CEC TEN-T ATM Task UK/96/94

ACCESS

ATN Compliant Communications

European Strategy Study

Define Geographic Area + Services

ATN Data Link Services in the ACCESS Area

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Revision Number	Date	Description of Change
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0.2	30/05/97	First stable version for review by ACCESS partner.
0.3	03/07/97	Section on ground services and applications modified based on DFS input and WP201.
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1.0	19/09/97	Output of the Toulouse ACCESS meeting (10/09/97) Document Title changed. Focus on the ACCESS ATN instead of the European ATN. Sections 2.2.2.3 and 2.2.4.6 on Radar Data modified. Section 2.2.4.3 on AMHS modified. Section 2.2.5.2 on location of gateways modified. Section "Proposed A/G D/L services in the initial European ATN" of version 0.4 removed Assessment of criticality refined in 3.5. Performance Requirements added in section 3.2.9.
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2.0	05/03/98	Document formally closed

EXECUTIVE SUMMARY

The introduction of the data link in the ATC environment will provide ATC users (aircrew, controllers, ground ATC systems, etc.) with a large range of new services based on exchanges of data between aircraft and ground systems. These services will relieve pilots and controllers of repetitive tasks likely to be carried out partially by the automation and will make known to them information they have no access in the current voice environment. Through the reduction of the aircrew and controller workload, the optimisation of the use of the voice channel and the remote and dynamic availability of aircraft or ground parameters, the data link is seen as the way for the ATC to handle the increasing global traffic capacity.

On the ground, as a consequence of the optimisation of the ATC resources through the centralisation of essential ATC functions (e.g. CFMU, radar processing system, etc.), the high level of co-ordination between ground ATC actors and the need to distribute more widely the ATC information, a new generation of data networks and communication systems is required.

The ATN has been designed to support the communication functions required to provide these data link services to both air and ground operational users.

European programs - such as the ATN Implementation Task Force - are currently being set up to study how the ATN will be implemented in Europe. The ACCESS project is providing inputs to these studies by proposing in a limited European area - the ACCESS area - a concrete example of ATN implementation. The purpose of work package 202 is to identify the air/ground and ground/ground data link services considered as the more appropriate in this ACCESS area. A two-step approach is taken: while focusing mainly on the target ACCESS ATN around 2010, some guidelines are provided for defining an initial ACCESS ATN around 2005. The criteria for selecting initial data link services in the initial ACCESS ATN are developed. They encompass for each data link service the assessment of the operational benefit in Europe, the standardisation status, the maturity in terms of experimentation, the interest of the European states, the existence of non-ATN solutions, etc…

The list of air/ground data link services deduced from selections already performed by European Standardisation bodies or studies related to the ATN applications identifies three main types of services for the target ATN:

- Services based on exchange of messages between the aircrew and the controller,
- Services providing ground systems and controllers with aircraft parameters, and
- Services providing aircrew with ground parameters.

Ground/ground data link services define exchanges of radar data, meteorological data, flow management and air space management data, ATC centres co-ordination data, etc.

The region considered here is a limited set of states stating data link requirements representative of most European States. An attempt is made to locate the ATN End Systems hosting the selected data link applications in this area.

The set of services identified for target ACCESS ATN shall be considered as a working hypothesis for the ACCESS project. It will be used in other ACCESS work packages to propose possible ATN router topologies in the ACCESS area. When the output of the studies lead by European CAAs about the implementation of the ATN in their ATC region will be available, the set of services identified here will certainly have to be updated.

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1 Introduction

1.1 Scope of the ACCESS Task 202

The "ATN Compliant Communications European Strategy Study" (ACCESS) project that is being run under the European Commission’s programme for financial aid in the field of Trans-European Transport Network (TEN-T), ATM Task UK/96/94, aims at defining the initial architecture of the ATN in Europe (i.e. selection of the initial applications, definition of the initial network topology, definition of the routing organisation and addressing plan, etc.) and participating in the AMHS interoperability testing activities set up in Europe. This project will propose initial solutions as regards to the security, safety/certification, network management, institutional, and other issues as well as a transition plan.

Part 1 of ACCESS project focuses on ATN Implementation with the objectives of proposing a network architecture, solutions for network implementation issues and a plan for transition from the existing network infrastructure to the proposed ATN infrastructure. It addresses topics related to both network and application infrastructure.

Part 2 of ACCESS project covers the AMHS Interoperability/Validation testing.

This report presents the outcomes of the Work Package 202 (entitled “Define Geographic Area and Services ”) and represents one part of the ACCESS interim deliverable 1 in part 1.

1.2 Geographical area and time frame considered by ACCESS

The geographical area considered in ACCESS consists of the following countries as illustrated in Figure 1: UK, Ireland, Benelux, Germany, France, Italy, Spain and Portugal. These States were chosen for the following reasons:

- **They have a direct connection to the CFMU and/or are involved in the control of North Atlantic traffic.** States connected directly to the CFMU - in 1997 - were selected because this enables the major ground/ground data flows in Europe to be included in the study. North Atlantic Region States were selected, as this Region is likely to provide the first operational implementation of ATN services.
- **The study is representative of both Oceanic and Continental ATC**. Including the NAT Region and European States allows routing and architecture issues between boundary Regions to be studied.

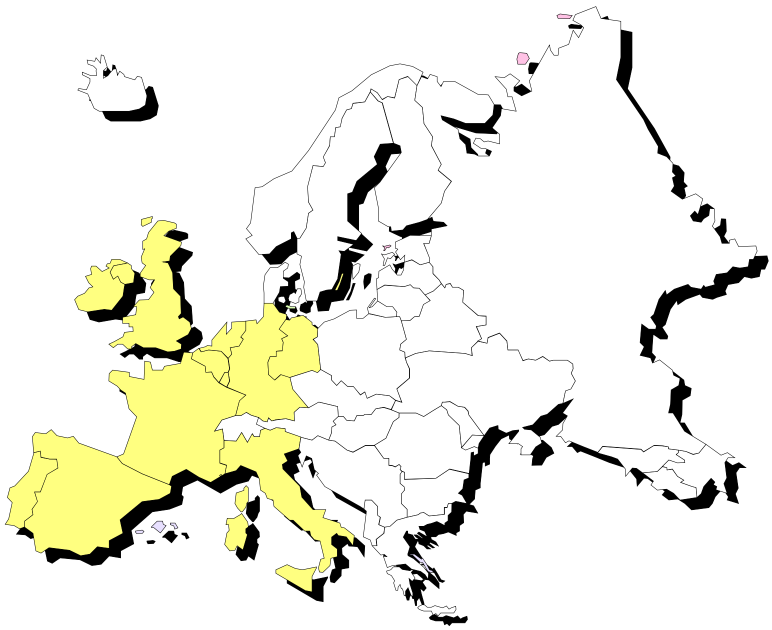

Figure 1: The geographical area considered by the ACCESS project

Choosing a larger Study area, such as the entire ECAC area, would prevent any useful conclusions being developed in the study time available.

According to the ACCESS Work Package 201 ("Current Communications Infrastructure"), all these countries currently operate interconnected ground networks for radar data exchange, OLDI links for ACC co-ordination and AFTN/CIDIN for messaging functions (AIS, OPMET). Only few of them have started the deployment of air/ground data link sub-network.

The time frame considered in the ACCESS project is 2000-2010. The initial ACCESS ATN is assumed to be deployed during the initial period 2000-2005. This initial ACCESS ATN must however be considered in the time as the first brick to a global and mature target ACCESS ATN that would meet most of ground-ground and air-ground ATN communication requirements currently identified. The target ACCESS ATN is assumed to be deployed in years 2005-2010 where new data link services and new communication networks will be set in operation and additional ground facilities will be equipped. These two steps are identified in this document as the **Initial ACCESS ATN** and the **Target ACCESS ATN.**

The initial ACCESS ATN must consist of the first elements on an expandable ATN infrastructure that will actually allow, in some further implementation steps, the building of the target ACCESS ATN of year 2010. The initial ACCESS ATN is therefore viewed as a transition step toward the target infrastructure.

As a practical approach for the definition of the initial ACCESS ATN, it is considered that ACCESS must focus on the target ACCESS ATN and that the initial implementation will be derived in the scope of the ACCESS transition planning Work Package (WP240).

Following this approach, the scope of this document has not been limited to the selection of data link services for the target ACCESS ATN. It provides in addition some guidelines for the pre-selection of air/ground data link services in the initial ACCESS ATN.

Given the speed of the standardisation process and the time needed to implement certified products in the ATC environment, this two phases approach is realistic. The first period will be used to gain experience through the implementation of a limited set of ATN applications and sub-networks. The next period will see a rapid growth of the ATN use for ATS services.

1.3 Purpose of the Document

ACCESS WP202's objectives are to determine which data link services will likely needed in the ATC environment of 2010 and to provide inputs for the selection of these services likely to be implemented in the intermediate infrastructure in 2005. This selection and the transition issues will be covered in another ACCESS work package.

The first objective of this document is to present the ATS data link services which will be operated in the ACCESS ATN of year 2010, and if possible to draft the associated ground ATN topology - in terms of location of ATN End Systems - to support these services in Europe.

Ground and air/ground data link services for ATS are first described from an operational viewpoint, independently of the supporting communication environment. The data link services of the future ACCESS ATN have been selected because operational requirements were formally expressed for them, either by European standardisation working groups (e.g. ODIAC) or by European States in national plans or initial studies on the data link deployment. In no circumstances, it has been the prerogative of ACCESS to define such operational requirements. This ACCESS work package simply synthesises them and classifies them in term of priority for implementation.

The possible ground topologies in terms of location of ATN End Systems are then presented. The objective here is not to describe in detail the ground architecture suitable in Europe. This would be impossible given the flexibility allowed by the ATN for defining the ground organisation. The ultimate choice will be made by the States on technical and political considerations (existing ATS systems, data link services and sub-network selected, etc…). Instead, two possible ground implementations are described and technically compared but no final choice is proposed.

The target ACCESS ATN will not be implemented in one day. It will be necessary to evolve the existing infrastructure towards the target architecture. Some data link services are more sensible and should be implemented first in an intermediate ATN environment allowing a smooth transition to the final environment. The second step of this study has consisted in identifying the main criteria that would be used by ATC Administrations, Airlines and Aircraft Manufacturers to select this first set of data link services in the 2000-2005 timeframe.

It is important to take into account the way the Aeronautical Operational and Administrative Communications (AOC/AAC) services are integrated in the ATN. ATN routers are designed to handle both ATSC and AOC traffic. Thus, a cost-efficient sharing of the ATN communication infrastructure by both communities could be considered. As far the ATN applications are concerned, the ATS and AOC End Systems will be dedicated respectively to ATS and AOC services. On the other hand, the selection of ATS services does not depend on the selection of AOC/AAP services carried out by airlines. As a consequence, AOC/AAC services have not been considered in this work package, although they are in subsequent work packages (e.g. WP203).

1.4 Document Structure

This document is structured as follows:

Chapter 2 presents the air/ground and ground data link services identified for the Target ACCESS ATN of 2010. Then, two deployment scenarios are provided as example.

Chapter 3 identifies the criteria which may be used for the selection of data link services in the Initial ACCESS ATN.

Appendix A lists all the abbreviations used in the document.

1.5 References

ACCESS Reference	Document Reference	Document Title
[A201]	ACCESS/DFS/201/WPR/001	ACCESS - Current Communication Infrastructure
[EAT12]	OPR.ET1.ST05.1000-ORD-01-00	Operational Requirements for ATM Air/Ground Data Communications Services
[EAT13]	COM.ET2.ST15.1000-REP-xx-xx – Version 0.7	Analyse Options for Initial Air/Ground Data Networks - Phase 1 Report: Inventory and Analysis of A/G Applications and Data Networks
[CEC3]	COPICAT	Technical Aspects
[EAT5]	EUNIS	European Ground Data Network Integration Study – Inventory and Profile Description of Ground Data Applications - WP 2000 Report.
[CEC8]	EOLIA	D21 – ATC Data link Service Definition
[ICA4]	ADS Panel	ICAO Manual of Air Traffic Services (ATS) Data Link Applications
[ICA5]	ATN Panel	Annex 10, Volume III, Part 1, Chapter 3 (ATN), Sub-Volume II - ATN Air-Ground Application SARPs

1.6 Definitions

The terms data link "service" and data link "application" are used in this document with the following meaning:

- A data link service is a set of ATM related transactions, both system supported and manual, which have a clearly defined operational goal and begin and end on an operational event.
- A data link application is the set of co-operating capabilities within ATM systems which takes part in the communication activities required to provide one or more data link services.

The data link service shall be seen as the functional description of the air-ground or ground-ground data exchanges needed to meet an operational goal. The data link service does not make any assumption on the way the communication functionality is performed in terms of communication architecture, protocols and physical network.

The data link application is the technical description of communication rules in a specific environment. For instance, the ICAO SARPs for air-ground applications defines the actions of the four CNS/ATM-1 Application Entities in the ATN environment.

2 ATS Data Link Services for the Target ACCESS ATN

This chapter aims at collecting information about the different data link services for which operational requirements exist in Europe and to synthesise this information in a way that will allow to derive a feasible initial ATN data link operational framework in Europe.

2.1 ATS Air Ground D/L Services and Applications

2.1.1 Introduction

The first part of this section includes an inventory of ATS data link services involving aircraft and ground systems. It should be noticed that an air-ground service might define in addition to air/ground transactions some transactions between ground systems.

These services are identified by the aeronautical community as serious candidates for implementation in the emerging data link environment. They are fully specified in international committees or in projects developing experimental or operational data link platforms.

No assumption is made on the supporting communication infrastructure.

This inventory is based on the following sources:

- The "Operational Requirements for Air Traffic Management (ATM) Air/Ground Data Communications Services" document [EAT12] produced by the ODIAC Task Force. This document contains Recommended Practices for ECAC member states intending to provide ATM air/ground data link services.
- The "Analyse Options for Initial Air/Ground Data Networks - Inventory and Analysis of A/G Applications and Data Networks" report [EAT13] produced by the COM.ET2.ST15 EATCHIP Task. In addition to a detailed description of air/ground services, the status of experiments and operational implementation of the applications providing these services in Europe is provided in chapter 2 of this report.
- The "Draft ICAO Manual of Air Traffic Services (ATS) Data Link Applications" produced by the ICAO ADS Panel [ICA4].

The second part of this section describes briefly the ATN applications – standardised by ICAO - carrying out the communication functions required for providing some of the data link services identified in the first part.

2.1.2 ATS Air/Ground Data Link Services

2.1.2.1 General

ATS Air/Ground data link services are grouped into the three main categories as defined in the ODIAC-TF document [EAT12]:

1. **The Controller Pilot Data Link Communications (CPDLC) services**: a means of communication between controller and aircrew, using data link for Air Traffic Control communications.
2. **The Automated Downlink of Airborne Parameters (ADAP) services:** a means of providing aircraft status and aircrew preferences information to controllers and ground systems using air/ground data communications.
3. **The Data Link Flight Information Services (D-FIS) services:** a means of providing flight information (e.g. ATIS and meteorological information) to aircrew using air/ground data

communications.

Additional air/ground data link services do not enter in any of these three categories, either because they do not provide a pure ATS operational service or because they address more than one category.

2.1.2.2 Overview of the CPDLC-Based Services

Controller-Pilot Data Link Communications (CPDLC) is a means of communication between controllers and aircrew using data link for ATC communication.

The controller is provided with the capability to issue altitude assignment, crossing constraints, lateral deviations, route changes and clearances, speed assignments, radio frequency assignments, and various requests for information. The control centre where the controller responsible for the aircraft is located is designed as the "Controlling ATSU" or C-ATSU.

The aircrew is provided with the capability to respond to messages, to request clearances and information, to report information and to declare/cancel an emergency. The aircrew is provided with the capability to request conditional clearances and information from an ATSU that does not control the aircraft yet (the so-called "Downstream ATSU" or D-ATSU).

In addition, a "free text" capability is provided to exchange information not conforming to defined formats.

CPDLC-based services for which operational requirements exist are the following:

- The **Clearance and Communication Information (CIC) service** or ATC Clearance (ACL) service is used for the exchange of controlling and informative messages between the aircraft and the C-ATSU.
- The **ATC Communication Management (ACM) service** defines a co-ordination dialogue between the aircraft and the C-ATSU to handle the transfer of voice and data link communications.
- The **Downstream Clearance (DSC) service or Oceanic Clearance Management (OCM) service** is used for the exchange of non-controlling messages between the aircraft and the D-ATSU.
- The **Departure Clearance (DCL) service** defines the initial dialogue between the aircraft and the C-ATSU at the departure airport.
- The **Pushback Clearance Request/Delivery service** is used by the aircrew to request to and obtain from the ground controller a pushback clearance.
- The **Taxi Request/Delivery service** is used by the aircrew to request to and obtain from the ground controller taxiing guidelines before take-off.

2.1.2.3 Overview of the ADAP Services

The aircraft avionics, e.g. navigation and flight management systems, are capable of making available in real time, data that may be of use to controllers and ground systems. This includes air speed, heading and vertical rate.

ADAP usually defines automated system to system exchanges. Normally, neither the aircrew nor the controller are involved in the data-link exchange. However, some information downlinked from the aircraft may be made available to the controllers.

