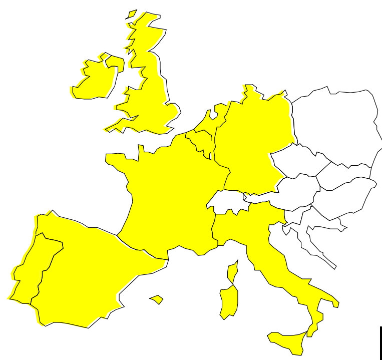
ATN Implementation Feasibility Studies
CEC TEN-T ATM Task 1996-GB-94-S



Final Report of the ATN Compliant Communications Strategy Study (ACCESS) Project

ACCESS

FINAL REPORT

Programme	European Commission Funded Trans European Networks for Transport (TEN-T)
Project Name	ATN Compliant Communications European Strategy Study (ACCESS)
Task Number	ATM Task 1996-GB-94-S
Deliverable Title	Final Report
Deliverable Version	Issue 1.0
Date Prepared	April 1999
Internal Reference	ACCESS/NATS/301/WPR/116
Project Manager	Brian Dennis

DOCUMENT APPROVAL

Title	Signature	Date
Brian Dennis Project Manager, NATS		27.4.99
R Johnston Director Infrastructure Services, NATS		May 99.
G Dickhaut Head of Telecommunications, DFS		28/4/99
D Azema Director of STNA-Toulouse, STNA		28/4/99

The work described herein has been undertaken by the author(s) as part of the European Community ACCESS project, within the framework of the TEN-T programme, with a financial contribution by the European Commission. The following companies and administrations are involved in the project: National Air Traffic Services (NATS), Deutsche Flugsicherung (DFS) and Service Technique de la Navigation Aérienne (STNA).

EXECUTIVE SUMMARY

1. Study Objectives and Participation

The "ATN Compliant Communications - European Strategy Study" (ACCESS) project was undertaken between January 1997 and March 1999 by National Air Traffic Services Ltd (NATS), the Service Technique de la Navigation Aérienne (STNA) and the Deutsche Flugsicherung (DFS) and part-funded from the European Commission's programme for financial aid in the field of Trans-European Networks - Transport (TEN-T).

As TEN-T ATM Project 1996-GB-94-S, "Aeronautical Telecommunications Network Implementation Feasibility Studies", the main objectives of the study were:

a) Development of an ATN Architecture;

b) Development of an Implementation Plan in the European core area in conjunction with EUROCONTROL;

c) Interoperability and validation trials between States using ATN-compliant ATS Message Handling Services.

The geographical area considered in the ACCESS study comprised the following countries: Belgium, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain and the United Kingdom. However, the architectural principles proposed in this Study are also applicable to the whole European area.

The ICAO ATN SARPs and Guidance Material explain the origin and purpose of the ATN as follows:

The Aeronautical Telecommunication Network is an integral part of the CNS/ATM concept and has been designed to provide data communications services to Air Traffic Service provider organisations and Aircraft Operating agencies for the following types of communications traffic:

a) air traffic services communication (ATSC);

b) aeronautical operational communications (AOC);

c) aeronautical administrative communication (AAC); and

d) aeronautical passenger communication (APC).

The ATN is distinguished from other data communication systems because it:

a) is specifically and exclusively intended to provide data communication services for the aeronautical community, including ATS providers/users, the aeronautical industry and airline passengers;

b) provides communication services between ground and airborne systems as well as between multiple ground systems, whereby various mechanisms within the communication system (e.g. route selection) are transparent to the user;

c) provides a communication service which has been designed to meet the security and safety requirements of the application services;

d) accommodates various classes of service and message priorities required by various ATN applications; and

e) uses and integrates various aeronautical, commercial and public data networks into a global aeronautical communication infrastructure.

2. Target ATN Architecture

The initial part of the ACCESS study proposes a "Target ATN Architecture" for 2010 in a European core area. The purpose of first defining a Target Architecture for 2010 was to ensure that the design of a long term European ATN would be undertaken using principles that ensure optimal network performance into the future. Given an optimal Target Architecture to aim for, a transition path can be defined that directs local ATN development initiatives towards the Target Architecture, thus the separate elements of the network evolve within a co-ordinated design.

2.1 Target ATN Services

The introduction of datalink in the ATS environment will provide ATS users (aircrew, controllers, ground ATS systems, etc.) with a large range of new services based on exchanges of data between aircraft and ground systems. These services will relieve pilots and controllers of repetitive tasks that are suitable for partial automation and will provide them with access to information that is not available to them in the current voice communication environment. The use of datalink is seen as the most effective way for ATS to handle the increasing global traffic capacity in the longer term. Datalink can reduce the workload for aircrew and controller, and optimise the use of the voice channel and the remote and dynamic availability of aircraft or ground parameters.

The ACCESS study considered those datalink services being defined in international groups and considered whether they were likely to be deployed within the Target ATN by 2010. The maturity of Standards and operational benefits, such as workload and provision of new information, were some of the selection criteria used.

2.2 Target ATN Infrastructure

One of the important decisions in the definition of a 'Target ATN Architecture' for the European Region is the selection of suitable air/ground subnetworks to support air/ground datalink communications. Issues that affect the selection include: the ability of a subnetwork to meet operational performance, reliability and coverage requirements; the maturity of the subnetwork standards; the availability of products; the capital cost of deployment; the ongoing revenue costs after deployment, and ownership of the subnetworks.

The ACCESS study considered the ATN air/ground subnetworks that have been standardised in ICAO SARPs, and concluded that the VHF Digital Link Mode 2 subnetwork (VDL Mode 2) would be the primary air/ground subnetwork used in the ACCESS area. The back up subnetwork would be a combination of the Aeronautical Mobile Satellite Service (AMSS) and Mode S for communication purposes.

The existing packet-based national ground communications subnetworks are capable of meeting the ATN quality of service requirements now and for the foreseeable future. The expected development of international WAN services and the evolution of switching technologies and products will provide further interconnectivity and capacity options without compromising the overall ATN architecture.

2.3 Target ATN Routing Organisation

The routing architecture of the ATN is defined in terms of Routing Domains, Routing Domain Confederations and ATN Islands[1] and the interconnection of these at a National, European and global level. It was accepted from the beginning that the defined architecture could not be

[1] These terms are defined in ICAO ATN SARPs. They refer to the grouping of ATN systems (routers and ESs) into so-called 'domains' which share common addressing space and common policy rules as regards the exchange of routing information.

implemented immediately, but the aim of defining a target architecture for 2010 was to allow States and Organisations to work towards this target architecture as their own ATN Infrastructure is deployed. The consequences of a State ATN deployment without a coordinated high level plan would be the development of a non-optimal ATN with the associated cost and performance penalties.

2.3.1 European ATN Routing Architecture

The European ATN should consist, at the highest level, of one single, global European ATN Island, complemented by an independent, separate European "Home" Routing Domain Confederation (RDC) which hosts the home Routing Domains of the European Airlines. Dividing this European ATN Island into several sub-islands allows the routing update rate, a key performance parameter, to be maintained within acceptable limits. The ACCESS routing architecture proposes the division of the Target European ATN Island into three sub-regions:

1. A Western ATN sub-region, which covers the oceanic area and most of the core area;
2. An Eastern ATN sub-region, which covers a part of the core area, and south-east European countries;
3. A Northern ATN sub-region, which covers Scandinavia and countries around the Baltic Sea.

2.3.2 Routing Organisation for Airlines and Communication Service Providers

It is expected that Communication Service Providers (CSPs) will be major providers of the AOC data transfer service. However, some Air Traffic Service Organisations (ATSOs) may open their own ATN ground networks to the transit of AOC traffic.

The Routing Organisation for this element of the ATN infrastructure was out of the scope of the ACCESS study.

2.4 European ATN Naming and Addressing

The ATN internetwork address is used to uniquely identify and locate a given network service user within the context of the ATN. The ATN SARPs define the structure of the ATN internet address and, within that address format, some of the address fields are left for Regional and National allocation.

The ACCESS Study developed an addressing scheme that is fully compliant with the Target ATN routing architecture and this addressing scheme proposes the field allocations for the European Area. In addition, the ACCESS Study has proposed naming and addressing schemes for the ATN applications hosted in ATN End-Systems.

2.5 System Management and Security

The solutions proposed for the European ATN have been developed with consideration to the current ICAO/ATNP activities.

The ACCESS Study considered performance management, troubleshooting, configuration changes and accounting. It has concluded that a co-ordinated system management with the distribution of system management responsibilities among organisations can be achieved with minimum changes to the traditional network management approach. The responsibility for the management of the national ATN is left in the hands of the ATSOs (and other ATN organisations), while responsibilities for the co-ordination of some inter-domain system management activities (e.g. accounting management) are vested in a central co-ordination entity.

On ATN security, the study concluded that a security framework based upon the use of security keys and digital signatures to ensure the authentication and integrity of the ATN messages was required. Secured exchanges of ATN application level messages, ATN system management messages and ATN routing information will be necessary and a distributed Public Key

Infrastructure (PKI) dedicated to the European ATN operation will be required. These technical provisions will depend on a well-defined security policy, which regularly assesses the overall security process.

3. Transition to ATN

Due to the many factors that may influence the deployment of ATN in the longer term, the study has concentrated on the transition towards an Initial ACCESS ATN. This decision reflects the current perspective of the aeronautical community who are more concerned with the first steps that are required to initiate the deployment of the ATN.

3.1 Current ATN Initiatives

The first ATN deployments in the ACCESS area are the ATN infrastructures that have been developed in the context of national/regional initiatives or European pre-operational ATN projects. These will result in the deployment of components of an ATN network (e.g. ATN routers, VDL stations, etc.) on future operational sites. These first initiatives or projects have started in a context where no well-defined and co-ordinated ATN deployment programme exists at the European level. The ACCESS Study is intended to facilitate the production of such a programme.

3.2 From Current Initiatives towards the Initial ATN

It is expected that the initial stages of a wide scale ATN deployment in Europe will be based on the incremental expansion of the "local" datalink services that have demonstrated their operational benefit to their users. This pre-Target ATN is known as the 'Initial ATN' and will consist of a coherent regional ATN infrastructure. The ACCESS Study has assumed it will be completed by the 2005 timeframe. It is envisaged that a European ATN implementation programme that integrates these early implementations will drive this deployment. To meet increasing datalink communication needs, this programme will require ATN stakeholders (and more particularly ATSOs) to make commitments at the highest level.

3.2.1 Initial ACCESS ATN Infrastructure

The Initial ACCESS ATN infrastructure will be driven by the requirements of the initial ATN services and by the technical, economical and organisational constraints/trends inherent to the overall ATS context. An example of this is the current trends affecting the air/ground aeronautical communication market, which is migrating from ACARS to VDL Mode 2 for AOC purposes. This migration is not directly bound to the ATN development.

Ground Subnetworks

It is not realistic for cost, organisational and political reasons to assume that a *new* and *dedicated* network infrastructure will be implemented in Europe to support the ATN trans-national communications. Instead, it is expected that ATN ground subnetworks will be mainly supported by *existing* (and evolving) infrastructures (either for national or trans-national communications). The European-wide connectivity offered by the European ATSO Network (EAN) will therefore be particularly beneficial for the Initial ATN deployment.

Air-Ground Subnetworks

Two types of air/ground subnetworks are envisaged for the Initial ACCESS ATN: VDL Mode 2 and AMSS subnetworks. The VDL Mode 2 capability will be provided by Communication Service Providers (CSP) in the Initial ACCESS ATN.

The ATN Datalink Server

The introduction of datalink in the ATM environment assumes a new systems architecture approach for ATC centres. The concept of a new system dedicated to support datalink services (the "datalink server") is being studied in Europe and, whilst it is only one option for the introduction of datalink functionality, it is the only solution likely within the initial ACCESS timeframe. A datalink server is a ground communication management unit responsible for the air/ground datalink communications with the aircraft. This system would be configured by each ATSO to support one or several communication technologies appropriate for the operational services provided.

Initial ATN Routing Organisation

The ATN Administrative Domain of an ATSO may consist of one single Routing Domain or may be divided into several local Routing Domains. It is difficult to say more on the internal ATN routing organisations of the ATSOs in the ACCESS area in 2005, as they are very dependent on local requirements and constraints. It is anticipated that each ATSO will form one single Routing Domain Confederation (RDC) which hides the detail of its internal routing organisation to the adjacent ATSOs.

Considering the limited number of Air/Ground Boundary Intermediate Systems (BISs) that will be deployed, the limited number of ATN-equipped sites, and the relatively limited number of ATN-equipped aircraft in 2005, it can be assumed that very simple routing organisations will be sufficient and suitable for the support of the routing traffic.

ATN Routers

The availability of ATN ground and air/ground routers is a prerequisite for the initial deployment of the ATN ground network infrastructure. This covers both technical (availability of operational ATN-conformant routers with appropriate administrative and/or management tools) and economical (availability of distribution channels with appropriate maintenance and support services, availability of a licensing policy, etc.) aspects.

Given the specific requirements and constraints of the aeronautical community (e.g. certification, quality of service requirements, etc.) and of the ATN itself, it is generally assumed that ATN systems will be developed by a limited number of manufacturers.

In the light of the current situation and trends of the ATN router market, the following deployment scenario is anticipated for the initial ACCESS ATN deployment:

1. Up to 2001: deployment of several first generation[2] BISs, for example ProATN BISs, in Europe in the context of ATN or datalink experimental or pre-operational projects (use of CNS/ATM 1-compliant products);
2. Up to 2005: the deployed first generation BISs used in pre-operational projects will be used as fully ground-based operational routers. Within this timeframe, it is likely that the second generation[3] BISs, e.g. the RRI-based ATN BISs, will appear on the market, so that a mixture of first generation and second generation routers may appear in Europe up to 2005. Moreover it is possible that second generation routers will progressively substitute first generation routers in parallel with a CNS/ATM-1 to CNS/ATM-2 transition.

It is important that the ATSOs, Airlines and other agencies encourage the development and deployment of second generation, purpose built ATN Routers to benefit from increased functionality and volume production discounts.

[2] First generation BISs are considered to be those whose functionality is primarily software, provided on COTS workstation products.

[3] Second generation BISs are considered to be those whose functionality is coded into standard router platforms, for example the RRI BIS.

Aircraft Equipage

The ATN equipage of aircraft is a critical factor in the deployment of ATN and a major cost component because:

- the potential number of aircraft that can be equipped is large, this can represent a major financial investment for the Airline Operators, especially if the ATN equipment is accompanied by the simultaneous installation of new onboard communication equipment (e.g. VHF Digital Radio (VDR));
- the process of integrating new equipment onboard is made more difficult due to the specific constraints affecting airborne systems (e.g. certification, establishment of new operational procedures, etc.).

System Management

In the period up to 2005, some initial management co-ordination requirements will need to be fulfilled. The first priority in the implementation of cross-domain system management functions is likely to be related to the real-time exchanges of trouble tickets and performance data for co-ordinating fault and performance management activities, and to basic off-line exchanges of configuration and accounting information. In this period, it is unlikely that an ICAO SARPs compliant solution for the cross-domain exchange of management information will be available for operational implementation and it is therefore expected that some ad hoc solutions, based on available commercial products, will be introduced.

Security

It is expected that the CNS/ATM-1 products will not integrate any of the ATN standardised security mechanisms. These should be available at a later stage through the CNS/ATM-2 products and include ATN upper layers' security mechanisms, Inter Domain Routing Protocol (IDRP) authentication, system management security functions, which essentially deal with the protection of ATN communications. However, the available security measures will still include aspects such as physical protection, access control, system security, etc.

3.2.2 Organisational Aspects

This study focused on technical issues; however, organisational aspects are of great importance for the successful deployment of the ATN in Europe. The co-ordination required for deployment of the Initial ATN and the required organisational model should ideally result from a European programme set up for the deployment of operational datalink applications and of the supporting ATN infrastructure across Europe. This programme can only be effectively instigated through the high-level commitments of ATSOs to develop datalink and ATN activities.

3.2.3 Safety

The ACCESS study has defined two distinct ATN transitional phases. The first is the implementation of local initiatives of datalink services, which can be introduced relatively independently by individual States. The second is a coherent ATN infrastructure offering a range of datalink services covering multiple Flight Information Regions (FIR) and States. Local implementations will use existing procedures adopted for other safety critical systems to provide the necessary safety assurance to the regulating authority. The coherent infrastructure will require coordination of safety activities between States who will need to adopt consistent criteria for the introduction of systems into service. This may require the development of an internationally agreed standard to cover specific implementations and metrics defined to ensure that consistent system acceptance criteria are employed across the institutional boundaries.

3.2.4 Third Party Service Provision

There is an increasing general trend for businesses to improve efficiency by identifying those non-core services/functions, which may be outsourced to a third party service provider. In the case of an ATSO the core service is clearly the provision of the operational Air Traffic Services (ATS), which requires a number of supporting services (e.g. data communications between ATCCs). In today's environment such support services are typically provided by the ATSOs themselves, i.e. "in-house" provision. However, as the aeronautical community moves towards the implementation of the CNS/ATM system it is necessary for the users (ATSOs and Airlines) to consider the issues involved in the provision of the support services required by the future ATM environment. A major issue is whether users should provide these services themselves, or contract them out to a third party service provider.

ACCESS has identified that a number of points/segments exist in the end-to-end ATN communications service/architecture where an ATSO may elect to contract a CSP. Furthermore, the Study provides guidance on a method by which a CSP may be managed by a Service Level Agreement (SLA).

3.2.5 Institutional Issues

In general the efforts of the ATSOs supporting the ATN are currently devoted to the elaboration of a technical architecture and its implementation planning. However, the results of these necessary activities cannot be realised unless they are complemented by the proposition of adequate solutions for the organisational, institutional and economical aspects, which are tightly coupled. The feasibility of the ATN implementation plan proposed by ACCESS is likely to be undermined unless the essential institutional and/or non-technical enabling activities can also be accomplished in a timely way.

It is beyond the scope of the ACCESS project to resolve institutional issues such as the need for ATN regulation. However, by taking a more pragmatic approach, ACCESS has examined the mechanisms required to put the technical building blocks in place to enable an Initial ATN to be implemented. For example, the use of third party communications service providers and the development of detailed service level agreements to control and manage this relationship; the development of techniques to enable the end-to-end "certification" issue to be addressed through a modular approach to the construction and maintenance of system safety cases. During this part of the study, no conflicts or constraints have been identified between specific institutional issues studies such as the ATNII Study [CEC16, 17], and the technical approach taken by ACCESS.

4. ATN-Compliant Message Handling Services Interoperability and Validation Trials

During the initial planning of the ACCESS Project, it was anticipated that systems suitable for ATS Message Handling Services (ATSMHS) interoperability validation trials would become available during the project timeframe as a result of national planning activities and Eurocontrol initiatives. However, the subsequent timing changes to these activities have meant that such testing has not been possible during the timeframe of the ACCESS Project. It was therefore decided to complete the work to define ATSMHS Interoperability and Conformance testing and to postpone the trials and testing activities until such time as sufficient systems become available. The result of this work is a framework for the establishment and conduct of interoperability trials between two or more AMHS equipments, and for specific conformance testing activities on individual AMHS equipments. These interoperability and conformance test environments can be used by States or other organisations as the basis for testing. This will expedite the efficient operational introduction of such systems in the future.

4.1 Interoperability Testing

The Interoperability Trials should cover the following aspects of interoperability testing:

a) protocol testing;

b) functionality testing;

c) resilience testing;

d) performance testing;

e) control and monitoring service testing;

f) addressing scheme testing.

It was noted that security testing would not be possible until the ongoing specification of ITU-T X.509 compliant security services for the AMHS, particularly to support authentication, has been completed. The X.500 and security specification is not scheduled to complete within the timeframe of this project.

4.2 Conformance Testing

Although interoperability testing is appropriate for the testing of the ATS Message User Agent and the ATS Message Server it is recommended that, in addition, conformance testing is conducted on new implementations of the AFTN/AMHS Gateway for the following reasons:

- The Gateway has been specified for the first time in [ICA14] and represents a new set of functions;
- Various manufacturers are implementing the functions specified in [ICA14] for the first time;
- No well-tried, established procedures exist yet for conformance testing and type approval of implementations of the AFTN/AMHS Gateway.

5. Conclusion

The definition of the Target ACCESS ATN for the European core area allows guidelines and principles to be set down for services, infrastructure and routing to ensure an optimal network evolution. Given a target to aim for, a transition path can be defined that directs local ATN initiatives towards this target and ensures that separate elements of the network evolve within a co-ordinated design.

The establishment of an Initial ACCESS ATN is a key stage in the deployment of ATN-based services within Europe. This Initial ATN will be based on the following principles:

- A well-defined subset of the ATN applications will be required to support an initial set of ATM services (e.g. ATC Communication Management (ACM));
- The initial ground ATN subnetwork architecture will make extensive use of the evolving European ATSO Network (EAN);
- Initial VHF Datalink capability will be mainly provided by third party service providers with optional AMSS backup;
- The ATN naming and addressing scheme proposed by ACCESS will be used;
- Initial Systems Management & Security procedures will be based on existing (and evolving) best practices and commercially available products.

