EUROCONTROL

AERONAUTICAL TELECOMMUNICATION NETWORK PANEL

WORKING GROUP 3 (APPLICATIONS AND UPPER LAYERS)

Rio de Janeiro, Brazil, 16 - 20 March 1998

(Information paper)

Data Link Application Servers in Europe

Prepared by: Tim Maude

Presented by: Danny Van Roosbroek

SUMMARY

This paper explores the concept of operating data link services through the use of data link application servers within Europe. The concept is explored from a number of aspects: state related, operational requirements, organisational, procedural, safety, systems management, financial and technical.

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Scope

This paper explores the concept of operating data link services through the use of data link application servers within Europe. The concept is explored from a number of aspects: state related, operational requirements, organisational, procedural, safety, systems management, financial and technical. The purpose of this paper is to explore the concept, obtain an initial idea of the benefits and note any issues that arise.

1.2 Background

Over a number of years, the concept of data link applications has been developed. This section provides a brief overview of some of the developments relevant to Europe.

ICAO has published SARPs for the for the following applications:

- Context Management (CM) - allowing an aircraft and ground system to exchange technical details of data link applications. The information exchanged is necessary before the initiation of any of the other data link applications.

- Automatic Dependant Surveillance (ADS) - allowing the ground system to request the aircraft to downlink certain parameters, in particular, its current position.

- Controller Pilot Data Link Communication (CPDLC) - allowing the controller and pilot to exchange messages.

- Flight Information Services (FIS) - allowing the aircrew to obtain airport terminal information services (ATIS) information.

The ICAO SARPs contain a fairly basic but flexible level of functionality. They do not define how the services should be used, as this is subject to national and regional agreements. Within Europe, Operational Requirements for ATM Air/Ground Data Communications Services (ORD) are being developed by the ODIAC task force. In contrast to the requirements specified in the ICAO SARPs, the ORD defines how data link services will be used. Also in contrast with the ICAO SARPs, the ORD defines requirements for European airspace, rather than being world-wide. The development of the ORD is an on-going process, and so the complete list of services it defines cannot be listed here. However, those services currently defined and in the process of being defined include:

- Clearances and Information Communications (CIC) Service

- ATC Communications Management (ACM) Service

- Downstream Clearance (DSC) Service

- Departure Clearance (DCL) Service

- Controller Access Parameters (CAP) Service

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

- Data Link Runway Visual Range (D-RVR) Service

- Dynamic Route Availability (DYNAV) Service

- Flight Plan Correlation (FLIPCY) Service

- Airport Terminal Information Service (ATIS)

In addition to the development of the requirements documents - both the ICAO SARPs in the international arena, and the ORD within Europe - pre-operational software is being developed to meet these requirements.

The ProATN project is developing pre-operational software that meets the requirements specified in the ICAO SARPs for CM, ADS, CPDLC and FIS. The software is being developed by a consortium of companies (the ProATN consortium) under the EC fourth framework programme.

The EOLIA project is developing pre-operational software that meets the requirements specified in the ORD for CIC, ACM, FLIPCY, DYNAV, DSC and ATIS. The software is being developed by a consortium of companies (the EOLIA consortium) under the EC fourth framework programme, and funded by Eurocontrol.

1.3 The Concept of Data Link Servers in Europe

The concept explored in this document is that of a Data Link Application Server. In all the background material described in section 1.2 above, there is an underlying assumption that each application on board the aircraft communicates with a separate application for each ATSU through whose control it passes. This is illustrated in figure 1-1. The concept of a Data Link Application Server is that a single application may serve several ATSUs. This is illustrated in figure 1-2.
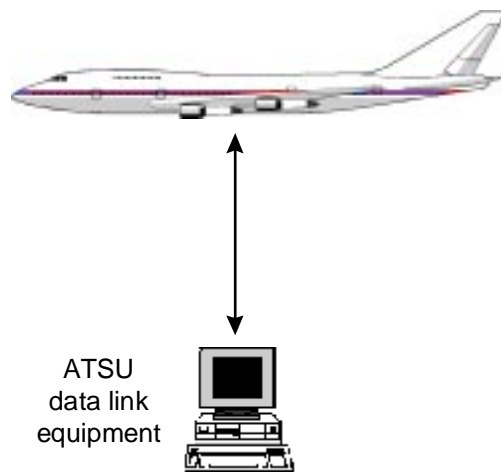