ADAP services for which operational requirements exist are the following:

- The **Controller Access Parameter (CAP) service** addresses the automatic delivery of data usually provided by pilots to controllers by VHF (heading, speed).
- The **Aircraft Parameter Reporting (APR) service** addresses the automatic delivery of surveillance data from the aircraft to the controllers.

- The **Meteorological Data Downlink (MET) service** addresses the automatic delivery of meteorological data from the aircraft to meteorological offices or airlines offices.
- The **Flight Plan Consistency (FLYPCY) service** addresses the automatic delivery of flight plan data from the aircraft to ground FPDS for flight plan consistency activities.
- The **Pilot Preferences Downlink (PPD) service** is used to transmit for information to the controller information related to the intention of the pilot usually exchanged by voice.
- The **System Access Parameters (SAP) service** addresses the automatic delivery of position data from the aircraft to automated system assisting the controllers, e.g. in the detection and the resolution of conflicts or route deviation.

2.1.2.4 Overview of the D-FIS services

The D-FIS service provides a means for the pilot to get Flight Information Service (FIS) data and any update of this information via data link.

D-FIS services for which operational requirements exist are the following:

- The **Data Link Operational Terminal Information Service (D-OTIS) service** addresses the uplink transfer of Flight Information Service data such as ATIS, METAR, etc… on request of the aircrew.
- The **Data Link Runway Visual Range (D-RVR) service** addresses the uplink transfer of Runway Visual Range data on request of the aircrew.
- The **Data Link Significant Meteorological Information (D-SIGMET) service** addresses the uplink transfer of ground-related meteorological data on request of the aircrew.

2.1.2.5 Overview of the other data link services

Other data link services considered in this study are the following:

- The **Data Link Initiation Capability (DLIC) service** is the data link service mandatory operated before any other data link service. It provides data link communication peers with the means to get addressing information and aircraft identification information.
- The **Dynamic Route Availability (DYNAV) service** defines a co-ordination dialogue between the pilot and the C-ATSU to negotiate (i.e. accept or reject) a new route.
- The **Traffic Information Service (TIS) service** is used to inform the pilot of the presence and the position of other aircraft.
- The **ATFM/Slot Allocation service** defines a co-ordination dialogue between the aircraft and the CFMU to negotiate a new arrival slot.
- The **4D Trajectory Negotiation (4DTN) service** defines a co-ordination dialogue between the aircrew and the C-ATSU to negotiate an optimised 4D trajectory.

2.1.2.6 Description of the CPDLC-based Services

2.1.2.6.1 Clearances and Information Communications Service (CIC)

The CIC service describes aircraft and C-ATSU message exchanges and procedures for the following:

- Aircrew’s reports and clearance requests,
- Controller’s delivery of clearances, instructions and notifications to aircraft, and
- Support and system messages (e.g. Logical Acknowledgement).

The CIC data link service description states the exchanges that could be conducted via data communications, the rules for the combination of voice and data link communications and abnormal mode requirements and procedures.

2.1.2.6.2 ATC Communications Management Service (ACM)

When a flight is about to be transferred from one sector (or ATSU) to another sector (or ATSU), the aircrew is instructed to change to the voice channel of the next sector (or ATSU) to take control of the flight.

The ACM data link service provides automated assistance to the aircrew and current and next controllers for conducting this transfer of ATC communications. The ACM data link service encompasses the transfer of all controller/aircrew communications, i.e. both the voice channel and the new data communications channel used to accomplish the ACM service.

2.1.2.6.3 Downstream Clearances Service (DSC)

Aircrew, in specific instances, needs to obtain clearances or information from ATSUs that may be responsible for control of the aircraft in the future, but are not yet in control of it.

Such ‘downstream’ clearances and information are often provided through ground/ground co-ordination, but are also obtained via direct contact with the ‘Downstream’ ATSU (D-ATSU) in certain circumstances (e.g., when ground/ground communications are unavailable or inefficient, or due to the size of the airspace, or due to the complexity of the route structure, or due to meteorological conditions).

The DSC data link service provides assistance for requesting and obtaining D-ATSU clearances or information, using air/ground data link.

The DSC data link service is a superset of the Oceanic Clearance Management service (OCM).

2.1.2.6.4 Departure Clearance Service (DCL)

A flight due to depart from an airfield must first obtain departure information and clearance from an approach C-ATSU. The DCL data link service provides automated assistance for requesting and delivering departure information and clearance, with the objective of reducing aircrew and controller workload and diminishing clearance delivery delays.

A departure clearance contains information relative to the take off phase of flight (e.g. take off runway, standard instrument departure, SSR code, departure slot, next contact frequency).

2.1.2.6.5 Push-back Clearance Request/Delivery Service (PushBack)

The control of aircraft on ground is conducted through radar or visual means. An automated surface movement control and guidance of aircraft would be useful especially under low-visibility conditions.

The Push-back data link service permits a very simple dialogue (request/response) to take place between the pilot and airline or airport ground staff.

2.1.2.6.6 Taxi Request/Delivery Service (Taxi)

The Taxi data link service permits a very simple dialogue (request/response) to take place between the pilot and the ground control.

2.1.2.7 Description of the ADAP Services

The ADAP service provides the possibility to extract (supposedly suitably refreshed) pieces of information from an aircraft and to make them available to users on the ground. Several uses of such an application are foreseen.

2.1.2.7.1 Controller Access Parameters Service (CAP)

The Controller Access Parameter data link service aims at enhancing the ATC surveillance and the availability of aircraft parameters to the controller by extracting and downlinking data from the airborne system (in particular heading and air speed) today exchanged by VHF.

The CAP data link service is foreseen to be primarily used in continental airspace, both in en-route and terminal areas.

Aircraft parameters needed on the ground may differ from one controller to another. An en-route controller would be interested in having the heading and the air speed data while approach controller would like to know in addition the vertical rate and some weather data.

2.1.2.7.2 Aircraft Parameter Reporting Service (APR)

The APR data link service aims at downlinking aircraft data for surveillance purposes. The surveillance capability will be increased in over water and remote land areas, where either the provision of radar is difficult and uneconomic or the required radar coverage cannot be provided. Useful information dowlinked correspond to the ADS data blocks "groun vector" and "short term intent".

The use of APR data link service in the NAT and MED areas would allow getting a "pseudo-radar" display before the aircraft enters the radar coverage. This will smooth the transition from oceanic airspace into radar controlled areas eliminating the operational differences between these areas.

2.1.2.7.3 Meteorological Data Downlink Services (MET)

The MET data link service is used to downlink data items such as the temperature, the pressure and the wind vector. This information corresponds to the ADS data blocks "basic ADS" and "meteorological information". This information is of interest for meteorological offices that will improve meteorological-based data processing. The automatic gathering and transmission of accurate data will eliminate encountered errors caused by the manual treatment of received voice reports and delays before reaching the processing centre.

2.1.2.7.4 Flight Plan Consistency Service (FLIPCY)

The FLIPCY or PLN (Flight Plan Conformance) data link service permits the ground system to check that flight data in the FDPS correspond to planned flight plan stored in the aircraft navigation systems.

This service will increase safety by ensuring common flight plan between aircraft and ground systems, reduce voice communications and improve ATC planning due to confidence in flight plan information.

2.1.2.7.5 Pilot Preferences Downlink Service (PPD)

The PPD data link service permits the downlink of pilot preferences to the ground system for display to controllers. These preferences relate to flight parameters having operational implications for ATC and not requiring Controller response.

2.1.2.7.6 System Access Parameters Service (SAP)

This SAP service aims at downlinking aircraft parameters to be used by several ground functions. SAP is an automatic system to system service, without Aircrew or Controller involvement.

Examples of ground systems using aircraft parameters ("short term intent", "projected profile" and "extended projected profile" ADS data blocks):

- Short Term Collision Avoidance (STCA),
- Minimum Safe Altitude Warning (MSAW),
- Medium Term Conflict Detection Service (MTCD).

2.1.2.8 Description of the FIS-based Services

2.1.2.8.1 Data Link Operational Terminal Information Service (D-OTIS)

The D-OTIS data link service provides automated assistance in requesting and delivering compiled meteorological and operational flight information derived from ATIS, METAR and OFIS (NOTAMs / SNOWTAMs), specifically relevant to the departure, approach and landing flight phases.

Both the demand mode (i.e. one request / one reply) and the contract mode (i.e. one request / one reply for each update of the OTIS information) are available.

2.1.2.8.2 Data Link Runway Visual Range (D-RVR)

The D-RVR data link service provides automated assistance in requesting and delivering the up-to-date Runway Visual Range (RVR) to the Aircrew.

The uplinked information contains the time of issue, the runway identification and the RVR associated with it and the location of the mid point and the end point for that runway. Both the demand mode (i.e. one request / one reply) and the contract mode (i.e. one request / one reply for each update of the RVR information) are available.

2.1.2.8.3 Data Link Significant Meteorological Information (D-SIGMET)

The D-SIGMET data link service provides automated assistance in requesting and delivering SIGMET information to the Aircrew.

The purpose of SIGMET information is to advise pilots of the occurrence or expected occurrence of en-route weather phenomenon which may affect the safety of aircraft operations. The uplinked information contains the identification of the applicable FIR, the period of validity and the description of the phenomenon (type, location, level, movement, speed).

Both the demand mode (i.e. one request / one reply) and the contract mode (i.e. one request / one reply for each update of the SIGMET information) are available.

2.1.2.9 Description of the Other Data Link Services

2.1.2.9.1 Data Link Initiation Capability (DLIC)

The DLIC data link service provides access to all other data link services. In addition to the exchange of naming and addressing information related to air- and ground-based applications, the DLIC service allows for the transfer of the information required for the flight plan correlation (i.e., aircraft identification, departure and arrival aerodrome, aircraft address and estimated time of departure).

2.1.2.9.2 Dynamic Route Availability Service (DYNAV)

The DYNAV data link service provides automated assistance for the proposal of alternative routes to aircrew as they become available (e.g. when military areas become free to civil use). The ATC Ground Flight Data Processing System (FDPS) computes a potential route modification and uplinks it to the aircrew which shall accept or reject it. This FLIPCY service could take place automatically after the completion of the DYNAV service to check that the new route has been correctly introduced onboard.

This service will provide automatic aid support to the en-route controller and participate in the reduction of both controller's workload and R/T workload.

2.1.2.9.3 Traffic Information Service (TIS)

The TIS service consists of displaying in a cockpit display the position of other aircraft flying within a certain range.

This application needs the periodical positions of other aircraft. There are different means to collect this information: airborne radar, reception of position reports (uplinked by a ground system or broadcast by other aircraft, e.g. ADS-B).

A very high proportion of aircraft must be equipped to make this application operationally interesting. This will not be the case in the first days of the ATN.

2.1.2.9.4 ATFM/Slot Allocation Service

The ATFM/Slot Allocation Service consists of a dialogue between the pilot or the AOC and the ATFM entity.

In Europe the entire flight plan submission and subsequent distribution process and flow management will be centrally co-ordinated and managed through automated systems. Radar or satellite derived actual traffic data will enable a centralised unit to generate a dynamic and selective situation display of the traffic flows as an aid to the flow management process. Where individual aircraft are datalink-equipped, the foreseen slot may be negotiated directly with the pilot.

A good proportion of aircraft must be equipped to make this application operationally interesting. This will not be the case in the first days of the ATN.

2.1.2.9.5 4D Trajectory Negotiation Service (4DTN)

The 4D Trajectory Negotiation data link service consists of a dialogue between the pilot and the controller to negotiate an optimised trajectory. The dialogue can be initiated with a trajectory proposal coming from the aircraft or from the control centre. The trajectory negotiation takes place periodically as required by changing constraints imposed on the flight (weather, medium term traffic pattern, airspace congestion, etc.).

2.1.3 Supporting A/G Communication Environments

2.1.3.1 General

Several data link communication environments are being developed, validated and to some extent deployed. These environments - providing hosting structures for data link applications - may be listed into two categories: the ATN and non-ATN environments, as described below.

- In the ATN data link environment, the communication activities required to provide data link services to operational users are carried out by the ATN applications (CM, CPDLC, ADS and FIS-ATIS), the ATN Upper Layers and the ATN Internet based on Satellite, VHF and Mode-S sub-networks.

- Amongst the non-ATN data link environments:
  - The ACARS data link environment using the VHF sub-network provides with the ARINC 622 set of protocols a transport-like service to ATS applications. It is recognised that this transport service is not a end-to-end reliable service (as TP4 is in the ATN) which could not be suitable for critical or safety related ATS applications.
  - The Mode-S acts as an ATN sub-network and provides additional services to direct users (the so-called "Specific Services"). These services comprise datagram uplink and downlink service, an uplink and downlink broadcast service and the GICB (Ground Initiated Comm B) service. The GICB service allows the ground to read registers containing aircraft parameters (aircraft address, way-points, meteorological data, etc…).
  - The ADS-Broadcast data link environment, in which aircraft use the data link network (Mode-S squitter or VDL-STDMA/mode 4) to broadcast position, altitude, vector and other data provided by onboard equipment. Any user, either aircraft or ground-based, within range of this broadcast, may choose to receive and process this information to provide operational data link services to end-users.

Table 1 defines the relationships between the air/ground data link services and the data link environments providing the communication services they require.

	ATN Environment				**Other Data Link Environments**
ATS Air/Ground Services	CM	ADS	CPDLC	FIS ATIS	
CPDLC-based services					
Clearance and Information Communication Service (CIC)	N/A	N/A	Yes	N/A	
ATC Communication Management Service (ACM)	N/A	N/A	Yes	N/A	
Downstream Clearances Service (DSC)	N/A	N/A	Yes	N/A	ACARS
Departure Clearance Service (DLC)	N/A	N/A	Yes	N/A	ACARS
Push-back Request/Delivery Service	N/A	N/A	Note	N/A	
Taxi Request/Delivery Service	N/A	N/A	Note	N/A	

Note: the CPDLC message set does not contain the relevant messages yet.

	ATN Environment				**Other Data Link Environments**
ATS Air/Ground services	CM	ADS	CPDLC	FIS ATIS	
ADAP services					
Controller Access Parameter (CAP)	N/A	Yes	N/A	N/A	Mode-S/Specific services, ADS-B
Aircraft Parameter Reporting (APR)	N/A	Yes	N/A	N/A	Mode-S/Specific services, ADS-B
Downlink Meteorological Data (MET)	N/A	Yes	N/A	N/A	Mode-S/Specific services
Flight Plan Consistency Service (FLIPCY)	N/A	Yes	yes	N/A	
Pilot Preferences Downlink Service (PPD)	N/A	N/A	yes	N/A	
System Access Parameters Service (SAP)	N/A	Yes	N/A	N/A	Mode-S/Specific services, ADS-B

	ATN Environment				**Other Data Link Environments**
ATS Air/Ground services	CM	ADS	CPDLC	FIS ATIS	
Data Link FIS services					
Data Link Operational Terminal Information Service (D-OTIS)	N/A	N/A	N/A	yes	ACARS
Data Link Runway Visual Range (D-RVR)	N/A	N/A	N/A	note	
Data Link Significant Meteorological Information (D-SIGMET)	N/A	N/A	N/A	note	

Note: it is likely that the FIS Application will be modified to support additional types of FIS information (CNS/ATM-1 specifies exchanges for ATIS only).

	ATN Environment				Other Data Link Environments
ATS Air/Ground services	CM	ADS	CPDLC	FIS ATIS	
Others services					
Data Link Initiation Capability Service (DLIC)	yes	N/A	N/A	N/A	Not supported
Dynamic Route Availability service (DYNAV) (*)	N/A	N/A	yes	N/A	
Traffic Information Service (TIS)	N/A	N/A	N/A	N/A	ADS-B
ATFM/Slot Allocation Service	N/A	N/A	N/A	N/A	
4D Trajectory Negotiation Service	N/A	Partially	N/A	N/A	

(*) The DYNAV service is supported by the CPDLC service but is not considered as a CPDLC-based service since the controller is not involved in the data exchange.

Table 1: Mapping Data Link Services / Data Link Communication Environments

2.1.3.2 CNS/ATM-1 Air/Ground ATN Applications

An initial set of ATN applications has been specified by ICAO. Standard And Recommended Practices (SARPs) [ICA5] have been fully validated and approved for four air/ground applications. In addition to the specification of the ATN Upper Layer Architecture, several ATN Application Service Elements supporting each a specific communication function have been specified. This specification contains the following items:

- A description of the service provided to the application users (the abstract service),
- A description of the actions mandated in the air and ground systems to guarantee the inter-operability (the protocol), and
- An unambiguous description of the contents of the application messages (using the ASN.1 notation).

2.1.3.2.1 Context Management (CM) ATN Application

In an ATS data link environment, the CM application allows datalink-equipped aircraft and ground system to exchange and update data link application information and flight plan association data each other. In addition, the CM application defines a communication protocol used by ground systems to exchange via ground networks addressing information received from aircraft.

Functions supported by the CM application are:

- The **logon function** which constitutes the initial data link exchange between the aircraft and the ground.
- The **contact function** used by a ground system to request the aircraft to initiate data link with a other ground system.
- The **update function** used by a ground system to uplink ground addressing information to the aircraft.
- The **ground forwarding function** used by a ground system to forward the addressing information received from an aircraft to another ground system.
- The **registration function** performed locally by both systems to make available the received addressing application to local applications.

