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ATN Naming, Addressing and Registration Concept

INFORMATION PAPER

SUMMARY

This document attempts to lay the framework of a strategy for ATN naming, addressing and registration of certain information objects within the scope of the CNS/ATM-1 Package. It is intended that this work will be used as an input to the ATNP WG1-16 deliverable on naming, addressing and registration.

DOCUMENT CONTROL LOG

Section(s)	Date	Amendment Number	Reason for change and/or Change Note Number.
All	13/2/95	0_A	Initial draft
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1. INTRODUCTION

1.1. Scope and Purpose

This paper is intended to define a preliminary framework for naming, addressing and registration of certain information objects relevant to the CNS/ATM-1 Package (*Package 1*). It further identifies some of the longer-term issues required for successful worldwide development and operational use of ATN systems and services expected as follow-on functionalities, perhaps in the yet-to-be defined *Package 2* timeframe. This material may serve as a baseline for the refinement and further specification of the ATN naming, addressing and registration strategy for *Package 1*.

1.2. References

1. *Draft Manual of the Aeronautical Telecommunication Network (ATN)*, ICAO, November 19, 1993

2. VDL Manual, ICAO

3. AMSS SARPS, ICAO

4. *Automatic Dependent Surveillance (ADS) and Air Traffic Services (ATS) Data Link Applications guidance Material*, ADS Panel, ICAO, May 1994

5. *DO-223 - Minimum Operational Performance Standards for Aircraft Context Management (CM) Equipment*, RTCA SC-169, July 13, 1994

6. DO-212 - *Minimum Operational Performance Standards for Automatic Dependent Surveillance*, RTCA SC-169

7. DO-219 - *Minimum Operational Performance Standards for Two-Way Data Link*, RTCA SC-169

8. *Mode S SARPS*, ICAO

9. *Proposed Draft SARPS for CNS/ATM-1 FIS Application*, France, January 30, 1995

10. AFTN Specification, *TBD*.

X.25 *Recommendation X.25 - Interface Between DTE and DCE for Terminals Operating In the Packet Mode And Connected to Public Data Network by Dedicated Circuit*, CCITT, 1988

X.121 *Recommendation X.121 - International Numbering Plan for Public Data Networks*, CCITT, 1992

7498-3 *ISO/IEC 9834-1 - Basic Reference Model, Par 3: Naming and Addressing*, ISO, 1989

9834-1 *ISO/IEC 9834-1 - Procedures for the Operation of OSI Registration Authorities: General Procedures*, ISO, 1993

9834-6 *ISO/IEC 9834-6 - Procedures for the Operation of OSI Registration Authorities: Application Processes and Application Entities*, ISO, 1993

1.3. Glossary

ADM	Administration Identifier
AFI	Authority Format Identifier
AMSS	Aeronautical Mobile Satellite Service
ARS	Administrative Region Selector
ATCC	Air Traffic Control Centre

ATN	Aeronautical Telecommunication Network
ATNP	ATN Panel
ASO	Application Service Object
BCD	Binary Coded Decimal
CLNP	Connectionless Network Protocol
DNIC	Data Network Identification Code
DTE	Data Terminal Equipment
IDI	Initial Domain Identifier
LOC	Location Identifier
MTN	Mega Transport Network
NSAP	Network Service Access Point
OOOI	Out-Off-On-In application
OSIE	OSI Environment
PSDN	Packet Switched Data Network
RDF	Routing Domain Format
SARPS	Standards and Recommended Practices
SEL	Selector
SNPA	Subnetwork Point of Attachment
SYS	System Identifier
TSAP	Transport Service Access Point
TSEL	Transport Selector
VER	Version Identifier
VDL	VHF Data Link

2. Problem Statement

The ATN naming, addressing and registration issues is potentially vast. The principal question is the meaning of naming and addressing elements: how do ATN systems and applications use this information and how may it be administered on a global basis? Although a well-defined internetwork addressing (NSAP) plan already exists ([1]), there are many related issues which require resolution before the ATN can be successfully deployed. In the short term, a naming, addressing and registration plan must be defined for the ATN *Package 1* deployment. In the long term, a broader approach must be taken to cover the more general ATN applications and architecture. Issues requiring short term resolution include

1. Mobile subnetwork addressing and registration and how this relates to the ATN internetwork addressing and routing;
2. Use of the internetwork addressing plan and internetwork address registration procedures;
3. *Package 1* application naming, addressing and registration and how these elements are used in relation to directory services;
4. Assumed upper layer architecture and ASO naming;
5. Migration requirements for Package 2 and beyond.

3. Naming, Addressing and Registration Overview

The concepts of *name* and *address* are defined in *The OSI Basic Reference Model, Part 3* (ISO 7498-3). In brief, a *name* is used to identify an object (e.g. a system, a protocol, an application, etc.) while an *address* is used to locate an object. Names typically have meaning to upper layer elements, applications and people and are thus generally expressed in a mnemonic format. Correspondingly, the significance of addresses typically increases as we descend in the OSI stack and are generally expressed in a coded or numeric format for machine processing. In either case, in order to ensure unambiguous assignments, names and addresses must be *registered* by registration authorities within the context or environment in which they are to be used.

In order to manage the inherent complexity of large networks, names and addresses should be assigned according to hierarchical name/address trees. The structure of these trees should, in principal, represent the structure of the network operating environment. For example, as the ATN is an international network involving primarily two principal interest groups (ICAO and IATA), the top levels of the ATN internetwork (NSAP) address tree has been chosen as depicted in Figure 1. The address structure, and thus the responsibility for registration, has effectively been divided between ICAO and IATA. Each organisation is responsible for address allocation and registration within their sub-trees. The responsibility for NSAP address field allocation would then likely be further delegated to the countries and airlines within ICAO and IATA. The tree structure closely follows the air transport community's administrative topology. Correspondingly, other name/address trees should follow a similar structure as detailed in §5.