ATSU
data link
equipment

Figure 1-1: Normal view of a data link connection

ATSU
data link
equipment

Data link
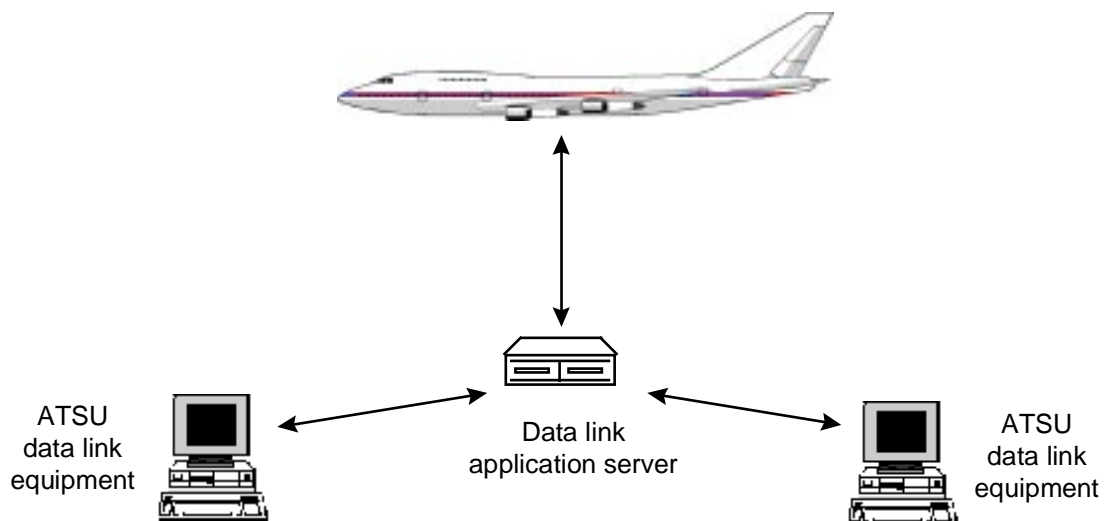application server

ATSU
data link
equipment

Figure 1-2: Concept of a data link application server

One view of this concept is that it is a technical issue only, and that from the users' perspective, the service should remain identical. In many ways this viewpoint is correct, however, there are many organisational, commercial, technical and state issues that arise that must be considered.

The data link application server may be operated by a number of different organisations:

- by a state's ATC organisation - providing a single server for all sectors within the state's airspace,

- by joint agreement between two or more states - providing a single server for all the collaborating states,

- by a service organisation - providing a service that can be used by one or more states' ATC organisations.

1.4 References

[1] ORD - Operational Requirements for Air Traffic Management (ATM) Air/Ground Data Communication Services, Edition 0.g, 15 June 1997.

[2] ICAO Document 9705-AN/956 (Application SARPs - CM, ADS, CPDLC, FIS, ICAO version 2.2)

2. BENEFITS

2.1 Introduction

Clearly, the concept of a data link application server is a technical one. The concept has little effect on the operational requirements for data link applications.
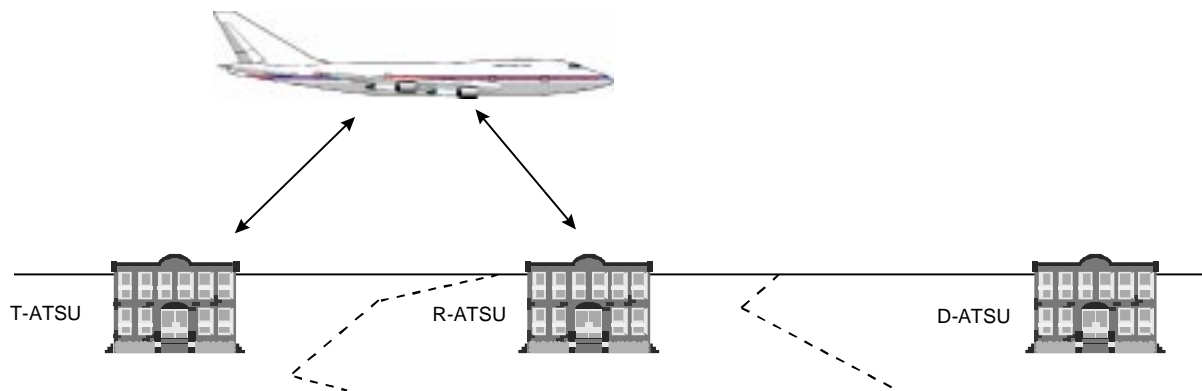
2.2 Transfer of Control

Figure 2-1: Transfer of Control

When an aircraft is transferred from one sector (the transferring ATSU or T-ATSU) to another (the receiving ATSU or R-ATSU) under separate data link control (see figure 2-1), there are a number of actions that must take place:

- A context management exchange must take place, with the use of CM-contact or CM-update.