2.1.3.2.2 Automated Dependant Surveillance (ADS) ATN Application

The ADS application is a surveillance technique in which aircraft automatically provide via a data link data derived from on-board navigation and position-fixing systems, including aircraft identification, four-dimensional position, and additional data as appropriate.

Functions supported by the ADS application are:

- Establishment and operation of a **Demand Contract**,
- Establishment and operation of an **Event Contract**,
- Establishment and operation of a **Periodic Contract**,
- Establishment and operation of **Emergency Contracts**,
- Cancellation of contracts, and
- **Ground Forwarding** of ADS reports.

2.1.3.2.3 Controller Pilot Data Link Communication (CPDLC) ATN Application

In an ATS data link environment, the CPDLC application will be a means of communication of routine messages between a controller and the aircraft he is controlling. It is a one-to-one link, with no broadcast facility, and only one controller exercising control over an aircraft at any one time. There are very limited facilities to allow an aircraft to contact another control authority for the purpose of obtaining specific information for a future part of the flight.

Functions supported by the CPDLC application are:

- The **Controller-Pilot Message Exchange** function,
- The **Transfer of Data Authority** function,
- The **Down Stream Clearance** function, and
- The **Ground Forward** function.

2.1.3.2.4 Flight Information Services / Automatic Terminal Information Service (FIS/ATIS) ATN Application

The FIS application allows a pilot to request and receive FIS services from ground FIS services.

In a fully operational ATS data link environment, FIS will be used as the main means of passing flight information as Automatic Terminal Information Services (ATIS), notices to airmen (NOTAMs), meteorological aerodrome reports (METARs) and extracts from aeronautical information circulars (AICs).

Functions supported by the FIS application are:

- Establishment and operation of **Demand Contract for ATIS information**,
- Establishment and operation of **Update Contract for ATIS information**, and
- Cancellation of contracts.

2.1.4 Proposed Air/Ground Services and Applications for the Target ACCESS ATN

2.1.4.1 The ATN: An Appropriate Way to Provide Air/Ground Data Link Services

It is recognised world-wide that the provision of ATS services on air/ground data links will enhance significantly the current ATC capacity and allow for a better handling of the always increasing aeronautical traffic with the same safety constraints. The data link ATS services will mainly bring the three following enhancements:

- move of a non-negligible part of the VHF communications to the data link increasing the quality of the Pilot/Controller dialogues,
- automation of several tasks keeping the pilots and the controllers busy, and
- increase of the accuracy and the amount of information known by the ground ATC people (resp. the crew) about the aircraft parameters (resp. about the ground parameters).

Data link is therefore promising especially in Europe where the traffic is continuously increasing, congestion problems are increasingly encountered and where the usual solutions can not be reused anymore (e.g. the sectorisation, procedures, etc.).

The ATN provides valid technical solutions to the problems raised by air/ground data link communications as for instance the aircraft mobility, the addressing and routing issues, the integration of heterogeneous mobile sub-networks, the compliance to performance requirements in terms of transit delay, end-to-end data integrity and quality of service, etc… Other features as security and network management functions are under investigation.

In addition, the ATN provides a flexible and extensible framework for defining data link applications. The initial ATN applications (ADS, CPDLC and FIS) already provide the basic communication functions required by the three main types of a/g data link services: pilot/controller messaging (CPDLC-based services), downlink of aircraft parameters (ADS-based services) and uplink of ground parameters (FIS-based services). Thus, the ATN will provide very quickly the communications means sufficient to support most data link services. Therefore, the difficulty for the development of the ATN is not the provision of the communication functions but the integration of the new exchanged data in the operational ATC environment and in the aircraft, as well as the impact on the current operational procedures.

However, the ATN is not the universal solution for all air/ground data link services. For technical, performance, cost or availability reasons, Mode-S, ACARS-based or ADS Broadcast solutions may be preferred over ATN in some regions or for some services.

2.1.4.2 Recommendation for CPDLC-based services

Because the CPDLC-based services constitute a key factor for the enhancement of the ATC, it is proposed that the target ACCESS ATN be designed to support everywhere all the CPDLC-based services identified in this document. This will require in the next years some additional standardisation work for some of them (Puskback and Taxi) and many experiments/studies to determine how to adapt the aircrew/controller working positions and the current ATC systems to these new services.

The CPDLC application as designed for ATN by ICAO has taken into account the specific European requirements, such as the possibility to request and send a delivery report (LACK or Logical Acknowledgement) indicating the reception at the system level of a CPDLC message or such as the Downstream Clearance function. Lessons have been taken from the FANS1/A experience and the resulting CPDLC application covers more precisely the operational needs.

2.1.4.3 Recommendation for ADAP services

For surveillance purpose, given the performance requirements and the existing radar infrastructure, the ATN (ADS-based) solution should not be chosen for the continental area. Where no other means can be employed, over oceanic areas for instance, the ADS ATN application is the only solution to enhance the surveillance capability of the ATC.

However, the number of ADAP services shows that there are many ground ATS users interested by the ADS service. In addition, it is likely that airline operators want to access to similar services for AOC purposes. The ADAP services will certainly not be all implemented by 2010 and they will not be in use uniformly in the ACCESS area. The main services foreseen are ADAP services for meteorological, conflict detection or flight plan verification purposes. The ATN ADS application is an appropriate means to retrieve the aircraft parameters relevant for those services.

It is proposed that the target ACCESS ATN be designed to support the ADS application everywhere an oceanic control is performed. Optionally, the ATN ADS application should be supported in continental area where services requiring aircraft parameters are implemented on one hand and when these parameters can not be retrieve by the existing communication infrastructure on the other hand.

2.1.4.4 Recommendation for D-FIS services

Benefits from D-FIS services are obvious and will contribute to the enhancement of the aircrew environment: more accurate information available onboard, availability of information independently of the VHF coverage, optimisation of the R/T channel, controller workload reduction, etc… It is likely that the next version of the FIS application standardised by ICAO will support communication services for other types of information (RVR, SIGMET).

It is proposed that the ATN be designed to support the D-FIS application and its corresponding services.

2.1.4.5 Recommendation for the other services

Due to the number of ATN End Systems deployed world-wide and to the non-homogeneity of the ATN capability of the aircraft and the ground control centres, it is clear that a service handling dynamically the exchange of ATN capability and addressing information is mandated. In addition, to be operational, the data link shall provide the ground ATC authorities with a means to identify unambiguously an aircraft and to associate it with a flight plan. The DLIC service provides exactly these functions and consequently will be selected for implementation in the target ACCESS ATN.

With respect to the other services of this category, the DYNAV and 4DTN services are the more mature and could bring substantial enhancements in the way route modifications are handled.

As it is difficult to say today whether or not the ATC and airborne systems will be ready in 2010 to handle and process the data involved in these exchanges, a reasonable estimation is to not foresee these services in the target ACCESS ATN.

2.1.5 Location of Air/Ground End Systems

2.1.5.1 General

A distinction has to be done between the final users (i.e. the operational users or systems) of the data link services and the ATN End Systems (i.e. the systems implementing the data link).

ATS data link services are provided to users in several ATS entities, located in:

- The aircraft (aircrew or airborne systems),
- The en-route Air Traffic Control Centres (controllers, flight plan processing , etc.) controlling the FIRs, and

- The approach Air Traffic Control Centres (approach controllers) controlling the TMAs.
- The airports (pre-flight and tower controllers, ATIS systems, etc.).

Considering the data link services proposed for the target ATN architecture, it is possible to deduce the physical location of these data link users. For the CPDLC-based services, the controllers of the en-route ATC centres and the main approach ATC centres shall have access to the ACM and CIC services and shall be provided with aircraft parameters. The ADS service could be proposed for surveillance to controllers of oceanic areas. Other users of the ADS services are meteorological users or controller-aid systems (as conflict detection). The main airports shall be able to provide aircraft with Departure Clearances, Taxi and Pushback. However, the ESs supporting the datalink applications are not automatically located where the end users are.

It appears that whereas it is possible to identify functionally the finals users it is very difficult to locate the ATN ESs. The location of the ESs is tied too much to the existing topology of the Air Control systems in each state and the strategy of these states (see below).

2.1.5.2 ATN End Systems

An ATN End System is the system that manages the connection with the peer and operates over that connection the ATN upper layers and application protocols. The End System therefore hosts the communication applications required to provide the operational service to the users connected to that system, i.e. CM, ADS, CPDLC and/or FIS. An ES can host one or several ATN applications.

Several ground ATS users may share the same ES to communicate with the aircraft.

An End System is identified in the communication environment by an ATN NSAP Address. The communication part of the ATS applications (i.e. the "Application Entity") hosted in the End System is identified by the complete ATN address (composed of the NSAP Address and a Transport selector) and a name (i.e. the "Application Entity Title").

Airborne ATN ES

The airborne part of air/ground ATS applications is hosted by one or several End Systems in the aircraft. The air CM application entity is aware of which applications are activated in the aircraft and what their ATN address and version number are.

The AIRBUS approach consists in developing a stand-alone system dedicated to the data link communications (the ATSU system). This system would host all the ATS applications. An other approach is to implement in an existing airborne computer like the FMS the data link applications (e.g. FANS/1 on Boeing).

The airborne topology (i.e. the number of ESs in the aircraft) is completely hidden to the ground applications.

Ground ATN ES

Topology on the ground is much more complex. A least five types of basic topology may be proposed but a combination of the different topologies for different applications is also possible.

1. The final user acts as an End System (e.g. the Controller Working Position for CPDLC-based services).
2. An ES in each ACC (en-route and approach) serving several local clients (e.g. the final users located in the ACC, such as the CWPs or FDPS).
3. An ES in each en-route ACC only serving local and remote clients (i.e. the final users located in the en-route ACC and those located in the approach ACCs attached to the en-route ACC).

4. One ES per country. This system is providing data link services to all final users at the scope of a country.

5. One ES for Europe. This system is providing data link services to all final users at the scope of Europe.

Solution 1 is relevant only for data link services for which a specific controller is identified (e.g. the DCL service). This solution will generate a non-negligible overhead in traffic, type and procedure since the full transfer of communication (i.e. VHF and data link) is carried systematically between two sectors.

Solutions 2 and 3 optimise the use of the data link since the same CPDLC or ADS connection will be used for several final users.

Solutions 4 and 5 do not seem realistic for CPDLC-based and ADAP services. They would require the centralised system to know in real time the exact configuration of all ACCs in the country or in Europe. In other words, this centralised ES has to know who and where the final ATS user of each aircraft is (for instance the active controller) to be able to forward the exchanged data between the aircraft and this user. For FIS data link services, these solutions might be very convenient.

2.1.5.2.1 ES for CPDLC-based applications

Due to the aircraft mobility and the way the air control is organised, the ground interlocutor (i.e. the active controller) is changing in the time. Thus, from the communication viewpoint, this is the aircraft that is fixed and the ground user that is moving from one location to another. Subsequent instances of communication, each corresponding to a separate controller, have to be set up in sequence. The airborne application user has a single address, whereas the active ground user has one or several depending on how the "mobility" of the active controller is hidden from the aircraft communication system.

- **Option 1: Controllers are gathered in a pool of controllers**.

The active controller is not identified as such. A CPDLC ES is responsible for the communication with the aircraft on behalf of all controllers. Any data received from an aircraft is forwarded to the appropriate controller responsible for this aircraft. A single connection between the aircraft and the server is needed whatever the active controller is.

The granularity of the pool of controllers has to be defined. It could correspond to the set of controllers of all the sectors of an ACC as illustrated in Figure 2, or of several ACCs as illustrated in Figure 3.

The CPDLC ES must maintain dynamically the relationship (aircraft, active controller) for each aircraft in order to be able to forward the data received from an aircraft to the appropriate CWP.

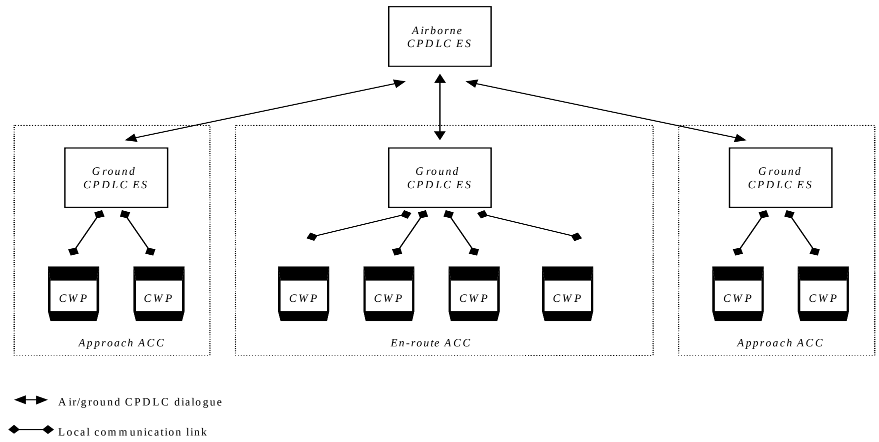

Figure 2: One ground CPDLC ES per ACC (en route and approach)

The transfer of control inside the pool of controllers has no effect on the D/L communication means, i.e. there is no transfer of D/L communication when the aircraft is passed from one controller to another. This means no air/ground exchange of addressing information and no establishment of parallel connections.

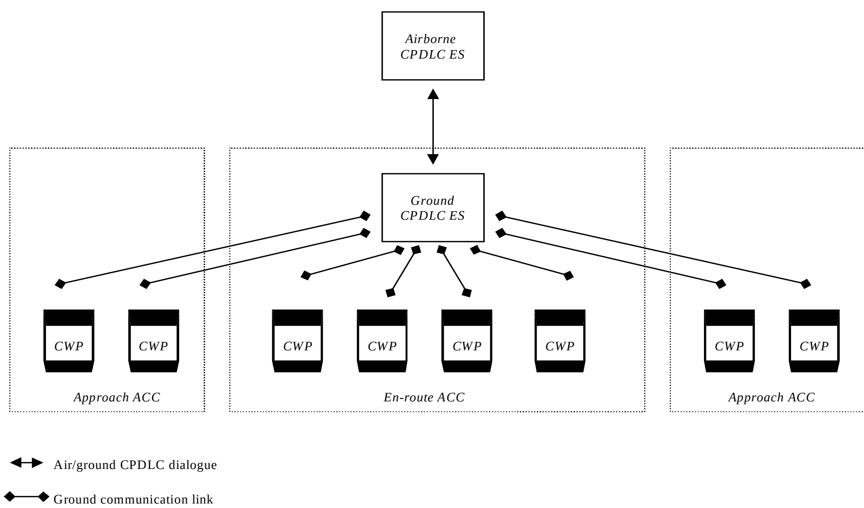

Figure 3: One ground CPDLC ES per en-route ACC

The transfer of control between controllers of the same pool consists in the exchange of the frequency channel of the next controller. The same CPDLC dialogue between the aircraft and the ground is used before and after the transfer of control.

The transfer of control includes a data link change (NDA message) only when the next controller is outside the pool and a new CPDLC dialogue is required. In that case, a CM exchange is needed for the aircraft to get the ATN address of the next CPDLC ES.

This configuration is more appropriate for CPDLC-based services involving a long dialogue to be maintained between the aircrew and the ("moving") active controller: CIC, DSC and ACM.

- **Option 2: Controllers are acting as separate communication actors.**

There is one CPDLC ES per controller, as illustrated in Figure 4. Each controller is assigned a CPDLC address that has to be uplinked by a CM exchange to the aircraft.

In this configuration, the transfer of communication includes both the frequency change and the data link change each time an aircraft is to be passed from one controller to another. This means the establishment of a new connection for each transfer of control, even from one sector to another in the same ACC.

This ground configuration seems to be more appropriate for simple CPDLC-based services involving a short dialogue (Request/Reply) between the aircrew and a particular fixed controller: DCL, Pushback, Taxi.

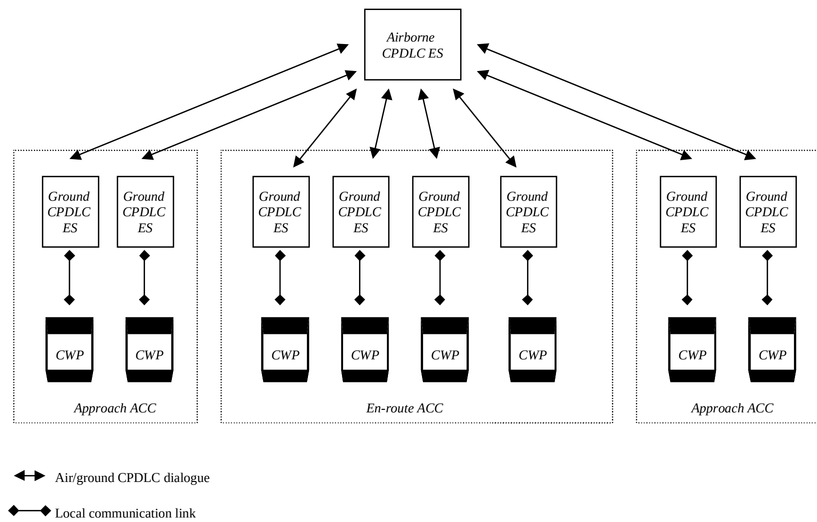

Figure 4: One ground ES per Controlling Working Position

2.1.5.2.2 ESs for ADAP-Services

The use of the downlinked aircraft parameters is foreseen in a lot of functional area:

- Position data for surveillance,
- Pilot short-term intent on request of the controller,
- Data used by ground automated system responsible for triggering alarms to the controllers,
- Data for conflict detection/resolution,
- Flight plan processing systems (air/ground consistency, update, etc…)
- External systems, such as meteorological systems.