Naming, addressing and registration concepts are closely related to directory services. A *directory* may be used to store name and address information and can provide lookup functions to determine the address or characteristics of a given application or service. Directory information may be stored local to a given application process if the addresses of all other applications and services with which it will communicate are known ahead of time. However, in an operating environment like the one for which ATN is intended, applications cannot always know in advance the address of all other relevant applications. Thus, a simple directory service, the *context management function*, is required per [4] and [5].

4. *PACKAGE 1* ASSUMPTIONS

4.1. Overview of Applications and Upper Layer Architecture

The following applications are expected to be part of the initial application set for the CNS/ATM-1 Package. These functionalities of these applications are used to determine the associated naming, addressing and registration requirements.

1. **Automatic Dependent Surveillance (ADS).** ADS will be the primary application used to support air traffic management services. The operational requirements for ADS are described in [4].

2. **Controller-Pilot Communications (CPC).** CPC will also be an application used to support air traffic management. The operational requirements for CPC are described in [4] and [6].

3. **ATS Interfacility Data Communication (AIDC).** This application is required for exchange of information between ATS units such as aircraft tracking information, coordination of hand-offs and transfer of control. The operational requirements for AIDC are implicitly described in [4].

4. **Context Management (CM).** CM is a basic directory service used to support ATM-based applications. The operational requirements for CM are implicitly described in [4] and [7].

5. **Flight Information Services (FIS).** Flight information services may also be included in *Package 1*. The operational requirements for FIS are currently being defined in [9].

6. **Message Handling Services (MHS).** MHS services may also be included in *Package 1*. Although it is expected that MHS will be used to support the AFTN, specific operational requirements for MHS in *Package 1* are currently not defined.

The ADS, CPC, CMA, AIDC and FIS applications are taken into consideration in the development of the *Package 1* naming, addressing and registration concept. Naming, addressing and registration requirements should be derived from the ATN MHS when this application and the corresponding operating concept is defined.

Package 1 is also expected to support airline-specific messaging and distributed applications. The operational requirements of these applications are not globally-defined and are outside the scope of this activity. It is not expected that the introduction of airline-specific applications will adversely affect the ICAO naming, addressing and registration concept. However, airline-specific considerations should be considered as a follow-on activity.

Until early 1995, the upper layer architecture for all *Package 1* applications considered in this document was expected to be minimal. Specifically, the principal standards from RTCA defining the ADS, CPC, and CM applications ([5], [6] and [7]) indicated that the applications would run directly over the connection oriented transport service without any support from the session, presentation or application services. However, recent developments in the ATNP/WG3/SG3 (ATN Upper Layer Architecture Subgroup) have led to the conclusion that common ATN application services should be based on the extended application layer structure including the use of an extended ACSE. As ATNP/WG3/SG3 is still working on the details of the definition, this paper will only introduce some of the aspects corresponding to upper layer addressing.

4.2. Internetwork Topology

The ATN internetwork topology is expected to be a loosely connected internetwork of routing domains providing the connectivity required to support ATM and airline-specific services. Specifically, we can foresee ATC centres being connected together via local means within an ICAO Member State and via international WANs and the ATN backbone between ICAO Member States. Communications between aircraft and ATC centres will be ensured by the ATC's Mode S subnetwork as well as air/ground service providers AMSS and VDL subnetworks. Both airlines and ATC authorities may rely on traditional air/ground service providers to provide managed ATN services including air/ground as well as ground/ground ATN communication services.

The ATN internetwork will be comprised of both *transit routing domains and end routing domains*. Transit routing domains are typically responsible for switching ATN traffic between themselves and to and from end routing domains. For example, the SITA ATN routing domains, as part of the ATN backbone, are able to switch traffic for the entire ATN community. ATN end users are typically only responsible for end routing domains, which do not switch traffic for other ATN routing domains. For example, each ATN aircraft may have exactly one ATN end routing domain on board.

4.3. Subnetworks Used

In order to interconnect ATN routing domains, the respective interdomain routers must be connected via a subnetwork. The principal ATN subnetworks to be used during the *Package 1* timeframe will be X.25 PSDNs for ground-based communications as well as the VDL, AMSS and Mode S air/ground subnetworks.

4.4. Elements of ATN Naming and Addressing

This section outlines the basic elements within the ATN environment requiring names and addresses.

4.4.1. Subnetwork Elements

1. **X.25 Network Addresses**. A X.25 network address identifies the SNPA of a DTE/router on a given X.25 network. It has meaning only within the context of the X.25 network on which it is used subject to the provisions in [X.25].

2. **AMSS Network Addresses**. An AMSS network address identifies the SNPA of a DTE/router on a given AMSS subnetwork. An AMSS DTE may be either be located on an aircraft or at a fixed site. The AMSS network address has meaning only within the context of the AMSS network in which it is used subject to the provisions in [3].

3. **VDL Network Addresses**. A VDL network address identifies the SNPA of a DTE/router on a given VDL subnetwork. An VDL DTE may be either be located on an aircraft or at a fixed site. The VDL network address has meaning only within the context of the VDL network in which it is used subject to the provisions in [2].

4. **Mode S Network Addresses**. A Mode S network address identifies the SNPA of a DTE/router on a given Mode S subnetwork. A Mode S DTE may be either be located on an aircraft or at a fixed site. The Mode S network address has meaning only within the context of the Mode S network in which it is used subject to the provisions in [8].