A number of specific actions have been identified in this Report which will facilitate transition towards Initial ATN[4]. However service deployment is expected to be more gradual and evolutionary than originally envisaged and specific dates have to be treated with caution. It is also noted the industry trends for ATN-based support of non-ATSC (e.g. AOC) data services will be influential in determining the general rate of initial ATN systems and services deployment.

The ACCESS project has made an active contribution to, and received comments and contributions from, other ATN implementation planning groups, in particular the EATCHIP ATN Implementation Task Force (ATNI-TF) to establish the basic building blocks for ATN implementation in a core European area. The next stages will depend on the collective will of the Stakeholders.

[4] A more detailed list of actions has been identified in the ACCESS 'Transition Planning' report.

Table Of Contents

1. INTRODUCTION 15

1.1 Study Objectives and Participation 15

1.2 Project Conduct and Report Structure 15

1.3 Overview of the ATN 16

2. TARGET ATN ARCHITECTURE 18

2.1 Target ATN Services 18

2.2 Target ATN Infrastructure 19

2.2.1 Air/ground subnetwork selection 19

2.2.2 Ground/ground subnetwork selection 20

2.2.3 ATN Routing Architecture 21

2.2.4 European ATN Naming and Addressing 27

2.2.5 System Management and Security 28

3. TRANSITION TO ATN 31

3.1 The Initial ACCESS ATN 31

3.2 Current ATN Initiatives 31

3.3 From Current Initiatives towards the Initial ATN 32

3.3.1 General 32

3.3.2 Initial ATN Services 32

3.3.3 Initial ACCESS ATN Infrastructure 34

3.3.4 Organisational Aspects 45

4. KEY ISSUES 46

4.1 Safety Assessment & Certification 46

4.2 Third Party Service Provision 47

4.3 Life Cycle Costs 48

4.4 Performance Analysis & Dimensioning 49

4.5 Institutional Issues 51

5. ATN-COMPLIANT MESSAGE HANDLING SERVICES INTEROPERABILITY AND VALIDATION TRIALS 53

5.1 Introduction 53

5.2 Conformance versus Interoperability Testing 53

5.3 Interoperability Testing 54

5.3.1 Scope 54
5.3.2 Interfaces 55
5.3.3 Scenarios 56
5.3.4 Test Specification 58
5.3.5 Test Schedule 60
5.3.6 Use of Test Tools 61

5.4 Conformance Testing 61
5.4.1 The Need to Perform Gateway Conformance Testing 61
5.4.2 AFTN/AMHS Gateway 61
5.4.3 Conformance Testing Strategy 62
5.4.4 Conformance Tests 62

5.5 Complete Test Specifications 63

6. CONCLUSIONS AND RECOMMENDATIONS 64

APPENDICES

Appendix 1: ACCESS Deliverables and References 67

Appendix 2: Glossary and Definitions 70

Appendix 3: ATN Overview 73

Appendix 4: ACCESS Addressing Plan 75

LIST OF TABLES

Table 5-1: Gateway Normal Condition Test Scenarios 59
Table 5-2: Gateway Abnormal Condition Test Scenarios 59
Table 5-3: Message Server Normal Condition Test Scenarios 60
Table 5-4: Message Server Abnormal Condition Test Scenarios 60
Table 6-1: Summary of Specific Actions to Facilitate Transition towards an Initial ATN 66
Table A1-1: ACCESS Work Package Deliverables 67
Table A1-2: ACCESS Final Report References 68

LIST OF FIGURES

Figure 2-1: Proposed overall Routing Architecture for the European ATN 21
Figure 2-2: Proposed Internal Routing Architecture of the European ATN Island 22
Figure 2-3: Proposed basic ATN architecture in a European sub-region 24
Figure 2-4: Baseline ATN infrastructure in Airports 25
Figure 2-5: Baseline ATN infrastructure in ACCs 26
Figure 3-1: VDL Mode 2 Coverage in 2005 36
Figure 3-2: Location of ATN Datalink Servers in the Initial ACCESS ATN 38
Figure 3-3: Proposed Overall Architecture of the Initial ACCESS ATN 41
Figure 3-4: Initial ACCESS ATN Backbone 41
Figure 5-1: Schematic distinction between interoperability and conformance testing 54
Figure 5-2: Interoperability Interfaces 56
Figure 5-3: Configuration 1 - gateway to gateway 57
Figure 5-4: Configuration 2 - gateway to message server 57
Figure 5-5: Configuration 3 - message server to gateway 58
Figure 5-6: Configuration 4 - message server to message server 58
Figure 5-7: Configuration 5 - user agent to message server 58
Figure 5-8: Logical structuring of the Gateway 62
Figure A3-1: The ATN Concept 74

1. Introduction

1.1 Study Objectives and Participation

The "ATN Compliant Communications - European Strategy Study" (ACCESS) project was undertaken between January 1997 and March 1999 by National Air Traffic Services Ltd (NATS), the Service Technique de la Navigation Aérienne (STNA) and the Deutsche Flugsicherung (DFS) and part-funded from the European Commission's programme for financial aid in the field of Trans-European Networks - Transport (TEN-T).

As TEN-T ATM Project 1996-GB-94-S, "Aeronautical Telecommunications Network - Implementation Feasibility Studies", the main objectives of the study were:

a) Development of an ATN Architecture;

b) Development of an Implementation Plan in the European core area in conjunction with EUROCONTROL;

c) Interoperability and validation trials between States using ATN-compliant ATS Message Handling Services.

At the commencement of the ACCESS Project, the draft ICAO Standards and Recommended Practices for the "CNS/ATM-1 Package" were nearing completion. Whilst these Standards addressed issues related to inter-operability of systems, States contemplating ATN implementation would still need to coordinate on the tasks such as network topology, addressing, routing, safety, security, management, *et cetera*, before the ATN could be deployed. This study is intended to facilitate that coordination task.

The geographical area considered in the ACCESS study comprised the following countries: Belgium, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain and the United Kingdom. These States were chosen for the following reasons:

a) They had a direct connection to the European Central Flow Management Unit and/or were involved in the control of North Atlantic traffic;

b) The study was representative of both Oceanic and Continental ATC.

However, the architectural principles proposed in this Study are also applicable to the whole European area.

Similarly, whilst the ATN is designed to accommodate all aeronautical communications, the ACCESS Study concentrated on those directly related to the provision of Air Traffic Services (ATS). The other users of the ATN were not ignored, but the resulting network architecture does not consider those user requirements. However, this does not invalidate the design of the ATN in this study.

1.2 Project Conduct and Report Structure

The ACCESS Study was undertaken in two main parts, an ATN Infrastructure part and an ATS Message Handling Service (ATSMHS) part. The ATN Infrastructure part was further broken down into three phases which addressed the ATN Network Architecture, Network Implementation Issues and Transition to the ATN. The work was managed as a series of work packages (see Appendix 1, Table A1-1), which were summarised into Interim Deliverables as each part or phase ended.

This document, "The ACCESS Final Report", is aimed at managers in the aeronautical industry and consequently is at a less technical level than the underlying work packages from which it is produced. The structure of the report is as follows:

Section 1.3 provides a very short introduction to the ATN concept.

Section 2 describes the proposed architecture of the European ATN in 2010, which the ACCESS Study refers to as the 'Target ATN'.

Section 3 describes the transition from the existing ATS infrastructure to the 'Target ATN' Infrastructure, concentrating on the initial steps required in the short to medium term.

Section 4 describes key issues that the ACCESS Study considered important to the deployment of an ATN Infrastructure, such as safety issues and life cycle costs.

Section 5 describes the work carried out on ATSMHS Interoperability and Validation.

Section 6 contains the conclusions and recommendations of the ACCESS Study.

Appendices are provided which contain references, definitions, a glossary, a longer overview of the ATN and the proposed European ATN Addressing Scheme.

During the course of the Study, the consortium representatives have worked closely with the EATCHIP ATN Implementation Task Force (ATNI-TF). Issues and ideas have been discussed and exchanged, implementation planning material has been submitted and reviewed. The ACCESS Project Team would like to recognise and thank the ATNI-TF participants for their contribution to the Study and, also to thank the ATNI-TF Chairman for his coordinating role between ACCESS and other related activities, in particular the recent ATN Institutional Issues (ATNII) Study for the European Commission.

1.3 Overview of the ATN

The ICAO ATN SARPs and Guidance Material ([ICA9] and [ICA11]) introduce the ATN as follows:

The 1993 ICAO Future Air Navigation Systems (FANS) Committee created the global communications, navigation, and surveillance/air traffic management (CNS/ATM) systems concept which identified the use of data communications and satellite-based systems as the two major areas of improvement to the then existing systems. The Aeronautical Telecommunication Network is an integral part of the CNS/ATM concept.

The ATN has been designed to provide data communications services to Air Traffic Service provider organisations and Aircraft Operating agencies for the following types of communications traffic:

a) air traffic services communication (ATSC);

b) aeronautical operational communications (AOC);

c) aeronautical administrative communication (AAC); and

d) aeronautical passenger communication (APC).

From a data communication users point of view, the ATN offers a reliable, robust and high-integrity communication service between two computer systems (End Systems), either at a fixed location such as an ATS unit, or mobile location such as an avionics end system, while taking into account requirements (e.g. transition paths, end-to-end delay etc.) expressed by supported applications. The ATN is distinguished from other data communication systems because it:

a) is specifically and exclusively intended to provide data communication services for the aeronautical community, including ATS providers/users, the aeronautical industry and airline passengers;

b) provides communication services between ground and airborne systems as well as between multiple ground systems, whereby various mechanisms within the communication system (e.g. route selection) are transparent to the user;

c) provides a communication service which has been designed to meet the security and safety requirements of the application services;

d) accommodates various classes of service and message priorities required by various ATN applications; and

e) uses and integrates various aeronautical, commercial and public data networks into a global aeronautical communication infrastructure.

2. Target ATN Architecture

The initial part of the ACCESS Study proposes a "Target ATN architecture" for 2010 in the Core European Area. This Target ATN Architecture would need to be defined in terms of:

- the subnetworks that would be used, both the air/ground subnetworks and the ground/ground subnetworks;
- the types of ATN End-systems that would be deployed and their locations;
- the types and locations of the ATN Routers (also called Intermediate Systems, ISs) that would need be deployed;
- a routing architecture and addressing scheme to link the physical systems into an ATN Internetwork;
- a system management and security framework.

The purpose of first defining a Target Architecture for 2010 was to ensure that the design of a long term European ATN would be undertaken using principles that ensure optimal network performance into the future. Given an optimal Target Architecture to aim for, a transition path can be defined that directs local ATN development initiatives towards the Target Architecture, thus the separate elements of the network evolve within a coordinated design.

2.1 Target ATN Services

The introduction of datalink in the ATS environment will provide ATS users (aircrew, controllers, ground ATS systems, etc.) with a large range of new services based on exchanges of data between aircraft and ground systems. These services will relieve pilots and controllers of repetitive tasks that are suitable for partial automation and will provide them with access to information that is not available to them in the current voice environment. The use of datalink is seen as the most effective way for ATS to handle the increasing global traffic capacity in the longer term. Datalink can reduce the workload for aircrew and controller, and optimise the use of the voice channel and the remote and dynamic availability of aircraft or ground parameters.

The ACCESS Study considered those datalink services being defined in international groups and considered whether they were likely to be deployed within the Target ATN by 2010. The maturity of Standards and operational benefits, such as workload and provision of new information, were some of the selection criteria used.

The conclusion is that in the Target ATN environment:

- push back and taxiing phases will be monitored through datalink dialogues;
- ADS will provide additional surveillance for oceanic regions;
- the transfers of communication and exchanges of usual clearances and pilot acknowledgements, which take up much of the pilot and controller work time, will be automated (e.g. departure clearances);
- consistency between the controller clearances and the aircraft's path will be monitored more precisely, for instance through the comparison of the onboard flight plan and the ground-based one;
- Automated Flight Information Services will be available to the aircrew at any time, including ATIS, RVR and SIGMET;
- Ground systems will be able to process up-to-date data coming from the aircraft and provide increased assistance to the controllers for detecting conflict situations and raising alarm warnings;

- on the ground, ATC co-ordination messages will transit through ground networks via AIDC protocols and the usual AFTN/CIDIN traffic will gradually be handled by ATS MHS systems.

Although the ACCESS Study only considered Air Traffic Services (ATS), it is widely expected that many ATN-based AOC services will be developed and that these will have a significant influence on ATN deployment.

2.2 Target ATN Infrastructure

2.2.1 Air/ground subnetwork selection

One of the important decisions in the definition of a Target ATN Architecture for the European Region is the selection of suitable air/ground subnetworks to support air/ground datalink communications. Issues that affect the selection include; the ability of a subnetwork to meet operational performance, reliability and coverage requirements; the maturity of the subnetwork standards; the availability of products; the capital cost of deployment; the ongoing revenue costs after deployment, and ownership of the subnetworks.

The ACCESS Study considered the ATN air/ground subnetworks that have been standardised in ICAO SARPs, namely:

- the Aeronautical Mobile Satellite Subnetwork (AMSS);
- the Mode-S subnetwork;
- the VHF Digital Link Mode 2 subnetwork (VDL Mode 2);
- the HF Digital Link subnetwork (HFDL).

Note - Other technologies are emerging for further air/ground subnetworks, for example further VDL modes and LEO/MEO satellites. It is likely that additional air/ground subnetworks will be deployed before 2010, but insufficient detail is available to determine any deployment architectures. However, it is certain that their deployment will not impact on the overall Target ATN architecture, as the ATN was expressly designed to accommodate new subnetworks without affecting existing infrastructure.

Each of the subnetworks has relative advantages and disadvantages in relation to the operating environment in the study area.

The AMSS subnetwork provides total European coverage and is already deployed. However, it has the longest transit delays (because of the use of geostationary satellites) of those considered, although with a relatively deterministic performance, and it currently has the highest revenue cost in terms of cost per kilobit. It should be noted that European short-haul aircraft are not expected to be equipped with AMSS equipment and consequently the use of AMSS in European airspace will be limited for such flights.

The Mode S subnetwork provides a limited bandwidth service (of the order of 300bps) but with a deterministic, short transit delay. The equipment required to support this service has been prototyped, but is not deployed operationally. There continues to be doubt whether it will be deployed operationally as an ATN subnetwork as it does not currently attract active airline support.

The VDL Mode 2 subnetwork provides a 31.5 kbps bandwidth, but, as it is based upon CSMA technology, it does not provide a deterministic transit delay. It does enjoy strong airline support for deployment, where it is seen as the successor of the ACARS VHF datalink that is in service today. International Communication Service Providers are preparing the deployment of the VDL Mode 2 service, initially to support the airlines increasing Aeronautical Operational Communications (AOC) and Aeronautical Administrative Communications (AAC) requirements.

The HFDL subnetwork provides a 300 bps bandwidth and is being deployed to provide a service in Oceanic and Polar Regions. Its use in high traffic density European areas is not expected, as more effective alternatives will exist.

It was noted that an IATA datalink task force report presented a strong airline preference for VDL based air/ground services. This was understood by the ACCESS Study to mean VDL Mode 2 implementation.

In conclusion, the commercially provided VDL Mode 2 service will be dominant in the provision of ATS datalink services in the deployment of the ATN in Europe. There is a broad consensus that the VDL Mode 2 subnetwork will be the primary delivery media for air/ground datalink communications within the European Region and the ACCESS architecture will be based upon this air/ground subnetwork.

There is no clear consensus on which of the other subnetworks should be the complementary subnetwork for European Airspace. The EUROCONTROL EATCHIP programme, under the COM.ET2.ST15 study, has been assessing the suitability of potential complementary subnetwork candidates e.g. Mode-S and AMSS [EAT8, EAT15 and EAT19]. However, ST15 merely states the suitability of the subnetworks for selected environments; it does not make a recommendation for a specific complementary air/ground subnetwork for Europe.

The scenario for the deployment of VDL Mode 2 is discussed in section 3.3.3.3.1.

2.2.2 Ground/ground subnetwork selection

The selection of suitable ground/ground subnetworks is more certain. The ATN Infrastructure will be deployed to support CM, CPDLC, FIS and AMHS services everywhere in the European Region. It is expected that the ADS service will only be deployed in those areas where existing surveillance coverage requires enhancement.

To support these various datalink services, ATN End Systems (ES) will be widely deployed in ATSO premises e.g. in ACCs, Com-Centres, AIS Offices, CFMU facilities and Met Offices.

These ATN Systems will require local ground subnetworks to provide their communication service. Whilst the selection of the local ground subnetwork technologies is a local implementation issue, with no real impact upon overall ATN Infrastructure architecture, the deployment of ATN Routers (Intermediate Systems) will be required on these subnetworks to provide the interconnection with the off-site peer End Systems. These ATN Routers then require interconnectivity to create the ATN Internetwork.

The initial interconnection of the Intermediate Systems in different Routing Domains is expected to be via the existing Packet Switched Wide Area Networks e.g. CAPSIN, RAPNET, RENAR. The existing PSNs are capable of meeting the ATN requirements for Quality of Service (QoS) now and into the foreseeable future. The interconnection of these national WANs is in progress and the resulting international WAN will be an ideal subnetwork for the interconnection of the national BIS Routers. Further, this will permit both non-ATN systems and ATN End System traffic to share the same infrastructure thus minimising the investment required to establish the ground ATN Internetwork.

Other ATSO ground subnetworks that are planned for deployment in the ATN timeframe can also be utilised as ATN subnetworks. Where international WANs are not currently deployed, the deployment of a high capacity backbone subnetwork is likely to be required.

It is expected that CSP-provided subnetworks will form a significant part of the ground ATN Infrastructure to complement the ATSO element of the ATN, at least for the transport of

AOC traffic.

2.2.3 ATN Routing Architecture

Having determined the ATN services, the air/ground subnetworks and the ground/ground subnetworks that would constitute the European ATN, these elements need to be combined to form the optimal Target ATN Architecture for 2010. This approach enables the definition of a network that will retain its overall stability and performance through to 2010 and beyond.

The routing architecture of the ATN is defined in terms of Routing Domains, Routing Domain Confederations and ATN Islands[5] and the interconnection of these at national, European and global levels. It was accepted from the beginning that the defined architecture could not be implemented immediately, but the aim of defining a target architecture for 2010 was to allow each State and Organisation to work towards this target architecture as their own ATN Infrastructure is deployed. The consequences of State ATN deployment without a coordinated high level plan would be the development of a non-optimal ATN with the associated cost and performance penalties.

2.2.3.1 Overall European ATN Routing Architecture

The European ATN should consist at the highest level of one single and global European ATN Island, complemented by an independent separate European “Home” Routing Domain Confederation (RDC) formed by the Airlines and their telecommunications service providers, which hosts the home Routing Domains of the European Airlines. The proposed overall organisation is illustrated by Figure 2-1.

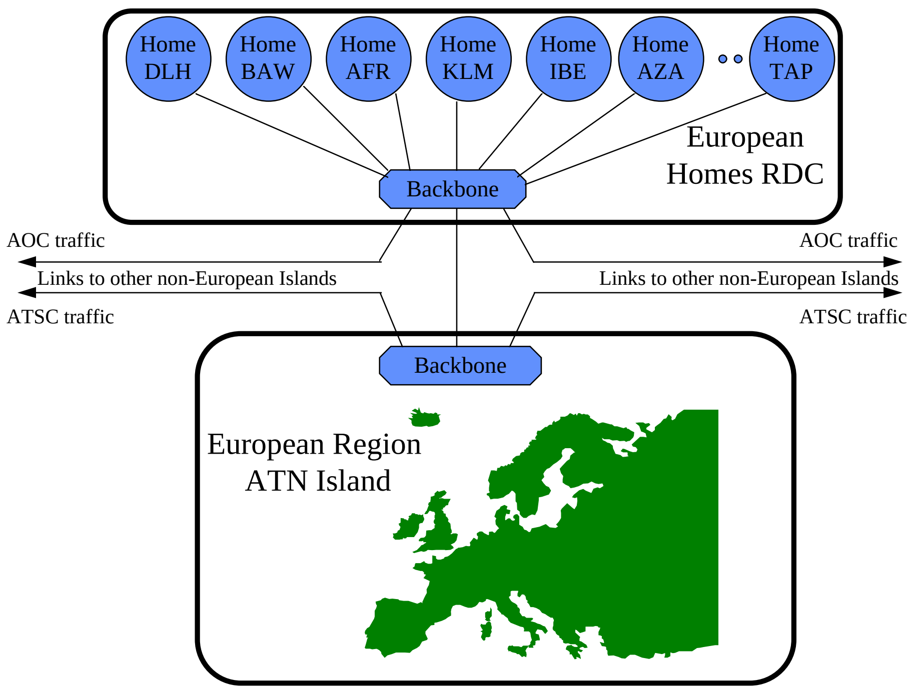


Figure 2-1: Proposed overall Routing Architecture for the European ATN

The “Home” concept is an ATN function which allows one Routing Domain (or one Routing Domain Confederation) to attract and receive all the information on routes to all

[5] These terms are defined in ICAO ATN SARPs. They refer to the grouping of ATN systems (routers and ESs) into so-called ‘domains’ which share common addressing space and common policy rules as regards the exchange of routing information.

aircraft of the associated airline (or of the associated group of airlines). This concept exists for allowing inter-Island communication with aircraft. This facility will mainly be required by airlines to reach their aircraft. Separating the "Home" domains from the European ATN Island alleviates the European ATN Island backbone from the airline specific inter-island routing and data traffic.

