INTERNATIONAL CIVIL AVIATION ORGANISATION
ASIA PACIFIC OFFICE

GUIDANCE MATERIAL FOR GROUND ELEMENTS IN ATN TRANSITION

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Executive Summary

The document provides a technical guidance on Planning and Implementing ATN (Aeronautical Telecommunication Network) Transition of Ground Communication within the ASIA/PAC region.

The material is technical in nature, and the description is brief so that the intention of the document is to provide the whole picture of the subject. The planning and implementation details are left to the detailed technical documents.

The material is intended for the Regional Planning. Although the plan itself is mainly left to States for planning and implementation, it is hard to differentiate the regional planning from State planning. In chapter 3 of the document, the issues to be addressed during the planning and implementation are listed, and the classification of Regional/States planning is given.

To provide a clearer view, some questions on the meaning of 'ATN' and 'Transition' need to be addressed. It follows then to elaborate on what is planned and how is it planned.

What is ATN?

The ATN is proposed by ICAO as a framework for the future aeronautical telecommunication, which is required to be global and seamless. The ATN also provides a set of defined communication services. The ATN SARPs (Standards and Recommended Practices) cover the Ground-to-Ground communications as well as Air-to-Ground communications. Based on the standards defined, States and industries are implementing the communication services. Without such standardization and the complied implementations, the global and seamless communication services will not be provided. As a basis for standardization, ISO (International Organization for Standardization)/OSI (Open Systems Interconnection) reference model is adopted.

The ATN plays the C (Communications) role within CNS/ATM systems. The true ATM system will not be possible without data collected through global and seamless communications. In order to be global and seamless, all networks participating in ATN; airborne networks, air-to-ground data links and ground networks, have to comply with the communication protocols defined by ATN SARPs. The users of the ATN will depend on the ATN for all aspects of aeronautical telecommunication, and will mind themselves of the non-communication aspects. This separation of communication aspects from overall ATM aspects makes it possible to adopt advanced communication technologies as available without major changes in the non-communication aspects, and vice versa.

To make the communication global and seamless, The ATN SARPs themselves are organized as two major layers structure; Internetworking and Messaging. The Internetworking is to interconnect various networks, existing or would be available in future, so that data will be transferred from any network to any network globally, using the existing networks and being extensible for the future networks. The Messaging is to provide messaging/communication capabilities of specific ATM functions, e.g. ADS, CPDLC, FIS, over the Internetworking. It is to be noted that the same networks interconnected are used for such various messaging capabilities. Standardizing also these messaging capabilities, all aspects of the communications will be global and seamless.

The data collected by an ATM system (or a part of system) will be transferred through ATN, and will be fed to another ATM system(or another part of system). The users of the ATN are then the non-communicating portions of ATM systems.

In chapter 2 of the document, ATN Concepts and Elements are summarized. In the ATN SARPs, 34 high level technical requirements, called as System Level Requirements, are stated. In the document, each requirement is associated with the description of ATN concepts and elements as appropriate.

As the ATN concepts, Administrative and Routing Domain, Routing, Naming, Addressing, Traffic Type and Quality of Services are explained briefly. Also provided are the summaries of End-to-End communication and internetworking.

The purpose of Administrative Domain is to clearly indicate the domain of an organization's responsibility and differentiate communication within an organization from the communication between organizations. The Routing Domain is within an Administrative Domain.

The Routing is to select data path from origin to destination over the interconnected autonomous networks, satisfying the constraints on the way messages transferred, depending on the nature of messages, type of services provided.

In ATN, the communication is based on addresses, that is, it is an addressed communication, not broadcasting. All End Systems and ATN Routers are given unique addresses. Naming is for the convenience of human being.

The Traffic Type is a means to distinguish the types of message traffic for the purpose of establishing communication paths to support operational and legal requirements of the message.

The Quality of Service is an information relating to data transfer characteristics, such as delay, cost, error and priority.

As ATN elements, End System and ATN Router (Intermediate System) are also explained in the document.

The End System contains the OSI seven layers and contains one or more end user application processes.

The Intermediate System performs relaying and routing functions and comprises the lowest three layers of OSI reference model.

What is ATN Transition?

The ATN is the new infrastructure for data communication, but the data communication itself is not new. Given the diversity of systems currently in service, transition plans should address the issue of support for legacy systems.

In order to manage the introduction of the ATN services, each region, State and organization will need to plan for the transition from the current infrastructure and procedures to those required for the operation of the ATN environment. The resulting plans will necessarily address the following two issues:

- existing communication infrastructure; and
- new communication infrastructure.

The ATN can not be implemented instantaneously. The ATN should be implemented in phases.

If new ATN application message processors and data link systems are implemented, they should support code- and byte-independent data transmission and be fully compatible with the ATN.

The need for transition planning applies to all parties involved in the provision of components of the ATN. It is essential that the plans of these various organizations be coordinated. During the transition, States should co-operate on a bilateral and multilateral basis to ensure that the operation of the ATN meets the needs of international aviation and the States. The world-wide co-ordination of these activities is necessary if optimal use to be made of the ATN.

It is also important that the pace of the implementation of the different systems be coordinated between States in order to ensure compatibility with users operating in multiple FIRs. The transition should be carefully planned so as to avoid degradation in performance. The safety and performance that is apparent today should not be compromised at any point during the transition.

To allow a smooth transition to the CNS/ATM environment, procedures will be required to address both technical and operational issues related to the concurrent operation with existing systems.

What is to be planned?

The Planning and Implementation activities are the emerging issues for the ATN. The ATN Panel developed 'Planning and Implementation Guide' as a part of Guidance Materials, where the following steps are recommended as planning and implementation process with brief description:

- CNS/ATM Operational Concept;
- Network Operating Concept;
- Transition Planning;
- Implementation Planning;
- Operational evaluation; and
- Certification and commissioning.

In chapter 3 of the document, all issues to be addressed are listed, and at the end of chapter, a sequential process of 10 steps for regional planning (and associated State planning) is developed, associated with issues to be addressed in each step, as follows:

Step 1) Identify and integrate existing and newly required infrastructure for transition, with respect to inter-domains connections;

Step 2) Provide service definition, benefit analysis and develop procedure of ground messaging services with respect to inter-domains operations;

Step 3) Provide information on Administrative Domain and its definition within State;

Step 4) Provide information on architectural design of ATN ground within State;

Step 5) Address the issues of interconnections with respect to inter-domains, including inter-domain internetworking (between ground subnetworks, interconnection to air-ground subnetwork), and ground-to-ground service components interfaces (inter-domain end-to-end services and AFTN/ATN gateway);

Step 6) Identify traffic type, and Quality of Services through the target network, with respect to inter-domains connections;

Step 7) Address the performance issues of reliability, maintainability and availability with respect to inter-domains operations;

Step 8) Develop transitional procedure with respect to inter-domains operations;

Step 9) Provide cost analysis of ground elements of ATN with respect to inter-domain connections; and

Step 10) Provide ATN Security solution.

Essentially, the issues related to inter-domain (between States) are the subjects of Regional Planning, while the matters within domain are ones of the States' planning.

As the first step, the description of ATN transition is provided, followed by the benefit analysis of messaging over ATN.

It is the responsibility of the States to design Administrative Domain and Network Architecture. The regional planning group will be responsible for addressing the interconnection issues, Traffic Types and Quality of Service, performance issues and transitional procedure between domains.

The cost analysis will be conducted after the plan is detailed. At the end, the security, system management and directory services are addressed.

Since the document addresses only the GROUND aspect (including ground portion of Air-to-Ground communications), Airborne Elements and Air-to-Ground Data Links of Air-to-Ground communications are not discussed.

How is the plan developed?

Following the steps given in the regional planning process, the guide to the plan of each step is provided in the document, summarized as follows:

Step 1 (section 4.1);
the transition is extensively discussed and gateway approaches are detailed, together with transition scenarios. The advantages/disadvantages of the approaches are discussed.

Step 2 (section 4.2);
the benefit analysis for store-and-forward messaging is described. The benefit analysis of air-to-ground messaging is not included. It will be included, as it becomes available.

Step 3 (section 4.3);

the information on Administrative Domains and some basic ATN elements (End Systems, Intermediate Systems, and Messaging Services) is provided.

Step 4 (section 4.4);
the information on design of subnetwork interconnections and the allocations of End Systems, Intermediate Systems and Gateways (within Domain) is provided.

Step 5 (section 4.5);
the issues of interconnected subnetworks and the allocations of End Systems, Intermediate Systems and Gateways (between Domains) are discussed.

Step 6 (section 4.6);
the Traffic Types and Quality of Service are explained.

Step 7 (section 4.7);
the performance aspects are described.

Step 8 (section 4.8);
the transition paths and procedures are described for AMHS and AIDC.

Step 9 (section 4.9);
the costs; development and operational/maintenance cost are analyzed.

Step 10 (section 4.10);
the ATN Security solutions are provided.

1. Introduction

This document contains the required guidance material for the ATN transition, intended for the regional planning, especially on the ground elements in the ASIA/PAC region.

1.1 Objectives

The objectives of the document are to provide:

1. concepts and facilities defined in the ATN, primarily focusing on the ground elements;
2 identification of planning activities expected in the ASIA/PAC; and
3 possible implementation approaches and their evaluations.

This document is intended for the transition planning at the regional level, and providing information for the decision making.

1.2 Scope

The scope of the document includes:

1. The ATN concepts and facilities, primarily focusing on the ATN ground elements and the ATN ground-to-ground service components, that is, the Air-Ground Data Links are not the subjects of the document, although it is mandatory for the ground elements to provide the message transfer capability of the Air-Ground Data Link messages over the ground subnetworks;
2. regional transition planning, which is based on ICAO planning document[3, PART I]; and
3. possible implementation alternatives with the technical analyses for estimating the cost of specific implementations in transition. The benefit analysis is limited only to the ground-to-ground service components.

1.3 Document structure

In chapter 2, the ATN Concepts (Domain, Routing, Names and Address, Traffic Type, Quality of Service, End-to-End, Internetworking) and ATN elements (End System, Intermediate System, Subnetwork, Gateway) are summarized in general terms.

In chapter 3, the issues addressed by ATN planning document [3, PART I] are recognized, noting whether the issues are regional matters or individual State matters. Ten issues for the regional planning are identified.

In chapter 4, The ten issues identified in chapter 3 are discussed in detail and appropriate actions are suggested as guidance material.

1.4 Terms used

Air elements of the ATN; a set of elements in the Airborne system, which includes Air End Systems, Airborne ATN Router, and Airborne subnetwork.

Air-to-Ground elements of the ATN; a set of elements in the Air-to-Ground system which includes Air-to-Ground data link and Air-to-Ground (ground based) ATN Router.

Ground elements of the ATN; a set of elements in the Ground system, which includes Ground End Systems, Ground-to-Ground ATN Routers, and Ground-to-Ground subnetworks.

Service components of ATN; in the application layer of communication services.

Ground-to-Ground service components of ATN; a set of ground-to-ground end-to-end communication services, e.g. ATSMHS, and ICC (AIDC), which solely use the ground elements of the ATN.

Air-to-Ground service components of ATN; a set of air-to-ground end-to-end communication services, e.g. ADS, CPDLC, FIS and CM, which use all of the air elements, air-to-ground elements and ground elements of the ATN.

End System (ES) is defined as follows; 'a system that contains the OSI seven layer and contains one or more user application process'

Application Entity (AE) is defined as follows; part of an application process that is concerned with communication within OSI environment, located in the application (seventh) layer of the OSI, i.e. the portion of Service Components within the End System (ES)

In order to identify the OSI application layer portion of service component within ES, the terms ATSMHS AE or ADS Ground AE, for instance, is used for the ATSMHS or ADS specific portion, i.e. excluding the ATN common portion, of ATSMHS or ADS within Ground End System. The Service Component includes two communicating AEs (of same type) together with the ATN environment. For the detailed, see the subsequent chapters.

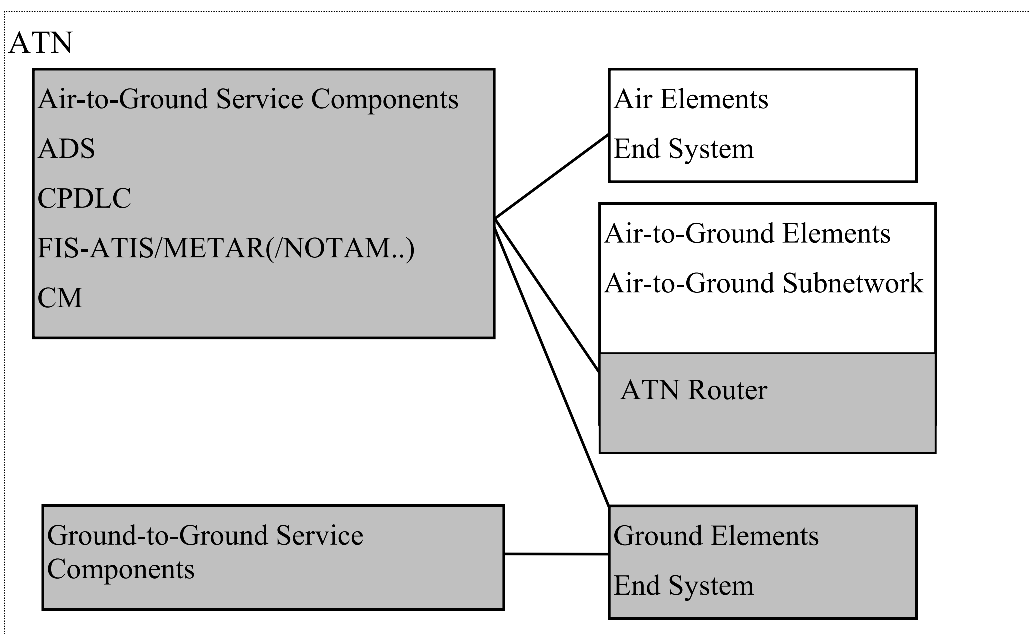


Figure 1.4-1 Terminology

The shaded portion in Figure 1.4-1 is the area discussed in the document.

1.5 References

Reference 1 Annex 10 VOLUME III (PART 1-DIGITAL COMMUNICATION SYSTEMS) CHAPTER 3 AERONAUTICAL TELECOMMUNICATION NETWORK

Reference 2 ICAO DOC 9705-AN/956 Manual of Technical Provisions for Aeronautical Telecommunication Network (ATN)

Note: Previously described as detailed ATN SARPS.

Reference 3 ICAO DOC 9739

Note: Previously described as CAMAL; Comprehensive ATN Manual or Guidance Materials (Part 1 through 4)

Reference 4 ASIA/PACIFIC Regional Interface Control Document for ***ATS Inter-Facility Ground/Ground Data Communications (AIDC)*** Version 1.0 1, June, 1995

Reference 5 ASIA/PACIFIC Regional Interface Control Document **X.25 for AFTN**, Issues 1, February, 1996

2. ATN Overview

In this chapter, ground elements of ATN are briefly described. Each System Level Requirement in SARPs [Reference 1] ('SLR' with No.) is associated with each section.

Note: the System Level Requirements (SLR) are high-level technical requirements that have been derived from operational requirements, technological constraints and regulatory constraint.

SLR #1 The ATN shall use ISO communication standards for Open Systems Interconnection (OSI).

SLR #2 The ATN shall provide a means to facilitate migration to future versions of application entities and/or the communication services.

SLR #27 Where the absolute time of day is used within the ATN, it shall be based on coordinated universal time (UTC).

2.1 ATN Fundamentals

2.1.1 Administrative Domain and Routing Domain

Administrative Domain is administered by a single organization or authority. The purpose of administrative domain is to clearly indicate the domain of an organization's responsibility and differentiate communication within an organization from the communication between organizations.

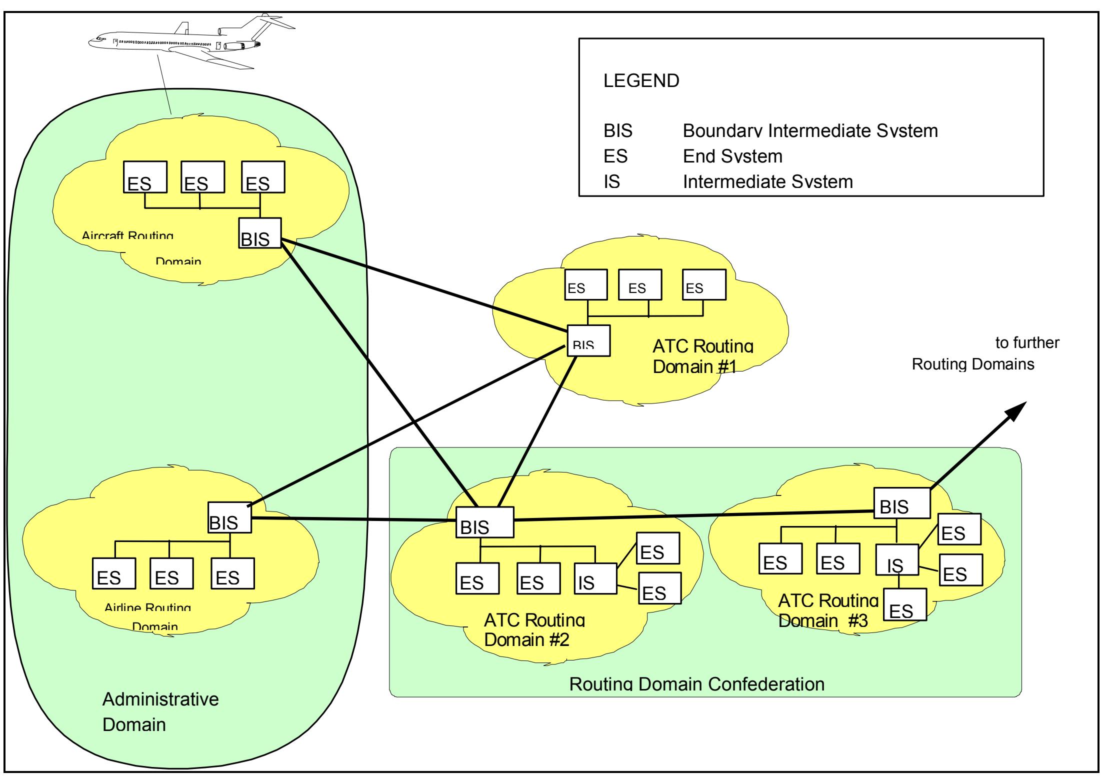


Figure 2.1-1 Example for an ATN Domain Structure

Within an administrative domain, there may be one or more routing domain. Routing domain consists of one or more than one inter-domain routers, and end systems.

Note: There must be at least one BIS and one ES. It is not mandatory to have an IS. If there is only one ground subnetwork in the routing domain, the BIS can be acting as an IS as well

Routing domains are elements of the physical structure of the ATN.

The adjacent administrations may combine their routing domains into single domain (routing domain confederation).

2.1.2 Routing

SLR #5 The ATN shall accommodate routing based on a pre-defined routing policy.

SLR #9 The ATN shall enable application exchange of information when one or more authorized paths exist.

SLR #10 The ATN shall notify the appropriate application process when no authorized path exists.

Since many subnetworks are interconnected, there may be multiple paths from the origin to the destination of messages. It is desirable to select the best path, if there is any, to transfer messages. The route selection strategy to find better path is called ‘best effort’.

There may also be some constraints on the way messages transferred, depending on the nature of messages, type of service provided. Routing messages is one of key concepts in the ATN.

Within a routing domain, the ES informs its connectivity information to the connected IS(including BIS) and all ISs exchange connectivity information among them within a routing domain.

In case of the interconnected domains, the connectivity information exchanges among all ISs could be enormous. The IS situated at the domain boundary, called Boundary IS (BIS), handles the connectivity information exchanges between Domains. The protocol for such inter-domain connectivity information exchanges is called IDRP (Inter-Domain Routing Protocol).

Subnetworks in various administrative domains may be operating based on different routing policies, so that for inter-domain routing, the distributed approach, rather than centralized approach, is adopted, where all participants on routing comply with a set of rules while they keep an autonomy of their policy.

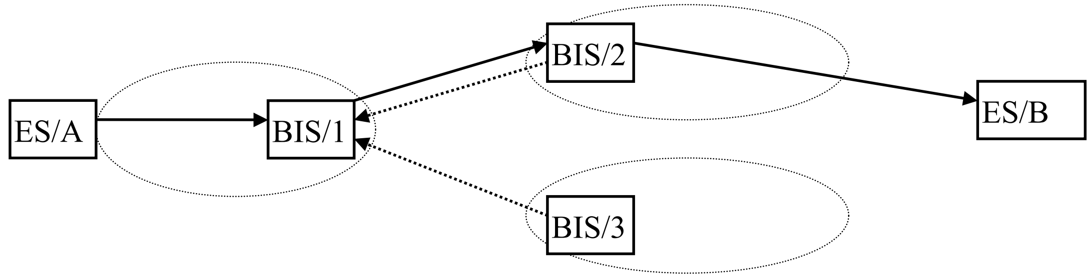


Figure 2.1-2 Route information exchanges

For instance, shown as dotted arrows in the figure, adjacent BISs (BIS/1 and /2, and BIS/1 and /3) exchange the information on routes to the reachable ESs (e.g. ES/B in the figure) with values of Quality of Services (delay, cost and integrity), without exposing the routing policies within each domain. Exchanging route information is not centrally controlled by anyone, i.e. it is distributed. Each BIS makes routing decisions, like solid lines in the figure, based on the exchanged route information.

2.1.3 Names and Addresses

SLR #11 The ATN shall provide a means to unambiguous address all ATN end and intermediate systems.

SLR #12 The ATN shall enable the recipient of a message to identify the originator of that message.

SLR #13 The ATN addressing and naming plans shall allow States and organizations to assign addresses and names within their own administrative domains.

A name is used to identify an object, and an address is used to locate an object. Typically names have meanings to application and people, so that generally expressed in a mnemonic format, while addresses are generally expressed in a coded or numeric format.

2.1.3.1 Naming and Addressing Requirements

In the ATN environment, the technical aspect requirements are:

REQ 1) unambiguous identification of certain objects;

REQ 2) the assignment of names and addresses to these objects to achieve this identification;

REQ 3) the exchange of these names and addresses in order to establish a topological map of the network and identify the sender and/or receiver of a given piece of information;

The administrative aspect requirements are:

REQ 4) the recording of definitions of the instances to which those names and addresses are assigned; and

REQ 5) the propagation of registered names and addresses both on a global and on a local level.

2.1.3.2 Naming and Addressing Concepts

The concepts, principles, and rules on names and addresses in ATN environment have to be formulated and understood to satisfy the REQ 1) and 2) above.

In order to take necessary actions in each state, it is important to understand the concepts, principles, and rules of naming and addressing in the ATN environment. This is described precisely in the relevant chapters of [3 Part II], in particular,

6.4 ATN Elements Subject to Naming and Addressing (REQ 1)

ATN elements, which are required to be identified.

6.5 ATN Address and Name Definitions (REQ 2)

ATN naming and Addressing rules

Subnetworks (section 4.5.1),

Internetwork (section 4.5.2),

Transport, Upper Layer and Application Addressing (section 4.5.3), and

Application Naming (section 4.5.4).

REQ 3) is satisfied by ATN implementation.

Guidance for States to assign actual values of names and addresses is provided in the next chapter of this document on assignment of names and addresses.

2.1.3.3 Names and Addresses registration

The REQ 4) and 5) require procedures to be set up within State or globally (within ICAO).

At second ATN Panel meeting, two recommendations are made;

Recommendation 4/1 Advice to States on ATN addressing issues

That ICAO advice States and international organizations to take the necessary actions for the assignment, administration and registration of ATN names and addresses within their allocated name/address space, using the information provided.

Recommendation 4/2 Setting up of an ICAO ATN addressing process

That ICAO take the necessary actions to provide a facility for maintaining an up-to-date repository of ATN addresses and names registered in the ATSC domain, and publish the repository entries at usual regular intervals.

The recommendation 4/1 asks for States to take necessary actions on REQ 4) and 5) above within their domain. The necessary actions are as follows:

1. establish the necessary administrative structure to carry out allocation, assignment and administration activities for ATN names and addresses;
2. establish procedures for such activities.

   (See 3.4 ATN Physical and Administrative Structure in [3 Part I]

   4.3 Naming and Addressing Authority and 4.7. ATN Name and Address Registration in [3 Part II])

   These issues are strictly State matters and will not be discussed in this document.

2.1.4 Traffic Types and Quality of Service

SLR #6 The ATN shall provide means to define data communication that can be carried only over authorized path for the traffic type and category specified by the user.

SLR #7 The ATN shall offer ATSC classes in accordance with the criteria in Table 2.1-1.

Note 1. When ATSC class is specified by an ATN application, packets will be forwarded in the ATN Internet communication service on a best effort basis. Best effort basis means that when a route is available of the requested ATSC class the packet is forwarded to that route. When no such route is available, the packet will be forwarded on the first known route of ATSC class higher than that requested, or if there is no such route, first known route of lower ATSC class than that requested.

Note 2.- The ATN communication services will not inform application entities if the requested ATSC class was not achieved. It is the responsibility of the application entities to determine the actual transit delay time achieved by local means such as times stamping.

SLR #8 The ATN shall operate in accordance with the communication priorities defined in Table 2.1-2.

2.1.4.1 Traffic Types

The Traffic Type is a means to distinguish different types of message traffic for the purposes of establishing communication paths to support operational and legal requirements.

There are four Traffic Types:

a) operational communication traffic type
   1) ATS communication
   2) Aeronautical operational control (AOC)

b) administrative communication

c) general communication

d) systems management communication

The Traffic Type is a part of the application names. All applications originally specified in the ATN SARPs are operational Traffic Type, except SMA(System Management Application).

The messages of these Traffic Types are conveyed over the ATN. The differentiation of messages by Traffic Type is required because the different data traffic may have different access to subnetworks.

The Traffic Type is conveyed in the ATN security label of ISO/IEC 8473(SNDCF) and ISO/IEC 10747(IDRP). It is used to qualify data packets and (inter-domain) routes according to the class of traffic they carry. Based on this qualification, access to subnetworks is controlled by ATN Internet communication service.

For ATS communication, ATSC classes ('A'- 'H') within ATS communication is defined, and Traffic Type policy is conveyed in the ATN security label for ATSC class.

Table 2.1-1 Transit Delay Value for ATSC Class

ATSC Class	One Way ATN End-to-End Transit Delay at 95% probability(seconds)

ATSC Class	One Way ATN End-to-End Transit Delay at 95% probability(seconds)
A	Reserved
B	4.5
C	7.2
D	13.5
E	18
F	27
G	50
H	100
No Preference	No Value Specified

For AOC, the air-to-ground subnetwork preference is conveyed in the ATN security label.

2.1.4.2 Quality of Service

The Quality of Service is defined as information relating to data transfer characteristics(e.g. requested throughput and priority) used by a router to perform relaying and routing operations across the subnetworks, which make up a network.

For example, there are four Network QOS attributes.

Transit Delay

Expense

Residual Error Rate (RER) and

Priority

The values of first three attributes would be used while selecting route of messages to destination along the path.

Performance requirement related to RER for the ATN End System is specified as follows.

SLR #28 The end system shall make provisions to ensure the probability of not detecting a 255-octet message being mis-delivered, non-delivered or corrupted by the internet communication service is less than or equal to 10^{-8} per message.

Note:-It is assumed that ATN subnetworks will ensure data integrity consistent with this system level requirement.

The priority level for transport and network layer are defined in ATN SARPs. Each ATN application is mapped onto one of the priority levels listed in Table 2.1-2.

Table 2.1-2 ATN Communication Priority Mapping

Message Category	ATN Application	Corresponding Protocol Priority		
		Transport Layer Priority		Network Layer Priority
Network/System Management	SM	0	0	14
Distress Communication		1	1	13
Urgent Communication		2	2	12
High Priority Flight Safety Message		3	3	11
Normal Priority Flight Safety Message	CPDLC,ADS,AIDC	4	4	10
Meteorological Communication		5	5	9
Flight Regularity Communication	CM,ATSMHS	6	6	8
Aeronautical Information Service Messages Network System Administration	METAR,ATIS SM, DIR	7 8	7 8	7 6
Aeronautical Administrative Messages		9	9	5
<unassigned>		10	10	4
Urgent Priority Administrative and U.N. charter Communication		11	11	3
High Priority Administrative and State/Government Communication		12	12	2
Normal Priority Administrative communications		13	13	1
Low Priority Administrative communications and Aeronautical Passenger Communications		14	14	0

Note: The network layer priorities shown in the table apply only to connectionless network priority and do not apply to subnetwork priority.

2.1.5 End-to-End Communications and Internetworking

The communication services provided in ATN have end-to-end significance. ATN will operate in an environment where many subnetworks are interconnected, although subnetwork itself is not part of the ATN. In order to provide end-to-end communication services with various subnetworks interconnected, a SNICF + SNDCF scheme plays an important role in the ATN.

2.1.5.1 CLNS: Connectionless Mode Network Service and CLNP; Connectionless Network Protocol

CLNS consists of a single end to end primitive - the N-UNITDATA service.

NS-User	Network Layer	Subnetwork	Network Layer	NS-User
N-UNITDATA Request →		Data NPDU →		→ N-UNITDATA Indication

NS-User; Network Service User, i.e. Transport Service. NPDU; Network Packet Data Unit

Figure 2.1-3 Connectionless mode network service

CLNS is a service provided to a network service user when ISO/IEC 8473 connectionless network Protocol (CLNP) is used as a SNICF (Subnetwork Independent Convergence Function).

The service is requested by the sender who passes, as the service parameters, the user data, the network address of the destination, the sender's own source address, and the indication of the quality of service required, Network Priority and associated ATN security label.

The Unit data then passes through the network, independently of any other data passed between the same source and destination and delivered to the addressed destination.

2.1.5.2 Internetworking various subnetworks

In the ATN Network layer, CLNP is supported. In order to incorporate any specific type of subnetworks, Subnetwork Dependent Convergence Function (SNDCF) of the specific subnetwork to support CLNP, the specific functionality for the intended subnetwork, is required and is placed in the lowest sub-layer of Network layer. The SNDCF for various subnetworks, air-ground and ground subnetworks, are described in the ATN Internet SARPs. The ground networking technologies that may be used as subnetworks in the ATN, include LAN and X.25. It may include Frame Relay and ATM and others.

