CEC TEN-T ATM Task UK/96/94

ACCESS

ATN Compliant Communications
European Strategy Study

Current Communications Infrastructure

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DOCUMENT CONTROL LOG

Revision Number	Date	Description of Change
0.1	25/04/97	rudimentary first draft showing structure
1.0	09/06/97	supplements and corrections using structure of V0.1
1.1	25/07/97	includes corrections and additions to V1.0
2.0	15/8/97	first published version; minor editorial changes to V1.1
2.1	14/9/97	minor editorial changes to V2.0
3.0	05/03/98	Final version

EXECUTIVE SUMMARY

The implementation of the ATN in Europe will not be a sudden introduction of new technology and equipment but will evolve gradually from the existing aeronautical data communications situation. For this reason it is necessary to document the existing communications infrastructure as is done in this paper. In the context of ACCESS this documentation can be used as a reference on which planning tasks are based.

A number of surveys and audits of European data communications infrastructure have been performed in the recent past and it is not intended that this document be a substitute for them. In any case, the effort to recompile such surveys and audits is not available within the scope of ACCESS. The primary purpose here is to extract relevant information from existing reports and to present this in a uniform way for the purpose of providing a basis for ACCESS planning tasks. Additional sources of information are used only where existing documents are out of date or relevant details are missing.

The core of the paper is a country-by-country description of existing networks which are related to generic network types and to international and regional networks. The use of national networks by applications is also described and related to generic aeronautical applications.

Where appropriate, comments are made on ATN migration.

TABLE OF CONTENTS

1. Introduction

1.1 Scope

Whereas information on current network infrastructure is available in existing surveys and audits, it is not in a form which might be useful for ACCESS. In preparing this report, information from other sources has been collated and presented in a concise and uniform manner and with a view to being input to ACCESS planning tasks.

The geographical area covered is that defined for ACCESS. Only ground data networks and the few existing air/ground data networks are considered together with the major applications using them.

1.2 Purpose of Document

The current aeronautical network situation in Europe is characterised by

- the lack of an overall, unified networking concept,
- the use of different, application-specific network types in a fragmented fashion and
- the use of technology which is not “state-of-the-art”.

The transition from this situation to the ATN will take place gradually over a number of years. This is due to the volume of the necessary investments, the scope of relevant projects and to the planning and co-ordination needed among different participants such as ICAO States.

As a result, the initial implementation of the ATN will depend heavily on parts of the existing infrastructure: these will be used in parallel within the current networking context and within the ATN. The initial implementation of the ATN will also have to support current applications.

The purpose of this document is to provide a description of the existing infrastructure which can be used as a basis for the ACCESS planning tasks to follow. The description also contains a catalogue of applications using the current network infrastructure which can serve as a source of requirements placed on the initial ATN implementation.

1.3 Document Structure

The body of the document, Chapters 2, 3 and 4 deal with aeronautical networks on varying geographical scales: from national up to international. Reference is made to networking technology (Chapter 6) and the aeronautical applications involved (Chapter 5). The structure is shown schematically in Figure 1.

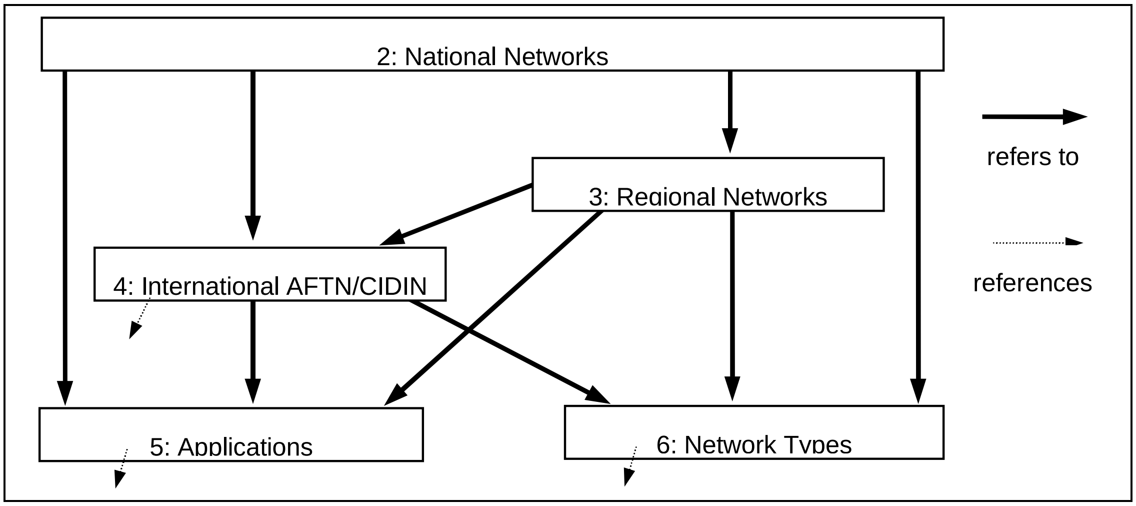

Figure 1: Logical structure of the document

1.4 References

Reference	Title
[EAT1]	Application Requirements for Data Communications Services, Edition 1.0, Eurocontrol, December 1995
[EAT2]	EATCHIP 2370 Task 5, Inventory of Existing Ground Data Networks, Final Report, Issue 2, Eurocontrol, April 1993
[EAT3]	EATCHIP 2370 Task 5, Inventory of Planned Data Networks in the ECAC Area, Final Report, Issue 2, Eurocontrol, March 1994
[EAT4]	EUNIS WP1000 Report, Inventory of Ground Data Networks, Issue 2, Eurocontrol, February 1996
[EAT5]	EUNIS WP2000 Report, Inventory and Profile Description of Ground Data Applications, Issue 2.0, Eurocontrol, February 1996
[EAT6]	EUNIS WP3000 Report, Network Interconnection Analysis, Issue 1.1, Eurocontrol, November 1996
[CEC1]	COPICAT, Users Requirements and Expectations, Edition 1.1, CEC DGXIII, February 1997
[SAT1]	Satellite Communications and Ground Earth Station Institutional Issues Study, Final Report, Version 1.0, Eurocontrol SATCNS WG, December 1995
[ICA1]	EUR CIDIN Manual, European and North Atlantic Office of ICAO, January 1996
[LUX1]	Course Notes, CFMU III Communications Architecture, B. Sefsaf, Eurocontrol Institute Luxembourg, April 1997
[LUX2]	Course Notes, FDE ICD Part 1, E. Cerasi, Eurocontrol Institute Luxembourg, April 1997.
[LUX3]	Course Notes, Radar Data Networks, M. Houben, Eurocontrol Institute Luxembourg, April 1997

2. National Networks

This section represents the top level of description of network infrastructures in this document. It is structured according to country. References are made to aeronautical applications, the international AFTN/CIDIN and to network types as described elsewhere in this document. In the descriptions emphasis is placed on aspects which might be relevant to a future migration of applications or networks to the ATN.

2.1 Belgium

2.1.1 Data Networking

The Belgian Airport and Airways Agency has implemented a national packet switching network based on MEGAPAC X.25 switches. Its ring configuration is shown in Figure 2. Lines between nodes have a capacity of 64 Kbps.

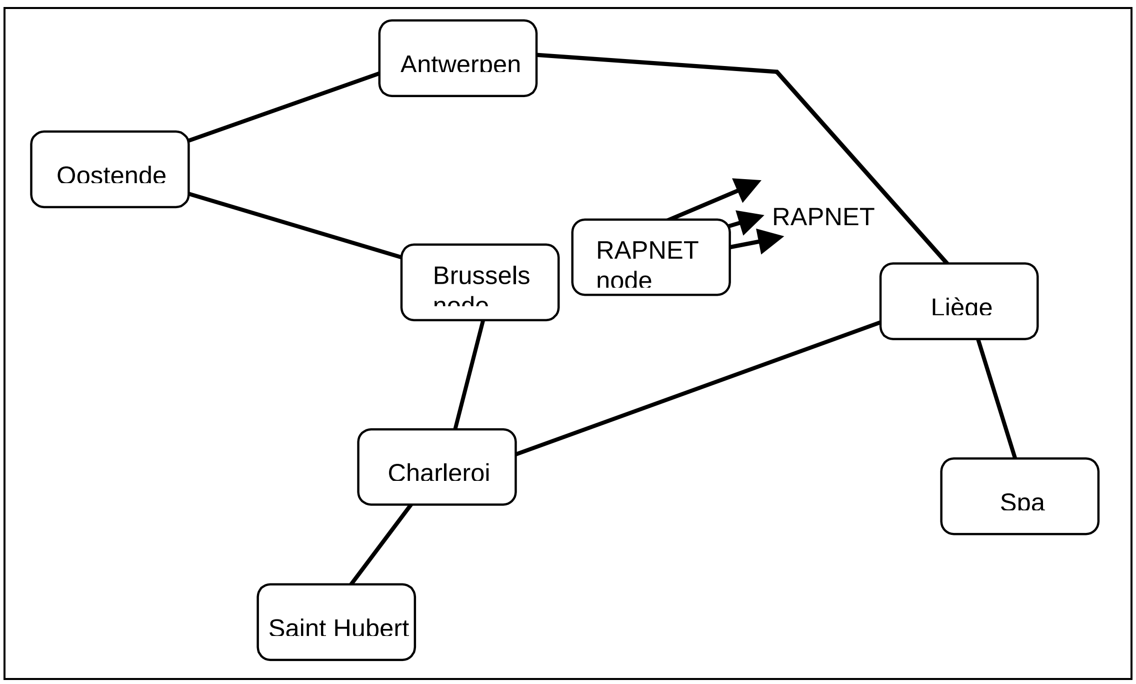

Figure 2: Configuration of the Belgian national data network

There is no direct connection between the national data network and RAPNET: interworking of messaging applications is provided by the AFTN/CIDIN switch and the AIS database BNASC in Brussels - see Figure 3.

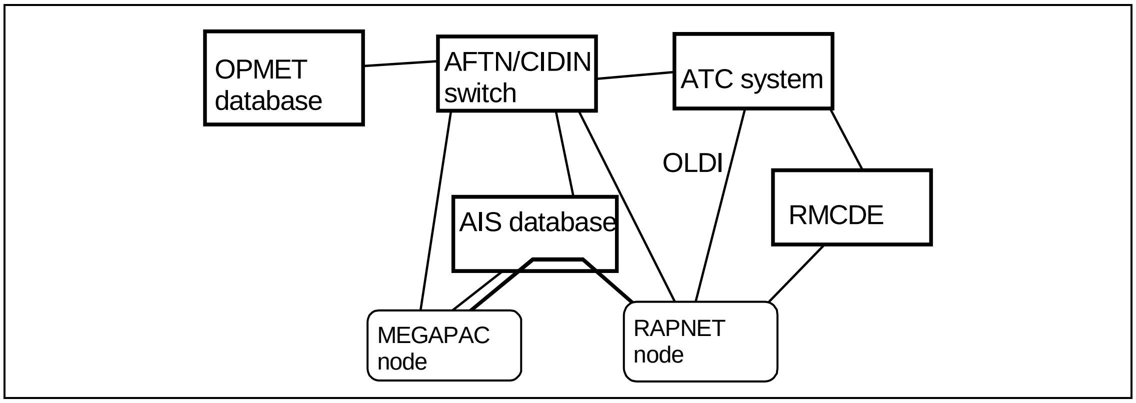

Figure 3: Relationship of systems in Brussels

2.1.2 Messaging

Messaging functions are performed centrally in the AFTN/CIDIN switch at Brussels which is a node in the international AFTN/CIDIN. National access is via AFTN procedures over the national packet switching network.

2.1.3 OLDI

OLDI connections exist between the Brussels ATC Automation System and

- Amsterdam
- Maastricht and
- Frankfurt (ZKSD)

via RAPNET and between Brussels and

- Athis-Mons,
- Reims and
- London

via dedicated lines. It is planned to migrate the Athis-Mons and Reims connections to the RAPNET-RENAR interconnections.

2.1.4 Radar Data Exchange

There is an RMCDE installation in Brussels which communicates with other RMCDE sites via RADNET.

2.1.5 AIS

The Belgian National AIS System Centre is connected with regional AIS terminals via the national network and via RAPNET to terminals in Luxembourg.

2.1.6 OPMET

The OPMET database in Brussels plays a major role in OPMET distribution in Europe: it is the recipient of reports from outside Europe which are then distributed within Europe from Brussels. It is a source of all OPMET data for European users. (The OPMET database in Vienna plays a similar role.)

Message exchange is performed by the AFTN/CIDIN switch via dedicated lines, RAPNET and the national packet switching network.

2.1.7 Other Applications

Administrative applications also use the national data network.

2.2 France

2.2.1 Data Networking - RENAR

2.2.1.1 Overview

The introduction of data processing into air traffic control in France dates from the 1960s. In just three decades, the operating concepts of this technique have undergone constant change, from the advent of the first computers used for automatic processing of flight plan messages, to the global French integrated operational data processing system: the CAUTRA. The distributed nature of the CAUTRA applications and the decentralised organisation of the Administration led to considerable inter-site communication requirements and obliged the administration gradually to produce its own telecommunication media.

The implementation of a packet switching network was the solution adopted by the STNA to meet the new technical and economic demands .

The name of the network is REseau de la Navigation AéRienne (RENAR). It is a national X.25 network built from Northern Telecom DPN100 equipment and SAT Megapac equipment, and has been implemented over the past year.

RENAR is deployed in the air navigation regional centres (CRNA), the Paris Airport Terminal Centres (Paris-Orly and Roissy-Charles-de-Gaulle) and the Airports of Lyon-Satolas, Nice-Côte d'Azur, Marseille-Provence, Toulouse-Blagnac and shortly Bâle-Mulhouse, and to date covers all the major communications axes in France. The recent decision to extend the network to Geneva as part of Franco-Swiss exchanges will eventually provide the corresponding transalpine data links.

Based on an almost complete network of high-speed trunks linking the five French ACCs, RENAR constitutes a centralising integrated network for all CAUTRA, AFTN, radar, etc. systems and users. Its technology offers high levels of performance while its redundant architecture provides dependability, in particular leading to an ability to absorb simultaneous failures while maintaining the service.

2.2.1.2 Topology

The main structure of RENAR is established around the five ACCs (Athis-Mons near Paris, Reims, Brest, Aix-En-Provence and Bordeaux). These centres group the majority of network users and naturally constitute the most important nodes in terms of connection and transmission capacity. To connect them , a total mesh is implemented, based on the use of the permanent high-speed digital circuits (128 kbit/s) leased from France Telecom through a TRANSFIX service subscription.

To this basic assembly are attached the other lower capacity sites (Paris Roissy-CGG, Paris Orly, Toulouse, Marseille, Nice, Lyon and Bale-Mulhouse), also via TRANFIX links (at 64 kbit/s or 128 kbit/s depending on the volumes of traffic exchanged).

Gateways configured on either side of the network provide controlled openings to the outside world; public network (TRANSPAC), military network (RESEDA) or even foreign Air Navigation network.

From the functional viewpoint, each node on the network contains switching equipment responsible for transmission and routing. This equipment thus maintains an exact real-time picture of the network topology, which means that data can be at all times routed on the best circuits.

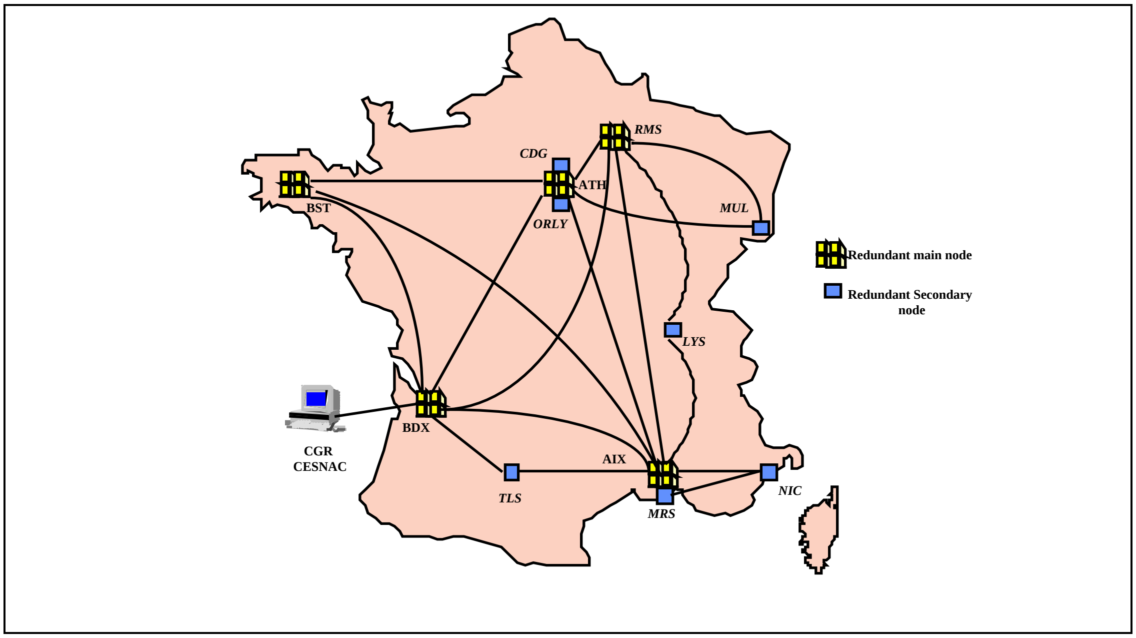

Figure 4: RENAR configuration

RENAR is inter-connected with the following networks:

- RAPNET
- Transpac (the Public French X.25 network)
- RESEDA (the French X.25 Military Network)

Further interconnection with other networks is likely in the short to medium term and notably the interconnection with the UK CAA network CAPSIN, the Spanish network REDAN and with the SITA network.

2.2.1.3 Technology and Standards

The switching exchanges used for RENAR belong to the Magellan DPN-100 range from NORTEL (Northern Telecom). The modularity of these devices offers considerable extension capacity for future requirements. It should be noted that this system is already widely used in public network world-wide, as well as the civil aviation community by companies such as Air France, American Airlines, SITA or by the German and more recently the Spanish Air Navigation authorities.