Due to the variety of users and locations of these users, it is difficult to identify the optimal localisation for the ground ES hosting the ADS application. Depending on the requested data in the contracts, downlink data are processed by the Radar Data Processing System, the radar display, the FDPS, or external systems. The ES may be integrated in any of these systems or in a new ADS-dedicated system.

In addition, the number of ground systems authorised to establish ADS contracts with the aircraft (the minimum being set to four) is limited. A technical constraint defined in the ADS protocol prevents ground systems from establishing several ADS contracts of the same type with the same aircraft.

This leads to choose a centralised solution for the ground ADS ES, as depicted in Figure 5. A unique ES in the ATCC operating ADS would establish contracts on behalf of all the interested systems in the ACC with the aircraft and forward the ADS reports to the actual users of the received aircraft parameters. Other ESs could be installed for those external systems identified above.

The ground/ground communication would be performed based on ICAO protocols, such as the ADS-forward protocol defined by ATNP.

It has been already mentioned that in Europe the ADAP services may also be provided based on data received from Mode-S or ADS-B sub-networks. The advantage of the centralised solution would be to hide the users the actual technology used to retrieve the data. In most cases, the sub-network would be Mode-S GICB or ADS-B (continental area). For others, e.g. in the NAT area, the ATN ADS application over the ATN will be activated. The provided application service would be the same. Figure 6 illustrates an ADAP server supporting different technologies.

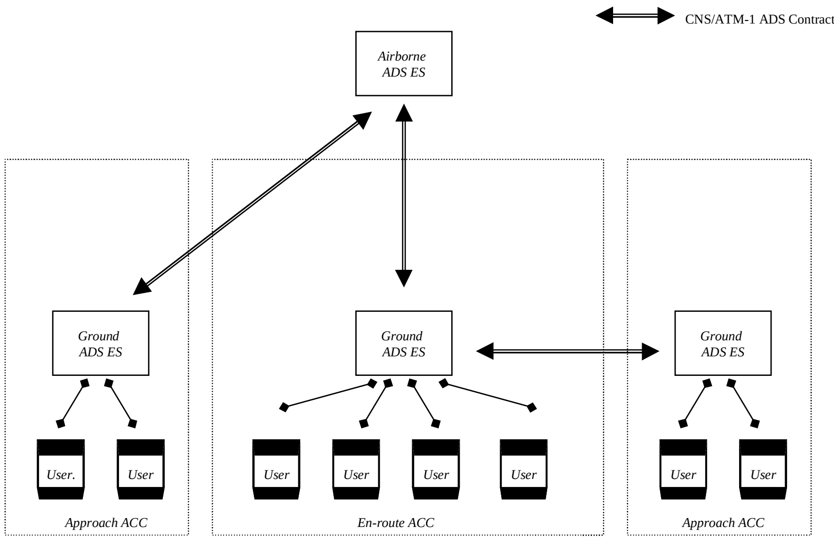

Figure 5: Ground topology for CNS/ATM-1 ADS Application

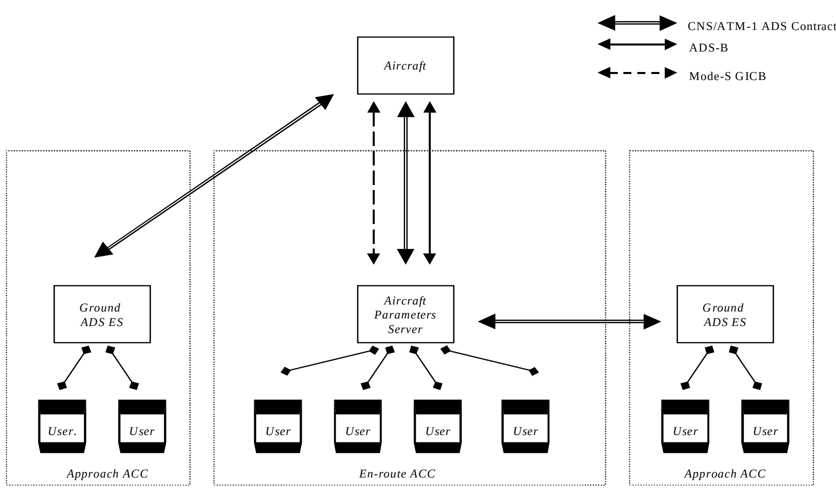

Figure 6: Ground topology for multi-protocol ADS server

2.1.5.2.3 ESs for D-FIS Services

Three approaches can be envisaged for the implementation of End Systems providing D-FIS services:

- **Option 1: A centralised FIS server contacted by all aircraft for transmission of flight information related to the area defined for the server (figure 7).**

The area can be a region, a country or a set of countries. This configuration requires a ground communication infrastructure for transmission of the data from the source (airports for instance) to the server. The main advantage is the limited number of addresses (one per server) to be distributed. When the DLIC service is operated, the logon exchange with any of the ground CM system in the area will allow the aircraft to get the address of this FIS server.

- **Option 2: Several FIS ground systems not dedicated to a specific type of information (ATIS, METAR, etc.) or to a specific airport (figure 8).**

Any ground system can be contacted by the aircraft, whatever the type of FIS information requested and the airport related to the request are. The request for an information not locally hold is forwarded to the relevant ground FIS system that returns the requested data. This distributed configuration is very flexible for the service users since they don't have to care with the address of a particular FIS server. Any ground server can be contacted to retrieve the information. This configuration requires the specification of a ground protocol between FIS servers. The CNS/ATM-1 FIS SARPs do not specify such a protocol (neither the ADS Panel nor the OSIAC-TF has specified operational requirements). This means that the distributed solution can be implemented at the scale of a region if a ground protocol is operated in this region.

- **Option 3: A FIS ground system installed closed to the source of the information and dedicated to this source (figure 9)**.

For ATIS, the source is an airport. The ground system hosts only the information from this source and is not able to forward the request to an other ground system when the information is not stored locally. The air-initiated request is simply rejected. This solution implies a heavier management of the addresses since the address of the FIS server attached to the airport the requested information is related to shall be known by advance by the aircraft. A logon exchange with the appropriate CM ground system (i.e. the one which "sees" the FIS server) should have been done before the FIS request can be issued.

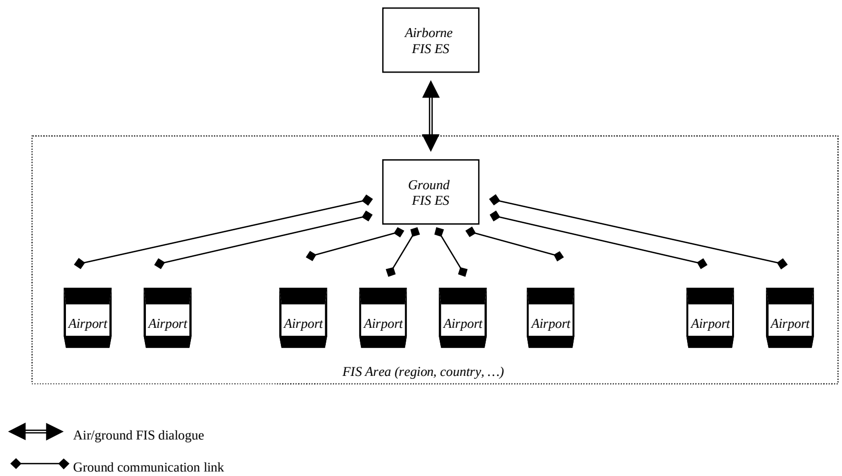

Figure 7: Ground topology with a centralised FIS server

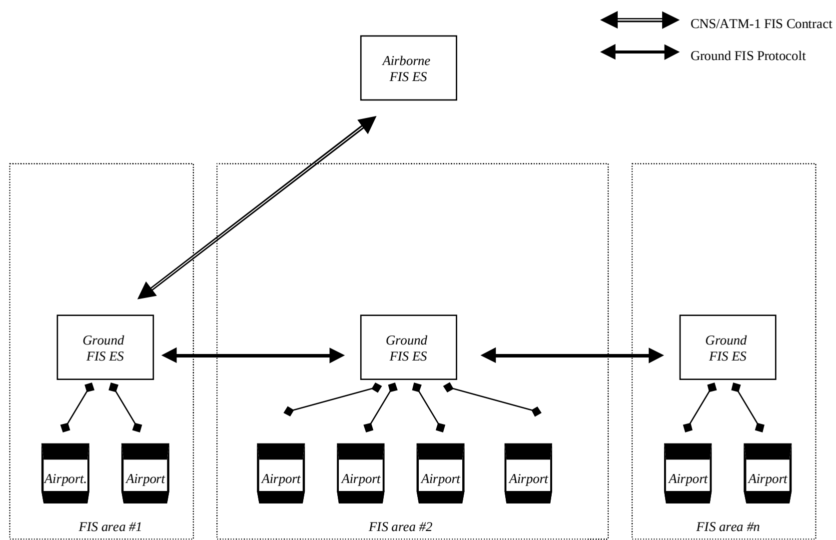

Figure 8: Ground topology with interconnected FIS ground systems

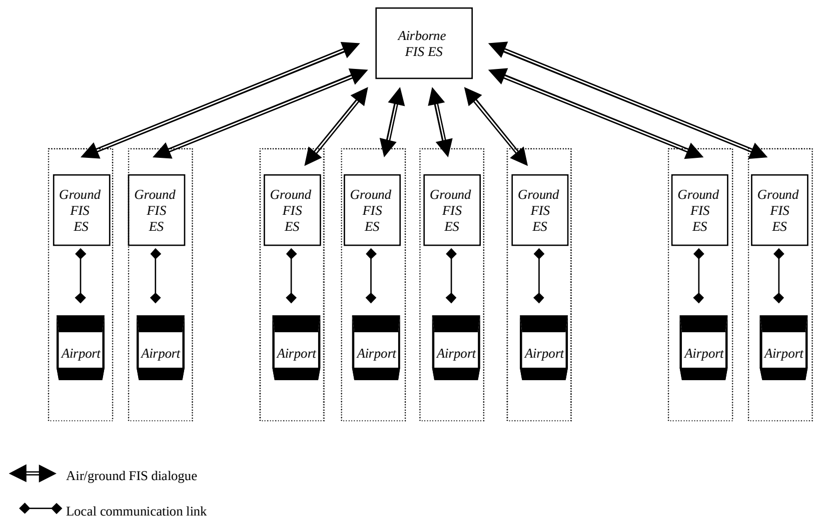

Figure 9: Ground topology with non interconnected FIS servers

2.1.5.2.4 Conclusion

There are therefore several possible configurations resulting from the type of the ES implemented. The ESs can be of type "server" (or gateway) or of type "terminal". This choice can be done only locally – for instance, at the scale of a state - based on the actual organisation of the control systems and the nature of the data link service set in operation.

The "server" ES seems more appropriate in most cases for ATS services. CPDLC and ADAP ESs implemented in en-route and main approach ACCs would provide dialogues with pilots and aircraft parameters to controllers and systems of these ACCs. FIS servers covering regional or national areas would provide flight information services to all aircraft.

2.1.5.3 Location of A/G ES in the area considered by ACCESS

As mentioned before, the location of the ATN ES in a State will depend of local parameters: current organisation of the ATC systems, current ground communication infrastructure, selection of the data link services for the ATN, etc. It is therefore not possible to indicate here precisely where the ATN ESs will be installed in the ACCESS area.

However, a first try of drafting the ACCESS ATN map in terms of ESs in the 2010's could be done based on two theoretical scenarios.

The main assumptions are that all ATC Authorities of the ACCESS will implement the ATN by 2010 to provide ATS services and that the 3 types of data link services (CPDLC-based, ADAP and FIS) are implemented in each State of the ACCESS area, that is at least one data link service of each type is required.

1. The "Min" scenario puts forwards the concept of "data link server", i.e. the ground End Systems act as much as possible as a communication gateway to the aircraft. The connections established with the aircraft are therefore shared by several users. The gateway is responsible for forwarding each message received on the connection to the relevant recipient. Ground communications are required between the gateway and these recipients. The scenario considers that aircraft parameters are made available through non-ATN continental sub-networks (Mode S GICB).

   The "Min" scenario required ESs located in the following places:

- CPDLC-based services: **one CPDLC ES per en-route ACC**. Each CPDLC ES supports CPDLC dialogues for all CPDLC-based services (CIC, ACM, DSC, DLC, Push-Back, Taxi) between the aircraft and the controllers of the en-route area, the adjacent approach ACCs and the main airports. The same CPDLC link is used to exchange data between the pilots and all these controllers.

- FIS services: **one FIS ES per country and per type of information** (D-FIS, D-RVR, D-SIGMET). This could lead to the definition of 1, 2 or 3 End Systems.

- Limited use of ADAP services: **one ADS ES is installed per ACC controlling an oceanic area**. These ADS ESs supports ADS contracts for surveillance purpose only (APR).

1. The "Max" scenario proposes a heavier ground topology where the ESs are closer to the source and the recipient of the exchanged data. ADS is used here to retrieve aircraft parameter for several clients.

   The "Max" scenario required ESs located in the following places:

   - CPDLC-based services: **one CPDLC ES per en-route, approach ACC and main airport**. The CPDLC ES located in an approach ACC supports the CPDLC dialogues for all CIC and ACM, those located in the main airport supports CPDLC dialogues for CIC, ACM, DLC, Pushback and Taxi). The CPDLC ES located in an en-route ACC supports CPDLC dialogues for some CPDLC-based services only (CIC, ACM and DSC).

   - FIS services: **one FIS ES per en-route, approach ACC**. ESs installed in approach ACCs provide D-OTIS, D-RVR and D-SIGMET. ESs installed in en-route ACCs provide D-SIGMET information only.

   - Extensive use of ADAP services: **one ADS ES per en-route and approach ACC**. Each ADS ES supports ADS contract for several ATC functions (surveillance, flight plan processing, conflict detection, meteorology, etc.). Supported data link services could be APR, MET, FLIPCY, PPD and SAP. Ground ES could implement the ground forwarding function only and receive data from an aircraft through an other Ground ES.

It is likely that the reality will be a mix of the two solutions. Each state or group of states will deploy its own ATN based on national or regional considerations.

Tables 2, 3 and 4 indicate based on these assumptions where the ATN ES should be installed in the ACCESS area and which application(s) these ESs should host. The list of ACCs is extracted from the Convergence and Implementation Programme (CIP) document from Eurocontrol. The list of airports with more than 500 daily movements is extracted from the COPICAT project [CEC3].