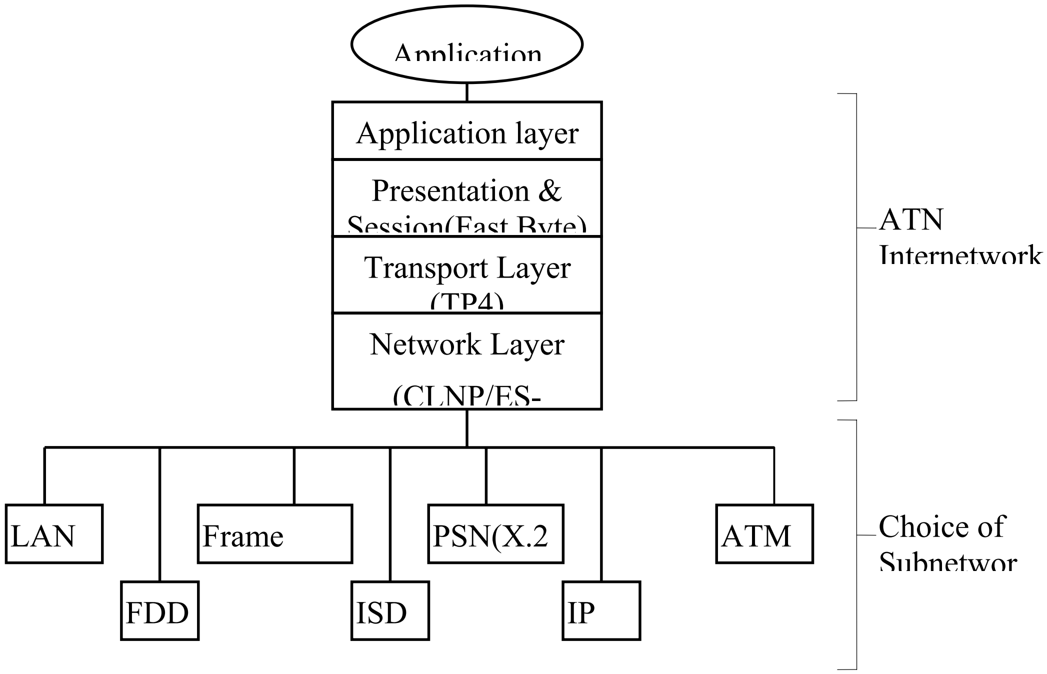


Figure 2.1-4 Various ground subnetworks

It has to be noted that the ATN Internet SARPs cover the Network Layer in the Figure 2.1-4, and define SNDCFs of various ground subnetworks. The ground subnetworks themselves are not part of the ATN Internet SARPs. Merely adopting any one of ground subnetworks, e.g. X.25, whose SNDCF is defined in ATN Internet SARPs, does not mean 'ATN implemented'.

2.2 ATN Elements

The main infrastructure elements of the ATN are, the End Systems, the ATN Routers (Intermediate Systems), and the subnetworks.

A subnetwork is part of the communication network, but is not part of ATN SARPs.

In this section, End Systems, ATN Routers, and subnetworks are briefly described.

2.2.1 End Systems

The ATN end systems are capable of communicating with other ATN end systems to provide end-to-end communication services to the ATN applications. The ATN end systems includes a full 7-layer protocol stack, defined in the OSI Reference Model, to host the appropriate communication services.

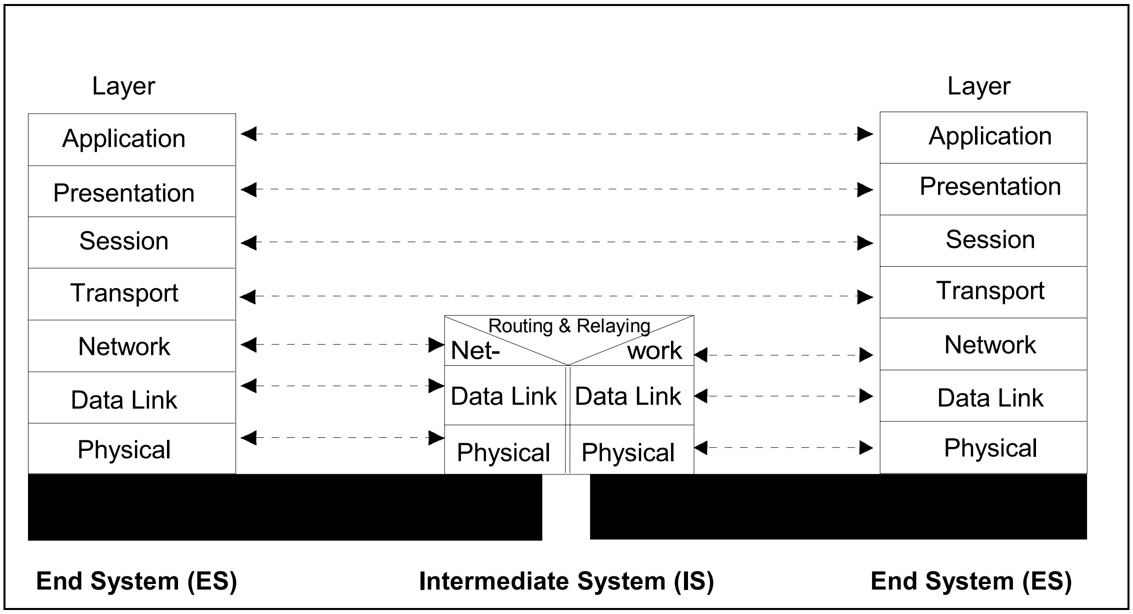


Figure 2.2-1 OSI Reference Model

2.2.2 Router

SLR #17 The ATN shall enable an aircraft intermediate system to be connected to a ground intermediate system via concurrent mobile subnetworks.

SLR #18 The ATN shall enable an aircraft intermediate system to be connected to multiple ground intermediate systems.

2.2.2.1 Role of Routers

The routers are the intermediate systems comprising the lower 3 layers of the OSI reference model and includes the appropriate set of routing protocols. The routers exchange routing information, i.e. information about available routes, their characteristics, and the end systems reachable via these routes, to other adjacent routers.

Note: There are routing protocols between routers to exchange the routing information. The routing protocols are different from the user data transfer protocols. The routing information and user data information is exchanged over the same network.

The routers are responsible for forwarding each packet containing the user data via the appropriate path, taking into account the particular service requirements encapsulated in the header of the packet.

When forwarding the user data packets through the network, the choice of the appropriate subnetwork to be used is based on connectivity, security and quality of service considerations.

2.2.2.2 Types and Classes of ATN Routers

2.2.2.2.1 Types of Routers

There are two different types of routers, which support routing packets;

a) Intra-domain routers,

b) Inter-domain routers.

These are defined in the OSI standards.

The intra-domain routers are for use only within the ATN routing domain and it is not specified in the ATN SARPs. The inter-domain routers (BIS; Boundary Intermediate System) are required to provide the ATN-compliant, standardized communication service to adjacent routing domains and other routers of same type within their own routing domain.

Note: BIS may talk to another BISs within the same domain as well as BISs in the other domain.

Inter-domain routers have the capability to apply routing policies when disseminating route information to other BIS in the neighboring domains.

If the routers encompass the functionality of inter-domain and intra-domain capability, then the intra-domain portion is a local matter.

2.2.2.2.2 Classes of ATN Router (BIS)

Three classes of the ATN Routers for inter-domain use, specified in the ATN Internet SARPs, are:

a) Airborne Router,

b) Air-Ground Router (ground based), and

c) Ground-Ground Router.

2.2.2.2.3 Differences between OSI Router (BIS) and ATN Router (BIS)

There are differences between a standard OSI router and the ATN inter-domain router.

The key differences are:

a) application of specific routing policies in support of mobile communication

b) use of security tag for ATN routing.

c) use of compression for efficiency over the air-ground links,

d) support of route initiation and termination.

Note 1: It has to be recognized that ATN inter-domain router is an OSI router, but all OSI routers implemented are not necessary ATN inter-domain routers. Certain provisions in OSI standards on Routers are provided in ATN Internet SARPs

2.2.2.3 Ground-Ground (G-G) Router

2.2.2.3.1 Ground-Ground router requirements;

As far as the Security Path Attribute to support mobile routing is concerned, G-G router passes through the Security Path Attribute in exchanging routing information between G-G BIS routers.

2.2.2.3.2 Ground-Ground Route Initiation

In the Guidance materials of ATN Internet SARPs ground-ground route initiation is explained in section 5.10.2[2] as follows:

(1) Initial route initiation; to establish the underlying communication circuits between BISs and hence establishes logical communications path;

(2) route initiation in CLNP to associate the data link to CLNP; and

(3) route initiation in IDRP.

2.2.2.3.3 Routing Policy

(1) Ground-ground routing policy is a local matter.

(2) Air-Ground routing policy is specified in ATN Internet SARPs, Section 5.3.7 [Reference 2 ICAO DOC 9705-AN/956 Manual of Technical Provisions for Aeronautical Telecommunication Network (ATN)].

2.2.3 Ground Subnetworks

Subnetworks may be distinguished as either ground, air-ground or airborne.

The Ground Subnetworks can be classified into LANs (Local Area Networks) and WANs (Wide Area Networks). LANs are typically used to interconnect ESs and ISs (e.g. within an ATC center). WANs are used for the long-distance connections between ISs.

It should be recognized that a subnetwork does not posses any ATN specific functionality. ATN Router adapts the data packets to the specifics of the subnetwork through SNDCF for transfer between adjacent ATN systems.

For the ground subnetworks, a number of networks for communication within ATS centers and between host computers of ATS centers are available. Such possible candidates for subnetworks are LANs (e.g. Ethernet, Token Ring, FDDI) and WANs (e.g. X.25, Frame relay, ATM or ISDN).

2.2.4 Data Link between Domains

SLR #14 The ATN shall support data communication to fixed and mobile systems.

SLR #15 The ATN shall accommodate ATN Mobile subnetworks as defined in the ATN SARPs.

SLR #16 The ATN shall make provisions for the efficient use of limited bandwidth subnetworks.

Data Link as well as ground subnetwork does not posses the ATN specific functionality. It is considered that any ground subnetwork is contained within a domain. The issue related to inter-domain connectivity has to be addressed from the aspect of a data link between domains, as well as interconnected subnetworks.

From the ATN transition and implementation aspect, provision of data links between domains is the one that planners have to take into account, so that the data link between domains is singled out as an item different from ground subnetwork.

2.3 Ground-to-Ground Service Components of ATN

SLR #25 The ATN shall be capable of establishing, maintaining, releasing and aborting peer to peer application associations for the ATS messaging handling services

(ATSMHS) application.

SLR #26 The ATN shall be capable of establishing, maintaining, releasing and aborting peer to peer application associations for the ATS interfacility data communication (AIDC) application.

The ground-to-ground service components specified in CNS/ATM are ATSMHS and ICC (AIDC).

2.3.1 ATSMHS

ATSMHS; ATS Message Handling Services allows store-and-forward messaging. The ATSMHS consists of ATS Message Service.

The ATS Message Service is provided by the implementation over the ATN of the MHS; Message Handling Systems specified in ISO/IEC 10021 and ITU-T X.400, which gives an economical benefit using Commercial Off the Shelf products. The ATS Message Service also includes a gateway functionality for exchanging messages with the AFTN.

Three types of End Systems are defined in ATSMHS:

1) ATS Message Server;
2) ATS Message User Agent (UA); and
3) AFTN/AMHS Gateway.

The communications between End Systems implementing ATS Message Handling Services are shown in the following table.

Table 2.3-1 Communications between ATS End Systems Implementing ATS Message Handling Services

ATN End System 1	ATN End System 2
ATS Message Server	ATS Message Server
ATS Message Server	AFTN/AMHS Gateway
ATS Message Server	ATS Message User Agent
AFTN/AMHS Gateway	AFTN/AMHS Gateway

See ATSMHS SARPs[2] for further details.

2.3.2 AFTN/ATN Gateways

SLR #3 The ATN shall enable the transition of existing AFTN users and systems into the ATN architecture.

2.3.2.1 Types of Gateways

There are two gateways defined in the SARPs, the AFTN/AMHS Gateway and the CIDIN/AMHS Gateway. Both gateways functions are for the Ground-to-Ground message service only. The CIDIN/AMHS Gateway is generally used in Europe and will not be discussed any further in this document.

In the ATN SARPs, there is no other gateway function defined. It is possible for States to implement gateway functions outside of ATN framework to interface to the ATN Ground components.

2.3.2.2 AFTN/AMHS Gateway

An AFTN/AMHS Gateway consists of three components:

- AFTN component,
- Message Transfer and Control Unit(MTCU), and
- ATN component.

The ATN component is in fact ATS Message Server itself.

The received AFTN messages are converted to ATSMHS messages before being conveyed over ATN. Since the messages are converted to ATSMHS, The AFTN/AMHS Gateway can provide interworking between the AFTN and the ATN such that AFTN/AMHS gateway can communicate with ATS Message Servers as well as with other AFTN/AMHS Gateways.

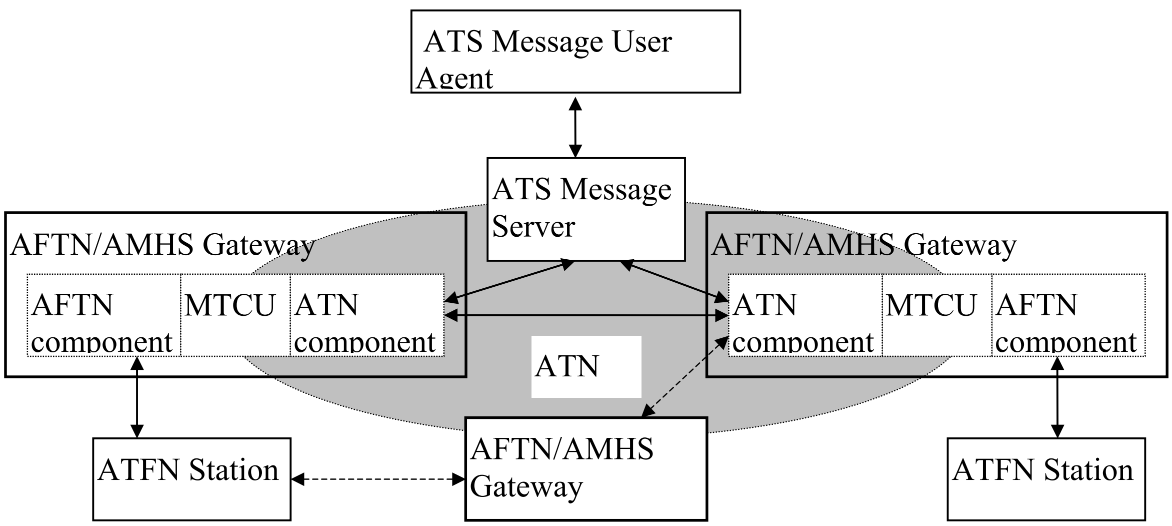


Figure 2.3-1 AFTN/AMHS Gateway

The AFTN/AMHS Gateway is able to talk to both the AFTN/AMHS Gateway and ATS Message Server within the ATN Environment. The AFTN/AMHS Gateway provides the messaging services between AFTN stations via ATN, as well as, the messaging services between the AFTN station and the ATSMHS End System.

Users of AFTN/AMHS Gateway can be AFTN station or ATS Message User Agent.

If AFTN/AMHS Gateway or any ATS Message Server fails, the messages can be diverted to an alternate AFTN/AMHS Gateway or ATS Message Server automatically, i.e. the message re-routing through the dotted lines shown in Figure 2.3-1.

In summary, possible connectivities via gateway are given as follows.

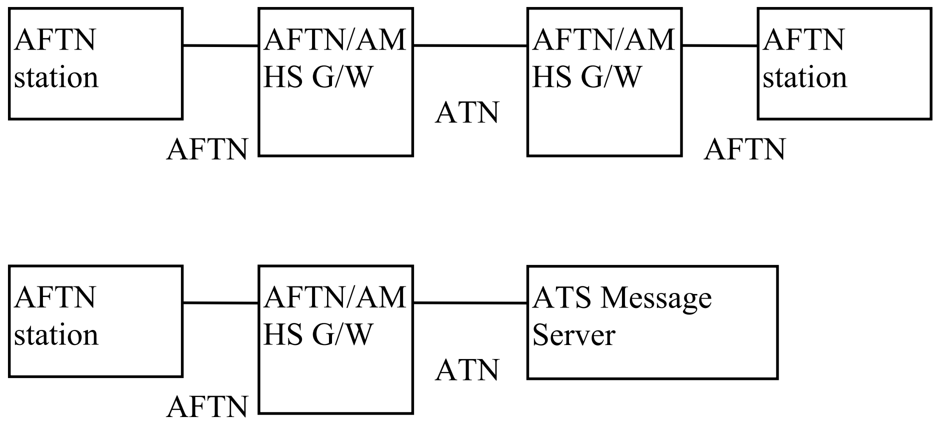


Figure 2.3-2 AFTN/ATN Gateway Connectivity

2.3.3 ICC (AIDC)

ICC: Inter-Centre Communication, application service, allows the real-time communication between ATS entities. Currently only AIDC; ATS Inter-facility Data Communication, is specified in ICC SARPs. The structure of ICC (AIDC) SARPs is similar to the Air-to-Ground service component SARPs.

The difference between ICC (AIDC) SARPs and Air-to-Ground service component SARPs is that in ICC (AIDC), many dialogues will be active at same time. One dialogue for each flight, over the physical connection between the ATS Units. This is not the case for the Air-to-Ground service components, although in the Air-to-Ground service component, there have to be many physical connections, one connection per flight under control.

The ICC (AIDC) SARPs and Air-to-Ground service component SARPs depend on the similar underlying services for association management, where in the ATN SARPs, only one association is allowed over one logical connection and one association is needed for each flight under control. It implies that in the ATN SARPs, there would be as many logical connections as the number of flights under control.

Another provision in the ICC (AIDC) SARPs includes the extensible message sequencing rules, which dictate the strict implementation of sequencing messages exchanged.

See AIDC SARPs[2] for further details

2.4 Air-to-Ground Service Components of ATN

SLR #4 The ATN shall make provisions whereby only the controlling ATS may provide ATC instructions to aircraft operating in its space.

Note: This is achieved through the current and next authority aspects of the CPDLC application entity.

SLR #19 The ATN shall be capable the exchange of address information between application entities.

SLR #20 The ATN shall support context management (CM) application when any of the other air-ground applications are supported.

SLR #21 The ATN shall be capable of establishing, maintaining, releasing and aborting peer to peer application associations for the context management (CM) application.

SLR #22 The ATN shall be capable of establishing, maintaining, releasing and aborting peer to peer application associations for the automatic dependent surveillance (ADS) application.

SLR #23 The ATN shall be capable of establishing, maintaining, releasing and aborting peer to peer application associations for the controller pilot data link communication (CPDLC) application.

SLR #24 The ATN shall be capable of establishing, maintaining, releasing and aborting peer to peer application associations for the automatic terminal information service (ATIS) application.

SLR #34 The ATN shall be capable of establishing, maintaining, releasing and aborting peer-to-peer application associations for the aviation routine weather report service (METAR) application.

The air-to-ground service components specified in the ATN SARPs are:

CM: Context Management,

ADS: Automatic Dependent Surveillance,

CPDLC: Controller Pilot Data Link Communication,

FIS: Flight Information Services (e.g. ATIS; Automatic Terminal Information Service and METAR: aviation routine weather report service).

CM exchanges the address information of ADS, CPDLC and FIS between air and ground. Before any data link activities begin, air CM initiates Log-on to ground CM. Ground CM responds to the Log-on request by providing appropriate address information of the ground counterpart ADS, CPDLC and FIS to air CM. After receiving appropriate address information, aircraft is able to communicate with the ground ADS, CPDLC and FIS.

Note: The CM SARPs defines only communication aspect and there is no specification how the address information is provided to ADS, CPDLC and FIS.

ADS provides reporting capability (periodic, event, demand, and emergency) from aircraft ground based on the contract requests by the ground.

CPDLC provides the Controller Pilot communications where both air and ground are able to initiate the communications and exchanges.

FIS (ATIS and METAR) provides the information capability from the ground to the air based on the request from the air.

2.4.1 Use of Ground Elements in Air-to-Ground Service Components

The air-to-ground service components use the Ground Elements, Air-Ground Routers, Ground Subnetworks, Ground-Ground Routers. The Ground End Systems of Air-to-Ground service components are one of Ground Elements.

2.4.2 Ground Forwarding in Air-to-Ground Service Components SARPs

Also it has to be noted that there is a need of communication between Ground End Systems of Air-to-Ground service components; namely:

- in CM SARPs, there is a 'CM-forward' service such that a CM Ground End System forwards the aircraft information received by log-on from aircraft to a neighboring CM Ground End System;
- in ADS SARPs, there is a 'ADS report forward' service such that a ADS Ground End System forwards the ADS information to a neighboring ADS Ground End System; and
- in CPDLC SARPs, there is a 'CPDLC-forward' service such that a CPDLC Ground End System forwards the CPDLC messages to a neighboring CPDLC Ground End System. It can be used for messaging from current data authority to next data authority, or from down stream data authority to current data authority.

The ground forwarding services are included in the Air-to-Ground service components in the ATN SARPs. The Air-to-Ground SARPs are developed as the standalone documents.

2.5 ATN Security Service

SLR #29 ATN end systems supporting ATN security services shall be capable of authenticating the identity of peer end systems, authenticating the source of application messages and ensuring the data integrity of the application messages.

Note. Application messages in this context include messages related to ATS, systems management and directory services.

SLR #30 ATN ground and air-ground boundary intermediate systems supporting ATN security services shall be capable of authenticating the identity of peer boundary intermediate systems, authenticating the source of routing information and ensuring the data integrity of routing information.

The System Level Requirement #29 states the requirement for the ATN Application Security, while the System Level Requirement #30 states the requirement for the inter-domain routing.

The security solution for the ATN has mechanisms to provide security for application and routing related communications within the ATN. This is the requirement at System Level stated above.

The security solutions employed uses public-key cryptography.

The Public Key Infrastructure (PKI) provides the requisite support to distribute the public keys of ATN entities and therefore enable the operation of the ATN security solutions.

The ATN PKI is based on the ITU-T X.509 authentication framework.

2.5.1 ATN PKI Architecture

This section describes the ATN PKI architecture and which entity plays in it.

a) Entities in ATN PKI

- ICAO
- State and State CA(Certificate Authority)
- Aircraft Operating Entity (AOE) and AOE CA
- Ground CMA
- Ground AMHS
- Other Ground Applications
- Aircraft Applications(including CMA)
- Ground Router
- Aircraft Router

The architecture is summarized in Figure 2.5-1. In the figure, a solid arrow from entity A to entity B indicates that A issues certificates to B, while a dotted arrow indicates that A optionally issues certificates to B.

2.5.2 ATN Security Solution

The ATN application and IDRP security solutions are based on the elliptic curve digital signature algorithm, the elliptic curve Diffie-Hellman protocol and the HMAC MAC scheme.

ATN Security solution will be provided to Application Communication and routing information exchanges.

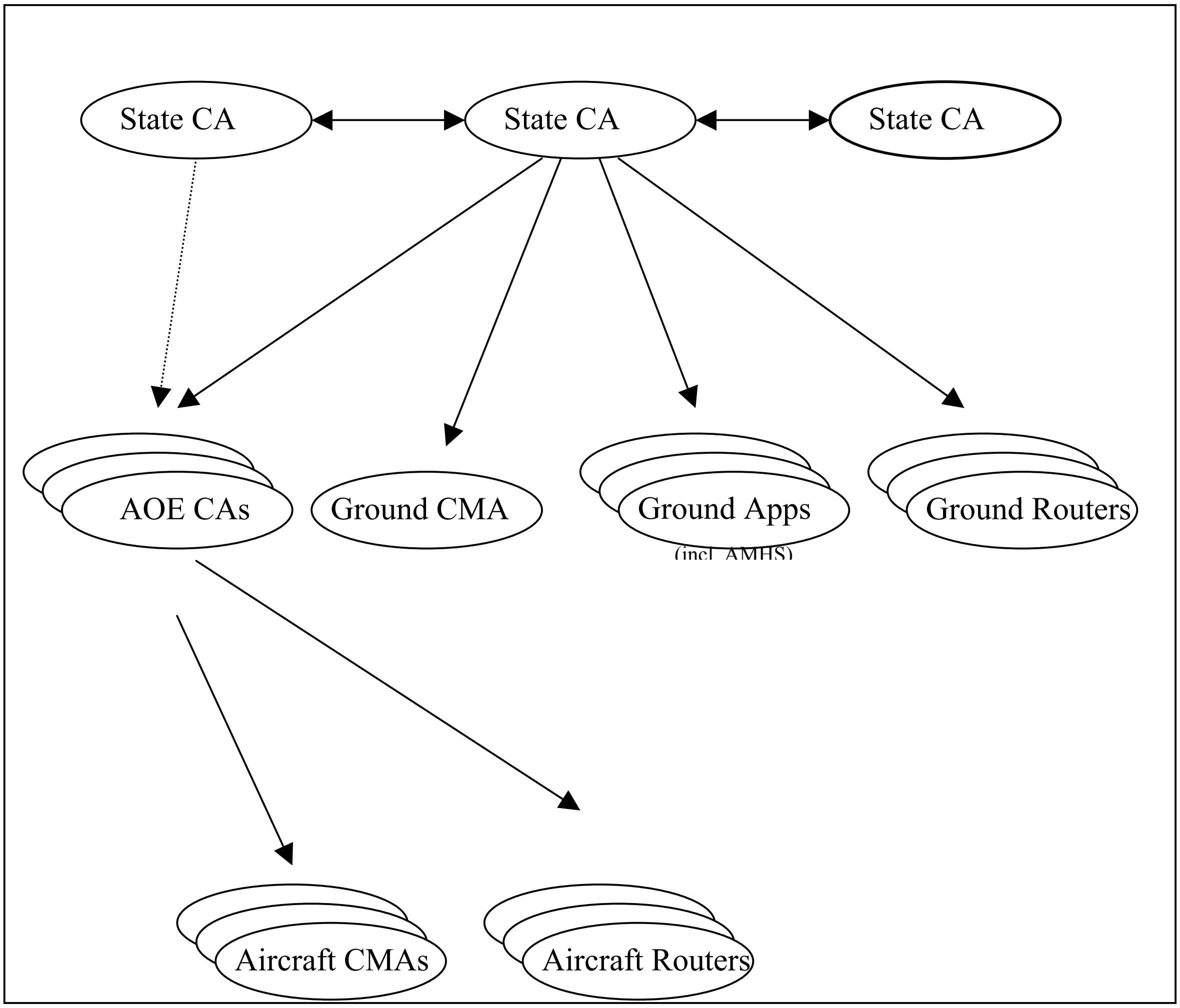


Figure 2.5-1 ATN PKI Architecture

2.6 ATN System Management

SLR #32 ATN systems supporting ATN systems management shall facilitate enhanced continuity of ATN operations, including the monitoring and maintenance of the quality of the communications service.

SLR #33 The ATN shall be capable of establishing, maintaining, releasing, and aborting peer to peer application associations for the Systems Management (SM) application.

Systems Management provides mechanisms to monitor, control and co-ordinate communications, applications, and other (as required) resources with the goal of achieving a seamless communications service in support of real world air traffic operations. To achieve this goal, it is required that specific management information, functions and protocols be designed and built into any supporting communications network to provide deterministic and controllable network behavior.

2.6.1 Concepts and Elements of System Management

2.6.1.1 Organizational Structure related to System Management

a) Administrative Domain

The owner and/or operator of an ATN network is defined by the term Administrative Domain. An Administrative Domain is the set of resources under the administrative control of a single authority.

Every Administrative Management Domain will have a two level hierarchy of active managers, Area Administrators and Network Managers which operate according to contracts, agreements and policies made by Management Domains.

b) Area Administrators

For those management domains that choose to define areas, every area will have an Administrator which has responsibility for its own area. These Managers may use subordinate managers/agents at their disposal (e.g. managers of networks) involving the collection and organization of data concerning operations of the network.

c) Network Managers

Every network will have a Network Manager which has responsibility for the detailed operation of the equipment in the network. The Network Manager has access to the many pieces of distributed physical equipment. It collects data and administers the Management Information Base for groups of Host Computers, Routers and Subnetwork Components via "Management Agents" resident in those systems.

d) Regional Domain

In some instances, a group of Administrative Domains, e.g., all the CAAs within an ICAO Region, may join together into a Regional Domain.

Note: Each aircraft has its own administrative management domain based upon its need to manage the ATN end-systems and communication facilities.

2.6.1.2 Managers and Agents in System Management Configuration

The system management configuration has a managing system consists of 'manager' and managed systems consist of 'agents'.

On managing systems (or management stations) reside applications called 'managers''. On managed systems (or network elements being managed), reside applications called 'agents'.

2.6.2 Cross-Domain System Management

The management information exchange definition at an interface between Management Domains is the point where information standardization is required.

The management information, functions and protocols applied to ATN are described in the following sections.

2.6.2.1 System Management Information

The network is described as a collection of discrete objects that incorporate both data structure and behavior. These objects are termed 'managed objects (MOs)'.

The Management Information Base (MIB) is a repository of management information. It is a view of all objects to be managed.

The Cross-Domain MIB (XMIB) is the MIB in which are gathered the elements of management information on the local ATN management domain that are shared with external ATN organizations.

2.6.2.2 System Management Functions

There are three functional blocks in the functional architecture of System Management.

a) XMIB User:

   A Management application operating in the manager role and to be implemented by organizations wishing to retrieve information from the XMIB maintained by other organizations

b) XMIB Agent:

   A Management application operating in the Agent role which performs the operations on the local XMIB. The XMIB Agent handles information retrieval requests from XMIB Users. This system is implemented by the organization providing XMIB access services.

c) Local Systems Management Function:

   The local ATN organization operates a Systems Management Application that has the capability to collect, via local Systems Management procedures, management information from the individual pieces of ATN equipment distributed in the local domain. and to filter and process the gathered information in support of the provision of XMIB access services.

2.6.2.3 System Management Protocols

Common Management Information Service (CMIS) is defined as the service for the exchange of management information. CMIS provides the service primitives such as M-GET, M-SET, M-ACTION, M-CREATE, and so forth.

CMIS is provided by the Common Management Information Service Element (CMISE), and the interaction between CMISE entities is defined by the Common Management Information Protocol (CMIP).

The functional architecture of CDSM provision is depicted in Figure 2.6-1.

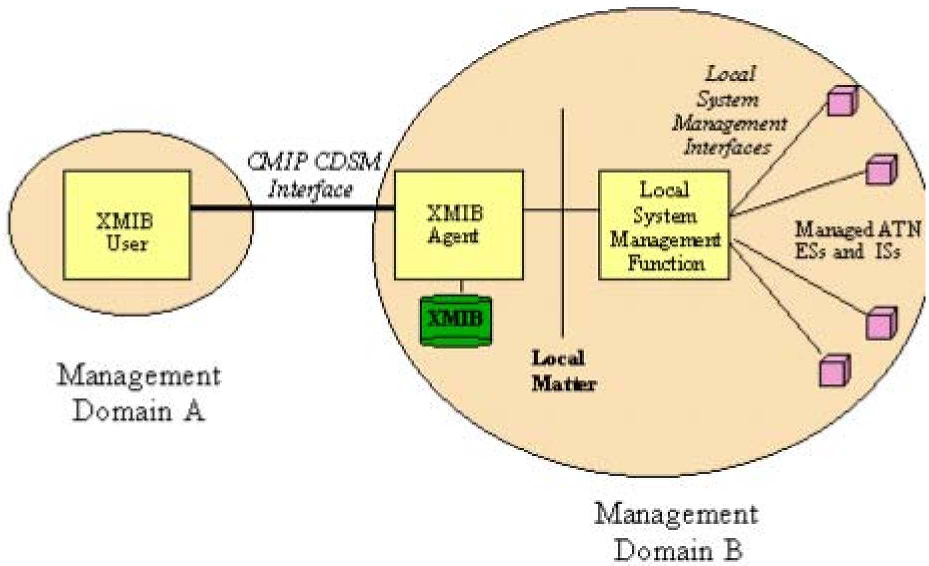


Figure 2.6-1 Functional Architecture for CDSM Service Provision via CMIP Interface

2.7 ATN Directory Services

SLR #31 The ATN shall be capable of establishing, maintaining, releasing and aborting peer-to-peer application associations for the exchange of directory information.