2.2.3.2 Internal Organisation of the European ATN Island

Assuming that in 2010, a significant number of aircraft will be ATN-equipped, and on the basis of the results of the "*ATN Islands and Home IDRP Convergence*" study [EUR3], this routing architecture proposes the division of the target European ATN Island into three sub-regions:

1. A Western ATN sub-region, which covers the oceanic area and most of the core area;
2. An Eastern ATN sub-region, which covers a part of the core area, and south-east European countries;
3. A Northern ATN sub-region, which covers Scandinavia and countries around the Baltic Sea.

Each sub-region would form a separate Routing Domain Confederation. These three "Sub-Island RDCs" would be interconnected via an upper level backbone as depicted in Figure 2-2. The exact composition of countries in each sub-island would need to be confirmed as part of detailed implementation planning.

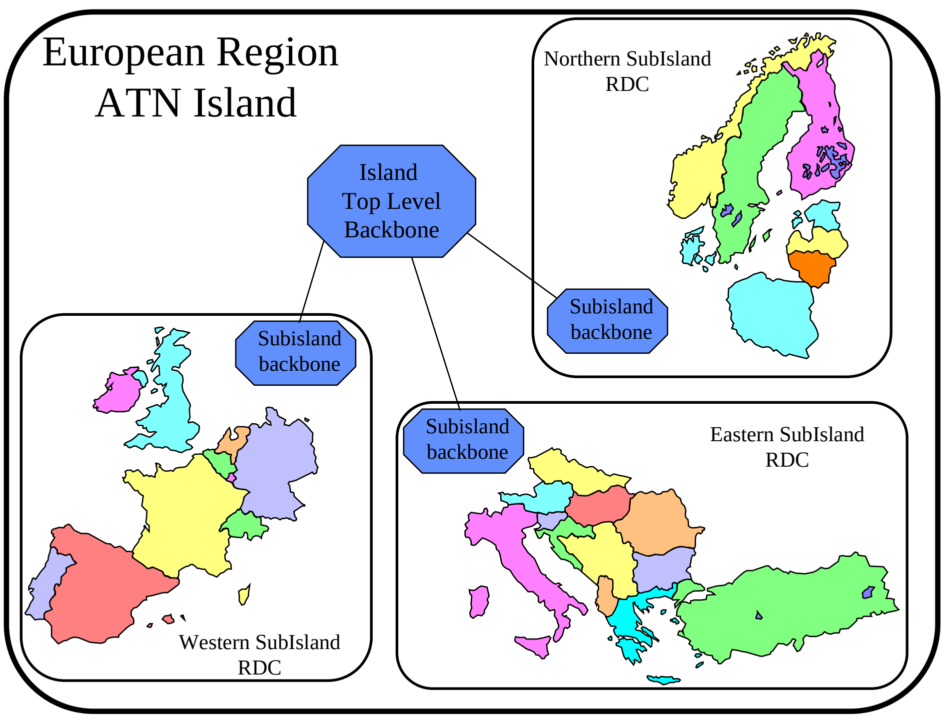


Figure 2-2: Proposed Internal Routing Architecture of the European ATN Island

This architecture allows containment of one of the critical performance parameters of any ATN routing organisation: the routing update rate. Routing updates are generated when aircraft move their network point of attachment to the ground ATN when they connect via new air/ground BISs during their flight. This information is advertised throughout the ground ATN with a routing update message. The routing update rate corresponds to the frequency of the changes in the routing tables of the ATN backbone routers. The purpose of this proposed routing architecture is the minimisation of the number of routing updates in the European Region thus ensuring routing stability because routers are processing and advertising fewer routes to each other.

The ATN can only work effectively if the backbone routers are able to receive and process the routing updates in real time and converge quickly to valid routing decisions. Dividing the European ATN Island into several sub-Islands allows the routing update rate to be limited.

2.2.3.3 Internal Organisation of the European SubIslands RDCs

Each geographical sub-region is considered as a Sub-Island RDC containing its own backbone and the Routing Domains of the different organisations within the sub-region. As a generic scenario it has been assumed that the States will form one Routing Domain around each national ATC Centre and will group all their Routing Domains into national RDCs.

Another assumption is that ATS Organisations will generally not offer their ATS-dedicated ATN networks to serve as transit networks for AOC or long distance ground/ground ATSC traffic (i.e. ATSC traffic between non-adjacent ATSOs). National ATSOs will choose to have their Routing Domain Confederations acting as non-transit RDCs, and will rely on the backbone for multi-national communications. Each national ATS Routing Domain or Routing Domain Confederation will consequently have to be directly connected to the backbone of the Sub-Island RDC.

Within each sub-region, the routing backbone is therefore perceived as a key element for the global routing performance.

To optimise the performance of the backbone it is proposed that a special router, called a route server is used. A route server is a system dedicated to the processing of routing information and which does not participate in the actual user data packet forwarding. A route server is dedicated to the acquisition of the routing information, to the processing and selection of the optimal routes and to the redistribution of these routes to standard ATN routers. This allows the standard ATN routers to focus on switching user data.

The use of a route server allows the optimisation of the routing, minimising the number of router interconnections and avoiding the routing stability problems inherent to meshed topologies.

As a basic proposal, it is recommended that the route server is used in the backbone for the distribution of routes to backbone routers. The resulting basic proposal for the routing architecture within a sub-region is illustrated by Figure 2-3[6].

---

[6] The on-going DFS facility consolidation programme will result in the eventual closure of the Berlin and Dusseldorf centres.

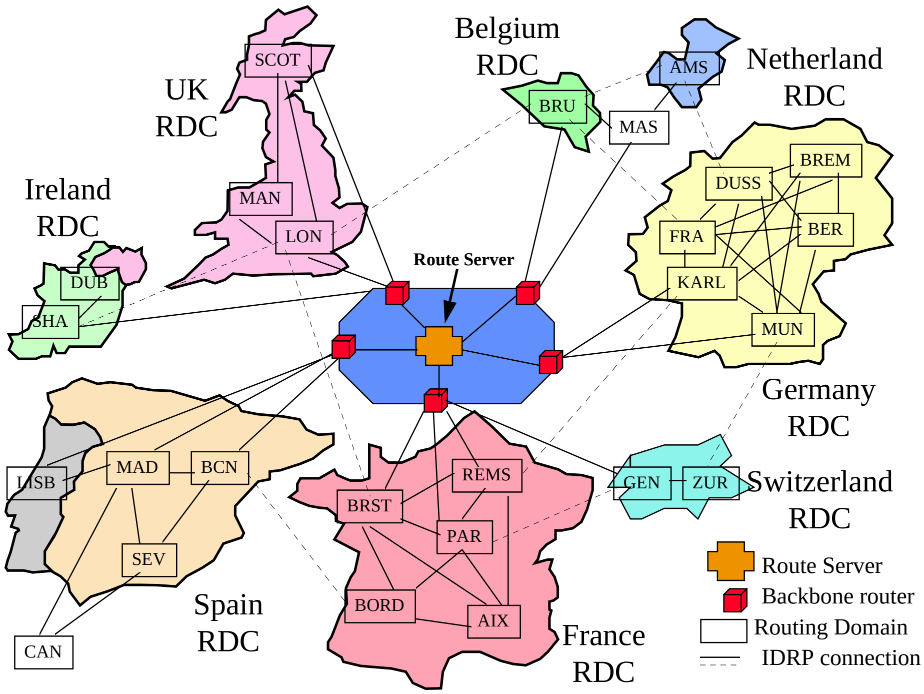


Figure 2-3: Proposed basic ATN architecture in a European sub-region

The use of a route server will also allow the deployment of backbone routers close to (within) the national Routing Domain Confederations, and consequently to shorten the paths between communicating End Systems (ES). In the Western Sub-region, it has been assumed that:

- Germany would operate its own backbone router;
- France and Switzerland could share a backbone router administered by France;
- Spain and Portugal could share a backbone router administered by Spain;
- UK and Ireland could share a backbone router administered by UK;
- The Benelux countries and EUROCONTROL could share a backbone router administered by Eurocontrol.

Clearly this technical proposal would need political endorsement between the States concerned.

It is further proposed to extend the benefits of the route server, beyond the backbone, to the distribution of routes to off-backbone routers.

2.2.3.4 Routing Organisation for Airlines and International Aeronautical Communication Service Providers

It is expected that Communication Service Providers (CSPs) will be major providers of the AOC data transfer service. However, some ATSOs may open their own ATN Infrastructure to the transit of AOC traffic. CSPs (with aircraft operators) are assumed to participate in the implementation of the ATN at the following three levels:

1. At national level, for the provision of general ATN services (e.g. AOC, AAC communication) complementing the services provided by the national ATSO. Depending on the national strategy of the ATSO, CSPs may be contracted for the provision of ATN services meeting local ATS communication requirements;
2. At sub-regional/regional level, CSPs may deploy an ATN infrastructure meeting the

airlines' communication requirements, and potentially completing the regional ATS communication service by offering alternate/backup ATN routes to the aircraft;

3. At inter-regional level, CSPs and airlines are assumed to look after the implementation and interconnection of Home Routing Domains and consequently to participate in the routing and forwarding of inter-island data traffic to/from aircraft.

It is assumed that CSPs and airlines will implement the ATN infrastructure suitable at each level for meeting the particular requirements. The Routing Organisation for this element of the ATN infrastructure was out of the scope of the ACCESS study.

2.2.3.5 ATN Systems Deployment Scenario

2.2.3.5.1 Deployment of ATN Routers

ATN routers will in general be deployed on the sites where ATN applications are run (i.e. the sites that were listed in section 2.2.2). At each of these sites, the ATN routers may be intra-domain routers, ground inter-domain routers (ground BISs) or air/ground inter-domain routers (A/G BISs) depending on the adopted routing organisation and on the air/ground connectivity requirements.

Many pre-tactical and tactical ATS and AOC applications are run at airports. This physical concentration of services makes airports a good opportunity for exploiting the benefits of an ATN-based data communication integration solution. Consequently it is proposed that each airport be equipped with at least two ATN routers:

- an ATS-dedicated ground BIS; and
- a general purpose Air/Ground BIS.

This provision allows establishment of an ATS-only internetworking subset to address different responsibility and liability concerns with respect to ATS applications.

Based on the identified connectivity requirements, the baseline architecture for interconnecting ATN components in an airport is the generic model depicted in Figure 2-4:

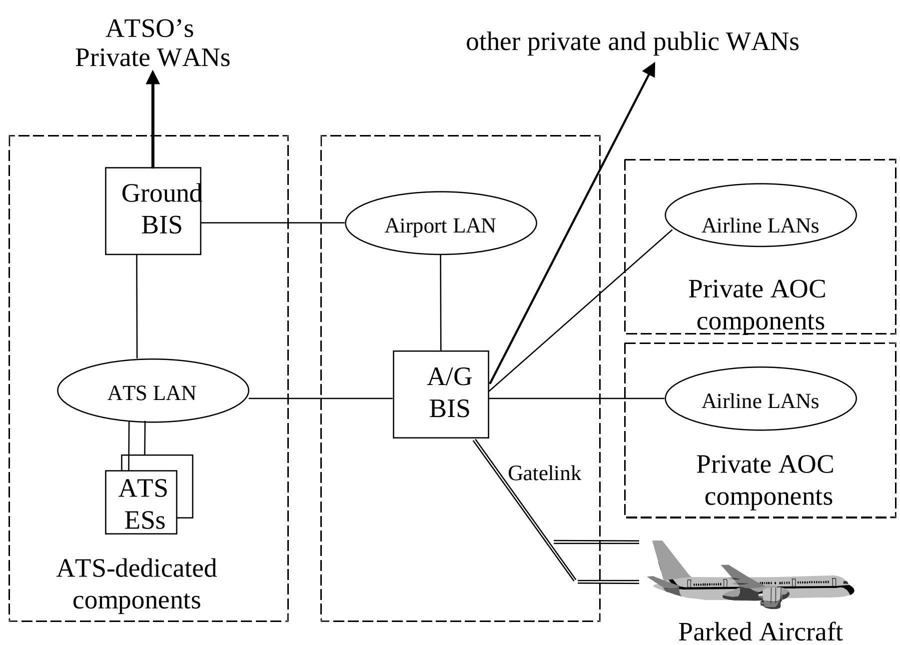


Figure 2-4: Baseline ATN infrastructure in Airports

Each Area Control Centre (ACC) should be equipped with at least one router[7] for interconnecting the ACC LAN(s) to the national ATS WAN.

In ACCs with air/ground connectivity, this router will be an A/G BIS, thus being additionally connected to air/ground subnetworks. If one of the attached mobile subnetworks is authorised for AOC traffic, this air/ground BIS must be connected to a CSP network and/or to other private or public WANs, to allow AOC ATN communication between remote Airline Centre of Operations and the Aircraft.

In ACCs without direct air/ground connectivity, this router may be either an Intra-Domain router or a ground BIS depending on whether the router is at the boundary of a Routing Domain or not.

For an ACC with direct air/ground connectivity, the baseline architecture is the one depicted in Figure 2-5. It is simpler than for an airport as there is only one main user and one category of applications involved.

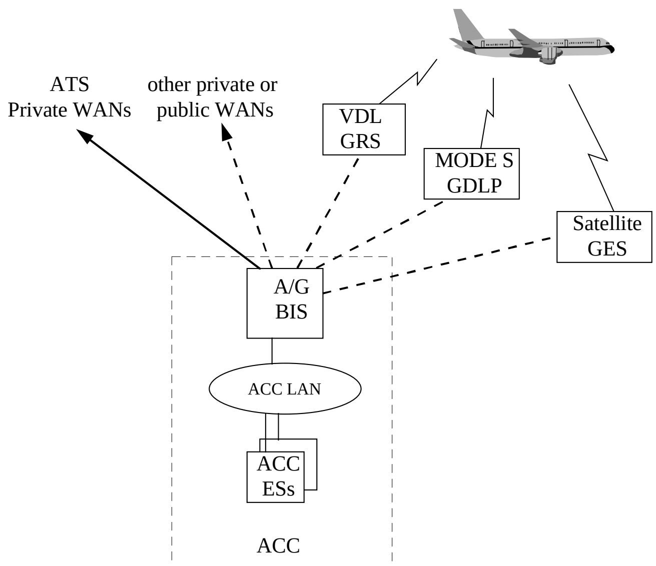


Figure 2-5: Baseline ATN infrastructure in ACCs

Other ATS Sites should be equipped with at least one ATN router for interconnecting the LAN(s) to the national ATS WAN and possibly to other private and/or public WANs if connectivity is required with non-ATS ATN users or to provide air/ground connectivity.

Assuming that these ATS Sites have no direct air/ground connectivity, the router may be either an Intra-Domain router or a ground BIS depending on whether the router is at the boundary of a Routing Domain or not.

2.2.3.5.2 Generic national ATN deployment scenario

Within a given European country, the resulting ATN Architecture proposal for the generic and overall interconnection scenario is as follows:

1. National ATS Organisation
    - An ATS Routing Domain is created in each national ATS RDC around each

[7] There are seven classes of router identified in the ATN SARPs. They are distinguished by the protocols and functionality they support. Different functionality is required for routers that only forward data within their own routing domain compared with those, for example, that forward data between domains over air/ground subnetworks.

national ATC Centre. This Routing Domain encompasses the ATC Centre, and all airports and other possible ATS sites in the related FIR. Within each such Routing Domain, all BISs are directly interconnected with each other, as required by the relevant Standards.

- It is assumed that the national RDs will be directly interconnected with every other national RD by interconnecting the A/G BIS of each ACC with each A/G BIS of the other ACCs.
- The A/G BISs that accept AOC traffic will be interconnected with a BIS of a CSP;

2. National Airport Operator
   - In the main airports, the airport operator will form a Routing Domain (which may contain an A/G BIS offering Gatelink access to the aircraft) consisting of its own ESs, and possibly the ESs of other local non-ATM organisations having a requirement for ATN communication.
   - The Airport Operator's BIS will be interconnected with the local ground BIS of the national ATS Organisation and with a BIS of a CSP. The CSP will accept the transit of all types of traffic to/from the Airport Operator;
3. National Military organisations
   - It is assumed that the military organisations will access the European ATN by direct interconnection with their national ATS Organisation. Secure gateways should be used to provide interoperability between ATN ESs and military operated ESs. It is assumed that the military ESs are located on a secure network operated and managed by the military for operational purposes. The ATN side of the Gateway should act as an ATN ES of the national ATSO, located within the routing organisation of the national ATSO and, as such should appear in the national ATSO ATN addressing plan. The ATSO should be responsible for management of the ATN side. The military organisation should be responsible for the management of the non-ATN side and of the security implications.
4. National Meteorological Service Providers
   - It is assumed that the meteorological organisations will access the European ATN by direct interconnection with their national ATSO. The meteorological ESs should act as ATN ESs of the national ATSO, located within the routing organisation of the national ATSO and as such should appear in the national ATSO ATN addressing plan.
5. Local Aircraft Operators
   - In Airports serving as their centre of operation, the airlines are assumed to implement ESs and form a Routing Domain. They may implement a Ground BIS or prefer to rely on the ATN service provided by an CSP. Airline ground Routing Domains will be interconnected with the local Airport Operator and with the CSP.

2.2.4 European ATN Naming and Addressing

2.2.4.1 European ATN Internetwork Addressing

The ATN internetwork address that is used to uniquely identify and locate a given network service user within the context of the ATN, is called the ATN Network Service Access Point (NSAP) address. The ATN SARPs define the structure of the 20-octet string that forms an ATN NSAP address. Within that address format, some of the NSAP address fields are left for Regional and National allocation.

The ACCESS study developed an addressing scheme that is fully compliant with the Target ATN routing architecture. This addressing scheme proposes the field allocations for the European Area. An overview of this scheme is given in Appendix 4 of this report. More detail is available in the ACCESS Addressing Report.

2.2.4.2 Guidelines for the naming and addressing of applications in European ATN systems

In addition to an ATN Internet NSAP Address, each application hosted in an ATN End System is assigned an application name and an ATN address. The ACCESS Study proposed European ATS application naming and addressing schemes, these are summarised in Appendix 4 and again, more detailed information is available in the ACCESS Addressing Report.

2.2.5 System Management and Security

2.2.5.1 System Management

The solutions developed for the system management of the European ATN have been developed with consideration to the current ICAO/ATNP activities on Systems Management, and take into account current European network management practices and European specific requirements.

Currently, the majority of system management exchanges (and the associated technical, operational and organisational issues) are arranged on a bilateral basis between interconnected States. However, recent developments in network management for two of the main ATS data networks in Europe (the European CIDIN network and the interconnection of European ATSO Packet Switched Networks) have highlighted the need for co-ordinated and dynamic network management between European ATSO data network facilities. It is accepted that overall network management solutions with centralisation of functions are required for efficient co-ordination. Progressive approaches are currently taken for the introduction of these co-ordination functions in the management of the CIDIN and of the ATSO Networks Interconnection.

There are many options for developing an organisation for managing a multi-national ATN network. This could be vested in a central organisation, distributed across all States and organisations, or a combination of the two. The ACCESS Study assumed that States and organisations will wish to keep supervisory and administrative control of their ATN infrastructure, however, it is still necessary for management coordination to occur. In a Region such as Europe, constituted by many inter-adjacent organisations, a centralised co-ordination approach is considered to be more appropriate than a distributed co-ordination approach.

The ACCESS Study considered performance management, troubleshooting, configuration changes and accounting. It has concluded that a co-ordinated system management approach with the distribution of system management responsibilities among organisations can be achieved with minimum changes to the traditional network management approach. The responsibility for the management of the national ATN is left in the hands of the ATSOs, (and other ATN organisations) while responsibilities for the co-ordination of some inter-domain system management activities (e.g. accounting management) are vested in a central co-ordination entity.

It should be noted that there are a number of issues to be resolved, and activities to be undertaken before a satisfactory European system management co-ordination model can be completely specified and implemented. Further activities on the ATN system management subject are detailed below.

1. The development of SARPs on ATN System Management is underway and the SARPs are expected to be completed by ATNP/3 in February 2000. However, since CNS/ATM Package 1 SARPs were completed, many ATSOs have directed their resources to work on the implementation of these SARPs in preference to the development of Package 2 SARPs. This may delay the completion of the SARPs and this situation is a cause for concern. The provision of a full ATN System Management capability is an essential pre-requisite to the longer-term development of the ATN.
2. Resolution of institutional issues on the creation of a central co-ordination body, and production and endorsement by the States of a document specifying the roles and responsibilities of each organisation.
3. Validation of SARPs with implementation and test of SARPs-compliant Network Management Systems.
4. Integration of the SARPs-compliant Network Management System within the Network Operation Centres of the European organisations.

2.2.5.2 Security

There are three high level objectives of security when applied to information systems, these are confidentiality, integrity and availability. A secure system should ensure that information is protected and cannot be modified or manipulated by unauthorised users. In addition, the information must be readily available to authorised users. Prior to any countermeasures being implemented to protect a system, it is necessary to identify the threats.

