candidate for the next generation of data link systems. In response to the views of the US airlines the FAA no longer has plans to deploy Mode S data link as an ATN subnetwork. Mode S for basic surveillance is currently operational in the majority of US airspace. The FAA plans to introduce Mode S based enhanced surveillance from the end of 1997 onwards.

It is expected that both the current major aeronautical telecommunications service providers, ARINC and SITA, will be in a position to be offering initial VDL Mode 2 services circa 2000 that will provide coverage for the core area of Europe. The question of third party service provision of communications services is the subject of a subsequent ACCESS Work Package.

Given the analysis conducted in the development of this report it is concluded that in the ACCESS time-frame (i.e. up to 2010) that the VDL Mode 2 subnetwork be integrated within the European ATN infrastructure as the primary means for the provision of air/ground services. There is currently no clear agreed European policy as to which VDL Mode should be deployed beyond the foreseen ACCESS time-frame. With respect to a secondary back-up air/ground subnetwork service the WP was not in a position to conclude the preferred technology and recommends that a further study is initiated to identify the optimal solution for a secondary air/ground subnetwork taking into account the needs, requirements plans and constraints of the European region.. This further study should, inter alia, take into account current European plans for the deployment of Mode S, the stability and maturity of the VDL Mode 4 SARPs, the availability and costs of the AMSS subnetwork and the plans regarding the emerging LEO/MEO satellite based systems.

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1. Introduction

This report presents the results of the ACCESS WP 205 ("Define Network Topology: Air/Ground Subnetworks").

The specification and scope of WP205 is defined in [A001] as:

"A short summary of air/ground subnetwork types, operation and performance characteristics will be prepared as an introduction to the deliverable. Taking into account existing European work on this subject, such as the EATCHIP deliverable ST-15, the choice of air/ground subnetworks will be made. Consideration of coverage (including overlap), availability and capacity will be included. The existing plans of European States intended usage of air/ground subnetwork types will be incorporated.

The work package will draw upon the output of WP_201 and WP_202, and will by completed with close co-operation with WP_204 and WP_205, the routing architecture and ground/ground network choice.

The deliverable will also consider the impact upon airlines and how will choice/availability of air/ground subnetworks in the study area impact upon aircraft fit."

1.1 Scope

The scope of this report is bounded by the Work Package Specification as reproduced above.

1.2 Acronyms & Abbreviations

ACARS	**Aircraft Communications Addressing and Reporting System**
ADLP	**Airborne Data Link Processor**
AMSS	**Aeronautical Mobile Satellite Service**
ATIS	**Automated Terminal Information Service**
ATSO	**Air Traffic Service Organisation**
CSMA	**Carrier Sense Multiple Access**
DCL	**Departure Clearance**
GDLP	**Ground Data Link Processor**
HFDL	**High Frequency Data Link**
IACSP	**International Aeronautical Communications Service Provider**
OCM	**Oceanic Clearance Message**
RGS	**Radio Ground Station**
STDMA	**Self-Organizing Time Division Multiple Access**
TDMA	**Time Division Multiple Access**
VDL	**VHF Digital Link**

2. Summary of Air/Ground Subnetwork types

Note: In the interests of efficiency the following summaries air/ground subnetwork types are largely based upon material contained in the AMCP [ICA3] draft document. A detailed description of each of the addressed air/ground subnetwork types is included in the EATCHIP ST15 Study Phase 1 Report [EAT13].

2.1 AMSS

Satellite communications provides a very attractive option for aeronautical communications as it provides virtually global coverage (except the polar regions) with little requirements for the installation of ground infrastructure. It is the only option (with the exception of HF) for communications in oceanic regions and is likely to remain the only cost effective option for many remote continental regions where installation of ground based infrastructure would be prohibitively expensive. However, aeronautical users alone are unlikely to be able to justify the costs of satellite network implementation and SATCOM use will be shared between aeronautical, land and maritime users. At present, INMARSAT is the only organisation offering a world wide mobile satellite system although there are other organisations planning to offer services in the near term future, e.g ICO, Iridium.

The INMARSAT system is based upon a constellation of 4 geostationary satellites providing global coverage (except polar regions). These satellites operate in the L-band (1-2 GHz). The INMARSAT aeronautical system has been designed to provide voice and data services. These are supported via service providers and three consortia act as service providers world-wide:

- **Skyphone** - BT, Norwegian Telecom, Singapore Telecom;
- **Satellite Aircom** - SITA, France Telecom, OTC Australia, Teleglobe Canada;
- **COMSAT/KDD** consortium.

The INMARSAT geostationary satellite service provides circuit switched voice services and the following packet data services:

- **Data 2**: supports character-oriented connectionless services compatible with ACARS, it can support bit-oriented services;
- **Data 3**: has a full ATN-compliant network layer interface and is compliant with AMSS SARPs.

In addition, circuit-mode data services are available. A number of channels are available as follows:

The P channel is a packet-mode time division multiplexed channel used in the ground-to-air direction. It carries signalling and user data and is transmitted continuously from the ground earth station (GES). The R channel is a random access used in the air-to-ground direction carrying signalling and user data. The T channel is reservation time division multiple access channel and is used in the air-to-ground direction. The C channel is a circuit mode channel used in both directions. Possible data rates are:

C-channel:	5.25 kbps	6 kbps	10.5 kbps	21 kbps;	
P-channel:	0.6 kbps	1.2 kbps	2.4 kbps	4.8 kbps	10.5 kbps;
R-channel:	0.6 kbps	1.2 kbps	2.4 kbps	10.5 kbps;	

T-channel: 0.6 kbps 1.2 kbps 2.4 kbps 10.5 kbps.

Selection of the R or T channel for down-linking messages is dependent upon the length of the message and priority. The ability to utilise higher bit rates is dependent upon the antenna type carried on the aircraft. At present three antenna types, low, intermediate and high gain are available.

Note that an important issue for the use of satellite communications for flight safety applications is the impact of loss of the satellite. To address this INMARSAT is placing standby satellites in geostationary orbit. INMARSAT plans to reduce the time required for switching to a standby satellite from 30 minutes to 90 seconds.

2.2 VDL

VDL (VHF data link) defines the protocols needed to exchange bit-oriented data across an air/ground VHF data link in an ATN compliant environment. Different forms of VHF data link have been defined:

- **Mode 1** - CSMA with MSK-AM modulation at 2.4 kbit/s (similar to ACARS);
- **Mode 2 -** CSMA with D8PSK modulation at 31.5 kbit/s;
- **Mode 3 -** TDMA with D8PSK modulation at 31.5 kbit/s providing integrated voice and data services;
- **Mode 4 -** current candidate technology for Mode 4 is STDMA providing data only services with GFSK or D8PSK modulation.

2.2.1 VDL Mode 1

VDL Mode 1 is a low-speed bit-oriented data transfer system. It used a CSMA (Carrier Sense Multiple Access) channel access mode. The physical layer conforms with the existing ACARS system (at the same data rate) and layer 2 and 3 to OSI protocols. ICAO SARPs completed.

2.2.2 VDL Mode 2

VDL Mode 2 is similar to the VDL Mode 1 in many ways. Yet VDL Mode 2 uses a much more efficient modulation scheme to support a greatly improved data rate. One of the most significant limitations of Mode 2 is the lack of support for prioritisation of data. The ICAO SARPs have been completed and validated.