- A new CPDLC connection must be established (the Next Data Authority - NDA).

- A negotiated hand over of data authority must take place; in Europe this will be through the use of the ATC Communications Management (ACM) service, which will also transfer the voice communications.

- The old CPDLC connection must be taken down.

- If ADS is being used for surveillance, before the hand over of authority, the R-ATSU must establish a set of ADS contracts.

- The T-ATSU must cancel its ADS contracts.

The transfer is further complicated when the aircraft will only be in the R-ATSU airspace for a short period. In this case the transfer from R-ATSU to a D-ATSU (Downstream ATSU) will have to start before the transfer from T-ATSU to R-ATSU has completed.

This is not a neat transfer and has a number of risks associated with it. It could lead to either gaps in communication, or significant overlaps in the connection. Several connections have to be made and broken during the process, which is an expensive overhead. The greater the number of connections that must be made and broken, the greater the chances of connections failing and therefore the process failing. With several connections being established and broken during the same period, the possibility of network congestion increases significantly.

The use of a data link application server, used by both T-ATSU and R-ATSU (and potentially D-ATSU), removes the need to conduct this transfer over the air-ground data link. All transfer of control occurs in the ground based data link application server. It is therefore not limited by the artificial constraints of the air-ground data link.

2.3 Ground End User Equipment

Where there is no data link application server, each ground end user must be equipped with the full application architecture. That is, it must contain:

- The user application (implementing the user interface and the services defined in the ORD)

- Context Management (CM) application software

- Automatic Dependant Surveillance (ADS) application software

- Controller Pilot Data Link Communications (CPDLC) application software

- The upper layers stack

- ATN transport and lower layers

Moreover, this set of functions must be present in each ATSU.

A data link application server would also have to contain this complete set of functionality. However, the ground end user equipment could have a very simple interface to the data link application server. For example, it could be implemented with a Remote Procedure Call (RPC) mechanism over another type of network infrastructure. This is illustrated in figure 2-2.
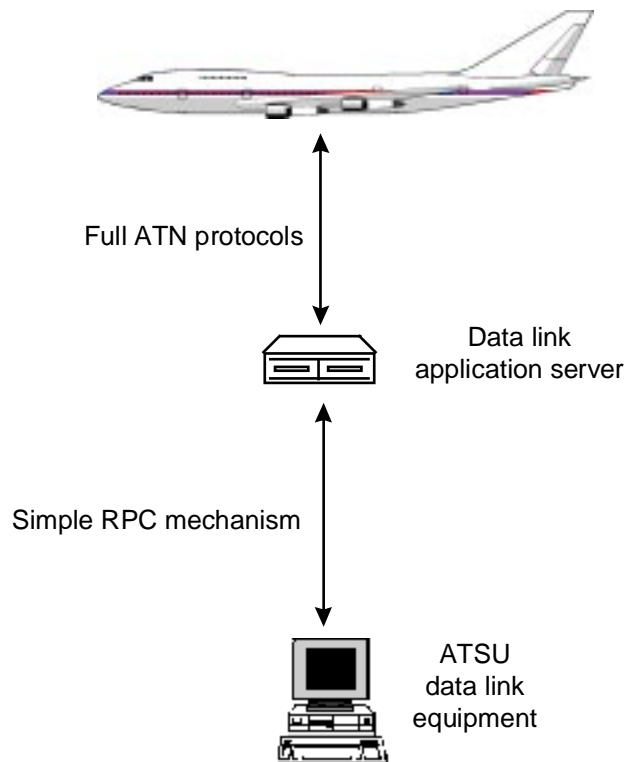
Figure 2-2: Use of simple protocols in the ATSU data link equipment

Clearly, the advantage here is a much simpler system architecture in the ATSU itself. This will therefore be cheaper to implement and simpler to validate. The commercial advantages grow with the number of ATSUs served by the data link application server.