Main Approach ACCs in the ACCESS area		
	Scenario "Min"	Scenario "Max"
UK		-
London ACC (TMA)		CM, CPDLC, ADS, FIS, RVR, SIGMET ES
Manchester ACC (TMA)		CM, CPDLC, ADS, FIS, RVR, SIGMET ES
France		
Paris-Orly APP		CM, CPDLC, ADS, FIS, RVR, SIGMET ES
Paris-CDG APP		CM, CPDLC, ADS, FIS, RVR, SIGMET ES
Germany		
Berlin APP		CM, CPDLC, ADS, FIS, RVR, SIGMET Es
Dusseldorf APP		CM, CPDLC, ADS, FIS, RVR, SIGMET ES
Frankfurt APP		CM, CPDLC, ADS, FIS, RVR, SIGMET ES

Munich APP		CM, CPDLC, ADS, FIS, RVR, SIGMET ES
Benelux		
Brussels APP		CM, CPDLC, ADS, FIS, RVR, SIGMET ES
Amsterdam ACC		CM, CPDLC, ADS, FIS, RVR, SIGMET ES
Italy		
Milan ACC		CM, CPDLC, ADS, FIS, RVR, SIGMET ES
Rome ACC		CM, CPDLC, ADS, FIS, RVR, SIGMET ES
Spain		
Barcelona ACC (TMA)		CM, CPDLC, ADS, FIS, RVR, SIGMET ES
Madrid ACC (TMA)		CM, CPDLC, ADS, FIS, RVR, SIGMET ES
Palma APP		CM, CPDLC, ADS, FIS, RVR, SIGMET ES

Table 2: Location of ATN ES in the Approach ACCs in the ACCESS area

En-route ACC in the ACCESS area		
	Scenario "Min"	Scenario "Max"
UK	FIS, RVR, SIGMET ES	-
London ACC (en-route)	CM, CPDLC	CM, CPDLC, ADS, SIGMET ES
Manchester ACC (en-route)	CM, CPDLC	CM, CPDLC, ADS, SIGMET ES
Scottish ACC	CM, CPDLC, ADS	CM, CPDLC, ADS, SIGMET Es
Ireland	FIS, RVR, SIGMET ES	-
Dublin ACC	CM, CPDLC	CM, CPDLC, ADS, SIGMET ES
Shannon ACC	CM, CPDLC, ADS	CM, CPDLC, ADS, SIGMET ES
France	FIS, RVR, SIGMET ES	-
Paris ACC	CM, CPDLC	CM, CPDLC, ADS, SIGMET ES
Reims ACC	CM, CPDLC	CM, CPDLC, ADS, SIGMET ES
Aix-Marseille ACC	CM, CPDLC	CM, CPDLC, ADS, SIGMET ES
Bordeaux ACC	CM, CPDLC	CM, CPDLC, ADS, SIGMET ES
Brest ACC	CM, CPDLC, ADS	CM, CPDLC, ADS, SIGMET ES
Germany	FIS, RVR, SIGMET ES	-
Berlin UAC/ACC	CM, CPDLC	CM, CPDLC, ADS, SIGMET ES
Bremen ACC	CM, CPDLC	CM, CPDLC, ADS, SIGMET ES
Dusseldorf ACC	CM, CPDLC	CM, CPDLC, ADS, SIGMET ES
Frankfurt ACC	CM, CPDLC	CM, CPDLC, ADS, SIGMET ES
Karlsruhe UAC	CM, CPDLC	CM, CPDLC, ADS, SIGMET Es
Munich UAC/ACC	CM, CPDLC	CM, CPDLC, ADS, SIGMET ES
Benelux	FIS, RVR, SIGMET ES	-
Brussels ACC	CM, CPDLC	CM, CPDLC, ADS, SIGMET ES
Amsterdam ACC	CM, CPDLC	CM, CPDLC, ADS, SIGMET ES
Eurocontrol		

Maastricht UAC	CM, CPDLC	CM, CPDLC, ADS, SIGMET ES
Italy	FIS, RVR, SIGMET ES	
Brindisi ACC	CM, CPDLC	CM, CPDLC, ADS, SIGMET ES
Milan ACC	CM, CPDLC	CM, CPDLC, ADS, SIGMET ES
Rome ACC	CM, CPDLC	CM, CPDLC, ADS, SIGMET ES
Padua ACC	CM, CPDLC	CM, CPDLC, ADS, SIGMET ES
Spain	FIS, RVR, SIGMET ES	-
Barcelona ACC (en-route)	CM, CPDLC	CM, CPDLC, ADS, SIGMET ES
Canarias ACC	CM, CPDLC	CM, CPDLC, ADS, SIGMET ES
Madrid ACC (en-route)	CM, CPDLC, ADS	CM, CPDLC, ADS, SIGMET ES
Seville ACC	CM, CPDLC	CM, CPDLC, ADS, SIGMET ES
Portugal	FIS, RVR, SIGMET ES	-
Lisbon ACC	CM, CPDLC, ADS	CM, CPDLC, ADS, SIGMET ES

Table 3: Location of ATN ES in the En-Route ACCs in the ACCESS area

Main airports in the ACCESS area		
	Scenario "Min"	Scenario "Max"
UK		-
London-Heathrow		CPDLC
London Gatwick		CPDLC
Manchester		CPDLC
France		
Paris-Orly		CPDLC
Paris-CDG		CPDLC
Germany		
Frankfurt am Main		CPDLC
Munich		CPDLC
Dusseldorf		CPDLC
Benelux		
Brussels		CPDLC
Amsterdam-Schipol		CPDLC
Italy		
Milan ACC		CPDLC
Rome ACC		CPDLC
Spain		
Barcelona		CPDLC
Madrid		CPDLC

Table 4: Location of ATN ES in the Approach ACCs and main airport in the ACCESS area

2.2 ATS Ground D/L Services and Applications

2.2.1 Introduction

The approach taken for air/ground data link services and applications is reused here for ground services and applications. This section includes an inventory and an analysis of ATS ground data link services. Then, it describes the ground CNS/ATM-1 ATN applications defined for supporting these services.

This inventory is based on the ACCESS WP 201 "Current Communications Infrastructure" and the EUNIS WP 2000 Report " Inventory and Profile Description of Ground Data Applications" [EAT5].

It should be noticed that a formal definition of the ground ATS data link services does not exist, as it is the case for air-ground services (through the work of the ODIAC-TF). The main difference with the air-ground environment is the existence of technical and fully operational solutions. Ground communication services between ATS systems are already provided by AFTN/CIDIN and/or X.25 network and communication protocols have been developed to handle ground data transfers (e.g. OLDI). Users are already provided with an operational basic messaging service.

The introduction of the ATN for ground communications addresses in fact two objectives:

- the enhancement or the replacement of the existing communication infrastructure by a more homogenous, integrated, flexible and efficient infrastructure, and a transition path between the two, and
- the provision of new ground data link services.

2.2.2 ATS Ground D/L Services

2.2.2.1 Overview of the ATS ground D/L Services

The ground ATS data link services investigated are categorised into two sets addressing respectively each objective identified above:

- The basic communication services:
  - ATS Message Handling service,
  - AFTN to/from ATN Message Communication Service, and
  - CIDIN to/from ATN Message Communication Service,
- The ATS operational services:
  - Radar Data transfer service,
  - Meteorological Data transfer service,
  - Aeronautical Information service,
  - Flight Plan Data transfer service,
  - Airspace Management (ASM) and Air Traffic Flow Management (ATFM) Data transfer service, and
  - ATCC co-ordination data transfer service.

The way the ATS operational services are supported in the current ATS environment is described in detail in chapter 5 of ACCESS Task 201 [A201].

2.2.2.2 ATS Message Handling Service

Today, ATS messages (flight plan, NOTAMs, etc.) are conveyed through the AFTN/CIDIN network. The main characteristics of these networks dedicated to aeronautical data exchange are the nature of provided service (connectionless), the nature of the transmitted data (character-oriented: ITA2 and IA5), the multiple dissemination feature and the low throughput provided.

The ATS Message Handling service provides an enhanced messaging service compared to the AFTN communication service:

- Transmission of operational messages in the "store-and-forward" mode,
- Data exchanges between users and/or ground systems,
- Generation of delivery/non-delivery reports, and
- Multiple body and multiple content type supported (not only characters).

For transition purpose – it is clear that AFTN/CIDIN will be kept in use in some areas for years - it is required to allow the existing AFTN/CIDIN messaging service co-operating with the ATN-based messaging service. AFTN/CIDIN users and ATS Message service users should be able to communicate, whatever is (or are) the communication infrastructure(s) operating between them.

This service is not really an operational service – likewise the DLIC service – but more a system management related service.

2.2.2.3 Radar Data Transfer Service

Two flows of radar data are concerned by this broadcast data transfer service:

- The data flow between the radar data servers (i.e. the RMCDEs and SIRs) and the radar clients (i.e. the radar sensors and the Radar Data Processing Systems (RDPS) at the ATCCs, and
- The data flow between radar data servers.

ACCESS WP 201 [A201] identified the networks and the data formats used internally by each country for both types of data flow. Several radar data formats exist (ASTERIX, AIRCAT, RDIF, etc.); however, the ASTERIX format is being recognised by most countries as the European standard. Dedicated X.25 networks (RADNET), X.25 network (RENAR) or leased lines are currently used as communication supports.

The choice of the communication infrastructure and the data format for the first data flow identified above is left to each ATC Authority, as well as the data flow between radar data servers of a country.

On the contrary, exchange of radar data between adjacent countries has to be harmonised. The standardisation of a format for radar data is a strong pre-requisite to the inter-connection of national radar data network. The ASTERIX format seems to emerge as the standard for radar data. The second pre-requisite is the implementation of international communication protocols (such as X.75) by the different European countries required for a full network interconnection. The Internet ATN provides by definition this interconnection and is a serious alternate candidate to support the radar data flows between some radar data servers.

However, the specific performance and timing requirements of the transfer of radar data shall be taken into account. It is not clear today if the ATN service (based on TP4) can meet these requirements. It seems therefore premature to use the ATN for all types of radar data exchanges.

2.2.2.4 Meteorological Data Transfer Service

Meteorological data originate at meteorological authorities (World and Regional Area Forecast Centres). They are made available to aeronautical offices at ICAO States.

The distribution among aeronautical meteorological offices and to users for pre-flight and in-flight briefing is the service provided by the Operational Meteorological Data (OPMET) application.

2.2.2.5 Aeronautical Information Service

The provision of this service is the responsibility of the states. AIPs, supplements, AICs, Pre-flight Bulletins and NOTAMs data are stored and managed in AIS databases. All these data may be made available on a world-wide basis.

2.2.2.6 Flight Plan Data Transfer Service

The Flight Plan Data Transfer Service specifies the exchange the following data:

- The Flight Plan requests are submitted by AOCs and national Flight Plan processing systems to the IFPS (Initial Flight Plan Processing System) located in the CFMU.
- Flight Plans are then distributed by the CFMU IFPS to all ATC units responsible for the flight.
- Flight plan cancellation,
- Flight plan modification,
- Flight plan delay, and
- Flight plan departure time.

2.2.2.7 Airspace Management (ASM) and Air Traffic Flow Management (ATFM) Data Transfer Service

Airspace Management is concerned with the planning, definition, allocation and regulation of both national and international airspace to meet the needs of the states involved. It is responsible for defining route structures, airways, control areas, restricted areas, including horizontal and vertical dimensions and the regulations which must be observed in their use. It can include short-term reallocation of defined airspace, to improve utilisation and efficiency of traffic flow.

The Air Traffic Flow Management is centrally performed by the CFMU. Based on the ATC flight plans and the knowledge of the capacity of individual sectors as reported by the ATC centres, the CFMU allocates a departure slot to the aircraft sent to the aircraft operators and the ATC units concerned. Allocated slots may be revised or cancelled.

The ASM and ATFM services are operated before the flight of the aircraft:

- Airspace Management (CFMU TACT Application)
  - Up-to-date ATC and airspace sector capacity information, sent by Flow Management Positions (FMP) at ACCs to CFMU,
  - Overall capacity situation information from the CFMU to the FMPs.
- Slot Allocation Management (CFMU CASA Application)
  - Slot Request messages, from aircraft operators to CFMU,
  - Slot Allocation, re-routing and alternative flight profiles, from CFMU to aircraft operators and ACCs, and
  - ATFM Notification message sent by the CFMU to ATC units describing the ATFM measures which will be in force on the following day.

The ATN could provide potential benefits by the substitution and/or enhancement of existing communication networks used for ATFM-communications (AFTN, SITA) with more cost-effective networks. However, these benefits at this time are difficult to quantify.

2.2.2.8 ATCC Co-ordination Data Transfer Service

Co-ordination messages are exchanged between ATC systems to synchronise and update the flight databases.

The ATCC Co-ordination Data Transfer service is used to exchange between CWPs the following data:

- Flight Notification messages, and
- Co-ordination messages such as: ACT (activation of stored flight plans), LAM (logical acknowledgement by the controller to an ACT) and ABI (advance boundary information).

2.2.3 Supporting Ground Data Link Environments

Non-ATN ground environments are described in ACCESS WP201 [A201] chapter 6. They include packet switching networks, AFTN/CIDIN techniques, proprietary networks, leased lines, TCP/IP networks and local area networks.

As far as the ATN is concerned, SARPs have been produced for ground applications. They contain the same kind of information than the air/ground ATN application, i.e. a description of the abstract service, a definition of the communication protocol and a specification of the message contents.

2.2.3.1 ATS Message Handling Services Application (AMHS)

The AMHS application provides for the exchange of operational messages between users and/or ground systems. It matches the service currently provided by the AFTN and uses – in a transparent manner – the existing AFTN infrastructure of the AFTN as well as the forthcoming ATN infrastructure.

The AMHS environment is based on two types of systems both operating the Message Handling Service protocols:

- The **ATS Message Server**. This ATN End System provides the ATS Message service to final end-users.
- The **AFTN/ATN Gateway**. In this system, a message conversion is carried out as follows. The protocol headings are "translated" from the AFTN message format into the MHS message, and vice-versa. The text of the AFTN message – unchanged – is transmitted in a transparent manner to its destination.

2.2.3.2 ATS Inter-facility Data Communications Application (AIDC)

The AIDC application exchanges information between ATS Units (ATSUs) for support of critical Air Traffic Control (ATC) functions:

- Flight notification,
- Flight co-ordination,
- Transfer of control,
- Transfer of communications,
- Transfer of surveillance data, and
- General information interchange.

2.2.3.3 Supporting G/G Communication Environments

Table 5 identifies the environments (ATN and non-ATN) providing the ground data link services identified above. For instance, the exchange of ATS messages is currently supported by the AFTN/CIDIN network and will be supported in the ATN by the AMHS application.

In the ATN environment, the communication activities required to provide data link services to operational users are carried out by the ATN applications (AMHS and AIDC).

	ATN Environment		**Non-ATN Environments**
ATS Ground services	AMHS	AIDC	
Basic Communication services			
ATS Messaging Service	Yes	No	AFTN/CIDIN
AFTN to/from ATN Gateway Service	Yes	No	Not applicable
CIDIN to/from ATN Gateway Service	Yes (note 1)	No	Not applicable
ATS operational services			
Radar Data Transfer Service	No	No	X.25/X.75 (e.g. RADNET)
Meteorological Data Transfer Service	Yes	No (note2)	OPMET application on AFTN/CIDIN
Aeronautical Information Service	Yes	No (note 2)	AFTN/CIDIN
Flight Plan Data Transfer Service	Yes	No (note 2)	AFTN
ASM and ATFM Data Transfer Service	Yes	No (note2)	TACT over X.25 and CASA application over AFTN/CIDIN
ACCs Co-ordination Data Transfer Service	Yes	Yes	OLDI/SYSCO protocols over point-to-point link

Note1: The standardisation of the CIDIN/ATN gateway is in progress at ICAO. The standard will be available for the time frame considered here.
Note 2: The current AIDC SARPs does not support this service. However, it is likely that future ICC SARPs (CNS/ATM-2) will be developed to support it.

Table 5: Mapping Ground data link services / data link environments

2.2.4 Proposed Ground Services and Applications for the Target ACCESS ATN

The services and applications treated here are those with no A/G component. They are services and applications currently in operation and follow the structure laid down in ACCESS WP201 [A201]. However, within the time frame considered for the establishment of the ACCESS target architecture, it is likely that completely new ground services and applications will come into being.

2.2.4.1 The Importance of Ground Services and Applications for the ATN

The traffic volumes currently handled by existing aeronautical ground networks are considerable: consider, for example, the continuous data stream generated by radar data message handlers (RMCDE) or the message volume, typically 50,000 to 100,000 per day, handled by major AFTN/CIDIN switches in Europe. These volumes continue to increase and will probably multiply several times before the target ATN architecture has been set up. The introduction of the CFMU alone has led to significant increases in a very short time period. The traffic volumes are therefore likely to be on the same scale as the traffic generated by A/G applications.

One of the primary motivations for the ATN is the use of a common technology and infrastructure supporting a wide range of applications, including ground applications. This commonality provides the operational and economic benefits which justify the setting up and operation of the ATN. This situation is well known, for example, in the use of packet switching networks: the more traffic handled by a network, the more cost-efficient per unit of traffic it becomes.

However, a possible continued existence and operation of infrastructure dedicated to some or all ground applications would weaken the justification for implementing the ATN. It seems unlikely that ATSOs, when making budget decisions, would consider investing in ATN technology if infrastructure dedicated to ground applications must be continually extended, maintained and operated. This could endanger the implementation of the ATN and, at the same time, reduce its possible benefits.

For these reasons, a wide-ranging proposal concerning the support of ground applications in the target architecture is made here.

2.2.4.2 Use of ATN Infrastructure on Different Levels

In general, ground services can make use of ATN infrastructure on various levels. This is illustrated in Figure 10 by means of the arrows and the four distinct cases are described below.

1. The ground service is the object of ATN SARPs and is completely defined there together with its implementation with ATN applications. The only current example of this type is AIDC for inter-centre communications.

2. A general-purpose ATN application, together with ATN upper layers, is defined in the ATN SARPs. This, in itself, does not constitute a service, however through additional standardisation (which is not part of the ATN SARPs) it can be used to provide a ground service. The AMHS is the only currently defined ATN application of this nature. For comparison: the AFTN and CIDIN are currently used in this mode to provide ground services (although the terminology “service” and “application” are used quite differently there).

3. It is conceivable that ground services which are not (yet) covered by ATN SARPs might be implemented in Europe and might need to be supported by the ATN target architecture. In this case, the ground services, possibly together with protocol layers above the transport layer, would need to be defined and standardised in their area of use, e.g. within the European Region. The services would use the ATN internet together with the ATN transport protocols. A candidate for this mode of operation might be the transfer of radar data.

4. This case is included here for completeness. It shows that ground services (existing or new) can – outside of the ATN context – make use of sub-networks which are integrated into the ATN. This is possible because the ATN routing architecture is independent of its physical implementation with sub-networks: these provide a (sub-)network service to the ATN and simultaneously to applications using them directly. Higher level protocols would need to be defined for such applications. A distinction between the two sets of users on common sub-networks might be implemented by means of disjoint address spaces A current example of this mode of working is OLDI via PSN. It is likely that at least some ATN sub-networks will be used in parallel in this way.