2.2.3 VDL Mode 3

VDL Mode 3 is an integrated voice and data link technology based on the TDMA (Time Division Multiple Access) principle. Mode 3 will support a priority scheme. The Mode 3 SARPs are expected to be adopted in Spring 1999. Validation of the vocoder is expected to be completed by late 1998.

2.2.4 VDL Mode 4

Self-Organizing Time Division Multiple Access (STDMA). STDMA is a concept that is being promoted as VDL Mode 4 . It uses a number of 25 kilohertz (KHz) channels in the very high frequency (VHF) band. Transmissions are co-ordinated in the sense that only one aircraft transmits in any slot in any channel and each aircraft is equipped with a receiver as well as a transmitter. STDMA data is transmitted at a rate of 31.5 or 19.2 kilobits per

second (kbps). Each aircraft's transmission would be accompanied by an off period (guard time) of several milliseconds to account for differences in transmission times between transmitters and receivers. The STDMA design has yet to be validated and is considered to be unstable at this point in time. Draft SARPs are currently under development.

2.3 Mode S Data Link

The Mode S is an evolution of the traditional Secondary Surveillance Radar (SSR), which is based upon Mode A/C interrogation/reply scheme. In the Mode S system, this scheme has been enhanced, by uniquely identifying each aircraft using a world wide 24 bit aircraft address, and by allowing the transmission of interrogations selectively addressed to a single aircraft, instead of being broadcast in the whole antenna beam.

A Mode S radar is able to perform surveillance (i.e. to output the aircraft position, in addition to the standard SSR modes (Mode 3/A, Mode C)). It also has data-link capabilities, i.e. the ability to send or extract frames containing binary data. The data-link can operate only on aircraft being tracked by the surveillance processing. From an operational point of view, the priority is always given to the surveillance processing (the detection of a target and the transmitting of the corresponding information shall never be degraded for any data-link reasons).

The selective addressing ability of Mode S lends itself to be the basis of a data link. ICAO has developed (and overseen the validations of) SARPs for the Mode S subnetwork. The Mode S subnetwork comprises a ground component (GDLP) and an airborne component (ADLP) that provide an ATN compliant interface to the airborne and ground routers respectively .

2.4 HF Data Link

HFDL is a packet data communications system that utilises the bands in the 2.85-22.00 MHz range which are allocated to the Aeronautical Mobile (R) Service. ICAO SARPs for HFDL are complete and are expected to be adopted by AMCP in April 1998. The HFDL will be designed to function as a subnetwork of the Aeronautical Telecommunications Network (ATN).

HFDL communications technology has been undergoing extensive trials in the North Atlantic in recent time, though not within an ATN compliant infrastructure. These HFDL trials have demonstrated a high level of communication reliability and availability compared to the present day HF voice system. HFDL appears to offer a very practical means of data communications that could be utilized as a backup or complement to satellite data link. ARINC estimates the equipage costs to be approximately 20% of the equivalent costs to equip with SATCOM.

2.5 LEOS/MEO Satellite Services

Due to the geostationary nature of the INMARSAT satellites and the resulting power requirements on the ground equipment their use for personal mobile communications has been considered to be too costly. In order to meet the growing demand for personal mobile communications a total of six new satellite services will be launched by various consortia (e.g. IRIDIUM, GLOBALSTAR, ICO GLOBALCOM, KEYBRIDGE, TELEDESIC) from 1999 onwards, these being based on "Low Earth Orbit" (LEO), "Medium Earth Orbit" (MEO) satellites. Such systems are typically are expected to be placed in orbit from 250 - 900 miles for LEO and 6,600 miles for MEO (c.f. 22,000 miles for the geostationary

satellites). The resulting power requirements on the ground systems to make use of services based on LEO/MEO systems are considerably reduced thereby reducing their costs consequently increasing their attractiveness for use in personal communications. It is understood that some of the consortia consider the aeronautical community as potential customers for use of their services including support of ATS communications. The ICAO AMCP WG-A is currently assessing the applicability and suitability of these types of systems to support ATS communications.

2.6 Gatelink

Though not strictly an air/ground subnetwork the "gatelink" subnetwork has been standardised in AEEC standards to enable data communications between an aircraft and a network or host on the ground at an airport terminal or at a maintenance position. Examples of the type of communication include:

- update of onboard databases;
- download of engine performance data;
- data communications.

Two modes are possible for connection of the aircraft:

- using a physical optical fibre connection;
- line-of-sight infrared (IR) link.

Gatelink operates like an extension of a local area network (LAN) to an aircraft. It offers high bit rate communications making it suitable for transactions requiring high bandwidth which are not generally possible on mobile datalinks. It also reduces dependency upon radio links and could free up spectrum in the airport environment.

Data originating from a ground based computer system is transmitted through a ground based node to an airport local area network (LAN) where it is converted into FDDI (Fibre Distributed Digital Interface) format and bit rates. The data is transmitted to the parked aircraft at the gate via an infrared (IR) or optical fibre interface.

ARINC 751 describes the interfaces for ARINC 636. ARINC 636 defines the first two layers and is based on two ISO standards, the FDDI protocol (ISO 9314) and the logical link control protocol (ISO 8802-2). The network and upper layer specifications are defined by ARINC 637 and ARINC 638 respectively.

3. Applicable Issues Arising out of Related ACCESS Work Packages

3.1 WP 201 - Current Communications Infrastructure

The WP201 deliverable [A201] "Current Communications Infrastructure" refers to the interim use of ACARS for initial air/ground data link services by UK and France. However, the use of ACARS is not within the scope of this work package which is focused on the selection of bit-oriented, ICAO standardised air/ground technologies.

3.2 WP 202 - Geographical Area and datalink Services Proposed for the European ATN

The following points from the WP202 deliverable [A202] "Geographical Area and Application Services Proposed for the European ATN" have been identified as being relevant to this WP:

- the geographical area considered for ATN implementation, i.e. UK, Ireland, Benelux, Germany, France, Italy, Spain and Portugal;
- the fact that the area defined is representative of the two types of air traffic control in Europe, namely continental control and oceanic interface;
- the data link services presented have been primarily been chosen based on existing operational requirements, i.e. from various documents issued by the EATCHIP ODIAC SG (ORD [EAT12]) and the Draft ICAO Manual of Air Traffic Services (ATS) Data Link Applications" produced by the ICAO ADS Panel [ICA4].
- the fact that implementation of AOC services is outside the scope of this study.

3.3 WP 203 - Definition of the European ATN Routing Architecture

During the development of WP205 and WP203 it has been concluded that:

- the proposed Routing Architecture has no influence on the choice for an air/ground subnetwork.

3.4 WP 204 - Definition of ATN ground-ground subnetworks

It has been concluded that there is minimal relationship between the choice of an air/ground subnetwork and the ground/ground infrastructure issues addressed in WP204. However, it, is likely that one scenario in the provision of an air/ground service is that an organisation such as SITA is contracted to provide a VDL service in which case it would be probable that their ground/ground infrastructure is a prime candidate for the provision of the associated ground/ground services. Section 3.4 of the WP204 report notes that the physical location of the air/ground subnetwork access points with respect to the location of the air/ground BISs will determine whether a PSN or a dedicated leased line is selected.