In the ACCESS context, i.e. the European ATN network, the elements vulnerable to attack are:

- the individual resources of the network: ground and air/ground subnetworks, intermediate systems (BISs and intra-domain ISs), ATN end systems and ATN network management systems;
- the end-to-end communication services provided by the ATN network to ATN user entities[8];
- the ATN administration and network management communication services (e.g. communications between ATN managed resources and network management systems, configuration of ATN resources, etc.).

Security precautions consist of both technical and physical (procedural) provisions, thus allowing countermeasures to be developed and put in place to meet the agreed predefined security objectives. A selection of these provisions is summarised below.

Physical (procedural) provisions include:

1. The physical protection of ATN resources (e.g. ATN ES);
2. User access control to ATN resources;
3. Physical provision to minimise network single points of failure.

[8] The protection of ATN user applications and their possible end users (e.g. controllers, pilots, etc.) is considered to be out of the scope of ACCESS.

(The actual implementation of these provisions will be a local issue and depend greatly on existing security practices at those locations.)

Core technical provisions include:

1. A security framework based upon using security keys and digital signatures to ensure the authentication and integrity of the ATN messages. The European ATN security architecture will be based upon ISO 7498-2 (ITU-T X509 framework);
2. Secured exchanges of ATN application level messages, ATN system management messages and ATN routing information.

Additional technical provisions include:

1. The implementation of a distributed Public Key Infrastructure (PKI) dedicated to the European ATN operation;
2. An associated distributed European PKI repository used for the distribution of relevant security information (public keys etc.).

The technical provisions detailed above will in turn require the definition of additional security objectives and hence more physical and technical provisions. This reiterates the need to define a security policy, which continually assesses the security process and its ability to fulfil its mission.

3. Transition to ATN

One of the main objectives of this study was to define a transition plan to the target European ATN network applicable to the ACCESS geographical area by 2010. However, due to the many uncertainties currently affecting long term ATN implementation objectives and the absence of any expressed commitment from ATN stakeholders to launch ATN-based datalink applications and infrastructures, the study has concentrated on the transition towards an Initial ACCESS ATN. This is based on facts or transition steps that can be reasonably forecast. Evolution beyond the Initial ATN to the Target ATN has not been developed in detail in this study because of the many uncertainties already affecting the earlier phases. Predicting that evolution would be very speculative and would be unlikely to serve any useful purpose. The aeronautical community is more concerned with the first steps required to initiate the deployment of the ATN.

3.1 The Initial ACCESS ATN

The Initial ACCESS ATN can be defined as a coherent Regional ATN infrastructure based on the evolution from local ATN initiatives to implement datalink services. This pre-Target ACCESS ATN has been assumed to be complete by the 2005 timeframe. These local ATN initiatives will demonstrate the benefits of operational ATN-based datalink services and will also provide the foundation for the subsequent development of the initial ACCESS ATN.

The set of initial ground/ground and air/ground ATSC datalink services, as currently identified in the European community as being the best candidates for initial deployment, was used as the basis for definition of the Initial ACCESS ATN. The proposed scenarios are generally based on reasonable assumptions about short-term evolutions of aeronautical communications and/or ATN implementation.

Finally, although the scope of this study is limited to ATSC services, it is likely that AOC services will be an important driver for ATN deployments in the ACCESS area. If Airlines promote the development of AOC applications on top of an ATN/VDL Mode 2 network infrastructure, then this will allow deployment of part of the infrastructure required for the operational use of ATN-based ATSC services.

3.2 Current ATN Initiatives

The first part of the ATN deployment in the ACCESS area is considered to be the set of embryonic ATN infrastructures that have been developed in the context of national/regional initiatives or European pre-operational ATN projects. This will result in the deployment of components of an ATN network (e.g. ATN routers and VDL stations) on future operational sites.

These first initiatives or projects have started in a context where no strictly defined and co-ordinated ATN deployment programme at the European level exists – the ACCESS Study is intended to facilitate the production of such a programme.

These initiatives and projects include Petal II (ATN Extension), EuroVDL and the ongoing AMHS projects. The ATIF, although it will not support operational traffic, will also be influential because it will provide the first elements of the test/integration ATN infrastructure associated to the future operational ATN network. Similarly the CAERAF development will enable candidate operational systems to be tested and verified against a common reference and promote consistent implementation solutions.

The ProATN/EOLIA project was also considered in this study but is not explicitly represented in the transition analysis as it will not directly result in the deployment of ATN components in future operational sites. ProATN/EOLIA is a fundamental initiative for the

European ATN deployment process, its results are expected to:

- help define/study the implementation of datalink services;
- develop ground-based and airborne systems with the capability to become operational systems.

In particular, Petal II (ATN Extension) and EuroVDL should be key drivers for the ATN deployment in Europe as they should demonstrate, in operational conditions, the true benefit brought by datalink applications based on ATN infrastructures and services. It is assumed that the ATN infrastructure elements deployed in operational sites for those projects (VDL Mode 2 ground stations, attached ATN BISs, datalink servers, etc.) will serve as the first elements of the future European ATN.

3.3 From Current Initiatives towards the Initial ATN

3.3.1 General

It is expected that the initial stages of a wide scale ATN deployment in Europe will be based on the incremental expansion of the “local” datalink services (as noted in section 3.1) that have demonstrated their operational benefit to their users. It is envisaged that a European ATN implementation programme that integrates these early implementations will drive the Initial ATN deployment. In order to meet the increasing need for datalink communication, this programme will require ATN stakeholders (and more particularly ATSOs) to make commitments at the highest level.

3.3.2 Initial ATN Services

The ACCESS Study considered the work of various operational groups and projects to identify the most likely Initial ATN ground and air/ground services. This section contains recommendations on both the air/ground services and ground/ground services that can be assumed to be supported by the Initial ACCESS ATN and provided by ATSOs to ATN-equipped aircraft in the ACCESS area by the 2005 timeframe[9]. The main criteria driving the selection of the initial datalink services was to select the services which would provide the best operational benefits to the ATS actors, both ATSOs and airlines.

All ATSOs will not implement the Initial ATN services in the ACCESS area in the same way and at the same time. In order to cope with the required co-ordination to implement distributed services and also to permit the flexibility needed by each ATSO to implement datalink equipment, two levels of implementation planning, at National and Regional level, will be necessary.

It is believed that operational ATN-based services will be first deployed in ATSO domains during the period up to 2005, each ATSO following the implementation timescales and priorities defined in its National Implementation Plan. Subsequently, each ACCESS ATSO will enhance its ATM environment to eventually incorporate its national services into the Regional ATN service.

[9] The dates stated in the ACCESS Study for Initial and Target ATN deployments were considered achievable when the Study commenced. It has since become apparent that the wide-scale deployment of the ATN has significant dependence on institutional and political decisions, which may delay the deployment of some of these services.

3.3.2.1 Initial Air/Ground ATN Services

At the Regional level the planning for the period up to 2005 should consider the following services:

- **CPDLC-based services**. Most ACCESS en-route ATSUs would support the ACM and CIC services. The DCL service should be available in all major ACCESS airports. The oceanic ACCESS ATSUs should support the DSC service;
- **ADAP-services**. The oceanic ACCESS ATSUs should support the APR and FLIPCY services. The ADS ground forward service will not be supported in the initial ACCESS ATN;
- **D-FIS services**. A national or international ATIS server should be identified for each ATSO;
- **DLIC service.** The DLIC service must be available wherever an air/ground service is provided.

Action ACCESS1	**To develop a Regional ATN Service Implementation Plan.**	**All ATSOs & Airlines together (e.g. in the framework of LINK2000+)**

At the National level the planning for the period up to 2005 should consider the following services:

- **CPDLC-based services**. The national plan states which area/approach/tower/ground controllers have access to the CIC and ACM services. The regional plan defines the set of CPDLC messages operationally supported by the ground ATS systems in the initial ACCESS ATN. The location of the CPDLC End Systems (either in the en-route or in the approach ATSU) is defined in the national service profile;
- **ADAP-services**. The decision to have the ACCESS non-oceanic ATSUs supporting these ground-initiated services (APR and FLIPCY) is left to each ATSO;
- **D-FIS services**. Each ATSO is responsible for selecting which airports are covered by the national ATIS server. The way the ATIS information is sent to the national/international FIS server must be defined (there is no FIS ground protocol defined so far);
- **DLIC service.** the national plan contains the list of the adjacent ATSOs with which the ground CM-forward service is operated. It also identifies the approach ATSUs where a CM ATN ES must be installed.

The national implementation planning process will also describe how an ATSO will accommodate or migrate its current operational non-ATN to the ATN environment.

Action ACCESS2	**To develop a National ATN Service Implementation Plan consistent with the Regional ATN Service Implementation Plan.**	**Each ATSO individually**

3.3.2.2 Initial Ground/Ground ATN Services

It is recommended that AMHS be the only ground service assumed to be supported directly by the initial ACCESS ATN. Although the other services could benefit, in principle, from a migration to the ATN, this is not considered to be realistic within the time frame leading up to the appearance of the Initial ACCESS ATN.

The AMHS has been designed specifically with the ATN internet as the underlying network infrastructure in mind and AMHS Message Servers fit well into the category of ATN End Systems. In addition, the existing networks, AFTN and CIDIN, are urgently in need of a long-term development path as part of the future Aeronautical Fixed Service. Interfacing between the AMHS and the AFTN is defined in SARPs, while interfacing between the AMHS and the CIDIN is being defined for inclusion in the CNS/ATM-2 Package SARPs. Furthermore, such interfacing is making progress in a number of implementations.

A Regional AMHS Implementation Plan will be required. All National AMHS Implementation Plans will decide whether the deployed AMHS infrastructure is to be used by native users[10]. Furthermore, it must be consistent with the requirements of the Regional Implementation Plan.

The planning of the future European AMHS is in itself a major task and a separate CEC sponsored study project, SPACE, dedicated to AMHS planning in Europe, has been set up for this purpose.

3.3.3 Initial ACCESS ATN Infrastructure

3.3.3.1 Introduction

The Initial ACCESS ATN infrastructure will result from the following elements:

- the requirements raised by the provision of the initial ACCESS ATN services, as described in the previous section;
- the constraints inherent to the overall ATS context (technical, economical, organisational) that will influence the initial ACCESS ATN. An example of this is the current trend affecting the air/ground aeronautical communication market (i.e. the migration from ACARS to VDL Mode 2 for AOC purposes) which is not directly bound to the ATN development.

3.3.3.2 Ground Subnetworks

3.3.3.2.1 Network Technologies

It is not realistic for cost, organisational and political reasons to assume that a new and dedicated network infrastructure will be implemented in Europe to support the ATN trans-national communications. Instead, it is expected that ATN ground subnetworks will be mainly supported by existing (but still evolving) infrastructures either for national or trans-national communications. The European-wide connectivity offered by the European ATSO Network (EAN) will therefore be particularly beneficial for the Initial ATN deployment.

Around the 2005 timeframe, it is likely that most ATSOs in the ACCESS area will be part of the EAN, with each ATSO providing at least one EAN entry point (several entry points may be provided, e.g. one per ACC). The backbone BISs will be physically attached to the EAN entry points to establish the initial ACCESS ATN backbone.

[10] "Native users" are users that communicate with only AMHS Message Servers rather than via an AMHS/AFTN Gateway. This mode of operation enables the full capabilities of AMHS to be used.

Action ACCESS3	**To ensure that the EAN development and the ATN deployment are compatible (geographic coverage in the ACCESS area, schedules, access requirements, etc.).**	**All ATSOs**

3.3.3.3 Air/Ground Subnetworks

Two types of air/ground subnetworks are envisaged for the initial ACCESS ATN: VDL Mode 2 and AMSS subnetworks (other possible air/ground subnetworks are not considered for the Initial ACCESS ATN).

3.3.3.3.1 VDL Subnetworks

Concerning VDL Mode 2 subnetworks, two strategies were envisioned with respect to their deployment in the ACCESS area:

1. the first is CSP-driven, assuming airlines will require an upgrade of their datalink system from their CSPs to meet their increasing AOC needs, specifically in the core area where ACARS capacity limitations are most felt;
2. the second is ATSO-driven, resulting from a commitment of ATSOs to deploy VDL Mode 2, with appropriate European co-ordination, in order to support their ATSC applications and possibly some AOC flows.

It is expected that the initial deployment of VDL Mode 2 in Europe will be driven by CSPs to meet AOC requirements where they are most critical, i.e. in the European core area. The general deployment of VDL Mode 2 by ATSOs does not look realistic in the short term. Within this scenario it is thought that the ATSOs would own and operate VDL Mode 2 air/ground BISs because that would make it easier for ATSOs to control and ensure the strict QoS requirements of ATSC traffic.

The business strategies of SITA and ARINC for the European market are key factors for VDL Mode 2 deployment. The anticipated VDL Mode 2 deployment scenario may not cover the whole ACCESS area by 2005 and possibly beyond, as a consequence of the commercial considerations of the CSPs who may see no benefit in extending their coverage to certain parts of the Region. The expected VDL Mode 2 coverage in 2005 is illustrated in Figure 3-1 below.

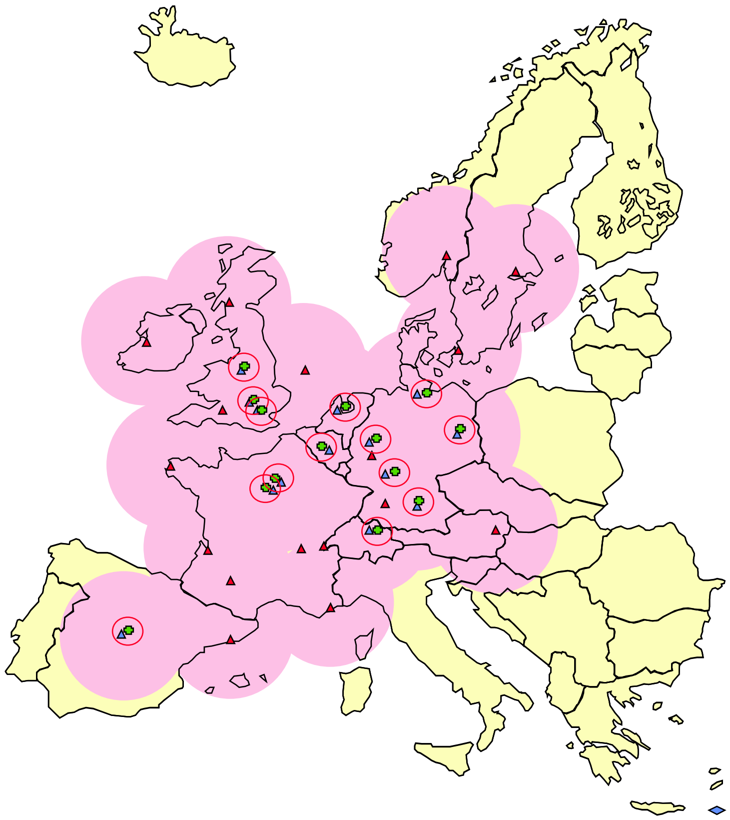


Figure 3-1: VDL Mode 2 Coverage in 2005

Action ACCESS4	**To ensure that CSPs' VDL Mode 2 deployment strategy and activities are compliant with the Regional ATN Service Implementation Plan**	**ATSOs**

3.3.3.3.2 AMSS Subnetworks

AMSS will not be the preferred air/ground subnetwork in Europe. Its use is expected in fringe areas (especially in oceanic regions like the NAT area) and/or for optional backup purposes over the European core area.

The use of AMSS subnetworks is influenced by the subnetwork performance as the long transit delays limit its use in high density traffic areas. Another factor is the relatively high charges currently levied for the use of Inmarsat-based satellite communications. In future, it is likely that various competing LEO/MEO satellite systems (which are currently under development) will become available and these may be proposed for aeronautical use. Although they aim at supporting a broad range of applications, especially in the public mobile telephony field, they could emerge as new competitive candidates for supporting satellite-based ATN subnetworks, provided their suitability for ATSC safety critical communications is verified.

3.3.3.4 ATN Air/Ground End Systems and Datalink Servers

3.3.3.4.1 The ATN Datalink Server

The introduction of datalink in the ATM environment assumes a totally new approach for ATC centres. The concept of a new system dedicated to support datalink services (the "datalink server") is being studied in Europe. Whilst it is only one option for the introduction of datalink functionality, it is the only solution likely within the ACCESS timeframe. A datalink server is a ground communication management unit responsible for the air/ground datalink communications with the aircraft. This system would be configured by each ATSO to support one or several communication technologies appropriate for the provided operational services.

An ATN datalink server is a ground-based system hosting an ATN air/ground ES. The ATN ES provides the ATN "communication" service at the application level, e.g. the CPDLC services, and user software in the server carries out the processing needed to provide the "operational" service, e.g. ACM.

Additionally, in supporting the ATN application protocols and services, the role of the datalink server is to interface the ATN-equipped aircraft or remote ground ATC centres with the local ground ATC systems, e.g. the Flight Data Processing System (in en-route ATSUs), or the Controller Working Positions (en-route and/or approach).

It is expected that the Initial ACCESS ATN architecture will be based on ATN datalink server functionality for ATSC air/ground services. This does not mean that a separate dedicated system must be developed. Some ATSOs could choose to develop a stand-alone ground datalink server system, whereas other may prefer to integrate the functions of the server in existing ATC systems.

It is recommended that the ATN datalink servers be located as follows:

- **A datalink server in all ACCESS continental en-route ATSUs** (i.e. 25 ESs in the ACCESS area) including the CM, CPDLC and ADS applications to support the ATN communication requirements of the DLIC, ACM and CIC services and, optionally, the FLIPCY and DSC services;
- **A datalink server in the ACCESS oceanic en-route ATSUs** (i.e. 3 ESs in the ACCESS area) including the CPDLC and ADS applications to support the ATN communication requirements of the DSC and APR services in addition to the services of a continental en-route ATSU;
- **A FIS/ATIS server per country or set of countries** (i.e. a maximum of 8 ESs in the ACCESS area) to support the ATN communication requirements of the ATIS service. The FIS/ATIS server does not support the DLIC service, so the CM application of any ATSU will return the address of the FIS application for the concerned country;
- **Optionally, a datalink server in the ACCESS approach ATSUs covering the major airports** (i.e. 10 ESs in the ACCESS area) including the CM and CPDLC applications to support the ATN communication requirements of the DLIC, ACM, CIC or/and DCL services.

Figure 3-2 shows one possible deployment scenario for ATN datalink servers in the Initial ATN.

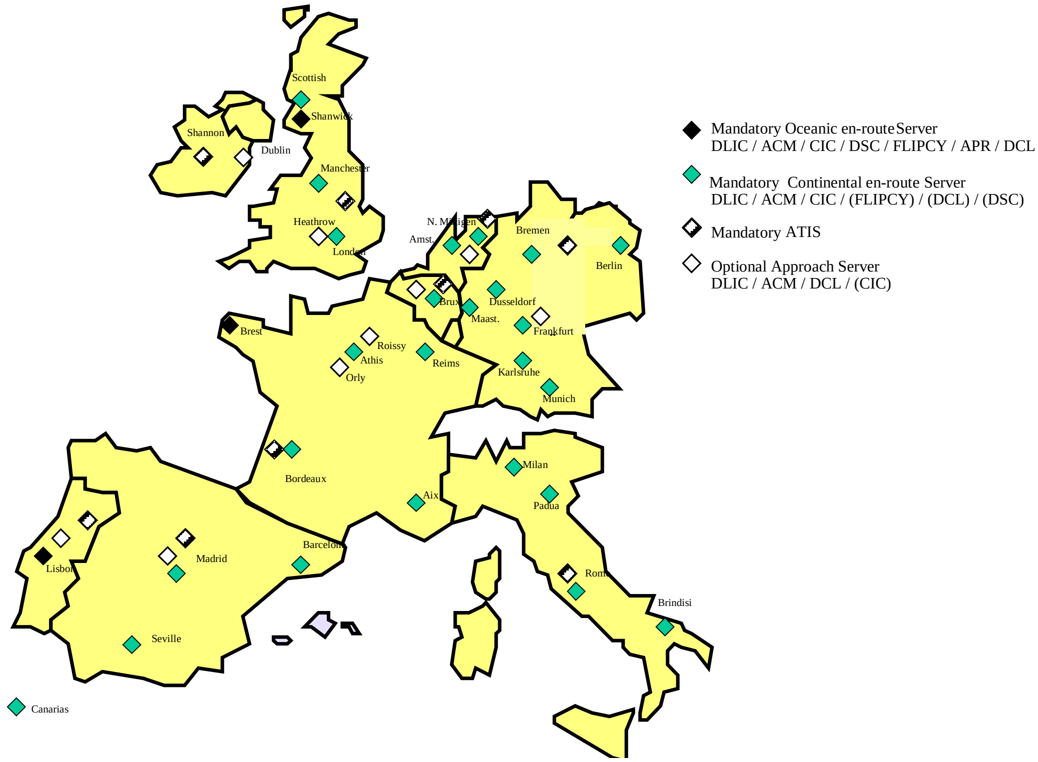


Figure 3-2: Location of ATN Datalink Servers in the Initial ACCESS ATN

Action ACCESS5	**To validate the concept of the ATN datalink server and enable further evaluation at the ACCESS area scale through European datalink programmes**	**All ATSOs (in close coordination with EuroAGDL)**

3.3.3.5 ATC Systems

3.3.3.5.1 General

The provision of ATN datalink services is not limited to the deployment of ATN End Systems and routers. The deployment requires that some of the current ATC systems in the ATN-equipped ATSUs be customised for datalink. It is assumed that the following ATC systems are at least implemented in an ATSU:

– The **Flight Data Processing System** (FDPS) provides in real-time the en-route and approach controllers with the information related to the aircraft they may be interested in. The FDPS is also involved in the aircraft/flight plan association processing, the processing of clearances and the flight plan validation.