Functionally, the network consists of two types of DPN switches those of the network called RM (resource Module) and those for access called AM (Access Module). These switches use the same hardware base and are only differentiated by some of their software.

The RMs are high-capacity switches, used on the Inter-ACC structure. They are tripled or even quadrupled and interconnected at 2 Mbit/s on each of these sites to form high-redundancy switching nodes supporting the main network lattice. They are in charge of processing calls and routing data and constitute special connection points for the high-rate RENAR users. The AMs, which are lower capacity switches, are used like concentrators on the other sites for all their users. The particularity of DPN technology lies in its two-level network architecture :

- The first, governing inter-switch exchanges, operated in connectionless mode with a set of proprietary protocols and services called UTP (Universal Trunk Protocol).

In this mode, the protocol header of each datagram packet contains the entire addressee address, which enables it to be routed independently of its predecessor. Using this technique offers numerous advantages, in particular adaptation to failures and congestion (bypassing and dynamic distribution of traffic in the network).

- The second is peripheral to the first and offers the network users access in connected mode with the X.25 protocol.

Around this DPN structure, which provides all basic RENAR services, another technology is used to perform the broadcasting function. This is MEGAPAC from the SAT company. MEGAPAC was originally a small « X.25 »switch and has been converted to a network data server (SIR). When connected as particular users to the DPNs, the SIRs constitute RENAR access points for systems whose data need to be broadcast.

These devices ensure multi-source, multi-sink broadcasting, remotely and in X.25 via the DPN network, and locally in LLC1 on Ethernet, on X.25, HDLC or even BSC.

The network information servers (SIR) are currently used for the main broadcasting application: provision of radar surveillance data to the centres.

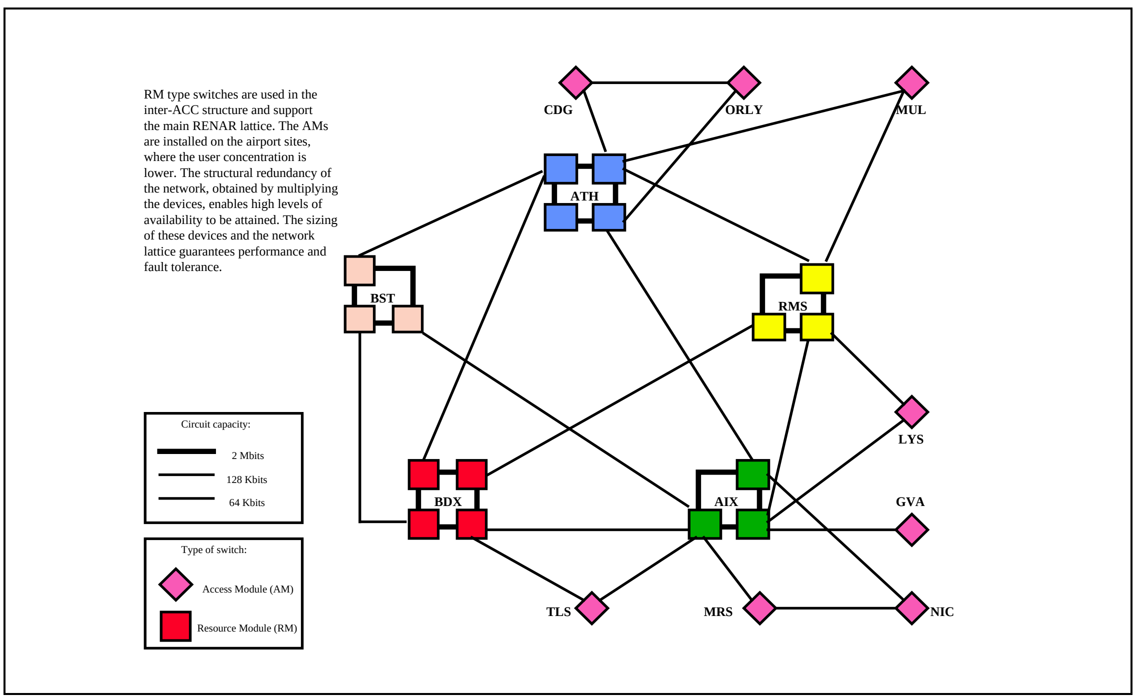

Figure 5: RENAR configuration details

The network supports both the 1984 and 1988 versions of X.25. The version can be configured on a per port basis, and if necessary the 1980 version can be supported as well.

Apart from the basic functions that derives from X.25, RENAR opens up a broad range of additional services. This in particular concerns:

- The priority transmission
- The Call redirection
- Hunt groups
- Broadcast

- automatic reconnection
- access security (Closed User Group, Network User Identification, outgoing or incoming call barring, address validation.

RENAR also complies with other ITU-T standards which gravitate around X.25, and principal among which are:

- X.121 concerning network numbering plans,
- X.28,X.3,X.29 concerning asynchronous access to a packet switching network,
- X.75 concerning interconnection of networks such as these
- X.32 concerning access to a packet switching network via the PSTN or ISDN.

2.2.1.4 Addressing

The addressing scheme used for RENAR conforms fully to X. 121, and at the highest level is structured as follows:

P	+	DNIC	+	PNIC	+	Network Terminal Number (NTN)
		4 digits		*2 digits*		*up to 8 digits*

The DNIC used for the network is 2083. This is followed by the PNIC of 27. In Recommendation X.121, the Data Country Code(DCC) 208 is allocated to France. The French administration has allocated DNIC 2083 to government bodies. This has been further subdivided through the use of a two-digit PNIC. The digits '27' have been allocated to RENAR.

For calls within RENAR, it is expected that the NTN on its own will be used by DTEs. Calls to other networks are indicated by a single digit prefix.

The Network Terminal Number comprises a maximum of 8 digits, structured as follows:

Network Terminal Number

1	2	3	4	5	6	7	8

Subaddress

Application

Site Identification

The first three digits identify the site at which the access port is located - so far 12 sites are in existence. The next three digits identify the application or host computer at that site. The final two digits are the standard X.25 subaddress. This structure indicates plenty of spare capacity for further systems, possible interconnection gateways, etc.

Addresses on the network are therefore of the form 2083.27.xxxxxx.ss.

2.2.1.5 Performance and Quality of Service

Designed in particular for transportation of operational CAUTRA and radar data, the RENAR network is thus highly sensitive. The importance of the data related to air traffic control and their delicate nature justify the high quality of service demanded in terms of performance, availability and reliability.

As a model, the radar data have the most restrictive and most interesting characteristic with regard to the design of the network: each radar station outputs an average of 20 kbit s of data so that with each 4 second antenna rotation it can cover up to 300 moving aircraft. RENAR has to be able to absorb the traffic volumes resulting from distribution of these data to all the user sites and has to be able to do it quickly. Furthermore, continuity of service and overall reliability of the system - notions which are firmly anchored in the spirit of the Air Navigation for the network - are major obligations for the network, all the more so as it is becoming the central link in the main chains linking the centres together.

The constraints are thus heavy indeed, but RENAR was able to integrate them into its architecture, dimensions and quality of service and to demonstrate the following good performance:

- level 2 fault tolerance of RENAR, in that it is able to absorb at least 2 failures simultaneously on trunks or switches, while maintaining performance within satisfactory levels,

- low transit delays , which measurements have situated at an average of 50 to 60 milliseconds in nominal operating conditions. In heavily degraded conditions (multiple failures or network congestion), this value remains far below 800 milliseconds. Distribution times are also very low, ranging from 60 to 100 milliseconds.

- Good service availability for all network users, resulting from a negligible failure rate. It should be noted that theoretical calculations had predicted a maximum down-time of 12 seconds per year.

2.2.1.6 Network Management

With regard to network management, the use of both DPN and MEGAPAC technologies nonetheless leads to a diversity of supervision platforms, which will doubtless have to be integrated in the near future. For the time being, the RENAR operators have three different platforms :

1. NMS/NAS for management of DPN equipment, supplied by Northern Telecom on SUN workstation and VAX computer respectively,
2. SVR/STM for management of SIR equipment, supplied by SAT on PC,
3. and STS, tailor-made under the aegis of the SCTA to complete local supervision of RENAR, on DEC ALPHA workstation.

An integrated, automated management centre situated in the Centre des Systèmes de la Navigation Aérienne Centraux (CESNAC), performs the effective supervision and monitoring of the network in a user-friendly manner, using multi-windows, graphic interfaces, pull-down menus and on-line help, etc..

Operator stations are also available on each network site, for local supervision of equipment.

2.2.2 RSTNA the little brother...

Installed on the STNA Toulouse (la Mounède and Basso Cambo), CENA (Toulouse and Paris), Orly and Rouen Modes S experimental sites, the dedicated air navigation test network (RSTNA) consists of the same equipment as that used on RENAR (DPN and SIR). While reproducing the typical configurations of RENAR in terms of topology and services, RSTNA is the prime platforms for technical evaluations of all sorts; new applications and links aimed at RENAR (Mode S link for example, currently under experimentation between Orly and Rouen), new network functions and services, and of course new versions of both network and user system hardware and software. In parallel with this application, RSTNA serves most of the STNA and CENA « X.25 » users, offering them an economical and powerful inter-communication facility with key services such as :

- interconnection of the different computers and systems,
- access to the public TRANSPAC network via an X.25 gateway,
- recovery of operational data in real-time from RENAR (radar data in particular), for testing and debugging of applications, via an X.75 gateway joining the two networks.

Finally, given its availability and its configuration relatively close to that of the operational centres, RSTNA has one last application, as a training platforms for all operators and users of RENAR.

2.2.2.1 Principal uses/services

RENAR is currently operationally used to support the following data traffics:

- Radar data traffic
- AFTN traffic (partly at the moment).
- The access to the Aeronautical Information (NOTAM) stored in the French central Aeronautical Data Base (the BDA)
- Air Traffic Flow Management application traffic (PREVI/IMAGE): PREVI is the central French Air Traffic Flow Management System. IMAGE provides an overall and macroscopic vision of the national air situation. Both systems are located in CESNAC. Through RENAR, this national situation is made available to the various user stations installed in the air navigation services.

The CAUTRA network, consisting of a large number of point-to-point leased lines, many of them duplicated to provide connectivity for particular applications and connecting the French ACCs and some main airports, is however still used to exchange flight plan and flight co-ordination data. These CAUTRA applications are expected to migrate in a near future to RENAR.

2.2.2.2 Future Plans

Designed to take traditional applications, RENAR is today keeping its promises. Faced with the irresistible growth in traffic volume, under the combined effect of new applications, the multiplication of increasingly powerful user systems, the new client-server systems and the prospect of multi-media applications, migration to high rates is essential. The opening of RENAR to new services such as Frame Relay is already envisaged and its extension to other sites is under study.

As far as supporting application services are concerned, RENAR as the integrated network is intended to cater for all requirements, and hence all ATC-related applications will migrate onto the network.

In the longer term, it is likely that further airports and other sites will be added to the network, that further access ports will need to be implemented, and that traffic will increase significantly. Further steps will also be taken to improve and integrate the network management facilities.

Further interconnection with other networks is likely in the short to medium term and notably the interconnection with the UK CAA network CAPSIN, the Spanish network REDAN and with the SITA network.

As concerns the performance of the network, and although the current network architecture offers level 2 fault tolerance, the number of simultaneous failures on the network, in particular on the France Telecom trunks remains an uncontrollable factor. Systematic oversizing of the network in order to remedy these failures, is a low-efficiency solution which is costly in terms of line leasing fees. The use of a switched type transmission medium to back up these basic trunks seems in this context to be a judicious compromise in terms of cost effectiveness.

Given the switched services offered by France Telecom today and the levels of performance required by RENAR, the use of NUMERIS ISDN as a final backup of the first network is essential. Connection of the two networks is thus under study, via the SUMO project (French acronym for final backup of operational network). This automated system will, in addition to improving RENAR availability, allow on-demand intermittent increase in the latter's bandwidth.

2.2.3 Messaging - AFTN

2.2.3.1 Overview

The French AFTN is constituted around the French message switching centre, installed on the Orleans-Bricy airbase, about 150 Km from Paris, and where is operated the national message handling system: the AERMAC (AERonautical Messages And Communications).

On an international level, the AERMAC system is connected to the CFMU on its 2 sites of Haren and Bretigny, and is directly linked with the AFTN centres of the following 8 countries: Spain, UK, Belgium, Swiss, Italy, Germany, Ireland and Algeria. The centre is also used as an entry and exit point for the traffic between Europe and Africa.

On a national level, the centre has simultaneous, bi-directional communication links with some 300 subscribers including:

- the SITA, the Air France and military networks,
- the 2 aircraft parking management systems of the Paris Airports,
- the French Meteorological centre,
- the central and local CAUTRA computers and
- teleprinters or other terminal in ATS reporting offices or airlines offices.

Currently, and with the exception of a CIDIN link which has been set-up at the beginning of 1997 between the AERMAC and the Frankfurt Centre, the connections with the CFMU, the foreign AFTN centres and the national subscribers are asynchronous and handled using standard AFTN procedures. The subscriber asynchronous messages are converted to X.25 synchronous messages before being transferred to and processed by the AERMAC.

In 1997, it is envisaged to replace some of the asynchronous links by CIDIN connections (the CFMU and the German, Belgium, English, Spanish and Swiss AFTN centres support CIDIN connections).

2.2.3.2 Topology

The topology is decentralised in terms of equipment, with a unique supervisory system. It consists of:

- the AERMAC is a stratus 600 computer which operates as a centralised connection and transit node for the AFTN. This central computer is fault-tolerant. It handles subscriber message exchanges, addressing and routing functions and offers specific electronic mail services such as multi-distribution, pre-determined addressing lists, priorities and archiving.

- front-end communications computers, known as CBMs (French acronym for low and medium rate concentrators) which relieve the central computer from its telecommunication tasks and handle asynchronous subscriber concentration. They operate as a PAD (Packet Assembler/Disassembler) by converting subscriber asynchronous protocol to X.25 synchronous protocol.

X.25 links are used between the central and the front-end communication systems. As a result these front-enders may be co-implanted with the message handler or remotely located. They are installed in the five French ACCs, and in the main airports. The AERMAC-CBM link is a master/slave.

The leased line supporting the X.25 connections between CBMs and the AERMAC are currently in the process of being replaced by the use of connections to the RENAR network. The current topology is depicted on Figure 6. The future topology is represented on Figure 7.

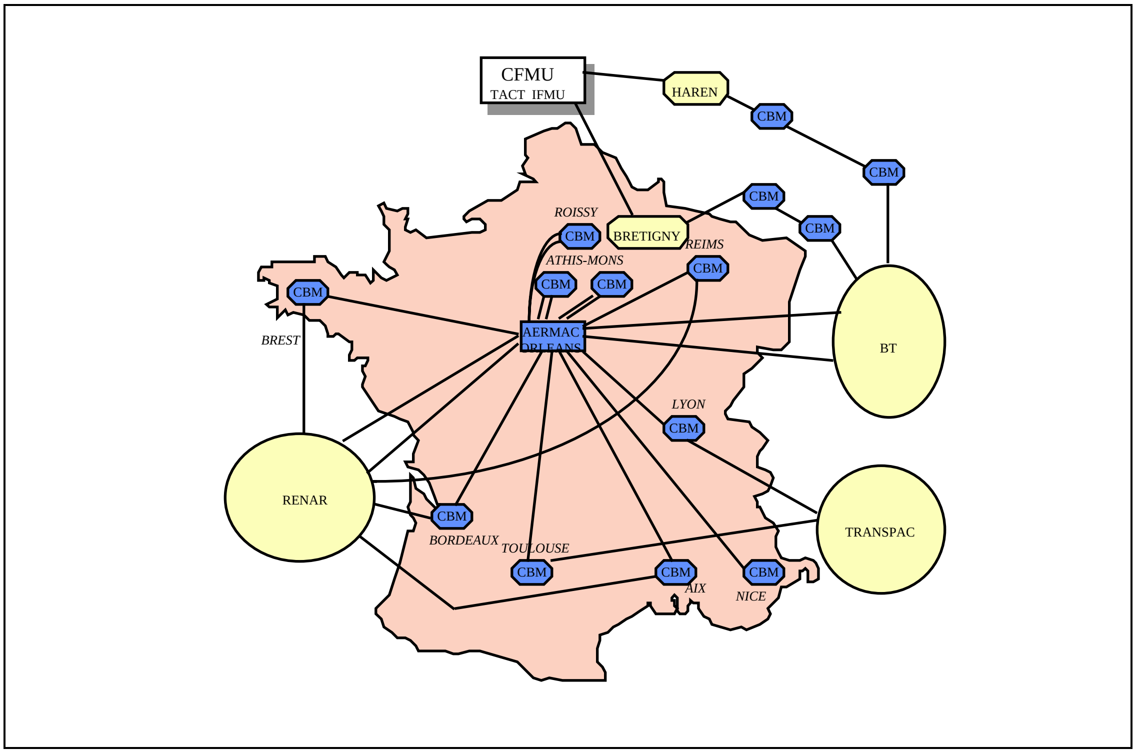

Figure 6: Current French AFTN topology

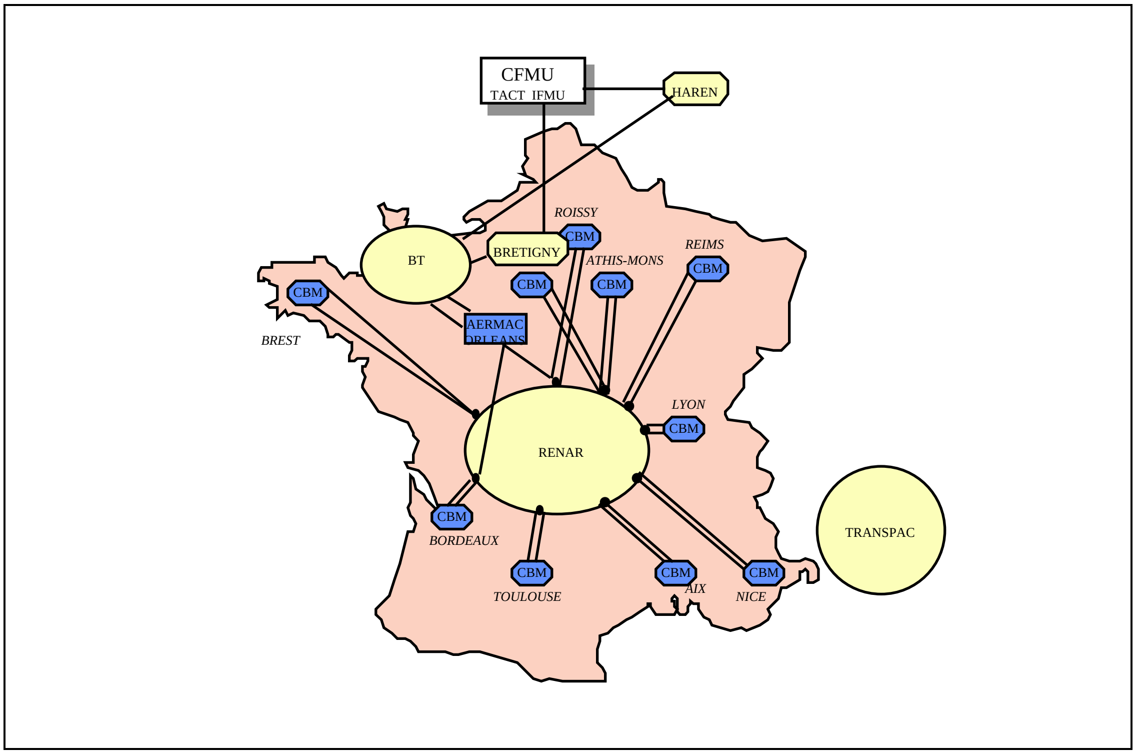

Figure 7: Future French AFTN topology

2.2.4 OLDI

Exchange of OLDI messages is established between all French ACCs and with the main airports in the Paris TMA and the other important airports in France, and between the French ACCs and the Swiss ACCs and the Maastricht ACC using a CAUTRA specific protocol.