4. Applicable Studies

4.1 Analysis Options for Initial Air/Ground Data Networks (EATCHIP COM.ET2.ST15)

4.1.1 General

The objectives of the EATCHIP COM.ET2.ST15 were to :

- *"to identify the most mature application(s) (from an operational point of view), amongst ATC applications;*
- *to propose two or three schemes of both data link applications and air/ground communication technologies which can be implemented in the various homogeneous ECAC areas within the next five to ten years;*
- *to propose an implementation plan for each scheme with special care to its integration into the ATN environment."*

To reach these objectives the study was accordingly divided in three main steps :

- **Phase 1:** Inventory and Analysis of air/ground ATS applications, of experiments and trials, of the planned or existing air/ground data networks and of the plans and policies of the different actors (CAAs, Airlines, Industry, and Network Service Providers).
- **Phase 2:** Criteria selection and choices for the most appropriate combination of ATS applications and air/ground data networks. From this set of choices two or three options will be selected. The list of criteria will be established in considering both the ground side for the different homogeneous areas and the airborne side.
- **Phase 3:** Feasibility study, a subsequent deployment strategy plan (one per option) will be provided.

All three Phases have been completed.

4.1.2 Phase 1 Report - Inventory and Analysis of A/G Applications and Data Networks

The Phase 1 study [EAT13] concluded with a number of possible combinations of data link technology and services as summarised in the table below which is **reproduced** from the Phase 1 report. The SARPs for TP4/ATN/VDL/CSMA[1] (Mode 2) have since been completed and validated.

"The table lists, in an ATN perspective, the 11 main datalink services (consisting of a protocol stack, equipment type and/or access method over a given air-ground medium) and the main technical; operational and political factors favouring or hampering their availability in the 1995-2005 time range.

[1] TP4 is in fact included in the ATN. The term "TP4/ATN/VDL/CSMA" originates from the [EAT13] reference.

datalink services	***favourable factors***	***hampering factors***
ARINC623 (-622)/ACARS/ VHF	*available now ; aircraft equipped for AOC applications*	*non-ATN protocol; limited QoS*
ARINC622/ACARS/ Data2-Inmarsat	*available now ; aircraft equipped for AOC applications ; upgradable by data 3*	*non-ATN protocol; limited QoS; costly equipment*
TP4/ATN/ Data3-Inmarsat	*Data3 equipment available ; experimental ATN stack; system available around 2000 ; limited implementation cost ; (incremental w.r.t. data2 satCom)*	*no immediate benefit from upgrade to data3; costly as first equipment*
ATN gateway/ Mode S/GICB	*experimental components available; system available around 2000 ; limited implementation cost ; (incremental w.r.t. Mode S surveillance)*	*full prototype system not yet available; industrial components not yet available; airlines not interested (system dedicated to ATS applications) ; cost-effectiveness unproved outside Core Area*
ATN gateway/STDMA (for ADS-B)	*system optimised for broadcast; experimental components available; co-ordinated experimental trials under way (SU-DK-GE) ; limited implementation cost ; SARPs available possibly by 2000.*	*limited availability of VHF band ; competition with Mode S/AICB.*
TP4/ATN/VDL/CSMA	*prototype equipment expected in 97 system available around 2000 ; fully ATN compatible subnetwork ; natural evolution of ACARS ; usable for both AOC/AAC and ATS; limited implementation cost (upgrade of existing equipment) ARINC standard*	*experimental system not yet validated limited efficiency of the access policy possible early obsolescence due to the emergence of TDMA-based systems*
ATN gateway /Mode S/AICB (for ADS-B)	*SARPs expected in 96 ; experimental components available; experimental trials under way (US-FR) ; low cost passive antenna on the ground ; air-air protocol already validated (TCAS)*	*retrofit of Mode S transponders ; competition with STDMA*
TP4/ATN/CSMA/HF	*experimental HF transceiver available ; experimental trials under way (Canada, Iceland) lower-cost alternative (or backup) medium with respect to SatCom*	*SARPs not yet defined ; aircraft equipment still costly for backup (although less than SatCom)*
TP4/ATN/Mode S	*SARPs validation expected in 1996; experimental SARPs compliant system available (US 1995, Europe 1996)*	*limited QoS (throughput and delay) ; most airlines not interested or hostile (ATS-only medium)*
TP4/ATN/VDL-STDMA	*strong promotion at ICAO and In Europe by the Swedish CAA; SARPs validation expected in 1997-98; relatively low equipment cost*	*not designed for supporting two-way air-ground data communications ; ATN integrability not clear ; incompatible with US-TDMA*
TP4/ATN/VDL-TDMA	*strong promotion at ICAO by the FAA single integrated digital equipment for air-ground voice and data ; SARPs validation expected in 1997-98;*	*costly fully digital radio equipment ; no important operational benefits expected from digitised voice in Europe; conflict with 8.33kHz channel spacing (early migration strategy for voice in Europe) ATN integrability proposed but not fully designed ; divergent operational requirements between voice and data ; compatibility with STDMA not yet proven*

Table 1 - Conclusions of Phase 1 Study

4.1.3 Phase 2 Report - Criteria Selection and Options

Having defined various criteria for the selection of data link technology/service combinations (e.g. only addressing those data link services and air-ground technology that will be available in the 2000 and 2005 time-frames) the Phase 2 study concluded the following:

Recommendations for 1997 - 2000

- 1997 - 2000: Due to the very short time horizon, only existing technology can be considered. Therefore, an ACARS based Datalink is considered for providing non mandatory and non time and safety critical Services. The concerned services are Automated Terminal Information Service (ATIS), Oceanic Clearance Message (OCM) and Departure Clearance (DCL).
    - **Option 1: OCM, DCL and ATIS over ACARS/VHF**
    - **Option 2: NAT-ADS over ATN/SatCom Data 3**

Option 1 represents early continental applications that can be deployed on the ACARS system (then migrated in one step to the VDL/Mode 2).

Option 2 represents early NAT area applications, which are mentioned here for the sake of completeness.

Recommendations for 2000 - 2005

- *"2000* to- *2005: For this time period it was proposed to study the VDL* (*Mode 2*) *system as a candidate for a main subnetwork. It was also proposed to study the VDL Mode 4, the Mode S and the SATCOM systems as possible complementary options. The COM Team amended the proposal of the Phase 2 study by requesting that the VDL Mode 4 subnetwork be examined as a candidate for a main subnetwork in addition to VDL Mode 2 subnetwork*". [EAT 19]

The study concluded that:

"Continental area :

Taking into account the results of the datalink ranking (chapter 3.4) and the results of the QoS matching analysis (conducted in chapter 4), the VDL-CSMA/Mode 2 can be proposed as the main option. This is due to its position in the datalink ranking and the fact that most of the applications requirements are met by the VDL-CSMA/Mode 2.

For providing a secondary/backup option, we have to choose among the remaining datalinks which satisfy most of the applications requirements. Using the compliance matrix introduced in chapter 4, there are two possible options: the Mode S ATN full network scenario and the STDMA ATN integration scenario.

The comfort margins matrices for throughput and transfer delay show that both Mode S ATN and STDMA ATN provide the same margins. However, for STDMA the margins decrease noticeably when the number of aircraft increases, whereas for Mode S this is not the case.

On the other hand, STDMA presents more advantages in terms of adaptability to other applications and especially to Navigation.

As a consequence, we propose jointly Mode S and STDMA for building up a second option for the whole ECAC area, owing to their mutually complementary coverage. Note again that we recommend them only as a backup to VDL CSMA/Mode 2.