4.4.2. Internetwork Elements

1. **Network Entity Title (NET).** An ATN system's NET is a 20-octet string used to uniquely identify and locate the internetwork protocol entity of the system, and thus, the system itself. Thanks to the hierarchical ATN internetwork addressing plan defined in [1], a system's NET can be used to locate it anywhere within the ATN topology. The syntax of an ATN NET is equivalent to that of an ATN NSAP address and should, in fact, only differ from the systems' NSAPs in the last octet per §A7.5.9.3 [2]. A given NET must identify exactly one ATN system.

2. **NSAP Address**. An ATN NSAP address is a 20-octet string used to uniquely identify and locate a given NSAP within the context of the ATN.

3. **Administrative Domain Identifier**. Each ATN administrative domain can be identified by unique, unvarying domain address comprising of the AFI, IDI, VER and ADM fields of the ATN NSAP. An administrative domain identifier is the prefix of all ATN NSAP addresses and NETs within the same ATN administrative domain

4. **Routing Domain Identifier**. Each ATN routing domain can be identified by unique, unvarying 11-octet ATN routing domain identifier comprising of the AFI, IDI, VER, ADM, RDF and ARS fields of the ATN NSAP. A routing domain identifier is the prefix of all ATN NSAP addresses and NETs within the same ATN routing domain.

4.4.3. Applications

1. **Transport Address**. As defined in [1], a transport address, or more specifically a *TSAP address*, uniquely identifies a given transport service user within the context of the ATN. A TSAP address is comprised of a one- or two-octet TSAP selector appended to the host system's NSAP address.

2. **Application Address**. The address of an OSI application is typically its *presentation addresses*. As *Package 1* applications may be defined to be users of the extended application layer structure, ATN application addressing should follow the OSI standards currently under development.

3. **Application Name.** OSI applications are generally given a globally unique application process title (AP-title) and one or more globally unique application entity titles (AET). These names are used to identify the application within the ATN operating context. They may be used as inputs to a directory service to determine the presentation address of a given application. A means of naming *Package 1* applications is introduced in [5] and further explained in §5.3.

4.4.4. Aircraft

1. **ICAO 24-bit Address**. Each aircraft can be identified by a unique, unvarying 24-bit identifier assigned by the manufacturer under the authority of ICAO. This address is

used in many address components including the NSAP addresses as well as the VDL, AMSS and Mode S SNPAs.

2. **Registration Mark**. Each aircraft can be identified by a unique, unvarying registration mark. The registration mark of the aircraft may be used in certain messages and may also be included in the aircraft's flight plan. In some cases, the registration mark may be derived from the ICAO 24-bit address, while in others there is a one-to-one mapping with the ICAO 24-bit address.

3. **Flight Number.** During any given flight or flight segment, an aircraft is generally assigned a *flight number* comprised of the operating company's IATA 2-character identifier and a unique number of up to four digits. The flight number is included with an aircraft's flight plan. ATC authorities currently use an aircraft's flight number to identify aircraft within their control.

4. **Aircraft Routing Domain Identifier**. Each aircraft can be identified by unique, unvarying 11-octet ATN routing domain address assigned as a function of the airline operator (identified in the NSAP ADM field) and the aircraft's ICAO 24-bit address (identified in the NSAP ARS field). The aircraft domain address is the prefix of all ATN NSAP addresses on board the aircraft.

4.4.5. ATC Centres

1. Air traffic control centres (ATCCs) are responsible for ATM within an ATC *control region*. There is exactly one ATCC system. A control region is an area which operates its own flight plan data processing systems. There may be one or more control regions per flight information region (FIR). Currently, each ATCC is assigned an address per [10]. Within the ATN, each ATCC and, hence a control region, should be identified by an RDI based on the current ATCC administrative topology.

5. NAMING, ADDRESSING AND REGISTRATION REQUIREMENTS

5.1. Subnetwork Considerations

Subnetwork naming and addressing is important to consider in the ATN context as ATN systems must use subnetwork points of attachment (SNPAs) to address other ATN systems. In general, SNPAs are treated as addresses and have no relationship to an object name. Additionally, registration of SNPAs is generally a consideration local to a subnetwork, but the SNPAs assigned to specific systems or services should be made available to all interested parties attached to a given PSDN. This section presents addressing issues related to subnetworks likely to be used for interconnecting various ATN organisations and routing domains.

5.1.1. X.25 Subnetworks

Addressing of systems (typically referred to as DTEs on X.25 networks) attached to an X.25 network is treated in [X.25] and [X.121]. Generally an X.25 network has a well-established local addressing plan according to the needs identified by the network operator. DTE addresses on a given network typically contain up to 10 BCD digits. For calls placed to destinations outside of the network, a 4-digit BCD DNIC defined by [X.121] or other international agreements must be prepended to the DTE network address. DTE network addresses do not need to be registered within the ATN-wide context as their use does not have ATN-global impact. Rather, organisations will exchange DTE network addresses as appropriate according to a prior agreement or service contract.

An ATN system connected to an X.25 network must have preconfigured knowledge of the DTE network addresses of the systems with which it will communicate using the X.25 network. Typically, this information should be loaded in the CLNP routing table by systems management functions prior to putting the system into service.

5.1.2. VDL Subnetworks

The addressing plan for the VDL subnetwork is described in [2]. The scope and impact of the VDL addressing plan is limited to the VDL subnetwork. Systems not directly attached to the VDL subnetwork are not affected by the VDL addressing plan.

The two principal types of ATN systems which use the VDL subnetwork are airborne routers and air/ground routers. The VDL address of an airborne router is comprised of an 8 digit BCD-encoded representation of its ICAO 24-bit address plus an optional one or two digit subaddress. The VDL address of an air/ground router may simply be its DTE network address as assigned by the network operator to which it is attached. For example, air/ground routers attached to the SITA VDL network will be assigned DTE network addresses according to the SITA X.25 numbering plan. A system not directly attached to a VDL subnetwork may be able to call a router attached to the VDL subnetwork by prepending the DNIC of the destination network to the VDL address of the called system.