French ACCs are connected with most adjacent ACCs through OLDI links, most of them following the OLDI standard (X.25;ST-ICD). the existing OLDI links are listed below:

- **Paris:** London, Brussels,
- **Reims:** London, Brussels,, Frankfurt, Rhein, Stuttgart
- **Aix:** Barcelona, Milan, Rome, PAlma
- **Bordeaux:** Madrid, Barcelona
- **Brest:** Madrid, London, Shanwick, Shannon, Jersey

2.2.5 Radar Data Exchange

The surveillance function in France is provided from 2 types of radar sites: civil radar and some military radar, used for civil purposes.

There are 5 French civil SSR (previous generation), 13 French civil MSSR (by Mid 96) and 2 Military PSR/SSR for En-Route surveillance. Some of them share radar data between 2 or more ATC units, as detailed in the tables below. The use of ASTERIX, as the European standard for radar data transmission is underway.

Radar in operation

Radar Name/Location	Civil/Military	Type	Units served
Boulogne	civ	MSSR	Paris Reims
Paris Nord	civ	MSSR	Paris Reims Brest Orly App Roissy App
Paris Sud	civ	MSSR	Paris Reims Brest Bordeaux Orly App Roissy App
Chaumont	civ	MSSR	Paris Reims Geneva
Nevers	civ	MSSR	Paris Reims Bordeaux Aix Geneva Orly App Roissy App
Grenoble	civ	MSSR	Aix Lyon App
Grasse	civ	MSSR	Aix Nice App
Auch	civ	MSSR	Bordeaux Aix Toulouse App
Avranches	civ	MSSR	Paris Reims Brest Jersey App
Tours	civ	MSSR	Paris Brest Bordeaux Orly App Roissy App

Bordeaux	civ	MSSR	Bordeaux Brest Bordeaux App
Mont Ventoux	civ	MSSR	Aix Marseille App
Biarritz	civ	MSSR	Bordeaux Brest
Brest	civ	SSR	Brest
Nantes	civ	SSR	Brest Bordeaux
Vitrolles	civ	SSR	Aix Marseille
Sainte Beaume	civ	SSR	Aix
La Chatre	civ	SSR	Bordeaux Aix
Narbonne	mil	SSR	Bordeaux Aix
Drachenbronn	mil	SSR	Reims
La Dole (Switzerland)	civ	MSSR	Paris Reims Aix
Espineiras (Spain)	civ	SSR	Brest
Randa (Spain)	civ	SSR	Aix
Monte Lesima (Italy)	civ	MSSR	Aix

Planned Radar:

Radar Name/Location	Civil/ Military	Type	Units served	Planned date of operation
Montpellier	civ	MSSR	Bordeaux Aix Montpellier App	4Q97 will replace Narbonne
Limoges	civ	MSSR	Bordeaux Aix	2Q97 will replace La Chatre

La Roche sur Yon	civ	MSSR	Brest Bordeaux	2Q97 will Replace Nantes
Grand Ballon	civ	MSSR	Reims Paris Bale Mulhouse App	4Q97 will replace Drachenbronn
Bretagne	civ	MSSR	Brest	98 will replace Brest
Corse	civ	MSSR	Aix	98

2.2.6 AIS

The Aeronautical Data Bank (BDA) is the tool made available to the French Aeronautical Information Service, to enable it to optimise the majority of the processing operations concerning temporary and permanent aeronautical information. The BDA is the central reference system of DGAC for NOTAM information. The NOTAMs, received from around the world via the AFTN, are entered into a data base, and may be corrected by the system or operators of the international NOTAM office and then re-issued. Similarly, requests for French NOTAMs received via the AFTN are converted into NOTAMs by the operators and released world-wide to system subscribers. Management of the AIP document tables is also the responsibility of the BDA. Two consultation interfaces for the information are offered by the BDA. A general public videotex service, and an advanced graphic interface provided to the regional aeronautical information services.

One of the main characteristics of the BDA is compliance with the NOTAM system standard defined by the ICAO.

The BDA server is situated in the Bordeaux CESNAC.

2.2.7 Data Link Applications

Two A/G data link applications are currently operationally used in France:

- The CLAIRE application aims at automating the generation of the departure clearance, with parameters derived from the CAUTRA and the aircraft, and its transmission to the aircraft via the SITA AIRCOM air-to-ground data link system. Over this VHF-based data link system, the ACARS free text mode is used for the moment. The next version will support the ARINC 623 and 622 formats, interface via X.25 to SITA and will be based upon the DCL service as recommended by EUROCONTROL. CLAIRE has been set up at Roissy CDC, Orly and Lyon Satolas airports and is used by the following airlines: Air Afrique, Air France, Air Canada, British Airways, Delta Airlines, Swissair TWA, United Airlines

- The ISATIS system enables the generation of the ATIS message and its transmission over ACARS data link. the pilot makes the ATIS request on his MCDU and transmits the request to the ground system via the SITA AIRCOM network; the ground system processes the request and transmits, via the SITA AIRCOM network, the ATIS which is then printed on the flight deck printer. ISATIS has been set up at Orly and Roissy CDG airports and is currently used by Air France and Delta Airlines.

2.2.8 Mode S

The current Ground Mode S infrastructure in France consists of:

- an experimental Mode S interrogator located in Orly, under DGAC responsibility
- an experimental Mode S interrogator located in Rouen, owned by DGAC and under Thomson responsibility
- an experimental Mode S GDLP (the MSGDLP) implemented on a Vax system and located in Orly. This GDLP is not compliant with the ICAO standard.
- the AGLAE (Air Ground Data Link Application Experimentation) mock-up allowing to experiment the Mode S Data Link. AGLAE provides a remote application connection service to potential Ground users of the air-Ground Mode S link and is currently used to experiment the airborne data collection, a controller-pilot trajectory negotiation application (E-FMS experimentation), a TAF/METAR application, and an ATIS transmission application.

This Mode S infrastructure is currently not compliant with the ICAO standards but is in the process to be made compliant by the following upgrades:

1) The MSGDLP is going to be replaced by one of the 3 T-GDLPs developed under Eurocontrol contract. This T-GDLP was installed in December 96 in STNA premises in Toulouse and will be connected to the Rouen and Orly interrogator via the RSTNA.
2) AGLAE is going to be upgraded to a new version, named GESCOM, which will take into account the new interface with the T-GDLP and will allow the CENA experiments to continue with the ICAO conformant Mode S infrastructure.

The following phase (pre-operational) will be triggered by the availability of the POEMS Mode S interrogator, planned to be delivered in September 1999. This first pre-operational unit will be installed at the current location of the experimental Mode S station at Orly, and will be tested on site first in isolation, then with links to the 2 other (UK and German) POEMS stations. According to the validation results and subject to an european co-ordinated deployment plan, a procurement is planned for the installation and the implementation of a first set of Mode S stations in the French core area. The installation of this first set of Mode S station would then took place by 2003 at the following location: Paris Nord, Paris Sud, Chaumont, Avranches, Boulogne, Le Grand Ballon. A second phase, not yet agreed, already identifies the procurement of a second set of mode S stations.

It must however be noted that this national strategy concerns the implementation of the Mode S Enhanced Surveillance service. No firm plan exists concerning the use of Mode S as an air-ground data link subnetwork.

2.2.9 VDL

No firm plan exists concerning the use of VDL as an air-ground data link subnetwork. However cost/benefit studies are underway.

2.3 Germany

2.3.1 Data Networking

With the exception of radar sensors and navigation equipment, all DFS locations involved in operational data traffic are equipped with one or several RAPNET nodes. These nodes are referred to collectively as the Packet Switching Network, PSN (formerly “DAKOS”) of the

DFS and represent a major part of RAPNET. All data networking is performed via RAPNET using X.25 as access protocol.

2.3.2 Messaging

The major applications using the national aeronautical messaging services are Flight Plan Processing (ZKSD) and AIS (NfL/GB). A messaging infrastructure over the PSN has been set up consisting of 19 nodes, each of which has a redundant configuration. There are 4 regional Network Management Systems and a central Network Management System in Frankfurt. This infrastructure is referred to as the “Value Added Network”, VAN.

Communication among the VAN nodes is with TCP/IP over X.25 together with a proprietary messaging protocol. Access of users to the VAN nodes is also with TCP/IP.

The VAN nodes also function as CIDIN entry/exit centres (“CIDIN Stations”). A major use of this functionality is for communication between the Frankfurt host computer (“Flugdatenverarbeitung”, FDV), on which the FPL and AIS applications run, and the VAN nodes. The VAN locations can be addressed directly from outside Germany with CIDIN addresses.

The international AFTN/CIDIN centre (Flugfernmeldezentrale, FFZ) is located at Frankfurt and is interfaced to the VAN. Although the FFZ is stable and currently able to cope with throughput requirements, an upgrade to include ATN functionality would not be possible. Its future replacement, the Advanced Node for Data Relay in the ATN, ANDRA, is currently in the planning stage.

National AFTN users (military) are not significant from a traffic volume point of view. The most important military data communications system is FsInfoSys in Goch. It is connected to the FFZ via CIDIN with a backup via leased line to London/Gatwick.

The logical relations on the message handling level are shown in Figure 8.

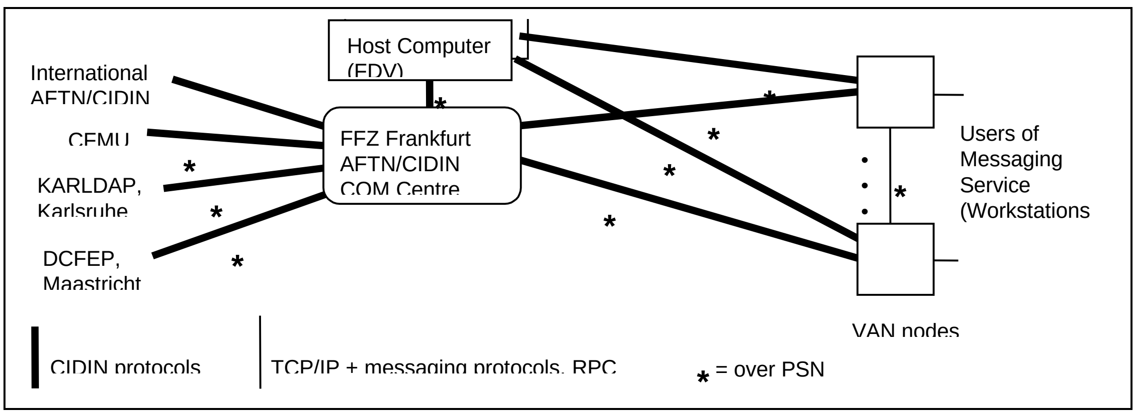

Figure 8: Logical relationships on a messaging level in the German VAN

2.3.3 OLDI

Co-ordination among German ATC units as well as between German ATC units and their international partners is performed via the flight plan processing system ZKSD in Frankfurt. This implementation departs from the normal situation in which OLDI messages are exchanged between controllers. The following list which is illustrated in Figure 9 shows the international OLDI logical “links”.

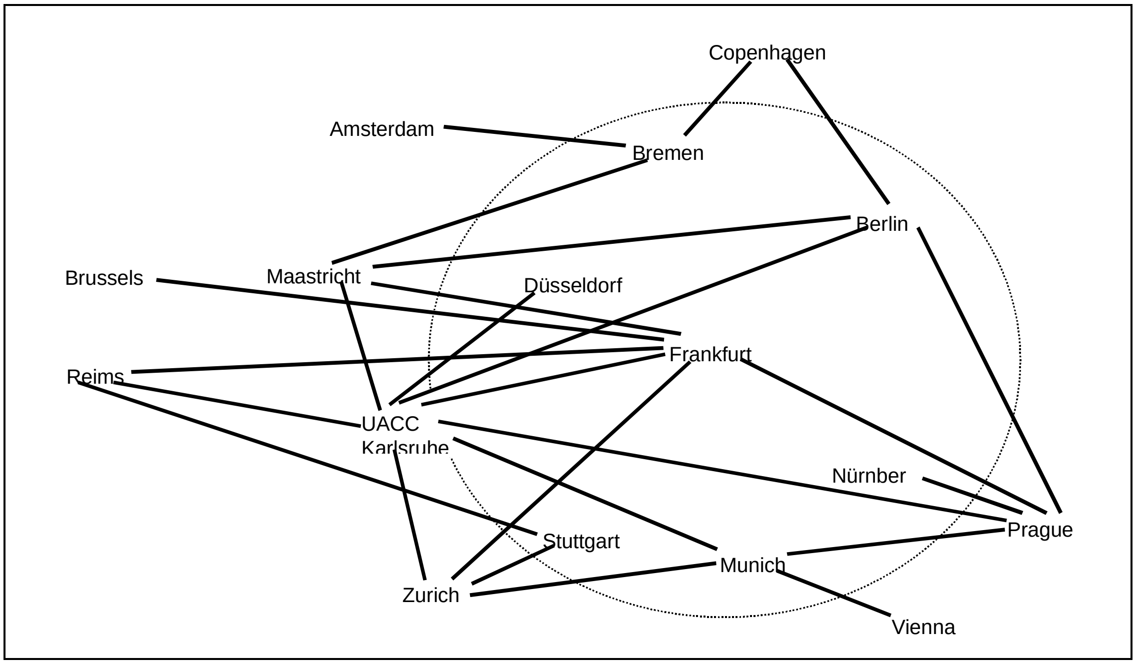

Figure 9: Logical international OLDI "links"

RK Bremen: Amsterdam, Copenhagen, Maastricht

RK Berlin: Maastricht, Copenhagen, Prague, Karlsruhe

RK Düsseldorf: Maastricht, Brussels, Karlsruhe

RK Frankfurt: Maastricht, Karlsruhe, Brussels, Reims, Prague, Zürich

RK München: Zürich, Vienna, Prague,

UACC Karlsruhe: Maastricht, Frankfurt, Reims, Zürich, Munich, Prague, Berlin, Düsseldorf

Stuttgart APP: Zürich, Reims

Nürnberg APP: Prague

Physical data exchange takes place over RAPNET, including its X.75 extensions.

2.3.4 Radar Data Exchange

RMCDEs are installed at the following 19 locations: Düsseldorf, Bremen, Frankfurt, Munich, Berlin, Karlsruhe, Nürnberg, Münster, Hannover, Köln-Bonn, Hamburg, Dresden, Leipzig, Frankfurt-Süd, Langen (Training Centre), Frankfurt (Test Centre), Langen (ACC), Stuttgart, and Offenbach.

ASTERIX is used as presentation format between RMCDEs.

For the purpose of radar data collection, approximately 30 radar sensors are connected to corresponding RMCDEs via leased lines.

2.3.5 AIS

The AIS database system of the DFS is located on a mainframe in Frankfurt and is a major user of AFTN/CIDIN. For the exchange of bulletins between Frankfurt and other German locations, the VAN is used.

2.3.6 OPMET

Aeronautical meteorological briefing is not provided by the DFS (by comparison with most aeronautical administrations) but by German Meteorological Service. For this purpose, the Service operates its own database system in Frankfurt and uses the AFTN/CIDIN.

2.3.7 Other Applications

The following additional applications and network users which create data traffic have been identified:

- administrative office communication, SAP applications, centralised information servers,
- Co-ordination Centre for Military Airspace Utilisation
- Departure Co-ordination System, DEPCOS
- WIAS Weather Information and Display System

The communication requirements of the P1 project which is a reimplementation of ATC support systems could have a major impact on the DFS communication infrastructure.

2.4 Ireland

2.4.1 Data Networking

At the present time Irish Aviation Authority (IAA) services use different data networks. In the near future there are plans to combine AFTN, OLDI and OPMET data on to the same new private X.25 network. The planned network is shown in Figure 10. The second phase of the network development will allow Radar Data Exchange, this is shown in Figure 11.