Satcom data 3, which has been already retained as the main option for the NAT area by year 2000, could also be envisaged as a backup to VDL for the ECAC area in the timeframe 2000-2005.

NAT area:

For the non-continental side, the QoS matching results (chapter 4), it seems logical to propose Satcom data 3 as the first option for the best datalink to support non-continental applications.

As shown in chapter 3.4, the HF datalink is seen as a good candidate in terms of cost. But since the proposed throughput is too low (see the throughput margins matrix), HF is proposed only as a secondary/backup option in the NAT area."

4.1.4 Status of Phase 3 - Feasibility Study

The objective of this phase is to study the feasibility of the options selected in Phase 2 in terms of the technical feasibility, cost and implementation programme.

Taking into account the Phase 2 proposal and the decision of the COM Team, the Phase 3 was split into two parts: one dealing with the short term horizon (1997 - 2000) and another dealing with the medium term horizon (2000 - 2005).

The Phase 3.1 report, deals with an implementation plan for ACARS [EAT8] and the Phase 3.2 report deals with the implementation feasibility of the Air/Ground data subnetworks identified by Phase 2 of the ST15 study

4.1.5 Analysis and Conclusions

The ST15 study scope and results to date are considered to be directly applicable to this WP. This conclusion is further reinforced by the fact that both the ST15 study and ACCESS WP202 have been based on the ODIAC defined air/ground data link services with respect to the identification of air/ground communications service requirements.

Of key interest to this Work Package are the ST15 conclusions of Phase 2, i.e.:

- VDL Mode 2 as the primary air/ground subnetwork to be deployed in the ECAC area;
- VDL Mode 4 (STDMA), Mode S and/or SATCOM as possible back-up or complementary options to the primary VDL Mode 2 subnetwork.

The results of the ST15 Phase 3 study were presented to the COM Team at the COMT-11 meeting held in Brussels (10-11/2/98). COMT endorsed the ST15 report and recommended " *to implement in the ECAC States the VDL Mode 2 system, as the first ATN air-ground subnetwork, to support initial ATS and Airline data link services*" [EAT20]. The COMT also made recommendations regarding the use of other air-ground subnetworks e.g. Mode-S, SATCOM and VDL Mode 4. In particular "*to include, inside the EATCHIP Communication Work Program, complementary activities relating to:*

- *The definition or selection of the QoS requirements that will be representative of future Air/Ground datalink services;*
- *The availability of necessary standards;*

- *To assess the ability of VDL Mode 4 to fulfil these requirements; and if the assessment is positive to:*
    - *develop the operating concept of VDL Mode 4*
    - *conduct a safety analysis for VDL Mode 4.*

To continue to monitor VDL Mode 3 developments and assess its capabilities as appropriate." [EAT 20]

4.2 AMCP WGD

The AMCP is currently developing two documents, the results of which are potentially relevant to this Work Package:

- "AMCP study report for the evaluation of CNS systems", [ICA2];
- "AMCP study report for the development of data links for navigation and surveillance requirements", [ICA3].

4.2.1 AMCP study report for the evaluation of CNS systems

The version of document [ICA2] available is the second draft dated 2nd April '97 presented for review at the AMCP WGG-D meeting in April 97. The sub-group of AMCP WG D has been tasked with producing an **assessment** of the various air/ground datalinks available and being developed against their operational requirements and provide an overview of the performance characteristics of these systems.

This report will present the results of an analysis of the capabilities of various air/ground data link technologies to meet foreseen requirements of data link services. The version of the report available at the time of study was incomplete and it is not possible to draw any conclusions from the available material other than that the analysis will progress along similar lines to the ST15 study.

4.2.2 AMCP study report for the development of data links for navigation and surveillance requirements

The version of document [ICA3] available is draft 0.6 dated 20th June '97. The sub-group of AMCP WGD has also been tasked with a conducting a **comparative analysis** of the candidate data-links for navigation and surveillance systems. The draft of the report available is insufficiently complete for any firm conclusions to be drawn from its contents.

4.2.3 Analysis and Conclusions

Given the relative immaturity of the deliverables to date it would be pre-mature to draw any conclusions. It is however recommended that the recommendations of WP205 are reviewed once the AMCP reports are finalised which is expected to be end 1997.

4.3 IATA Data Link Task Force Report

The IATA Flight Operations Committee recently formed a Data Link Task Force with the following terms of reference:

Objective: ***The objective of the DLTF is to establish the airlines' requirements for the future data link infrastructure and document these in a report.***

The task force will perform the following tasks:

- *Evaluate the present, planned and future aeronautical data link communication systems taking due account of possible regional developments*
- *Develop an inventory of desired data services and associated preferred operational procedures*
- *Monitor associated activities in ICAO, RTCA and AEEC.*
- *Determine the possible effects on the voice communication infrastructure*
- *Review and appraise the Required Communication Performance (RCP) aspects related to the free flight concept*
- *Review the User Driven CNS/ATM Implementation Plans in relation to communication requirements and transitory aspects to ensure plans are harmonised with the DLTF recommendations*
- *Make an inventory of the service provision options*
- *Evaluate equipment certification, approval and qualification requirements*.

Due to the time constraint and the fact that the AMCP WG-D is performing a full assessment of the various air-ground data link options, the DLTF did not evaluate the subnetworks from a performance and capacity perspective.

The Task Force resulted in a final report [IAT1] that was endorsed by the Flight Operations Committee. Of direct relevance to this WP are the following statements regarding air/ground subnetwork implementation:

"The air-ground data link options to support ATN are to be divided in two categories:

a) line of sight communication supported by VDL and Mode S.

In general the airlines will have the preference to use VDL over Mode S for the following reasons:

1) *VHF uses frequency diversity for communications and surveillance, whereas Mode-S carries all services on same frequency, so a failure of Mode S effects communication, surveillance and Collision Avoidance*
2) *VDL supports both ATS and AOC traffic, whereas some states will not carry AOC over Mode-S.*
3) *For Mode-S to provide adequate capacity in core areas, cost prohibitive ground structure using E-Scan antennas would be required.*
4) *VHF supports both data and voice communications.*
5) *Mode-S datalink could adversely affect ACAS operations.*
6) *Mode-S datalink coverage will not be global since a number of states have stated that Mode-S datalink will not be supported, therefore aircraft would be required to equip for both Mode-S and VHF.*
7) *Many areas do not support SSR coverage due to economic reasons.*

b) long range communication supported by HFDL and SATCOM.

The two options for long range communication are SATCOM and HFDL. While HFDL may overcome most of the problems which we presently experience with the HF voice, the economics are not certain. SATCOM has the advantage over HF that it supports all aeronautical services meaning that costs can be shared between the various services. However, HF provides polar coverage where SATCOM does not.

Long range communication is presently mainly used in a relatively low density strategic ATC environment. To transition to a more tactical environment it is expected that HFDL and SATCOM are needed to compliment each other to meet the availability requirements.

HFDL is expected to be a lower cost alternative for equipage, however it can only be used for safety communications."

4.3.1 Analysis and Conclusions

There is clearly an IATA preference for VDL over Mode S datalink. Though the Task Force did not investigate/analyse performances of the various air/ground technologies it is assumed that IATA would encourage the implementation of VDL Mode 2. It is understood that IATA foresee future need for an integrated data/voice system as promised by VDL Mode 3. On Mode 4 (STDMA) there is no clear IATA position, IATA recently organised a Workshop in 3rd Q '97 to discuss the relative merits of Mode-S extended squitter or VDL Mode 4.