2.7.1 ATN Directory Service Model

The followings are the concepts and elements related to the ATN Directory Service.

a) Directory

The Directory is a collection of systems which cooperate to hold a logical database of information about a set of objects in the real world.

b) ATN Directory Service Users

The users of the Directory, including people and computer programs, can read or modify the information, or parts of it, subject to having permission to do so. Each user is presented in accessing the information by a Directory User Agent (DUA), which is considered to be an application process.

c) Directory User Agent (DUA)

d) Directory Service Agent (DSA)

A Directory Service Agent (DSA) is an application process which is part of the Directory and whose role is to provide access to the DIB to DUAs and/or other DSAs. A DSA may use information stored in its local database or interact with other DSAs to carry out requests. Alternatively, the DSA may direct a requester to another DSA which can help carry out the request. Local databases are entirely implementation dependent.

e) Directory Management Domain (DMD)

A set of one or more DSAs and zero or more DUAs managed by a single organization may form a Directory Management Domain (DMD).

f) Directory Information Base (DIB)

The information held in the ATN directory is collectively known as the Directory Information Base (DIB).

g) Directory Information Tree (DIT)

The structure of the DIB, called the Directory Information Tree (DIT), defines the hierarchy of record types contained in the directory.

h) Object class

Each record type is defined by an object class. Object classes define the abstract syntax of each record.

i) Directory Schema

The fields of each record are defined by attributes. The Directory Schema defines which attributes are contained in each object class.

Example of description:

```
atn-AmhsUser   OBJECT-CLASS        ::=      {
                         SUBCLASS OF           {mhs-User}
                         MUST CONTAIN          {atn-amhs-extended-service-support|
                                          atn-amhs-direct-access }
                         MAY CONTAIN           {atn-PerCertificate |
                                          atn-DerCertificate |
                                          atn-AF-address |
                                          atn-Cidin-mcf |
                                          atn-Ax-or-primary-Ax-address |
                                          atn-Ax-secondary-address
                                          }
                         ID                    id-oc-atn-AmhsUser }
```

j) Directory Access Protocol (DAP)

An ATN Directory Service user interfaces with the directory through a DUA.

A DUA implements the Directory Access Protocol (DAP) for its communication with the directory server, or Directory Service Agent (DSA). The use of the DAP by a DUA which invokes an operation on a DSA and receives a response

k) Directory Service Protocol (DSP).

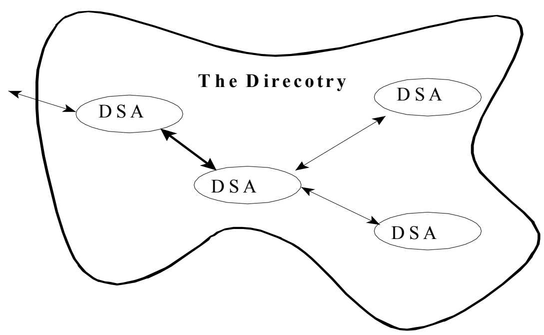


Figure 2.7-1 Functional Model of the ATN Directory

2.7.2 ATN Directory Service Provision

The ATN Directory Service shall be based on ISO/IEC 9594:1995 (ITU-T X.500:1993) specifications.

The systems comprising the ATN DIR shall themselves be comprised of the following functional objects, the general role of which is described in ISO/IEC 9594-1:1995.

a) Directory Service Agents (DSAs); and

b) Directory User Agents (DUAs).

DSA

- The DSA is concerned with carrying out the requests of DUAs, and with obtaining the information where it does not have the necessary information.
- It may take the responsibility to obtain the information by interacting with other DSAs on behalf of the DUA.

ATN Directory Service Users shall use the ATN Directory Service at an ATN Directory User Agent (ATN DUA).

DUA

- The DUA interacts with ATN Directory (DIR) by communicating with one or more DSAs.
- A DUA need not be bound to any particular DSA.
- It may interact directly with various DSAs to make requests.

- For some administrative reasons, it may not always be possible to interact directly with the DSA which needs to carry our the request, e.g., to return some directory information.
- It is also possible that the DUA can access the ATN DIR through a single DSA. For this purpose, DSAs will need to interact with each other.

An ATN Directory System Agent shall include either one or both of Directory Access Protocol (DAP) or Directory Service Protocol (DSP).

An ATN Directory User Agent shall include DAP.

2.8 Typical ATN Connectivity

Typically ATN elements are interconnected as depicted in

Figure 2.8-1.

Between (ground-ground) domains, there are following cases:

1) ATSMHS-to-ATSMHS

<table>
<tr><td>ATN-ES(ATS
Message Server)</td><td>I
S</td><td>BI
S</td><td></td><td>BIS</td><td>IS</td><td>ATN-ES(ATS
Message Server)</td></tr>
<tr><td colspan="3">Ground Domain A</td><td>G-G Inter-
Domain</td><td colspan="3">Ground Domain B</td></tr>
</table>

2) AIDC-to- AIDC

<table>
<tr><td>ATN-ES(AIDC)</td><td>I
S</td><td>BI
S</td><td></td><td>BIS</td><td>IS</td><td>ATN-ES(AIDC)</td></tr>
<tr><td colspan="3">Ground Domain A</td><td>G-G Inter-
Domain</td><td colspan="3">Ground Domain B</td></tr>
</table>

3) ATSMHS-to-AFTN station via AFTN/AMHS Gateway

<table>
<tr><td>ATN-ES(ATS
Message Server)</td><td>I
S</td><td>AFTN/AMHS
Gateway</td><td></td><td>AFTN
Station</td></tr>
<tr><td colspan="3">Ground Domain A</td><td>AFTN
Circuit</td><td></td></tr>
</table>

4) ATSMHS-to-AFTN station via Ground Domain and AFTN/AMHS Gateway

ATN-ES (ATS Message Server)	IS	BI S		BIS	AFTN/AM HS Gateway		AFTN Station

Ground Domain A	G-G Inter-Domain	Ground Domain B	AFTN Circuit	

5) AFTN Station-to- AFTN Station via AFTN/AMHS Gateway and ATN Domains

<table>
<tr><td>AFTN Station</td><td></td><td>AFTN/AMHS Gateway</td><td>IS</td><td>BIS</td><td></td><td>BIS</td><td>AFTN/AMHS Gateway</td><td></td><td>AFTN Station</td></tr>
<tr><td></td><td>AFTN Circuit</td><td colspan="3">Ground Domain A</td><td>G-G Inter-Domain</td><td colspan="2">Ground Domain B</td><td>AFTN Circuit</td><td></td></tr>
</table>

For the Air-to-Ground service components, only ADS is shown:

6) Air ADS-to-Ground ADS

<table>
<tr><td>Air ATN-ES(ADS)</td><td>BIS</td><td></td><td>BIS</td><td>Ground ATN-ES(ADS)</td></tr>
<tr><td colspan="2">Aircraft Domain C</td><td>A-G Inter-Domain</td><td colspan="2">Ground Domain A</td></tr>
</table>

Note: Aircraft Domain C BIS is Airborne Router, and Ground Domain A BIS is Air-Ground router.

7) Air ADS-to-Ground ADS via Ground Domain

<table>
<tr><td>Air ATN-ES (ADS)</td><td>BIS</td><td></td><td>BIS</td><td></td><td>BIS</td><td>IS</td><td>Ground ATN-ES (ADS)</td></tr>
<tr><td colspan="2">Aircraft Domain C</td><td>A-G Inter-Domain</td><td>Ground Domain A</td><td>G-G Inter-Domain</td><td colspan="3">Ground Domain B</td></tr>
</table>

Note: Aircraft is in Aircraft Domain C, and ATN organization or Air-Ground ATN Organization could be in Ground Domain A or B in this case. Aircraft Domain C BIS is Airborne Router, Ground Domain A BIS is Air-Ground router, Ground Domain B BIS is Ground-Ground router.

Ground forwarding in Air-to-Ground service components:

8) Ground ADS-to-Ground ADS (Ground Forward)

ATN-ES(ADS Report Forward)	IS	BIS		BIS	IS	ATN-ES(ADS Report Forward)
Ground Domain A			G-G Inter-Domain			Ground Domain B

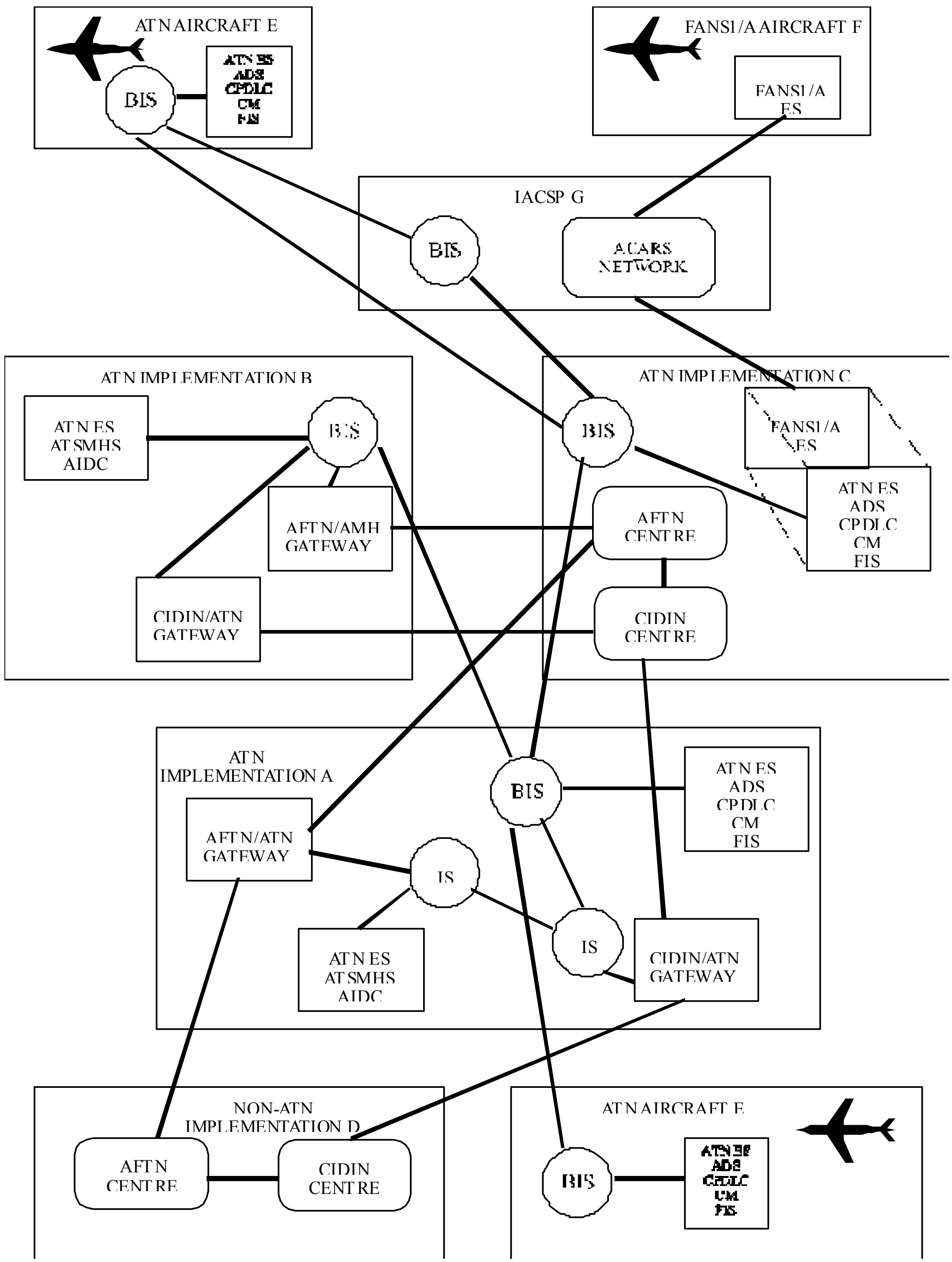


Figure 2.8-1 Typical ATN Connectivity

3. Planning Issues to be Considered

As a regional planning guide, it is necessary to identify what is planned in the ASIA/PAC region and by individual States. From summarization of the ICAO Planning document, the following issues need to be addressed by the regional planning group.

3.1 Issues Addressed by ICAO ATN Panel Guide: Summary

The following steps are recommended to be part of the ATN planning and implementation processes.

(See 4. ATN Planning and Implementation Process in [3 PART I].)

a) ATM Operational Concept

b) Network Operating Concept

c) Transition Planning

d) Implementation Planning

e) Operational evaluation

f) Certification and commissioning

Since this document is a planning document, step e) and f) are excluded from the document, although it is essential to plan what is to be evaluated and tested in step d) and e). In the following sections, step a) CNS/ATM Operational Concept, b) Network Operating Concept, step c) Transition Planning and d) Implementation Planning are elaborated further, only for the ground elements of the ATN, including evaluation and testing aspects.

3.1.1 ATM Operational Concept

'The ATN is an enabling technology in that it does not directly deliver benefits to users. Rather, it enables the introduction of new air traffic services, which provide operational capabilities that benefit both the airspace managers and users.'(see [3 PART I] 4.2.3.1.1)

Note: What this quoted sentence emphasizes is that the ATN is the infrastructure, and the air traffic services using the infrastructure are important rather than the infrastructure itself. Accepting the statement above, it is contradictory to discuss ATN benefits in an ATN planning document. However, here in this document, the benefit of the ATN will be discussed since the ATN ground-to-ground service components are assumed to be ones of the air traffic services over the ATN.

The Operational Concept is provided by documenting:

1) what air traffic services are and what resources and procedures are required to provide them, (see [3 PART I]4.2.3.2 Scope, 4.2.3.2.1);

2) existing environment and a plan for the future evolution of the environment, (in this sense, operational concept document and transition plan document have to share the change process ,while the nature and timing of changes of operational environment are taken into considerations.)(see [3 PART I] 4.2.3.2 Scope, 4.2.3.2.2-4.2.3.2.4);

3) how the services by the ATN achieve the benefits claimed in cost/benefit analysis,

(see [3 PART I]4.2.3.2 Scope , 4.2.3.2.5);

4) as a pre-requisite for the introduction of new services, the development of procedures should take a high priority in the overall implementation process; and

5) effects on operational concept caused by any changes to the environment by others.

Note: If the environments of the involved organizations are independent, the changes of environment in one organization may not impact the other organizations. Since the ATN provides the common environment, the changes in one organization, e.g. services provided and addresses assigned, causes relatively greater impacts on the other organizations.

In the following subsections, each issue mentioned above is discussed.

3.1.1.1 Air Traffic Services, Resources and Procedure

An organization documents how the air traffic services are provided:

a) what air traffic services are?

b) what resources are required to provide them; and

c) what procedures are required to provide them?

Note 1: For AFS, there are various questions to address; Are there any new services requested? Are there any new requirements for improvements of services? These are to be addressed in the future, but currently, there is no newly identified service.

Note 2: In the existing AFTN, the communication is based on the link level operation, where the confirmation of message delivery is managed by link basis. The ATSMHS over the ATN as an AFTN equivalent service, the end-to-end communication takes place when the delivery of message is managed by end-to-end basis, based on ITU-T standards.

Note 3: The ATN is not only for the ATSMHS over the ATN as an AFTN equivalent service. The ATSMHS may be extended in future. Also there exist a set of services e.g. Inter-Centre Communication (ICC), including ATS Inter-facility Data Communication (AIDC), Flight Planning, Air Traffic Flow Management, Air Space management, and so forth, in the ground-to-ground service components over the ATN.

Note 4: The ATN ground elements will be used for the air-to-ground service components as well as for the ground-to-ground service components.

Note 5: These mentioned above are new services over ground elements of the ATN to be identified in a planning document. Although the services, resources and procedures involved are wide in scope, this document deals primarily with the ATN ground-to-ground service components.

3.1.1.2 Existing Environment and the Future Evolution

An organization documents the existing environment and a plan for the future evolution of the environment.

It is required to identify what is the ‘existing’ and ‘future’ environment. In the context of ATN Transition for ground elements in the ASIA/PAC region, it is obvious that the ‘existing’ means the AFTN environment, and the ‘future’ is an ATN environment. The issue is then, how to migrate from the ‘existing’ to the ‘future’, while minimizing cost and maximizing or optimizing early benefits.

The future environment has to include new services through ground elements of the ATN, including the air-to-ground service components, as part of evolution, not just the existing services.

3.1.1.3 Services Benefits

An organization documents how the services by the ATN achieve the benefits.

The cost/benefit has to be analyzed to achieve the improvement of the existing environment as well as to provide the new services mentioned above.

The benefit analysis is conducted during the operational concept development, while the cost analysis is conducted during the transition and implementation planning.

The cost analyses of services (e.g. Messaging, AIDC) and communication infrastructure (e.g. ATN internetworking) have to be provided separately, since the infrastructure cost is the fixed cost. If the cost of communication infrastructure is not singled out, any new and additional service components enjoy the ‘free rider’ benefit without any infrastructure costing.

3.1.1.4 Procedure Development

An organization documents the development of procedures.

It is necessary to understand the nature of the ATN and impact of introducing the ATN before developing procedure.

3.1.1.5 Effects of Changes

An organization analyzes the effects on operational concept caused by any changes to the environment by other organizations.

The communication architecture (i.e. internetworking of various interconnected subnetworks) of ATN has been standardized carefully to eliminate any dominance by anyone, by adopting the concepts of Management Domain, Autonomous Message Routing Scheme/Policy (IDRP; Inter-Domain Routing Protocol), and Inter-networking of autonomous networks. It is essential to conform to the ATN architectural framework, to avoid any significant effects by changes in the environment The service portion of the ATN has to be coordinated carefully among the participating members.

3.1.2 Network Operating Concept

Network Operating Concept is what the system will look like, and how it will be managed.

In order to develop the Network Operating Concept, the following topics have to be addressed.

1) Network Architecture/Topology and Network Sizing
2) Security Management
3) System Management
4) System Performance

5) Integration into Global ATN
6) Domain Administration
7) Naming and Addressing Administration

In the following subsections, each topic and expected activities are summarized.

3.1.2.1 Network Architecture/Topology and Network Sizing (see [3 PART I] 4.2.4)

The objective of this task is to design the overall architecture of the network based on the ATN elements; End System, ATN Routers, Subnetworks and Gateways, capable of achieving the functional, topological and performance requirements.

With regard to the ground elements of the ATN, the main implementation issues are:

a) Definition of Administrative Domains

Providing information on what is Administrative Domain and how to define is one of the tasks to be undertaken by the regional planning group, but the design itself is the responsibility of each State.

b) Design the architecture of Administrative Domain

1) Identification of End Systems, Fixed and Mobile Subnetworks, ATN Routers (IS; Intermediate System or BIS; Boundary IS, i.e. situated at the boundary of domains) in the domain,
2) Connectivity between the various elements.

Providing information on how to design the architecture; elements identification and connectivity provisions are possibly one of the tasks undertaken by the regional planning group, but the design itself is the responsibility of each State.

c) Identification of the Traffic Type and Quality of Services

This will result in the definition of routing policy within the routing domain.

The discussions on the identification of Traffic Type, and Quality of Services through the target network can be regional or State matter depending on the concerned network. Inter-Domain traffic may be discussed in region or established through mutual agreements between adjacent domains. The matters related within a domain are strictly State matters.

d) Global consolidation of the design with adjacent Administrative Domains.

<u>**Note:**</u> The consolidations on the design of the targeted network should be discussed in region or mutually agreed among the adjacent domains.

3.1.2.2 Security Management

The Public Key Infrastructure (PKI) provides the requisite support to distribute the public keys of ATN entities and therefore enable the operation of the ATN security solutions.

3.1.2.2.1 Role of ATN PKI entities

1) ICAO

ICAO has overall control of the ATN PKI. It specifies how the ATN PKI operates, it carries out a review of the PKI at least every 5 years, and it acts as a repository for salient information such as the identities of State-designated State CAs.

2) State and State CA(Certificate Authority)

   States govern the ground application entities, ground routers, and aircraft operating entities within their domain. They ensure and facilitate the effective and secure operation of the ATN PKI within their domain.

   State CAs issue certificates to the ATN entities operating within their State(s). In particular they issue certificates to the ground application entities, ground routers, and aircraft operating entities' CAs within their State(s). State CAs also cross certify other State CAs so that ATN entities within their State(s) can obtain the public keys of ATN entities operating within other States. State CAs may also certify aircraft operating entities' CAs within other States to reduce the amount that aircraft operating entities rely on a single State CA.

3) Aircraft Operating Entity (AOE) and AOE CA

   Aircraft operating entities govern the aircraft within their domain. They ensure and facilitate the effective and secure operation of the ATN PKI within their domain.

   AOE CAs issue certificates to the aircraft operating within their domain.

4) Ground CMA

   Ground CMA entities play a central role in the provision of security for application communications within the ATN. They are involved in a mutual authentication protocol with aircraft during CMA login, and they help ensure that session keys for applications are unique to each CMA session.

5) Ground AMHS

   AMHS entities may also be involved in the provision of security within the ATN. They may send and receive AMHS messages in an authentic manner.

6) Other Ground Applications

   Other ground application entities which use the upper layers communications service are also involved in the provision of security for application communications within the ATN. They send messages in an authentic manner to aircraft, and receive messages in an authentic manner from aircraft.

7) Aircraft Applications (including CMA)

   Aircraft application entities are involved in the provision of security for application communications within the ATN. Aircraft CMA entities are involved in a mutual authentication protocol with ground CMA entities during CMA login, and they help ensure that session keys for applications are unique to each CMA session. Other aircraft application entities send messages in an authentic manner to ground application entities, and receive messages in an authentic manner from ground application entities.

8) Ground Router

   Ground routers are involved in the provision of security for routing related communications within the ATN. They receive IDRP communications from aircraft in an authentic manner, and may also send IDRP communications in an authentic manner to aircraft and other ground routers.

9) Aircraft Router

Aircraft routers are involved in the provision of security for routing related communications within the ATN. They send IDRP communications to ground routers in an authentic manner, and may also receive IDRP communications in an authentic manner from ground routers.

General ATN PKI Certificate Format:

```
Certificate ::= SEQUENCE {
tbsCertificate              TBSCertificate,
signatureAlgorithm                    AlgorithmIdentifier,
signatureValue  BIT STRING
}
TBSCertificate ::= SEQUENCE {
version [0]                 EXPLICIT Version DEFAULT v1,
serialNumber                CertificateSerialNumber,
signature                   AlgorithmIdentifier,
issuer                      Name,
validity                    Validity,
subject           Name,
subjectPublicKeyInfo        SubjectPublicKeyInfo,
issuerUniqueID              [1] IMPLICIT UniqueIdentifier OPTIONAL,
subjectUniqueID             [2] IMPLICIT UniqueIdentifier OPTIONAL,
extensions                  [3] EXPLICIT Extensions OPTIONAL
    }
```

Note: State/State CA actions

- Generate a key pair which it uses to sign certificates and CRLs (certificate revocation lists). The recommended lifetime of this key is 20 years. Strong security measures should be used to guard this key against compromise because it represents an attractive target for attack.
- Issue certificates to ATN entities operating within their State(s) – specifically ground application entities, ground routers, and aircraft operating entities' CAs (and aircraft if the State CA has been asked by an AOE to issue certificates direct to its aircraft). State CAs may also issue certificates to aircraft operating entities' within other States. The recommended validity period for most of these certificates is 5 years, however

the validity period for certificates issued to ground CMA entities and ground routers should be considerably shorter – initially the recommended validity period for these certificates is one week.[1]

- Issue certificates to other State CAs. Again the recommended validity period for these certificates is 1 week. In order to shorten certificate paths and simplify certificate path processing, no certificate path in the ATN should contain more than one certificate issued by one State CA to another. This means that a State CA should cross-certify with the State CA of every other State – unless of course the State CA wishes to exclude the entities within its domain from communicating securely with the entities within the domain of the other State CA.

3.1.2.3 System Management Information

ATN Management Information is defined by specifying the containment (naming) hierarchy and others. The upper part of containment tree is illustrated as follows.

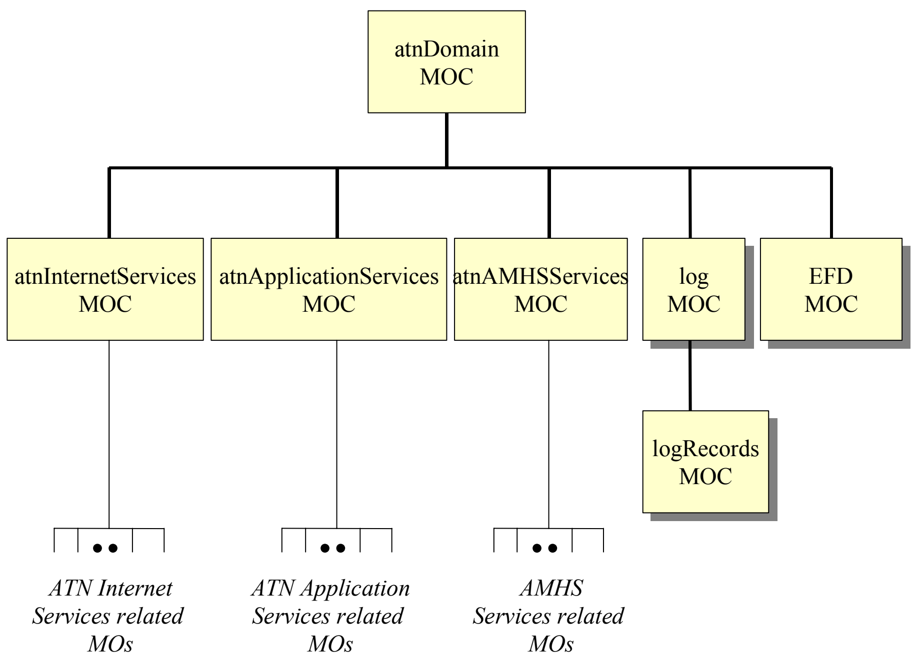


Figure 3.1-1 Upper Part of Containment Tree of System Management Information

The example of XMIB is as follows: containment tree of XMIB User in Domain A and containment tree of XMIB Agent in Domain A, where MOC stands for Managed Object Class.

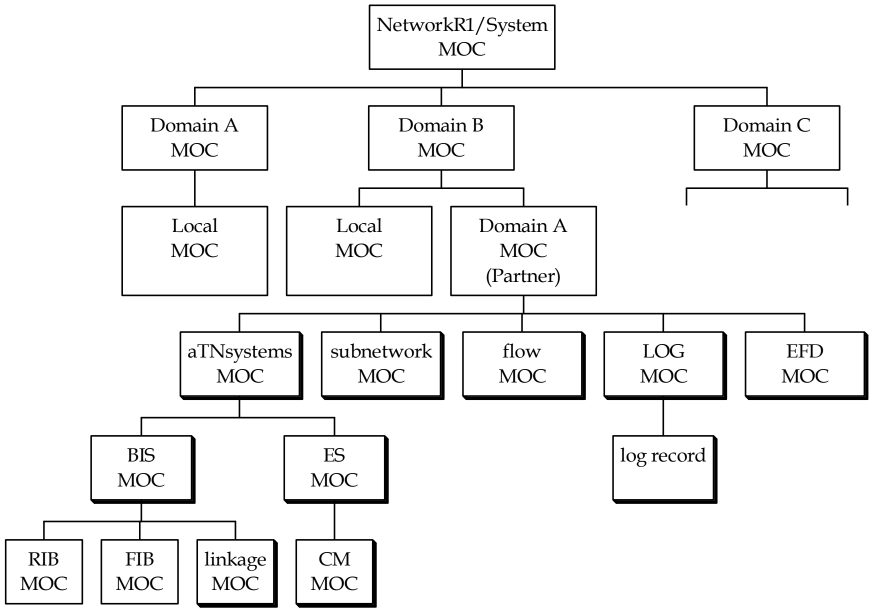


Figure 3.1-2 Example of Containment Tree of XMIB User in a Domain

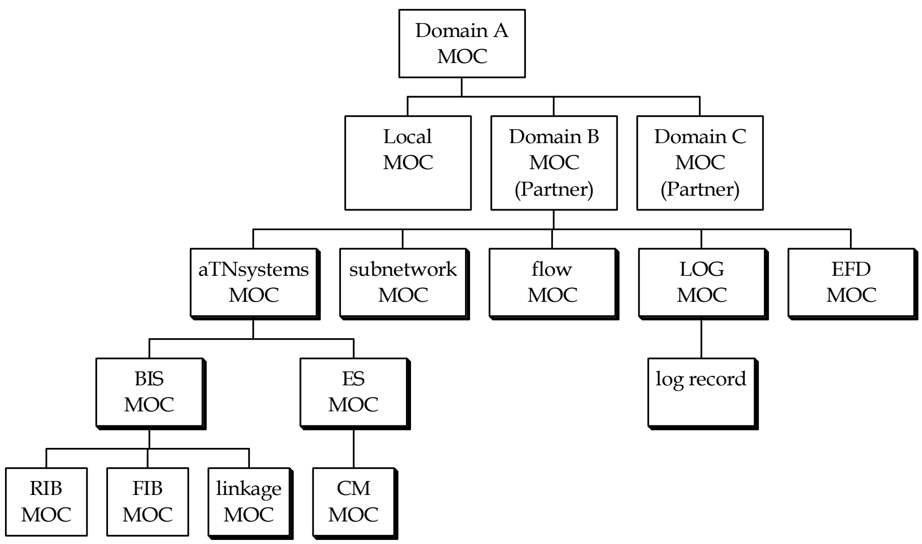


Figure 3.1-3 Example of Containment Tree of XMIB Agent in a Domain

3.1.2.4 System Performance (see [3 PART I] 4.2.4.6)

It is necessary to address the performance issues of reliability, maintainability and availability.

The addressing the performance issues of reliability, maintainability and availability can be regional or state matter depending on the concerned network. Inter-Domain may be discussed in region or established through mutual agreements between adjacent domains States. The matters within domain are strictly State matters.

3.1.2.5 Integration into Global ATN (see [3 PART I] 4.2.4.8)

a) Issues relating to the interconnection of the isolated ATN implementation with the global operational ATN must be addressed, including conformance, interoperability testing and routing efficiency and others.

Even if each State implements its own services based on the common standards and recommended practices (SARPs), there might be a misunderstanding of the SARPs. Since any implementation discrepancies impact effective ATN operations, the issues related to the interconnections must be addressed as part of ATN integration. The addressing the issues of interconnections is regional matter or established through mutual agreements between adjacent States.

b) Impact of the design of the new system to be connected on overall performance needs to be examined.

The performance impact of implementing new system has to be examined depending on the ways the services implemented and provided. The ATN services are provided through the ATN components of various organizations, so that each organization has to satisfy the required performance for the services. If the new service is to be provided over the existing infrastructure, the overall performance impact of new service to the existing operations has to be examined. The examination of impact on the new systems is the regional matter or established through mutual agreements between adjacent States.

3.1.2.6 Domain Administration

A management domain is a collection of managed objects, and inter-domain relationships.

Organizational requirement; Each organization is responsible for managing its own portion of the ATN. Within the ATN each administrative domain will coincide with a management administrative domain. The related objects in the management administrative domain, are the responsibilities of one and only one administrative authority.

Administrative requirements: See 3.1.2.3 System Management for establishing and maintaining the respective management authorities.

3.1.2.7 Name and Address Administration (see [3 PART I] 4.2.4.9)

The Address allocation principles and Application naming are as follows.

Name; the name is an AE-Title, where the AE-Title consists of an AP-Title plus an AE-qualifier. The AP-Title is derived from the 24-bit ICAO ID for Aircraft, and the eight-character ICAO facility designator for the ground assets.

The AP-Title sources have registration authorities. The AE-qualifier is expressed as a three-character string standardized in the ATN. The current registration authority for the AE-qualifier is expressed in the ATN document

Note: Naming rules are expressed in the ATN document, so that they are global.

Address; the ATN Address plan consists of 11 consecutive address fields.