As all calls placed over the VDL subnetwork must be originated by airborne routers, the addresses of appropriate air/ground routers must be known before a call is placed. An airborne router must have the ability to determine which air/ground routers can be called via a given ground station. Ground stations providing the VDL service will broadcast information about reachable air/ground routers and will allow airborne routers to call a *default* router without having to know its DTE network address. The specific operation of these VDL functions are addressed in [2].

5.1.3. AMSS Subnetworks

The addressing plan for AMSS is treated in [3]. The scope and impact of the AMSS addressing plan is limited to the AMSS subnetwork. Systems not directly attached to the AMSS network are not affected by the AMSS addressing plan.

The two principal types of ATN systems which use the AMSS subnetwork are airborne routers and air/ground routers. The AMSS address of an airborne router is formatted using BCD-encoded digits as follows:

<AMSS airborne address> :: <DNIC> ‘5’ <AES> > <D>

<DNIC> :: ‘1111' (AOR-E satellite) or ‘1112’ (POR satellite) or ‘1113’ (IOR satellite) or ‘1114’ (AOR-W satellite)

<AES> :: 8-digit BCD-encoded 24-bit address of aircraft

<D> :: Optional subaddress digit

The digit ‘5’ following the DNIC is a discriminator indicating that the address refers to an airborne system. A example AMSS address of an airborne router flying over the Atlantic Ocean may be `1111.5.46721005`.

The AMSS address of an air/ground router is formatted using BCD-encoded digits as follows:

<AMSS ground address> :: ‘26’ <DNIC> <NTN>

<DNIC> :: 4-digit DNIC of the ground network as registered in [X.121] or by international convention (e.g. SITA’s DNIC is ‘1116’).

<NTN> :: Up to 9-digit network terminating number (DTE network address) of the air/ground router on the provider’s network identified by the ASNID.

The digits ‘26’ comprise a prefix indicating that the address is used to access an internetwork router within the AMSS addressing plan. As an example, a SITA air/ground router AMSS address may be `26.1116.2331123`.

As part of the routing initiation process over an AMSS subnetwork, airborne routers are required to place the initial to the air/ground router. Therefore, the addresses of appropriate air/ground routers must be known before a call is placed. An airborne router must have the ability to determine which air/ground routers can be called via a given ground station. This information can be pre-configured into the airborne router by systems management. Therefore, limited address registration may be required within the scope of the AMSS.

5.1.4. Mode S Subnetworks

Mode S subnetworks are effectively seen as X.25 networks from the users' (routers') perspective. It is expected that airborne Mode S systems will be addressed by deriving a DTE network address from the aircraft's 24-bit ICAO address. A Mode S addressing plan should be defined.

5.1.5. Minimising The Impact of Topology Changes and Outages

From time to time, a subnetwork topology may change or a system outage may occur which effectively changes the subnetwork topology. Because ATN subnetworks are expected to be used to support air traffic management applications, operational availability must be very high. Consequently, the effects of ATN subnetwork topology changes must be minimised in order to avoid losing vital communication paths.

The primary problem occurs when a given service, in this case a router or end system, is apparently no longer at the expected subnetwork address. This could occur due to a new subnetwork address being assigned, system failure or network failure. These problems can be addressed as follows:

1. For foreseen subnetwork address changes, any system known to need to communicate with the system whose address will change must be informed of these changes well in advance. This scenario applies to both ground and air/ground subnetworks, however recognising that the VDL provides a means of broadcasting subnetwork address information, airborne VDL systems may not need explicit or manual updates as VDL addressing information is learned dynamically.
2. If a system attached to a subnetwork fails, a standby or backup system may be available. If this is the case, the replacement system should effectively adopt the subnetwork address of the failed system. In X.25-based subnetworks such as VDL, AMSS and Mode S, this could be achieved virtually automatically by using the X.25 call redirection or hunt group facilities. These facilities provide a means of logically addressing a service or function rather than a specific system.
3. Failures truly internal to a subnetwork should be hidden from subnetwork users as much as possible. For example, many X.25-based subnetworks such as SITA's Mega Transport Network (MTN) will reroute packets around a failed node without clearing the associated circuits or otherwise impacting the end users. Issues involving subnetwork-internal failures have no impact on subnetwork addressing.

Any subnetwork topology changes local to a given routing domain are expected to be resolved internally by the organisation responsible for the domain so that the problem is not propagated to other domains (e.g. if a given end system within a domain is moved to a new subnetwork address, only the local intradomain routing tables must be updated accordingly).

5.2. Internetwork Considerations

5.2.1. Internetwork Addressing

The ATN internetwork addressing plan is defined in §A7 of [1]. This hierarchical addressing plan reflects the expected topology of the ATN internetwork based on the *administrative topology* derived from how the network may be used by the ATN community. During the early use of the ATN, this internetwork addressing plan will be subject to validation as the community evaluates the appropriateness of the selected plan. However, strict adherence to this hierarchical addressing plan is required for proper operation of the ATN.