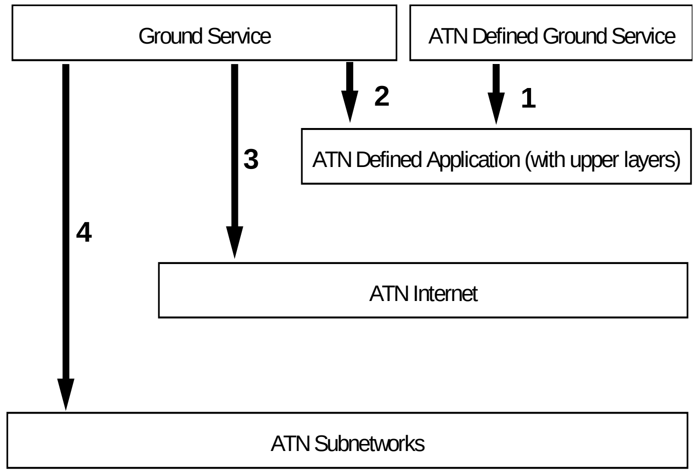

Figure 10: The use made by ground services of ATN infrastructure on various levels

This structure is used below in discussing the individual services and applications.

2.2.4.3 The AMHS Application and its Services

As described in ACCESS WP201 [A201], a majority of ground services are currently implemented using a messaging infrastructure. This is partly due to the fact that the services have message handling characteristics but also due to historical reasons because, at their time of implementation, the messaging infrastructure was the only one which was widely available for use. In Europe, the current messaging infrastructure is AFTN/CIDIN.

The messaging application defined in the ATN SARPs is the AMHS. Its interworking with the AFTN is defined in the specification of the AMHS/AFTN Gateway. The interworking of the ATN with CIDIN, for those services which are based directly on the use of CIDIN, is not yet defined. For recommendations on the locations for gateways, see Section 0 below.

The following services (see WP201 [A201]) currently make use of the AFTN/CIDIN:

- CFMU IFPS,
- CFMU CASA,
- AIS distribution, and
- OPMET distribution.

These services represent the major part of traffic handled by the AFTN/CIDIN. They can be expected to be present in the period assumed for the ACCESS target ATN architecture. Their implementation corresponds to case 2 in Figure 10.

CFMU IFPS shows all the characteristics of a messaging service. Because of its importance and large traffic volume, it alone would justify the implementation of the AMHS application. CFMU CASA is currently implemented as a messaging service, although it places demanding requirements on messaging handling times that are not typical of a messaging service. AIS and OPMET distribution are currently implemented as messaging services although they could also be classed as file transfer services. Extensive use is made of the multiple dissemination feature common to message handling systems and, in particular, the AMHS. Within the ACCESS time-frame new implementation structures (central European databases) for AIS and OPMET could come into being.

It is proposed that the ATN be designed to support the AMHS and its corresponding services.

The services listed above can use the ATN, in principle, in two different ways:

1. as AFTN/CIDIN applications: these would then have to be mapped to corresponding AMHS applications (using AFTN/CIDIN formats) and when the messages cross the boundary of the ATN, AFTN/AMHS or CIDIN/AMHS gateways are involved;

2. as applications (still to be defined) using the AMHS directly (in a native fashion). In this case the gateways are not involved and the applications are only relevant to those users with AMHS message servers.

The goal, from an ATN perspective, is to migrate as quickly as possible to the second mode.

For the purpose of defining the target architecture, estimating traffic volumes etc. within ACCESS, realistic assumptions must be made about the migration from the first mode of operation (AFTN/CIDIN) to the second mode (AMHS) by 2010. For this, OPMET is chosen as a representative application which has a reasonable chance of migrating completely. It is assumed that the other applications still use the AFTN/CIDIN mode of operation in 2010.

2.2.4.4 Other Flow Management Services

In comparison to IFPS and CASA, the CFMU TACT service uses a distinct infrastructure, currently serving approximately 60 Flight Management Positions in ACCs. Its service elements and coverage are likely to increase during the ACCESS time-frame.

Because of the their extent and geographical coverage, it is proposed that those flow management services not accounted for under heading 0 be supported by the ATN. Their implementation corresponds to case 3 in Figure 10. An exception made here is the service used for connecting the CFMU locations Haren and Brétigny: this high-speed link is of such a special nature, that its implementation on the ATN does not seem sensible or feasible.

2.2.4.5 OLDI / AIDC

The Flight Data Interchange service, currently implemented according to the OLDI procedures and intended to migrate to the ATN application AIDC, currently connects approximately 20 pairs of ACCs internationally. Equivalent procedures are in operation nationally. Some such OLDI “connections” are of a logical nature, e.g. via national flight plan processing systems and are not necessarily physical connections. The migration to AIDC is foreseen by means of AIDC interworking units. This corresponds to a migration from case 4 to case 1 in Figure 10.

If access to the ATN at the ACCs using OLDI/AIDC services or at the corresponding locations of flight plan processing systems is present, it would be logical to assume that the ATN support such services. This assumption is underlined by the existence of the standardised AIDC service. Further, although the service places high availability requirements on a network infrastructure, its data volumes are small and it would be difficult to justify a dedicated network for it. This provides additional support for the assumption.

2.2.4.6 Radar Data Exchange

This service provides for the exchange of processed radar data, mainly among ACCs using the European standardised format ASTERIX. It is not an obvious candidate for support by the ATN for the following reasons:

- no standardisation has taken place in the ATN context at an ICAO level;
- there are relatively fixed communication relationships with constant data flows which do not profit greatly from the addressing and routing flexibility of the ATN;

- concern has been expressed on whether the additional overhead caused by the ATN internet in comparison with the use of bare sub-networks can be justified.

However benefits to be gained from the use of one common ATN infrastructure for all ground services outweigh these considerations.

For international transmission in particular, the radar data exchange service profits from the additional robustness of the network made possible by dynamic ATN routing techniques which are not available in a connection-oriented environment. Current experiments being organised by Eurocontrol are demonstrating that the transmission of radar data via the ATN internet is technically feasible and that the overhead is not excessive[1].

For these reasons, it is proposed that the ACCESS ATN be designed to support part of the radar data exchange service, as illustrated in Figure 11.

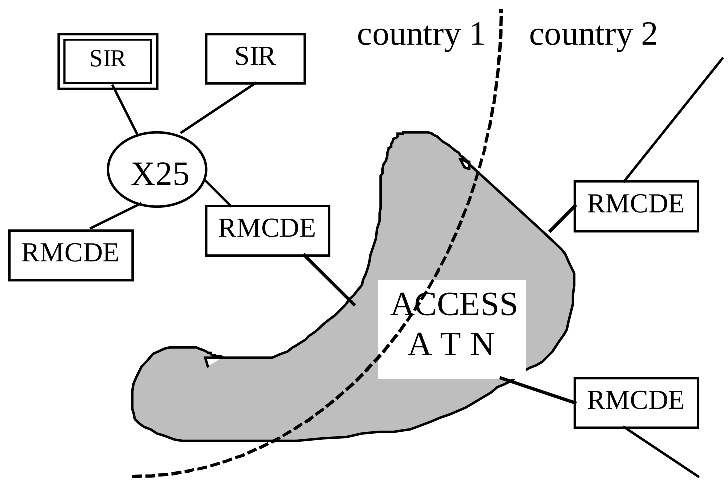

Figure 11: International Radar Data Exchange through the ATN

Current implementation can be classified as type 4 in Figure 10. Since no ATN standardised service or application can be expected in the ACCESS time-frame, this proposal would raise the implementation only to type 3 in Figure 10.

2.2.5 Location of Ground ATN Systems

2.2.5.1 Locations of End Systems

Recommendations on the locations for ATN end systems follow from the choice of services and applications in the preceding sections. They are:

- CFMU Brussels and Brétigny,

[1]This situation can be compared with the current implementation of speech services in the Internet. Although such services have traditionally been implemented using connection-oriented, i.e. circuit switched, techniques (cf. radar data transmission over switched or permanent virtual X.25 calls) the economies of scale in the connectionless environment of the Internet and the falling prices of bandwidth are currently demonstrating its suitability for speech services.

- AIS Offices (ATSO and AOC),
- MET Offices (ATSO and AOC),
- ATSO Flight Plan Submission Offices,
- AOCs for flight plan processing,
- ACCs for Flow Management Positions, radar data processors and RMCDEs, and
- Flight Plan Processing Systems and Controller Positions for OLDI/AIDC.

In cases where the users present at these locations are served by systems at central locations, the list would be shortened accordingly.

2.2.5.2 Locations of Gateways

AMHS/AFTN and AMHS/CIDIN Gateways are special ATN end systems. The following principles for recommending the location of gateways may be considered:

- It is assumed that AFTN and CIDIN have been completely replaced by the AMHS in the ACCESS core area.
- For availability reasons, at least two gateways must be foreseen.
- Communications between the AFTN/CIDIN and the AMHS must be maintainable when one of the gateways is not operational. This should be possible without long re-routings within the AFTN.
- The main traffic flows between AMHS users must be considered.
- Gateways have responsibility for connecting the AMHS with a specific part of the AFTN/CIDIN.
- Gateways with responsibility for a specific part of the AFTN/CIDIN must each have high capacity connections to at least two centres in those areas.

Assuming that the above conditions are met, the exact geographical location of the gateways is of relatively minor importance.

It is likely that practically the two types of gateways (AMHS/AFTN and AMHS/CIDIN) will be co-located in one system at each location.

These principles lead to the following proposal for locating gateways:

- two gateways (a principal and a secondary) for each traffic to and from the ACCESS core area: North Atlantic, South America, Africa, Eastern Europe and Middle East;

This proposal is shown schematically in Figure 12: each COM center maintains the current links (7 AFTN/CIDIN/AMHS Gateways).

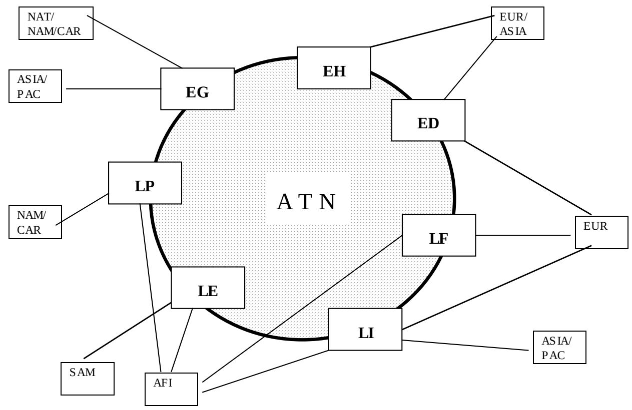

Figure 12: Schematic representation of proposed gateway locations

3 Guidelines for selecting ATS Data Link Services for the Initial ACCESS ATN

3.1 General

This chapter aims at defining criteria and methods for the selection of the most appropriate services in the initial ACCESS ATN in the 2000-2005 time frame.

It is proposed to apply a kind of multi-stage filtering process taking as its input the inventory of air/ground and ground/ground data link services and delivering as its output the proposed initial services.

The feasibility will be determined from technical, economical, geographical and strategic constraints based on the following criteria:

- The **operational benefit** criteria evaluates the impact of a data link service on the global ATC capacity,
- The **standardisation status** criteria measures the amount of work carried out on a data link service by operational and technical experts,
- The **degree of experimental maturity** criteria evaluates to what extent the operational and technical specifications of a data link service have been validated,
- The **criticality** of a data link service (depending on the impact of the service on the safety for instance) is a criteria which should not be disregard,
- The **initial ATN implementation plan of each European State (when any)** shall be taken into account in order to guarantee that the overall ACCESS ATN Implementation Plan meets the requirements specific to these states,
- The **economical** factor may strongly impact the selection of data link services if the associated cost (in terms of deployment and operation) is considered too high by airlines and CAAs,
- The **necessary proportion of aircraft population required to be equipped** criteria, like the previous one, may influence the selection of data link services,
- The **unavailability of specific sub-networks** may jeopardise or delay the implementation of data link services mandating these sub-networks, and
- Likewise, the **unavailability of hosting systems supporting the data link** (in the aircraft or on the ground) or the unavailability of some specific functionality may delay the implementation of some data link services.

Each of these criteria will be discussed in turn in the following sections.

3.2 Operational Benefit

The main driving force for selecting data link services in Europe is the operational benefit provided to European airspace users (controllers, pilots, airlines, etc.).

Air-Ground Data Link Services

The main benefits expected from ATS data link services and generally expressed by the aeronautical community are the following:

1. **Improve the quality of the controller-pilot dialogue.**

   It is recognised in Europe that one of the major limitations of the actual ATC system is the overload of the VHF channel. The addition of new voice channels in the VHF frequency range to comply with the growing traffic is nearly impossible due to the congestion already encountered in Europe. Data link will help to reduce communication workload imposed on the controller and the pilot and will lead to a more efficient, reliable usage of available frequency channels.

   Some CPDLC-based services (ACM and CIC) and ADAP services (CAP, FLIPCY) will optimise obviously the use of the VHF channel. Data link will improve comprehension of the dialogue because fixed text messages are exchanged and there is no possibility of mishearing a transmission. Data link will avoid controllers uplinking by voice the VHF channel of the next ATCC and some clearances. It will avoid aircrew downlinking by voice aircraft parameters (heading, speed) and route information.

2. **Facilitate the integration of aircraft-generated data with the existing ATS information system of the ground.**

   The ADAP service will facilitate the automatic downlink of aircraft generated parameters. Some parameters of high importance for the controller and the ground automated systems can be retrieved through the operation of the ADS applications: meteorological information, short term intent, flight profile or flight plan correlation information.

3. **Provide aircrew with ground-generated data independently of the sub-network availability.**

   For instance, meteorological information stored in ground local databases and distributed under standard formats either on request or by repetitive loop broadcast will be available for aircrew at any time during the flight. With datalink, more reliable and actual data will be available to all airborne users e.g. for real-time flight optimisation by pilots or FMS.

4. **Improve planning and co-ordination tasks.**

   This issue addresses the enhancement of the co-ordination activity between controllers. Some co-ordination messages can be sent automatically or with a minimal action of the controller. The planning task will be improved by the availability in real-time of aircraft parameters.

5. **Enhance the actual surveillance capability.**

   In Europe, the actual surveillance capability is very high due to the existing radar coverage. The introduction of data link applications will not provide substantial benefits in this area, except in the NAT airspace. In this area, enhancements of the current surveillance and communication techniques would allow for the reduction of horizontal separation minima between suitably equipped aircraft and for the improvement of on-track flexibility.

6. **And as the direct consequence of the above benefits, increase the global ATC system capacity.**

Ground Data Link Services

Most of the ground ATS services considered in this document are already operational in a non-ATN environment. Radar data, flight plan, ASM and ATFM data are exchanged successfully through point-to-point, X.25 or AFTN/CIDIN networks.

Therefore, the operational interest of these communication services when provided by ATN applications is not obvious. Basic functionality today provided by OLDI with a limited set of messages is considered as already fulfilling the operational requirements for ground communications. The functions added in the AIDC SARPs – e.g. during the transfer of control between ACCs – are not seen as necessary. Moreover, the fact that the message sequencing is strongly checked by the communication protocol is not welcomed by the controllers. With OLDI, any message can be sent at any time.

A first prioritisation can therefore be made based on the expected benefits of the data link services on the five topics mentioned above. One assumes that the optimisation of the use of the VHF channel has the highest priority:

- High operational benefit: ACM, CIC, CAP and FLIPCY
- Medium operational benefit: APR (oceanic), MET, PPD, SAP, Taxi RD, Pushback RD, DCL, FIS/ATIS, OCM/DSC, DYNAV, TIS, 4DTN and ATFM/Slot Allocation
- Low operation benefit: APR (continental), AMHS, Radar Data Transfer, Flight Plan Data Transfer, Meteorological Data Transfer, AIS Data Transfer, AIDC and DLIC.

3.3 Standardisation Status

Applications implemented at a world-wide or regional scale must have been the object of international standardisation. Since the interoperability capability between air and ground systems is an essential factor in the implementation of data link applications, a stable and mature specification of these applications is strongly required.

The groups involved in the standardisation process for ATN data link services and applications are the following:

- The **ADSP** (Automatic Dependent Surveillance Panel) is specifying operational requirements, procedures and guidance material on oceanic ADS and continental ATS air/ground data link services. The main output of this panel is the "ICAO Manual of ATS Data Link Services".
- The **ODIAC-TF** (Operational Development of Initial Applications of A/G Data Communications) defines operational requirements and procedures for air-ground data link services harmonised within Europe.
- The **ATNP** (Aeronautical Telecommunication Network Panel) is developing SARPs and Guidance Material for ATN Internet, Upper Layers and Applications based on the ADSP Manual.

Two levels of standardisation are required to resolve the interoperability issue:

- The **technical interoperability** is obtained by specifying the contents of the messages exchanged by the communicating systems and the encoding of these messages. In addition, the message sequencing during a nominal communication activity is unambiguously determined, any exception to these rules being considered as the failure of the peer system. Such specification – the protocol definition - produced for each data link application does not make any assumption of the way the communicating systems shall be built. Any system claiming compliance with this specification is able, by definition, to communicate with any other system operating the same protocol.