The Address values of first two fields (AFI, IDI) are assigned by ISO, next field (VER) by ICAO, next two fields (ADM, RDF) by ICAO and IATA, next three fields (ARS, LOC, SYS, N-SEL) by State authorities, and last two fields (T-SEL, P-SEL) locally.

States must establish the necessary administrative structure to carry out allocation, assignment and administration activities for the ATN addresses, by establishing an address and naming registration authority.

The role of address registration is to:

1) assign and make available unambiguous names and addresses;

2) record definitions of the objects to which names and addresses are assigned; and

3) propagate assigned and registered addresses to interested parties within its sphere of responsibility.

The establishment of an addressing and registration authority has to be planned and prepared in advance. Address allocation on a more or less random basis during its initial experimental and test phases should be avoided. The re-allocation of addresses, if overall ATN has reached a certain population, impacts all its communication partners.

3.1.3 Transition Planning

There are two levels of planning guidelines:

- general guidelines; and
- transition issues to be addressed.

3.1.3.1 General guidelines

The general guidelines for transition to the ATN communication system, are:

- ATN implementation should be in phases;
- Newly introduced ATN application message processors and data link systems support code- and byte independent data transmissions , fully ATN compatible;
- States should coordinate among themselves to meet operational needs during transition; and
- States should establish procedure for security and interoperability.

a) ATN implementation should be in phases:

In the CNS/ATM provision, the ATN applications, (i.e. ADS, CPDLC, FIS, CM, ATSMHS, and AIDC) are introduced. Although each ATN application introduced provides the 'end state' capability for the specific application, it is highly recommended to implement services in the standardized order.

This guideline addresses the transition between CNS/ATM versions to be delivered in sequence. The transition in phases between the existing infrastructure and new infrastructure is addressed in the next list of guidelines.

b) Newly introduced ATN application message processors and data link systems support code- and byte independent data transmissions and fully ATN compatible:

This guideline addresses two elements; ATN application message processor and data link system, and two requirements; code/byte independent data transmission and full ATN compatibility.

It should be understood that the services provided by ATN application message processor and data link system are clearly distinguished, and the former is to comply with ATN applications SARPs, and the latter is to comply with ATN Internet SARPs.

The code/byte independence is implicitly provided, if the associated SARPs are rigorously followed.

In the ASIA/PAC ground environment, the new data link system will be the interconnected ground subnetworks, where internetworking is complying with ATN Internet SARPs, while ATN Application message processor provides services defined by the ATN ground-to-ground service component (application) SARPs.

c) States should coordinate among themselves to meet operational needs during transition:

In general, there should be coordination among States during the transition. It is hard to give any specific guidance material on what has to be coordinated, since it depends upon the specific situations affecting each State.

In the ASIA/PAC ground environment, the transition has to be cost effective as well as limiting disruptions in operations.

d) States establish procedure for security and interoperability

It is known that the ATN provides various communication services over the interconnected ground subnetwork, so it provides the interoperability for various types of messaging. The provisions for interoperability may cause fragility in security if no attention paid. The security for messaging should not be compromised because of interoperability. ICAO ATN Panel provides separate guidance material for security management.

3.1.3.2 Transition issues (see [3 PART I] 4.2.4.10)

Transition planning will be necessary to address the following issues:

- Existing communication infrastructure issues
- Use of existing subnetwork
- Integration of infrastructure
- New communication infrastructure issues
- Integration of new type of subnetwork
- Integration of enhanced/new ground based automation system
- Transitional procedure required to address both technical and operational issues
- ATN interface options
- Interface to another ATN organization
- Interface with AFTN organization

In ASIA/PAC region, it is noted that, 'planning for elements of the AFS is progressing in accordance with the ATN transition guideline specified in the ASIA/PAC Regional Implementation Plan for the new CNS/ATM. The first phase is achieved by upgrading the ground-to-ground data communication capability by employing X.25 protocol, and the deployment of critical transition element of the ATN, such as ATN routers and AFTN/ATN gateway. The second phase of the ATN is achieved by implementing the air-ground ATN routers and associated protocols.'

Following the above mentioned transition approach, a transition planning guide has to be provided to document the transition to and implementation of ground elements of the ATN.

The identification and integration of the existing and required new infrastructure with respect to the inter-domains connections can be planned by the regional planning group, avoiding duplications and inconsistency of activities and results. The issues within domain are State matters, although it is necessary to coordinate among participating States. Since the selection of non-ATN (i.e. AFTN)/ATN interface options impact the interconnected domains, it is necessary to initiate the regional planning, while the implementation details are left to States as intra-domain issues.

a) Existing communication infrastructure issues

There are two issues to be addressed:

(1) Use of existing subnetwork

The ATN architecture has been designed to allow existing subnetworks to be used for the exchanges of ATN messages.

The subnetwork here has to be interpreted like X.25 subnetwork. Communication services over network, transition issues are discussed in terms of Gateway between existing AFTN and ATN.

(2) Integration of infrastructure

The initial transition to the ATN infrastructure will primarily be achieved through the integration of existing ATS communication infrastructure into a homogenous network.

A homogenous network is assumed to imply the network with the ATN concept.

b) New communication infrastructure issues

New communication system would be required the integration of additional infrastructure element; including new ground subnetwork, and enhanced/new ground based automation system.

(1) Integration of new type of subnetwork

Besides integrating the existing subnetworks, new types of subnetworks would be introduced. Such a subnetwork will be defined as a subnetwork of ATN in ATN Internet SARPs and the SNDCF; Subnetwork Dependent Convergence Function for the subnetwork is implemented.

(2) Integration of enhanced/new ground based automation system

In the ground environment, there are many existing ground components, primarily used for the ground-to-ground communication, not necessarily compatible to the ATN concept.

In the case of developing a new ground based automation system, where the communication capability is defined in the ATN service component (application) SARPs, it is recommended to adopt the ATN service component (application) SARPs and implement them.

In the case of developing a new ground based automation system, where the communication capability is not defined in the current ATN SARPs, the ATN communication infrastructure may be used, but it is not clear how this can be done, and the consequence of this to the ATN overall operations.

In the case of integrating existing ground based automation system, it can be connected to the ATN infrastructure, with some modifications, or it can be done by developing another gateway connecting the existing communication network to the ATN. The gateway approach will be discussed under the topics of 'Interface to AFTN organization'.

c) Transitional procedure required to address both technical and operational issues

To allow a smooth transition to the CNS/ATM environment, the procedure for concurrent operation with the existing systems has to be provided.

In the ASIA/PAC ground system environment, the transitional procedure for the concurrent, operations of the AFTN and new network/services is required as well as the procedure for new network operation and new messaging services.

d) ATN interface options

When a State or organization migrates to an ATN environment, consideration must be given to interfacing with other States and organizations. The entity migrating to the ATN environment is called ATN organization. The ATN organization interfaces either to another ATN organization or an AFTN organization.

(1) Interface to another ATN organization (see [3 PART I] 4.2.4.10.2)

Interface to an ATN organization (e.g. State operating ATN) will be done by arranging for a wide-area network (WAN) connection such as an X.25, between the BIS; Boundary Intermediate System, of the two organizations.

The issues related to service interface options are not addressed here in the ATN Panel Planning Guide document. In the ASIA/PAC ground environment, two service interfaces have to be addressed; ATSMHS and AIDC.

(2) Interface with AFTN organization (see [3 PART I] 4.2.4/10.3)

Interface with an AFTN organization will be performed using the AFTN protocol. An AFTN/ATN gateway must be provided to translate ATN protocols, messages, and addresses to the equivalent AFTN protocols, messages, and addresses and vice versa.

The interface options addressed here should be interpreted as the service interface, not network interface. An AFTN/ATN gateway provides the translation only for messaging services. An AFTN/ATN gateway does not provide translation of all ATN messages to the AFTN messages, for instance, an AFTN/ATN gateway does not convert CPDLC messages to AFTN messages, ATN internet data packets to AFTN messages nor vice versa.

The main type of AFTN/ATN gateway that can be used is the AFTN/AMHS Gateway.

3.1.4 Implementation planning

The implementation planning should take into account the following:

- concept of operation;
- international standards;
- national regulations;
- user requirements;
- system integration requirements; and
- human-machine interface.

A co-operative effort is required to validate the interoperability among the ATN systems, where the design reviews, testing are taken place.

Although the implementation planning has to be addressed, the implementation issues related to only transition will be discussed as part of transition planning issues.

3.1.5 Proposed Regional Planning Activities for Transition

Based on the summary described above, the expected activities for the regional planning group to be responsible are listed, as a proposal, in a sequence of planning process.

Table 3.1-1 Planning Items Mapping

	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Note
3.1.1.1 a)		X									Note 1
3.1.1.1 b)				X							Note 1
3.1.1.1 c)		X						X	X		Note 1
3.1.1.2	X										
3.1.1.3		X									
3.1.1.4		X						X			
3.1.1.5					X			X			
3.1.2.1 a)			X								
3.1.2.1 b)				X					X		
3.1.2.1 c)						X					
3.1.2.1 d)					X						

	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Note
3.1.2.2										X	Note 2
3.1.2.3										X	Note 3
3.1.2.4							X				
3.1.2.5 a)					X						
3.1.2.5 b)							X				
3.1.2.6			X								
3.1.2.7			X								
3.1.3.1 a)											Note 4
3.1.3.1 b)											Note 5
3.1.3.1 c)											Note 5
3.1.3.1 d)										X	
3.1.3.2 a)(1)									X		Note 6
3.1.3.2 a)(2)	X								X		
3.1.3.2 b)(1)				X					X		
3.1.3.2 b)(2)				X					X		
3.1.3.2 c)								X			
3.1.3.2 d)(1)					X				X		
3.1.3.2 d)(2)	X				X				X		

Note 1: Ground-to-Ground service components (ATSMHS) only

Note 2: Physical access is strictly State matter.

Note 3: Partly regional matter.

Note 4: The backward compatibility considerations are taking into account in the ATN SARPs.

Note 5: These guidance materials provided in ICAO ATN Panel have not identified any specific actions. This guidance material can be expressed in other guidance material, so that they are not discussed here.

Note 6: The issue is taken into consideration as a basic assumption, so that it is not addressed here explicitly.

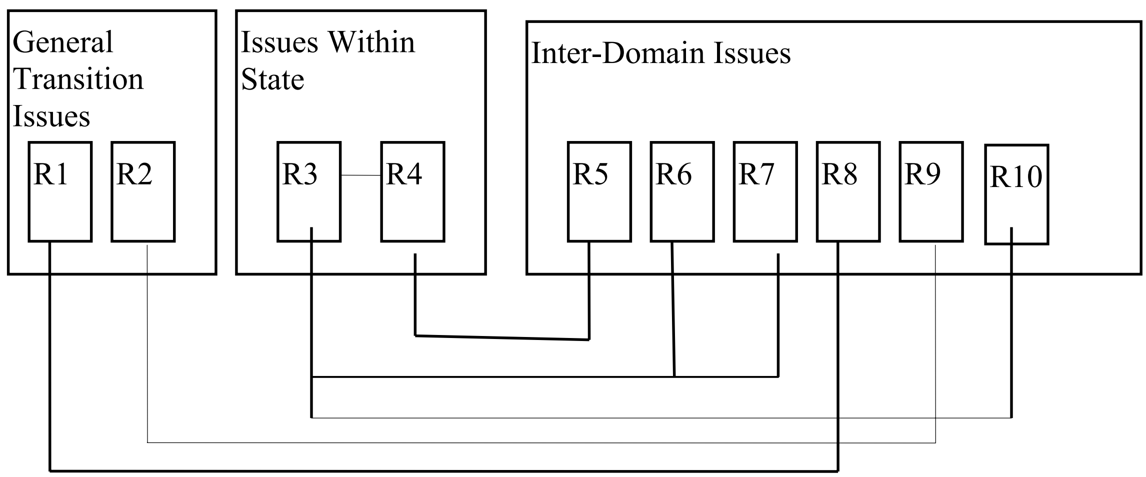


Figure 3.1-4 Planning Items Relationships

Items R1 through R10 show the relationship to each other (Figure 3.1-4).

R1) identify and integrate existing and newly required infrastructure for transition, with respect to inter-domains connections:

(1) the existing and the future evolution in CNS/ATM operating concept (see 3.1.1.2);

(2) integration of infrastructures as a transition issue (see 3.1.3.2 a)(2)); and

(3) interface with AFTN organization as a transition issue (see 3.1.3.2 d)(2)).

R2) provide service definition, benefit analysis and develop procedure for ground-to-ground store-and-forward messaging services (AFTN-ATSMHS functionality) with respect to inter-domains operations:

(1) air traffic service in CNS/ATM operating concept (see 3.1.1.1 a));

(2) required procedure for air traffic services (see 3.1.1.1 c));

(3) service benefit in CNS/ATM operating concept (see 3.1.1.3); and

(4) development of procedure(see 3.1.1.4).

R3) provide information on Administrative Domain and its definition within a State:

(1) definition of Administrative Domain (see 3.1.2.1 a));

(2) domain administration (see 3.1.2.6); and

(3) name and address administration (see 3.1.2.7).

R4) provide information on architectural design of ATN ground within State:

(1) resources required for air traffic services (see 3.1.1.1 b));

(2) design the architecture of Administrative Domains (see 3.1.2.1 b));

(3) integration of new types of subnetwork in transition (see 3.1.3.2 b)(1)); and

(4) integration of ground based automation system in transition (see 3.1.3.2 b)(2)).

R5) address the issues of interconnection with respect to inter-domains , including inter-domain internetworking (between ground subnetworks, interconnection to air-ground subnetwork), and ground-to-ground service components interfaces (inter-domain end-to-end services and AFTN/ATN gateway):

(1) effect of changes (see 3.1.1.5);

(2) global consolidation of design (see 3.1.2.1 d));

(3) integration into global ATN (see 3.1.2.5 a));

(4) interface options to ATN organization (see 3.1.3.2 d)(1)); and

(5) interface options to AFTN organization (see 3.1.3.2 d)(2)).

R6) identify traffic type, and Quality of Services through the target network, with respect to inter-domains connections:

(1) identify the type of traffic and Quality of Services(see 3.1.2.1 c)).

R7) address the performance issues of reliability, maintainability and availability with respect to inter-domains operations:

(1) system performance (see 3.1.2.4); and

(2) impact of the design of new system on overall performance (see 3.1.2.5 b)).

R8) develop transitional procedure with respect to inter-domains operations:

(1) required procedure for air traffic services (see 3.1.1.1 c));

(2) development of procedure(see 3.1.1.4);

(3) development of change procedure (see 3.1.1.5); and

(4) development of transitional procedure (see 3.1.3.2 c)).

R9) provide cost analysis of ground elements of ATN with respect to inter-domain connections:

(1) resources required for air traffic services (see 3.1.1.1 c));

(2) design the architecture of administrative domain (see 3.1.2.1 b));

(3) use of existing communication system (see 3.1.3.2 a)(1));

(4) integration of infrastructure (see 3.1.3.2 a)(2));

(5) additional infrastructure elements in transition (see 3.1.3.2 b));

(6) interface to an ATN organization (see 3.1.3.2 d)(1)); and

8) interface to AFTN organization (see 3.1.3.2 d)(2)).

R10) provide the system management, and security management:

(1) security management facility (see 3.1.2.2); and

(2) system management (See 3.1.2.3).

3.2 Proposed State Planning Activities for Transition

Based on the summary described above, the expected activities for State are listed in a sequence of planning process.

S1) identify and integrate of existing and newly required infrastructure for transition within domain

Note: *In conjunction with R1) step.*

S2) provide service definition; benefit analysis and procedure development of ground-to-ground, stored-forward messaging service (AFTN-ATSMHS functionality) within domains

Note*: In conjunction with R2) step.*

S3) define Administrative Domains

Note: *Referring outcomes of R3) step, if necessary.*

S4) establish the necessary administrative structure to carry out allocation, assignment and administration activities for ATN addresses

S5) assign, establish, and maintain network management authorities

S6) design the architecture; components identification and connectivity provisions

Note*: Referring the outcomes of R4) step, if necessary.*

S7) identify traffic type and Quality of Services through the target network within a domain

Note: *In conjunction with R6) step.*

S8) address the performance issues of reliability, maintainability and availability within a domain

Note: *In conjunction with R7) step.*

S9) provide control of network resources

S10) provide key generation, distribution, and management

S11) provide physical security

S12) develop transitional procedure within domains

Note: In conjunction with R8) step.

S13) provide ATN interface options to AFTN organization.

S14) cost analysis of ground elements of ATN within domains

Note: Referring the outcomes of R9) step, if necessary.

4. ATN Transition Planning Guidance for Ground Based Elements

In this chapter, the guidelines of each issue identified in the preceding chapter are presented. The issues discussed are related only to ground elements of the ATN and inter-domain operations. Also guidance information for States is provided.

4.1 Identification and integration of existing and newly required infrastructure in inter-domain operation for transition

In this section, the infrastructures of both existing AFTN and newly required ATN are identified. Also guidance material is provided to integrate infrastructures for transition.

4.1.1 Identification of existing infrastructure

The AFTN is identified as existing infrastructure today. The AFTN consists of a series of data links (circuits) providing messaging services.

The AFTN may be considered to be generic enough to convey any messages, but its operational mode is limited to store-and-forward on link-by-link basis.

The AFTN is dedicated for one operation, i.e. AFTN messaging service.

4.1.2 Identification of newly required infrastructure

The ATN is identified as a newly required infrastructure in inter-domain operation. The ATN is domain-oriented as described in the preceding chapter.

In the context of ground elements of the ATN in the ASIA/PAC region, each State administers one or more than one domain. Interconnections between States are inter-domain connections, since two ends of an interconnection belong to different domains.

Each administrative domain has one or more than one routing domain, but typically one administrative domain would have only one routing domain.

In each routing domain, there exist many interconnected subnetworks, although the interconnection issues within one administrative domain are not the subjects of the ICAO ATN SARPs, nor the ASIA/PAC regional planning.

The ATN provides a communication infrastructure for many types of communication services, including ATS messaging services. The ATN also includes the services of the communication infrastructure.

The store-and-forward mode of communication services is captured in AMHS (ATS Message Handling System), which, in future, may provide extended service capability beyond the current AFTN functionality.

The ATN is also intended to provide ground-to-ground communication services other than store-and-forward, e.g. interactive communication between controllers.

It should be noted that there exists one network of the ASIA/PAC region for messaging service within the ATN framework. There exists a collection of interconnected ground networks where each interconnected ground network is administered by each State. Communication services are provided over the interconnected networks, where one of these communication services is the AFTN-like messaging service.

Also a clear distinction is made in the ATN between communication services (e.g. ATS Message Service) and network operations (Internetworking of subnetworks).

The network of the ATN is capable of accepting messages of any communication services defined over the ATN. If a new communication service is required in the future, it can be readily added to the ATN environment.

In order to interconnect many types of subnetworks and keep the network flexible , the network layer of the ATN is structured in two parts, dependent to specific type of subnetworks and independent to specific type of subnetworks, i.e. common to all types of subnetworks. It has to be noted that, the subnetwork main body itself is not a part of the ATN. The ATN is able to adopt any available subnetworks, if such subnetworks are agreed to be part of the ATN. In the case of introducing new type of subnetwork, development of only subnetwork specific functionality to adapt the subnetwork is required for inclusion in the ATN environment.

4.1.3 Integration of existing and newly required infrastructure for transition

The integration of infrastructures implies that the existing and newly required infrastructure co-exist, interconnected and operational at same time. If it is not the case, there is no need to consider integration.

It is generally agreed that existing infrastructure is the AFTN, and the targeted infrastructure is the ATN, and two infrastructures co-exist and are interconnected. It is also proposed that the transition has to be made in phases.

There are two possible approaches for integration of these two different infrastructures, one is by the protocol conversion at network/data link layer level and the other is by the message conversion at application layer level, i.e. using gateways.

Taking into consideration the significant differences in communication architecture between the AFTN and the ATN, the gateway approach, i.e. message conversion at application layer level, is preferable to the protocol conversion at network/data link layer level.

By deciding to adopt gateway approach, the following observations should be made:

1) by definition, the integration via gateways takes place at the application layer of protocol (7th layer in OSI protocol stack);
2) two communication infrastructures, which are related only up to transport layer protocol(1st-4th layer of OSI protocol stack), are independent from one to the others, by definition; and
3) the ‘integration’ via gateway does not mean that two dissimilar network infrastructures become one. It means that one communication service operating over two dissimilar network infrastructures is supported via the gateway function situated at the boundary of two infrastructures.

In summary, it is noted that:

1) gateway supports the AFTN messages over the ATN but naturally gateway does not support to exchange all ATN messages over the AFTN (e.g. ATN messages of ADS or CPDLC are not going to be conveyed over

the AFTN). The services provided in the ATN are broader in scope than ones in the AFTN; and

2) over the ATN, gateway depends on the internetworking services of the ATN infrastructure; and

3) over the AFTN, gateway depends on the AFTN services.

Note: Similar functions may be provided for ACARS/ATN 'gateway' and FANS-1/ATN Service Gateway for Air-to-Ground Service Components. Significant differences between ground-to-ground messaging services and air-to-ground service components are that the AFTN and ATS messaging service are based on store-and-forward operation, while air-to-ground service component, especially CPDLC, is interactive in nature, and the gateway function in between, if any, may not be appropriate for translating protocols or messages.

4.1.4 Integrated service over existing and newly required infrastructure for transition

Based on the previous discussions, only the integrated service for transition is discussed, in this subsection.

4.1.4.1 Cases in integration

It is useful to list cases of possible situations for needed integration of the AFTN services and the ATN services. It helps to identify the feasible transition phases.

Table 4.1-1 Possible Cases of Services

Case	Domain A	Domain B	Domain C
1	Full AFTN Services Potential ATN Services*	Full AFTN Services Potential ATN Services*	Full AFTN Services No ATN Services*
2	Full or Partial ATS Message Services Potential ATN Services*	Partial AFTN Service and Partial ATS Message Services Potential ATN Services*	Full AFTN Services No ATN Services*
3	Full ATS Message Services Potential ATN Services*	Full ATS Message Services Potential ATN Services*	Full AFTN Services No ATN Services*

Note: Assume that there is a direct connection between Domain A and B, and also between Domain B and C. Here 'ATN Services*' are, for instance ADS, CPDLC, i.e. other than AFTN and AMHS services.

Case 1)

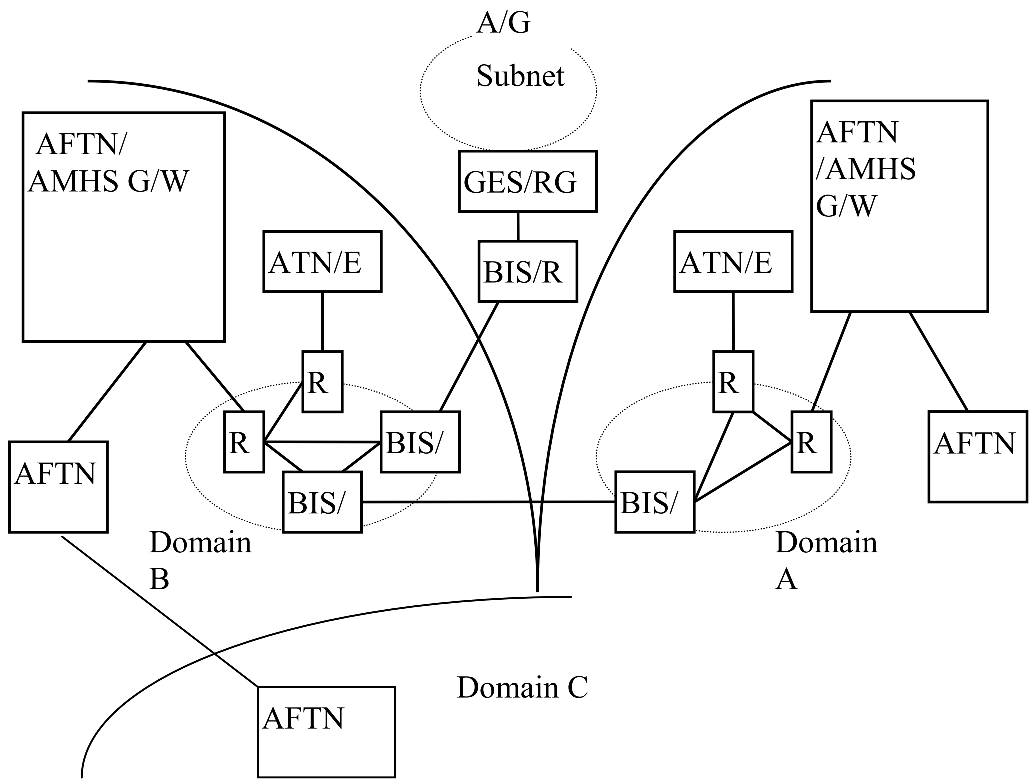
More than one State in the ASIA/PAC region has decided to implement the ATN service components, mutually as well as internally, while they retain the AFTN messaging service as it is:

a) more than one State in the ASIA/PAC region has decided to implement the ATN infrastructure internally,

b) between these States, there exists a direct (ground-ground) data link, and

c) both States mutually have agreed to exchange the ATN format messages over the data link.

In this case, the ATN inter-domain connection is required between these States in the ASIA/PAC region.



R: ATN Router; BIS/R: Boundary Intermediate System/ATN Router, ATN/ES: ATN End System,

GES: Ground Earth Station, RGS: Remote Ground Station.

Figure 4.1-1 Transition Case 1)

Note 1: It has to be noted that there is little meaning for implementing the ATN inter-domain connections in a region, if the States concerned are not implementing the ATN infrastructure internally.

Note 2: Also it has to be cautioned that:

(1) The ATN network operation planning; definition of Administrative Domain, Address Planning, and so forth, are the pre-requisite to any ATN operational

trials. ‘Address allocation on a more or less random basis during its initial experimental and test phases should be avoided, as it is cumbersome to cancel existing assignments and re-allocate addresses to objects, if overall ATN has reached a certain population.'

(2) Mutually adopting the ATN messaging services mutually among States may happen because the ATN based Air-Ground communication service applications may be operational and there is a need to exchange the messages between domains, or simply adopting new communication technologies because of efficiency and system management capability provided by the ATN.

In such a case, it is assumed that AFTN is operating as usual within States and the ATN messaging services are provided in inter-domain and there is no new requirement for the existing AFTN operations.

This implies that exchanges AFTN messages over the ATN and the AFTN/MHS gateway have to be introduced, since:

- integration of two infrastructures is required, and
- integration of two infrastructures by using gateways is preferable.

Even without any new requirements for the AFTN, the AFTN messaging services have to be migrated to the ATN environment by adopting gateways.

The requirements for transition in this case are:

(a) provide internetworking capabilities in inter-domain connections, i.e. internetworking among subnetworks of States, for the required ATN message exchange; and

(b) provide the gateway for existing AFTN services to the ATN message exchange.

As indicated in the Figure 4.1-1, there will be also inter-domain connections to Air-to-Ground Subnetworks, connecting to SATCOM via GES, or VHF Data Link Subnetwork via RGS, if the Air-to-Ground subnetwork belongs to any other domain (service providers or another States).

The case 1) represents the final phase of transition for ATN communication service components (e.g. ADS, CPDLC) other than ground-to-ground communication, as far as the ground portion of communication is concerned.

Case 2)

More than one State in the ASIA/PAC region has mutually decided to implement the ATS Message Service but only partially within State.

a) more than one State in the ASIA/PAC region has decided to implement the ATS Message Service partially within State;

b) between these States, there exists a direct (ground-ground) data link; and

c) both States mutually have agreed to exchange the ATS Message Service messages over the data link.

In this case, the ATN interconnection is required between these States in the ASIA/PAC region.

The reasons for partially adopting ATS Message Service may be operational improvements, for instance, applied only to international operations within States without major impacts on internal operations for the time being, partially adopting new communication technologies, partially adopting system management capability , the cost trade-off and/or user interface compatibility to deploy the ATS Message Service.

Since the ATS Message Service is partially implemented, there is a need for the gateway between the AFTN and the AMHS within State(e.g. see Domain B). There are many alternative places where the gateway may be situated. By introducing the AFTN/AMHS gateway as described in this case, the ATS Message Service and the AFTN services co-exist within State during a transition.

The only gateway adopted for this case is theAFTN/AMHS Gateway (Figure 4.1-2).

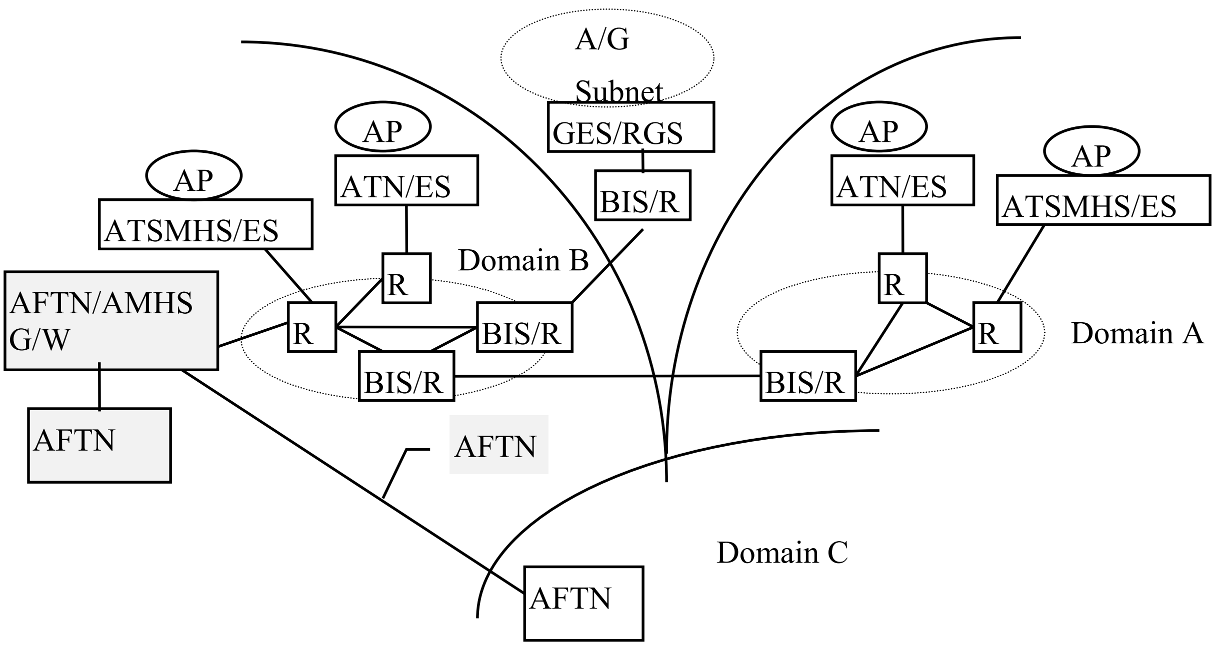


Figure 4.1-2 Transition Case 2)

The case 2) represents the intermediate phase to final phase described in case 3). Before migrating to the final phase of ATSMHS, the AFTN operation may remain for some time.

Shifting boundaries between the AFTN and the AMHS, and extending the ATN portion internally within State or a region among States, it is possible to improve operational efficiency gradually, without impacting provisions of the AFTN service.

Case 3)

More than one State in the ASIA/PAC region has decided to fully implement the ATS Message Services, mutually as well as internally.

a) more than one State in the ASIA/PAC region has decided to fully implement the ATS Message Service internally,

b) between these States, there exists a direct (ground-ground) data link, and

c) both States mutually have agreed to exchange the ATS Message Service messages over the inter-domain connection.