5.2.1.1. The NSAP Address

Field Name	**Size (Octets)**	**Value / Range (Hex)**	**Meaning**	**Registration Authority**	***Package 1* Status**
AFI	1	47	Basic NSAP Format	ISO	Fixed
IDI	2	00 27	ATN NSAP	ISO	Fixed
VER	1	01 81	AISC Address ATSC Address	ICAO	Fixed Fixed
ADM	3	*00 00 00 - FF FF FF*	ISO Country Code IATA Code	ICAO IATA	Variable Variable
RDF	1	01 81	Fixed Routing Domain Mobile Routing Domain	ICAO	Fixed
ARS	3	*00 00 00 - FF FF FF*	Admin. Region / ATSC Admin. Region / AISC 24-bit Aircraft ID	*Per ADM Field* *Per ADM Field* ICAO	Variable Variable Fixed
LOC	2	*00 00 - FF FF*	ATN Routing Area	*Per ADM Field*	Variable
SYS	6	*00 00 00 00 00 00 - FF FF FF FF FF FF*	Local System Identifier	*Per ADM Field*	Variable
SEL	1	00 01 02	Network Entity / IDRP ISO 8073 / TP4 Entity ISO 8602 CLTP Entity	ICAO	Fixed Fixed Fixed

Table 1. *Package 1 ATN NSAP Address Definition*

The use of the ATN internetwork addressing plan for *Package 1* is outlined in Table 1. This table describes the complete ATN NSAP address format from which are derived NETs, RDIs and NSAP address prefixes. Of the nine address components, five already have fixed values per ICAO definitions. The values of the remaining four fields, marked as *Variable* in Table 1, may be allocated as follows:

ADM The value of the ADM, combined with the values of the preceding fields, determines the system's ATN administrative domain. Each ICAO Member State, airline or other organisation participating in the ATN should be responsible for exactly one ATN administrative domain.

If the VER field indicates an ATSC address format, ICAO is the registration authority responsible for the ADM field and the corresponding ATN administrative domain. In this case, the ADM field should contain the ISO country code of the ICAO Member State responsible for the system addressed by the corresponding NSAP.

If the VER field indicates an AISC address format, IATA is the registration authority responsible for the ADM field and the ATN administrative domain. In this case, IATA will assign ADM fields according to the procedures outlined in §5.2.3.

ARS The value of the ARS, when combined with the values of the preceding fields, determines the system's ATN routing domain. Each ICAO Member State, airline or other organisation identified by the value in the ADM field will be responsible for establishing one or more ATN routing domains according to their local addressing requirements.

If the RDF field indicates a mobile routing domain, the ARS shall be the hexadecimal-encoded value of the aircraft's ICAO 24-bit identifier. The ATN systems onboard an aircraft comprise a single routing domain.

If the RDF field indicates a fixed routing domain and the VER field indicates an ATSC address format, the ARS shall contain either the ICAO location identifier or other meaningful indication (e.g. the flight information region indicator) of the routing domain.

If the RDF field indicates a fixed routing domain and the VER field indicates an AISC address format, the ARS shall contain the IATA location identifier or other meaningful indication of the routing domain.

LOC The value of the LOC field is under the responsibility of the organisation identified in the ADM field and should be assigned a meaningful value within the context of the administrative region identified in the ARS field. This field may be used to subdivide large routing domains according to local needs.

SYS The value of the SYS field is under the responsibility of the organisation identified in the ADM field and should be assigned a meaningful value within the context of the administrative region and location identified in the ARS and LOC fields. This field may be used to identify a specific ATN system within a given routing domain

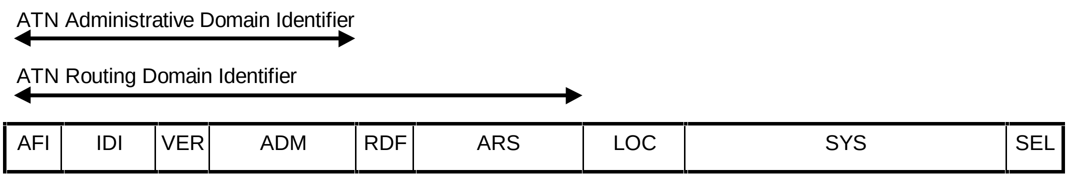

Figure 2. ATN NSAP Format

5.2.1.2. The Network Entity Title

A NET is in fact the name (title) of the CLNP network entity in any given ATN system. However, as an ATN system may have exactly one CLNP network entity, the NET in fact “names” the entire system. Further, as ATN NETs are derived from the ATN addressing plan, the NET may also be used as an ATN address to locate a given system, or as a source from which to derive address prefixes of all systems within a given routing domain (e.g. during routing initiation).

For internetwork addressing consistency within the ATN, the NET and all NSAPs in use on a given system should only differ by the value of the SEL field per Table 1.

5.2.2. Internetwork Naming

Thanks to the hierarchical NSAP addressing plan, ATN internetwork object names can be implicitly derived from the NSAP addressing plan as outlined in *Table 1* and *Figure 1*. Within the scope of *Package 1*, these names will likely not be used except for operators’ references to ATN systems and, perhaps, within the scope of systems management functions including configuration and topology displays.

ATN internetwork entity names must unambiguously identify the object in question. Specifically, as indicated in §5.2.1, a NET may be used to “name” a given ATN system. A systems’ name may be derived from the NET with a mnemonic structure compatible to the hierarchy of the NSAP address plan as follows:

Top Level Domain : “ATN”
ATN Registration Authority :: “ICAO” or “IATA”
Administration :: ISO country code or IATA stakeholder designator
Address Type :: “Ground” or “Air”
Area :: IATA or ICAO location identifier or ICAO 24-bit address (hex)
Location :: String assigned per local needs
System :: String assigned per local needs

This assumes that "ATN" is suitable for identifying the ATN in the OSIE. Example mnemonic forms of a NET could be

```
ATN.ICAO.USA.Ground.WAS.Tower.Primary
ATN.IATA.SIT.Ground.PAR.OPS.Hermes
ATN.IATA.UAL.Air.56AC23.OP.FMC
```