- The **operational interoperability** describes the correct manner to use the technical service provided by data link applications. This could be seen as a restriction of the use of the technical service to meet the operational requirements defined on a worldwide or region-wide basis. These rules followed by the operational users of the data link applications do not impact the communication capability of the systems. Therefore they are not checked by the communication system itself and may be different from one region to another.

A typical example of the need of procedures for guaranteeing the operational interoperability is the CPDLC application. The CPDLC application provides a generic mean for establishing a communication path between the pilot and the controller and transmitting messages on this dialogue. Subsets of messages can be extracted from the CPDLC message set to meet a dedicated operational functionality (e.g. Frequency Change, Departure Clearance, etc…). For each set of messages, specific message sequencing is operationally defined.

Another example of operational interoperability rules is the management of the CPDLC message attributes (e.g. closure, response and urgency). These attributes are not controlled at all by the communication system but the way they have to be used by the application users is strictly specified.

ICAO SARPs address mainly the **technical interoperability** issue for the basic ATS data link applications defined in the CNS/ATM-1 Package: CM, CPDLC, ADS, FIS and AIDC. AMHS SARPs guarantee by default the technical interoperability by mandating the compliance to the ISO Standards (IS) and the International Standardised Profiles (ISP) related to the ISO Message Handling System.

The ODIAC-TF has addressed the **operational interoperability** issue by specifying the European operational use of some data link services. In many cases, they match the ADSP requirements. Sometimes it has been felt that the European use should differ from the one specified by ICAO. These discrepancies are fully identified in the ODIAC document [EAT12]. Differences with the European and international procedures are acceptable as long as they do not introduce any increase in workload or have a negative impact on safety.

Table 6 identifies the data link services subject to international standardisation.

	Standardisation Status			
ATS Air/Ground Services	Existing ODIAC standard	In work program of ODIAC	Existing ADSP standard	In work program of ADSP (1998)
CPDLC-based services				
Clearance and Information Communication Service (CIC)	Yes		Yes	
ATC Communication Management Service (ACM)	Yes		Yes	
Downstream Clearances Service (DSC)	Yes		Yes	
Departure Clearance Service (DLC)	Yes		Yes	
Push-back Request/Delivery Service				Yes
Taxi Request/Delivery Service				Yes
ADAP services				
Controller Access Parameter (CAP)	Yes		Yes	
Aircraft Parameter Reporting (APR)	Yes (ADS)		Yes	
Downlink Meteorological Data (MET)				Yes
Flight Plan Consistency Service (FLIPCY)		End 97		
Pilot Preferences Downlink Service (PPD)		End 97		
System Access Parameters Service (SAP)		Yes		

Data Link FIS services				
Data Link Operational Terminal Information Service (D-OTIS)	yes		Yes	
Data Link Runway Visual Range (D-RVR)		yes		
Data Link Significant Meteorological Information (D-SIGMET)	Yes			
Others services				
Data Link Initiation Capability Service (DLIC)	yes		Yes	
Dynamic Route Availability service (DYNAV)		End 97		
Traffic Information Service (TIS)				yes
ATFM/Slot Allocation Service				Timeframe 2000
4D Trajectory Negotiation Service				

Table 6: Standardisation status of the air/ground data link services

It is clear that non-standardised services, even if recognised as crucial in the ATS environment, can not be selected for early implementation in Europe. As soon as communications are involved, a stable and mature protocol specification is required for controlling the data exchange. This specification shall be enhanced by the description of the operational use of the application. In addition, given that the standardisation process is very slow, it can not be expected that new standards are available for the initial implementation of the ATN.

It is therefore possible to classify the data link services in terms of maturity of standardisation into three categories:

- European standard available: CIC, ACM, DCL, DSC, CAP, D-OTIS, D-RVR, DLIC, Flight Plan Data Transfer and ATCC Co-ordination Data Transfer.

- Potential Standard: PPD, SAP, APR(ADS), D-RVR, FLIPCY and DYNAV.

- No European standard available: Pushback RD, Taxi RD, MET, TIS, ATFM/Slot Allocation, 4DTN, Radar Data Transfer and ATFM Data Transfer.

3.4 Degree of Experimental Maturity

The first data link services implemented in Europe must have been tested by means of pre-operational validation or prototyping/simulation programs.

This validation activity encompasses two aspects:

- **Validation of the operational service**. Note that this activity can be performed through applications running in a non-ATN environment but providing the same operational service (e.g. DCL, OCM, ATIS, ADS and CPDLC over ACARS, DAP over Mode-S, TIS/STDMA, FIS(METEO)/Mode-S, etc...).
- **Validation of the technical specification**. This task consists in checking the rightness and the level of accuracy of the protocol description. Thus, erroneous, duplicated or missing requirements in the specification are identified and corrected.

As far as the CNS/ATM-1 applications are concerned, a major validation program has been carried out by several states and organisations by means of paper analysis, prototyping, simulation, implementation and interoperability testing activities. A very high level of confidence in the application specification has been reached.

AMHS is a particular case. Indeed, this application is based on fully validated ISO standards and profiles. Message Handling Systems (X.400) protocols have been implemented for many years in many systems for many purposes (office programs, bank applications, etc…). In Europe, profiles have been defined as well as procedures to check conformance to these profiles (e.g. WAN-CTS). Consequently, off-the-shelf products have been developed and are available on the market. Only a small part of the AMHS specification needs to be validated, the one corresponding to the AFTN/ATN Gateway.

Table 7 identifies the European projects implementing some data link services. The projects related to these applications have been briefly described in section 3.7.2.

ATS Air/Ground Services	European Projects
CPDLC-based services	
Clearance and Information Communication Service (CIC)	EOLIA, PETAL II, TES
ATC Communication Management Service (ACM)	EOLIA, PETAL II, TES
Downstream Clearances Service (DSC)	EOLIA, UK Trials, TES
Departure Clearance Service (DLC)	CLAIRE (France), UK Trials
Push-back Request/Delivery Service	
Taxi Request/Delivery Service	
ADAP services	
Controller Access Parameter (CAP)	DADI, PETAL II
Aircraft Parameter Reporting (APR)	EOLIA, PETAL II, ADS-Europe, TES
Downlink Meteorological Data (MET)	AGLAE (France), DADI
Flight Plan Consistency Service (FLIPCY)	EOLIA
Pilot Preferences Downlink Service (PPD)	
System Access Parameters Service (SAP)	
Data Link FIS services	
Data Link Operational Terminal Information Service (D-OTIS)	EOLIA (ATIS), ISATIS (France)
Data Link Runway Visual Range (D-RVR)	
Data Link Significant Meteorological Information (D-SIGMET)	
Others services	
Data Link Initiation Capability Service (DLIC)	EOLIA, ADS-Europe, TES
Dynamic Route Availability service (DYNAV)	EOLIA
Traffic Information Service (TIS)	North European ADS-B / JANE project
ATFM/Slot Allocation Service	
4D Trajectory Negotiation Service	PHARE Demo 1/2/3

Table 7: Experimentation Status of Air/Ground data link Services

It is therefore possible to classify the data link services in terms of maturity of experimentation into three categories:

- High: CIC, ACM, DSC, DCL, CAP, APR, D-OTIS, FLIPCY, DYNAV, DLIC, TIS, Flight Plan Data Transfer, ATCC Co-ordination Data Transfer, Radar Data Transfer and ATFM Data Transfer.

- Low: MET, SAP and 4DTN.

- No experimentation: Pushback RD, Taxi RD, PPD, D-RVR, ATFM/Slot Allocation and D-SIGMET.

3.5 Criticality of the Data Link Services

For most CAAs, non-critical data link services are the only likely candidates in the European airspace for early implementation. Airlines also share this viewpoint. It seems therefore reasonable to start with implementing simple applications providing basic services and then to enhance the systems based on these applications to provide more sophisticated applications. Non-critical services do not affect safety. With the experience gained from these initial operational data link services, more critical services will be gradually integrated.

This is why – for the first operational services - datalink is not envisaged by many CAAs as the primary mean of communication between pilots and controllers for the highest normal operational priorities of CPDLC messages but only as a backup to voice.

The level of criticality of the data link services could be assessed through the evaluation of their reliability and availability requirements. Usually, 2 indicators are used for that purpose:

- MTBF: the Mean Time Between Failure indicates the level of reliability of the data link service,

- MTTR: the Mean Time To Repair per failure indicates the level of non-availability of the data link service.

The PCR study carried out by the ST15 study [EAT13] is summarised in the following table. The figures should be interpreted as orders of magnitude. Three levels of criticality have been deduced

	MTBF **1: < 1 day** **2: < 1 month** **3: < 1 year** **4: > 1 year**	**MTTR** **1: > 1 hour** **2: > 10 mn** **3: > 3 min** **4: < 1 mn**	**Service Criticality**
CPDLC-based services			
Clearance and Information Communication Service (CIC)	4 (clearances) 2 (report/ advisories)	4 (clearances) 2 (report/ advisories)	H M
ATC Communication Management Service (ACM)	3	2	M
Downstream Clearances Service (DSC)	3	3	M
Departure Clearance Service (DCL)	3	3	M
Push-back Request/Delivery Service	3	3	M
Taxi Request/Delivery Service	3	3	M
ADAP services			
Controller Access Parameter (CAP)	2	3	M
Aircraft Parameter Reporting (APR)	4 (continental) 2 (oceanic)	4 (continental) 2 (oceanic)	H L

Downlink Meteorological Data (MET)	2	1	L
Flight Plan Consistency Service (FLIPCY)	3	3	M
Pilot Preferences Downlink Service (PPD)	2	3	M
System Access Parameters Service (SAP)	4	4	H
Data Link FIS services			
Data Link Operational Terminal Information Service (D-OTIS)	2	2	L
Data Link Runway Visual Range (D-RVR)	2	2	L
Data Link Significant Meteorological Information (D-SIGMET)	2	2	L
Others services			
Data Link Initiation Capability Service (DLIC)	2	2	L
Dynamic Route Availability service (DYNAV)	-	-	H
Traffic Information Service (TIS)	2	3	M
ATFM/Slot Allocation Service	-	-	H
4D Trajectory Negotiation Service	-	-	H
Ground services			
ATC Co-ordination	4	4	H

Table 8: Data link Services Performance Requirements

Based on this table, a first attempt of classification of the data link services as far as the criticality is concerned is proposed here (it will have to be refined):

- High criticality: CIC (Clearances), APR (continental), SAP, DYNAV, ATFM/Slot Allocation and 4DTN.
- Medium criticality: CIC (Report/Advisories), ACM, DSC, DCL, Pushback RD, Taxi RD, APR (oceanic), CAP, FLIPCY, PPD and TIS.
- Low criticality: MET, DLIC, D-OTIS, D-RVR and D-SIGMET.

3.6 ATN Implementation Plan of European States

3.6.1 Introduction

Two separate regions have to be distinguished in Europe: the NAT region and the continental region. Both operational requirements and ATN infrastructure may be different.

The full CPDLC application encompasses various functions that are either not relevant for continental Europe (e.g. pilot to controller position reporting) or that could be replaced by more efficient automated applications (e.g. ADS). The use of CPDLC will therefore be limited to a subset of messages corresponding to the selected CPDLC-based services (DSC, ACM, DCL, etc…).

Likewise, the aircraft position report service is not seen as a prime candidate to data link implementation in continental Europe. The benefit of continental operation of the basic ADS service has never been demonstrated. It is likely that the actual surveillance capability provided by the radar technology will be, if needed, replaced or enhanced by the ADS broadcast technology, and not by the ADS ATN application. However, this application could be envisaged on the European Atlantic border to enhance the actual radar surveillance capability.

A characteristic of Europe is the number of sectors created for minimising the workload of each controller. But this area sharing has reached its limits and the negative drawback of this method is the augmentation of the co-ordination messages between the controllers and the pilot and between controllers. The automation by data link of these co-ordination dialogues (ACM service) would be therefore very helpful in this context.

In Europe, the operational requirements for air-ground applications have been specified by the ODIAC Task Force. This work constitutes naturally the framework for the implementation of the data link by the European States and Organisations.

In parallel, some CAAs are studying how and when they will implement the ATN in their current ATS environment.

The policy and implementation plans of the European States - when defined – shall be taken into account in the specification of the overall ATN strategy in Europe. This section reflects the status of the studies performed on the subject by the European CAAs based on the available information.

3.6.2 France

3.6.2.1 ATN Air/Ground ATS Applications

The SCALA project ("Stratégie Commune pour les Applications des Liaisons Air-Sol") is a feasibility study aiming at proposing the French CAA strategy for the implementation of air-ground data link services.

The first step of this project was to define the operational concept for the introduction of the data link in France. This led to identify 20 data link services considered as the most interesting and to classify them within 3 categories:

- Existing data link services already deployed in some TMAs in France: Departure Clearance (DC) and Automatic Terminal Information Service (ATIS).
- Short and medium term data link services, as those supporting the controller access to aircraft parameters, the frequency change or the enhancement of the trajectory prediction, and
- The other services (long term), as for instance pilot selected parameters use and the trajectory negotiation.

An initial selection came out with four high priority data link services, in addition to the Data Link Initiation Capability (DLIC) service:

- The ATC Communication Management (ACM) service,
- The ATC Clearance Management (CIC) service at least in case of VHF failure,
- The Flight Plan Consistency (FLIPCY) service , and
- The Controller Access Parameter (CAP) service.

A main criteria in the selection of the two last services is the minimal impact of the application implementation on the HMI; the data collection is performed without human intervention.

The second step is to propose technical solutions to cope with the new data link functionality within the current ATC system (CAUTRA). The concept of an Air Server dealing with all data-link communications with aircraft implemented in each en-route ATC Centre has emerged. Functional and architectural studies for this new system are under investigation. In parallel, cost/benefit studies are carried out to identify and quantify - when possible - costs associated with the development, the deployment and the exploitation of such a system. A cost benefit study will also be performed to assess the potential benefits for airlines. Benefits are expected mainly in the optimisation of the use of the VHF bandwidth and ultimately in the expanded capacity of the ATC Centres.

The Air Server would be a new CAUTRA system responsible for managing the air-ground dialogues between pilots, controllers or automated systems. The ATN protocols required to support the selected services (CM, CPDLC and optionally ADS) are operated by the Air Server. The Air Server will interface with the current operational systems (FDPS, CWP, RDPS). These systems are unaware of the ATN protocols and the sub-networks used to communicate with the aircraft. Acting as a gateway between the aircraft and the controller, the Air Server is responsible for selecting and forwarding data to the appropriate Controller Working Position. It shall be designed in such a flexible way that it can be configurable in terms of services supported and connection to other operational systems.

The Air Server will be able to hide different data-link protocols to the end users. The main foreseen protocols handled by the server are the ATN CNS/ATM-1 and Mode-S GICB protocols and possibly the ACARS protocol for transition issue.

The Air Server would support the services listed above, i.e. ACM, ACL, FLYPCY/ and CAP. Where necessary, it could be envisaged to support the APR service, although this service is not considered as a high priority application. The Air Server concept will also be used for FIS services (ATIS, MET) although it is not clear today whether or not it will be integrated with the other services.

It is envisaged to install one Air Server per en-route ATCC. The ground topology for Approach ATCCs is not yet determined: Air Servers could be installed also in approach ATCCs or the en-route ATC Air Servers could act as gateways towards these ATCCs.

3.6.2.2 Studies and Projects

In line with the global strategy described above, the French CAA has launched or is involved in the studies and projects listed hereafter.

- **CLAIRE** Pre-operational data link system delivering the Departure Clearance at Roissy, Orly and Lyon Satolas airports. The procedures are compliant with the ODIAC.
- **ISATIS** Pre-operational data link system delivering the ATIS in Orly airport.
- **VIVO** Operational data link system providing CPDLC and ADS dialogues for oceanic airspace.
- **DRUIDES** Mock-up of a controller working position used to study the co-existence of two means of pilot/controller dialogue (voice and data link).
- **CAMELIA** Inter-connection of ground ATC system and cockpit simulators. Evaluation by pilots and controllers of initial data link services (Frequency Management, Altitude Change Clearances, Downlink Aircraft Parameter, DCL and ATIS).
- **ADS-EUROPE** Implementation in real aircraft of CM and ADS applications over satellite. Evaluation of performances. Project in co-operation with NATS and NLR.
- **CALLIOPE** Experimentation in operational environment of data link services (downlink aircraft parameters, flight plan consistency).
- **MAGIC** Study of the impact of the data link service 'trajectory negotiation'.

3.6.3 UK

The ATN topology envisaged to be developed in UK to enable data link services with aircraft flying the oceanic area includes the following components:

- The Flight Data Processing System. The new FDPS is scheduled for operational transition at Prestwick in beginning 2000. It will interface with CN/ATM-1 and compliant systems and provides data link services to equipped aircraft.

- ATN Internet Infrastructure comprising an ATN router and accesses to WANs and satellite communication sub-networks.

NATS has been conducted experiments on Oceanic Clearance Management (OCM) data link service over ACARS for several years. Trials are being conducted on Departure Clearance at Gatwick airport.

3.6.4 Ireland

ADS and CPDLC data link applications will be integrated in the existing ATS infrastructure.

3.6.5 Portugal

This country is interested by the operation of ATIS, Departure Clearance and ADS services as data link applications at the Lisbon airport.

The rationale behind the interest for a data link ATIS service is the high proportion of NAT traffic at Lisbon for which the knowledge of meteorological information and airport configuration have to be known far prior the landing and the activation of continental air/ground sub-networks.