4.4 Performance Assessment

In the context of the validation of the draft ATN SARPs the FAA presented an updated Working Paper [ICA15] at the ATNP WG1 - Eleventh Meeting in Brazil. The WP presented the results of on-going simulation work addressing the performance of the various ICAO defined air/ground data links when operated within the bounds of an ATN infrastructure for various scenarios. The paper focused on the validation of the system level requirement:

"The ATN shall offer ATSC classes in accordance with the criteria in Table 3-1."

The overall conclusions for the simulations within the defined scenarios are presented in the table below thus providing an indicative basis from which performance assessment in a European environment may be conducted.

Note 1: For each subnetwork [ICA 6] provides the end to end performance figures for two different airborne configurations:

1. Preferred Airborne Configuration - consists of the connectionless Williamsburg protocol and high speed ARINC 429.
2. Retrofit Airborne Configuration - consists of the connection oriented Williamsburg protocol and low speed ARINC 429.

Note 2: Three scenarios were developed to assess the different performance characteristics for the VDL Mode 2 subnetwork only. The performance characteristics are valid providing the subnet is used within the intended capacity. The scenarios are:

1. Scenario 1 - Airport Surface Domain

2. Scenario 2 - Terminal Domain

3. Scenario 3 - En-Route Domain.

One way ATN End-to-End Transit Delay at 95% probability (seconds)	ATSC Class	Mobile Subnetworks supporting this ATSC Class
Reserved	A	
4.5	B	VDL Mode 2[2] (Scenario 1 & 2)
7.2	C	VDL Mode 2[3] (Scenario 1,2 & 3) and Mode S[4]
13.5	D	VDL Mode 2 (Scenario 3)[5], Mode S[6] and 10.5Kbps AMSS[7]
18	E	10.5Kbps AMSS[8]
27	F	
50	G	
100	H	600bps AMSS

[2] Valid if the 'preferred airborne configuration' is supported.

[3] Scenario 3 is valid if the 'preferred airborne configuration' is supported and Scenarios 1 & 2 are valid if the 'retrofit airborne configuration' is supported.

[4] Valid if 'preferred airborne configuration' is supported.

[5] Valid if 'retrofit airborne configuration' is supported.

[6] Valid if 'retrofit airborne configuration' is supported.

[7] Valid if 'preferred airborne configuration' is supported.

[8] Valid if 'retrofit airborne configuration' is supported.

5. Applicable Trials and Implementation Initiatives

5.1 Mode S

In January 1997 EUROCONTROL let a contract for the development of a pre-operational SARPs compliant Mode S system (POEMS). The system will support both the basic and enhanced forms of Mode S surveillance. The contract is scheduled to deliver three Mode S interrogators that will be deployed in the UK, France and Germany by the end of 1999. The POEMS will have an interface for the Mode S GDLP and therefore be capable of supporting ATN compliant Mode S data link services. The FITAMS project (involving the UK DRA, EUROCONTROL and possibly STNA) and the ProATN project will implement a complete ATN/Mode S chain in 1998 on three sites: Toulouse (STNA), Gatwick (NATS) and Gotzenhaim (DFS). As regards the ProATN Toulouse site, the experimental Mode S ground station, previously located in Rouen will be moved to the STNA building, connected to the T-GDLP (also located in Toulouse) provided under a EUROCONTROL contract. The Mode S station should be installed in Toulouse in July 98, the T-GDLP is already available at STNA-Toulouse and the complete Mode S/ATN chain be integrated later in 1998.

5.2 VDL Mode 2

There are currently two initiatives that will result in the availability of an initial VDL Mode 2 service in a significant portion of European airspace, these being:

- Pro-ATN and
- EURO VDL Mode 2.

The high level objective of the ProATN project is to “develop, integrate and validate a pre-operational and pre-industrial prototype of the ATN, conforming to the greatest extent possible to the ICAO CNS/ATM-1 Package definition in both networking and application aspects. Additionally, the project plans to deliver both ground and airborne components that are certifiable on an end-to-end basis, and to verify and demonstrate these components through flight trials incorporating both airline and experimental aircraft. The services developed under the EOLIA project will be ported onto the ProATN infrastructure. The ProATN prototype will comprise End Systems, Boundary Intermediate Systems, Network Management System, Satellite Subnetwork, VHF Subnetwork, Mode S Subnetwork and an avionics platform. The ProATN consortium members are Cap Sesa Tertiaire (CST), ISDEFE, NLR, Sextant Avionique, Syseca, , DLR, Air France, British Airways, NTUA, TUB, , Thomson/CSG-Airsys, NATS, Aerospatiale, DFS, SITA and Sofrevia/STNA.

The ProATN project will deploy VDL Mode 2 ground stations in addition to procuring Mode 2 compliant avionics systems for the AIRBUS. Based on current planning, the complete ATN/VDL Mode 2 chains deployed in ProATN will be available in the 3Q1998.

The EURO VDL Mode 2 (co-funded by the CEC under the TENS initiative) project is a joint initiative between the UK NATS, STNA France , ENAV Italy, DFS Germany, EUROCONTROL and SITA. The objective is to define all the elements necessary for the deployment of VDL Mode 2 in Europe. The project will result in the deployment of VDL Mode 2 ground stations in Europe and the availability of Mode 2 compliant avionics

systems. It is expected that the project may include a contract for Aerospatiale to implement VDL Mode 2 capability in the ATSU for AIRBUS aircraft.

The major airlines of the participating ATS provider states, British Airways, Air France, Lufthansa and Alitalia are participating, initially as observers. Each will decide during the project, once the avionics have been implemented, whether to equip either A320's or A330/340's. SITA's role in EURO VDL Mode 2 is to provide a continuous VHF datalink service to the airlines which decide to equip their aircraft. The aircraft will be able to switch transparently between the VHF ACARS ground stations and the EURO VDL Mode 2 ground stations and communicate with the same Datalink Service Processor for access to airline ground systems. The aircraft may have separate connections for ATS communications.

The baseline for the EuroVDL ATSU package development will be the production of a "pre-FANS-A" ATSU which will be installed on the A320 family and the "FANS-A" ATSU on the A330/340 family from early 1998. The Euro VDL Mode 2 ATSU package will support all the existing ACARS airline AOC applications.. A change will be that software to handle the VDL Mode 2 protocol will be added alongside the software AEEC 620 which handles the VHF ACARS protocol so that the ATSU can communicate using either protocol transparently.

The EuroVDL Mode 2 implementation of the VDL Mode 2 protocol will be SARPs compliant except that the SNDCF will have to be adapted because the "user" will not be as a first step an ATN router. The EuroVDL Mode 2 ground stations will be designed to be compliant with ATN/VDL avionics.

Based on current planning the EuroVDL Mode 2 project will be deployed in the mid 1999 time-frame.

One of the key issues that the project will address is the migration of current ACARS based AOC applications to operate over a VDL Mode 2 service. Though AOC applications are outside the scope of the ACCESS study it is expected that AOC will be a key driver for VDL Mode 2 implementation. This expectation must consequently be taken into account by this WP when selecting the air/ground subnetwork for ATS purposes.

It is intended that the coverage to be provided through deployment of EURO VDL Mode 2 ground stations will be complementary to the coverage foreseen to be provided by the Pro-ATN project. The combined coverage to be provided by both initiatives will provide total coverage of the areas foreseen by the ACCESS study as indicated in Figure 1 (Coverage Status as at 1997).