– The **Controller Working Positions** (CWPs) are the HMI of the controllers. The datalink is one of numerous new features to be integrated in the new CWPs. Although experimental datalink CWPs are being developed and validated by controllers through European projects (e.g. EOLIA, EOLIA-2, PETAL-2), the time scale for the provision of datalink functions to the controllers is very dependent on the timescale of the replacement of the current ATC equipment.

– The **Radar Data Processing System** (RDPS) displays the air situation based on information received in real-time by the radar stations and the information of the FDPS identifying the aircraft.

- The **ATN Datalink Server** as described above is responsible for the ATN communications with the aircraft and the interface with the existing ATC systems.

Action ACCESS6	**To launch study and development programmes aiming at integrating the datalink capability in the existing and planned operational ATC systems (CWPs, FDPS, etc.)**	**Each ATSO**

3.3.3.6 AMHS Systems

3.3.3.6.1 AMHS as an Intermediate Service

In order to develop a strategy for the implementation of AMHS as a service being supported by the Initial ATN, it is necessary to investigate the way in which it is used and, from this, the demands it places on the ATN.

The AMHS is different from other services considered in this context to the extent that it does not provide a complete "end user" service. In order for services such as Flight Plan or ATFM Transfer to be made available, there need to be additional formats and protocols defined. The exchange of messages within the context of these services remains separate from each other, (e.g. by means of disjoint address spaces). Even the simple exchange of messages among human users, e.g. terminal operators, may need to be well defined as a separate service. The planning of the future European AMHS itself is a major task and a separate CEC sponsored study project, SPACE, dedicated to AMHS planning in Europe, has been set up for this purpose.

3.3.3.6.2 Configuration of the AMHS for the Initial ACCESS ATN

In the initial ACCESS ATN the following principles need to be considered when configuring the co-located ATS Message Servers and AFTN/AMHS Gateways interfacing between the European Region and other Regions:

- The major transit traffic flows need to be identified and accommodated;
- Because of the high availability requirements and importance of the European AMHS as a transit network, sufficient redundancy among the AFTN/AMHS Gateways needs to be provided, as well as alternative routes across the European Region for transit message traffic. This means that, in general, non-European Regions are connected to two Gateways;
- A sufficient number of Gateways needs to be implemented so that the second principle can be applied and their responsibilities distributed appropriately.

3.3.3.7 Initial ACCESS ATN Internet

3.3.3.7.1 ATN Routing Organisation of the ATSO ATN Domains

The ATN Administrative Domain of an ATSO may consist of one single RD or may be divided in several local RDs. It is difficult to say more on the internal ATN routing organisations of the ATSOs in the ACCESS area in 2005, as they are very dependent on local requirements and constraints.

Considering the limited number of Air/Ground BISs that will be deployed, the limited number of ATN-equipped sites, and the relatively limited number of ATN-equipped aircraft in 2005, it can be assumed that very simple routing organisations will be sufficient and suitable for the support of the routing traffic. For most ATSOs in the ACCESS area, one single Routing Domain will be an appropriate initial routing architecture. In large countries comprising several large airports, it could be necessary to split the local ATN domain in two or three Routing Domains so as to divide and distribute the amount of routing information to be processed by the ATN routers.

It is anticipated that each ATSO will form one single Routing Domain Confederation (RDC) which hides the detail of its internal routing organisation to the adjacent ATSOs.

3.3.3.7.2 Routing Organisation for the Initial ACCESS ATN

The European ATN will be divided into two major entities:

- a European Region ATN Island RDC; and
- a separate independent European Homes RDC.

The European Region ATN Island RDC comprises the RDCs of the national ATSOs and the European Region Island's Backbone RD; it is primarily dedicated to ATSC traffic.

The European Homes RDC comprises the other European ATN ground systems. It is formed from the Home Routing Domains of the different European Airline Operators (AOs), the RDs of the airport operators (APOs), the RDs of the international aeronautical communications service providers (CSPs), and the European Homes Backbone RD.

The aircraft themselves are neither contained in the European Region ATN Island or in the European Homes RDC, but form their own independent RDs.

Regarding the interconnection of the European ATN with non-European Islands, the following assumptions are made:

- The European "Region" ATN Island will be directly interconnected with non-European Islands. These interconnections will primarily be used for the exchange of ground/ground ATSC traffic. The European "Region" ATN Island will be interconnected with the European "Homes" RDC. Interconnection between Islands will be established between backbones;
- The European "Homes" RDC will be interconnected with the European "Region" ATN Island and with other Islands on other continents. These interconnections will primarily be used for the exchange of ground/ground and air/ground AOC traffic.

This overall architecture is represented in Figure 3-3.

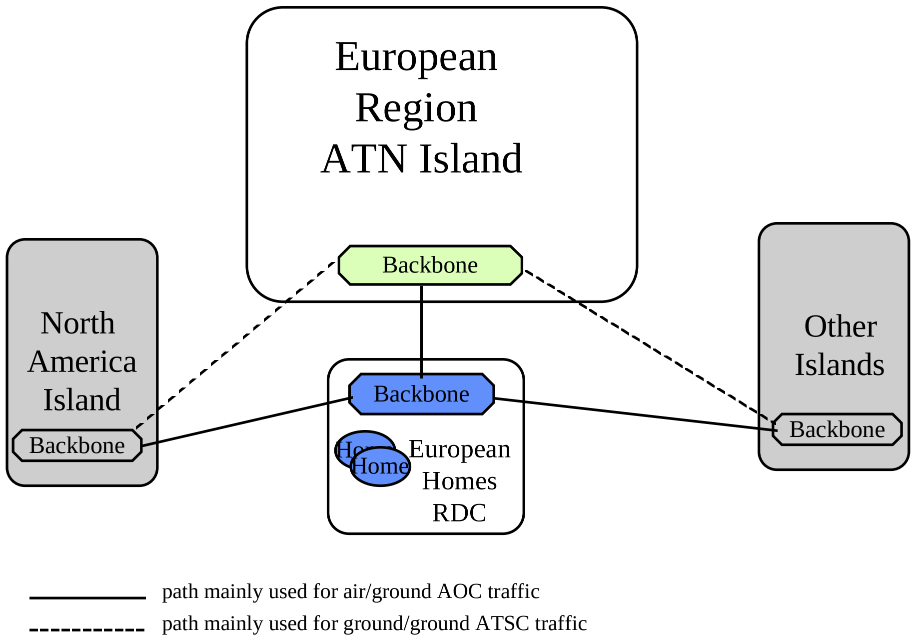


Figure 3-3: Proposed Overall Architecture of the Initial ACCESS ATN

For the initial ATN, the European Region ATN Island will not be divided into multiple sub-regions.

As far as the ATN backbone is concerned, it can be reasonably assumed that:

- a single backbone architecture will be sufficient to meet the performance and connectivity requirements;
- the requirement for route servers (as proposed in section 2.2.3.3 for the backbone of the target European ATN) will not exist at this stage of the ATN deployment in Europe.

Figure 3-4 describes a possible topology for the Initial ACCESS ATN backbone.

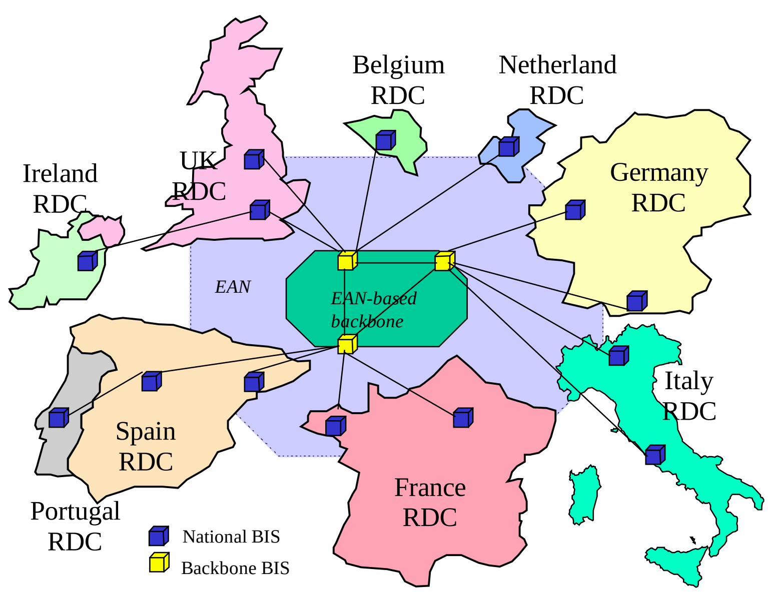


Figure 3-4: Initial ACCESS ATN Backbone

The lines represent the IDRP BIS-BIS connections supported by the underlying EAN infrastructure and used for cross-domain traffic, i.e. the backbone links and the connections of the various RDCs to the backbone. The following assumptions are made regarding that topology:

- between one and three fault-tolerant backbone BISs form the initial backbone at that stage of the ATN deployment. They are interconnected using meshed EAN links. Their location is not specified; it will depend on the interest of ATSOs in the participation to the European ATN backbone infrastructure (this is considered an institutional issue);
- there is at least one national fault-tolerant BIS per ATSO directly connecting the corresponding ATSO RDC to one of the backbone BISs (or indirectly, via a national BIS of a neighbouring ATSO RDC, e.g. Ireland and Portugal). Additionally, it is possible that some RDCs get connected to the backbone by several links (e.g. UK, Germany, France, Spain and Italy);
- the figure does not aim at representing the other national BISs or links that make up the diverse ATSO RDCs.

Action ACCESS7	**To define the European backbone router architecture**	**ATSOs with CSPs**
Action ACCESS8	**To define the various national parts of the initial ACCESS ATN internet (air/ground BIS siting, connection to the backbone, internal topology, etc.)**	**Each ATSO**

3.3.3.8 ATN Routers

3.3.3.8.1 Product Availability

The availability of ATN ground and air/ground routers is a prerequisite for the initial deployment of the ATN ground network infrastructure. This covers both technical (availability of operational ATN-conformant routers with appropriate administrative and/or management tools) and economical (availability of distribution channels with appropriate maintenance and support services, availability of a licensing policy, etc.) aspects.

Given the specific requirements and constraints of the aeronautical community (e.g. certification, quality of service requirements, etc.) and of the ATN itself, it is generally assumed that ATN systems will be developed by a limited number of manufacturers.

In the light of the current situation and trends of the ATN router market, the following deployment scenario is anticipated for the initial ACCESS ATN deployment:

1. Up to 2001: deployment of several first generation[11] BISs, for example ProATN BISs, in Europe in the context of ATN or datalink experimental or pre-operational projects (use of CNS/ATM 1-compliant products);
2. Up to 2005: the deployed first generation BISs used in pre-operational projects will be used as fully operational routers. Within a similar timeframe, it is likely that the second

[11] First generation BISs are considered to be those whose functionality is primarily software, provided on COTS workstation products.

generation[12] BISs, e.g. the RRI-based ATN BISs, will appear on the market, so that a mixture of first generation and second generation routers may appear in Europe up to 2005. Moreover it is possible that second generation routers will progressively substitute first generation routers in parallel with a CNS/ATM-1 to CNS/ATM-2 transition.

It is important that the ATSOs, Airlines and other agencies encourage the development and deployment of second generation, purpose built ATN Routers.

3.3.3.9 Airborne Systems

3.3.3.9.1 Product Availability

No operational ATN airborne system is available at this time. The only known product that is currently targeted at the operational ATN airborne system market is the RRI software of ATNSI/ACI.

Issues surrounding the technical and commercial availability of airborne ATN systems are still unclear today: it is possible that the first ATNSI software products to be ported into avionics systems will be available in 2000. However, onboard integration and ensuing testing and certification of the airborne products may delay the availability of operational ready-to-use airborne systems up to 2003 or later.

3.3.3.9.2 Fleet Equipage

The ATN equipage of aircraft is a critical factor in the deployment of ATN and a major cost component because:

- the potential number of aircraft that can be equipped is large, which can represent a major financial investment for the Airline Operators, especially if the ATN equipment is accompanied by the simultaneous installation of new onboard communication equipment (e.g. VHF Digital Radio, VDR);
- the process of integrating new equipment onboard is made more difficult due to the specific constraints affecting airborne systems (e.g. certification, establishment of new operational procedures, etc.).

The uncertainties affecting the ATN deployment process and the ATSC datalink applications in general are largely due to the technical and financial impacts of such deployments in aircraft. These factors, without a clear benefits case, make it difficult to predict the equipage profile with any degree of confidence. However some recent initiatives involving airlines will explore the operational impacts and benefits of new services based on datalink and these will promote further progress in this area.

3.3.3.10 System Management

Effective system management is a critical factor for the widespread deployment of the ATN in Europe, as any deployment of ATN resources must be accompanied by adequate system management solutions allowing the ATN infrastructure to reach the high Quality of Service objectives of ATN users.

ATN system management can be split into two separate parts that have different development and deployment constraints (i.e. the System Management ICAO SARPs only focus on the inter-domain part):

- inter-domain system management: the specific requirements and constraints applicable

[12] Second generation BISs are considered to be those whose functionality is coded into standard router platforms, for example the RRI BIS.

to inter-domain system management, encompassing technical as well as organisational aspects (e.g. a centralised co-ordination model);

- national system management: solutions in this area are aimed at managing national infrastructures under the responsibility of a single organisation (i.e. the ATSO). Both technical and organisational solutions here may differ from the solutions selected for inter-domain system management.

The following scenario for the deployment of system management solutions is presented below:

- Up to 2003: in a first step ATSOs develop and deploy national system management solutions for managing their own infrastructure, which will be limited to embryonic sets of ATN systems and interconnections. The inter-domain system management functions that will be effectively required in that timeframe will be addressed by means of basic procedures specified by bilateral or multilateral agreements. In this period, however, regional agreement between the ATSOs must be reached on the European ATN management institutional and organisational issues. Action plans should be launched to progressively enhance the System Management co-operation and co-ordination procedures, with the ultimate goal of reaching an operational implementation of the ICAO standards at some further date.

In the period up to 2005: Initial co-ordination requirements will need to be fulfilled. The first priority in the implementation of cross-domain system management functions is likely to be related to real-time exchanges of trouble tickets and performance data for co-ordinating fault and performance management activities, and to basic off-line exchanges of configuration and accounting information. In this period, it is unlikely that an ICAO SARPs compliant solution for the cross-domain exchange of management information will be available for operational implementation and it is therefore expected that some ad hoc solutions will be used based on available products.

Action ACCESS9	**To further define and resolve the institutional, organisational and other non-technical issues required for the System Management of the European ATN**	**ATSOs, CSPs, Airlines**

3.3.3.11 Security

ATN security will depend on the use of interoperable mechanisms because of the nature of the ATN communications taking place between application entities pertaining to different organisations or countries. Initial ATN standardisation efforts have been focused on other development priorities and ATN security mechanisms are still in the course of being specified by the ATNP for an integration in future CNS/ATM-2 SARPs.

As a consequence, it is expected that the CNS/ATM-1 products will not integrate any of the ATN standardised security mechanisms (e.g. ATN upper layers' security mechanisms, IDRP authentication and system management security functions). These should become available at a later stage through the CNS/ATM 2 products, which essentially deal with the protection of ATN communications. However, the available security measures will still include aspects such as physical protection, access control, system security, etc.

Action ACCESS10	**To co-ordinate and agree on the security measures to be applied to the initial ACCESS ATN common resources (e.g. the backbone BISs): subnetwork-level measures (based on EAN facilities), user/administrator access control policy and configuration, etc.**	**All ATSOs (together)**

3.3.4 Organisational Aspects

This study focused on technical issues; however, organisational aspects are of great importance for the successful deployment of the ATN in Europe. The co-ordination required for the deployment of the Initial ATN and the derived organisational model should ideally result from a European programme set up for the deployment of operational datalink applications and of the supporting ATN infrastructure across Europe. This programme would directly result from the expected high-level commitments of ATSOs to develop datalink and ATN activities.

The overall deployment scenario is based on the assumption that local initiatives and/or pre-operational datalink projects will drive the first ATN deployments. Local initiatives and pre-operational projects should therefore result in small nuclei of ATN infrastructures providing datalink services on a relatively local basis and therefore the organisational requirements should be satisfied by ad-hoc project management structures, possibly on a multi-lateral basis depending on the project participants. As soon as ATN services are required on a distributed basis (even for pre-operational use) involving different organisations (ATSOs, AOs, etc.), a structured ATN will have to be built and will consequently require specific co-ordination efforts and associated organisational schemes.

In the Initial ATN implementation, the most suitable approach for the system management of the European ATN will be the centralised co-ordination model. In a centralised model responsibilities for the supervision and administration of the national ATN is left in the hands of the ATSOs, (and other ATN organisations) while responsibilities for the co-ordination of some inter-domain system management activities (e.g. accounting management) are vested in a central organisation.

In practice, however, it is assumed that a combination of the centralised co-ordination and distributed co-ordination approaches will be followed. Even if an agreement can be reached for the centralisation of the main system management co-ordination activities, direct bi-lateral co-ordinations are still likely to exist for certain aspects.

This organisational model for the operation of the ACCESS ATN should be compatible with the principles that split regulatory functions, operational management functions and administrative management functions and to establish them as distinct entities.

Action ACCESS11	**To specify and approve an organisational model and the ensuing structures required for the operation of the initial European ATN**	**ATSOs and Airlines**

4. Key Issues

This section of the report provides a brief summary of the other main areas of the study. The topics considered are:

1. Safety Assessment & Certification;
2. Third Party Service Provision;
3. Life Cycle Costs;
4. Performance Analysis & Dimensioning;
5. Institutional Issues.

4.1 Safety Assessment & Certification

The advent of end to end datalink technology and services in the ATS environment requires that the users of the technology and services provide the necessary safety assurances to the regulatory bodies prior to their certification and approval for operational use. This has resulted in a range of projects being initiated, projects whose specific aim is to provide guidance and develop ‘tools’ to support the approval of such systems into operational service. The EOLIA and ProATN projects have both undertaken preliminary safety assessment work to assist in the development of practical recommendations for assessing and certifying datalink services and the associated infrastructure. The objective of this work will be to allow the implementor to develop specific implementations of the datalink system components, e.g. routers, and verify and approve them using agreed standards and methodologies. The components, providing they gain certification approval, could then be introduced into the end to end system without the need to re-certify the existing components. All the work reviewed as part of this study detailed the importance of considering the institutional issues and to account for the scale of the CNS/ATM operations, i.e. it will encompass many States and Organisations.

The current procedures adopted by the majority of States rely on the ATS provider to adopt a formal Safety Management System with individual States applying their own adaptations of Safety Management. Safety Management allows organisations to implement an effective safety policy and to achieve high standards of safety and minimise the risks as far as is reasonably practicable. The majority of States will use the ‘Safety Case’ methodology as the focus of their Safety Management System. The Joint Aviation Authorities (JAA) is an integral part of the certification process for avionics manufacturers. It is important that any new standards and guidance material developed to address the safety implications of datalink services are recognised by the regulating authorities and organisations such as the JAA.

Communications Service Providers (CSP) who offer ATS data distribution services will also need to demonstrate the safety of their systems, via documented evidence, to the relevant aviation safety regulatory authority in support of their application to obtain certification for the operational use of their system.

The techniques and reference systems currently being developed by international bodies such as EUROCAE are considering an approach whereby ATN datalink services can be assessed and certified as separate entities to the ATN Communications Infrastructure (ACI)[13]. This approach would ensure that new datalink services could be developed and

13 ACI is the ATN communications stack up to and including the application entity; it does not include the application process.

certified without the need to re-certify the underlying infrastructure. The technique requires the safety requirements for ATN datalink services to be translated into QoS requirements for the ATN Communications Infrastructure. These QoS requirements can then be distributed to the sub-systems (e.g. routers and subnetworks) which form the underlying infrastructure. Existing sub-systems such as communications subnetworks may need to rely on in-service history and safety cases to provide the required safety assurance. Where new sub-systems, such as routers, are developed they will need to be designed using best practice, recognised standards and incorporate rigorous testing to include a reference facility to ensure interoperability. In all cases adequate levels of redundancy and 'fall-back' procedures will need to be demonstrated as part of the safety assurance process.

The safety assessment process will need to demonstrate that the QoS figures for the ATN Communications Infrastructure are achievable and maintainable. This can be achieved by utilising network and system management techniques to ensure that operational changes can be implemented in a controlled and timely manner and a safe service maintained.

A datalink system is highly integrated and any changes no matter how minor have the potential to adversely affect the end to end performance. It is important that any Service Level Agreement (SLA) with a CSP should allow for the testing and assessing of modifications, prior to implementation, to minimise the impact upon the operational ATS Service.