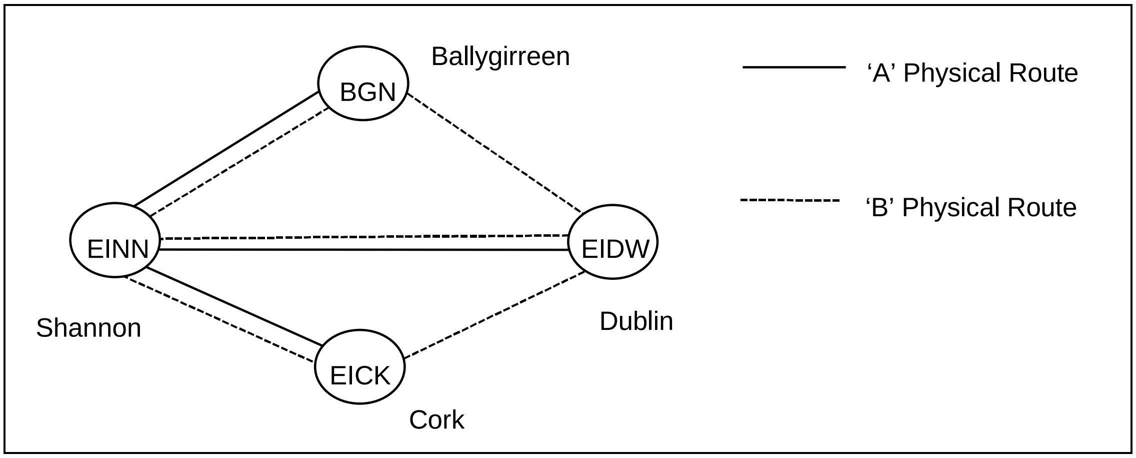

Figure 10: Phase 1 IAA data network

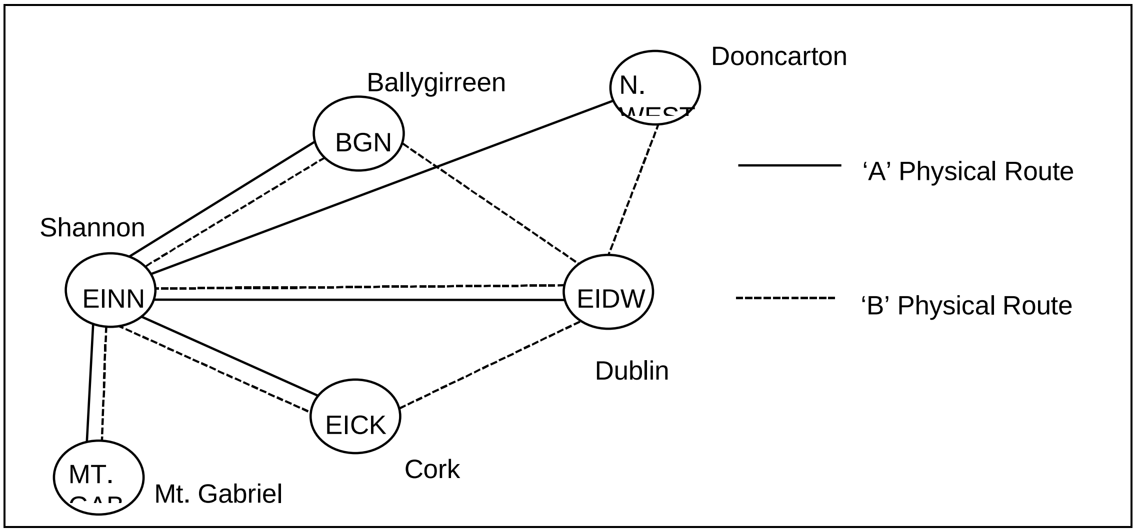

Figure 11: Phase 2 IAA data network

Note: local connections between Shannon ATCC and Radar sites Woodcock Hill and Shannon and connections between Dublin ATCC and both Dublin Radars are not shown.

2.4.2 Messaging

The current AFTN network has a star configuration with Ballygirreen AFTN switch at its centre, from this hub there are X.25 links to Shannon Area Control Centre (ACC) and Dublin ACC. A further X.25 link between Shannon ACC and London ACC also exists.

2.4.3 OLDI

Co-ordination between Irish ATC centres at Shannon and Dublin and the adjacent FIRs is currently carried out using a private X.25 network between the following locations:

Shannon: Brest, Dublin, London and Prestwick (Oceanic)

Dublin: London and Shannon

Note that the OLDI links to Shannon also carry OPMET and AFTN data from London.

2.4.4 Radar Data Exchange

The IAA Radar network consists of 8 radar sites connected to ATC centres at Shannon, Dublin, Cork, London and Brest. The following is a list of the Radar locations, their type either Primary Surveillance Radar (PSR) or Monopulse Secondary Surveillance Radar (MSSR), the ATC centres using the radar data and the format used:

Radar	Type	ATC Centre	Data Format
Woodcock Hill	MSSR	Shannon, Dublin & Cork	AIRCAT
Shannon	MSSR & PSR	Shannon, Dublin & Cork	AIRCAT
Dooncarton (N. West)	MSSR	Shannon & Dublin	AIRCAT
Dublin Head 1	MSSR & PSR	Shannon & Dublin	AIRCAT
Dublin Head 2	MSSR & PSR	Shannon & Dublin	AIRCAT
Cork	PSR	Cork	AIRCAT
Mount Gabriel Head 1	MSSR	Shannon, Dublin, Cork,	AIRCAT, RDIF

		London & Brest	& ASTERIX
Mount Gabriel Head 2	MSSR	Shannon, Dublin, Cork, London & Brest	AIRCAT & RDIF

2.4.5 AIS

The AIS data is received at the Ballygirreen AFTN switch.

2.4.6 OPMET

OPMET data is at present incorporated into the OLDI X.25 network. This data is broadcast from London to Dublin (State Services Building, Dublin Airport) where it is then sent to the MET service at Glasnevin.

The Meteorological data is sent from the National Meteorological Office at Glasnevin to Dublin and Shannon. To provide redundancy there is an AFTN link between Dublin and Shannon.

2.5 Italy

2.5.1 Data Networking

2.5.1.1 Transmission Equipment

Italy currently uses several types of links (cables, radio links, satellite links, etc.) to support ground/ground communications. According to their use, these links may be classified as voice lines, telegraphic lines, data lines and raw video lines.

Telegraphics lines are mainly used in the AFTN network. At national level, data lines are used for the exchange of data between the centrally located Aeronautical Operational Information Systems (AOIS) and the local Data Processing Systems in the ACCs as well as between the AOIS and other peripheral ATM Units. With the exception of one raw video line, data lines are used for the transmission of radar data from the radar sites to the ACCs' radar data processing systems.

2.5.1.2 Overview of AVNET

Italy is planning an integrated voice and data network, called AVNET. This network shall replace old data links and integrate separate subnetworks that exist today for voice communication, radar and flight related data and administrative message exchange.

High level requirements have been specified by AAAV (Azienda Autonoma di Assistenza al Volo), Italy's agency for air traffic and aeronautical services:

- AVNET shall integrate all existing services for voice and data communications
- packet switched network services shall be provided in a way similar to the existing networks in France (RENAR) and Germany (DAKOS).
- ICAO rules and EUROCONTROL standards must be taken into account for the network design
- the network shall conform to CCITT, ISO, ECMA, ETSI and national Italian standards
- the network shall connect all four Italian ACC's and all (ca. 35) national and international airports

Time schedules for the implementation of AVNET exist, but are rather provisional. The technical and functional specifications as well as the implementation plan for the exchange of aeronautical data and of radar data was expected to be available by the end of 1996.

The network will be owned and operated by AAAV, Italy's agency for air traffic and aeronautical services. It shall cater for all kind of ATS and AIS applications like radar data, flight plan and flight co-ordination data, OLDI, AFTN, CIDIN, NOTAM and administrative message exchanges.

A subnetwork for transmission of radar data already exists and shall be integrated. From about 10 radar stations data are transmitted via satellite to a central flight data processing system in Rome and distributed all over the country to CAAs and airports.

2.5.1.3 Planned Topology of AVNET

The network topology is not yet defined, but will likely consist of 4 or 5 main nodes located in

- Milano (ACC),
- Padova (ACC),
- Brindisi (ACC),
- Roma Ciampino (ACC) and
- Roma Salario (General Directorate with operational services).

Peripheral nodes will be located at sites of the two intercontinental airports in Milano Malpesa and Roma Fiumicino and probably further international and national airports.

The main nodes will probably be interconnected via n* 2 Mbps links (n=1..5) and the connections to peripheral nodes will probably consist of m* 64 Kbps links. The exact number of n or m respectively is still to be defined according to the user communication requirements that will have to be investigated.

Italy's agency recognises the need for interconnections to adjacent countries. Plans are being made and negotiations have already been undertaken with CAAs in France, Switzerland, Germany and Austria.

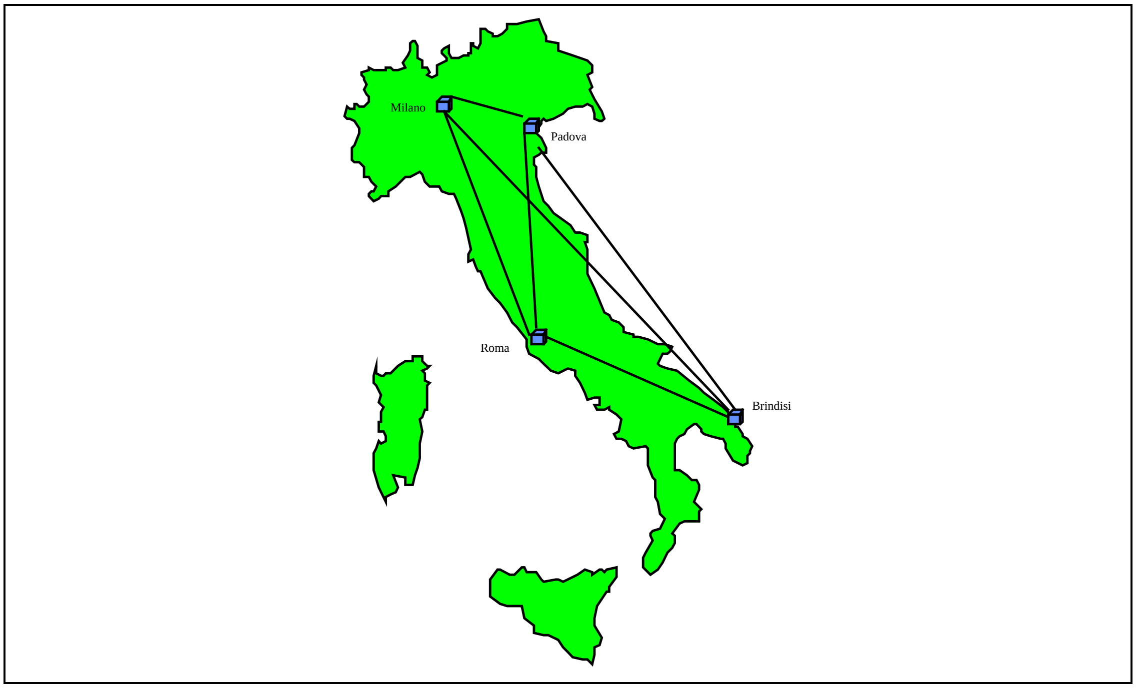

Figure 12: Planned configuration of AVNET

2.5.2 Messaging - AFTN

The Italian AFTN is constituted around the Rome ICC (International Communications Centre/Switching System). High-speed connections between Rome ICC and the CFMU/IFPS System have been implemented, in order to upgrade the AFTN Switching system to the required functionality.

AFTN connections are available between Italy (Rome ICC) and all adjacent AFTN Centres (Athens, Belgrade, Geneva, Ljubljana, Malta, Orleans, Tirana, Tunis, Vienna, Zagreb, Bretigny, Haren, Amman, Ankara, Bangkok, Cairo, Nicosia). the use of CIDIN procedures was planned to be activated by end 1996 with the AFTN centres of Athens, Geneva, Orleans, Vienna, Bretigny and Haren.

2.5.3 OLDI

Computer to computer data exchange with OLDI messages, for co-ordination with automated support (using the OLDI Standard /Short Term - Interface Control Document (ST-ICD)) is planned to be implemented between the Italian ACCs and the following groups of adjacent ACCs:

Brindisi ACC: Tirana, Zagreb, Belgrade, Athens, Padua, Rome

Milan ACC: Aix-en-Provence, Padua, Rome, Geneva (implemented), Zurich (implemented)

Padua ACC: Vienna, Zagreb Munich, Brendisi, Milan, Rome, Ljubljana, Zurich

Rome ACC: Aix-en-Provence (implemented), Athens, Brindisi, Padua, Rome, Malta, Tunis

2.5.4 Radar Data Exchange

The existing and planned radar stations are indicated in the following table:

Radar Station Name/Location	Type	ATM Units served

Brindisi Casale (Military)	PSR/SSR	Brindisi
Fiumicino (SELENIA)	PSR/SSR	Rome
Fiumicino (ATCR 33K)	PSR/MSSR	Rome
Fiumicino Maccarese	PSR/MSSR	Rome
Masseria Orimini	PSR/MSSR	Brindisi, Padua
Milan Lambro	PSR/MSSR	Milan
Milan Peschiera	PAR/MSSR	Milan, Padua
Monte Codi	PSR/SSR	Rome
Monte Lesima	PSR/MSSR	Milan, Padua, Aix-en-Provence, Zurich
Monte Stella	PSR/SSR	Brindisi, Rome
Poggio Lecceta	PSR/SSR	Milan, Padua, Rome
Ravenna	PSR/MSSR	Brindisa, Milan, Padua
Ustica	PSR/SSR	Brindisi, Rome
Adriatic Coast	MSSR	Brindisi, Padua
Calabria Region	MSSR	Brindisi, Rome
Sardinia	MSSR	Milan, Rome, Aix-En-Provence
Milan Malpensa	PSR/MSSR	Milan
Rome TMA	PSR/MSSR	Rome

At present, only the Mte Lesima MSSR radar data can be transmitted using the « Asterix » format. This format is planned to be used in all Italian radar stations.

The implementation of Mode S in the Italian part of the core area of Europe is under study. One Mode S radar head has already been foreseen for the Peschiera radar station, to be shared between Milan and Padua ACCs, and a second one for Rome ACC. Pre-operational trials are planned at Poggio Lecceta radar station.

2.5.5 AIS

– No information available when this version of the document was released. –

2.5.6 OPMET

– No information available when this version of the document was released. –

2.5.7 Other Applications

– No information available when this version of the document was released. –

2.6 Luxembourg

2.6.1 Data Networking

Luxembourg represents a single site from a data networking point of view. It is the location of one RAPNET node.

2.6.2 Messaging

The international AFTN message exchanges are performed via RAPNET and the Brussels AFTN/CIDIN switch, national exchanges via direct lines.

2.6.3 OLDI

Luxembourg does not yet participate in international OLDI communications. International OLDI communications are planned for 1999.

2.6.4 Radar Data Exchange

RMCDEs are installed which communicate via RAPNET.

2.6.5 AIS

AIS terminals are connected via RAPNET to the Belgian National AIS System Centre.

2.6.6 OPMET

There is access via AFTN to the OPMET database in Brussels.

2.6.7 Other Applications

No additional applications have been identified.

2.7 Netherlands

2.7.1 Data Networking

The centre of data networking in the Netherlands is at Amsterdam airport, the location of a RAPNET node. There is also a node operated by Eurocontrol at Maastricht. Fixed lines leased from the Dutch PTT connect Amsterdam in a star configuration with national airfields for messaging applications and for interfacing radar sites with the RMCDE. There is a pair of links between Amsterdam and London for OLDI communication.

2.7.2 Messaging

AFTN/CIDIN messaging is performed by the message switch AIDA at Amsterdam. International messaging is based on CIDIN only; for message exchange with national sites a simple, proprietary block-oriented protocol is used.

2.7.3 OLDI

OLDI communications exist between Amsterdam and

- Frankfurt,
- Maastricht and

- Brussels

via RAPNET. The communication with Frankfurt is via the application ZKSD there and allows logical connections to all German ACCs. For communications with London, direct links are used.

2.7.4 Radar Data Exchange

Duplicated RMCDEs are installed at both Amsterdam and Maastricht.

ASTERIX is used as presentation format between RMCDEs.

For the purpose of radar data collection, radar sensors are connected to corresponding RMCDEs via dedicated leased lines.

2.7.5 AIS

The AIS database system runs on dedicated hardware (DEC) and is located close to the AIDA installation. All access to the database is with AFTN/CIDIN via AIDA.

2.7.6 OPMET

The OPMET database, also running on dedicated hardware, is operated in the same fashion as the AIS database.

2.7.7 Other Applications

No additional applications have been identified.

2.8 Portugal

2.8.1 Data Networking

The Portuguese ATSO, ANA, is planning the introduction of a data network to be operated by a service organisation [EAT3]. The planned configuration is shown in Figure 13.

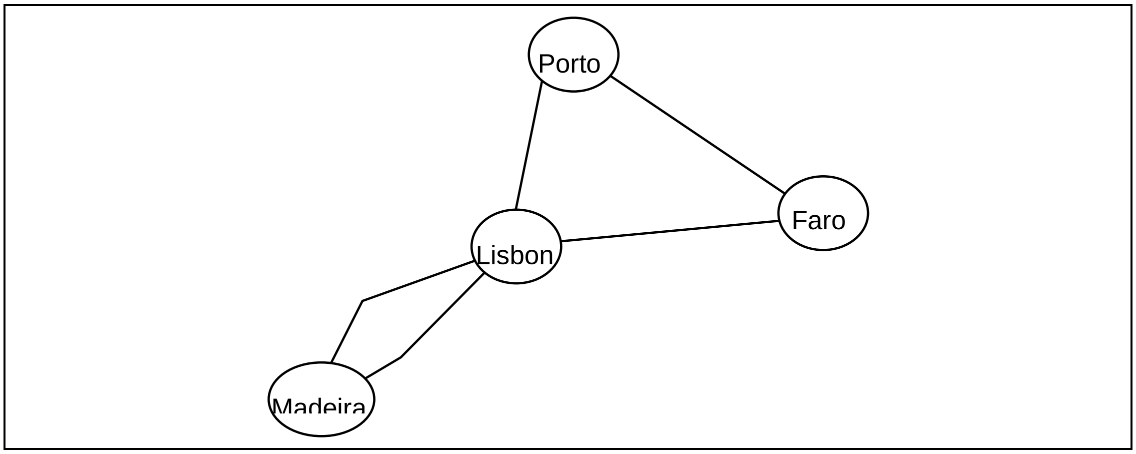

Figure 13: Configuration of the planned Portuguese network

Line speeds are planned to be 64 kbps. In addition to the four switching nodes shown in Figure 13, 8 access nodes are planned.