Correspondingly, ATN NSAP names can be derived from system NETs by appending an indicator of the network user, either IDRP, COTS, or CLTS. Example mnemonic forms of the NSAP names could be

```
ATN.ICAO.USA.Ground.WAS.Tower.Primary.TP4
ATN.IATA.SIT.Ground.PAR.OPS.Hermes.IDRP
ATN.IATA.UAL.Air.56AC23.OP.FMC.CLTP
```

Another important aspect of internetwork naming is the routing domain identifier (RDI) and administrative domain identifier per Figure 2. An ATN administrative domain is generally a single ICAO member state or IATA stakeholder. The administrative domain identifier is actually an NSAP prefix comprised of the AFI, IDI, VER and ADM fields of the NSAP address. All NSAPs within a given administrative domain begin with the address prefix formed by the administrative domain identifier. Similarly, the RDI is also an NSAP prefix comprised of the administrative domain identifier plus the RDF and ARS fields. An RDI identifies a routing domain. Both the administrative domain identifier and RDI must be unambiguous within the ATN and OSIE.

Example mnemonic forms of the administrative domain identifier could be

```
ATN.ICAO.USA
ATN.IATA.SIT
ATN.IATA.UAL
```

Example mnemonic forms of the RDI could be

```
ATN.ICAO.USA.Ground.WAS
ATN.IATA.SIT.Ground.PAR
ATN.IATA.UAL.Air.56AC23
```

`ICAO should identify a coherent internetwork naming plan including provisions for NSAPs, NETs, RDIs and administrative domain identifiers.`

5.2.3. Internetwork Name and Address Registration

To ensure internetwork name and address unambiguity within the ATN, certain fields of the NSAP address format, and therefore also the NET, RDI and administrative domain identifier formats must be registered according to a well-defined process. Specifically, values for both the ADM and ARS fields should be registered as follows:

1. The ADM field should be assigned a value representing the IATA or ICAO organisation which is responsible for the corresponding name or address as indicated by the value of the VER field. This will effectively define the ATN administrative domain identifier. The ADM should generally be an IATA 3-letter code for airlines (e.g. the "airline designator") and other stakeholders or a 3-letter country code for ICAO member states. IATA has already proposed a registration procedure through their Geneva offices based on the use of current alphanumeric "airline designators" with extensions for "other stakeholders" compatible with the IATA Passenger Services. ICAO has yet to define a registration process, but should follow the IATA example by assigning common country name abbreviations or those defined by ISO.

2. Although local to a given administration, the ARS fields of ground systems used by organisations with registered ADM values should also be registered within the context of the entire ATN. Since both the ADM and ARS are part of the RDI, the registration of both fields and the corresponding VER field effectively defines a routing domain. Although IATA and ICAO may delegate registration authority of the ARS field to the organisations which have registered ADM fields, the ARS should always be the IA-5 encoding of the IATA or ICAO location identifier per §A7.5.6 of [1].

A common ICAO/IATA database maintaining the above information, plus the ARS values of all ATN-equipped aircraft, should be kept and published through the appropriate ICAO and IATA channels. This database should be arranged to identify all possible ATN routing domains and the organisations responsible for each one. This database may be the basis of generalised directory services for post-*Package 1* ATN deployments.

Values for the LOC and SYS fields may be registered within a routing domain or administrative domain, but, in general, there is little need for ATN-wide coordination of these values. However, in order to support ATN directory services in the long term, the NSAP and presentation addresses of ATN applications should be maintained in a possibly-distributed ATN directory application.

5.2.4. Relationship To ATN Routing

In order to support the ATN routing concept, the ATN NSAP addressing plan must be respected, especially with regards to the registration and use of ADM and ARS values. As the NSAP addressing plan is based on the expected ATN topology, it has been defined hierarchically allowing routing information to be managed efficiently. Specifically, address prefixes comprising of simply an administrative domain identifier or routing domain address may be used to describe routes to all systems within a given domain. For example, the IDRP protocol may be used to indicate that a given router has routes to all systems in a given administration or airline rather than identifying every system individually. As an extension of this idea, there may some merit in considering minor modifications to the addressing plan allowing air/ground routers to efficiently advertise routes to “all mobiles” as a first step in broadcasting reachability information.

During the *Package 1* timeframe, IDRP may not be supported over the mobile subnetworks. This will have no impact in the addressing plan as the routing initiation process will ensure that both the air/ground and airborne routers will have enough information about each other and their corresponding communications capabilities. The air/ground router’s IDRP entity can forward the routing domain address of the aircraft (derived from the airborne router’s NET) to other domains requiring this information. On the other hand, the airborne router must have some pre-configured knowledge of the reachability of destination systems via a given air/ground router as there may not be any means of dynamically adverting route information to all aircraft.

5.2.5. Minimising The Impact of Topology Changes and Outages

From time to time, the ATN internetwork topology may change or a system outage may occur which effectively changes the internetowork topology. Because the ATN is expected to be used for air traffic management applications, operational availability must be very high. Consequently, the effects of ATN internetwork topology changes must be minimised in order to avoid losing vital communications paths.

The primary problem occurs when a given service, in this case a router or end system, is no longer reachable at a given address. This could occur due to a new NSAP address or NET being assigned, failure of a given end system, or topology changes due to a failure of an inter-domain router. These problems can be addressed as follows:

1. For foreseen NSAP address changes, perhaps due to moving a system to another routing domain, any system known to need to communicate with the system whose address will change must be informed well in advance. A period of time in which a system maintains two or more NSAP addresses for the same NSAP may also ease the transition. If this is the case, IDRP-equipped routers may broadcast the reachability of a given system by both its old and new address for a limited time, thus minimising the overall impact of the change. Additionally, use of directory services may be used to effectively map a desired application name to the appropriate NSAP.
2. If an end system fails, a standby or backup system may be available. If this is the case, the replacement system should effectively adopt the NSAP addresses of the failed system and the local routing tables updated to indicate the local topology change. Ensuring availability of ATM services when an end system fails is a local

matter, and the effects of the failure should not be propagated outside of the local domain.