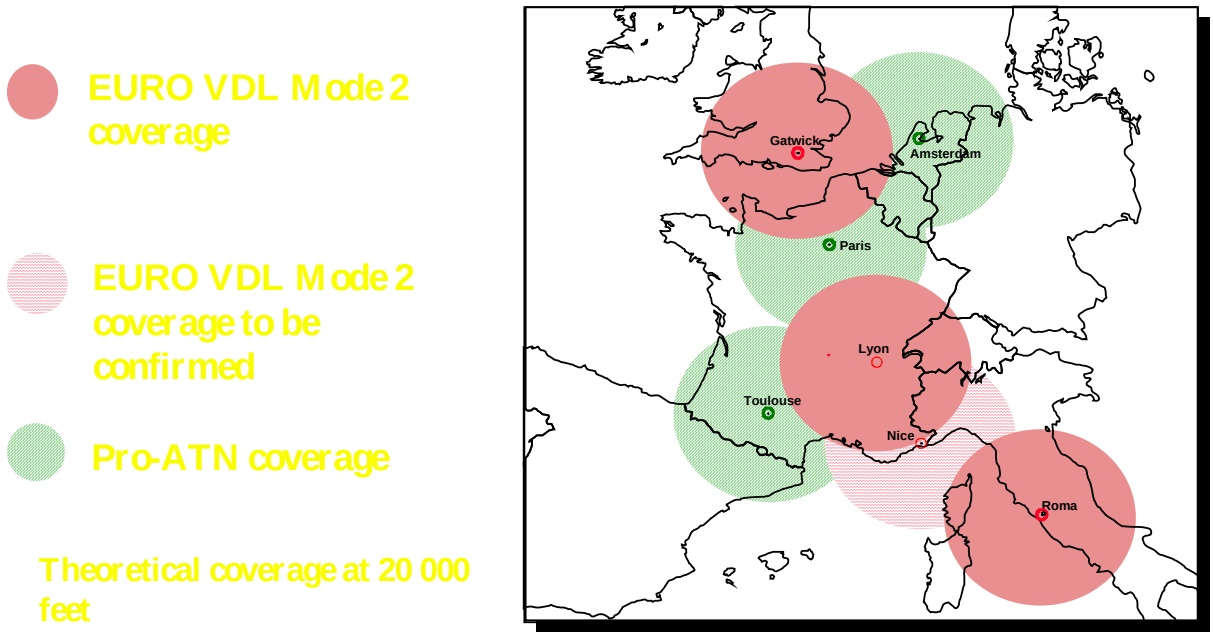

Figure 1 - 'Status as at 1997'

5.3 AMSS

As a result of the ADS Europe trial there is a considerable amount of operational experience that has been acquired with the use of the Data 3 AMSS when operated within an ATN infrastructure. The trial provided for almost global coverage using facilities provided by SATTELITE AIRCOM and Skyphone to include all INMARSAT satellites and corresponding GESs. The overall results of the first phase of the project, which were based on almost 5,000 hours of ADS data collection, demonstrated that a system based on the AMSS provided a range of performances compatible with a range of ATS based operational uses.

6. Current Implementation Plans and Policies

6.1 States

6.1.1 France

Like NATS, STNA considers that VDL Mode 2 will be the appropriate and main ATN air/ground subnetwork in Europe for the next decade, i.e. up to 2010. Mode S and AMSS will be considered to be used as ATN back-up subnetworks.

As regards, the future of VHF technologies, STNA considers that, up to 2010 at least, the "8,33 kHz" solution will satisfy the requirements for voice telecommunications and that no clear requirements for data/voice integration exist today in Europe. In fact, STNA is not convinced that such a requirement will ever arise. If so, VDL Mode 3, as it is specified today, is not believed to be the appropriate technical solution. In fact, given the foreseen increase in ATC data telecommunications, a dedicated data subnetwork with better performance than VDL Mode 2 might be the answer to future ATC air/ground telecommunications requirements. Clearly, this means that STNA believes that the current proposed VHF technologies ("8.33 kHz" for voice and VDL Mode 2 for data) will satisfy the ATC air/ground telecommunications requirements up to 2010, and that none of the currently proposed technologies are believed to be satisfactory for longer terms solutions.

VDL Mode 4 is only considered to be a possible complementary solution to Mode S for the support of ADS-B service, but the latter needs to be better defined in terms of operational objectives before the appropriate telecommunication supporting technology be precisely selected. VDL Mode 4 is not considered to be suitable for the support of point-to-point telecommunications in the context of ATN.

6.1.2 Germany

The DFS regard VDL Mode 2 becoming the primary link for non time critical ATS data link services in the medium time frame (from 2005 onwards). Therefore the VDL Mode 2 digital link will initially be used in parallel with ACARS (carrying initial data link applications) and will finally succeed ACARS. The necessity of the usage of a complementary data link (e.g. Mode S, SATCOM) will be the subject of further investigations to be concluded by 2001. The necessity of a data link for the provision of time critical ATS data link services (e.g. VDL Mode 3, VDL Mode 4) is a further subject of investigation to be concluded by 2002.

6.1.3 UK

Given the current status of the various data link technologies in terms of standardisation, validation, trials, development, expected service availability and performance NATS considers that VDL Mode 2 be the preferred choice for implementation as the primary data link technology up to at least 2005 in domestic airspace. NATS considers that VDL Mode 3, primarily due to the benefits to be gained through a digital voice system, and its data priority handling capability be the preferred successor to VDL Mode 2 in the 2005 to 2010 time-frame.

There are currently no requirements foreseen for the deployment of a Mode S data link facility. However, that is not to say that there will be no such requirement in the future.

For the UK NAT FIR NATS plans to offer an ATN compliant AMSS based ATS service circa 2000. The use of HF data link as a back-up service in the NAT is currently under review.

6.1.4 FAA

The FAA is currently working on Version 3 of its NAS System Architecture document which is expected to be approved around the end of 1998. The document will define the FAA plans in all areas of CNS/ATM implementation including the definition of air/ground data technology to be used. The following provides the current status:

- **Mode S for surveillance** - This is currently operational over a significant portion of U.S. airspace. It is planned to be deployed at all major terminals and en-route airspace above 12,000 ft. for all of the U.S. except remote parts of Alaska.

- **Mode S for enhanced surveillance -** Traffic Information Service is scheduled to be operational for terminal airspace with deployment to 119 sites starting in December 1997. The activities for other Mode S specific services are in the R&D phase and focus on FIS applications, such as graphic weather. No specific implementation plans are currently in place.

- **Mode S for data link - T**he FAA is no longer planning on the use of Mode S for data link as an ATN subnetwork. Its use for data link will be limited to Mode S specific services as indicated above.

- **VDL Mode 2 -** The FAA is pursuing an investigation in co-operation with ARINC on the capacity and performance of an ARINC operated VDL Mode 2 ATN subnetwork for supporting the early introduction of air traffic services within the U.S. This is not viewed as the long term solution, but rather a capability to support CPDLC, CM and FIS applications for a limited subset of the U.S. aircraft fleet. In order to use VDL Mode 2 for ATC the FAA consider that it may be necessary to segregate the ATC communications onto different VHF channels from the AOC due to the lack of priority support in VDL Mode 2.

- **VDL Mode 3** - This is still in the R&D phase and remains a candidate for the next generation voice and data system for the U.S. national airspace system.