The future ‘Data Network’ will use multiplexers to share bandwidth with the ATS voice and point to point data applications currently available. The multiplexer network will use digital links (64Kbits/s or 128 Kbits/s) connecting the main centres (nodes) of traffic listed below:

- ATS Centre (Lisbon)

- National Airports (Porto, Faro and Funchal)

Where needed, it is planned to install X25 switches and routers (TCP/IP, TP4/CLNP) linked by Frame relay, PPP or X25 protocol services to interconnect with Ethernet or FDDI LANs. These systems would be installed on the main nodes and collocated with the multiplexers.

X75 or X25 will be used for the interconnection to other networks.

2.8.2 Messaging

The international AFTN/CIDIN switching centre is located in Lisbon.

2.8.3 OLDI

– No information available when this version of the document was released. –

2.8.4 Radar Data Exchange

– No information available when this version of the document was released. –

2.8.5 AIS

– No information available when this version of the document was released. –

2.8.6 OPMET

– No information available when this version of the document was released. –

2.8.7 Other Applications

– No information available when this version of the document was released. –

2.9 Spain

2.9.1 Data Networking - REDAN

2.9.1.1 Overview

REDAN is the Spanish ATC private Wide Area Network. It is a value added network made up of an X.25 network and value added service elements which integrate Air Navigation data communications and guarantee their interconnection with international Aeronautical communications systems.

The network is owned and operated by Aeropuertos Españoles y Navegación Aérea (Aena), the Spanish CAA.

2.9.1.2 Topology

REDAN is a meshed network with 4 main switching nodes in Barcelona, Madrid, Sevilla and Gran Canaria. The switching nodes in Madrid, Barcelona and Sevilla are connected with two, three or five 64 Kbps lines, the node in Gran Canaria can be reached via Madrid or Sevilla over duplicated 64 Kbps lines. From the core network peripheral 64 Kbps links go to access nodes in Bilbao, Santiago, Palma de Mallorca, Valencia, Malaga and Tenerife Sur.

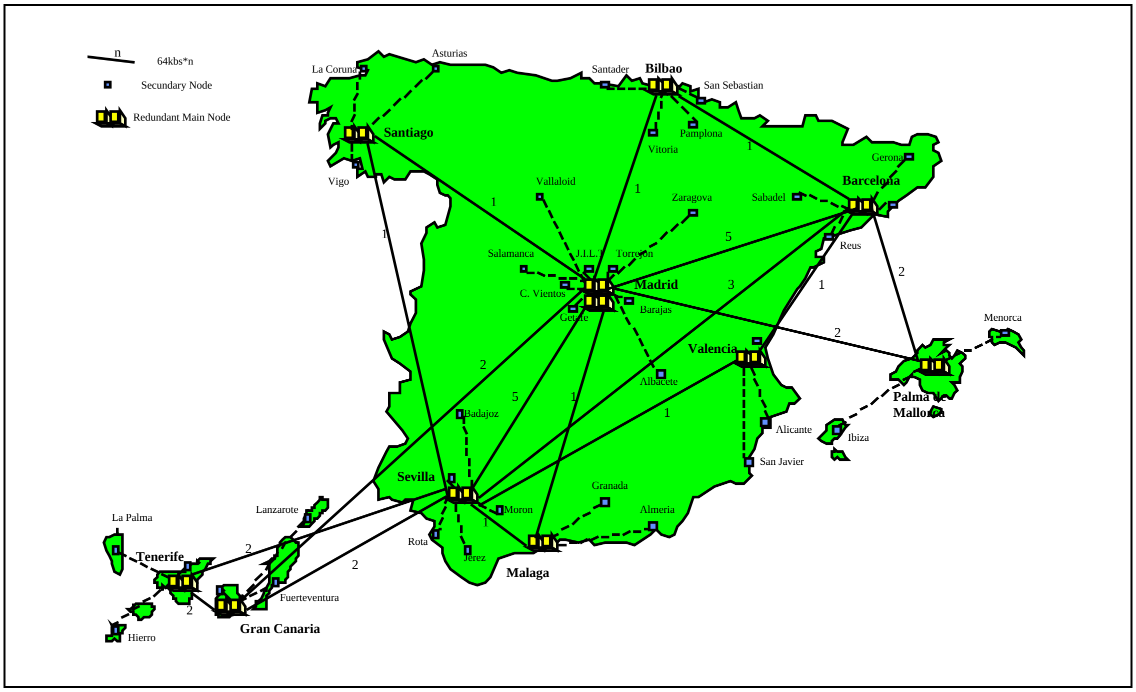

Figure 14: Configuration of REDAN

In the national environment, REDAN is interconnected with IBERPAC (Spanish X.25 PSPDN). Besides, plans of internetworking with aeronautical networks of neighbouring countries shall be defined, specifying applications to be shared.

2.9.1.3 Technology and standards

As RENAR, REDAN uses the Northern Telecom DPN-100 Access and Switching Elements in redundant configuration.

REDAN implements the following protocols:

- X.25
- X.3 / X.28 / X.29 and X.32

Both PVC and SVC services are provided. Furthermore, the implementation of Frame Relay services is foreseen in the future.

2.9.1.4 Addressing

The addressing scheme is fully compliant with X.121.

2.9.1.5 Performance and QOS

The maximum transit delay for a data packet across the network is expected to be 250 ms.

The maximum switching delay for a data packet across a mode is expected to be 10 ms.

The network node throughput for a 128 byte/packet complies with the port capacity defined for service and in any case, for basic nodes, this parameter can be increased until the value of 2400 pps, as a minimum

The availability figure presented by nodes is high.

2.9.1.6 Network Management

The REDAN Network Management is centralised around the Network Management System located in Madrid. Remotely, the system allows the management of all Network elements.

For management of DPN equipment a specific software supplied by Northern Telecom is used. SNMP is used for other elements (Modems, Routers).

The Network Management system is supported by SUN Units in redundant configuration.

2.9.1.7 Principal uses/services

REDAN is currently operationally used to support the following data traffics:

- Radar messaging applications
- FMU
- EDS (Management system)
- COM/AIS
- SACTA Remote Positions
- OLDI
- Electronic Message service (X.400)

2.9.1.8 Future Plans

Interconnection of REDAN with the French RENAR Network is being investigated.

In a future stage, REDAN will provide Frame Relay Services

2.9.2 Messaging

– No information available when this version of the document was released. –

2.9.3 OLDI

– No information available when this version of the document was released. –

2.9.4 Radar Data Exchange

– No information available when this version of the document was released. –

2.9.5 AIS

– No information available when this version of the document was released. –

2.9.6 OPMET

– No information available when this version of the document was released. –

2.9.7 Other Applications

– No information available when this version of the document was released. –

2.10 UK

2.10.1 Data Networking - CAPSIN

With the exception of radar and navigation equipment sites, all NATS locations involved in operational data traffic are equipped with one or more CAPSIN (Civil Aviation Packet Switching Integrated Network) nodes.

2.10.1.1 Topology

The CAPSIN network has undergone a topology transition from a loop based "Olympic" ring style topology to one that is based on a combination of hierarchical layers of network nodes with a high performance central core, whilst using an area based address allocation policy to allow independence between address allocation and physical topologies.

The benefits of this new topology are higher availability, independence from single PTT failure, flexibility for growth and changes, and reduced transit times.

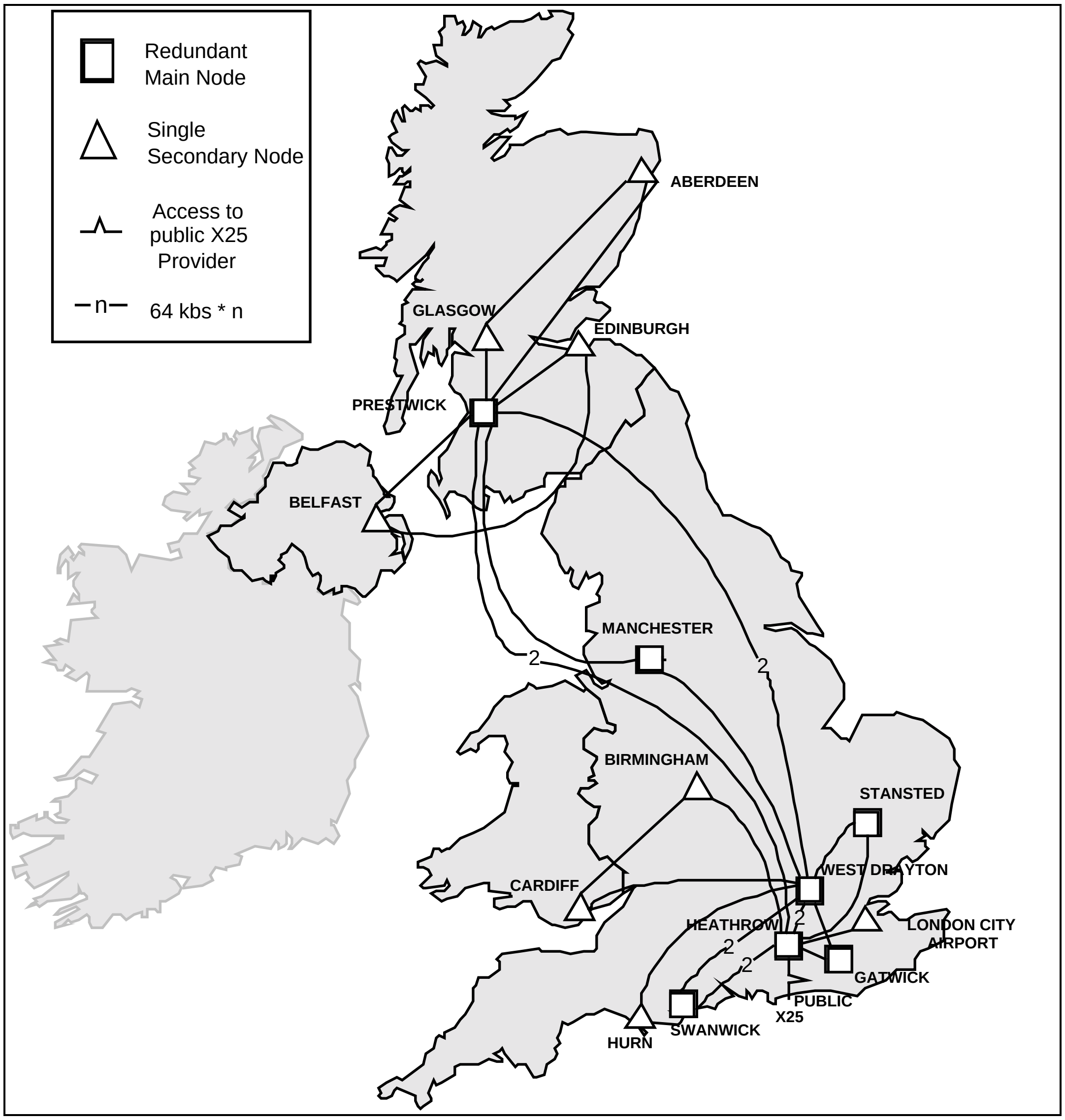

Figure 15: National diagram of nodes and connections

The Core of the topology operates using Telematics Network Protocol (TNP) to link sets of switching equipment that are arranged to provided dual on-line nodes. Each of these switching equipment has a minimum Core network connectivity of three. This arrangement is able to provide an extremely high availability service suitable for ATC area control centres.

Attached to the Core are smaller sets of Network switching equipment, linked by TNP, that again provide dual on-line nodes. Each of these switching equipment has a minimum network connectivity of two. This arrangement provides a high availability service suitable for ATC airport control.

Attached to either Core or Network nodes are access equipment, linked by X.25, that may provide for dual or singly connected services. Each of these equipment has a minimum network connectivity of two at sites with ATC operations, and single at other sites.

The topology diagram above shows only the main internal connections, there are too many actual connections to represent on a single diagram with any clarity.

The network has many international connections to support inter-FIR and inter-regional communications requirements.

2.10.1.2 Technology and Standards

The network operates on proven technologies that are also in service providing public data services. The equipment being deployed have all been software based for some time.

The network uses or offers services based on the ITU-T standards for packet switching networks. Specifically X.25, X.75, X.3, X.28, X29 and associated standards.

Assurance of conformance to these standards is provided by a combination of automated NET2 conformance tests and scenario based test scripts for additional areas.

In addition the network internally uses Telematics proprietary protocol TNP. This provides a number of benefits compared with the basic ITU-T protocols, whilst using them as a basis. The benefits of TNP include, simplification of routing tables, automatic re-routing to avoid failed links, seamless reconnection of calls on link failure and the conversion of external PVCs into SVCs so these gain all of the same benefits.

2.10.1.3 Address Allocation and Routing

All Network User Addresses (NUA) allocated for use within the network are based on the ITU-T X.121 standard. NUAs are allocated for physical connections, network equipment and software entities that may reside either within the network or in external host computers. CAPSIN has registered a Private Network Identification Code (PNIC), 235235.

The routing policy ensures that calls connect via the shortest available route over the network, and that calls may connect whenever a physical route is available.

The basic routing policy allows for any to any peer connectivity, subject to the requirements of the security policy.

The routing policy automatically prevents call bounce and circulation which could otherwise over allocate resources on the network.

2.10.1.4 Performance and Quality of Service

The network design permits a range of service qualities to be offered. Quality of service typically meaning the reliability and availability of the service within the required communications parameters, such as data throughput, transit delay etc. We ask subscribers to identify what requirements they have and match these with an appropriate design, service offering and price.

The process of network design and subscriber connection is arranged to ensure that the load on the network does not invoke flow control to the subscriber. In practise this is achieved through a combination of pre-connection modelling and post -connection monitoring.

The network management systems provide automatic collection of performance statistics for analysis and verification.

Over allocation of resources is taken care of through a combination of priority, and an automatically invoked staged load reduction algorithm to manage the problem without crashing a network node. This of course would only be invoked in the circumstances of a serious error, however it provides assurance that the network will not crash even under the most severe of circumstances.

2.10.1.5 Network Management

The network comprises equipment from two manufacturers, each having proprietary management systems. The management of Telematics nodes is carried out through an embedded software task called Interactive Network Facilities (INF). The management of the remaining Camtec access nodes is carried out through a separate host computer connected to the network, running an Informix database called OPTIO.

In both cases the management systems are duplicated, with automated switch-over for INF and manual switch-over for OPTIO.

The network management systems are centrally operated from the CACC at Heathrow Airport, with contingency systems in place at other sites. The CACC has H24 operations staff to provide for fault reporting and recovery.

The network management systems provide tools to assist with configuration management, collection of performance statistics, alarm monitoring, and implementation of the security policy.

2.10.1.6 Test and Development Facilities

In order to support the many groups carrying out software development and testing for computer systems that support the ATC operational environment, a separate set of network nodes are provided, with interconnection to the live network for the supply of live data, and for network management purposes.

This valuable interconnection could present a security risk and this is why the network facilities that are supporting the test environment are operated under the same security policy and configuration control restrictions as the operational network.

The security policy restricts communication between these parts of the network so that the computers in use for software development do not have to be subject to the same level of configuration control restrictions as their operational counterparts.

Test and development network facilities are available at several NATS sites and are not shown in the topology diagram above.

2.10.1.7 Applications

The design of the network makes it suitable for ATC, aviation and other safety and mission critical applications. When a new application is to be connected the process for obtaining connection ensures that the characteristics of the new application will not interfere with existing applications.

There is a substantial list of applications that are using the network, including:-

- NAS IRVR
- AFTN SMF
- OPMET NARIC
- MARS RCMS
- CBS ATN/ADS
- AIS RAASCLE
- OLDI POEMS

- DRDF

Some of these applications require multicast functionality. Multicast facilities are provided by the network using an embedded software task, this is called the Multiple Address Facility (MAF). The MAF provides a flexible way to create n:n entity relationships, over X.25 which does not as standard provide this functionality. The facilities available are based on the options available within the ITU-T X.6 standard. MAF reduces the capacity of the required multicast servers and provides for highly optimised broadcast distribution, significantly reducing the network bandwidth required and consequently increasing system performance.

2.10.1.8 Future Plans

2.10.1.8.1 Topology

The future challenges are mostly concerned with how to change and grow whilst improving the performance for existing services without interruption or enforced upgrades. This requires a software upgradable communications architecture, flexible hardware, and independence between physical topology and logical assignments such as routing and address allocation. In different parts of the network we have achieved these to varying degrees.

In the Core layer we will be using hardware that does not enforce a connectivity trade off as bandwidth is expanded up to 2M.

In the Network layer we will be installing more concentration nodes to increase the independence between layers, again to increase flexibility.

In the access layer we will be replacing Camtec nodes.

The networks international connections will be strengthened and reduced by an on going process to interconnect the data networks of European Air Traffic Service Operators.

2.10.1.8.2 Technology and standards

For the international connections we will be implementing more links using ITU-T X.75 in place of X.25.

As all communications tend towards data, then the standard protocols that are in use and readily available are changing. To this end Frame Relay (FR) and Internet Protocol (IP) are becoming market leaders and our strategy is to implement these as demand and benefits dictate.

All the technologies we are implementing will be suitable for ATN applications.