In this case, the ATN inter-domain connection is required between these States.This case is the same as case 1) except the messages exchanged over the ATN inter-domain connections include the AMHS user messages. It is possible that only one State may have decided to implement the ATS Message Service internally, but it is not the concern of regional planning.

The reasons for adopting the ATS Message Service may be operational efficiency improvements, by adopting new communication technologies and system management capability.

The difference between case 2) and case 3) is that there is no need of the gateway between the AFTN and the ATN anymore, since two States implementing the ATS Message Service do not have AFTN functionality anymore.

The case 3) represents the final phase of ATSMHS. But it is unrealistic to assume that all States convert into ATS Message Service at same time. There may be States in the ASIA/PAC region operating the AFTN, and there is a need for the State to send/receive the AFTN massages to/from the States, even if the State has already migrated to the ATS Message Service environment. In such a case, since the interoperability between the AFTN Service and the ATS Message Service can be provided by introducing the AFTN/AMHS Gateways, the State can operate the ATS Message Service internally, while sending/receiving the AFTN messages to/from any States through AFTN/AMHS Gateway (Figure 4.1-3).

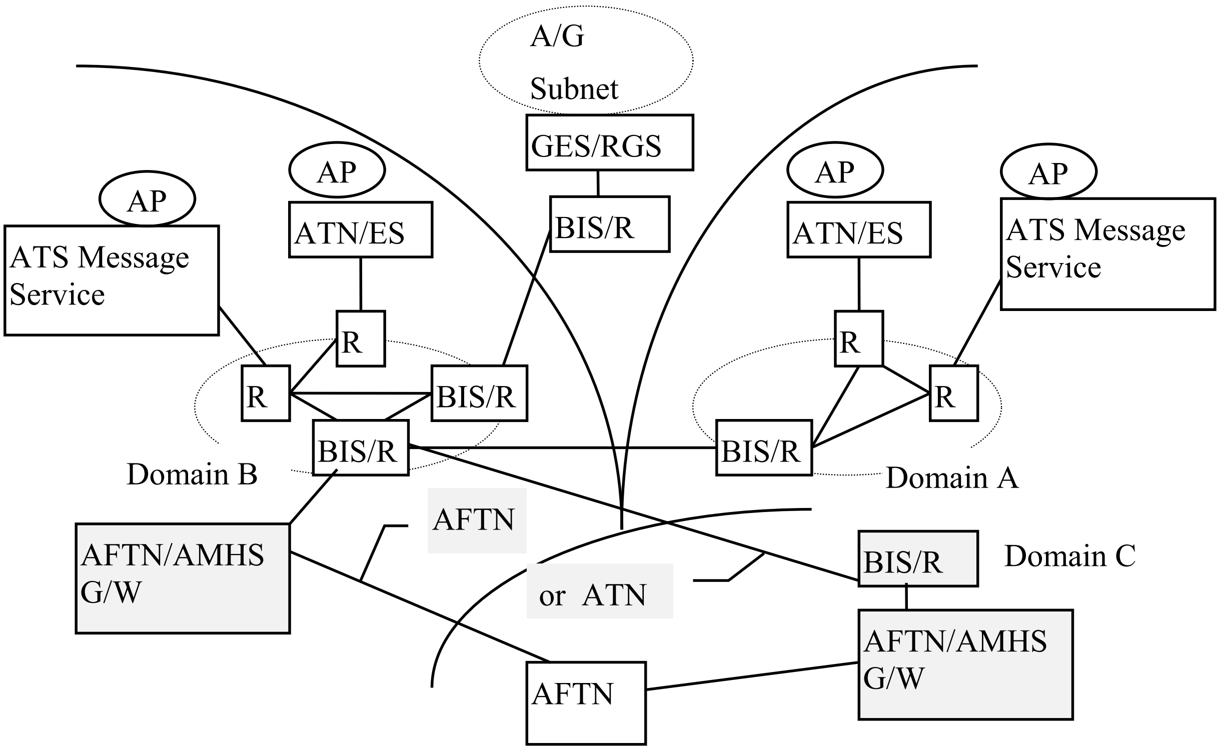


Figure 4.1-3 Transition Case 3)

There is a slight restriction to ATSMHS operation in case of messaging via the AFTN/AMHS gateway. The length of messages, and the maximum number of recipients are bounded to the AFTN constraints.

Before migrating to the final phase of the ATS Message Service in the region, the AFTN operation may remain for a considerable time. If this is a case, State can migrate to the ATN environment independent of the migration status of the neighboring States. In this sense, the AFTN/AMHS gateway approach provides a more flexible and adaptable migration path.

In case 2) or 3), there may still exist some States operating only the AFTN functionality.

For instance, let us assume that there are two adjacent data links between States A and B, also States B and C. States A and B have decided to implement the AMHS, but not in State C. There is a need of a gateway between B and C.

There are two alternatives States B and C may agree upon, as shown in Figure 4.1-3, either:

(1) interconnection between B and C remained as the AFTN circuit as it is, so that State B provides a gateway between the AFTN and the AMHS, as shown in case 3) as one of two alternatives and in case 2); or

(2) interconnection between B and C is migrated to the AMHS inter-domain interconnection, so that State C provides a gateway between the AFTN and the AMHS, as shown in the other one of two alternatives of case 3).

If the alternative (1) has been chosen, then State B, in the example has to implement a gateway between the AFTN and the AMHS, although State B is not operating the AFTN internally in case 3). In case 2) State B provides a gateway.

If the alternative (2) in the above example has been chosen, then State C has to implement a gateway between the AFTN and the AMHS, although State C is only operating the AFTN internally.

4.1.4.2 Transition phases and Transition path

In the previous description (see 4.1.2), it is stated that there should be clear distinction between:

(1) transition to and implementation of the ATN internetworking (infrastructure), specified by ATN Internet SARPs;

(2) Transition to and implementation of communication (including messaging) services, specified by ATN Applications SARPs over the ATN internet.

Transition related to the ATN internetworking needs a focus mainly for (inter-domain) connections, while the one related to communication (including messaging) services needs a focus for the provision of service elements, including the gateway, over the inter-domain connection.

4.1.4.2.1 Transition in ATN Internetworking

Transition related to inter-domain connection is rather straight forward, if the concept of internetworking is understood and implemented correctly.

4.1.4.2.2 Transition in service provision

Based on the three cases of integration discussed above (state-by-state basis), there are three conceivable transition phases of service provision over the inter-domain connections within region as a whole, combining alternatives of inter-domain connection, the AFTN or AMHS messaging service, and other ATN services over connection.

Phase a) only AFTN messaging service for messaging services and some other ATN services over inter-domain connection.

Phase b) partial ATS Message Service (including AFTN operation via gateway) and some other ATN services over inter-domain connection.

Phase c) full ATS Message services and some other ATN services over inter-domain connection.

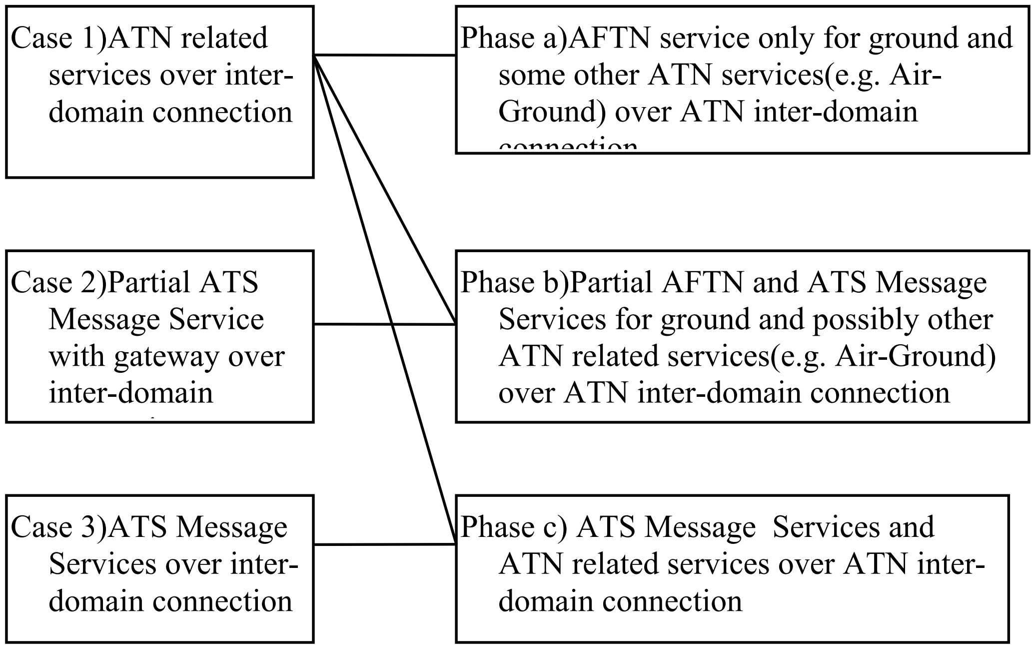


Figure 4.1-4 Transition Phases

The relationship between case and phase in Figure 4.1-4 shows that the phase can cover the related cases.

Phase a)

Description of phase

(Inter-domain connection/ service other than ground-to-ground/ ground-to-ground service)

1) Some interconnections between States in the ASIA/PAC region are the ATN inter-domain connections, while the remaining interconnections between States in the ASIA/PAC are the AFTN circuits.

2) There are message exchanges of the ATN related services (other than ground messaging services) over the ATN inter-domain connections, while clearly these ATN related service messages could not be exchanged over the AFTN circuits.

It means some States connected to the ATN inter-domain connections operate the ATN services (e.g. Air-Ground applications) mutually as well as internally.

3) Messages of ground messaging service over the ATN inter-domain connections are the converted AFTN messages and AFTN messages over AFTN circuits.

The gateway between the ATN environment and the AFTN environment within a State is required for the AFTN message conversion.

Status of service in States

States without any ATN inter-domain connections have no relationship to the ATN, and provide the AFTN messaging services.

States with any ATN inter-domain connections are:

either a State operating the ATN related services mutually over the ATN inter-domain connections as well as internally within the State. A State provides a gateway between the AFTN environment and the ATN environment within the State to provide the AFTN messaging service over the ATN inter-domain connections, but there is no ATS Message Services provided;

or a State is operating the AFTN messaging services, but not operating any ATN related services internally, and a State provides a gateway between the AFTN and the ATN at the boundaries, to provide the AFTN messaging services over the ATN inter-domain connections.

Phase b)

Description of phase

(Inter-domain connection/ service other than ground-to-ground/ ground-to-ground service)

1) Some interconnections between States in the ASIA/PAC region are the ATN inter-domain connections, while the remaining interconnections between States in the ASIA/PAC are the AFTN circuits.

2) There are message exchanges of the ATN related services (other than ground messaging services) over the ATN inter-domain connections, while clearly the ATN related service messages can not be conveyed over the AFTN circuits.

3) Messages of ground messaging service over the ATN inter-domain connections are the AMHS messages and/or the converted AFTN messages, and messages over the AFTN circuits are the AFTN messages and the converted ATSMHS messages.

Status of service in States

States without any ATN inter-domain connections have no relationship to the ATN, and provides the AFTN messaging services.

States with any ATN inter-domain connections are:

either a State is operating the ATN related services mutually over the ATN inter-domain connections as well as internally within a State. A State is operating the ATS Message Service mutually as well as internally in part, and also provides a gateway between the AFTN portion and the ATN portion within State to provide the AFTN messaging partially within State;

or a State is operating the AFTN messaging services, but not operating any ATN related services internally, and a State provides a gateway between the AFTN and the ATN at the boundaries, to provide the AFTN messaging services over the ATN inter-domain connections.

Phase c)

Description of phase

(Inter-domain connection/ service other than ground-to-ground/ ground-to-ground service)

1) All interconnections between States in the ASIA/PAC region are the ATN inter-domain connections.

2) there are message exchanges of the ATN related services (other than ground messaging services) over the ATN inter-domain connections.

3) messages over the ATN inter-domain connections are the AMHS messages.

Since new ATN related service might be standardized as an ongoing process, this phase is applied for introducing new services, but interconnections between States are not changed.

Status of service in States

All States are operating the ATN related services mutually over the ATN inter-domain connections as well as internally within a State, also all States are operating the AMHS mutually as well as internally.

It should be noted that phase c) is the final phase of the ATN transition, as far as ground messaging service is concerned, since in AFS, the AMHS based on X.400 is the targeted messaging service, specified in the ATN ATSMHS SARPs.

Transition path to the final phase could be any one of the followings:

1) phase a) - phase b) - phase c)
2) phase b) - phase c) for ground messaging service with underlying inter-domain connections.

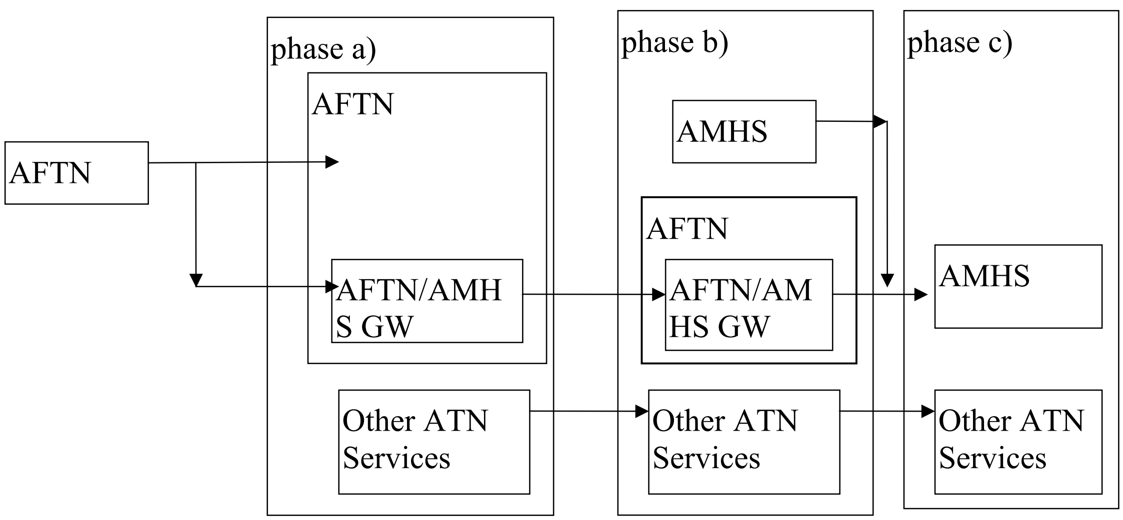


Figure 4.1-5 Transition Phase and Path

Each State:

1) provides the ATN inter-domain connections;
2) provides the ATN related services over the ATN inter-domain connections;
3) provides a gateway between the AFTN and the AMHS for messaging services over the ATN inter-domain connections; and
4) extend the ATS Message Services to replace the AFTN services where step 2)

and 3) are possibly in parallel or one follows the other.

4.2 Message Service Definition, Benefit and Procedure in Inter-Domain Operation

4.2.1 Phase a) AFTN with some other ATN services

4.2.1.1 Service definition

There exist the ATN services other than the ground messaging services. These services have to be defined in some way other than the ground messaging service.

4.2.1.2 Benefit

There could be significant benefits for the ATN services, other than the ground-to-ground messaging service, between States over the ATN inter-domain ground-to-ground connections. These benefits have to be analyzed and to be included in the document.

4.2.1.3 Procedure

The operations for the ATN services, other than the messaging services, are in an operational phase, so that the operational procedures for the network operations as well as for the ATN services have to be established.

The range covered by the procedures for the network operations may be far more in size and scope than the AFTN-like messaging services, e.g. management of addresses, network components.

Each ATN service may be introduced one by one or in phases between States as well as within State, so that, the management of networks has to track the implementation requirements as needed.

4.2.2 Phase b) Partial ATSMHS with some other ATN Services

4.2.2.1 Service Definition

The service to be defined in this phase is the ATS Message Service. The services defined in the ATSMHS SARPs currently are those of the AFTN equivalent, so that currently the ATSMHS is equivalent to the AFTN service. The difference is that the ATSMHS provides end-to-end services, while the AFTN service is the link-to-link services, thus in the ATSMHS, the service quality will be improved by guaranteeing the message delivery automatically to the destination, and by eliminating human efforts for the message delivery. The ATSMHS capability may be extended in the future. For instance, AIS messaging over AMHS may be one of them.

4.2.2.2 Benefit

Some benefits by adopting the ATSMHS are expected as follows:

1) Global message management using the unique message ID.
Using the unique identifier, it is capable of managing the messages globally;

2) Automatic reporting.
The Delivery/Non-Delivery report, and Recipient Notice can be provided automatically. The system managers or Control Positions can check the

log-file for message delivery;

3) Trace Information capability.
The trace information, like time, names of domains the message traversed, is added to the message envelope. It helps the status monitoring and analysis; and

4) Managing users in Management Domain using Originator/Recipient names.
The Originator/Recipient names are structured in a hierarchical way, so that each Management Domain can exercise the network management using the O/R names.

4.2.2.3 Procedure

In this phase, there are two new procedures to be introduced, one for the ATS Message Service operations and the other for the AFTN/AMHS Gateway operation.

Note: As described in 2.5.3, the fallback procedure for the AFTN/AMHS Gateway malfunctions would be automated, and less complex.

4.2.3 Phase c) Full ATSMHS with some other ATN Services

4.2.3.1 Service Definition

There is no new service other than described in phase b) , but in near future , new services will be proposed and introduced.

4.2.3.2 Benefit

The benefits of the yet defined services are not currently predictable.

4.2.3.3 Procedure

The procedure for the AFTN/AMHS gateways will not be necessary in this phase.

New procedures required for the new services are not available at this time.

Note: Any new services, benefits, procedures identified will be included in this section.

4.3 Guidance for Administrative Domain and its Definition within State

In order to define an Administrative Domain, it is required to identify the ATN to be administered by each State.

In this section, the information on the identification of the ATN ground elements within States (Administrative Domain) is provided. The allocation of the ATN ground elements within States and the address planning are design tasks, therefore the allocation of the ATN ground elements will be described in the section on the architectural design.

The Management aspect within an Administrative Domain is also discussed in this section.

The materials presented in this section are for information, and they are not mandatory. Each can decide and design its own Administrative Domain, using the information provided in the document.

If an Administrative Domain is large and complex, it is helpful to manage domain by dividing it into parts. A concept of Routing Domain is introduced, where each Routing Domain performs independent routings within an Administrative Domain. The Routing Domains identification is a State responsibility. In this section, Domain means Routing Domain.

4.3.1 Identification of Ground Elements

As described in the previous chapter, the ATN ground elements are ground subnetworks, Intermediate System, i.e. (ATN) router, and End System.

Since in the ATN we are concerned to interconnect the existing ground networks, designing the ground subnetwork itself is not major task. It is assumed ground networks are already in . Our concerns here are identifying them and using them to interconnect them to the routers. Another task is to identify the placement of the required Ground End Systems.

4.3.1.1 Routers

It is already shown that the role of routers is to route user data packets via appropriate paths from the origin to the destination, and there are two types of routers; BIS; Boundary Intermediate System and IS; Intermediate System(i.e. Non-Boundary). Routers exchange the route information among them.

4.3.1.1.1 Boundary Intermediate System: ATN Router

By definition, a BIS has to be situated at the boundary of a Domain. Within an Administrative Domain there will one or more Routing Domains.

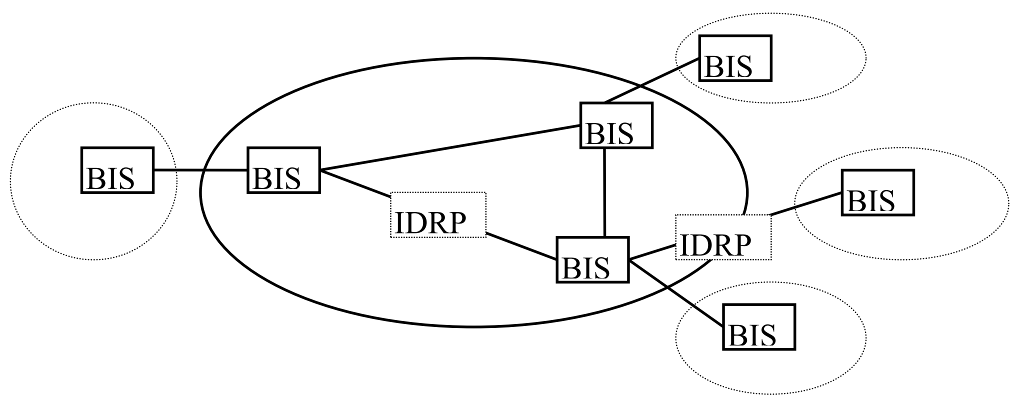


Figure 4.3-1 ATN Router(BIS)

The following rules are applied:

1) There should be direct inter-domain connections from BIS to other domains;
2) peer router in the neighboring Domain has to be a BIS;
3) routing information is exchanged between BISs within own Domain as well as between BISs over the inter-domain connection;
4) protocol used for routing information exchanges between BISs is the IDRP; Inter-Domain Routing Protocol, standardized in the OSI; and
5) Connections between BISs within a Domain are not necessarily the direct

connections between BISs, i.e. there could be ISs between BISs within a Domain.

The connections to Air-to-Ground Subnetworks are also the inter-domain connections and require a BIS as aircraft have their domains. As Air-to-Ground subnetworks may be administered by other organizations(other States or communication service providers), the controlling ground domain may be using the BIS, provided by these organizations.

If the ground portion of Air-to-Ground subnetwork is administered by one State together with the ground subnetwork, the Air-to-Ground subnetwork is part of the Administrative Domain and a BIS is required for air-to-ground communication. The aircraft subnetwork will be in a different Administrative Domain and another BIS is needed.

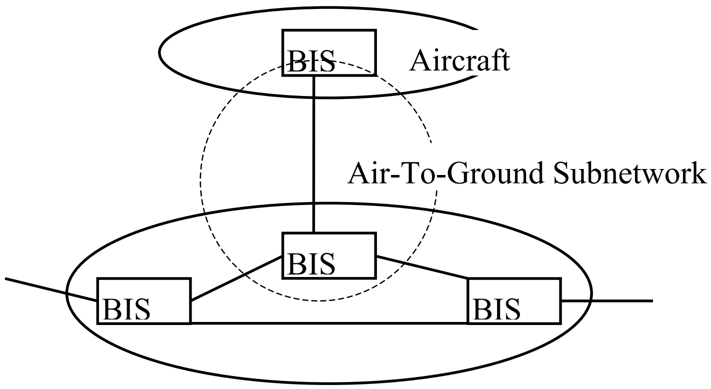


Figure 4.3-2 ATN Router(BIS) to Air-to-Ground Subnetwork owned by a Ground Domain State

4.3.1.1.2 IS: Intermediate System

An IS, situated at the boundary of the ground subnetworks within a domain, is responsible to route and forward user packet data to its destination within a domain.

An End System attached to an IS provides the connectivity information to the IS, using the ES-IS protocol and the ISs may exchange the connectivity/routing information among them using the IS-IS protocol. The ISs within a domain have complete knowledge of connectivity within a domain.

The BIS also has a capability of an IS.

The IS-IS protocol is optional in the ATN, as the ATN SARPs only specify IDRP. IS-IS is highly recommended.

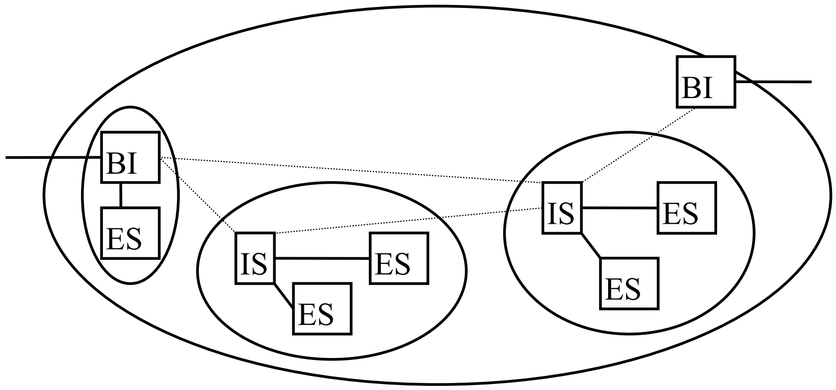


Figure 4.3-3 BIS, IS and ES

In the figure, the dotted lines are intended to show the IS-to-IS connections.

4.3.1.2 End Systems

The End Systems are attached to the ISs, and ES can talk to other ES. There is no broadcast capability in the ATN.

Each End System has a unique ATN address. A calling ES specifies the called ES address when sending messages.

There are two categories of ATN communication services, the Air-to-Ground communication service, and the Ground-to-Ground communication service.

In the Air-to-Ground Communication service, one of the communicating ESs is mobile and in the air and the other is on the ground and fixed.

Note: There is an exception where two ground ESs of Air-to-Ground communication service may communicate to each other (e.g. across the FIR boundary); namely ,Ground-Forwarding of the Air-to-Ground communication information.

In the Ground-to-Ground communication service, both ESs are on the ground and fixed. In this subsection, the ground elements of the Ground-to-Ground service components as well as the Air-to-Ground service components are discussed. Since the ground elements are situated within a domain, they are discussed from the intra-domain aspect here.

4.3.1.2.1 (Ground) End Systems in Ground-to-Ground Service Components

In the chapter 2, the Ground-to-Ground Service Components were discussed briefly. In the ATN SARPs, there are two types of Ground-to-Ground Service Components, ATSMHS and ICC(AIDC).

4.3.1.2.1.1 ATSMHS Application Entity(AE)

Three types of ATN End Systems are defined in the ATSMHS:

1) ATS Message Server;

2) ATS Message User Agent(UA); and

3) AFTN/AMHS Gateway.

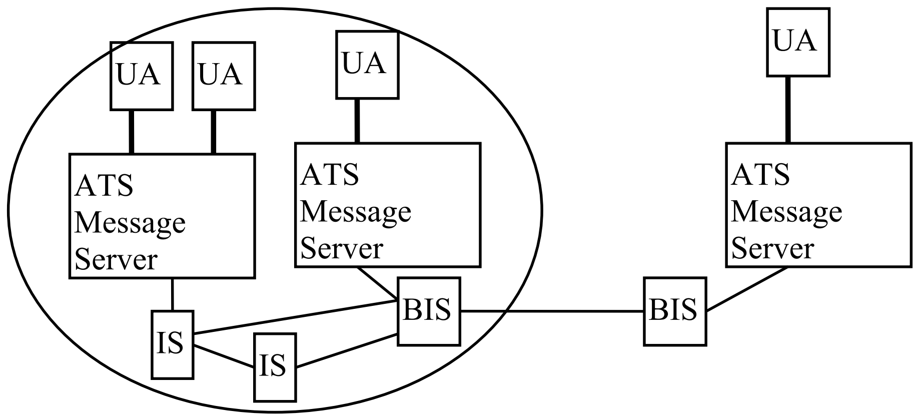


Figure 4.3-4 ATSMHS ES

Messages from one UA to another UA are store-and-forward, hopping from one ATS Message Server to another to the destination. There is a path traversing a sequence of ATS Message Servers. Such a path is managed by maintaining the ATSMHS routing information (Figure 4.3-4).

It should be recognized the difference between ATSMHS Messaging routing and ATN Internet routing, where the ATSMHS Messaging routing is between ATS Message Servers and the ATN Internet level routing is between ISs (and BISs). The difference is highlighted in the Figure 4.3-4, where for one ATSMHS Messaging route between two ATS Message Servers, there may be multiple ATN Internet level routes. In the ATSMHS, it is possible to send the same message to multiple recipients, in such a way that an intermediate ATS Message Server makes a copy of message and sends to a subset of recipients to the next ATS Message Server (Figure 4.3-5). The traversing paths are thus tree-structured paths, starting at the origin of message and terminating at each recipient.

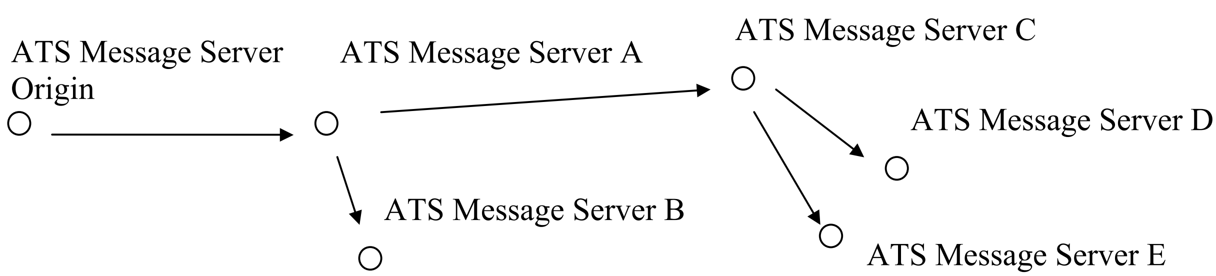


Figure 4.3-5 Multiple ATS Message Paths

In order to implement the ATSMHS within a domain, at least one ATS Message Server with at least one ATS Message User Agents is required.

The AMHS naming and addressing, routing and rerouting will be discussed in the addressing and management subsections.

4.3.1.2.1.2 ICC(AIDC)Application Entity(AE)

The AIDC is intended for Inter-Facility Communication between neighboring ATC Units on the flight related information. If there is a need of flight notification/coordination/transfer over the FIR boundary, the AIDC is required at each side of the boundary to provide the ground-to-ground communication services (Figure 4.3-6).

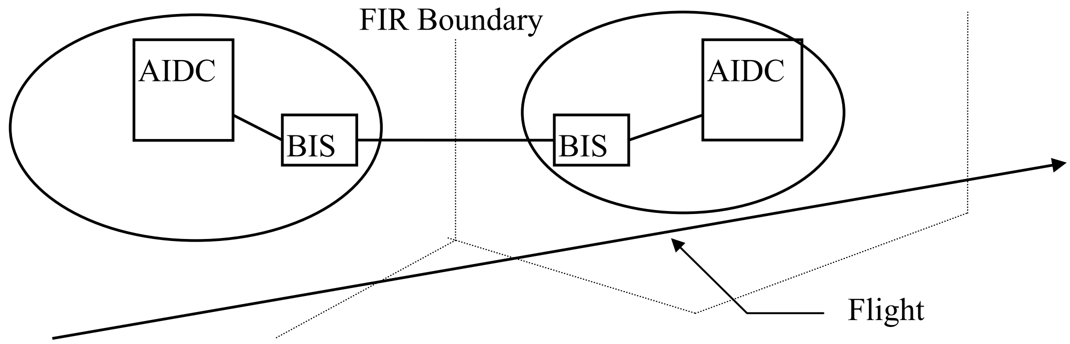


Figure 4.3-6 AIDC

There may be some cases of more than two ATS Units are involved in one flight; namely:

1) more than two ATS Units are involved for one flight because there are more than one neighboring FIRs for one flight at same time(parallel coordinations); and
2) more than two ATS Units are involved for one flight because of down stream coordination(serial coordinations).

Currently the AIDC SARPs do not allow more than one association for one flight. In case of 1) and 2) above, the separate associations have to be established between ATS Units.

One association is established for each flight when the current ATS Unit notifies the flight to the next ATS Unit, and is maintained until the flight is transferred to the next ATS Unit. Depending on the air traffic over the FIR boundary, there may exist more than 100 flights at a time(e.g. from 30 minutes before crossing the boundary to some minutes after crossing the oceanic boundary).