The ACCESS study has defined two distinct ATN transitional implementations. The first consists of local initiatives for implementing datalink services, which can be introduced relatively independently by individual States. The second is a coherent infrastructure offering a range of datalink services covering multiple Flight Information Regions (FIR) and States. Local implementations can use existing procedures adopted for other safety critical systems to provide the necessary safety assurance to the regulating authority. The coherent infrastructure will require coordination of safety activities with States needing to coordinate and adopt consistent system acceptance criteria. This may require the development of an internationally agreed standard to cover specific implementations and metrics defined to ensure that consistent system acceptance criteria are employed across the institutional boundaries.

The Target European ATN describes a routing architecture centred on a European ATN Island. The datalink services offered will consist of those identified in the Initial ATN and may include more safety critical datalink services. The approval of new services will, in principle, follow existing approval procedures, albeit requiring greater levels of coordination where more States are involved.

Action ACCESS12	**The end-to-end "certification" requirement for ATN datalink services should be addressed through a modular approach to the construction and maintenance of system safety cases including the separate assessment and certification of ATN Communications Infrastructure (ACI).**	**All ATSOs**

4.2 Third Party Service Provision

Increasingly, there is a general trend for businesses to improve efficiency by identifying those non-core services/functions that may be outsourced to a third party provider. In the case of an ATSO the core service is clearly the provision of the operational Air Traffic Services, which requires a number of supporting services (e.g. data communications between ATCCs). In today's environment such support services are typically provided by the ATSOs themselves, i.e. "in-house" provision. However, as the aeronautical community moves towards the implementation of the CNS/ATM system it is necessary for the users (ATSOs and Airlines) to consider the issues involved in the provision of the support services required by the future ATM environment. A major issue is whether users should provide these services themselves, or contract them out to a third party service provider.

The arguments applicable to contracting out non-safety services clearly need to be re-visited for their applicability to safety critical related services involved in ATM in order to assess the associated risks. The ATN is clearly considered as a support service to the future ATM system and elements of it, may either be provided directly by the ATS Organisation or may be contracted out to a third party Communications Service Provider (CSP). A CSP is defined as a commercial organisation (e.g. ARINC, SITA) that offers ATN compliant communications services to the aviation community.

In order to address these issues and provide guidance to ATSOs, an analysis has been undertaken on related studies, (e.g. ATNII Study [CEC16], [CEC17]). Practical trials and operational experience acquired during the ADS Europe Trial and FANS 1/A South Pacific experiences have been taken into account. As a result, ACCESS:

- has identified that a number of points/segments exist in the end-to-end ATN communications service/architecture where an ATSO may elect to contract a CSP;
- provides detailed guidance on a method by which a CSP may be managed, i.e. via a strict Service Level Agreement (SLA). SLAs can be used to specify key service parameters such as performance and quality of service requirements, performance indicators and liability assignments.

Although the SLA approach is a good method to specify communications service requirements, it is clear that the community (users and providers alike) have limited experience with the use/enforcement of SLAs for ATS based datalink. Consequently there is a need to develop further experience and practical understanding of the different aspects and implications of this approach.

Action ACCESS13	**A representative group of ATSOs, Airlines and CSPs should work together to develop and validate a SLA for ATN Services in Europe taking into account the issues raised in this report. Such a group could either be based on an existing European ATN implementation group or be constituted through a CEC-sponsored initiative**	**ATSOs, Airlines CSPs**

4.3 Life Cycle Costs

One of the key issues associated with ATN implementation is the forecasting of the likely costs (and benefits) to all involved stakeholders. ACCESS has devised a mechanism to identify and capture the main parameters which could impact on the ATN Life Cycle Costs, concentrating on the capital and running/ownership costs to the air traffic service organisations (ATSOs) but also considering the cost to airline operators of equipping and maintaining aircraft.

The various cost elements, e.g. communications charges, can be identified drawing on, for estimation purposes, figures from other European Commission funded projects (COPICAT and EOLIA) and Eurocontrol output, and captured in a user friendly Microsoft Excel spreadsheet model. The ultimate objective is to identify where and when every main component needs to be deployed and the spreadsheet model supports this level of detail.

The air/ground subnetworks considered are VDL Mode 2, the Inmarsat based Aeronautical Mobile Satellite Service (AMSS) and Mode S, where the first two are considered to be supplied and administered by a third party. The impact of different usage charges can be observed (e.g. AMSS has a significant ongoing charge for communications costs but Mode S has a high capital cost to the ATSOs but no communications charges are currently attributed).

Total airline fleet sizes and growth rates are estimated together with a profile for equipping aircraft for ATN. The cost of adaptation and the subsequent maintenance costs are included.

Some analysis has been performed with the model by postulating, realistic and optimistic scenarios where the latter envisages that the full ATN infrastructure[14] is in place at 20 area control centres, 14 approach control centres and 27 airports in the ACCESS region by 2010. It is recommended that further analysis be undertaken in order to refine the data set, in particular for the costs of end systems, Mode S and Gatelink subnetworks and ATN avionics. Third party subnetwork providers' charges can be significantly affected by commercial issues and need to be regularly reviewed.

The overall analysis demonstrates the potential impact of individual systems on the cost of ATN deployment based upon current understanding. It is anticipated that where more accurate figures, both prices and system developments, become available they can be easily incorporated into the model to produce better cost estimates.

The use of a spreadsheet model can play an important part in the investment analysis process by providing a convenient, flexible means of capturing and calculating approximate costs associated with ATN deployment and, should be of use to individual ATSOs in the planning of their transition strategies.

Action ACCESS14	**A spreadsheet model is a flexible computing tool enabling ATN life cycle costs to be estimated throughout the deployment period and should be considered by ATSOs as part of the investment analysis process.**	**ATSOs**

4.4 Performance Analysis & Dimensioning

The problem of predicting and analysing ATN performance and specifying parameters of ATN components is a complex design task which seeks to optimise a number of conflicting aspects e.g. topology, throughput capacity, and costs. To accomplish this task requires a framework to be defined and a large number of assumptions to be made. This framework will define a series of activities that must be undertaken when performance analysing and dimensioning the ATN. The results generated will be valid for the ATN in general and not just for the ATN in the ACCESS area.

The framework developed by ACCESS relies on:

1. establishing the application data traffic overhead for each class of application which the ATN must handle;

14 An operational Mode S subnetwork is only considered in the optimistic scenario

2. obtaining the throughput and transit delay characteristics, MTBF and MTTR of each subnetwork and router product proposed for use in the ATN;
3. specifying (in terms of locations, subnetworks etc.) the ATN topologies which are to be analysed[15];
4. determining the traffic profile due to fixed and mobile hosts. This profile results from the topology to be analysed and the volume of the application data traffic.

Once the above information is available, the calculations in this framework can be used to determine appropriate subnetwork, router and communications circuit sizes and the associated costs. This analytic approach may be used to eliminate obviously undesirable designs prior to running simulation tests on those designs which seem acceptable. The results must, however, be interpreted in the light of the following restrictions:

- The designs will indicate the minimum requirements of routers, subnetworks, switches and communications links, which are able to handle peak traffic loads. The requirements must be multiplied by a factor to ensure that abnormal loads and component outages can be dealt with;
- The designs do not take into consideration the requirement for duplications of ATN components to minimise the impact of component failures. Appropriate duplications must be included in the design of any proposed ATN topology.

As a result of this investigation, the following approach is recommended:

1. Manually design trial ATN topologies and test them with the analytic tools outlined;
2. Subsequently test the designs by simulation;
3. Develop analytic tools based on spreadsheet models for the ATN;
4. Use existing proprietary tools for subnetworks and routers where they are available;
5. Initiate research into actual application requirements in terms of expected data traffic flows, peak data volumes, transit time peak maxima and timings and other parameters for each application. Determine the overall constraints for each application. This is a significant and large task, the results of which are used in both analytic modelling and in simulation;
6. Initiate research into the availability of subnetwork capacity and router capacity available from the market, and determine their throughput/transit time delay characteristics;
7. Establish an Operational Context for the ACCESS region which specifies precise throughput, scope and transit time delay requirements;
8. Establish a framework for allocation of target parameter values (e.g. maximum allowed transit time delays) among the ATN operational authorities.

[15] The topology to be studied must be input to the task as a given fact, because it is unrealistic to expect the analysis to yield a topology.

Action ACCESS15	**The performance analysis and dimensioning framework should be used to determine minimum subnetwork, router and communications circuit sizes and the associated costs. This analytic approach may be used to eliminate obviously undesirable designs prior to running simulation tests.**	**ATSOs**

4.5 Institutional Issues

In order to avoid duplication of effort and to make best use of available expertise in related study areas, the ACCESS Project has used the first deliverable of the ATN Implementation Issues (ATNII) Study[16] as a baseline document for its work on Institutional Issues. Whereas ACCESS is primarily an engineering/system design study, the terms of reference of ATNII specifically address non-technical issues and deal mainly with the institutional environment in which the ATN is expected to come into being in Europe.

Using this approach, the ACCESS study was able to consider the correlation between the initial findings documented in Deliverable 1 [CEC16] of the ATNII Study and to identify any aspects of the ACCESS technical recommendations which might constrain potential future institutional scenarios for ATN and vice versa.

In general the efforts of the ATSOs supporting the ATN are being devoted to the elaboration of a technical architecture and its implementation plan. This is a necessary task that will prove to be unsuccessful unless it is complemented by the proposition of adequate solutions for the organisational, institutional and economical aspects, which are tightly coupled. The feasibility of the ATN implementation plan proposed by ACCESS is likely to be undermined unless the essential institutional and/or non-technical enabling activities can also be accomplished in a timely way.

It is acknowledged that these difficulties arise because the main players involved in the ATN have not made clear operational choices and because there is a lack of a clear CNS/ATM operational framework and associated business case. It can be reasonably assumed that a solid business case would enable and encourage the construction of the required organisational and institutional solutions.

The range of institutional issues raised is significant in scope, including the need for an ATN regulatory framework ("ATN Convention"). This would be a separate operational entity for the European ATN co-ordination, and the possible evolution towards a network built around commercial alliances and contracts instead of the usual multi-lateral co-operation between public administrations (ATSOs or CAAs). This evolution implies a new policy for aeronautical charges (e.g. differentiated services and charges) which could represent an incentive for the introduction of the ATN but whose feasibility can be questioned, at least in the ACCESS timeframe.

The interim work completed by the ATNII study identifies the potential need for fundamental changes to the institutional structures to exploit the full potential of enabling technologies such as ATN on the European ATM services. There is a commonality of these issues across the CNS/ATM concept, and the implementation period to bring about some of these changes would extend beyond the timeframe of the ACCESS study. However the impact of institutional issues when planning the development of the ATN is an important consideration.

[16] The ATNII Study was a CEC Project funded by the TEN-T Programme in 1998.

It is beyond the scope of the ACCESS project to resolve institutional issues such as the need for ATN regulation. However, by taking a more pragmatic approach, ACCESS has examined the mechanisms required to put the technical building blocks in place to enable an initial ATN to be implemented. For example, the use of third party communications service providers and the development of detailed service level agreements to control and manage this relationship; the development of techniques to enable the end-to-end “certification” issue to be addressed through a modular approach to the construction and maintenance of system safety cases. Where the possible evolution of institutional arrangements, as foreseen by the ATNII Study, introduces a potential impact on the technical approach taken by ACCESS, no conflicts or constraints have thus far been identified and vice versa.

5. ATN-Compliant Message Handling Services Interoperability and Validation Trials

5.1 Introduction

The ACCESS Study addressed ATS Message Handling Services (ATSMHS) Interoperability and Validation Trials by identifying a number of work packages as follows:

- Definition of Interoperability Trials Objectives;
- Definition of Interoperability Operating Scenarios;
- Interoperability Test Specification and Schedule;
- Use of Interoperability Test Tools;
- Configuration of Interoperability Trials Scenario;
- Conduct of ATSMHS Interoperability Trials;
- Definition of Conformance Testing Requirements;
- Conformance Test Specification.

The result of this work is a framework for the establishment and conduct of interoperability trials between two or more AMHS equipments and for specific conformance testing activities on individual AMHS equipments.

During the initial planning of the ACCESS Project it was anticipated that systems suitable for ATSMHS interoperability and validation trials would become available during the project timeframe as a result of national planning activities and Eurocontrol initiatives[17]. However, the subsequent timing change to these activities has meant that such testing has not been possible during the timeframe of the ACCESS Project. It was therefore decided to complete the work to define ATSMHS interoperability and validation trials and to postpone the completion of testing activities until such time as sufficient systems become available. Therefore the work completed under this study describes interoperability/conformance test environments which can be used by States or other organisations as the basis for testing. This preparatory work will expedite the launch of such testing activities in the future.

5.2 Conformance versus Interoperability Testing

The primary objective of ATSMHS Interoperability Testing is to confirm the end-to-end interoperability of two AMHS equipments that have both been developed to a common specification. This testing approach is distinct from other techniques such as conformance testing and reference testing.

Conformance testing can be defined as the exhaustive testing of a system under test against the functions and procedures defined in an agreed standard. A rigorous approach would test all the ‘shall’ and ‘should’ statements in the design specification.

The distinction is illustrated in a schematic way in Figure 5-1. In the case of interoperability testing, the "other production systems" should ideally consist of parts of the real operational AFTN and AMHS.

[17] A minimum of two independently developed systems are required for effective interoperability testing

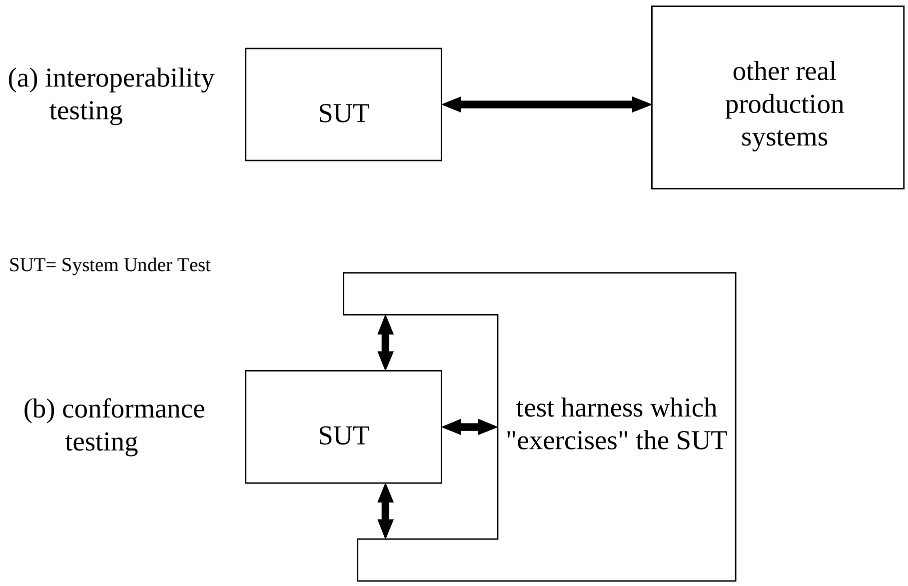


Figure 5-1: Schematic distinction between interoperability and conformance testing

It is clear that the type of testing performed during conformance testing is basically different from that of interoperability testing. In particular, in conformance testing:

- some test sequences can be performed which would not be possible within the scope of interoperability testing, thus exercising the full scope of the specification;
- whereas performance and load testing are possible, at least in principle in interoperability testing, this is not usually considered in conformance testing which is restricted to the "logic" of the protocol implementation;
- individual layers, components and interfaces of the SUT (System Under Test) might be considered individually whereas this is never the case in interoperability testing.

5.3 Interoperability Testing

5.3.1 Scope

The scope of the ATSMHS Interoperability Trials is limited to the ATS Message Handling System (AMHS), i.e. to the provider of the ATS Message Service as defined in the ATSMHS SARPs. Since there are no plans in Europe to support the ATN Pass-Through Service, nor to implement any AFTN/ATN Type A Gateway, such systems are out of the scope of the ATSMHS Interoperability Trials defined in ACCESS.

To achieve the above objectives, the Interoperability Trials should cover the following aspects of interoperability testing:

a) protocol testing, encompassing X.400 to X.400, X.400 to AFTN, AFTN to X.400 and AFTN to AFTN interoperability[18], and covering both message transmission and resultant acknowledgements;

[18] Note that network protocol interoperability is not explicitly tested. There is however an implicit testing of network protocol interoperability during the interoperability testing of the X.400 and AFTN messaging protocols. ATN compliant network services should be used to support the Interoperability Trials wherever possible.

b) functionality testing, to ensure the appropriate implementation of X.400 and/or AFTN functionality and services, and the correct mapping between X.400 and AFTN functions[19] (e.g. X.400 distribution lists and AFTN meteorological data, System to System communication and Flight Planning services), including rejection of messages that cannot be mapped (e.g. invalid content or body part type, invalid ATS Message Header);

c) resilience testing, particularly with regard to the recovery of communicating messaging systems and incomplete message transfers following system or network failure;

d) performance testing, to ensure that the AMHS messaging systems under test are capable of meeting the message throughput required to support the agreed end-to-end service levels[20];

e) control and monitoring service testing, to ensure that the appropriate management functions and interfaces are available to support the required message tracing and audit trail services;

f) addressing scheme testing, to ensure the full and open interoperability of AFTN and X.400 users.

Note that security testing will not be possible until the ongoing specification of ITU-T X.509 compliant security services for the AMHS, particularly to support authentication, has completed. The X.500 and security specification is not scheduled to complete within the timeframe of this project.

5.3.2 Interfaces

Figure 5-2 illustrates the interfaces to be tested within the scope of the Interoperability Trials.

[19] Because of the limited functionality of AFTN compared to X.400, X.400 users will initially be restricted to the use of AFTN compatible functions (i.e. the ‘basic service’). There is however work planned for the future, which will consider the exploitation of additional X.400 features, which may impact future requirements for interoperability testing. Since this study will not complete within the timeframe for the ACCESS project, only the ‘basic service’ is covered by the Interoperability Testing.

[20] Performance levels could be defined prior to testing or local targets could be set which would allow some confidence to be gained in the ability of the implementation to function under load.

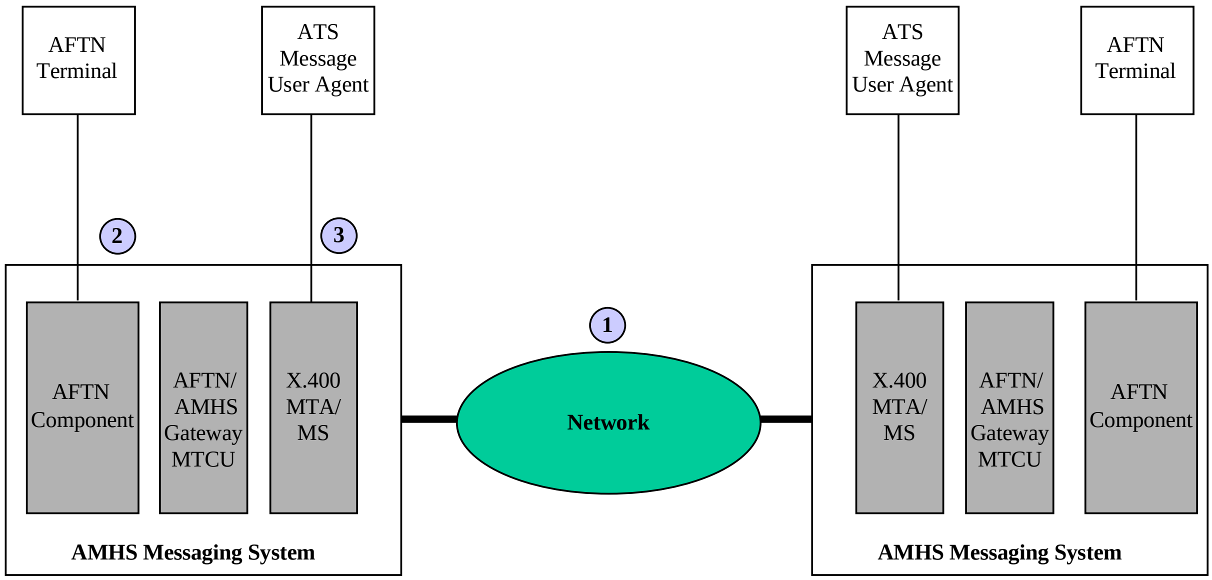


Figure 5-2: Interoperability Interfaces

It can be seen from Figure 5-2 that the following interfaces are tested:

1. The X.400 (P1) interface between the AMHS messaging system under test and the remote system;

2. The AFTN terminal interface to the AMHS messaging system;

3. The X.400 (P7) terminal interface to the AMHS messaging system.

It should be noted that the AFTN and ATS Messaging User Agent terminals used to generate and receive messages to/from the AMHS messaging system are outside of the scope of the Interoperability Trials. Were they to be considered to form part of end-to-end interoperability testing, then all terminals supported by a particular message switch would have to be tested. However, since such terminals will be required to exercise the AMHS messaging system, it is important that stable and (where available) widely used terminal products are used for this purpose.

5.3.3 Scenarios

The ATSMHS component functions identified in the ATSMHS SARPs [ICA14] are as follows:

- AFTN/AMHS Gateway, hereafter called a “Gateway”;
- ATS Message Server, hereafter called a “Message Server”;
- ATS Message User Agent, hereafter called a “User Agent”.