In conformance testing we are intending to switch to using an implementation of ISO 8882 in the near future.

2.10.1.8.3 Network Management

The management centre is in the process of being relocated to a new centre at Gatwick.

In communications the general trend of management is towards greater centralisation to improve economies of scale. To this end we will be installing standard management systems that will permit end to end, service oriented management.

2.10.2 Messaging

The AFTN/CIDIN message switch is currently located at Heathrow Airport. The AFTN data is delivered to/from national users via CAPSIN.

CIDIN is only used for international communication, it is not used for internal message distribution.

Existing CIDIN Links: Iceland, CFMU (two point to point links into the 'BT VAN')

Planned CIDIN Links: Amsterdam, Brussels, Lisbon, Orleans and Montreal.

Note: There is also an X.25 link to Singapore.

There are plans to replace the message switch with an X.400 compliant message switch by 2001. This message switch will be located at Gatwick.

2.10.3 OLDI

Co-ordination among UK ATC units is performed by the flight plan processing systems at the ATC units in Prestwick and London. The following list shows the OLDI links to locations outside the UK:

London: Amsterdam, Brest, Dublin, Jersey, Maastricht, Reims and Shannon

Prestwick: Brest and Shannon

Planned OLDI connections:

London: Brussels, Copenhagen and Paris

Prestwick: Madrid and Lisbon

Note the OLDI links to Shannon also carry OPMET and AFTN data.

2.10.4 Radar Data Exchange

UK RADNET is a stand alone data network which will be used for the exchange of radar data between ATC centres within the UK. The network will be operational in Autumn 1997. RADNET will support three data formats, one of which is ASTERIX.

2.10.5 MET/AIS

NATS operates a database system known as MARS (Meteorological and AIS Retrieval System); the MARS terminals are remote and communicate with a central database using CAPSIN. The terminals are located at aerodromes within the UK.

2.10.6 OPMET

Aeronautical meteorological briefing is provided by NATS. The OPMET data is compiled by the AFTN message switch at Heathrow Airport. It is then distributed to users connected to CAPSIN.

NATS is the source of OPMET data distributed by satellite broadcast, SADIS.

2.10.7 Datalink Applications

There are two A/G datalink applications that are currently used in the UK:

The first is the Gatwick Pre-Departure Clearance System (PDCS); this is a trials system which conducts Departure Clearance delivery transactions with suitably equipped aircraft participating in the trials. The system uses the air-ground VHF datalink service provided by SITA to support data communications with the pilot. The message structure used in the trials system is strictly as defined for ATS character-based applications in ARINC standards 620, 623 and 622 (if required by the airline).

The second is the use of an operational VHF Datalink service to westbound trans-Atlantic flights seeking Oceanic Clearances at the Prestwick ATCC. NATS commenced this operational service on 11th November 1996. This service allows suitably equipped flights to request, receive and acknowledge Oceanic Clearance Messages (OCM).

The air-ground datalink was provided by the SITA AIRCOM service using SITA's AIRCOM Service Processor (ASP) and network of Remote Ground Stations (RGS). The Aircom service was accessed from Prestwick via SITA's Data Transport Network (DTN) which incorporates a Message Storage and Switching System (MSS).

The Project's initial strategy was to offer only an "ARINC 623" service to airlines in accordance with airline views expressed at NATS "Oceanic Trials Working Group" and in the proceedings from AEEC meetings where the ARINC 623 standard was agreed.

Simultaneously, NATS were concerned to maintain the service offered previously to trials participants. For these reasons the Project requirement was amended in early 1995 to accept:

1) airline specific message formats,
2) the ARINC 623 message set and
3) a simplified mode of operation corresponding to that provided by the previous trials system.

Since November 1996 the system has operated with varying success. There have been several instances of prolonged message delivery times causing datalink transactions to break down. The operational inconvenience this causes has caused NATS to accept, for the moment, that a reliable service cannot be supplied to airlines. In the meantime joint SITA/NATS task team are investigating performance problems.

2.10.8 VDL

No firm plan exists concerning the use of VDL as an air-ground datalink subnetwork. However cost benefit studies are underway.

2.10.9 Other Applications

There is a business oriented data network within NATS but it is kept separate from the operational network and will not form part of the ATN.

3. Regional Networks

It is convenient to describe separately those networks which are not restricted to one country. Apart from the international AFTN/CIDIN, these are the CFMU network and the RAPNET.

3.1 CFMU Network

3.1.1 General

The following description concentrates on the CFMU usage of data communication facilities from the viewpoint of a possible long-term migration to an application-independent, common network such as the ground ATN. It does not consider in detail the design decisions which have been made and which have led to the current configurations.

The CFMU installations [LUX1] at Haren and Brétigny consist of large computer systems, most of which are redundant configurations for backup and test/development purposes. At each site the systems are connected by means of LANs. In keeping with the approach of this report, only wide area communications are described below.

CFMU operations are, by definition, highly international and there are a number of different data traffic types. The only international aeronautical messaging networks available when CFMU networking was planned were the AFTN/CIDIN and the SITA Type B network. By itself, the existing AFTN/CIDIN at that time was not able to satisfy all CFMU requirements and needed to be supplemented. For non-messaging traffic new solutions were required.

Basically three types of WAN communications need to be supported:

- communications to AFTN/CIDIN and SITA via a message switch “AN1”,
- communications using proprietary IBM protocols (SNA) via the front end processor “AN2” (IBM 3745) and
- LAN-LAN connection via IP-routers.

These requirements have led to a major networking infrastructure implemented and used by the CFMU.

3.1.2 CFMU Use of BT Services

Network services provided and managed by BT are used as a virtual backbone for CFMU communications. Packet switching (CPS) and frame relay (CFRS) services from BT are subscribed to by CFMU. The structure of the network providing the service is not visible (and probably not of interest) to CFMU.

The operational connections to the BT network, mostly at 64 kbps, are shown in Figure 16. A similar configuration is present in Brétigny. There the access points are Paris (La Défense), Lyon and Geneva.

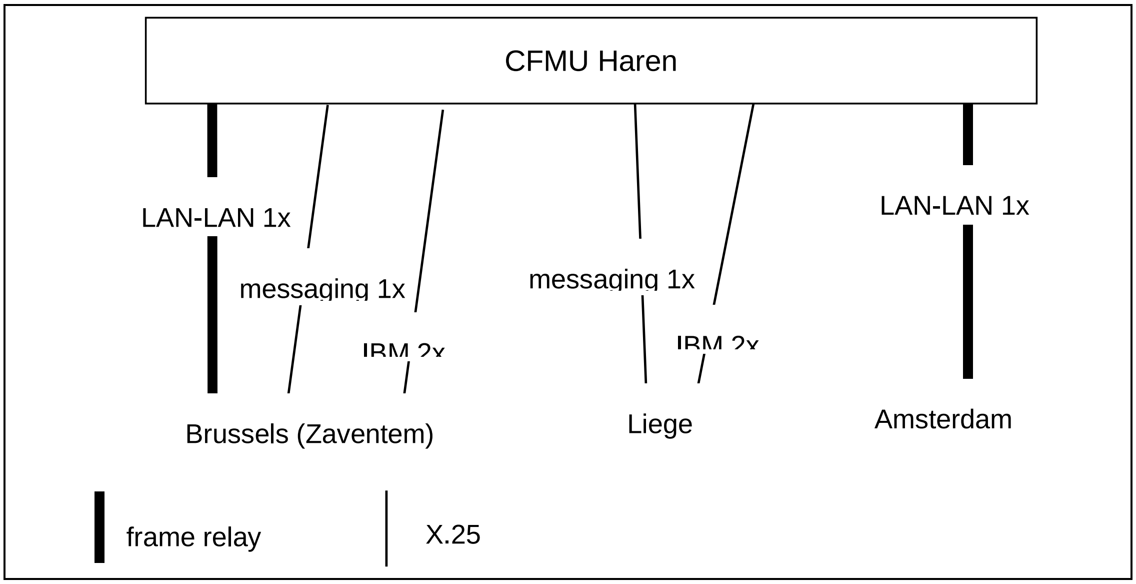

Figure 16: Configuration of WAN connections at CFMU Haren

This situation illustrates the situation when using the offerings of a service provider whose nodes are not co-located with the user and when high availability is a requirement: long, multiple leased lines to access nodes may be necessary. These are dedicated to only one type of traffic.

High availability is also a requirement at the (approximately) 60 Flow Management Positions located in ACCs and distributed widely across Europe. This application makes only light use of the dedicated 9,600 bps lines accessing the BT network. Its communication paths go via the IBM front-end AN2.

Duplicated dedicated backup access lines could not be justified for the flow management positions at ACCs: backup is provided as needed by switched PSTN connections - see the configuration shown in Figure 17.

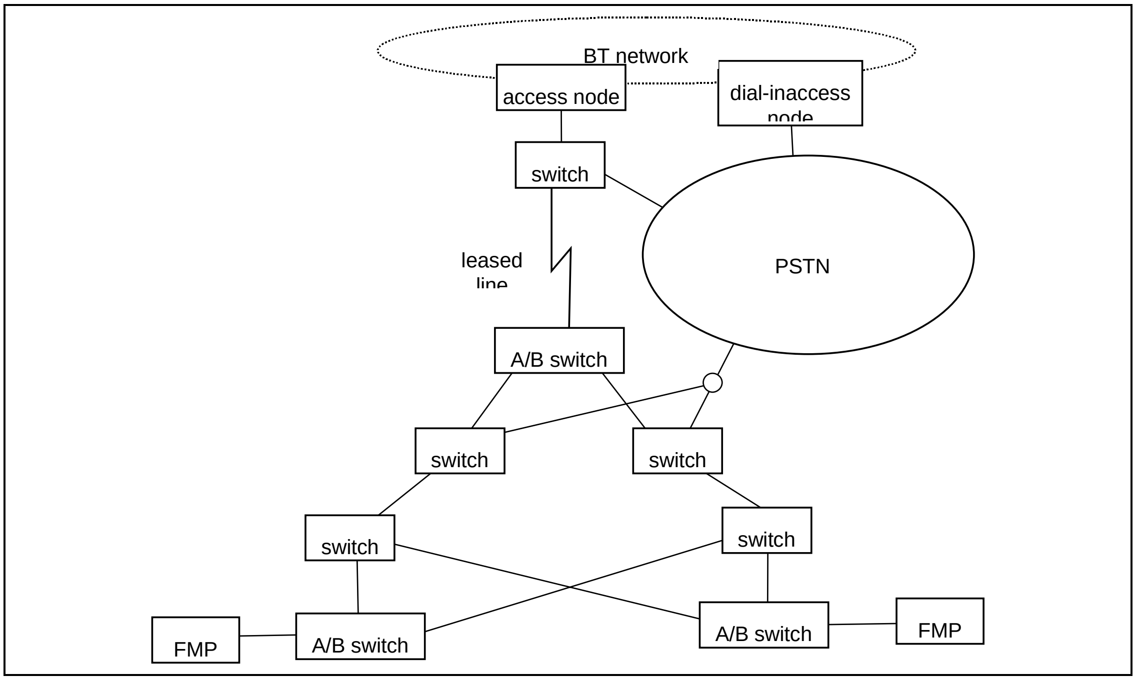

Figure 17: Connection of flow management positions, FMPs, to the BT network

3.1.3 CFMU Use of AFTN/CIDIN and SITA Networks

For the support of messaging applications, connections between the CFMU messaging front-end computers, AN1, to AFTN/CIDIN and SITA (Type B) networks are necessary. Other networks do not provide the necessary connectivity among aeronautical users. However, because of the large volume of message traffic generated and processed by the CFMU (comparable with that handled by a major AFTN/CIDIN switch), channelling the traffic through one or even a small number of switches would cause major bottlenecks. For this reason, the virtual network provided by BT is used to distribute message traffic across 6 AFTN/CIDIN nodes and 2 SITA nodes using X.25 services - see Figure 18. Note that also here leased lines are necessary to connect BT nodes with AFTN/CIDIN and SITA nodes.

With this method of accessing the AFTN/CIDIN, a significant overlay of the EUR AFTN/CIDIN has been implemented. This is justified by the large fraction of AFTN/CIDIN traffic which is destined for / originates in the CFMU. However it also represents a major duplication of resources since the AFTN/CIDIN extends almost up to the CFMU locations (Brussels, Paris). The CFMU only functions as a source/sink of message traffic and, in spite of the geographical coverage of its AFTN/CIDIN access, performs no routing functions in the network.

The design decisions leading to this configuration are partly a result of the state of AFTN/CIDIN at the time the CFMU network was being implemented. In the meantime the configuration and capacity of AFTN/CIDIN has evolved considerably.

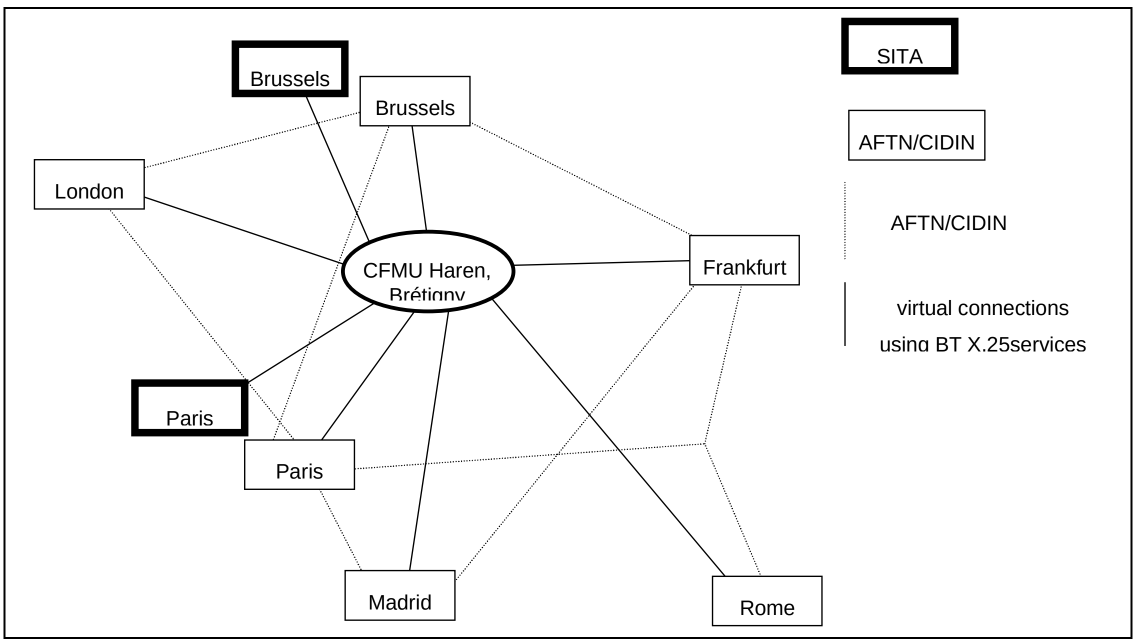

Figure 18: CFMU access to AFTN/CIDIN and SITA

Currently CFMU messages are transferred in AFTN format via CIDIN and AFTN protocols to the centres shown in Figure 18 and as SITA Type B messages to the two SITA nodes. No use is made of the fact that AFTN messages can be addressed directly via CIDIN addresses to many locations.

A general use of the ADEX-P presentation format, is planned by CFMU. It is already in use in the TACT application (non-AFTN communication) and in operational replies from the IFPS application. In the latter case, messages have to be restricted in length because of AFTN formats (even if the AFTN formats are being transmitted via CIDIN). General usage requires other solutions.

One solution to this problem would be the direct use of CIDIN for the message transmission without AFTN formats (an “ADEX-P application” of CIDIN). This is possible, in principle, in all AFTN/CIDIN nodes shown in Figure 18 and in a large number of adjacent nodes as well. Another possible solution would be the direct use of the AMHS (an “ADEX-P application” of AMHS) for those users with AMHS user agents. A conversion to and from CIDIN messages would have to be performed in CIDIN/AMHS Gateways for those users not participating in the AMHS.

3.2 RAPNET

The RAPNET is a packet switched data network with nodes at sites in Germany, The Netherlands, Belgium and Luxembourg. It is based on DPN100 switching technology from Nortel. Figure 19 shows the current (April 1997) configuration. The network is “closed” in the sense that protocols used between pairs of nodes are proprietary and specific to DPN100 products. External access is by means of X.25 and X.75.

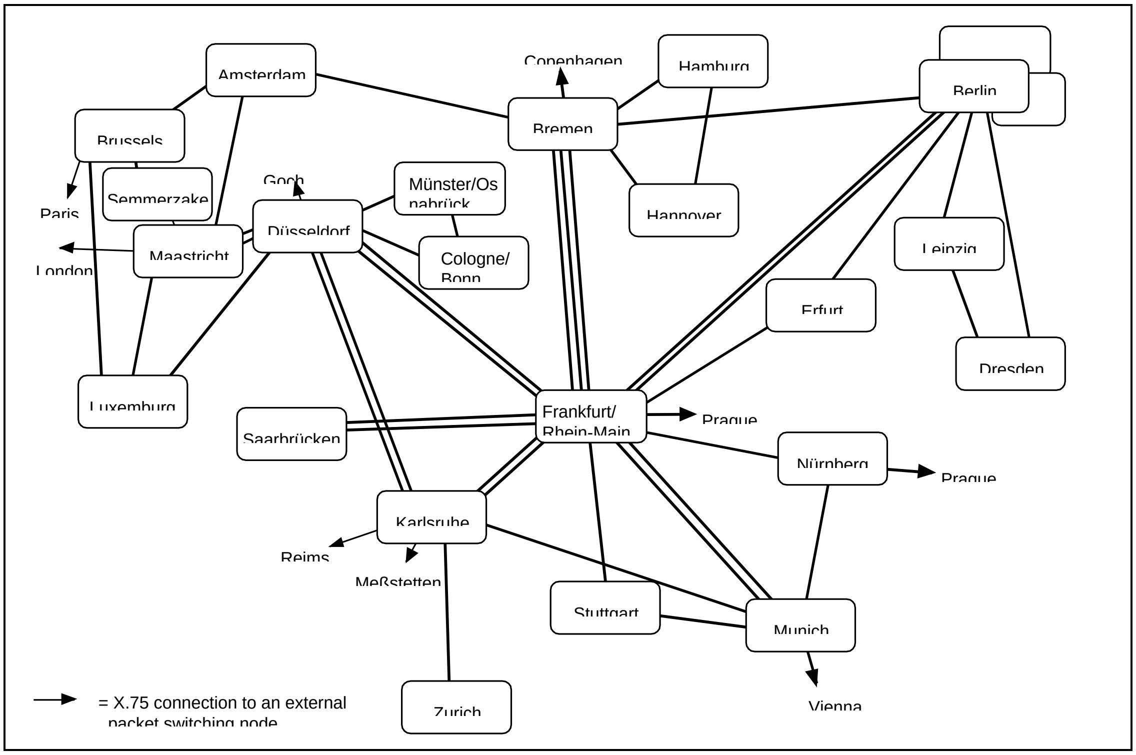

Figure 19: RAPNET configuration

There are 22 nodes which, depending on the use made of the network at a given location and on the status of the location in the network, are made up of different components from the DPN100 product family. The locations Berlin and Frankfurt contain independent nodes. In the Frankfurt area a 2 MB backbone ring using Nortel Passport systems has been set up which connects the sites separated by distances of the order of 10 km- see Figure 20.