Because of the current limitations on the association establishment discussed in the previous chapter, it would need to provide multiple AIDCs, over one FIR Boundary, depending on the air traffic. Depending on the implementation of underlying software, there may a limit on the number of connections allowed at same time. Logically a set of these multiple AIDC instances are considered as a single AIDC. There may be an address allocation issue; how to assign multiple AIDC addresses.

States also have to note that an AIDC is hardly used as a stand alone service within a domain. It is combined with some Air-to-Ground service components, like CPDLC and Context Management, since Notification, Coordination, and Transfer messages in the AIDC are related to the message exchanged in Context Management and CPDLC. It implies that CPDLC, Context Management and AIDC may be co-located and communicate among themselves.

There is no need to combine multiple AIDCs within a domain(i.e. within FIR), since it is assumed that there is no coordination for flights within a FIR, except the cases where a FIR has AIDC connections to more than two FIRs.

In the ATN AIDC SARPs, a set of AIDC messages are defined. This is a super set of messages adopted in some regions, including the ASIA/PAC region. The ASIA/PAC region should be implementing the APANPIRG ICC(AIDC) message set, a subset of the ICC(AIDC) SARPs message set. Selecting a message set is a matter of mutual agreements between States.

4.3.1.2.2 Ground End Systems in Air-to-Ground Service Components

In the ATN SARPs , four types of Application Entity are defined, for the ground portion of Air-to-Ground communications; CM ground AE, ADS ground AE, CPDLC AE and FIS ground AE. Each ground AE communicates to peer Air AE of same type, i.e. CM ground AE to CM air AE, etc.

In CM, ADS, and CPDLC, ground AE also communicates to another ground AE for 'ground forwarding' service.

For Air-to-Ground combinations, if the message service request is invoked and there is no existing underlying dialogue/association, then a dialogue is established automatically, i.e. without user interaction. It is not required that all ATS Units install all ground AEs. An ATS Unit may have only CM, ADS and CPDLC, or ADS, CPDLC, FIS and CM.

Ground AEs in the Air-to-Ground service components have a potential implementation issue, namely, there are many active connections/associations between air and ground for a considerable time, and ground ESs have to maintain the connections/associations. See also 2.4 for brief description of Air-to-Ground communications.

4.3.1.2.2.1 CM: Context Management Application Entity(AE)

In any domain, there should be at least one CM ground AE. It is expected only a small number of CM ground AE will be installed in a domain, since CM ground AE is a kind of communication portion in directory server, and it is not necessary for each ATS Unit to have CM ground AE.

It is required for State to make some decisions:

1) to decide the number of CM ground AEs within a domain and service coverage of each CM ground AE; and

2) to decide the correlation between each CM ground AE and any other ground AE supported by the CM ground AE, namely how to provide address information if CM ground AE and another ground AE are not co-located.

These decisions are considered as local matters.

Note: Currently there is no provision of directory services in CM SARPs, but there is a proposal to combine CM with ITU-T X.500 (Directory Service) in the ATN SARPs .

The issue of many connections/associations may not be critical in the CM ground ES, since the associations between CM air ES and CM ground ES may terminate after information exchange.

4.3.1.2.2.2 ADS: Automatic dependent Surveillance Application Entity(AE)

States have to decide on ADS ground AE as follows:

1) which phases and areas ADS has to be introduced: oceanic, en-route, terminal, and/or airport;
2) how many ADS ground AEs will be needed; and
3) for existing ADS equivalent service, how to coordinate the new and existing services, e.g. accommodating FANS-1 ADS, ATN ADS, radar and non-radar reparatory.

The issue of many connections/associations is critical in ADS ground ES, since the associations between ADS air ES and ADS ground ES are maintained for a considerable time, in most cases. It is an implementation issue and it is also depends on the air traffic in the area.

4.3.1.2.2.3 CPDLC: Controller Pilot Data Link Communication Application Entity(AE)

Similar to the discussions on ADS ground AE, States have to decide on CPDLC ground AE:

1) which phases and areas CPDLC has to be introduced; oceanic, en-route, terminal, and/or airport;
2) how many CPDLC ground AEs will be needed; and
3) there exists a CPDLC equivalent service, i.e. voice communication, how to coordinate the new and existing CPDLC services.

The issue of many connections/associations is also critical in CPDLC ground ES, since the associations between CPDLC air ES and CPDLC ground ES are maintained for a considerable time. It is an implementation issues and it is also depends on the air traffic in the area.

4.3.1.2.2.4 FIS: Flight Information Service Application Entity(AE)

Currently ATIS and METAR are defined in the ATN FIS SARPs.

States have to decide on ATIS and/or METAR ground AE; how many FIS ground AEs will be needed.

Note: The ground providing ATIS and/or METAR may not be the one of the controlling ground ATS Units. Aircraft in oceanic airspace may request ATIS and METAR.

The issue of the number of connections/associations may be critical in FIS ground ES, since the associations between FIS air ES and FIS ground ES may be maintained for a considerable time. It is an implementation issues and it is also depends on the air traffic in the area, and the number of information requests per flight.

4.3.2 Names and Assignment of Addresses

4.3.2.1 Application naming

There are two forms of application names; OID; Object Identifier form and Directory

Name form. These are different only for presentations.

The following name format is the OID form for the ADS ground ES:

ISO(1)+identified-organization(3)+ciao(27)+tan-end-system-ground(2)+facility-designator(1..n)+ops(0)+ads(0)

where + means the concatenation, and the values in parentheses are assigned. The value of facility-designator correspond to the ICAO Facility Designator. In the followings, the assigned values of last two fields are listed.

Under the ICAO Facility Designator, the following values are assigned as Traffic Type values:

Table 4.3-1 Traffic Type Values

Name	Integer Value
Ops: operational	0
Gen: general	1
Sys: system management	2
Adm: administrative	3

The values for OID form of the ATN application entities(AEs) for the ATN application service entity(ASE) Type, i.e. the last element of OID form, are assigned as follows:

Table 4.3-2 ASE Type Values

ASE Type	ATN AE-Qualifier Name	ATN AE-Qualifier Integer Value
Automatic Dependent Surveillance	ADS	0
Context Management Application	CMA	1
Controller Pilot Data Link Communication	CPC	2
Automatic Terminal Information Service	ATI	3
System Management Application	SMA	5
ATS Inter-Facility Data Communications	IDC	6
ATS Message Server	AMS	7

ASE Type	ATN AE-Qualifier Name	ATN AE-Qualifier Integer Value
AFTN/AMHS (Type B) Gateway	GWB	8
ATS Message User Agent	AUA	9
ADS Report Forwarding	ARF	10
Aviation Routine Weather Report(METAR)	MET	11
Generic ATN Communication Service(GACS)	GAC	12
CIDIN/AMHS Gateway	GWC	13

For instance, {1 3 27 2 n 0 0} is the OID form of ADS AP-Title of an operational application process hosted by a ground ATN end system in Facility 'n'(see 3.1.2.7 for AP-Title).

The following object classes are used in the Directory Name form:

O: Organization, e.g. ICAO;

ADM: Administration;

C: Country;

AO: Aircraft Operator;

AI: Aircraft Identifier;

ATCC: ATC Centre;

L: Location (location of a ground Aeronautical Industry Services Communications);

SE: Sector (to distinguish between different control sectors in an ATCC);

AP: Application Process, e.g. ADS; and

AE: Application Entity.

Specific to States are C, ADM (national CAA), ATCC and SE.

4.3.2.2 Addressing

4.3.2.2.1 Subnetwork Addressing

The subnetwork addresses are not any part of ATN addresses, but they are important identifying the appropriate subnetwork point of attachment(SNPA), so that the subnetwork address is mentioned here. Only addresses, not names, are assigned to SNPA. The registration of SNPAs is a local matter to the subnetwork.

Subnetwork types are specified in the ATN Internet SARPs through the specifications of SNDCFs.The specification of subnetwork itself is not part of the ATN SARPs. One supported subnetworks is the X.25 subnetwork.

References: ISO/IEC 8208:1995 X.25 Packet Layer Protocol for Data Terminal Equipment

ISO/IEC 8473-3:1995 protocol for providing the Connectionless-mode network service-Part 3: Provision of the underlying service by an X.25 subnetwork

The addressing of the systems attached to X.25 subnetwork is a local matter. The addresses need to be configured in the router.

4.3.2.2.2 Internetwork Addressing

For the internetwork addressing, the ATN NSAP(Network Service Access Point) address format is defined.

Each State, i.e. ATN Addressing Domain authority, is the registration authority for NSAP within its prefix and can allocate:

ARS: Administrative Region Selector (3 octets);

LOC: Location (2 octets); and

SYS: System Identifier (6 octets),

fields of NSAP addresses.

ARS

The purpose of the ARS field is to distinguish routing domains by State, i.e. State has to assign values if multiple routing domains within State are provided.

LOC

The purpose of the LOC field is to distinguish the routing areas within the same routing domain, i.e. State has to assign values in the field if multiple routing areas are provided within a routing domain.

SYS

The purpose of the SYS field is to uniquely identify an ATN end system or intermediate system.

The assignments of values in these fields, especially the LOC and SYS fields are local matters, but there seem to be two aspects of addresses, one is geographical and the other is functional. The addressing rules within a domain has to be clearly defined.

N-SEL

Another field N-SEL; Network Selector(1 octet), is used to identify the Network Service User Process.

N-SEL values for Intermediate System; stated in ATN Internet SARPs:

(1) N-SEL field value for Airborne Intermediate System for optional non-use of IDRP is [1111 1110];

(2) N-SEL field value for all other Intermediate Systems is [0000 0000]; and

(3) N-SEL field value [1111 1111] is reserved.

N-SEL values for End Systems, stated in the ATN Internet SARPs:

(1) N-SEL field values are not constrained, if the ES is not co-located with IS.

N-SEL values for Network Service User are not stated in ATN Internet SARPs, i.e. it is local matter.

4.3.2.2.3 Transport, Upper Layer and Application Addressing

The TSAP; Transport Service Access Point, SSAP; Session Service Access Point, PSAP; Presentation Service Access Point are defined as follows:

TSAP address is composed of NSAP plus a local transport selector(T-SEL);

SSAP address is composed of TSAP plus a local session selector(S-SEL); and

PSAP address is composed of SSAP plus a local presentation selector(P-SEL).

The TSAP, SSAP, and application addresses are constructed from NSAP.

ATS Message Server, ATS Message User Agent and AFTN/AMHS Gateway Address Format

The address format:

TSAP = NSAP + T-SEL;

SSAP = TSAP + S-SEL; and

PSAP = SSAP + P-SEL.

are applied to the ATS Message Server, ATS Message User Agent and AFTN/AMHS Gateway.

Air-to-Ground Service components, AIDC Address Format

For all Air-to-Ground Service components and AIDC, the S-SEL and P-SEL are null, i.e. the application address is same as TSAP.

PSAP= SSAP=TSAP= NSAP + T-SEL

T-SEL field shall be administered on a local basis. The valid values shall be in the range 0 to 65535.

4.3.2.2.4 AMHS Addressing

In the ATSMHS SARPs, the AMHS addressing is specified as follows:

There are two forms of AMHS addresses; MF-Address and XF(translated)-Address. There are also two types of ATS Message Service users; direct AMHS user and indirect AMHS user.

The direct AMHS user engages in the ATS Message Service at an ATN Message User Agent, while the indirect AMHS user is an ATS Message Service user at an AFTN station using AFTN/AMHS gateway to communicate with other AMHS user.

The MF-address and XF-address are conveyed in a message header, so that the ATS Message Server uses the address information to route messages over AMHS routes. An appropriate mapping table on AMHS address/ATN address will be provided in ATS

Message Server.

The MF-address is the MHS-form of Address for the direct AMHS user.

The XF-Address is for both direct and indirect AMHS users where:

> Organization-name attribute value = "AFTN", and
>
> Organizational-unit-name attribute value = 8-character alphabetical value of AFTN-form address, both as a printable string.

The translation between the XF-address form and the AFTN-address form is provided in the AFTN/ATN Gateway.

Note: Traditionally the term 'AFTN address' is used. It could be AFTN-user-name, rather than AFTN-address. In a similar way, MF-user-name, XF-user-name, instead of MF-address and XF-address.

4.3.3 Management

Management generally means a process of planning, exercising, monitoring and acting on outcomes, in a cyclic way. The objects of the ATN management are networks and systems,(i.e. services), or elements of them. Planning and acting on the outcomes are not automated in general, and procedural in nature. The monitoring networks and systems are possibly automated.

Planning guide for the ATN environment is provided in many documents, including this document. It is not clear whether the management of system may cover the management of the network in general, but it is important to distinguish the system management at the message services level from the network management.

Management of networks and systems in the ATN may or may not be similar to the existing networks and systems. There is a need to accumulate experiences through ATN trials and operations.

The performance management, including reliability, maintainability and availability, is important. In this section, the performance management within a State is discussed. The performance management for the inter-domain connection is discussed in a later section in this chapter.

4.3.3.1 Network/System Management

4.3.3.1.1 General Considerations on Network/System Management

Many issues of the network/system management are considered as State matters.

In the ATN SARPs, there is no provision on the network/system management. The status of the system management concept currently presented is summarized in a later section of this chapter.

A variety of mechanisms to achieve systems management follow:

1) Designing network architecture and components(e.g. use of fault tolerant systems, redundant routers);
2) Implementing operational procedures not requiring specific management functions or networking technology(e.g. voice control procedure);

3) Implementing automated or operator controlled management functions that do not communicate using OSI(e.g. using SNMP with TCP/IP); and

4) Implementing automated or operator controlled management functions using OSI (e.g. using CMIP) with SMAs.

The total solution will involve a combination of these approaches.

The SMA: System Management Applications can be defined as follows:

The SMAs are operating in either the manager role(SMA-Manager) or agent role(SMA-Agent). The SMA-Agents manage the local system and perform operations on the managed objects in response to the communications from an Management Information Service User taking the manager role.

The set of objects in a system(managed object) with their attributes constitutes the system's Management Information Base(MIB).

The System Management functionality is required in the following areas:

a) fault management;

b) accounting management;

c) configuration management;

d) performance management; and

e) security management.

From the monitoring aspect of networks, State provides the facility, for instance, each IS(router) has a SMA-agent, and a SMA-manager collects information on Managed Objects, and system management functions provide services to satisfy the user requirements.

If a State has decided to implement multiple routing domains, such domains are managed by providing domain management facility for each domain and national facility.

Each State needs to decide what kind of system management functions are implemented, what service elements are to be used, what objects are to be managed, and so forth. For instance, a State wishes to provide hot standby and/or automatic recovery, the appropriate managed objects have to be defined and the information collected, and the system management functions have to be provided.

In order to manage the system elements based on a standard, it is required to implement such service elements with protocols in ISs and ESs, i.e. each element is capable to provide such information.

If a State deploys the equipment and system management software necessary to carry out the network management functions, the networks could be managed well in the State.

There are two potential issues in such a case.

1) What will be the system management standard to comply with? Since many components may be interconnected, it is required to have a standard each component complies with. The system management provisions in products; hardware as well as software, are the market-oriented, and the selection of the

appropriate standard is essential, and any proprietary system management functions have to be avoided.

2) If any existing equipment is integrated to the ATN, the system management requirement is further complicated

From the monitoring aspect of the system (service) management, the same observation can be made, and also there may be service specific management functions.

4.3.3.1.2 ATN System Management

ATN System Management is based on the ISO/IEC and ITU-T international standards for OSI management. The concepts and elements are described in Chapter 2.

The XMIB is defined in DOC 9705, Sub-Volume VI Chapter 6.6.

In this section, the aspects of system management co-ordination among organizations/domains are described.

4.3.3.1.2.1 Systems Management Co-ordination

The system management co-ordinations needed across ATN administrative boundaries are described under the five management functional areas: Fault, Performance, Accounting, Configuration and Security Management.

a) Fault Management

Fault management is the set of facilities which enables the detection, isolation and correction of abnormal operation. Fault management includes functions to:

- Report troubles;
- Accept and act upon error notifications;
- Maintain and examine error logs;
- Trace and identify faults;
- Carry out diagnostic tests; and
- Correct faults.

Fault Management will be conducted by:

- Proactive maintenance; and
- Fault Detection and Mitigation.

These are the responsibility of all participating organizations.

There is a need of Fault Management co-ordination process to exchange 'trouble tickets' among organizations.

In the ATN, the general Fault Management co-ordination process will rely on the following basic Cross-Domain Fault Management Services:

- The ATN Cross Domain Alarm Notification service;
- The ATN Cross Domain Fault History service; and

- The ATN Cross Domain Trouble Report service.

b) Performance Management

The requirements for real time sharing of performance data include:

- Detection of network degradation;
- Centralized monitoring the overall ATN performance; and
- Billing verification.

Performance Management will be conducted by:

- Data collection; and
- Performance analysis.

There is also a need of Performance Management co-ordination process which will rely on the following basic Cross-Domain Management Services.

- The ATN Cross Domain Alarm Notification service.
- The ATN Cross Domain Fault History service.
- The ATN Cross Domain Trouble Report service.
- The ATN Cross Domain Performance Information service.

c) Accounting Management

Accounting issue has two aspects:

- Institutional issue of cost recovery; and
- Technical issues on possible ATN usage measurement and reporting.

There is no identified need for a uniform accounting management exchange across all organizations participating in the ATN. However, this does not preclude any agreement formed among organizations to exchange for accounting management information. Typically, the agreement is specific to a region and selective organizations.

d) Configuration Management

For a globally distributed ATN environment, certain configuration information in an ATN element can affect ATN elements in other organizations. This dependency of configuration information requires co-ordination among the participating organizations.

Co-ordination for configuration of the ATN system will be required on the following aspects:

- Attribution of values to the ATN system configuration parameters; and
- Modification of the current configurations.

In the ATN, the exchange of information on the current configuration of ATN systems will rely on the following basic Cross-Domain Management Service:

- The ATN Cross Domain Configuration Inquiry service.

e) Security Management

   The responsibility of network managers is to coordinate and control the security mechanisms built into the configuration of ATN networks and systems under their management control.

   Locally within each ATN organization, security management must keep account of activity, or attempted activity, and detect and recover from attempted or successful security attacks. This includes the following local functions related to the maintenance of security information:

   - Event logging;
   - Monitoring security audit trails;
   - Monitoring usage and the users of security-related resources;
   - Reporting security violations;
   - Receiving notification of security violations;
   - Maintaining and examining security logs;
   - Maintaining backup copies for all or part of the security-related files; and
   - Managing the ATN Systems MIB access control service by maintaining general user profile and usage profiles for specific resources.

4.3.3.2 Network/System Performance Management

Performance encompasses reliability, maintainability, and availability as well as response time and throughput. As described in the previous section, the performance management is part of systems management.

This subsection provides only general as the performance issues are wide in scope, and depend on the situation State faces.

Some Definitions

The reliability is the time from an initial instant to the next failure event, and statistically quantified as mean-time-to-failure(MTTF). The service interruption is statistically quantified as mean-time-to-repair(MTTR)

The availability is the ratio of the service accomplishment time to the elapsed time, and statistically quantified as MTTF/(MTTF + MTTR).

Fault/ Failure

When a Fault results in a service interruption, it must be detected, reported, corrected or repaired. The latency is the time from failure to detection.

For the reliability considerations:

1) conceivable fault locations and elements have to be identified; and
2) detection/reporting/correction/repair provided.

Avoiding or minimizing the outages of networks, redundancy may be introduced for such possible faults. States have to decide to what extent the redundancy is to be provided.

The Methods of Failure Avoidance and Fault Tolerance are classified as follows:

1) Quality construction: removes errors during construction process; and

2) Error Correction: reduces failures by fault tolerance.

   2.1) Latent Error Correction: to detect and repair the latent error before it occurs, i.e. preventive maintenance,

   2.2) Effective Error Correction: to correct the errors after it occurs.

   2.2.1) Error Masking: uses the redundant information to correct service, e.g. ECC

   2.2.2) Error Recovery: denies the requested service and sets to an error-free state

   2.2.2.1) Backward Error Recovery: returns to a previous correct state, i.e. Check point/Restart.

   2.2.2.2) Forward Error Recovery: constructs a new correct state, e.g. re-transmission of messages.

3) Error Bypass: detours error locations or elements.

(See e.g. Jim Gray and Andreas Reuter, 'Transaction Processing: Concepts and Technologies', 1993, Morgan Kaufmann Publishers. 3) Error Bypass is added here)

4.3.3.2.1 Reliability, Maintainability, and Availability Considerations for ATN Elements

By the nature of interconnected subnetworks in the ATN, the redundancy can be provided for Data Link, Subnetwork and Routers, in such a way that if any elements fail, then an alternative route is provided in the ATN. Of course, it has to be sure that the alternative route can avoid the failed elements.

For the Data Link, Subnetwork, Routers; Error Masking (correcting errors), Forward Error Recovery (re-try), then Error Bypass (selecting alternatives)could be the methods employed. The capacity of the ATN may need to be planned beforehand taking into account the failures, other wise, the capacity of the ATN may be degraded in case of some ATN elements failures.

For the End Systems; Error Masking (correcting errors), Forward Error Recovery (re-try), possibly Backward Error Recovery(restart), then Error Bypass (selecting alternatives) could be the methods employed. For the ground End Systems, it will also need redundancy, e.g. active and stand-by.

In order to recover and restart in case of the error detection, it is required to acquire information during the normal operations, e.g. logging or mirroring data.

For the availability, it is desirable to provide the non-interrupted service operations, for all ATN Elements.

For the maintainability, it is desirable to provide the on-line maintenance without any interruption to the service operation

4.3.3.2.2 Reliability, Maintainability, and Availability Considerations for ATN

Service Components

The reason why the ATN service components are separated from ATN Elements in performance considerations is that performance requirements are placed at end-to-end significance level.

In the ATN SARPs, there is a system level(high level) requirement on reliability as follows:

> 'The ATN end system shall make provisions to ensure the probability of not detecting a 255-octet message being mis-delivered, non-delivered or corrupted by the internet communization service is less than or equal to 10^{-8} per message.'

In the ATSMHS SARPs, the traffic logging at least thirty days is specified.

Except as mentioned above, there is no explicit expression on the reliability, maintainability and availability in the ATN ground-to-ground service components SARPs. These are considered as State matters, although the end-to-end service extends over multiple domains.

It suggests that States have to implement the ATN, including IS, ES, subnetworks within States in such a way that any problems on the reliability, maintainability and availability do no impact or are invisible to neighboring States.

4.3.3.2.3 Capacity Considerations for ATN Service Components

In the ATN SARPs, the ATSC Classes in transit delay are defined as follows (Table 4.3-3). The ATN End System specifies the class to establish the underlying transport connection.

Table 4.3-3 ATSC Class

ATSC Class	One Way ATN End-to-End Transit Delay at 95% probability(seconds)
A	Reserved
B	4.5
C	7.2
D	13.5
E	18
F	27
G	50
H	100
No Preference	No Value Specified

In the ATSMHS and ICC (AIDC) SARPs, ‘no traffic type preference’ is specified.

Except as mentioned above, there is no explicit expression on the transit delay and throughput in the ATN ground-to-ground service components SARPs. These are considered as States matters, although the end-to-end service extends over multiple domains.

It suggests that each State has to implement the ATN, including IS, ES, subnetworks in such a way that any problems on the transit delay and throughput do no impact or are invisible to neighboring States.

If there is an end-to-end requirement on the transit delay or throughout, the requirement has to be decomposed to elements, i.e. values of the transit delay or throughput have to be assigned to the elements of the end-to-end service components.

Note: There are some studies on Reliability and Safety problems. The cases related to communications failures, including civil aviation, air traffic control, are collected, and the following summary is provided

> 'the primary causes of communications problems collected were largely environmental, e.g. fire, or were the results of problems in maintenance and system evolution. Hardware malfunctions are involved most cases, but generally secondary causative factors.'

(See Peter G. Neumann, 'Computer Related Risks', Chapter 2 Reliability and Safety Problems, Section 2.1 Communication Systems, 1995, Addison Wesley)

4.4 Guidance for architectural design of ATN Ground elements within State

For the design of the ATN ground elements, two areas have to be considered; Network design, and Service design. The former includes the ground subnetwork interconnection and the ATN router allocation, while the latter includes the ATN End Systems allocation, including the Gateways over the network. In order to be interoperable, the networks designed have to conform to the ATN architecture.

This section provides general information for designing a network within a State. States are ultimately responsible to design their own network.

4.4.1 Network topology within one subnetwork

The subnetwork is a part of the overall network. The ATN Internet SARPs define SNDCFs of ground subnetworks, but as explained in the previous chapter, the subnetwork itself is not specified in the ATN Internet SARPs. Adopting any one of the subnetworks, whose SNDCF is defined in the ATN Internet SARPs, does not mean 'ATN is implemented'. The subnetwork is an important part of the ATN transition, in this subsection, some aspects of network topology within one subnetwork is described. X.25 is used as an example of the subnetwork. X.25 may be one of the subnetworks among others in the ATN.

A typical packet switch network consists of a collection of interconnected packet switches, where the terminals are connected to one of the packet switches as shown in the Figure 4.4-1.

See [Reference 5 ASIA/PACIFIC Regional Interface Control Document **X.25 for AFTN**, Issues 1, February, 1996].

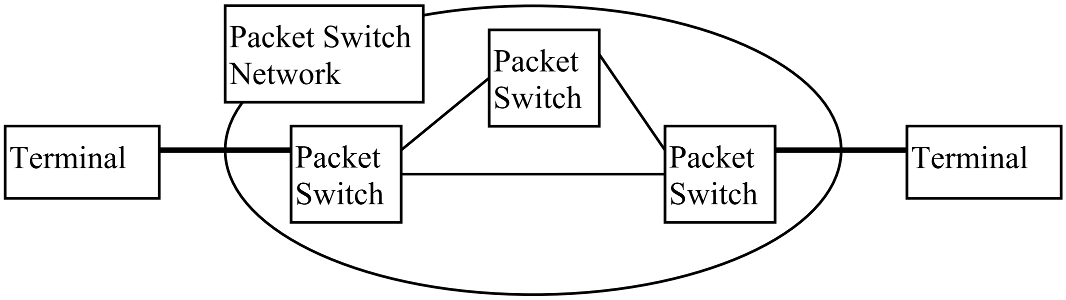


Figure 4.4-1 Subnetwork Within State

The protocol used for the communication between packet switch and terminal is X.25, where the terminal is defined as DTE and the packet switch is defined as DCE (Figure 4.4-2).

Usually, the protocol used for the communication between the packet switches is DCE-DCE, and it is not the subject covered by X.25. Since the DCE-DCE interface is not standardized in X.25, the packet switches made by the different vendors are not interoperable in general. X.75 is usually used for inter-connections between the packet switch networks. This subject will be discussed in the next subsection.

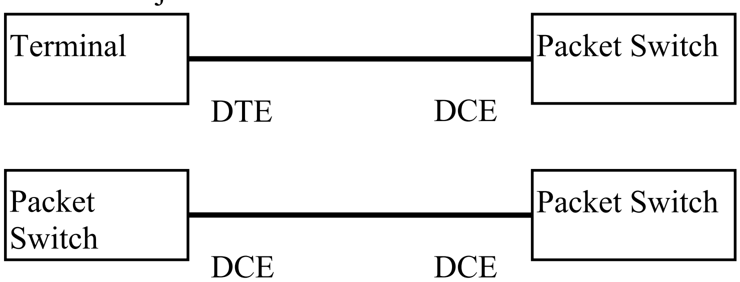


Figure 4.4-2 Interfaces in Subnetwork

There are many types of subnetworks besides the packet switch network, like LAN, Frame Relay, ATM and others.

<u>**Note**</u>: In the referenced ICD, the direct connection between AFTN switch is also described, but it will not be discussed in this section. There is also a description of 'via two or more packet switch networks' connection in the ICD, this subject will be discussed in the following section on the internetworking of subnetworks.

4.4.2 Interconnection of subnetworks within Administrative/Routing Domain

Within an Administrative/Routing domain of each State, there may exist many subnetworks where the types of subnetworks are possibly different, but still required to be interconnected.

The typical interconnections of the subnetworks are that Local Area Networks are interconnected via Packet Switch Network as described below (Figure 4.4-3).

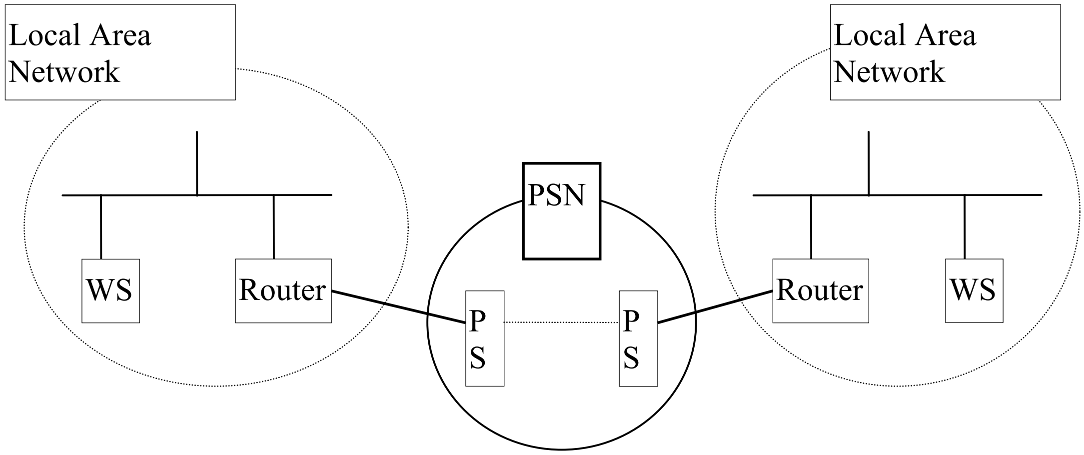


Figure 4.4-3 Interconnection of Subnetworks within State

In each Local Area Network, one Router is introduced to interconnect to a Packet Switch Network, where the router attached to a Local Area Network covers an area within the routing domain. It is also possible to interconnect multiple Packet Switch Networks via Routers, or the subnetworks can be interconnected without routers (Figure 4.4-4).

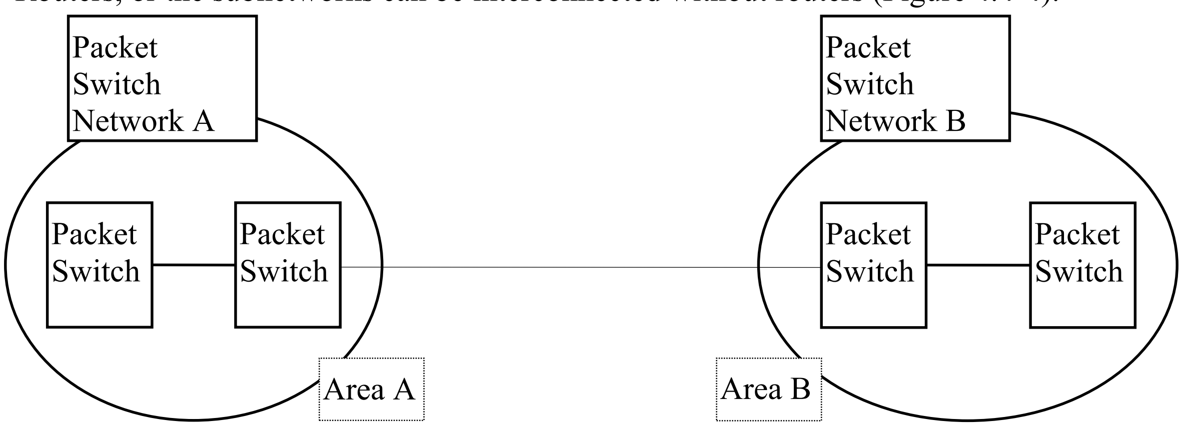


Figure 4.4-4 Direct interconnection of two Packet Switch Networks within State

In most case multiple Packet Switch Networks are interconnected using X.75 protocol.