- **VDL Mode 4** - The FAA has evaluated STDMA for ADS-B at Atlanta and a report is expected later this year. The FAA may also include a limited of evaluation of STDMA for ADS-B as part of their proposed, but as yet unfunded, Flight 2000 project. The FAA has yet to issue an official position on VDL Mode 4. For the ADS-B application Mode S extended squitter is the technology selected for the RTCA MOPS for the near term ADS-B capability. It also is the baseline ADS-B technology proposed for the Flight 2000 project, however both UAT and STDMA may also be evaluated on a limited basis. From the U.S. industry side, UPS is equipping their cargo aircraft with Mode S extended squitter, STDMA and UAT and will be conducting an evaluation of the three alternative ADS-B technologies. These aircraft will also be equipped with Mode S based Traffic Information Service (TIS) and cockpit displays for traffic information that will combine the ADS-B and TIS information.

6.2 Communications Service Providers

It is expected that both ARINC and SITA will be in a position to offer a VDL Mode 2 compliant service in Europe circa 2000. In general it can be expected that availability of

such services will be dictated by the demand for and availability of operational Mode 2 compliant avionics systems.

ARINC plan to be offering ACARS services in Europe in the near term with the objective of migrating these services to VDL Mode 2, subject to customer demand. SITA are participating in the EURO VDL Mode 2 project as indicated above in section 5.2.

7. Implementation Issues

Though outside the scope of this work package this chapter identifies some of the key issues that require to be addressed/resolved in order to implement, operate and use of the air/ground subnetworks.

7.1 VDL Mode 2

With respect to VDL Mode 2 implementation the following questions need to be addressed/resolved:

- Will the ATSOs deploy their own VDL Mode 2 ground infrastructure or will the they use the services of International Aeronautical Communications Service Providers (IACSPs) ?
- Is it technically possible to have both the CAAs and the IACSPs implementing VDL Mode 2 subnetwork services ?
- What should be the required number and the location of VDL Mode 2 ground stations to be deployed to achieve the global coverage of the ACCESS geographical area ?
- What are the detailed plans of IACSPs for VDL ground infrastructure deployment (number and location of GRS) ?
- How can it be ensured that the VDL Mode 2 implementation strategy ensures integration into the ATN infrastructure ?
- How can it be ensured that the performance of VDL Mode 2 will be sufficient to meet ATS end-to-end performance requirements in the context of the European environment taking into account foreseen traffic loads ?

7.2 AMSS

With respect to AMSS subnetwork, primarily in the context of the NAT environment, the following questions need to be addressed/resolved:

- What are the possible and likely scenario for the provision of the AMSS service ?
- Will the service be provided by the existing consortia (Skyphone, Satellite Aircom) or will the CAAs directly interconnect their A/G BIS with ground GES and establish direct agreement with GES operators ?
- Which GES (Aussaguel, Goonhilly, others ...) will be used ?
- Which ATSOs will implement A/G BISs with access to the satellite subnetwork ?
- What is the aircraft operator view on the use of AMSS for ATS via IACSPs with whom they have agreements ?
- What is the most appropriate charging/billing mechanism that should be implemented for the AMSS service ?

8. Overall Conclusions & Recommendations

Within the timeframe of the ACCESS project (i.e. up to 2010), taking into account various factors surrounding the selection of a technology for the provision of air/ground services including:

- foreseen requirements for air/ground data communications services;
- status of standardisation of the various air/ground technologies;
- assessment of their performance capabilities;
- planned coverage;
- plans/policies of ATS providers, aircraft operators (through IATA) and communications service providers;

It is concluded that the preferred primary air/ground subnetwork be VDL Mode 2 providing that it can be demonstrated that such a network deployed within Europe will be capable of maintaining the required Quality of Service for the forecasted level of demand. This is particularly significant due to the lack of a priority handling function in Mode 2. It is therefore recommended that appropriate studies and simulations are undertaken to assess whether a VDL Mode 2 service will be capable of meeting the QoS requirements for the forecast level of ATS demand in the European Region.

It is further concluded that there is not as yet a common European view on the successor to VDL Mode 2 implementation.

The Work Package was unable to conclude on a recommendation for a specific back-up air/ground subnetwork other than to endorse the conclusions of the ST15 study which listed the options as being Mode S, VDL Mode 4 (STDMA) or Data 3 AMSS. It is consequently recommended to further study these options in order to identify the most suitable taking into account the specific needs, plans and constraints of the European region.

Finally, it is recommended that the conclusions of this Work Package are revisited once the ICAO AMCP:

- report on the assessment/comparative analysis of data links has been finalised;
- and their report on the applicability of LEO/MEO satellite services in support of ATS communications is finalised.

9. Reference

ACCESS Reference	Title	Date Reference Added	Notes
[A001]	ACCESS Work Breakdown Structure	07/08/97	Latest Version
[A201]	ACCESS WP201 Deliverable: Current Communications Infrastructure Version 2.1	08/04/98	Final Version
[A202]	ACCESS WP202 Deliverable: Geographical Area and Application Services Proposed for the European ATN Version 2.0	08/04/98	Final Version
[A203]	ACCESS WP203 Deliverable: Definition of the European ATN Routing Architecture - Option 1	08/04/98	Final Version
[A203A]	ACCESS WP203A Deliverable: Definition of the European ATN Routing Architecture - Option 2	08/04/98	Latest Version
[A204]	ACCESS WP204 Deliverable: Definition of ATN Ground-Ground Subnetworks	08/04/98	Latest Version
[A205]	ACCESS WP205 Deliverable: Definition of ATN Air-Ground Subnetworks	08/04/98	Latest Version
[A206]	ACCESS WP206 Definition of Addressing Plan Version 1.0	08/04/98	Final Version
[A207]	ACCESS WP207 Performance Analysis & Dimensioning	08/04/98	Latest Version
[A220]	ACCESS WP220 deliverable: Proposed Solutions to Third Party Service Provision Issues	08/01/98	Latest Version
[CEC1]	COPICAT - Users Requirements and Expectations - Edition 1.1, CEC DGXIII, February 1997	09/06/97	WP102 REF13
[CEC2]	COPICAT - Economic and Technical Assessment of ATN Deployment in Europe - Executive Summary - Edition 1.1 - 29/11/96	18/06/97	WP102 REF12
[CEC3]	COPICAT - Technical Aspects - Edition 1.1 - 10/02/97	18/06/97	WP102 REF14
[CEC4]	COPICAT - Economic Assessment & Proposed ATN Organisation - Edition 1.1 - 10/02/97	18/06/97	WP102 REF15
[CEC5]	PRESTATN Phase 1 Report - ATN Requirements Assessment, Version 1.1, February 1996	18/06/97	WP102 REF22