The links between nodes shown in Figure 19 are provided by Deutsche Telekom and other (former) PTTs. In general, they have a speed of 64 kbps, the thin lines represent links at 9.6 kbps. In the cases where nodes are connected by “parallel” links, these follow, as far as possible, independent paths in the Telekom network.

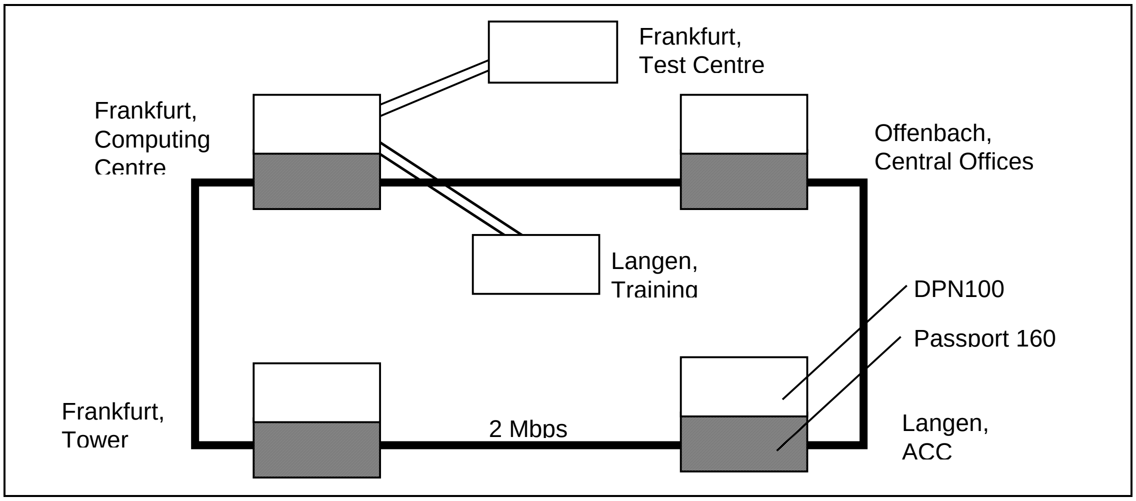

Figure 20: RAPNET configuration in the Frankfurt/Rhein-Main area

For administrative reasons, the network is partitioned into the “Packet Switched Network”, PSN, within Germany and the “Common Backbone Network”, CBN, in the other countries. Taking advantage of the possibility in DPN100 of partitioning the network into management domains, there is one network management centre in Frankfurt/Rhein-Main and one in Maastricht.

The connections to other networks shown with arrowheads in Figure 19 are implemented with X75. Although some of the packet switched networks to which RAPNET has interfaces are also based on Nortel DPN100 equipment, the use of X.75 allows a clean separation for administration and management purposes. It also reduces the dependence on proprietary Nortel interfaces. However this is done at the cost of separating into disjoint domains the areas in which efficient Nortel protocols can be used together with the high degree of meshing. The use of X.75 to interconnect PSNs is radically different from and not compatible with ATN techniques using routers - see Section 6.1 and ACCESS WP204.

The quality of service provided by the RAPNET is very high and is considered suitable for a wide range of aeronautical applications.

4. International Networks

4.1 AFTN/CIDIN

The international AFTN could be considered the “grandfather” of aeronautical message handling. It is still used extensively. In the geographical area of interest to ACCESS however, the transmission of AFTN messages is mostly done via CIDIN (The relationship between AFTN and CIDIN is described in Section 6.2). Figure 21 shows the current configuration in that area (more correctly: the configuration expected at the end of 1997).

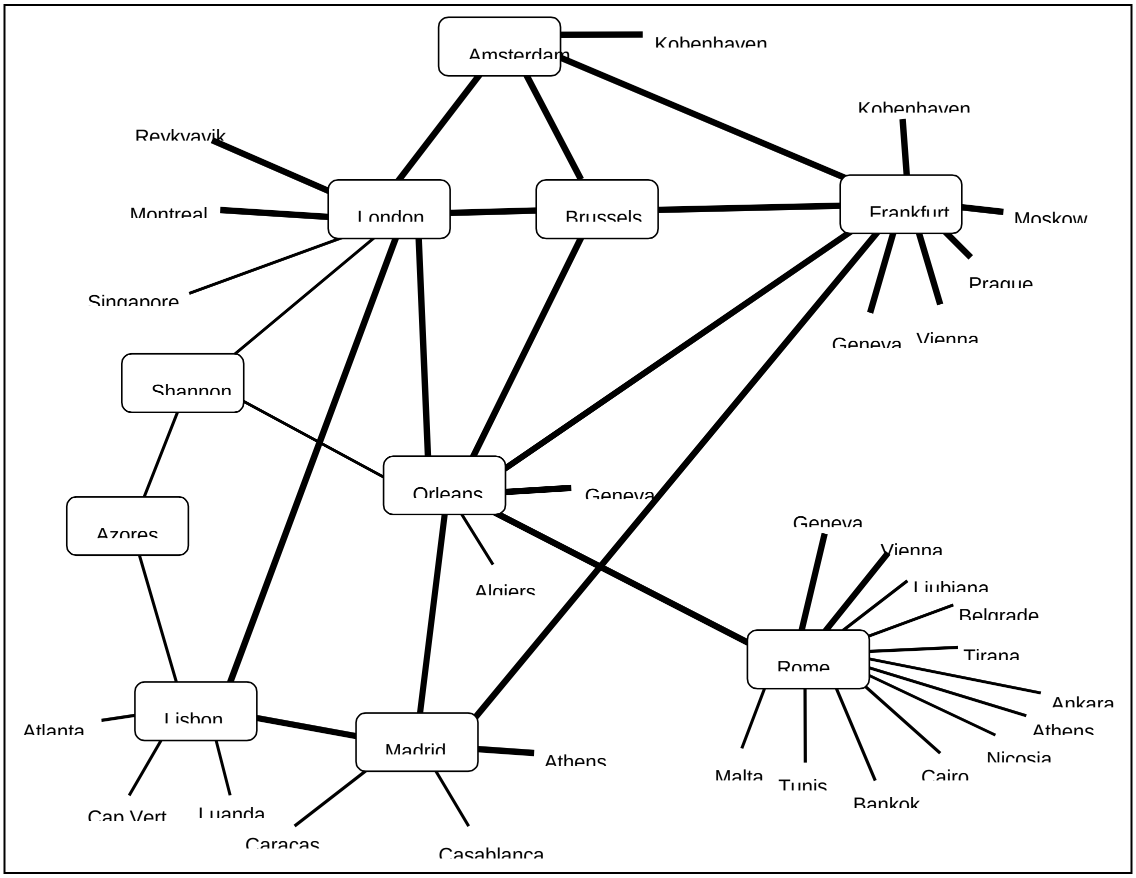

Figure 21: AFTN/CIDIN configuration

In Figure 21 only those centres with relay functions are shown. Other centres on the “periphery” of AFTN/CIDIN performing only entry/exit functions include national locations with no international connections, CFMU and the communications front-end to the Maastricht host computer, DCFEP. Although such centres can be addressed directly internationally, they act (from an international point of view) only as sources or sinks of messages (Compare, for example, the different roles of UA and MTA in an MHS). National AFTN and CIDIN networks access the international AFTN/CIDIN via the international centres shown in Figure 21)

Those links shown in Figure 21 with thick lines are used for CIDIN protocols and are operated at speeds of 9.6 kbps (some at lower speeds). The thin lines represent asynchronous links used for AFTN protocols and are generally operated at much lower speeds.

Most international links are implemented with leased lines, some with logical connections via packet switched networks. The latter is especially true of back-up connections (not shown in Figure 21).

Figure 21 shows that the international AFTN/CIDIN is highly meshed in central Europe. In spite of the low line speeds in some areas, a high throughput is generally achieved. A typical major AFTN/CIDIN switch such as London or Frankfurt handles up to 100,000 messages per day.

The network has been “fine tuned” to the needs of aeronautical applications during the long period of its operation: the introduction of new applications and significant new traffic flows lead to major reconfigurations. The European part of the international AFTN is also highly subject to influences from outside the European Region.

The network has a high level of availability in spite of the fact that each international switching centre is operated by a different administration and no overall network management function is in place (There are currently some activities being undertaken to introduce centralised network management functions). Robustness is achieved, for example, by automatic rerouting algorithms in CIDIN. However unacceptable levels of failures still do exist and CFMU statistics show, for example, that some destinations on the periphery of the network are not reachable for significant periods.

4.2 ACARS

The Aircraft Communication Addressing and Reporting System, ACARS is an aeronautical data link system used by airlines for exchanging messages between its aircraft on the one hand and its ground computer systems on the other [CEC1]. The ACARS subnetwork uses a character-oriented air-ground protocol developed by ARINC in the late 70s. Data link services offered to airlines for telecommunications over ACARS are possible with a VHF or satellite medium.

The normal means of communication is VHF for continental areas; longhaul aircraft are equipped for satellite communication, which for cost reasons, is only used in oceanic areas. In Europe, two VHF frequencies are allocated to provide telecommunications services over ACARS: one to AIRINC and the other to SITA. SITA currently offers the largest ACARS/VHF service (called AIRCOM) by means of more than 100 ground stations which provide an unbroken coverage of Europe.

ACARS messages are composed of characters with an overall total length of 220 characters. Longer messages, known as multi-block messages, can be sent as a series of ACARS messages. Messages (excepting broadcast messages) can be positively or negatively acknowledged.

ACARS communications are made available by the following service providers: SITA in Europe and other parts of the world, ARINC (mostly in the US), Air Canada in Canada and AVICOM in Japan.

Each service provider maintains one central computer for message handling, address location processing and network management. All messages handled, for example, by AIRCOM, are processed in this central AIRCOM computer in Singapore. Since the data link is a shared medium, collisions are possible and retransmission must be managed. The location of aircraft, derived from their downlinked messages, is maintained in lists in the central computer. The SITA network provides connectivity between remote ground stations and the central computer and between AIRCOM ground users with the central computer.

ACARS is mostly used by airlines for their AOC communications needs, either for “downlinking” or “uplinking”.

“Downlinking” refers to message transfer from aircraft to airline computer and is used in greatly varying ways by different airlines. Typical downlink messages are:

- schedule information such as flight plans, flight status, out of / on in times, load information,
- engineering data such as engine performance, fuel status and maintenance items
- messages transmitted as a service to passengers.

Downlinking over ACARS relieves the crew of having to send many of the routine voice messages by the automatic transmission of preformatted messages at specific times in the flight. On a modern aircraft, there are ACARS interfaces to all major systems. Manual generation of messages for downlinking is also possible.

“Uplinking” refers to message transfer from a ground computer to aircraft. Typical uplink messages are:

- dispatch and weather updates
- messages transmitted as a service to passengers.

Despite the wide use of ACARS for AOC purpose, its reliability and performance level has always been questioned by ICAO and no ATSO has decided to use it for safety-critical ATC data communications before the ARINC 622 protocol has been introduced. This standard adds a checksum to the ACARS protocol and allows the transfer of bit-oriented application data over the character-oriented ACARS subnetwork. This new feature has prompted some ATSOs to develop operational ATC communications over ACARS: non safety-critical messages such as Pre-Departure Clearances and ATIS (Automatic Terminal Information Services) started to be implemented and used operationally over ACARS in Europe and some CPDLC messages over low-density airspace, such as South Pacific. Although these services are considered useful by the users, some capacity and functional limitation (e.g. no message resequencing), and reliability problems (e.g. unexpected loss of long messages) are still encountered in the ACARS/A622 environment. Because of these problems, ICAO and especially the ATN Panel have never accepted to work on the integration of ACARS as an ATN subnetwork, but only on the future co-existence of ACARS and ATN systems. The current ICAO progress in this area leads towards an harmonisation of the application interfaces and the operational procedures of air/ground data/link services which will be provided either by ACARS or by ATN; currently no use of gateways or any modification of the technical design of either of the two systems is foreseen.

4.3 AMSS

The Aeronautical Mobile Satellite Service, AMSS, is the only currently available air/ground ATN subnetwork standardised by ICAO.

AMSS is the most recent generation of satellite data communications provided by Inmarsat and several ground telecommunication service providers, such as France Telecom and British Telecom which operate Ground Earth Stations (GES). This generation is also known as satellite data-3 mode telecommunications.

In compliance with the ICAO requirements for ATN air/ground subnetwork, AMSS provides an ISO 8208 (X.25) subnetwork service, which allows access by any public or private X.25 Wide Area Network at a compliant GES.

AMSS ICAO SARPs were approved in 1993, and most of the GES have been upgraded to comply with this new Data-3 mode. Airborne Earth Stations (AES), i.e. the airborne X.25 DTE, are now available, but only experimental tests have been conducted up to now.

Operational use of the AMSS for ATC data/link communications is foreseen in oceanic or desert regions, which require large coverage subnetworks.

In the European Core Area, 2 Data-3 GES are available: Goonhilly (UK) operated by British Telecom, and Aussaguel (France) operated by France Telecom.

5. Applications

5.1 Overview

Applications making use of the existing data communications infrastructure are important to this analysis of existing communications infrastructure because they illustrate the major communication relationships. Through an understanding of the applications, the infrastructure can be more easily appreciated. Applications are described in this chapter in an implementation-independent fashion, i.e. independent of their usage of networks in specific networks and countries. The main purpose of the description is that they can be referenced from other chapters of this document.

The emphasis is placed on applications which create *international* traffic: while it is recognised that applications which have only national significance may be important to the ATN, they can be accommodated by national planning (national subnetworks, nationally operated routers) within the international ATN. The applications described in this chapter are those which together lead to the majority of international data traffic. By comparison with other descriptions such as [EAT2] and [EAT5], the application descriptions are not abstract but focus on operational implementations.

The applications described are:

- CFMU: since the applications referred to as IFPS, TACT and CASA are distinct from a *communications point of view*, they are treated separately. Note that this classification does not necessarily represent the implementation of the "applications" as blocks of software.
- Aeronautical Information Service, AIS
- Distribution of Operational Meteorological Data, OPMET
- On-line Data Interchange for Co-ordination Purposes, OLDI
- Radar Data Transmission

Most of these applications do not have a direct equivalent in the ATN application SARPs. Exceptions are OLDI/SYSCO (ATS Interfacility Data Communication, AIDC) and ATIS (Flight Information Service, FIS). In addition, the AMHS will be able to support other current applications.

It is recognised that a significant volume of data transferred is "non-operational" in character. This administrative traffic which is not directly relevant to flight operations is not considered in this analysis.

The properties used to characterise the applications are:

- application purpose and structure
- communication relationships (point-to-point, point-to-mulitpoint, broadcast)
- communications type (message, dialogue, broadcast, file transfer)
- data volumes
- special communications requirements

- other characteristics

The descriptions have been derived partly from [EAT1]; other sources of information have also been used. Only information on currently implemented applications which is thought to be potentially relevant to a possible use of the ATN by the application is given. Only overviews of the applications are given. For more detail, the reader is referred to the references given.

5.2 CFMU IFPS

The Initial Flight Plan Processing System, IFPS, is a separate application within the CFMU.

application purpose and structure

The Initial Flight Plan Processing System is the integrated database containing information on every flight planned to take place in the CFMU area which consists of more than 30 States. It is the sole source for the CFMU demand database and for the distribution of flight plan and associated data to all relevant ATC units. Before the introduction of the IFPS in 1996, equivalent flight plan processing functions were carried out in most ECAC States.

communication relationships

There are two IFPS units, one co-located with the CFMU at Haren and the other at Brétigny. Flight plans (and associated messages such as CHG, DEP, CNL, etc.) are submitted by AOCs and national Flight Plan processing systems to both units. Only one of the IFPS units processes received messages depending on the airport of departure. The databases at the two locations are synchronised for availability reasons. After processing in the IFPS unit, a flight plan is accepted or rejected and the organisation which filed it is informed accordingly with a message.

Between 5 and 1 hour before information on a flight is necessary for ATC purposes, flight plans are distributed by the IFPS to all ATC units responsible for the flight.

communications type

The transmission of flight plan information is a messaging application.

data volumes

IFPS processes of the order of 150,000 messages input and output via AFTN and SITA at Haren and Brétigny and representing about 24,000 flights each day. Repetitive Flight Plans, RPL, representing regular scheduled flights for which separate Flight Plans, FPL do not have to be submitted, make up approximately 55% of the flights processed. This proportion may drop somewhat in the future.

A message typically contains 250 characters.

special communications requirements

The application is characterised by the large number of communication partners served by IFPS and is, for this reason alone, a typical messaging application. Extensive use is also made of the multiple addressing of messages.

other characteristics

The transmission of flight plans to and from IFPS represents an application of the AFTN which has been in place for many years. A new feature however is the large volume of traffic sent to and originating from one central site.