When an organisation procures a component of the AMHS, it will be required to perform interoperability tests with other components with which it will be required to inter-operate. The component to be tested is known as the ‘Implementation Under Test’ (IUT).

There will be cases where the IUT performs the functions of more than one component. For example, a single component may have the functionality of both a message server and a gateway. Where this situation occurs, the tests for both components will have to be combined.

Situations will occur where two components will be tested at the same time. The first interoperability tests will, of course, be in this situation. In such cases, it will be possible to merge the tests. For example, the test that checks that a message can be sent from a gateway to another will also act as a test that the other gateway can receive a message.

It should also be noted that there are scenarios included that are designed to test performance. However, it is not possible to define the required performance level in this document. When an implementation is established, it will be necessary to define the required performance level of that particular implementation. For example, a major node in the messaging network will have a much higher performance requirement than a small system serving only a few users. Performance tests will have to be performed against the required level of performance for the given implementation.

5.3.3.1 Gateway Scenarios

This section defines operating scenarios that can be used as a basis for tests for a Gateway that conforms to the ATSMHS SARPs [ICA14]. Figure 5-3 and Figure 5-4 show the two configurations used for the gateway scenarios. The configuration that should be used depends on the type of systems at the remote site.

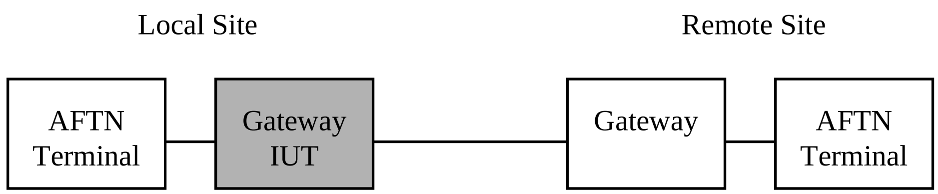


Figure 5-3: Configuration 1 - gateway to gateway

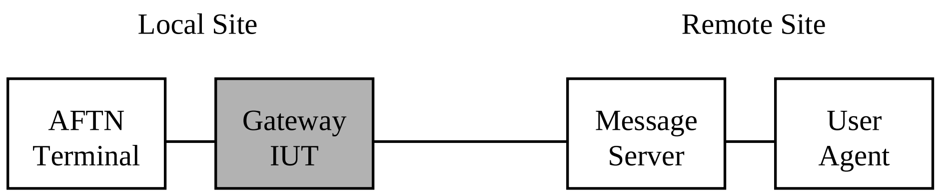


Figure 5-4: Configuration 2 - gateway to message server

5.3.3.2 Message Server Scenarios

This section defines operating scenarios that can be used as a basis for tests for a Message Server that conforms to the ATSMHS SARPs [2]. Figures 5-5, 5-6 and 5-7 show the three configurations used for the message server scenarios. The configuration that should be used depends on the testing and type of systems at the remote site.

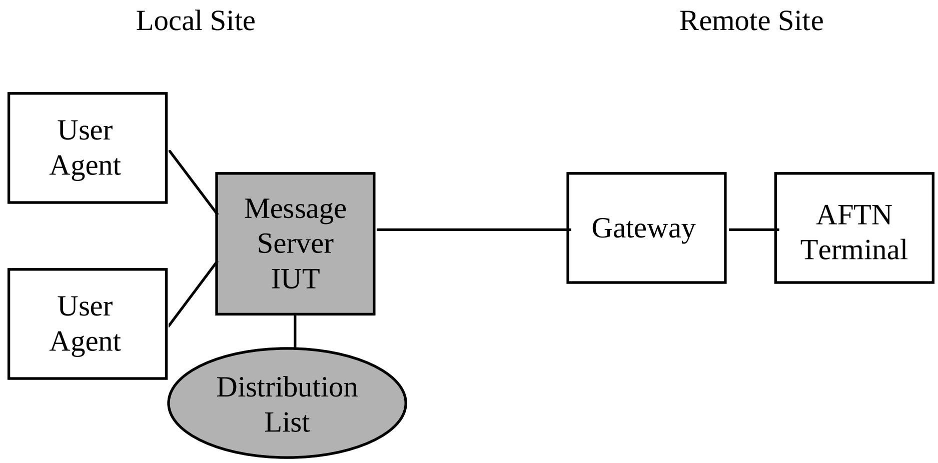


Figure 5-5: Configuration 3 - message server to gateway

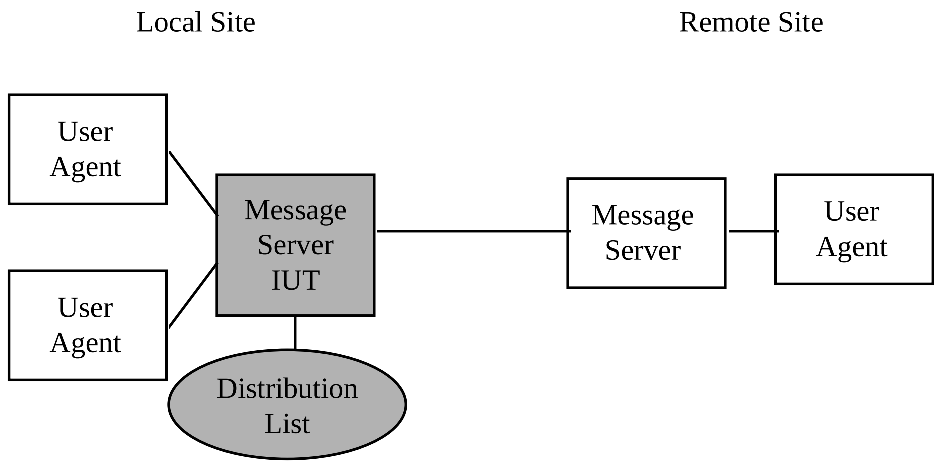


Figure 5-6: Configuration 4 - message server to message server

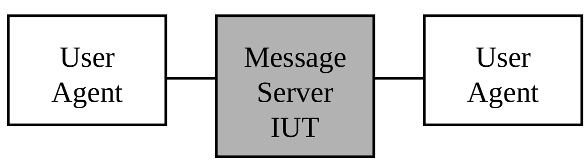


Figure 5-7: Configuration 5 - user agent to message server

5.3.4 Test Specification

Each test specification is a sub-set of an Operating Scenario and a summary of the Test Scenarios is provided in the following sections. Each of the Test Scenarios has been further refined into a set of one to four separately specified interoperability tests (not detailed in this report).

5.3.4.1 Gateway Test Scenarios

Gateway Normal Condition Tests	
	Sending a priority two message from a gateway to the remote system
	Sending a priority three message from a gateway to the remote system
	Sending a priority message one message from a gateway to the remote system
	Receiving a priority two message from a remote system
	Receiving a priority one message from a remote system
	Receiving a long message from a remote system
	Receiving a message with more than 21 recipients from a remote system
	Receiving a large message with more than 21 recipients from a remote system
	Conversion from AMHS IP RN to AFTN Acknowledgement Message
	Conversion from AFTN Acknowledgement Message to AMHS IP RN
	Conversion from AMHS NDR (unrecognised O/R name) to AFTN Unknown Addressee Service Message
	Conversion from AFTN Unknown Addressee Service Message to AMHS NDR (Unrecognised O/R Name)
	Gateway Throughput

Table 5-1: Gateway Normal Condition Test Scenarios

Gateway Abnormal Condition Tests	
	Network Failure and Recovery
	Unavailability of Remote System
	Unsuccessful Conversion of Addressee Indicator in Incoming AFTN Message
	Unsuccessful Conversion of Originator Indicator in Incoming AFTN Message
	Unsuccessful Conversion of Recipient O/R Name in Incoming AMHS Message
	Unsuccessful Conversion of Originator O/R Name in Incoming AMHS Message
	Receiving an Incoming AMHS Message with an invalid Content Type
	Receiving an Incoming AMHS Message with a non-AFTN compatible body part
	Receiving an Incoming AMHS Message with multiple IPM body parts
	Receiving an Incoming AMHS Message with a missing ATS Message Header
	Receiving an Incoming AMHS Message with an invalid ATS Message Header
	Receiving an Incoming AMHS Message containing an invalid character

Table 5-2: Gateway Abnormal Condition Test Scenarios

5.3.4.2 Message Server Test Scenarios

Message Server Message Transfer Tests	
	Outgoing IPM Transfer
	Incoming IPM Transfer
	Outgoing Probe Transfer
	Incoming Probe Transfer
	Outgoing Delivery Report Transfer
	Incoming Delivery Report Transfer
	Message Server Throughput
Message Server Distribution List Tests	
	Locally Generated Message Sent to Distribution List
	Remotely Generated Message Sent to Distribution List
Message Server Submission Tests	
	Message submission
	Probe submission
Message Server Delivery Tests	
	Message Delivery
	Delivery Report Delivery
	Non Delivery Report Delivery
Message Server Message Store Access Tests	
	Indirect Submission
	Summary of Message Store
	Listing of messages
	Fetching a message
	Deleting a message

Table 5-3: Message Server Normal Condition Test Scenarios

Message Server Abnormal Condition Tests	
	Message non delivery
	Distribution List Loop Detection
	Prohibited Use of Distribution List
	Distribution List containing a recipient which does not exist
	Network Failure and Recovery
	Unavailability of Remote System

Table 5-4: Message Server Abnormal Condition Test Scenarios

5.3.5 Test Schedule

A notional test schedule has been developed in order to plan the execution and to estimate the duration of the tests. The sequence given to perform the tests has been established to facilitate the linking, to minimise manipulations in order to minimise possible configuration errors and finally to reduce the global test performance duration. A number of assumptions have been made leading to a final estimate of test execution duration of up to 13 days for 2 people, one at each site.

5.3.6 Use of Test Tools

The possible use of test tools has been examined and the benefits that might be gained through the use of test tools identified. It is concluded that, from the viewpoint of efficient and reliable communications, automated test tools could be highly beneficial in the AMHS interoperability testing environment. The recommended subset of services consists of:

- interact with test database;
- support the test operators in controlling test execution;
- communicate with remote test operators;
- generate test data from test cases;
- support test operator in recording test results;
- maintain test case database;
- maintain test results database;
- generate test reports.

Concerning the implementation of these services, it is recommended that the test tools consist of one central computer installation with remote access by test operators. A list of functional and non-functional requirements placed on the system is available.

5.4 Conformance Testing

5.4.1 The Need to Perform Gateway Conformance Testing

Although interoperability testing is appropriate for the testing of the ATS Message User Agent and the ATS Message Server it is recommended that, in addition, conformance testing is conducted on new implementations of the AFTN/AMHS Gateway for the following reasons:

- The Gateway has been specified for the first time in [ICA14] and represents a new set of functions;
- Various manufacturers are implementing the functions specified in [ICA14] for the first time;
- No well-tried, established procedures exist yet for conformance testing and type approval of implementations of the AFTN/ATN Gateway.

5.4.2 AFTN/AMHS Gateway

The AFTN/AMHS Gateway is considered to be a network element providing interworking between two different environments without any further end system (or end user) functions. Conformance testing of the Gateway must ensure that this interworking function is implemented correctly. Interworking in this context implies that the network environment within the Gateway must appear to be compatible with the environment from which it is considered. This means that the AMHS infrastructure on the ATN, when seen via the Gateway from the AFTN, must appear to be part of the AFTN. Conversely, the AFTN, when seen via the Gateway from the ATN, must appear to be part of the AMHS. In addition, the Gateway must provide a control position and perform conversion functions which are not "'visible" in these two views. This decomposition has lead to a logical structuring of the Gateway into four components as shown in Figure 5-8.

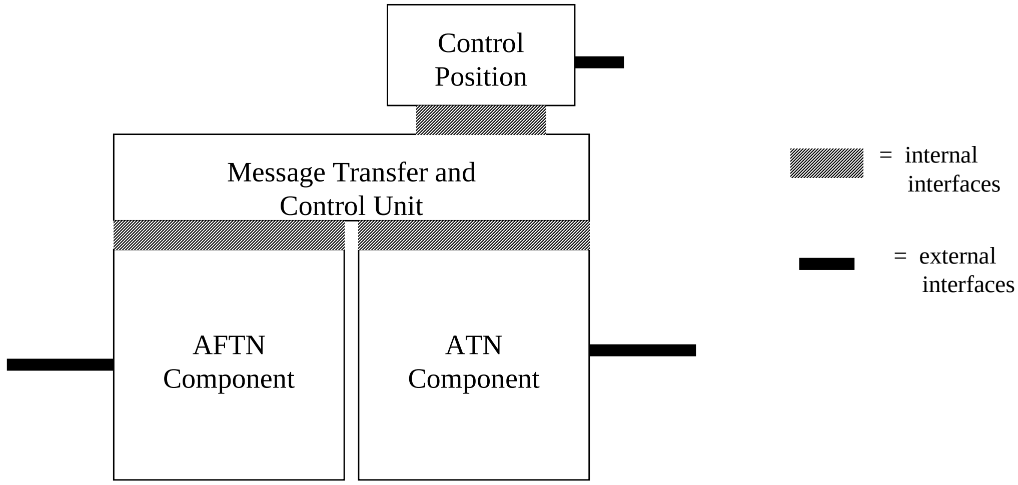


Figure 5-8: Logical structuring of the Gateway

The SARPs[ICA14] state clearly that, although this is a convenient way to partition the Gateway for purposes of defining its functions, there is no requirement for the Gateway to actually be implemented in this fashion. This is important from the point of view of conformance testing because it means that there is no possibility of accessing the internal interfaces shown in Figure 5-8 but only via the three external interfaces shown.

5.4.3 Conformance Testing Strategy

In order to make recommendations for conformance testing the AFTN/AMHS Gateway, conformance testing in two other contexts, OSI and CIDIN is considered. The degree to which the testing should be able to "look into" the Gateway being tested is addressed and the options from an organisational and equipment point of view identified.

Concerning the overall conformance testing strategy, three sets of recommendations are made:

- organisational arrangements should foresee, amongst other things, testing being performed by individual equipment providers and States using a common set of test suites which are maintained centrally;
- the Gateway should be tested as a "black box" on its external interfaces only;
- the availability of common test equipment or at least equipment conforming to common specifications is desirable. A set of high level requirements placed on Gateway conformance testing equipment is given.

5.4.4 Conformance Tests

The conformance tests can be identified from the SARPS [ICA14] as follows:

- Identification of all requirements (i.e. identifying all uses of the words 'shall' and 'should');
- Elimination of all 'shall' and 'should' statements which are 'configuration' statements;
- Elimination of all 'shall' and 'should' statements which should be tested during formal ISP or AFTN conformance testing which do not contain an AFTN/AMHS IUT component;
- Elimination of all statements which apply to internal interfaces within the IUT - these

are implicitly un-testable;

- Elimination of all other statements that cannot be tested by formal conformance testing.

Tests for the remaining requirements have been combined where reasonably possible to reduce the number of tests. They have then been related to the following sets of tests, each initiated by generation of either an AMHS or an AFTN PDU. The format of each test specifies:

- The selection of reference PDU elements to be used to initiate the test and specification of modifications or changes to specific field values to the reference PDU required to perform the test;
- The sequence of events required for a valid outcome - i.e. where the IUT is judged to conform to the tested requirement;
- Specification of AMHS and AFTN PDUs which should be generated as a result of the test;
- Specification of the resultant log contents;
- Specification of any errors which should appear at the IUT's control position.

The AFTN/AMHS Gateway conformance test specifications cover the following areas:

1) Control Position Tests;
2) AFTN Service message and channel check PDU suppression;
3) AFTN to AMHS message conversions;
4) Invalid AFTN messages;
5) AFTN message acknowledgement conversion;
6) AFTN unknown address service message conversions;
7) Conversion of AMHS IPM message to AFTN;
8) Reject AMHS PDUs;
9) AMHS receipt notification conversion;
10) AMHS non-delivery report conversion;
11) AMHS probe handling.

5.5 Complete Test Specifications

Full details of the Interoperability Test Specification (including details of O/R Names and AFTN Addresses Definitions) and the Conformance Test Specification (including details of Test PDUs and IUT configured parameters) are available on request.

6. Conclusions and Recommendations

The ACCESS project (CEC UK/96/94) was undertaken between January 1997 and March 1999 by DFS, NATS and STNA and part-funded from the European Commission's programme for financial aid in the field of Trans-European Networks - Transport (TEN-T).

The objectives of the study were to:

- Develop an ATN Architecture;
- Develop an implementation plan in the European core area in conjunction with EUROCONTROL;
- Conduct interoperability and validation Trials between States of ATN compliant message handling services.

The study was conducted in two separate parts:

- Part 1 of the study addressed ATN architecture and implementation planning in terms of transition arrangements and implementation issues. A Target ATN architecture has been defined for the 2010 timeframe; implementation stages have been identified from the current situation (1999) through to an Initial ATN implementation and the further evolution towards the Target ATN Architecture;
- Part 2 of the study addressed interoperability and validation trials between States of ATN compliant message handling services. The main focus of this work has been to define interoperability and conformance test specifications and scenarios as a pre-cursor to the conduct of trials, which depend on initial deployment of suitable systems.

The definition of the Target ACCESS ATN for the European core area allows guidelines and principles to be set down for services, infrastructure and routing to ensure an optimal network evolution. Given a target to aim for, a transition path can be defined that directs local ATN initiatives towards this target and ensures that separate elements of the network evolve within a co-ordinated design.

The establishment of an Initial ACCESS ATN is a key stage in the deployment of ATN-based services within Europe. This Initial ATN will be based on the following principles:

- A well-defined subset of the ATN applications will be required to support an initial set of ATM services (e.g. ACM);
- The ground ATN subnetwork architecture will make extensive use of the evolving European ATSO Network (EAN);
- Initial VHF Datalink capability will be mainly provided by third party service providers with optional AMSS backup;
- The ATN naming and addressing scheme proposed by ACCESS will be used;
- Initial Systems Management & Security procedures will be based on existing (and evolving) best practices and commercially available products.

With respect to the testing of ATN compliant message handling systems, a framework has been defined for the establishment and conduct of interoperability trials between two or more AMHS equipments and for specific conformance testing activities on individual AMHS equipments. These interoperability and conformance test environments can be used by States or other organisations as the basis for testing. This will expedite the efficient operational introduction of such systems in the future.

A number of specific actions have been identified in this Report which will facilitate transition towards an Initial ATN (see Table 6-1).

A Target date of 2010 was selected at the start of the Study, which assumed a co-ordinated European initiative, circa 2000, to plan the introduction of new ATM services over ATN. The necessary support by all the major stakeholders for such a significant step is now beginning to take shape through activities such as Link2000+. However service deployment is expected to be more gradual and evolutionary than originally envisaged and specific dates have to be treated with caution. It is also noted that the industry trends for ATN-based support of non-ATSC (e.g. AOC) data services will be influential in determining the general rate of ATN systems and services deployment.

The ACCESS project has made an active contribution to the implementation planning groups (e.g. ATNI-TF) to establish the basic building blocks for ATN implementation in a core European area. The next stages will depend on the will of the Stakeholders.

Action	Description	Actionee
ACCESS1	To develop a Regional ATN Service Implementation Plan.	All ATSOs & Airlines together (e.g. in the framework of LINK2000+)
ACCESS2	To develop a National ATN Service Implementation Plan consistent with the Regional ATN Service Implementation Plan	Each ATSO individually
ACCESS3	To ensure that the EAN development and the ATN deployment are compatible (geographic coverage in the ACCESS area, schedules, access requirements, etc.).	All ATSOs
ACCESS4	To ensure that CSPs' VDL Mode 2 deployment strategy and activities are compliant with the Regional ATN Service Implementation Plan.	ATSOs
ACCESS5	To validate the concept of the ATN datalink server and enable further evaluation at the ACCESS area scale through European datalink programmes.	All ATSOs (in close co-ordination with EuroAGDL)
ACCESS6	To launch study and development programmes aimed at integrating the datalink capability in the existing and planned operational ATC systems (CWPs, FDPS, etc.).	Each ATSO
ACCESS7	To define the European backbone router architecture.	ATSOs with CSPs
ACCESS8	To define the various national parts of the initial ACCESS ATN internet (air/ground BIS siting, connection to the backbone, internal topology, etc.).	Each ATSO
ACCESS9	To further define and resolve the institutional, organisational and other non-technical issues required for the System Management of the European ATN.	ATSOs, CSPs, Airlines
ACCESS10	To co-ordinate and agree on the security measures to be applied to the initial ACCESS ATN common resources (e.g. the backbone BISs): subnetwork-level measures (based on EAN facilities), user/administrator access control policy and configuration, etc.	All ATSOs (together)
ACCESS11	To specify and approve an organisational model and the ensuing structures required for the operation of the initial European ATN.	ATSOs and Airlines
ACCESS12	The end-to-end “certification” requirement for ATN datalink services should be addressed through a modular approach to the construction and maintenance of system safety cases including the separate assessment and certification of ATN Communications Infrastructure (ACI).	All ATSOs
ACCESS13	A representative group of ATSOs, Airlines and CSPs should work together to develop and validate a SLA for ATN Services in Europe taking into account the issues raised in this report. Such a group could either be based on an existing European ATN implementation group or be constituted through a CEC-sponsored initiative	ATSOs, Airlines CSPs
ACCESS14	The spreadsheet model is a flexible computing tool enabling ATN life cycle costs to be estimated throughout the deployment period and should be considered by ATSOs as part of the investment analysis process.	ATSOs
ACCESS15	The performance analysis and dimensioning framework should be used to determine minimum subnetwork, router and communications circuit sizes and the associated costs. This analytic approach may be used to eliminate obviously undesirable designs prior to running simulation tests.	ATSOs

Table 6-1: Summary of Specific Actions to Facilitate Transition towards an Initial ATN

Appendices

Appendix 1: ACCESS Deliverables and References

This section contains two tables, the first details the individual ACCESS work package deliverables and the second lists the reference material sourced in this report.