Being responsible for the control of an oceanic FIR makes Portugal a very likely candidate for operating ADS. The data link coverage will allow upgrading significantly the surveillance capability over this FIR.

3.6.6 Germany

DFS currently plans to implement two initial air/ground data link services, namely DCL and ATIS.

ATIS is provided since 1992 in all majors German TMA's (Frankfurt, Munich, Düsseldorf and Berlin).

Trials wad started with Lufthansa on PDC in Frankfurt in 1992. The trials were suspended due to performance issues. However, there are plans to off PDC again in 1998.

3.6.7 Spain

According to [EAT13], the main focus defined by AENA in 1995 was on planning the deployment of an ATN-conformant ground infrastructure making it easier and faster to integrate the future air-ground sub-networks into the global ATN framework. An AFTN/AMHS gateway is under investigation for soon operational implementation.

ATIS and PDC applications similar to those undertaken in France and UK were planned to be deployed in Madrid in 1997-1998.

The Aircraft Parameter Reporting service over oceanic areas, the distribution of meteorological bulletins by datalink, the services allowing the enhancement of the surveillance and the CPDLC service for continental ATC clearances are the most mature candidates for early implementation.

3.6.8 Eurocontrol

3.6.8.1 Studies and Projects

In collaboration with European CAAs and industrials, Eurocontrol is involved in the following projects:

- **TES** Validation of the communication protocols for the ATN Upper Layers and CNS/ATM-1 Applications (CM, ADS and CPDLC).
- **PETAL** CPDLC data link functions developed in aircraft and in the Maastricht ATCC. Evaluation by aircrew and active air traffic controllers using STDMA, CNS/ATM-1 and FANS/1/A.

- **EOLIA** The implementation of a representative set of data link applications will allow operational people (pilots and controllers) to evaluate the real use of the provided services. This European project sponsored by the CEC DG XIII and Eurocontrol includes the development of the following applications: DLIC, ACM, ACL, FLIPCY/DYNAV, ATIS and APR claiming full compliant with the ICAO SARPs for air/ground applications.
- **PROATN** This project will develop and deploy a pre-operational CNS/ATM-1 ATN infrastructure for European airspace. It will therefore provide the data link applications providing communication support of EOLIA services (i.e. CPDLC, CM, ADS and ATIS).

3.6.9 NAT Implementation Management Group (IMG)

The NAT Implementation Group is co-ordinating the development of ATMIP documents (ATM Implementation Plan for the NAT Region to 2015). It covers the definition of the NAT Programme Objectives, New Operating Concepts, Level 1 Operational Requirements and Technical Strategy.

The following datalink services have been selected for implementation in the considered timeframe:

- Automatic Dependent Surveillance (ADS),
- ATC Clearance Services (ACL),
- ATC Communication Management Services (ACM), and
- Downstream Clearances Services (DSC).

3.7 Existence of Operational Non-ATN Environments

Air-Ground ATS Services

- ACARS Environment

Departure Clearances and ATIS services are already operational in some TMA centres. They function in the ACARS over VHF communication environment. It seems difficult to ask airlines and CAAs that have already made an initial implementation effort based on the ACARS system to switch in the short term to ATN.

These data link services have been very well accepted by the aeronautical community, in particular by the pilots. They have proved to some extent the operational benefit of the data link.

However, the migration of these services to the ATN infrastructure would not change significantly the provided operational service. In the case of ATIS, the contract function (and maybe the ground/ground FIS protocol once defined) will be a very useful new functionality but this could not justify by itself the migration of the ATIS service to the ATN. The need for the migration is the result of the technical comparison of the communications services provided by the ACARS system and the ATN Internet. Performance and flexibility limitations of the ACARS system constraint this technology to the short-term period.

Data link services operated in non-ATN environment are therefore serious candidates for the ATN.

- Mode-S Environment

In radar covered areas, surveillance related services (CAP, APR) could be provided more efficiently by using the Mode-S Specific Services than by establishing ATN ADS contracts. Even if these data link services provide the same operational benefits, they should not be selected for the initial ACCESS ATN.

Ground ATS Services

In Europe OLDI links are used for flight data exchange between ACCs. European standardised communication protocols have been developed to provide application users with a connection-oriented and character-oriented data transfer service. This standard known as the Flight Data Exchange protocol is applicable for connection using point-to-point links and X.25 data networks. It supports data communications for OLDI (flight plan exchange) and has been designed to provide also communication services for other types of data: flight data exchange between ACCs, data exchanges between ACCs and the CFMU.

OLDI fully satisfies the European requirements for ground-ground communication between ACCs. AIDC provides additional functionality – ACCs co-ordination - during the transfer of control phase.

3.8 Economical criteria

The implementation of the ATN in Europe will require ground investments (End Systems located in the ACCs and main airports, routers and sub-networks VHF and Mode-S), but also important investments for the airborne equipment.

Four factors shall be considered in the cost study:

- Ground deployment cost,
- Air deployment cost,
- Operation cost including the communication fees and the maintenance costs, and
- Return on Investment, airlines considering that ATS applications requiring a significant level of investment must show a significant R.O.I.

The main cost of the ATN to be considered is the deployment of the communication infrastructure. The difficulty is to evaluate the cost related to the deployment of a specific application. One can evaluate the traffic caused by the operation of an application based on the frequency and the size of the messages exchanged. Nevertheless, the determining factor is ultimately the type of the sub-network used to exchange the data.

Independently of the selected sub-network, the operation cost is directly related to the message exchange rate, as roughly estimated below:

- High message exchange rate: CAP, APR, SAP and TIS.
- Medium message exchange rate: CIC, ACM, MET, FLIPCY, PPD, D-OTIS, D-RVR, D-SIGMET, DYNAV and 4TDN.
- Low message exchange rate: DSC, DLC, Pushback, Taxi, DLIC and ATFM/Slot Allocation.

The economical aspects of the different air/ground subnetworks are investigated deeply in the ST15 study [EAT12].

3.9 Necessary Proportion of Aircraft Population Required to be Equipped

For some services, the operational benefit by operating a data link service is directly depending upon the number of equipped aircraft. It is likely that the data-link equipped aircraft population in the short-medium term will be small.

Data link services requiring a high level of equipped aircraft should not be selected for early implementation of the ATN. This is the case for the TIS, SAP and ATFM/Slot Allocation data link services.

3.10 Suitability of Data Link Sub-Networks

3 three categories of sub-networks likely to support air/ground data link communications are basically the followings:

- **The Mode-S services**: the SVC service allowing a bi-directional exchange of messages can act as an ATN sub-network, the GICB service allows the ground to extract aircraft parameters and the ADS-B service providing a data transfer service in mode broadcast.
- **The VHF services** providing a character oriented (ACARS), bit oriented (VDL-CSMA/Mode 1 and 2) and broadcast (VDL-STDMA/ Mode 4) transfer services. The HF data link supporting currently communications for ACARS could act in the future as an ATN sub-network.
- **The Satellite services** for ACARS protocol (SATCOM/Data 2) and ATN protocol (SATCOM/Data 3).

According to the Eurocontrol study [EAT13], the foreseen data link communication environments (basic medium and protocol) in operation are as follows:

- In the 1995-2000 timeframe, available data-link environments will be the ACARS protocol over VHF and over SATCOM/Data 2. This is the continuity of the current situation, the existing ACARS network being used to provide early ATS data link services to equipped aircraft
- The ATN protocols over the SATCOM/Data 3 will be available around 2000. In the 2000-2005 timeframe, the ATN environment would include in addition the VDL-CSMA/mode 2. The VDL-CSMA/mode 2 is the preferred continental sub-network mainly because it meets the performance requirement of most data link services. During this period, the Mode-S/GICB for ground-based enhancement surveillance will be deployed.

The selection of the sub-networks suitable for a data link service should be done following four axes:

Adaptability Issue

Sub-networks adapted for surveillance purpose only are the Mode-S/GICB. They are therefore eligible mainly for CAP and APR services.

Sub-networks adapted for surveillance and communication purposes are the Mode-S/SVC, Mode-S/ADS-B and VHF-STDMA/Mode-4. They are therefore eligible for all data link services.

Sub-networks adapted for communication purpose only are VHF-CSMA/Modes 1 and 2. They are therefore eligible for all data link services.

Availability Issue

The operational availability requirements stated in 3.24 reflect directly the technical availability requirements put on the air/ground sub-network, since the a/g link is the weakest link in the communication chain.

The MTBF/MTTR requirements of the data link services should be compared with the availability characteristics of the sub-networks. [EAT13] has performed this comparison and has concluded that only CIC(Clearances) and APR(continental) may have their requirements unfulfilled by the foreseen sub-networks.

Coverage Issue

Most of data link services may be operated over all these sub-networks. Only the surveillance related services (CAP, APR) for oceanic use require obligatory the availability of satellite ATN sub-network. Some other data link services likely to be initiated from oceanic areas will also require the selection of the Satcom data link (DSC, CIC, MET, FIS, DLIC). Eventually, data link services based on exchange of information to multiple recipients (e.g. TIS) may require the availability of broadcast sub-networks (Mode-S broadcast or VDL-STDMA/mode 4).

QoS Provision Issue

Three other criteria could be used to assign sub-networks to data link services: the **data integrity**, the **transit delay** and **throughput**. The data integrity is expressed by an upper bound requirement on the probability that a transmission error in a message goes undetected to the receiving end of the application. The transit delay is the maximum transit delay acceptable for a message to go from the sender to the receiver. As this maximum transit delay must be statistically significant, it should exclude the far end of the delay distribution tail. Transit delay metrics refer therefore to the 90, 95 or 99% maximum transit delay (i.e. accepting a longer delay in only 10, 5 or 1 % of cases). The combination of the required transit delay with the maximum message length defines the peak throughput to be provided by the communication system to the application.

The performance requirements of the data link services should be compared with the performance characteristics of the sub-networks. [EAT13] has performed this comparison and has concluded that the most performance-constraining applications can be met only by the VDL/Mode-2/3/4 and the Mode-S.

In fact, few applications are dedicated to a specific sub-network except those requiring a broadcast medium. Based on the availability of the sub-networks in 2010, one can conclude that the ADS-B based data link services can not be selected for the Initial ACCESS ATN.

3.11 Availability of Air and Ground Systems supporting the data link

Data Link applications require new functionality in the air and ground system interfaces, such as specific windows for allowing the pilot and the controller to dialogue with the peer, proposition of pre-defined messages, intensive use of colours, sounds and symbols in the IHM, etc… Pilot and controller interfaces are both impacted by the introduction of CPDLC-based services, the pilot interface is impacted by the introduction of FIS services and the controller interface is impacted by the introduction of ADAP services.

In addition to the user interface issue is raised the problem of the data availability. With the introduction of the ADAP and FIS services, many aircraft and ground parameters are now made remotely available. This requires the modification of existing systems (e.g. for some aircraft parameters not exported by the FMS should be made visible) or the development of communication means for the transfer of these data from the systems generating them to the ATN End Systems.

Not all these new functionality will be developed in the existing systems or in new air and ground systems in one day, but in contrary they will be implemented gradually depending upon the technology evolution, the economic constraints and the policy of the ACCs, airlines and aircraft manufacturers.

The implementation of the ATS applications depends therefore mainly of the availability of the new generation of hosting systems. It is obvious that ATS applications impacting strongly the current systems and communication infrastructures on the ground or in the aircraft are not the more likely candidates for the implementation in the initial ACCESS ATN.

4 Conclusion

This document has reviewed the European CNS/ATM operational requirements for data link services and has proposed a wide selection of such services for the target ACCESS ATN. The data link environment will be organised following four main directions: data link pilot/controller dialogues, downlink of aircraft parameters, uplink of ground information and ground message handling capability.

In the target ATN environment, departure clearances will be delivered by data link. Push back and taxing phases will be monitored through data link dialogues. Surveillance by ADS will take over radar surveillance for oceanic regions. The transfers of communication and exchanges of usual clearances and pilot acknowledgements, usually taking up much of the pilot and controller work time, will be automated. Consistency between the controller clearances and the pilot actions will be checked more precisely, for instance through the comparison of the onboard flight plan and the ground-based one. Flight Information Services will be available to the pilot all around the word, including ATIS, RVR and SIGMET. Ground systems will be able to compute up-to-date data coming from the aircraft and provide a better help to the controllers for detecting conflict situations and raising alarm warnings. On the ground, ATC co-ordination messages will transit through ground networks via AIDC protocols and the usual AFTN/CIDIN traffic will gradually be handled by ATS MHS systems.

This overview provides guidelines for the definition of the framework for the introduction of ATN in Europe. A gradual introduction of the ATN in the States of the ACCESS area should be planned. Thus, criteria for the selection of initial services have been defined in this document: assessment of the operational benefit, standardisation status, experimentation status, etc… Based on these criteria, an example of an initial set of services has been proposed, with the main objective to reduce the current VHF communication activities of the controllers and the pilots.

Each State in the ACCESS area should be allowed to apply its own national implementation plan (i.e. set of services, timeframe, location of systems, communication networks, etc.) but should stay in conformance with a global and consistent European plan. As we are just at the beginning in planning the introduction of ATN services, few information have being collected from the States of the ACCESS area. However, it is likely that the emerging national strategies will impact the overall European strategy. The framework presented in this WP will have to be updated accordingly.

Appendix A – Abbreviations

4DTN	4D Trajectory Negotiation
ACCESS	ATN Compliant Communications European Strategy Study
A/G	Air / Ground
AAC	Aeronautical Administrative Communications
ACARS	Aircraft Communications Addressing and Reporting System
ACM	ATC Communication Management
ADAP	Automated Downlink of Aircraft Parameters
ADS	Automatic Dependent Surveillance
ADSP	ADS Panel
ADS-B	ADS Broadcast
AGADE	Air Ground Automatic Data Exchange
AIC	Aeronautical Information Circular
AIP	Aeronautical Information Publication
AIDC	ATS Inter-facility Data Communications
AIS	Aeronautical Information Service
AOC	Aircraft Operational Communications
APR	Automatic Position Reporting
ASM	Air Space Management
ATC	Air Traffic Control
ATCC	ATC Center
ATFM	Air Traffic Flow Management
ATIS	Automatic Terminal Information Services
ATM	Air Traffic Management
ATN	Aeronautical Telecommunication Network
ATNP	ATN Panel
ATS	Air Traffic Service
ATSO	ATS Organization
AMHS	ATS Message Handling System
ATSU	ATS Unit
C-ATSU	Controlling ATSU
CAA	Civil Aviation Administration
CAP	Controller Access Parameter
CASA	Computer Aided Slot Allocation
CDMA	Code Division Multiple Access
CFMU	Central Flow Management Unit
CIC	Clearances and Information Communication
CIDIN	Common ICAO Data Interchange Network
CMA	Context Management Application
CNS	Communications, Navigation and Surveillance
CPDLC	Controller Pilot Data Link Communications
CSMA	Carrier Sense Multiple Access
CWP	Controller Working Position
D-ATSU	Downstream ATSU
D-OTIS	Data Link OTIS
DAP	Downlink Aircraft Parameters
DCL	Departure Clearance
DLIC	Data Link Initiation Capability
DSC	Downstream Clearance
DYNAV	Dynamic Route Availability
D/L	Data Link
ECAC	European Civil Aviation Community
EOLIA	European pre-Operational data-Link Application
ES	End System
FANS	Future Air Navigation System
FDPS	Flight Data Processing System
FIR	Flight Information Region
FIS	Flight Information Services
FLIPCY	Flight Plan Consistency
FMP	Flow Management Positions
FMS	Flight Management System
GICB	Ground-Initiated Comm-B
G/G	Ground / Ground
HF	High Frequency
ICAO	International Civil Aviation Organization

IFPS	Initial Flight Plan Processing System
ISO	International Standardization Organization
METAR	Meteorological Reports
MSAW	Minimum Safe Altitude Warning
MTBF	Mean Time Between Failure
MTTR	Mean Time To Repair
MTCD	Medium Term Conflict Detection
NOTAM	Notice to Airmen
OACC Center	Oceanic Area Control
OCM Message	Oceanic Clearance
ODIAC	Operational Development of Initial Applications of A/G data Communication
ODIAC-TF	ODIAC Task Force
OSI	Open Systems Interconnection
OTIS	Operational Terminal Information Service
PCR	Performance Communication Requirements
PDC	Pre-Departure Clearance
PPD	Pilot Preference Downlink
ProATN	Pre-Operational Aeronautical Telecommunication Network
PSN	Public Switching Network
RD	Request/Delivery
RER	Residual Error Rate
RMCDE	Radar Message Conversion and Distribution Equipment
ROI	Return On Investment
RVR	Runway Visual Range
R/T	Radio/Telephone
SAP	System Access Parameter
SARPs	Standards and Recommended Practices
SICASP	SSR Improvements and Collision Avoidance System Panel
SSR	Secondary Surveillance Radar
STCA	Short Term Collision Avoidance
STDMA	Self organizing Time Division Multiple Access
TCP/IP	Transport Control Protocol / Internet Protocol
TIS	Traffic Information Services
TMA	Terminal Maneuvering Area
VDL	VHF Data Link
VHF	Very High Frequency