5.3 CFMU TACT

The “application” referred to (for communications purposes) as “TACT” encompasses the group of interactive functions between CFMU and Flow Management Positions, FMPs. This classification does not imply a software implementation separate from the CASA functions - see next section.

application purpose and structure

Interactions between the CFMU and FMPs, at ACCs and major control units represents a separate application from a communication point of view in this analysis although it is difficult to separate its functionally from CASA (see below). The FMPs, implemented on PCs, supply up-to-date ATC and airspace sector capacity information to the CFMU and are able to retrieve the overall capacity situation from the CFMU.

communication relationships

Approximately 60 FMPs are in operation in the 33 ECAC States, each of which has a logical point-to-point relationship with the CFMU.

communications type

Communication between an FMS and the CFMU is in the form of a dialogue and uses proprietary IBM protocols (SNA) over X.25.

data volumes

The use of FMT positions is sporadic during the day. During sessions, the dedicated 9,600 transmission capacity is utilised only to small extent. At other times it is not used.

special communications requirements

The short response times inherent in a dialogue application are required.

Because the reliability inherent in a message handling infrastructure is not used by this application, reliability has to be achieved by other means.

other characteristics

The implementation of this application is “closed” in the sense that proprietary protocols are used on all protocol layers (SNA SDLC is mapped onto X.25). Although the application might be a good candidate for migration to the ATN, this is likely to be difficult because of the protocols used.

5.4 CFMU CASA

The “application” referred to (for communication purposes) as “CASA” encompasses the functions (other than IFPS) communicating via message exchange. This classification does not imply a software implementation separate from the TACT functions - see previous section.

application purpose and structure

CFMU controllers monitor the airspace and flow management situation in the area under their supervision. They are supported by the Computer Aided Slot Allocation system, CASA. Its principal output consists of individual aircraft departure times (slots) where tactical flow measures are in effect as well as re-routings and alternative flight profiles.

In addition to this function on the day of the flight, the CFMU produces a tactical plan, the ATFM Notification Message. This informs aircraft operators and ATC units about the ATFM measures which will be in force on the following day.

communication relationships

The CFMU receives slot request messages from Aircraft Operators and flight plan activation messages from ATC units.

The CFMU sends slot allocations, reroutings and alternative flight profiles to Aircraft Operators and ATC units.

communications type

The transmission of flight plan information is a messaging application and uses AFTN/CIDIN as well as SITA Type B.

data volumes

The messages are short, of the order of 100 characters. The number of messages per day is dependent on the number of flights but also, more sensitively, on the number of regulations being activated/deactivated.

Typical message volumes are of the order of 40,000 messages sent and 40,000 messages received per day.

special communications requirements

The application requires message transmission within 3 minutes for flights in progress and 5 minutes for slot-related messages. In practice, message transmission times are of the order of a few seconds or less.

other characteristics

Although acknowledgements of the receipt of slot allocations would make sense in this application context, use is made of the inherent reliability of the messaging service so that it can be assumed that messages reach their destination.

5.5 AIS

application purpose and structure

Systems supporting the Aeronautical Information Service, AIS, process, store and manage NOTAMs in databases and make these available for retrieval by users.

communication relationships

Currently, AIS systems operate mainly on a national basis: only users in one State are served by its system. NOTAMs created in the one State may be transmitted to the systems of other States depending on fixed distribution lists. Only this international distribution of NOTAMs is discussed here: retrieval from databases, for example for pilot briefing, is considered to be a local matter up to individual States.

communications type

Although the transmission of partial databases as file transfers is obviously desirable, NOTAMs are currently still distributed as individual messages via AFTN/CIDIN. Distribution is controlled by fixed lists and much manual intervention is necessary. “System NOTAMs” contain “Qualifier Lines” in a fixed format and can be handled automatically.

data volumes

NOTAMs are short text messages which are capable of being sent as AFTN messages and are therefore shorter than 1,800 characters. A typical NOTAM has a length of between 200 and 300 characters. A typical AIS system handles of the order of 1,000 NOTAMs per day. and the application is considered to represent a considerable fraction (20%?) of AFTN/CIDIN traffic.

special communications requirements

AIS data is “public” and non confidential. Access to it via the Internet should be possible for organisations other than ATSOs and AOCs and for the General Aviation community. The *distribution* of AIS data, on the other hand, would be a good candidate for an application on the ATN.

other characteristics

Although the introduction of regional AIS databases together with a rationalisation of NOTAM distribution has been in planning for many years, little progress has been made in this matter. The implementation of a centralised European AIS Database, EAD, is currently being planned by Eurocontrol [EAT1], [LUX1] and would appear to be a good candidate for use of the ATN.

5.6 OPMET

application purpose and structure

Meteorological data originate at meteorological authorities (World and Regional Area Forecast Centres, WAFC, RAFC) and distributed among these using dedicated networks. They are made available to aeronautical meteorological offices of ICAO States. The distribution among aeronautical meteorological offices and to users for pre-flight and in-flight briefing is the subject of the Operational Meteorological Data, OPMET, application.

The major OPMET reports are Routine Aerodrome Reports, METARs, Aerodrome Forecasts, TAFs, and Special Air Reports, SIGMETs.

communication relationships

As with AIS, the application consists of two distinct parts: the distribution of meteorological reports among meteorological offices and the retrieval of information from these. Only the former is considered here since the latter is more a local matter.

The relationships among meteorological offices is, in general, one-to-many. The responsibility of meteorological offices to pass on reports to other meteorological offices is laid down in fixed distribution tables and depends upon the report types.

communications type

OPMET distribution is implemented as a messaging application. In the case of the “Satellite Distribution System”, SADIS, OPMET Reports and WAFS Products (including non-European ones) are collated in Bracknell and broadcast via satellite. Increasingly, AOCs perform distribution themselves for their own purposes by collecting OPMET data at a central site and transmitting it via ACARS. It follows that there is considerable duplication in the distribution of OPMET data.

data volumes

OPMET Reports typically have a size of 100 - 200 characters. A feeling for the volume of data involved can be gained from the fact that OPMET data was, until recently, distributed in Europe among 10 major offices via the MOTNE system. The MOTNE network, consisting of dual 100 bps loops, operated continuously and was connected via the major offices to other areas. The distribution is now being performed on AFTN/CIDIN and the volume transmitted is probably several times that transmitted via the MOTNE system which considerably restricted data volumes.

special communications requirements

Considerable use is made of the multiple dissemination messaging feature.

other characteristics

In order to increase the transmission efficiency, it is planned to make direct use of CIDIN with no recourse to AFTN messaging techniques.

Additional communications which are relevant to the ATN may come into existence when Aircraft become a source of raw meteorological data.

5.7 OLDI/SYSCO

application purpose and structure

ATC computers maintain databases containing information about planned air traffic (flight plans) and actual air traffic (current movements). For the computer-assisted co-ordination of flight data between pairs of sites, in particular for flight handover, message exchange is necessary. This is called on-line Data Interchange/System Co-ordination, OLDI/SYSCO. As well as the use of (internationally standardised) procedures, co-ordination is practised extensively on a national level within ATC systems.

communication relationships

Messages currently being used are: the activation of stored flight plans, ACT, the logical acknowledgement by a controller of an ACT message, LAM, and advance boundary information, ABI, announcing of a flight prior to the activation of a flight plan.

The relationships are point-to-point, controller-to-controller. There is a possibility of interactions being cascaded to further downstream controllers.

communications type

OLDI is implemented as message exchange on point-to-point links, each message being self-describing.

data volumes

Data volumes are small: messages contain of the order of 100 characters and the volume of messages can be roughly correlated with the number of flights in progress.

special communications requirements

Strict constraints are placed on availability (24 hours, 7 days: 99.86%), data integrity (max. 1 transmission error in 2000 characters),

other characteristics

An upgrade to OLDI is contained in the Eurocontrol Flight Data Exchange Interface Control Document, FDE ICD and contains additional messages and formats.

The corresponding G/G application defined for the ATN is ATS Interfacility Data Communication, AIDC and represents a significant upgrade of current OLDI/SYSCO techniques. This is likely to involve major transitional effort on the part of States currently using OLDI/SYSCO.

5.8 Radar Data Transmission

application purpose and structure

Target information is normally extracted from raw radar signals close to the radar sensor. From there it needs to be transmitted to radar processing and display systems, usually at ATC units. Thus the main transfer is a one-way data flow.

communication relationships

The relationship between radar sensors with their extractors (as sources of radar data) and radar data processing and display systems (as sinks of radar data) is, in general, one-to-many. For the establishment and maintenance of these relationships and the conversion among different radar data formats, a network of radar processing systems is implemented. These are, for example, Radar Message Conversion and Distribution Equipment, RMCDE, in the Four States Integration Project and SIR in France. Although up to the recent past networking among radar message equipment was done on leased lines, this has been completely migrated to packet switched networks. For the interconnection of packet switched networks, X.75 is used. The radar data network, e.g. RADNET, can therefore be considered to be a value added service on top of packet switched networks. A connection-oriented relationship exists via RMCDEs between a radar sensor and a user.

communications type

Fixed physical or LAN connections exist between an RMCDE and its users (radar sensor and ATC systems). Within the logical connection between pairs of users, radar data is sent as independent data blocks as needed. Where possible, a common presentation format, ASTERIX, is used. In addition to the production traffic, there is network administrative traffic for setting up filters and feeding track servers which can associate tracks with radar target data.

data volumes

Radar data transmission involves relatively large data volumes. An RMCDE is typically connected to a WAN with four 64 kbps links. Approximately 30 RMCDEs are in operation in the Four States Integration Project.

special communications requirements

Strict requirements are placed on the availability of network connections between pairs of radar message processors and on associated network delay times and data integrity. However because of the inherent repetitiveness and redundancy of radar data, the possible loss of messages is not a critical issue.

other characteristics

The interconnection of packet switching networks (which are considered by the ACCESS Consortium to be suitable ATN subnetworks) with X.75 is gaining momentum through this application because of the operational needs for radar data distribution, the need for long-term connection-oriented communication relationships and the success of integration projects.

6. Network Types

This chapter is provided as a brief summary of networking technologies used in the national, regional and national infrastructures described in this document. It is not intended to be complete but only to provide the reader with some background information and indications of useful reference material. Emphasis is placed on aspects of the technologies which are particularly relevant to the use of the technologies in an aeronautical environment.

6.1 Packet Switching Networks

Packet Switching Networks, PSN, are widely used by ATSO in Europe because of their many features, high quality of service, flexibility of use, level of standardisation and wide availability.

Packet switching techniques are based on the separation of a data flow into individual “packets”, e.g. 128 octets, which are then transmitted individually through the network. On exiting the network, the packets are reassembled in order to reconstitute the original data flow. A user of a PSN, a DTE, has to send and receive data as packets according to the ITU-T recommendation X.25.

The network access protocol X.25 consists of a physical, link and packet layer. The link layer uses a variant of HDLC, LAP-B, for transmitting bit streams in “frames” across the DTE-DCE interface. One of its features is the provision of a high level of data integrity. The packet level handles the transmission and reception of packets across the virtual switched or permanent virtual circuits, SVC and PVC.

Whereas the interface to a PSN on its boundary is highly standardised, the interfaces between nodes within the network (sections of SVCs and PVCs, network management, …) are proprietary and unique for each network supplier. They could be based on X.25 but this is normally not the case for performance reasons. The interconnection of PSNs from different suppliers is only possible on the boundaries of the individual networks using standard interface protocols. The extension of RAPNET across several domains in a meshed fashion has only been possible because the DPN100 equipment comes from the one supplier.

The DTE-DCE PSN interface X.25 is asymmetric because it takes into account the differences between DTE and DCE. The symmetric version, X.75, is very similar to X.25 and is used for interconnecting PSNs. Interconnection between a number of national PSNs belonging to ATSOs has already been implemented and the matter is subject to study under the EATCHIP ATSO task.

PSNs provide a “connection oriented” service across X.25: in a connection establishment phase, a remote DTE is called using an X.121 address and a virtual connection is set up. In the case of PVCs, this connection exists permanently. Packets are transferred across the network(s) within the context of such a virtual circuit. A virtual circuit does not necessarily have a fixed path through the network: PSN manufacturers use a variety of different techniques within the network. This service is different from the connectionless network service provided by the ATN whereby the units of data transferred by the network are independent from each other and have no logical context. A connection-oriented service is provided in the ATN by the transport layer.

6.2 AFTN/CIDIN Techniques

AFTN message handling techniques and the AFTN as an international network are unique to the aeronautical environment. They have a correspondence in the SITA type B service and also a military equivalent. The AFTN has been standardised by ICAO and been set up and operated by ICAO States over several decades. For this reason, it does not represent the technical “state-of-the-art”. However it remains the most important international aeronautical network for message handling applications with approximately 10,000 addressable users world-wide.

AFTN messages consist of readable text with an overall maximum size of 1800 characters. A message contains a fixed format header and message body separated and terminated by special character sequences. Some of the message handling procedures provided are:

- multiple addressing: in several address lines a number of 8-letter AFTN address indicating recipients of the message can be given. In its path through the network, a message can be duplicated as necessary to reach its destinations in a very efficient way and addresses which are no longer relevant are stripped from the header.

- priority: During message handling at an AFTN centre high priority messages overtake those with lower priority.

- service messages: A set of messages can be sent automatically and manually by operators of AFTN centres. These relate to the communications between pairs of adjacent AFTN centres or pairs of sender and recipient AFTN centres.

- responsibility: AFTN centres are held to be “legally responsible” for the message traffic handled by them. For auditing purposes, the traffic handled has to be recorded and archived.

The data unit which is stored and forwarded at each AFTN node handling a message is the complete message itself (and not parts of it). AFTN routing is largely static. The standard procedures for AFTN message handling are the “manual teletype procedures” which are executed automatically by modern AFTN switches.

The CIDIN has been standardised by ICAO and implemented mainly in Europe to provide an upgrade for the AFTN. CIDIN provides a connectionless transport service, and the unit of data switched through the network is the “CIDIN packet”. As a general-purpose “aeronautical internet”, CIDIN contains specific features for aeronautical applications. In case CIDIN were used in the ATN as a subnetwork, this transport service would be termed a subnetwork service. AFTN is just one of many possible applications which can be supported by CIDIN: others such as OPMET distribution have been defined and are being implemented.

International AFTN traffic in Europe is transported in general by CIDIN and this trend is extending to neighbouring Regions. The use of AFTN procedures in Europe is restricted to some few users in national environments. Connections between CIDIN centres are implemented by leased lines and by private and public PSNs.

6.3 Frame Relay

From a historical point of view, frame relay techniques have been derived from corresponding packet switching techniques: the quality of service provided by PSNs is usually more than sufficient because of the increasing performance of data transfer equipment and because of increasing intelligence in end systems. At the same time increasing requirements are being placed on networks for LAN-LAN connections.

By comparison with PSNs, a frame relay service has no packet layer. This makes higher transfer rates and shorter network transit times possible at the cost of possible loss of frames within the network. Users are informed when the network is overloaded and frame loss is likely. Frames are transferred in a connection-oriented mode within the context of frame relay virtual connections. These are usually fixed and not switched.

Frame relay as a wide area service is only interesting for bit rates of several Mbps and upwards. It provides an intermediate grade of service which can be seen as lying between packet switching and ATM cell relay techniques.

6.4 Proprietary Networks

Communications within and between ATSOs takes place in an “open environment” because of the need to establish communication relationships with many partners. At the time of specification and implementation it is usually not clear what relationships with other partners may be necessary in the future. In addition, a dependence on one supplier can seriously restrict future design decisions. For these reasons, ATSO network implementation usually avoids the use of closed systems. These are characterised by proprietary, non-public interfaces or equipment which does not use “industry standard” techniques.

However there are some instances of proprietary networks in the ACCESS core area which have been introduced for cost reasons or because of their special features.

6.5 Leased Lines

Functionally at the “lowest level” of wide area communications infrastructure, transmission lines provide the basic required connectivity.

No European ATSOs maintain their own lines. These are leased from service providers such as (former) PTTs and other operators. They can be leased at relatively short notice and for varying periods. They therefore do not represent a fixed long-term resource belonging to the ATSOs and are not considered in this document.

6.6 TCP/IP Networks

“TCP/IP” refers to a family of protocols which originated in the US ARPA project and, more recently, has provided the compatibility necessary for the growth of the Internet. The TCP/IP user community is expanding at an almost explosive rate.

IP is functionally similar to the ATN network protocol and TCP to the ATN connection-oriented transport protocol. Many other protocols are used in conjunction with TCP/IP, for example FTP (file transfer), SMTP (mail transfer), RIP (routing) and SNMP (network management).

Development of new TCP/IP protocols and maintenance of old protocols is co-ordinated by an independent organisation called the Internet Architecture Board while research and engineering activities are performed by task forces subordinate to it. The protocols can therefore be described as being truly “open”.

All manufacturers of general-purpose computing equipment support TCP/IP and standard software used in connection with TCP/IP is readily available. For these reasons, some ATSOs have implemented national networks based on TCP/IP. For the migration to an ATN architecture the national use of TCP/IP will have to be taken into account.

6.7 Local Area Networks

Local area networks, LANs, form an integral part of ATSOs' processing equipment: a LAN is present at almost every site at which computing equipment is installed. The extent of the network is up to a few hundred metres and the transmission capacity up to one hundred Mbps. Many different LAN technologies are available, with some predominance of Ethernet/FDDI.

Because of their current and future widespread use, LANs are likely to be present as subnetworks in many parts of the ATN, extending the ATN into sites containing distributed communications systems. For this task, ATN routers using the subnetwork services of WANs and LANs will be necessary.

However LANs will, to a certain extent, be topologically on the "periphery" of the ATN and are therefore not of central importance from a planning point of view. They are highly integrated with and dependent on rapidly changing computer systems implementation. For these reasons, no consideration is given to LANs in this inventory of existing communications infrastructure.