3. STATE ISSUES

Air traffic services in different European states have different legal statuses. These range from states where the air traffic services are totally owned and controlled by the national government, to states where the air traffic services are a wholly private concern licensed to carry out air traffic services by the government.

States will always require the retention of sovereignty over their own airspace. They may choose to licence the control of the airspace to another organisation. It is conceivable that a state could issue a temporary licence to control its airspace to an organisation outside its own borders. However, states will always require the retention of sovereignty.

The use of a data link application server will not affect this situation. A state that uses a server run by another state (by mutual agreement) or by a service organisation will not release sovereignty over its airspace by doing so.

4. OPERATIONAL ISSUES

The ORD [1] defines the operational requirements for datalink services in Europe in the near term (2000 - 2005 time period). The following table provides a brief overview of the services that are defined, or in the process of being defined, and an analysis to determine if the introduction of a datalink server would have any impact on operational requirements.

The fundamental operational requirement in each case is unaffected by the introduction of a data link application server.

Service	Description	Issues
Clearances and Information Communications Service (CIC)	This service covers message exchange between the aircrew and controller for: • aircrew reports and clearance requests • controller delivery of clearances, instructions and notifications • support and system messages	None
ATC Communications Management Service (ACM)	The ACM service provides automated assistance to the aircrew, current and next controllers for conducting a transfer from one ATSU to another. The ACM service encompasses transfer of both voice and data communications.	The ACM process, including the concept of Data Authority which is embodied in the ORD [1] must be re-examined in the light of the concept of a data link application server. It is likely that changes will be required.
Departure Clearance Service (DCL)	The DCL service provides automated assistance for requesting and delivering departure information and clearances prior to takeoff.	None
Controller Access Parameters (CAP) Service	The CAP service assists the ATC surveillance function by automatically providing aircraft parameter data, such as air speed and heading, to the controllers.	None
Data Link Operational Terminal Information Service (D-OTIS)	The D-OTIS service provides automated assistance for the aircrew in obtaining information derived from ATIS, METAR and NOTAMs/ SNOWTAMs.	None
Downstream Clearance Service (DSC)	The DSC service provides assistance in requesting and obtaining information and clearances from an ATSU that the aircraft may be controlled by at some time in the future.	The DSC service as currently defined assumes that a separate connection is required. The details of this service will need re-examining.
Flight Plan Consistency (FLIPCY) Service	The FLIPCY service detects discrepancies between the airborne flight plan and the filed flight plan stored in the flight data processing system.	The FLIPCY service should operate when the data communications with an ATSU are initiated. The timing of the use of the FLIPCY service should be examined in relation to the concept of a data link application server.
Dynamic Route Availability (DYNAV) Service	The DYNAV Service allows the controller to inform the aircrew of the availability of a route that is not in the current flight plan.	The DYNAV service operates with the current and receiving ATSU. It may be possible to make use of the data link server to co-ordinate the service.

5. ORGANISATIONAL ISSUES

There are a number of different organisations which might choose to operate a data link application server:

• a state's ATC organisation - providing a single server for all sectors within the state's airspace,

- joint agreement between two or more states - providing a single server for all the collaborating states,

- service organisations - providing a service that can be used by one or more states' ATC organisations.

The overall picture in Europe is likely to consist of a number of service organisations - providing data link services to some states, other states with their own data link applications servers, yet others sharing their servers, and some states not using the server concept at all.