3. The ATN is expected to have a certain amount of redundancy built in to minimise the impact of a given inter-domain route or path no longer being available due to system or subnetwork failure. Reliable redundancy mechanisms can be insured by proper use of IDRP which could allow rapid and efficient recalculation of inter-domain routes if the "best route" is no longer available.

Any internetwork topology changes local to a given routing domain are expected to be resolved internally by the organisation responsible for the domain so that the problem is not propagated to other domains. For example, if a given end system within a domain is moved to a new subnetwork address, local intradomain routing tables must be updated accordingly.

5.3. Application Considerations

5.3.1. Application Addressing

As indicated previously *Package 1* applications will likely be supported over an upper layer stack offering certain common application services to ATN applications. As a consequence, the address of a *Package 1* application will be its presentation address, which is based on an NSAP address plus transport and additional "selectors". There may be one or more applications on a given end system each one having an unique presentation address.

As the upper layer architecture is still evolving, it is difficult to define the exact application address format. However, if there is a requirement to use a single transport connection for multiple applications whenever possible, an ATN presentation address must consist the host system's NSAP, TSEL and at least one additional selector to identify a specific application using a given TSAP. ICAO should consider and develop the application addressing requirements and associated solution as the upper layer architecture is being developed.

5.3.2. Application Naming

During the *Package 1* timeframe certain ATM applications and other services, implemented as ATN applications, may need to be *named* in such a way to avoid the pre-assignment of application addresses. Application names are generally referred to as *AP-titles* and must be globally unique within the ATN context. Following ISO naming principals [7498-3], we can ensure that each AP-title is unambiguous within the ATN (and consequently the OSIE) by assigning it according to a well-defined AP-title naming tree under the ultimate authority of ICAO. The *Package 1* application naming tree should reflect the administrative topology of the network. Thus, we can envision four principal types of applications in the *Package 1* timeframe:

1. Ground based ATM applications under the responsibility of an ICAO Member State;
2. Airborne ATM applications under the responsibility of an airline, but deployed in order to obtain improved ATM services from ICAO Member States;
3. Ground based airline community applications under the responsibility of an IATA member;
4. Airborne airline community applications under the responsibility of an IATA member.

Each of the four application types could be found in an AP-title subtree under the authority of one or more registration subauthorites. Note that as the ATN is already registered by ICAO under the ICD 00027, ICAO is the ultimate ATN registration authority and has the responsibility to assign subauthorities as needed.

5.3.2.1. Ground-Based ATM Applications

For ground-based ATM applications, the naming tree could reflect the administrative hierarchy of the expected ATC centres as follows:

Top Level Domain :: "ATN"
    ATN Registration Authority :: "ICAO"
        Application Class :: "Ground"
            Administration :: ISO country code of ATC administration
                Centre :: ATCC name
                    Facility Designator :: "En Route", "Tower", etc.
                        Application ID :: "ADS", "CPC", etc.

Therefore, an example AE-title could be

```
ATN.ICAO.Ground.Ecuador.QTO.EnRoute.ADS
```

for an Ecuadorian ADS application in the Quito en route centre.

5.3.2.2. Airborne ATM Applications

Airborne applications which are used in support of ATM services should also reflect an administrative hierarchy as follows:

Top Level Domain :: "ATN"
    ATN Registration Authority :: "ICAO"
        Application Class :: "Airborne"
            Aircraft :: Flight Number
                Application ID :: "ADS", "CPC", etc.

Therefore, an example AT-title could be

```
ATN.ICAO.Airborne.AF002.ADS
```

for an airborne ADS application on the aircraft identified by the flight number AF002. Note that, in many cases, current ATC operations use an aircraft's flight number to identify the aircraft independent of any other aircraft address (such as the ICAO 24-bit address). Thus an ATN address lookup mechanism, perhaps based on the OSI Directory Services, may be required to map application names to addresses. In the short term, however, this name-to-address mapping may occur locally to a given system as explained in §6.

5.3.2.3. Other Ground-Based Applications

A separate naming tree under the IATA authority may also be envisioned for ground-based applications supporting non-ATM services such as interline communications and flight operations messaging:

Top Level Domain :: "ATN"
    ATN Registration Authority :: "IATA"
        Application Class :: "Ground"
            Administration :: IATA code of responsible organisation
                Area :: IATA location identifier or other code
                    Application ID :: "FlightOps", "OOOI", etc.

Therefor, an example AE-Title could be

```
ATN.IATA.Ground.AAL.DFW.FlightOps
```

for American Airline's flight operations application in Dallas Fort Worth, Texas.

5.3.2.4. Other Airborne Applications

Finally, airborne applications for which are used in support of non-ATM services should also reflect an administrative hierarchy as follows:

Top Level Domain :: “ATN”
  ATN Registration Authority :: “IATA”
    Application Class :: “Airborne”
      Aircraft :: Flight Number
        Application ID :: “EngineMonitor”, “OOOI”, etc.

Therefore, an example AP-title could be

```
ATN.IATA.Airborne.AF002.OOOI
```

for an airborne OOOI application on the aircraft identified by the flight number AF002.

5.3.3. Name and Address Relationship in *Package 1*

To date very little effort has been focused on the relationship between ATN application names and corresponding addresses outside of the scope of ADS, CPC and the supporting CM function. Based on the expected *Package 1* upper layer architecture and the expected limited deployment of ATN systems during the *Package 1* timeframe, the mapping between application names and addresses could be resolved *a priori* thus eliminating the need to impose application names in the short term. This assumption is not unreasonable, especially for applications such as AIDC which will likely have few address and name changes. However, unless the structure of application naming tree and the corresponding registration authorities are defined during *Package 1*, the scalability of the ATN may be limited by requiring that all ATN applications individually maintain addressing information about all other applications with which they may need to communicate. ICAO should pursue the definition of a naming tree allowing the development of ATN directory services to support the potential growth of ATN.