ACCESS Reference	Title	Date Reference Added	Notes
[CEC6]	PRESTATN Phase 2 Report - Survey of ATN Related Activities, Version 1.1, February 1996	18/06/97	WP102 REF23
[CEC7]	PRESTATN Phase 3 Report - ATN Recommendations for Future Activities, Version 1.0, February 1996	18/06/97	WP102 REF24
[CEC8]	EOLIA Project Deliverable D21 - ATC Datalink Service Definition - Issue B2 - 30/08/1996	18/06/97	WP102 REF25
[CEC9]	TENS Euro VDL Mode 2 - <TBD>	07/08/97	
[CEC10]	ADS Europe - Final Trials Report - ERP07 - December 1996	07/08/97	
[CEC11]	Requirements Analysis - A Review of the Safety Aspects of the ProATN - Ref ProATN/NATS/D12.4/97/022 - Version 0.2	08/01/98	
[CEC12]	A Preliminary Safety Assessment of two EOLIA Datalink Services: ATIS and DSC - EOL/WP2/NATS/069/DE22/C/0.A - 18/03/98	08/04/98	
[CEC13]	A Preliminary Safety Assessment of EOLIA Datalink Services - EOL/WP2/NATS/050/D22/C/1 - 12/12/97	08/04/98	
[EAT1]	Application Requirements for Data Communications Services, Edition 1.0, EUROCONTROL, December 1995	09/06/97	
[EAT2]	EATCHIP 2370 Task 5, Inventory of Existing Ground Data Networks, Final Report, Issue 2, EUROCONTROL, April 1993	09/06/97	WP102 REF5
[EAT3]	EATCHIP 2370 Task 5, Inventory of Planned Data Networks in the ECAC Area, Final Report, Issue 2, EUROCONTROL, March 1994	09/06/97	WP102 REF6
[EAT4]	EUNIS WP1000 Report, Inventory of Ground Data Networks, Issue 2, EUROCONTROL, February 1996	09/06/97	WP102 REF7
[EAT5]	EUNIS WP2000 Report, Inventory and Profile Description of Ground Data Applications, Issue 2.0, EUROCONTROL, February 1996	09/06/97	WP102 REF8
[EAT6]	EUNIS WP3000 Report, Network Interconnection Analysis, Issue 1.1, EUROCONTROL, November 1996	09/06/97	WP102 REF9

ACCESS Reference	Title	Date Reference Added	Notes
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[EAT8]	COM.ET2.ST15 - Analyse Options for Initial Air/ground Data Networks - Phase 3.1 Report - <Date TBD>	07/08/97	
[EAT9]	Quality of Service for Data Network Applications - Stage 2 - Define Service Level - Edition 0.3 - September 1995	18/06/97	WP102 REF3
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[EAT11]	EUNIS WP 4000 Report - Network Interconnection Specification - Issue 1.0 - October 1996.	18/06/97	WP102 REF10
[EAT12]	Operation Requirements For Air/Ground Air Traffic Management (ATM) Data Communications Services - Edition 0.f - 31/03/1997	18/06/97	WP102 REF19
[EAT13]	COM.ET2.ST15 - Analyse Options For Initial A/G Data Networks - Phase 1 Report: Inventory and Analysis of A/G Applications And Data Networks - Edition 0.7 - 12/04/1996	18/06/97	WP102 REF20
[EAT14]	COM.ET2.ST15 - Analyse Options For Initial A/G Data Networks - Phase 2 Report: Criteria Selection and Options - Edition 2.1 - 13/03/1996	18/06/97	WP102 REF21
[EAT15]	COM.ET2.ST15 - Analyse Options For Initial A/G Data Networks - Phase 2 Report: Criteria Selection and Options - Edition 2.2 - 15/05/1996	07/08/97	
[EAT16]	Report of EATCHIP COM-T/9 Drafting Group on the Feasibility of ATSO Data Network Service Integration - Date <TBD>	07/08/97	
[EAT17]	COM.ET2.ST12 - Future VHF Systems	29/08/97	
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[ECA2]	2nd JWG EUROCAE WG53/RTCA SC-189 Meeting (Seattle) - 2-6/06/97	19/01/98	
[ECA3]	5th EUROCAE WG53/RTCA SC-189 SG2 Meeting (Redondo Beach) - 9-13/02/98	08/04/98	
[EUR1]	Preliminary EUROCONTROL Test of Air/Ground data Link (PETAL) Final Report - Operational Air/Ground Datalink Trials Description, Conclusion, & Recommendations (Volumes 1, 2 and 3) - Version 1.0 - 21 August 1996	18/06/97	WP102 REF11
[EUR2]	IDRP Convergence Modelling Study: Final Report - Version 1 - 15/03/1996	18/06/97	WP102 REF17
[EUR3]	ATN Islands and Homes IDRP Convergence Modelling Study: Final Report - Issue 2.1 - 8/01/1997	18/06/97	WP102 REF18
[EUR4]	POEMS <TBD>	07/08/97	
[EUR5]	[141] EUROCONTROL , Satellite Communications and ADS Strategy, Annex A to Working Paper CE94/175/21	29/08/97	
[EUR6]	Revised Minutes of the 7th Meeting of the SATCOM/ADS Expert Sub-Group - 15-16/3/94 - Brussels	25/09/97	
[EUR7]	ATN Internet Project (ATNIP) - RAF User Requirements Document (URD) - DED1/ATNIP/RAF_URD/DEL/5 - Issue 3.0 - 20/06/97	19/01/98	
[EUR8]	ATN Internet Project (ATNIP) - URD Input Document Assessment - DED1/ATNIP/RAF_URD/DOC/02 - Issue 1.0 - 28/08/96	19/01/98	
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[ICA1]	EUR CIDIN Manual, European and North Atlantic Office of ICAO, January 1996	09/06/97	
[ICA2]	AMCP WGD Study 1 - <TBD>	18/07/97	

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[ICA3]	AMCP WGD Study 2 - <TBD>	18/07/97	
[ICA4]	ADS Panel - ICAO Manual of Air Traffic Services (ATS) Data Link Applications	15/08/97	
[ICA5]	ATN Panel - Annex 10 - Volume III - Part 1 Chapter 3 (ATN) - Sub-Volume II - ATN Air-ground Application SARPs.	15/08/97	
[ICA6]	ATNP WG1 WP8-5, Validation of ATSC Traffic Classes, March 1997	29/08/97	
[ICA7]	REPORT FROM THE AD HOC WORKING GROUP ON HF DATA LINK, Draft Version 2.0, Issue date: 27 January 1996	29/08/97	
[ICA8]	ATN SARPs - Sub-Volume 5 - Internet Communications Service	23/09/97	
[ICA9]	Guidance Material for the ATN Internet Communication s Service SARPs - Issue 2.0	23/09/97	
[ICA10]	Doc ICAO 9505 - AN/956 - Manual of Technical Provisions for the ATN - Sub-Volume 4 - Upper Layer Communication Services.	08/04/98	
[ICA11]	CAMAL Comprehensive ATN Manual	08/04/98	
[ICA12]	Doc ICAO 7910/78 - Location Indicators -ICAO - 78th Edition - May 1995	08/04/98	
[ICA13]	Doc ICAO 8585 - AN/956 - Designations for aircraft operating agencies, aeronautical authorities and services - 94th Edition - March 1995.	08/04/98	
[ICA14]	Doc ICAO 9505 - AN/956 - Manual of Technical Provisions for the ATN - Sub-Volume 3 - ATS Message Handling Service (AMHS).	08/04/98	
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[LUX2]	Course Notes, FDE ICD Part 1, E. Cerasi, EUROCONTROL Institute Luxembourg, April 1997.	09/06/97	
[LUX3]	Course Notes, Radar Data Networks, M. Houben, EUROCONTROL Institute Luxembourg, April 1997	09/06/97	
[SAT1]	Satellite Communications and Ground Earth Station Institutional Issues Study, Final Report, Version 1.0, EUROCONTROL SATCNS WG, December 1995	09/06/97	WP102 REF16