Table A1-1: ACCESS Work Package Deliverables

WP Deliverable	WP Title	Author	Document Size (No. of Pages)
	Part 1: Phase 1 - Target ATN Infrastructure		
201	Current Communications Infrastructure	DFS	63
202	Define Geographic Areas & Services	STNA	62
203	Routing Architecture Option 1	STNA	72
203A	Routing Architecture Option 2	NATS	18
204	Ground/Ground Subnetworks	DFS	28
205	Air/Ground Subnetworks	NATS	39
206	Addressing Plan	STNA	40
207	Performance Analysis & Dimensioning	DFS	64
208	Interim Deliverable 1 (Routing Architecture)	STNA	39
	Part 1: Phase 2 - Network Implementation Issues		
209	Selection of Routing Architecture	NATS/STNA	17
220	Third Party Service Provision	NATS	25
220A	Deployment Scenarios for Air/Ground Subnetworks	NATS/STNA	38
221	Operational Scenarios	DFS	41
222	Security Issues	STNA	69
223	Safety Assessment & Certification	NATS	34
224	Institutional Issues	NATS	19
225	Accommodation of FANS-1/A	NATS/STNA	27
226	Lifecycle Costs	NATS	26
227	Systems Management	STNA	66
228	Interim Deliverable 2	DFS	28
229	Update of Interim Deliverable 1	STNA	14
	Part 1: Phase 3 - ATN Infrastructure Transition		
240	Transition Planning (Interim Deliverable 3)	STNA	107

WP Deliverable	WP Title	Author	Document Size (No. of Pages)
	Part 2: ATSMHS Interoperability and Validation		
260	Define Trials Objectives	NATS	12
261	Define Operating Scenarios	NATS	40
262	Produce Test Specification	STNA	132
263	Produce Test Schedule	STNA	24
264	Define Interoperability Test Tools	DFS	18
265	Configure Trials Scenario	NATS	3
266	Conduct ATSMHS Trials	NATS	3
267	Interim Deliverable 4	NATS	54
270	AFTN/AMHS Gateway Conformance Testing Requirement	DFS	19
271	AFTN/AMHS IUT Conformance Testing Specification	DFS	92

Table A1-2: **ACCESS Final Report References**

ACCESS Reference	Document Title
Section 2	
[ICA9]	Guidance Material for the ATN Internet Communications Service SARPs - Issue 2.0
[ICA11]	Comprehensive ATN Manual (CAMAL) - Version 1.0
[EAT8]	COM.ET2.ST15 - Analyse Options for Initial Air/ground Data Networks Phase 3 Report Part 1 – Tentative Implementation Plan by Horizon 2000 (ACARS Datalink) Edition 1.0
[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
[EAT19]	COM.ET2.ST15 - Analyse Options For Initial A/G Data Networks - Phase 3 Report: Tentative Implementation Plan by Horizon 2000-2005 (ATN Datalink) - Part 2-1, 2-2, 2-4 and 2-5 Edition 1.0, Part 2-3 Edition 2.0
Section 3	
[EUR3]	ATN Islands and Homes IDRP Convergence Modelling Study: Final Report - Issue 2.1 - 08/01/97
Section 5	
[CEC16]	ATNII Study Interim Deliverable
[CEC17]	ATNII Study Final Report

ACCESS Reference	Document Title
Section 6	
[ICA14]	ATN SARPs Sub-volume III Ground/Ground Applications ATS Message Handling Services (ATSMHS), Version 2.2
Section 8	
[ICA19]	ATN SARPs - Sub-volume 1 - Introduction and System Level Requirements, Version 2.2, 16 January 1998
[ICA20]	ATN SARPs - Subvolume 5 - Internet Communications Service, Version 2.2, 16/01/98

Appendix 2: Glossary and Definitions

A2.1: Glossary

AAC	Aeronautical Administrative Communication
ACARS	Aircraft Communications Addressing And Reporting System
ACC	Area Control Centre
ACCESS	ATN Compliant Communications - European Strategy Study
ACI	ATN Communications Infrastructure
ACM	ATC Communication Management
ADAP	Automated Downlink of Airborne Parameters
ADM	Administrative Identifier
ADS	Automatic Dependent Surveillance
ADSP	ADS Panel
AFTN	Aeronautical Fixed Telecommunications Network
AIDC	ATS Inter-facility Data Communications
AIS	Aeronautical Information Service
AMHS	Aeronautical Message Handling System
AMSS	Aeronautical Mobile Satellite Service
AO	Airline Operators
AOC	Aeronautical Operational Communication
APC	Aeronautical Passenger Communication
APO	Airport Operators
APR	Aircraft Parameter Reporting
ARINC	Aeronautical Radio Inc.
ASE	Application Service Elements
ATC	Air Traffic Control
ATCC	Air Traffic Control Centre
ATFM	Air Traffic Flow Management
ATIF	ATN Trials Infrastructure
ATIS	Automatic Terminal Information Service
ATM	Air Traffic Management
ATN	The ICAO Aeronautical Telecommunications Network
ATNII	ATN Institutional Issues
ATNITF	ATN Implementation Task Force
ATNP	ATN Panel
ATS	Air Traffic Services
ATSC	Air Traffic Service Communication
ATNSI	ATN Systems Inc.
ATSMHS	ATS Message Handling Services
ATSO	Air Traffic Service Operator
ATSU	Air Traffic Services Unit
BIS	Boundary Intermediate System
CAA	Civil Aviation Authority
CAERAF	Common American European Reference ATN Facility
CEC	Council of the European Commission
CFMU	Central Flow Management Unit
CIC	Clearance And Information Communication
CIDIN	Common ICAO Data Interchange Network
CM	Context Management
CNS/ATM	Communications, Navigation and Surveillance / Air Traffic Management
COPICAT	Economic & And Technical Assessment for ATN Deployment in Europe
COPS	Common Operational Performance Specification
CPDLC	Controller Pilot Datalink Communications
CSMA	Carrier Sense Multiple Access
CSP	Communications Service Provider
CWP	Controller Working Position
DCL	Departure Clearance
DFS	Deutsche Flugsicherung
DLIC	Datalink Initiation Capability
DSC	Downstream Clearance
EACE	European ATN Coordination Entity
EAN	European ATSO Network
EATNA	European ATN Administration
EATCHIP	European ATC Harmonisation And Integration Programme
EOLIA	European Pre-Operational Datalink Applications
ES	End System
EUROCAE	The European Organisation for Civil Aviation Equipment
FANS	Future Air Navigation System
FDPS	Flight Data Processing System
FLIPCY	Flight Plan Consistency
FIR	Flight Information Region
FIS	Flight Information Service
HF	High Frequency
HFDL	HF Datalink
HMI	Human Machine Interface
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
ICC	Inter Centre Coordination
ICS	Internet Communications Service

IDRP	Inter Domain Routing Protocol
IS	Intermediate System
ISO	International Standards Organisation
ISP	Internet Service Provider
ITU	International Telecommunications Union
IUT	Implementation Under Test
JAA	Joint Aviation Authorities
LEO	Low Earth Orbit
MEO	Medium Earth Orbit
METAR	Meteorological Aerodrome Report
MIB	Management Information Base
MTBF	Mean Time Between Failure
MTTR	Mean Time To Repair
NATS	National Air Traffic Services Ltd
NMS	Network Management System
NSAP	Network Service Access Point
ODIAC	Operational Development of Initial Applications of Air Ground Data Communications
OLDI	On Line Data Interchange
OSI	Open System Interconnection
PDU	Protocol Data Unit
PKI	Public Key Infrastructure
PPSDN	Public Packet Switched Data Network
PSN	Packet Switched Network
ProATN	Prototype ATN
QoS	Quality of Service
RD	Routing Domain
RDC	Routing Domain Confederation
RDPS	Radar Data Processing System
RRI	Router Reference Implementation
RVR	Runway Visual Range
SARPs	Standards and Recommended Practices
SIGMET	Significant Meteorological Information
SITA	Societe Internationale de Telecommunications Aeronautiques
SLA	Service Level Agreement
SPACE	Study & Planning of AMHS Communications in Europe
STDMA	Self-Organising Time Division Multiple Access
STNA	Service Technique de la Navigation Aérienne
SUT	System Under Test
TSAP	Transport Service Action Point
VDL	VHF Datalink
VDR	VHF Datalink Radio
WAN	Wide Area Network

A2.2: Definitions

Administrative Domain *[ICA19]:* A collection of end systems, intermediate systems and subnetworks operated by a single organization or administrative authority. An administrative domain may be internally divided into one or more routing domains.

AFTN/ATN Type A Gateway *[ICA19]:* An end system, which provides a bi-directional interface between the ATN and the AFTN for the purpose of conveying AFTN messages over the ATN by implementation of the ATN pass-through service.

AMHS *[ICA19]:* The set of computing and communication resources implemented by ATS organisations to provide the ATS message service.

ATN Pass-Through Service *[ICA14]:* This is the ATS Message Handling Service offered over the ATN Internet Communication Services by the use of the Dialogue Service and of the associated ATN upper layer architecture to exchange AFTN messages formatted in IA-5.

ATSMHS *[ICA19]:* Procedures used to exchange ATS messages over the ATN such that conveyance of an ATS message is in general not correlated with the conveyance of another ATS message by the service provider. There are two ATS message handling services. They are the ATS message service and the ATN pass through service.

Boundary Intermediate System (BIS) *[ICA19][ICA20]:* An intermediate system that is able to relay data between two separate routing or administrative domains (running the ISO 10747 inter-domain routing information exchange protocol). An ATN BIS is a router whose protocol implementation is in conformance with the ATN Internet SARPs.

Dialogue Service *[ICA19]:* The lower service boundary of an Application Service Element (ASE); the service allows two ASEs to communicate, e.g. a CM ground-ASE to communicate with a CM air-ASE.

Router *[ICA19]:* The communication element that manages the relaying and routing of data while in transit from an originating end system to a destination end system. A router comprises an OSI intermediate system and end system supporting a systems management agent.

Routing domain (RD) *[ICA19]:* A set of end systems and intermediate systems that operate the same routing protocols and procedures and that are wholly contained within a single administrative domain. A routing domain may be divided into multiple routing sub-domains.

Routing domain confederation (RDC) *[ICA19]:* A set of routing domains and/or RDCs that have agreed to join together. The formation of a RDC is done by private arrangement between its members without any need for global coordination.

Appendix 3: ATN Overview

Introduction

The Aeronautical Telecommunications Network (ATN) is the future ICAO specified data communications network and forms an integral part of the global communications, navigation, and surveillance/air traffic management (CNS/ATM) systems concept. The first stage of this concept is CNS/ATM-1, and it defines six applications and the supporting data communications architecture as a set of Standards and Recommended Practices (SARPs). The core SARPs are contained in Annex 10, with the detailed application and communications service SARPs contained in an appendix to Annex 10.

The ATN will enable ATSOs and aeronautical operating agencies to provide datalink users with a range of datalink services, e.g. 'Pre-Departure Clearance', that will provide a safe and reliable alternative to voice communications. The development of new datalink services will provide additional benefits and flexibility in the ATM system. The datalink services will use the underlying ATN datalink applications, ATN end systems and ATN Internet Communications Service (ICS).

The ATN datalink applications, e.g. ADS, provide the communications functionality in the end systems that support the datalink services. The ATN ICS provides the interconnectivity between the ATN end systems (ES), both mobile (avionics ES) and fixed (ground based ES).

In essence, the ATN is an internetwork that will use the ISO OSI[21] suite of protocols to provide the required interoperability, utilise more efficient bit-oriented protocols and provide for more integrated applications and services. Existing and developing communications networks can be used to support the end to end communication of ATS and AOC data between end systems. The connectivity between the 'individual' networks is provided by ATN routers. Figure A3-1 illustrates the ATN concept.

Components of the ATN

The ATN is dependent upon three functional components.. These are:

1. ATN End Systems (ES) e.g. FIS Server;
2. Subnetworks e.g. X.25 PPSDN (Ground/Ground) and VHF Datalink (Air/Ground);
3. ATN Routers (Intermediate Systems (IS)).

ATN End Systems

The ATN End System (ES) contains all seven OSI layers in its protocol stack and one or more end user application processes. This provides the ATN ES with the capability to communicate with other ATN ESs to provide end to end communication services to ATN applications.

Subnetworks

A subnetwork is an independent communications network based on a particular communication technology, e.g. X25 or Frame Relay, which is used to physically transfer information between ATN systems. The ATN systems can use the subnetworks to transfer the information between air and ground based end systems.

The air/ground (mobile) subnetworks, e.g. VHF datalink (VDL), can be provided by the ATS provider or a third party service provider. To ensure the interoperability of the mobile

[21] ISO have defined a reference model which contains seven layers, each layer having a set of defined requirements, interfaces and supporting protocols.

subnetworks, ICAO have begun a programme of standardisation[22]. This will ensure the air traffic management benefits of the ATN are realised. Equally, there are ground/ground (fixed) subnetworks available, such as the state owned X.25 packet switching networks (CAPSIN, RENAR and RAPNET, etc.), which can be used to provide connectivity between the ATS centres.

ATN Routers

The ATN router is an intermediate system (IS) and contains the lowest three OSI layers in its protocol stack. The router provides the connectivity between the various subnetworks and routes messages across the appropriate subnetworks based on criteria such as route availability and priority.

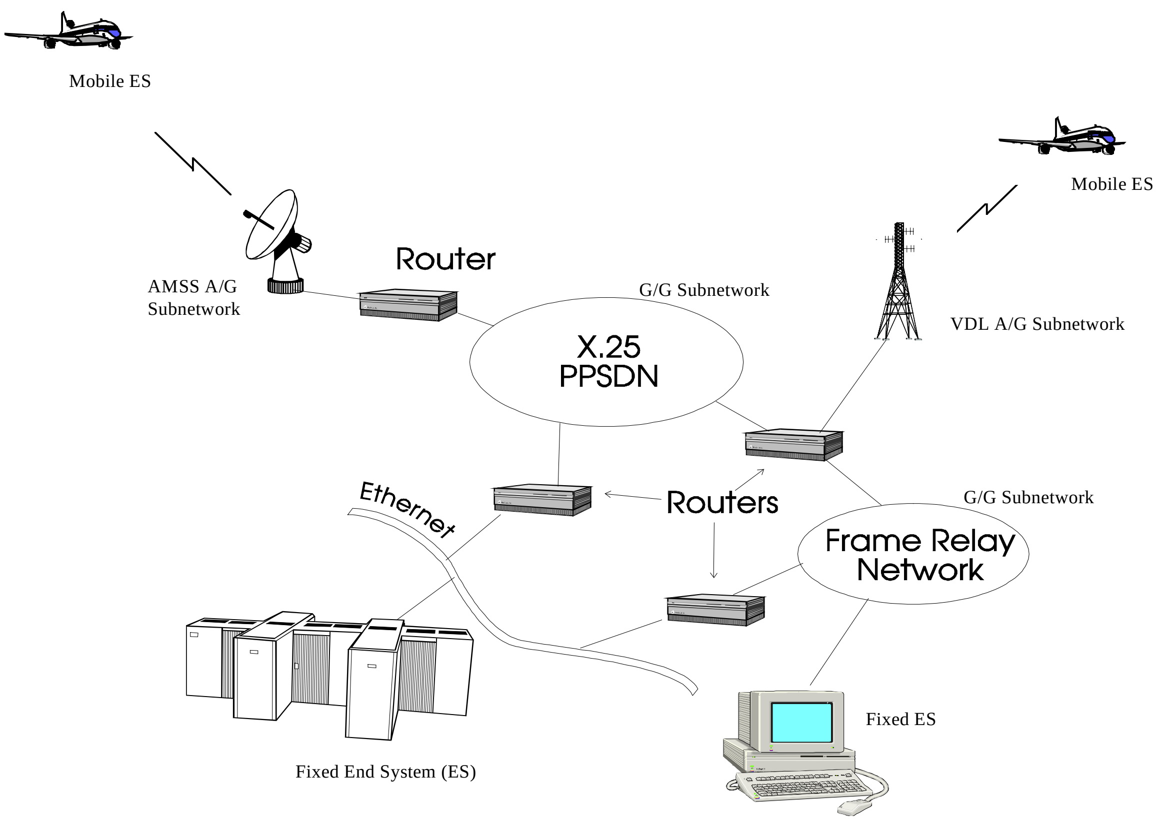


Figure A3-1: The ATN Concept

Conclusion

The ATN is a fully scaleable network offering prioritised end-to-end communications, policy based routing procedures and a high service availability to meet the stringent performance and safety requirements needed for ATS. To ensure the ATN can meet present and future demand a range of features including an addressing plan, congestion management and a routing framework have been defined in the ATN SARPs.

In conclusion, the ATN will offer a robust and high integrity communication service between two end systems, either at a fixed location (ATS centre) or mobile (aircraft ES), taking into account the specific requirements of the user.

[22] The SARPs for some air-ground subnetworks are already available e.g. AMSS.

Appendix 4: ACCESS Addressing Plan

ATN NSAP Address

According to the SARPs, the first 4 octets of the NSAP addresses shall be set to:

47002781hex in all ground systems administered by an ATSC authority

470027C1hex in all mobile systems administered by an ATSC authority

The ACCESS Study recommends that the fifth octet of the NSAP address of all European ATSC ground and mobile systems be set to 83hex (the ICAO Region Identifier for Europe)

The following approach is proposed for the allocation of values to octets 6 and 7 of European ATSC systems:

1. In systems administered by a national ATSC authority, octets 6 and 7 of the NSAP address should be derived from the State's two character alphanumeric ISO 3166 Country Code, represented as upper case characters. (e.g. 'FR' for all systems administered by a French ATSC authority)
2. In systems administered by a supra-national organisation, octets 6 and 7 of the NSAP address should be set to a two character alphanumeric code, registered with the European addressing authority and represented as lower case characters. (e.g. 'eu' for all systems administered by Eurocontrol)

According to the SARPs, octet 8 of the NSAP address shall be set to 00.

For mobile ATSC systems, octets 9, 10 and 11 shall be set to the 24-bit ICAO Aircraft identifier

For ground ATSC systems, octet 9 is proposed to be set as follows:

- 01 for systems in operational Routing Domains of a national ATSO
- 11 for systems in non-operational Routing Domains of a national ATSO
- 21 for systems in operational Routing Domains of a national military organisation
- 31 for systems in non-operational Routing Domains of a national military organisation
- 61 for systems in operational Routing Domains of a national meteorological organisation
- 71 for systems in non-operational Routing Domains of a national meteorological organisation

For ground ATSC systems administered by a national ATSO, octets 10 and 11 are proposed to be derived from the 2 last characters of the 4-letter ICAO location indicator associated with the FIR where the systems are located.

For the Airport operators, it is proposed that the value of octets 9, 10 and 11 be derived from the three-character alphanumeric international code of the airports (e.g. 'CDG' for Paris-CDG Airport operator).

Values of the other octets of the NSAP addresses are very dependent on the internal routing architecture of each organisation.

Guidelines for ATN Application Naming and Addressing.

1. For non AMHS-based applications (i.e. all air/ground applications and ground ICC applications)

The ATN address is composed of an NSAP address identifying unambiguously the end system within the ATN environment and a TSAP selector identifying the application within the scope of the end system. The structure and contents of the NSAP address shall follow the recommendations provided in the previous section. In addition, the ACCESS Study recommends that the TSAP selector be locally assigned for all applications except the CM application in case a logical application address is needed for CM.

The ATN application naming scheme defines an application name assignment procedure based on the geographical location of the system hosting the application and on the type of the application (see Sub-Volume 4 of the ATN SARPs). Therefore, as no possibility of customising the application names is given to the system administrators, the ACCESS Study need not provide any guideline on the way the application should be named.

2. For AMHS based applications

The ATN address of these applications is composed of an NSAP address and three selectors identifying in turn the Transport, Session and Presentation service-users. The structure and contents of the NSAP address shall follow the recommendation of the previous section. The value assignment for the selectors is considered to be a local matter for the organisations responsible for AMHS systems.

Application names are needed to identify the application entities participating in AMHS as well as the final AMHS users. Application names for AMHS application entities shall conform to the naming scheme defined in the ATN SARPs Sub-Volume 4 based on the location of the systems. Application names for AMHS users shall at least support the naming structure "XF-address" described in the SARPs when communications with AFTN users are foreseen. No particular constraint is put on the AMHS administrators to define their user names. However, as AMHS communications may be eased by the adoption of common naming rules, a European AMHS naming scheme is required. The European project SPACE (Study and Planning of AMHS Communications in Europe) will address this issue.