For distributed air/ground applications such as ADS and CPC, a basic name-to-address resolver, CM, has already been defined. CM is a critical function allowing systems onboard an aircraft and within a given ATC facility (or FIR) to identify their service capabilities (applications) and their corresponding addresses to each other. It should be noted however that, as demonstrated in §6, CM provides limited capabilities in a limited context.

5.3.4. Application Name Registration

ATN AP-titles should be registered based on the registration procedures [9834-1] and [9834-6]. Specifically, ICAO should operate as the International Registration Authority and delegate the name registration responsibilities to both itself (for ATM services and applications) and IATA (for non ATM services and applications). The name registration responsibilities may be further delegated according to the administrative taxonomy of the ICAO and IATA organisations. For example a given ICAO Member State could take responsibility for registering the nation’s ATM services, while a given IATA member could be responsible for the registration of its applications. It is recommended, however, that certain ATM services such as ADS, CPC and CM be assigned a common “application identification” within the context of a given ATC facility or FIR to minimise any potential confusion at the international level.

Both the *object identifier form* and *directory name form* described in [9834-1] may be used, especially when considering the potential use of OSI directory services for the ATN. As both forms relate to the same naming tree, either nomenclature could be used to identify a given application.

The object identifier form should be based on ICAO ICD (00027) and the ATN arc (0). As ICAO is registered under ISO, all ATN applications (in fact, all ATN objects) begin with the prefix {1 3 27 0}. It is currently understood that a hierarchy for the ATN object identifier “name space” has not yet been established. Unless an ATN object naming trees is defined, the ATN community will be forced to continue with virtually a "flat" object (and application) "name space". It is recommended that an object naming tree be defined by ICAO.

6. THE USE OF CONTEXT MANAGEMENT AS A BASIC DIRECTORY SERVICE

This section introduces the use of the ATN naming and addressing concept for ATM applications distributed between airborne and ground-based systems. Further and more detailed information about the context management application can be found in [5].

Within the *Package 1* timeframe, the CM application will provide a basic directory service which provides the following capabilities:

1. Ground-based ATM applications may determine the ATN application capabilities of a given aircraft and determine the addresses of relevant applications.
2. Airborne ATM applications may determine the ATN application capabilities within a given FIR and determine the addresses of relevant applications.
3. The ground-based CM function may advertise the update of relevant ground based ATM application addresses to the airborne CM application.
4. The ground-based CM function may direct its airborne peer CM to contact another ground-based CM application, perhaps in another FIR.

Once an aircraft has "logged on" (see [5]) using CM the onboard systems are able to determine the application addresses of ATM services available from the local control region. Correspondingly, the local control region's ATCC will know the aircraft's ATM application capabilities and their respective ATN application addresses at completion of logon. The logon process can be described as follows:

1. Assuming one does not already exist, the aircraft's CMA establishes a transport connection with the ATCC CMA in the control region currently responsible for the aircraft. The aircraft is required to know which control region it is in and the corresponding address of the CMA application.

   Note: In the absence of generalised directory services, it may be worthwhile to establish default CMA application addresses within each ATN equipped control region. This would simply mean defining, at the ICAO level, fixed LOC, SYS, NSEL, TSEL and additional upper layer selector values for the ground CMA applications. The RDI of a given control region can be derived from the name of the control region, presumably already known by the aircraft, and expressed in the ARS field. The airborne CMA would then append the predefined values of the above-listed fields to the RDI identifier to produce the required CMA address.

2. The aircraft CMA sends a *CMLogonRequest* message indicating the aircraft flight identification (its flight number), and an associative list of application names and addresses. The application names are in fact currently defined to simply be 3-character *Application IDs* (from §5.3.2.2) It is assumed that the ATCC can derive the full application name from the associated addressing information and flight identification. At this point, the ATCC will be able to associate the aircraft, identified in the flight plan by its flight identification, to the supported ATM applications and their corresponding addresses.
3. If the ground CMA is able to support the logon request, it sends a *CMLogonResponse* message indicating that the aircraft logon request has been accepted along with an associative list of applications and their associated application addresses similar to the aircraft's list. At this point, the aircraft will be able to associate the ATM applications supported by the ATCC with their corresponding applications addresses.

Following the logon procedure, peer application names and addresses can be distributed within the aircraft and ATCC domains by local means. At this point, ATM applications may now communicate between the aircraft and ATCC. If, for some reason, the ground application addresses change, the ATCC may send an updated associative name/address list to the aircraft. Additionally, to support transfer of control to the aircraft's next control region, the ATCC may send a *ContactRequest* message to the airborne CMA indicating the next control centre's CMA application address.

7. OUTSTANDING ISSUES

There are several issues identified which may deserve further consideration in the short to medium term:

1. X.400/MHS-specific naming, addressing and registration issues;
2. Naming, addressing and registration issues involving the interworking of the AFTN and ATN;
3. Naming, addressing and registration alignment between the ICAO ATN work and the IATA Aeronautical OSI Profile (AOP);
4. The impact of airline-related non-ATC applications to the naming, addressing and registration concept;
5. The potential need for general OSI-type ATN directory services and, therefore, address and naming trees for the information in the directory;
6. The potential need for a standardised ATN naming plan including managed objects, message syntaxes and other information objects;
7. The naming, addressing and registration transition strategy to support post *Package 1* environments;