4.4.3 Allocating of IS Routers

Related to the allocation of router within a domain, here only IS is discussed. (BIS will be discussed in the next section)

The allocation of IS router is closely related to the address assignment of NSAP LOC field. There are two aspects on allocating IS routers within a domain; one is the logical configuration and the other is the physical configuration, including the redundancy.

4.4.3.1 Logical Configuration

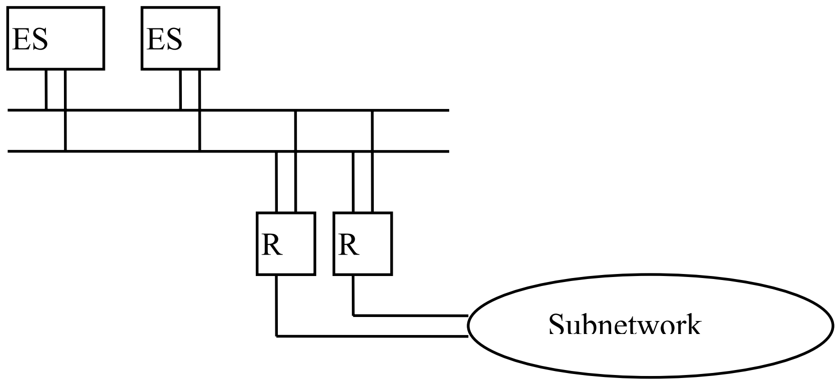
The IS routers are introduced at the boundaries of different types of subnetworks interconnected, e.g. X.25, LAN. So the allocation of IS routers really depends on the network design within States.

If the network is sufficiently complex, then designing networks in 2 or 3 levels of hierarchy where each level may use different network technologies, may be adopted.

Depending on such a network design, the IS routers are allocated logically at the boundaries of interconnected subnetworks.

4.4.3.2 Physical allocation

Taking into account the reliability, the routers may be configured in a redundant



configuration, which allows multiple paths to any End Systems (Figure 4.4-5).

Figure 4.4-5 Physical allocation of routers within State

4.4.4 Adding new types of subnetworks

Figure 4.4-6 shows the various ground networking technologies that may be used as subnetworks to support the ATN Internetworking. ([Reference 3 ICAO DOC 9739], 7. ATN Subnetwork, 7.5 Ground/Ground Subnetworks).

Note 1: X.25 could be one of the ground subnetworks among others as described in Figure 4.4-6.

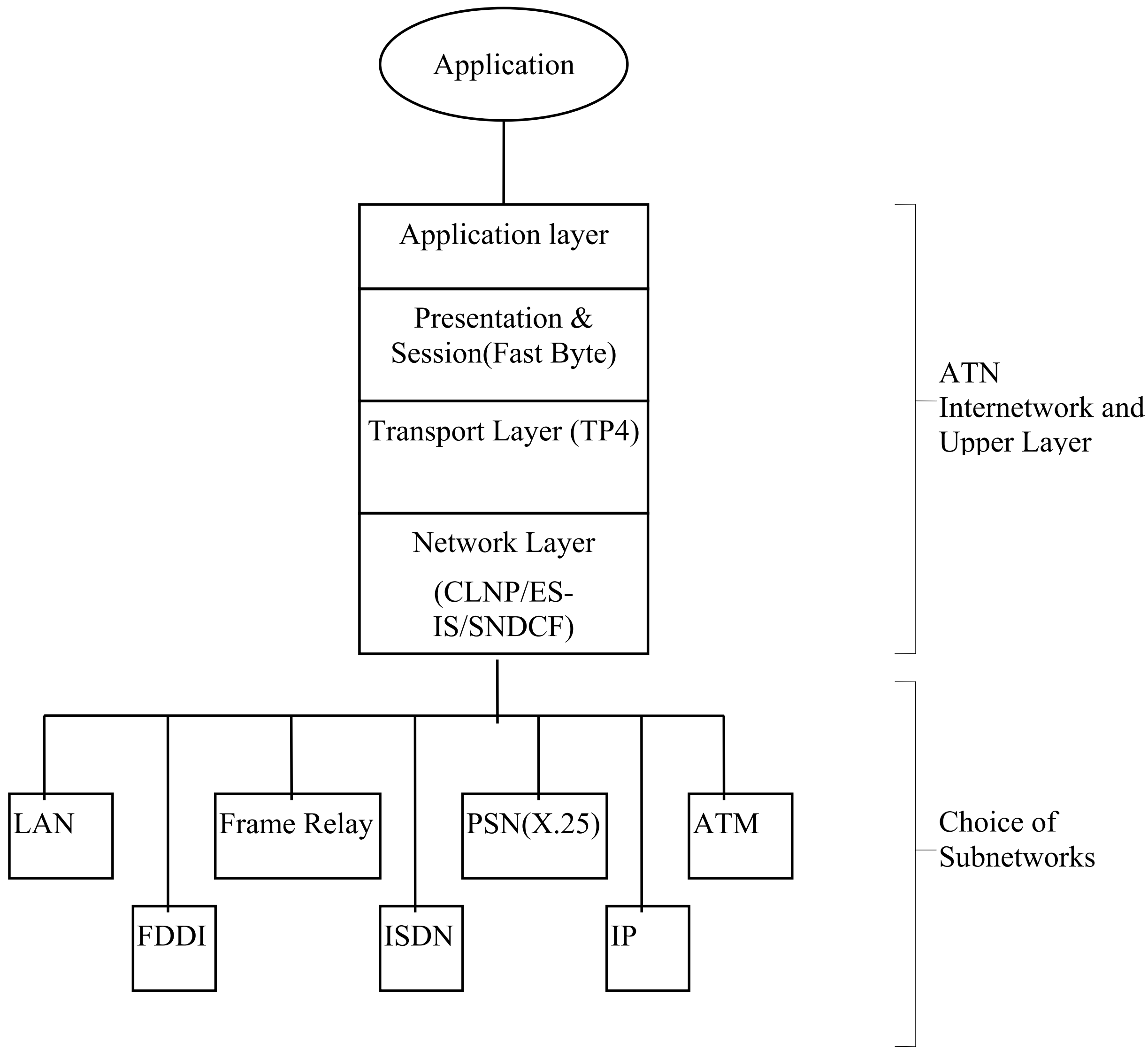


Figure 4.4-6 Various Ground Subnetworks

Note 2: Transport Layer (TP4: Transport Class 4) is a Connection-Oriented Transport Protocol.

CLNP: Connectionless Network Protocol.

Currently the ATN Internet SARPs do not specify the SNDCF; Subnetwork Dependent Convergence Function for use over a Frame Relay , ISDN; Integrated Services Digital Network or ATM; Asynchronous Transfer Mode.

In the future, the SNDCFs for additional subnetwork types, e.g. ATM, Frame Relay, will be provided.

For the WAN(Wide Area Network), X.25 has been adopted for many years now. There are pressing demands for more broader bandwidth in some application areas. Transferring radar data, and sending meteorological data are such applications. New applications will most likely demand more communication capacity.

There are two obstacles State will have to overcome; one is adopting new network technologies, and the other is to migrate existing systems into a new network infrastructure. The second issue will be discussed later in another section.

By adopting such SNDCF for specific subnetworks, a State is able to use new network technologies for their internal use.

4.4.5 Allocating ATN End Systems

There are two aspects when allocating ATN End Systems; logical and physical.

4.4.5.1 Logical configuration

By definition, the End System is a system containing the OSI seven layers and contains one or more end user application processes.

Where to allocate such End Systems(e.g. ADS, CPDLC) is totally up each State.

The possible logical configurations are shown in Figure 4.4-7.

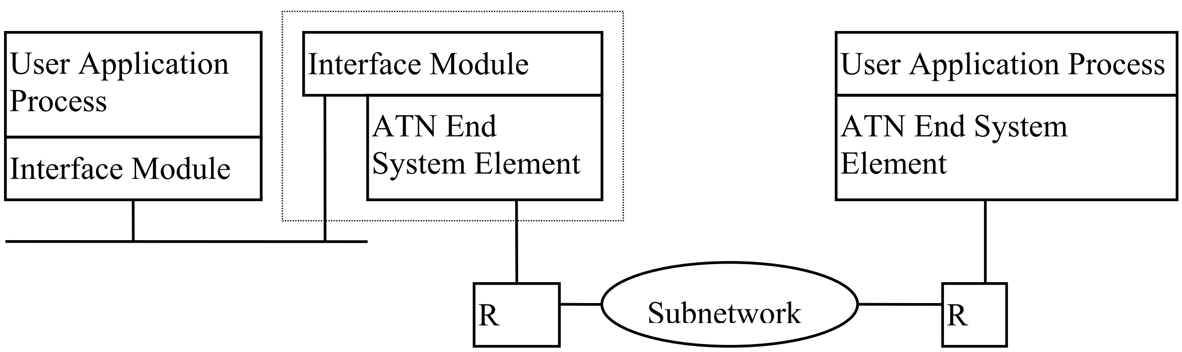


Figure 4.4-7 Logical Configurations of ATN End Systems

Note: The dotted portion on the left hand side of the figure indicates a physically isolated communication server.

There are two possible configurations in Figure 4.4-7, the one on the left hand side is called a front-end, or communication server approach while the one on the right hand side is an integrated approach.

Both approaches have advantages as well as disadvantages, from the view points of productivity of development, scalability, reliability, system management capability and so forth.

For example, the communication server approach has advantages of standard enforcement, scalability, and possibly the productivity of development, system management, compared to the integrated approach, because of the modular approach of the communication server. The disadvantages may be that if the End System(end-to-end) terminates at the 'Server', while the User Application may be located far from the 'Server', then the performance aspect between 'Server' and User Application has to be taken into account.

4.4.5.2 Physical Allocation

From the reliability aspect, redundancy may be introduced in configuring the ATN End Systems.

Figure 4.4-8 shows one possible redundant configuration of the ATN End Systems. There could also be another possibility and that is to configure the ATN End Systems as two independent ATN End Systems.

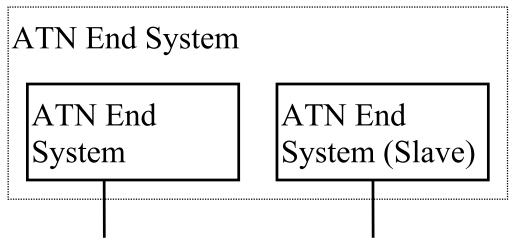


Figure 4.4-8 Physical Redundant Configuration of ATN End Systems

The physical configurations may also differ depending on the logical configuration approach chosen; i.e. front-end or integrated End Systems.

4.4.6 Allocating AFTN/AMHS Gateway

The AFTN/AMHS Gateway is defined in the ATN SARPs. Also there may be a case to integrate the existing or new ground based automation system to the ATN. The integration can possibly be implemented by a Gateway other than the AFTN/AMHS Gateway.

4.4.6.1 AFTN/AMHS Gateway

This topic has already been discussed extensively in the previous sections, so it will only briefly be mentioned here.

This could be internal as well as inter-domain, depending on the State operating the AFTN and/or the ATN.

4.4.6.2 Integrating Ground Based Automation System

The way to integrate the existing or new ground based automation systems obviously depends on the nature of the communication functions of automation.

If a ground based automation system uses the ATN defined communication services, like ADS, then it is readily integrated into the ATN environment, although there could be some alternatives to integrate systems, e.g. front-end approach or integrated approach discussed earlier.

If the communication of automation systems is a messaging service, then there is a possibility to build another Non-ATN/AMHS gateway (Figure 4.4-9).

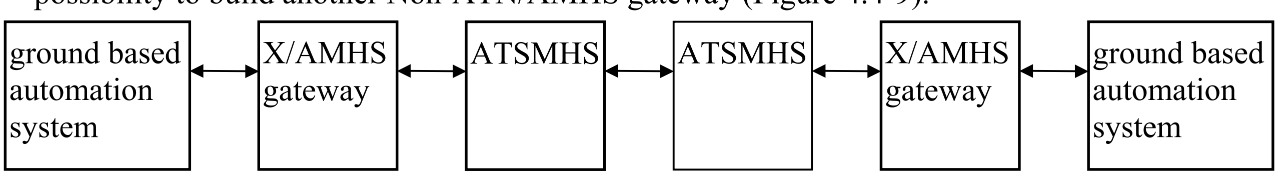


Figure 4.4-9 Another Non-ATN/AMHS Gateway

The benefits to develop such gateway have to be investigated. The benefits can be to use new network technologies, standardized interface, and so forth.

As indicated in the discussions on 'adding new subnetworks to the ATN', this is one way to interface to the ATN, but there could be a potential burden of gateway development and risk of non-standard gateway.

Another possibility is that ground based automation system may use the Transport Service provided in the ATN environment. It is not strictly an End System Integration, but sharing the ATN infrastructure.

4.5 Connection for Inter-Domain Operation and Guidance Material

In this section, the issues related to the inter-domain interconnections are discussed and guidance material for the interconnections presented.

4.5.1 Connection for Ground-Ground Inter-Domain Connectivity

There are two issues in the ASIA/PAC regional connectivity. One is to decide which data links are going to be the ATN inter-domain connections. Once the candidate data links are selected, the other issue is how to interconnect them.

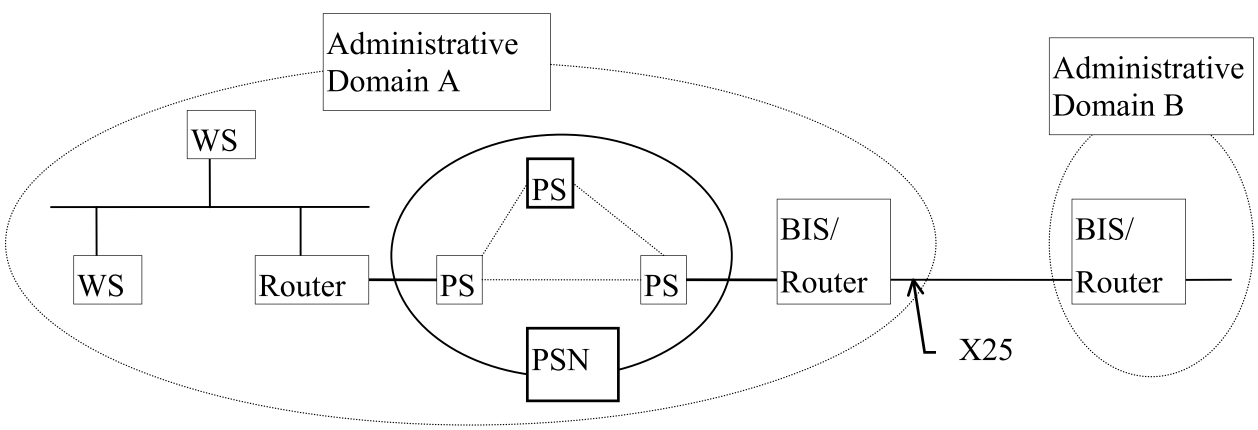
4.5.1.1 Selecting ATN Inter-Domain Connections in Region

In the ASIA/PAC region, there are two levels of the inter-connections; main trunks and subtrunks. The main trunk will be selected as the ATN inter-domain connection, before any subtrunks.

The subtrunks which requires to be the ATN inter-domain have to be mutually coordinated and discussed in the region planning.

How to interconnect ATN inter-domain connections

Typically the following network configuration is recommended to provide the



interconnection between ground domains (Figure 4.5-1).

Figure 4.5-1 Inter-domain Connection (Recommended)

This configuration has the following features:

1) clear interface definition in the inter-domain connections; and

2) avoiding the regional network management issues.

The following alternative network configuration may be proposed for the inter-domain connection, analogous to the one in the intra-domain connection (Figure 4.5-2).

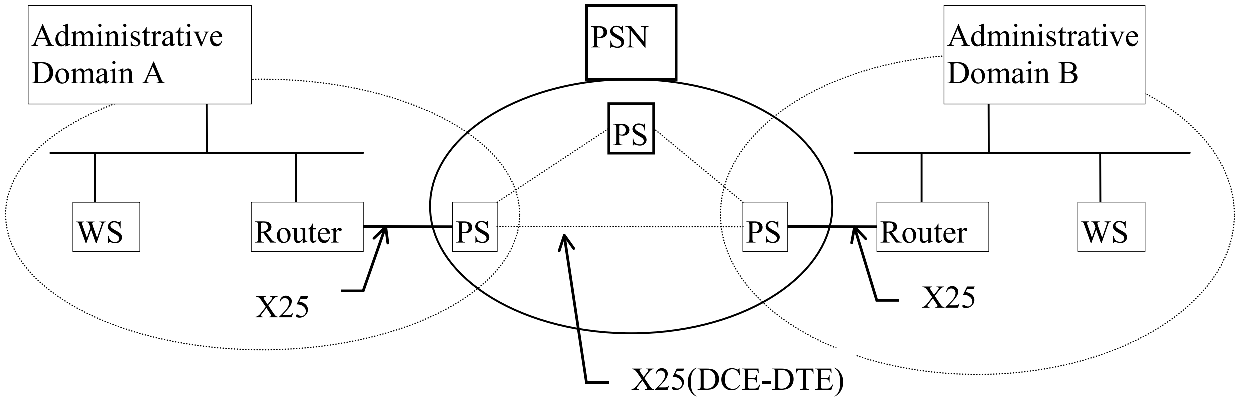


Figure 4.5-2 Another Inter-Domain Connection

This configuration causes some problems in at least two areas:

1) Usually the interface between the Packet Switches is DCE-DCE interface rather than DCE-DTE interface. Between the Packet Switch Networks, there is X.75 standards. In case of adopting X.25, there should be a capability for one packet switch to behave as a DTE in order to be interoperable. If the interoperability is not provided, then all participating States in a region have to deploy the packet switches/associated hardware and proprietary software from same vendor. This impacts the deployment policy in each State as well as the interoperability between States. In order to avoid such a case, States should be aware of the issues, and make sure that it is truly interoperable and to decide which side of the interconnection is providing DTE capability.

2) The packet switch network in this particular case is intended to provide only a set of data links between Routers, but there is a danger that the network itself stands as an independent network. This 'network' does not and shall not belong to any administrative domain, the network management has to based on the bilateral agreement of network management between States for each link.

It is important to provide a clear interface definition in the inter-domain connections, and avoid the regional network management issues as a whole. This is why the above recommendation (Figure 4.5-1) is made.

It should also not be confused that there will only be one network in the ASIA/PAC region for messaging service within the ATN framework. Instead, there will exist a collection of interconnected ground networks where each ground network is administered by each State. Over the interconnected networks, the communication services are provided, where one of these communication services is the AFTN like messaging service.

4.5.2 Connection to Air-Ground Router/Subnetwork in Inter-Domain Connectivity

The connection to an Air-to-Ground subnetwork as an inter-domain connection is similar to the ground-to-ground inter-domain connection, as far as the ground domain is concerned.

In the SATCOM, the GES is connected to a BIS, then two BISs are connected in the inter-domain connectivity.

If there are many BISs in the SATCOM subnetwork, then there is a choice to which BIS the inter-domain connection should be made.

In the case of the VHF Data Link subnetwork, the connection choice could be an issue, since there may be many RGSs and possibly many BISs. It is the decision by the Air-to-Ground subnetwork providers, whether one BIS is provided for each RGS, or one BIS is provided for many or all RGSs.

The management of the air-to-ground subnetwork may be easier in the former case.

Depending on the decision, the inter-domain connection will be made to a BIS of the air-to-ground subnetwork.

4.5.3 Allocating BIS Routers

If any ATN inter-domain connections are selected, a BIS has to be provided at both ends of the ATN Inter-domain connections.

From previous discussions, the BIS has to be allocated logically at the boundary of domains to the neighboring domains. Physically it will be allocated at the end point of the inter-domain data link and attached to an internal ground subnetwork.

The reliability, maintainability, availability considerations, e.g. back-up BIS, have to be taken into account, while allocating the ATN Router(BIS).

Also the address is assigned to the Routers, based on the address plan of the State.

4.5.4 Allocating AFTN/AMHS Gateway in Inter-Domain

Since the allocation of the AFTN/AMHS gateway is an allocation problem at the Non-ATN and ATN boundary, it is strictly not an inter-domain connection.

Allocating an AFTN/AMHS gateway with respect to the inter-domain connection happens in the following cases:

1) a State operates the ATN internally and at least one neighboring State operates the Non-ATN, i.e. AFTN; or
2) a State operates the AFTN internally and there is a requirement of an ATN inter-domain connection to at least one neighboring State.

There are two alternatives in the allocation of the AFTN/AMHS gateway, as described in the earlier section, i.e. either State allocates the AFTN/AMHS gateway. The decision has to be made based on mutual agreement. Logically they are allocated at the boundary of the ATN and the AFTN as well as the inter State connection. It may be located same as the BIS for the inter-domain connection.

Although the allocation of the AFTN/AMHS gateway within a State is a local matter, but if, in the near future, the gateway will operate for interoperating the AFTN and the ATN internally, then the allocation of the gateway is at the future boundary of the AFTN and the ATN.

Inter-Regional connections

Another area of consideration is the interconnections to another region; like African, Caribbean, European, Middle East and North Atlantic regions, where some member States have inter-region connections to other regions. Allocating the Non-ATN(i.e. AFTN)/AMHS gateway will be required, similar to the case of the intra-regional connections.

4.5.5 Coordination for Interoperability

In order to provide the interoperable services over the inter-domain connections, States have to coordinate among them.

The requirements for coordination such as AIDC as an example, are:

a) a common AIDC message set and associate services have to be agreed upon;

b) flight related conditions to which AIDC service invocations are dictated have to be agreed upon; and

c) timing associated with the use of AIDC services has to be agreed upon.

4.6 Identification of Traffic Type, and Quality of Service with Respect to Inter-Domain Operation

4.6.1 Traffic Type

For detail explanations of the traffic type, see 2.1.4.1.

The traffic types of messages conveyed over the inter-domain connection are to be mutually coordinated.

4.6.1.1 Specific use of Traffic Type in Air-to-Ground, and Ground-to-Ground Service Components

Each ATN Air-to-Ground service component SARPs, e.g. CM, ADS, CPDLC, defines a ‘class of communication service’ parameter in each service. The user of these ATN Air-to-Ground ES has to provide an ATSC class value for each service invocation. The value ranges from 'A' to 'H', as shown in Table 4.6-1, depending on the requirement of each instance.

In the ATN Ground-to-Ground service components SARPs, the values for ATSC class is defined as 'no traffic type preference'. Since the use of ATSC class is mainly for the Air-to-Ground service components, the discussions on the traffic type preference and the Air-to-Ground subnetwork preference are excluded here.

Table 4.6-1 Transit Delay Value for ATSC Class

ATSC Class	One Way ATN End-to-End Transit Delay at 95% probability(seconds)
A	Reserved
B	4.5

ATSC Class	One Way ATN End-to-End Transit Delay at 95% probability(seconds)
C	7.2
D	13.5
E	18
F	27
G	50
H	100
No Preference	No Value Specified

States have to provide such capability for the access of ground subnetworks to be controlled appropriately in the Air-to-Ground message conveyance of these traffic types.

4.6.2 QOS: Quality of Service

For detail explanations of the Quality of Service, see 2.1.4.2.

The values of the Network QOS(Transit delay, Expense, RER) are used by the ATN Router (BIS), i.e. IDRP uses the information extensively, to decide the route for messages. Providing the values of the subnetworks within a State will be a local matter.

Also provided in the ATN SARPs is the mapping of the ATN communication priority, as shown in Table 4.6-2.

One level for each ATN service component is assigned for Transport and Network Priority. These values are specified in each ATN service component SARPs, and each State providing the ES has to comply with the specification. The ATSMHS has to be implemented with the transport priority value = '6', while AIDC has to be implemented with the transport priority value = '4'.

Also each ATN service component may use an application dependent priority, e.g. the message priority in the ATSMHS and the AIDC. These are required in each ATN service component.

In the ATSMHS SARPs, AFTN priority indicator is mapped to the AMHS ATS-Message-Priority as shown in Table 4.6-3.

In the AIDC SARPs, three levels of message priority are defined; namely Normal, Urgent and Distress. The priority assignments are shown in Table 4.6-4.

Table 4.6-2 ATN Communication Priority Mapping

Message Category	ATN Application	Corresponding Protocol Priority

		Transport Layer Priority		Network Layer Priority
Network/System Management	SM	0	0	14
Distress Communication		1	1	13
Urgent Communication		2	2	12
High Priority Flight Safety Message		3	3	11
Normal Priority Flight Safety Message	CPDLC, ADS, AIDC	4	4	10
Meteorological Communication		5	5	9
Flight Regularity Communication	CM, ATSMHS	6	6	8
Aeronautical Information Service Messages	METAR, ATIS	7	7	7
Network/System Administration	SM, DIR	8	8	6
Aeronautical Administrative Messages		9	9	5
<unassigned>		10	10	4
Urgent Priority Administrative and UN charter Communication		11	11	3
High Priority Administrative and State/Government Communication		12	12	2
Normal Priority Administrative communications		13	13	1
Low Priority Administrative communications and Aeronautical Passenger Communications		14	14	0

Note: The network layer priority shown in the table apply only to connectionless network priority and do not apply to subnetwork priority.

Table 4.6-3 Mapping of AFTN Priority Indicator

AFTN Priority Indicator	AMHS Message Transfer Envelope Priority	AMHS ATS-Message-Priority priority-indicator
SS	Urgent	SS
DD	Normal	DD

AFTN Priority Indicator	AMHS Message Transfer Envelope Priority	AMHS ATS-Message-Priority priority-indicator
FF	Normal	FF
GG	non-urgent	GG
KK	non-urgent	KK

Table 4.6-4 AIDC Message Priority Assignment

Type of Messages	Assigned Priority
Emergency freetext	Distress
Surveillance data transfer	Urgent
All other AIDC messages	Normal

4.7 Performance issues of reliability, maintainability, and availability with respect to inter-domain connection

In order to identify the performance issues, it is required to have some measures on performance, and to specify the exact requirements.

In the ICAO Panels and working groups, there have been discussions on RCP; Required Communication Performance, Required System Performance, and so forth. The following definition on RCP is provided for information.

The performance related requirements are also explained which are described in the current ATN SARPs.

4.7.1 RCP Definitions Discussed

RCP may be characterized for a human to human dialogue based on the nature of ATS communication, and expressed by the parameters like Delay, Integrity and Availability.

The Delay is defined by the Transfer Delay, Integrity is defined by the Residual Error Rate, Availability is defined by the Unavailability Rate, Service Loss Reporting Time and Service Restoration Time.

Defining RCP is tasked to the ADS Panel, and the definitions presented here are not final. It is recognized the definitions of RCP are essential to discuss the performance issues here and should also be noted that these capabilities have end-to-end significance.

4.7.2 Reliability, Maintainability and Availability Considerations for ATN Elements

In the ATN SARPs, there is a system level(high level) requirement on the reliability , which states:

> ‘The ATN end system shall make provisions to ensure the probability of not detecting a 255-octet message being mis-delivered, non-delivered or corrupted by

the internet communication service is less than or equal to 10^{-8} per message.

Note: It is assumed that ATN subnetworks will ensure data integrity consistent with this system level requirement.' (see System Level Requirement #28[2])

There is no 'data integrity' definition in the ATN SARPs, but there is a definition of the Residual Error Rate(RER) as follows:

> ‘RER is the ratio of message mis-delivered, non-delivered or delivered with an error undetected by the system, to the total number of messages delivered to the system during a measurement period(adapted from ISO/IEC 8072),’ with a note ;'For ATN detected mis-delivered and non-delivered messages are not included in the ratio.'

There are two points to be clarified here; one is the performance measures, and the other is the scope of the requirement application.

It should be recognized the difference between the measures (and also ISO/IEC 8072) in the system level requirement #28 and the definition of the RER in the ATN. The measures in the SLR #28 include the ratio of message mis-delivered, non-delivered or delivered with an error undetected by the system, while the definition of the RER in the ATN is only the ratio of message delivered with an error undetected by the system.

The ratio of the delivered with an error undetected by the system can be defined using check sum technique. It is required to satisfy the other requirements, mis-delivered, and non-delivered messages ratios as well.

The ATN End System is required to satisfy the stated requirement, and the ATN subnetworks to be consistent with this requirement as described in the note above. It should be recognized that it is required for the ATN element to satisfy the requirement, while the requirements are supposed to be end-to-end significant in nature.

It should be interpreted that the end-to-end requirement is decomposed into an element level, and the requirement for the ATN End System element is stated. The reliability of the ATN elements other than the ATN End system is suggested to be consistent with the required level of the reliability.

Taking into account the possible definitions of RCP as well as the System Level Requirement in the ATN SARPs, and also the discussions provided in the previous section of this chapter on the Reliability, Maintainability and Availability within State, the Reliability, Maintainability and Availability considerations have to be materialized by implementing the ground elements

4.7.3 Reliability, Maintainability, and Availability Considerations for ATN Service Components

The system level requirement for the ATN service components should be consistent with the one stated for the ATN elements.

States implementing the requirements in the inter-domain environment, needs to coordinate mutually.

4.7.4 Capacity Considerations for ATN Elements and Service Components

There are two aspects on capacity; time and space(storage). The time aspect is more important than storage.

There are two measures on the time capacity; response time (or transit delay) and throughput.

The response time is the individual time capacity of an application in an operational environment, while the throughput is the collective time capacity of a system in an environment with possibly multiple applications.

In the discussions on the Traffic Type and Quality of Service, the ATSC Class is described, which is specified in the ATN SARPs. The transit delays are associated with each ATSC class in the ATN SARPs.

These are primarily for the Air-to-Ground service components, while the ATN elements in the Air-to-Ground service components include the Ground elements, i.e. ground subnetworks, ground ES.

Currently there is no provision that the application is informed whether the requested transit delay is satisfied. As noted in Note 2 of the System Level Requirement 7, the application entity or application process is responsible to determine the actual transit delay.

Taking into account the above information, the capacity of the ground elements , transit delay capacity planning as well as the throughput capacity planning, have to be conducted. It also depends on the specific requirements of the Air-to-Ground services in different flight phases, e.g. oceanic, en-route.

Since the requirements are end-to-end significant, it involves the inter-domain connectivity and coordination.

4.8 Transition paths and Transitional procedure in inter-domain operation

There are two aspects on the procedures related to the transition:

1) The procedure on how to migrate from the existing to the future environment. It may be called the transitional procedure, and represents the management view of the transitional planning.
2) The procedures on how to operate within each phase of the transition. It may be called the operational procedure within a transitional phase.

Once a transitional procedure is fixed, the operational procedures would be planned. In this section, only the transition procedure is discussed.

The transition paths are suggested in section 4.1. In this section, two major topics are discussed. One is for the ATN Internet transition, and the other is the ATN ground-to-ground service components transitions, AMHS and AIDC.

4.8.1 ATN Internet Transition and ATN Air-to-Ground Service Components Transition

The communication service provisions for the Air-to-Ground service components as well as ground subnetwork, router , and up to transport service transition are included here.

If the provisions are new, then the transition is to proceed to provide them.

If there are any existing provisions same as the new ones, then some considerations on transition have to be given. This is the case in the ASIA/PAC region.

The possible provisions for such transition are the inter-domain connection, the BIS ground-ground router, and the system management of the inter-domain connection as follows:

1) selection of the ATN inter-domain connections;
2) provisions of the interconnections;
3) provisions of the BIS routers;
4) provisions of the system management over the interconnections; and
5) testing and commissioning.

4.8.2 ATN Ground-to-Ground Service Components Transition

4.8.2.1 AFTN/AMHS

The transition paths from the AFTN to the ATN have been discussed in section 4.1. In the transition paths from AFTN to AMHS, there must be an AFTN/AMHS gateway if there is any co-existence of the AFTN and the ATN, as described in section 4.1.

1) Selecting the main trunks in the ASIA/PAC region as the candidates for the ATN inter-domain connections, with additional sub-trunks, if needed.
2) Mutual agreements on the provisions of such ATN inter-domain connections.
3) Planning of the data links, routers in the ASIA/PAC region or mutually among States.
4) Planning the provisions of the internal ground subnetworks and the AFTN/AMHS.
5) Gateway, where the existing and remaining AFTN circuits are connected.

Continue this activity for the remaining AFTN circuits, until it reaches other regions, or the AFTN circuit does not exist any more (Figure 4.8-1).

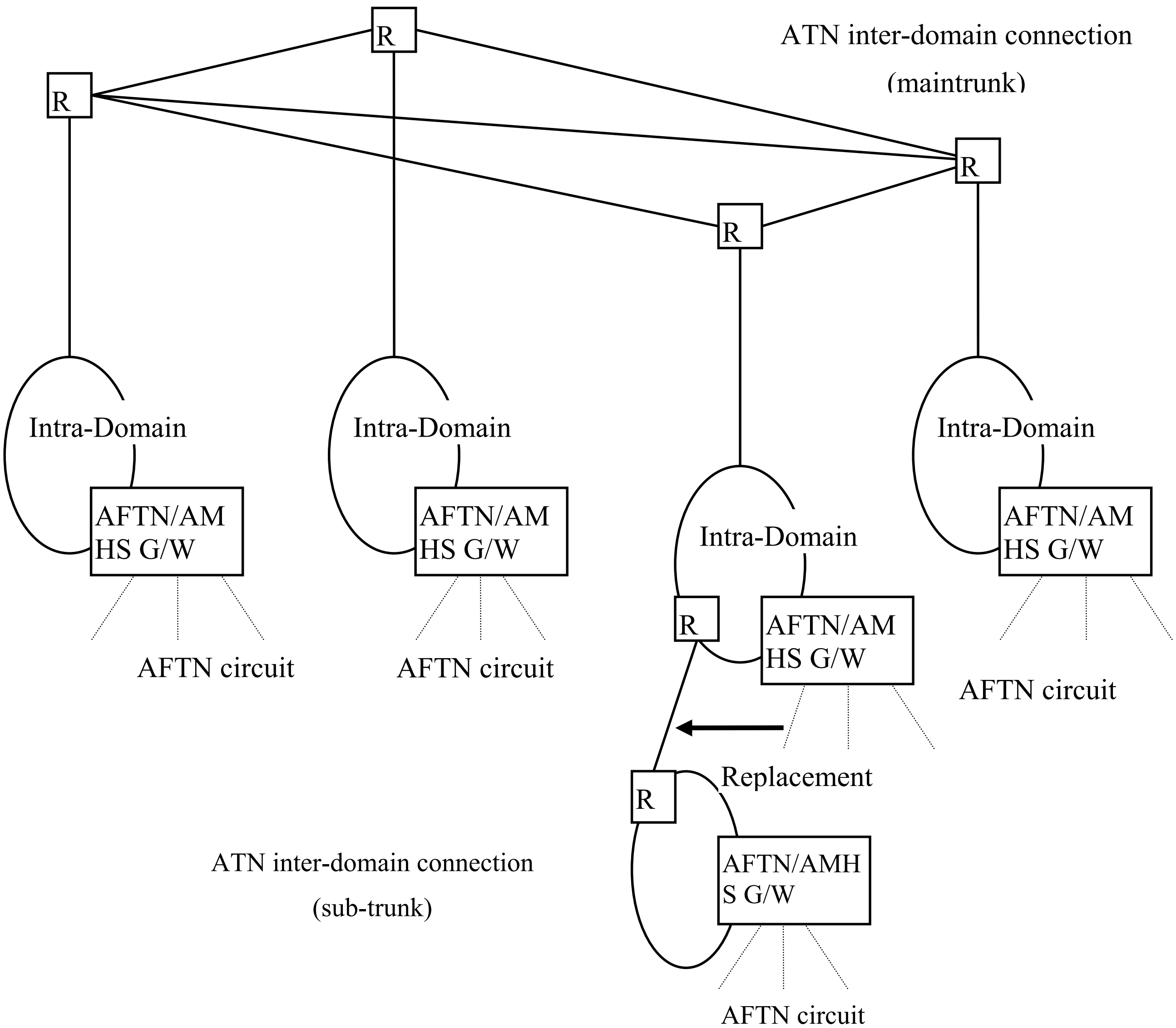


Figure 4.8-1 Transition path from AFTN to AMHS

4.8.2.2 AIDC Transition

Prior to the AIDC SARPs Standards, APANPIRG has developed AIDC ICD in the ASIA/PAC region. Unfortunately the two systems, based on the respective documents, are not interoperable nor compatible(i.e. it is hard to convert one to the other), because of technically critical differences between the two schemes.

Since there are on-going AIDC development activities based on the APANPIRG AIDC ICD, at least it is required to address the following AIDC transition issues:

1) identification of differences between the two documents;
2) possible ways to migrate the existing systems to the new environment;
3) possible ways to accommodate the differences for interoperating two dissimilar systems based on two different documents, for instance there may be two

neighboring ATS Units where one operates APANPIRG based AIDC, while the other operates ATN SARPs based AIDC, then interoperating two different systems might be considered; then

4) to evaluate what is the better solution to the problem.

Before the discussions of how to migrate one to the other, the comparison between the two documents is provided to identify the differences between the two.

After the identification of differences, first transition issue; how to migrate the existing (i.e. APANPIRG ICD based) AIDC to the ATN environment is discussed, then the second issue, how to interoperate two dissimilar systems (i.e. one is APANPIRG ICD based AIDC and the other is ATN SARPs based AIDC) within a region.

4.8.2.2.1 Identification of differences between APANPIRG AIDC ICD and ATN AIDC SARPs

The differences are categorized into five areas; message set including variables , message sequencing rules, message encoding, communication infrastructure and integrity features.

4.8.2.2.1.1 Message Set Differences

1) Message Types

There are message types in the ATN SARPs message set, but not in APANPIRG ICD message set. These message types are not discussed in the paper, since for the transition considerations, these message types are irrelevant.

As a conclusion, although there are some optional message types not covered by the ATN SARPs, the differences between the two are not significant.

2) Message Variables

The differences to be identified for the message variables are:

a) differences of variable types between the two; and

b) differences of ranges and resolutions of same variable between the two.

There are some differences between the ATN AIDC SARPs and the APANPIRG AIDC ICD, especially in Altitude and Speed of ATN AIDC SARPs , where the ranges and resolutions are finer than what is described in PANS-RAC 4444.

For instance, the resolution of Altitude in Feet in PANS-RAC 4444 is 100 feet, while in the ATN AIDC SARPs is 10 feet(these resolutions are consistent within ATN SARPs, like the ATN ADS SARPs, ATN CPDLC SARPs, and so forth).

Usually the ATN SARPs ranges and resolution are supersets of the existing standards, the migration to the new environment has no problem as far as the data between existing systems, i.e. APANPIRG based AIDC, are exchanged, since the ranges and resolutions are well within the APANPIRG AIDC ranges and resolutions.

If two different systems, i.e. APANPIRG based AIDC and ATN SARPs based AIDC, exchange data, ranges and resolutions may exceed the APANPIRG ranges and resolutions.

Similar analysis is provided for the differences between the FANS-1 ADS/CPDLC and the CNS/ATM ADS/CPDLC (ATN) message sets by the ADS Panel.

As a conclusion, for the variable types, there are some differences between the two. For the variable ranges and resolutions, careful assessments are needed especially for interoperating the two dissimilar systems.

4.8.2.2.1.2 Message Sequencing Rules

Since AIDC is interactive in nature, it is important to compare the message sequencing rules, i.e. which message type are assumed or allowed to be followed to each message.

There are no significant differences of message sequencing rules described in the two documents.

Comparing the message sequencing rules, however, the following differences are identified:

> In the ATN SARPs, the message sequencing rules are described as an important part of the Standards, and sequencing diagrams are extensively provided message by message with timers to be monitored.
>
> In the APANPIRG ICD, the message sequencing rules are described in the Guidance Materials in sentences, i.e. it is interpreted as a guidance rather than the rules. Also timers are mentioned in the Guidance Material.

This difference implies that the implementation of message sequencing rules in the APANPIRG based AIDC is up to the implementers, so that there may be different interpretations of rules and potential operational issues even between two implementations based on the same standards.

There are more timers in the ATN SARPs than the APANPIRG ICD, so that there are potential operational issues in case of inter-operating two different systems.

As a conclusion, it is not a problem of the message sequencing rules themselves, but the way the rules are specified and enforced.

4.8.2.2.1.3 Message Encoding

There are two issues under this category; one is that the two documents adopt two different encoding schemes, and the other one is that APANPIRG AIDC ICD extends the AFTN header for AIDC purpose, i.e. ODFs are used exclusively for AIDC purpose.

1) **ATN SARPs/APANPIRG ICD message data structure**

   In the APANPIRG ICD, the message type is one of variables in the message.

2) **Using ODFs for APANPIRG AIDC**

   The APANPIRG AIDC ICD adopts the AFTN as the underlying communication infrastructure. In order to identify the AIDC messages over the AFTN, the special feature of ODF(Optional Data Field) in the AFTN Header is specified in the APANPIRG AIDC ICD.

   This feature is special for the APANPIRG AIDC.

ODF itself is documented in Annex 10, but the feature shown above for AIDC is not approved to be adopted in Annex 10, so that the feature here is local to ASIA/PAC region, i.e. it is difficult to provide an AIDC system based on the APANPIRG ICD between the ASIA/PAC region and any other region.

4.8.2.2.1.4 Communication Infrastructure

As described above, the APANPIRG AIDC ICD adopts the AFTN as the underlying communication infrastructure, where the AFTN is identified as 'limited in throughput, data integrity, and ability to handle bit oriented message and data exchange', in the APANPIRG document.

The ATN AIDC SARPs is developed over the ATN. The AIDC is one of two Ground-Ground applications currently documented as SARPs. The other application is the AMHS, which is functionally equivalent to the AFTN messaging service.

The way to send messages over the AFTN and the AMHS are store-and-forward, while the data exchanges of AIDC are characterized as interactive.

One of the reasons why the AIDC SARPs is developed besides the AMHS SARPs is that the AIDC is interactive in nature, and using the AMHS for AIDC purpose would not be appropriate.

As a conclusion, there are extensive differences between interactive communication and store-and-forward communication.

4.8.2.2.1.5 Integrity Features

In the ATN, the integrity is provided by Checksum, while in the APANPIRG AIDC ICD, CRC is adopted in the extended header (ODF 5).

This difference is technical, and could be solved internally.

4.8.2.2.2 Migration of the existing systems to ATN environment

The possible ways to migrate the existing system(i.e. APANPIRG ICD based AIDC) to the ATN environment operation, are listed below.

All solutions are based on store-and-forward communication, which is not desirable for AIDC interaction.

4.8.2.2.3 Interoperating two dissimilar systems based on two different Standards

The possible ways to interoperate two different system are listed below.

Potentially, there are two paths between the APANPIRG ICD based AIDC and the ATN SARPs based AIDC as depicted in Figure 4.8-2.

One is to use the AFTN/AMHS Gateway and the AMHS between APANPIRG AIDC and SARPs AIDC marked as 1, while the other is to use the AMHS between them marked as 2. Besides the messaging service unit, some adapters are needed.

These solutions are based on store-and-forward messaging technology again, which would not be desirable for the AIDC interaction.

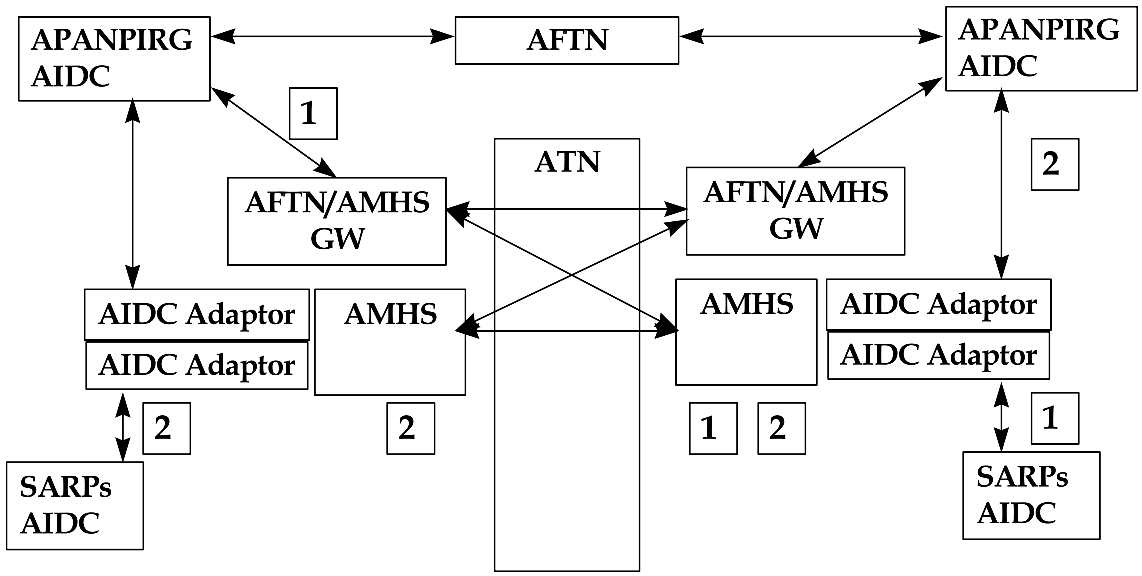


Figure 4.8-2 Two possible paths between APANPIRG AIDC and SARPs AIDC

The functional gap between the two systems has to be filled by implementing adapters, where the adapters will be more complex, i.e. expensive, than the AIDC systems themselves.

The provision of gateways and adapters for the migration and the interoperations may be also operationally complex. Any decisions have to be based on how extensively the APANPIRG AIDC are developed in the region and what is the communication performance requirements for AIDC.

As a conclusion, The direct migration to and implementation of SARPs AIDC as in Figure 4.8-3 are expected to be highly recommended.

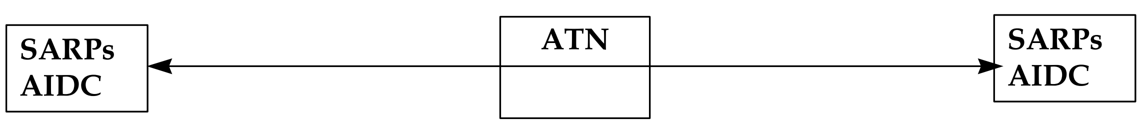


Figure 4.8-3 Direct path between SARPs AIDCs

4.9 Cost analysis of ATN ground elements in transitional development for inter-domain operation

In order to provide information on the cost for the transition, the development costs of following elements as well as the operational cost have to be analyzed:

1) data links cost, both new and upgraded;
2) provision cost of BIS router; and
3) cost of the AFTN/AMHS gateway.

4.9.1 4.9.1 Cost Types

There are two types of costs; development cost (initial investment cost) and operational cost including the maintenance cost. The former is the one-time expense, while the latter is the continuing expense as far as the system is in operational.

Migration from one phase to another in a transition path would require development of system element. This is a development cost.

While on one phase of a transition path and operating a system, would be an operational cost and the operational cost depends on the services provided in the phase.

Even if operating the current system as it is, without any transition, there would be an accumulated operational cost.

It is desirable both types of costs be taken into considerations when making decisions for the transition.

There are three possible elements to be developed.

AFTN/AMHS Gateway and

AMHS

Table 4.9-1 Services and Elements in Transition Phases

Phase	Service provided	Elements provided
a	AFTN only	AFTN
b	AFTN service & AMHS service via AFTN/AMHS Gateway and AMHS	AFTN & AFTN/AMHS Gateway and AMHS
c	AMHS only	AMHS

It has to be noted that in the interim phases, i.e. phases adopting Gateways, the services to be supported by the operational expenses, include the AFTN and/or the AMHS service as well as the services of enveloping and/or converting messages by the Gateways.

It should be noted that the AFTN/AMHS Gateway will be potentially retained until all States have moved to AMHS.

4.9.2 Comparative Analysis of Development Costs

It is expected that the development cost relationships will be as follows:

Development cost of Element	vs	Development cost of Element
AMHS	<	AFTN/AMHS Gateway

Reasons.

Development cost of Element	vs	Development cost of Element

AMHS	<	AFTN/AMHS Gateway

The AFTN/AMHS Gateway provides the AFTN message conversion capability in addition to the AMHS capability. The cost difference is the development cost for the AFTN message conversion.

4.9.3 Comparative Analysis of Operational Costs

It is expected that the operational cost relationships between phases is as follows:

Operational Cost of Phase	vs	Operational Cost of Phase
AFTN only	<	AFTN service & AMHS service via AFTN/AMHS Gateway
AFTN only	>	AMHS only
AFTN service & AMHS service via AFTN/AMHS Gateway	>	AMHS only

Reasons.

Operational Cost of Phase	vs	Operational Cost of Phase
AFTN only	<	AFTN service & AMHS service via AFTN/AMHS Gateway

Operational Cost of Phase	vs	Operational Cost of Phase
AFTN only	>	AMHS only

Applying new technology, it is expected the operational cost of the AMHS is lower than one of the AFTN.

Operational Cost of Phase	vs	Operational Cost of Phase
AFTN service & AMHS service via AFTN/AMHS Gateway	>	AMHS only

The environment of the 'AFTN service & AMHS service via AFTN/AMHS Gateway' requires the extra operational cost of the AFTN/AMHS Gateway and the AFTN service in addition to the AMHS service operational cost.

4.10 ATN Security Solution

There are two areas of security solution needed; application security solution and IDRP (inter-domain routing) security solution.

4.10.1 Application Security Solution

4.10.1.1 Air-ground application communication

a) Overview of secured air-ground application communication

The primary purpose of application security in the ATN is to ensure the authenticity of important inter-domain air-ground communications.

When an aircraft begins a flight or enters a new CM domain, it performs a secure CM-logon or initial CM-update protocol with the ground CMA. CM-logon is an air-initiated protocol that is used to setup communications with the first CM domain the aircraft enters, and which may also be used to setup communications with second and subsequent CM domains. Initial CM-update is a ground-initiated protocol that may be used instead of CM-logon to setup communications with second and subsequent CM domains. CM-logon and initial CM-update both consist of an authenticated key establishment protocol carried out by the aircraft CMA and the ground CMA.

These protocols are based on the elliptic curve Diffie-Hellman protocol. These protocols confirm the identities of the communicating parties. They also establish a session key, which will be used to authenticate CMA dialogues while the aircraft is in the CM domain, and a shared public value which will be used to help secure other applications while the aircraft is in the CM domain. The session key and shared public value will be used for the duration of the CMA session until the association expires or the aircraft leaves the CM domain or the aircraft or ground CMA explicitly ends the session for some other reason. The session key and shared public value may therefore be used to secure a number of application dialogues.

CMA messages that are exchanged during the CMA session after CM-logon or initial CM-update are secured using the MAC scheme HMAC under the session key established during CM-logon or initial CM-update to ensure their authenticity.

Subsequent to CM-logon or initial CM-update, when another application like CPDLC is invoked during the CMA session, both the ground CPDLC and the aircraft CPDLC compute a session key which they will use to secure communications. This session key is calculated from the aircraft key pair, the ground CPDLC key pair, and the shared public value established during CM-logon or initial CM-update. CPDLC messages that are exchanged are then secured using the MAC scheme HMAC under this session key to ensure their authenticity.

In order to operate this application security solution, each aircraft and each ground application must be provisioned with the requisite elliptic curve key pairs, and a Public Key Infrastructure (PKI) must be put in place to distribute public keys.

The selection of this solution was motivated by the following considerations. The international nature of the ATN and the number of distinct entities in the ATN make use of public-key cryptography appealing in order to facilitate effective key management. The limited bandwidth available for air-ground communications in the ATN make use of a hybrid public-key and symmetric cryptography approach appealing in this case. Elliptic curve cryptography was selected as the public-key technology since it consumes minimal bandwidth among internationally standardized public-key technologies. HMAC was selected as the symmetric technology since it is an efficient, internationally standardized algorithm. An additional feature of the solution is the use of the shared public value established during CM-logon or initial CM-update in session key calculation. This feature allows applications to rely only on static elliptic curve key agreement keys so that bandwidth is minimized, while ensuring that session keys are unique to a particular CMA session.

b) Example of CM_Logon and CPDLC_Start

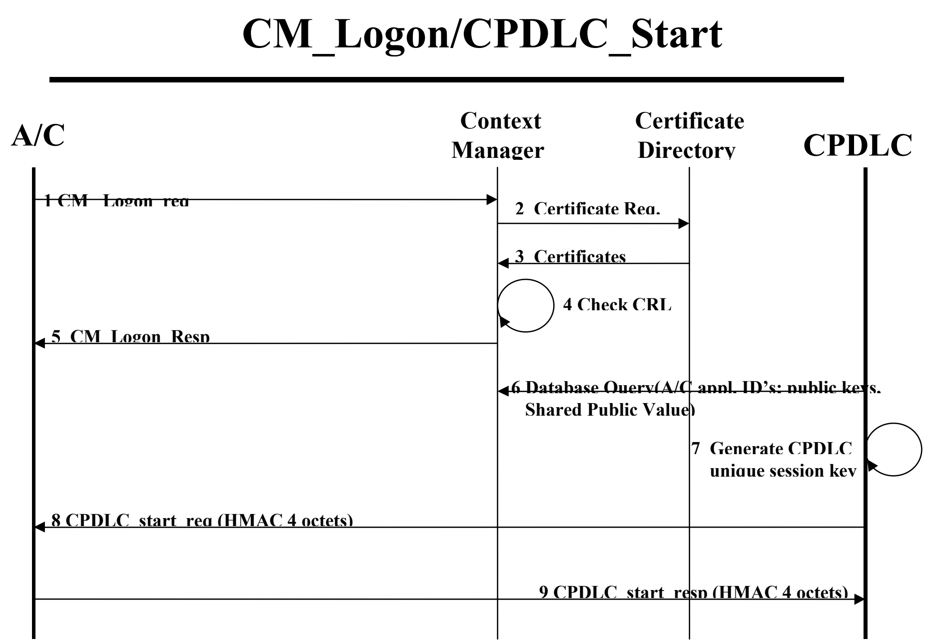


Figure 4.10-1 CM_Logon/CPDLC_Start

1. CM_Logon_req (Contains Aircraft's Signature using the A/C Private Key 163 bits).
   Signing of an ATN Log On message adds 50 octets to the ATN 1 Package Log On message.
2. Certificate Request: (Aircraft Entity) A Certificate Request contains the AE-title (NET including 24 bit ICAO ID if a BIS) with one certificate request per application or BIS.
3. Certificate (Aircraft Entity Certificate and A/C application Certificates)A Certificate contains the signature and key agreement keys public key for an Aircraft or applications.
4. Check CRL; the ground CM checks the CRL for revoked Certificates. The shared value is created by the CM, so is unique to that CM session. The Shared Public value and A/C information are stored at the ground CM database for query from the ground applications (e.g. CPDLC).
5. CM_Logon_resp (Contains the HMAC of the ground CM; 4 octets).
   HMACing of an ATN Log On Response message adds 4 octets to the

ATN1 Package 1. Transfer of the CM key agreement public key certificate adds 125 octets.

6. Database Query from a ground CPDLC that wants to have ATC service (A/C appl. ID's; public keys of the A/C, the Shared public value) <<Note that database query is a local implementation decision.>>

7. Generate CPDLC unique session key: CPDLC uses the shared value to generate its unique session key for the MAC of the start_req/resp and subsequent messages.

8. CPDLC_start_req (Contains the HMAC of the ground CPDLC Start_req 4 octets). HMAC of a CPDLC message gives an overhead of 32 bits (32 bits is the truncated output of an HMAC).

9. CPDLC_start _ resp. (Contains the HMAC of the A/C CPDLC Start_resp; 4 octets) HMACing a CPDLC message gives an overhead of 32 bits (32 bits is the truncated output of an HMAC).

NOTE: To save bits on the RF link a 32 bit HMAC is used. A 32 bit HMAC is still a very strong HMAC, which is derived by truncating the output of a MAC using SHA-1.

c) Actions needed by Air-Ground Application Entities

1) Ground CMA Entities

In order to support security, the ground CMA entities will need to perform the following actions:

- Generate a key agreement key pair and optionally a signing key pair (if they support initial CMA contact via CM-upate or provision of ground security using signatures). The recommended lifetime for these key pairs is 5 years.
- Obtain certificates on these keys from their State CA. The recommended validity period for these certificates is 1 week. (If the ground CMA entity does not support initial contact with aircraft using CM-update, its certificate on its signing key will never need to be passed up to aircraft on the RF link and so this certificate may have a longer lifetime of 5 years.)
- Obtain the certificate signing key of their State CA so they can validate the certificates of other ATN entities.

Ground CMA entities should be identified by their AE-title.

2) Other Ground Application Entities

The other ground application entities will need to perform the following actions:

- Generate a key agreement key pair and optionally a signing key pair (if they support provision of ground-ground security using signatures). The recommended lifetime of these key pairs is 5 years.
- Obtain certificates on these keys from their State CA. The recommended

validity period for these certificates is 5 years.

- Obtain the certificate signing key of their State CA so they can validate the certificates of other ATN entities.

Other ground application entities should be identified by their AE-title.

3) Aircraft Application Entities

In order to support security, aircraft CMA entities will need to perform the following actions:

- Generate a signing key pair and a key agreement key pair. The recommended lifetime of these key pairs is 5 years.
- Obtain certificates on these keys from their AOE CA. The recommended validity period for these certificates is 5 years.
- Obtain the certificate signing key of their State CA so they can validate the certificates of other ATN entities.

Aircraft application entities should be identified by their AE-titles.

4.10.1.2 Ground-ground application communication

An additional purpose of application security in the ATN is to secure important inter-domain ground-ground communications (such as CM-forward and CPDLC-forward). When required this is achieved as follows. Each time a ground application sends a message to another ground application, it signs the message using the elliptic curve digital signature algorithm or ECDSA. A time field is included in the message in order to guarantee its freshness.

Ground AMHS Entities

AMHS entities that support security will need to perform the following actions:

- Generate a signing key pair. The recommended lifetime of this key pair is 5 years.
- Obtain a certificate on this key from their State CA. The recommended validity period for this certificate is 5 years.
- Obtain the certificate signing key of their State CA so they can validate the certificates of other ATN entities.

4.10.2 IDRP Security Solution

4.10.2.1 Overview of Secured Routing Information Exchange

a) Authentication Approach

Entity authentication can be achieved in an asymmetric cryptographic environment by the claimant demonstrating possession of a private key. In the IDRP security solution, ATN intermediate systems demonstrate possession of a shared secret key by using the key in a Message Authentication Code applied to the exchange of routing information. Possession of the shared secret key implies possession of a specific private key since the shared secret key could only be successfully derived under the key agreement scheme if the claimant is also in possession of a private key corresponding to a verified public key. Verification of the claimant's public key is accomplished by obtaining it from a trusted third party, i.e., in a certificate signed by a certificate authority.

b) Mutual Entity Authentication vs Single Entity Authentication

Only single entity authentication is strictly required on IDRP air-ground connections, that is, the air-ground router must authenticate the airborne router. The rational is based on bandwidth considerations in the context of the relative consequence of an attack against the routing information base of an air-ground router versus an attack against the routing information base of an airborne router. It is clear that the former attack would be of more severe consequence than the latter, and therefore ATN boundary intermediate systems that support ATN security services should apply strong authentication to exchanges affecting the ground routing information base. It is important to note, however, that mutual authentication is not precluded. ATN boundary intermediate systems that provide ATN security services are required to be capable of mutual entity authentication. Whether or not to invoke mutual entity authentication service is a matter of local policy.

c) Replay and Interception Protection

Protection from replay and interception attacks is provided through a challenge-response exchange. A random variable is generated by each intermediate system and sent in the OPEN BISPDUs. The random variables are included as shared data in derivation of the MAC key for the connection. Verification of the challenge is achieved if the first UPDATE BISPDU contains a valid MAC tag. The IDRP sequence numbers protect subsequent BISPDUs from interception and replay.

4.10.2.2 Example of Routing Information Excahnge

IDRP Exchanges

1, 2. During the ISH exchange, the airborne and air-ground routers signal type 2 authentication by including the ATN Authentication Parameter in the ISH PDU with the parameter value set to indicate whether or not the peer router needs to send its certificate in the OPEN BISPDU.

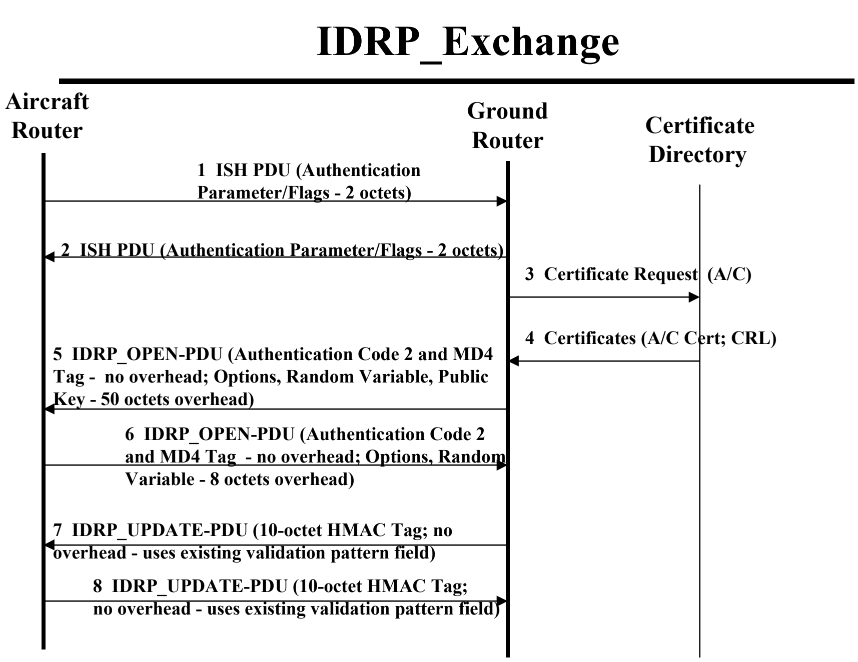
3. Ce

The air-gr
supporting

4. Ce ... ft.

5, 6. ID
Options ar ... nly)
- 42 octets

7, 8. ID
BISPDUs
Authentic



4.10.2.3 Actions needed by Routers

a) Ground Routers

In order to support security, ground routers will need to perform the following tasks:

- Obtain the certificate signing key of their State CA so they can validate the certificates of other ATN entities.

Ground routers may also need to:

- Generate a key agreement key pair. The recommended lifetime of this key pair is 5 years.
- Obtain a certificate on this key from their State CA. The recommended validity period for this certificate is 1 week.

Ground routers should be identified by their NSAP address.

b) Aircraft Routers

In order to support security, aircraft routers will need to perform the following actions:

- Generate a key agreement key pair. The recommended lifetime of this key pair is 5 years.
- Obtain a certificate on this key from their AOE CA. The recommended validity period for this certificate is 5 years.