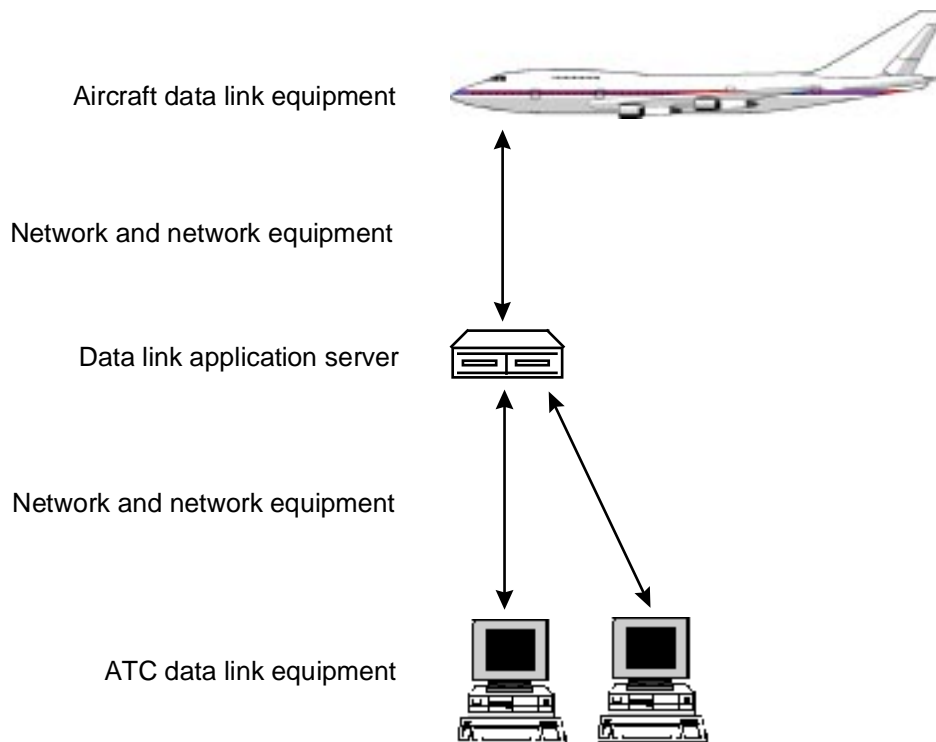Figure 5-1 shows the different functional components:

Aircraft data link equipment

Network and network equipment

Data link application server

Network and network equipment

ATC data link equipment

Figure 5-1: Functional Components of a Data Link Application Server in Operation

Clearly the aircraft data link equipment must be run by the airlines, and the ATC data link equipment must be run by the ATC organisations. The networks will be run by a combination of the ATC organisations (typically operating the LAN and, in some cases, the national WAN), and network service organisations. The financial implications of introducing a data link application server in the three cases listed above are as follows:

- by a state's ATC organisation - providing a single server for all sectors within the state's airspace; here there is no external financial exchange, as the operation is run and financed within the same organisation;

- by joint agreement between two or more states - providing a single server for all the collaborating states; here the costs of the service provision must be shared between the different states; bilateral agreements will have to be made;

- by a service organisation - providing a service that can be used by one or more states ATC organisations; here the service organisation is run as an independent financial organisation, and will offer its services through a tarriffing agreement.

Any tarriffing agreement will have a number of components:

- initial payments on taking up the service,

- monthly (or other periodic) payments,

- payments by number of transactions,

- payments by connection time.

6.   PROCEDURAL ISSUES

The procedures associated with the use of data link applications in Europe have not yet emerged. The impact of the use of data link application servers on these procedures cannot, therefore, be fully assessed yet.

7.   SAFETY ISSUES

Before implementation of a data link application server, a full safety analysis will have to be performed. However, it is possible to identify several major issues which must be addressed.

- Will a data link application server add delays to the passage of air-ground messages that will give rise to a safety problem?

- Can it be guaranteed that a connection through a data link application server will be routed to the correct end user?

- Can it be guaranteed that connections will be correctly identified so that proper correlation with the filed flight plan and the voice channel can be established?

- Will it always be possible for a connection to be made when required (in particular, will the data link application server have sufficient capacity)?

These issues are related to the implementation. The safety risks can be minimised by appropriate development methodologies and appropriate sizing.

8.   SYSTEM MANAGEMENT ISSUES

There are a number of functions that will have to be performed by a systems management function.

One of the main functions of a data link application server will be that of routing messages between aircraft and ATC equipment. It is important to distinguish between routing within the ATN network itself (network level routing), and routing within the data link application server (application level routing).

- The network level routing takes place in the routers, and ensures that messages get to the appropriate end system. The data link application server is an example of an end system to which the message will be delivered. Network level routing is performed only on the basis of a network address.

- The application level routing takes place in the data link application server, and ensures that messages are passed to the appropriate application (which may be running on another end system elsewhere in the network). The CPDLC application in an aircraft or an ATC system are examples of such applications. The application level routing is performed on the basis of things like: who is controlling the aircraft, and what ADS contracts have been set up.

The function of the data link server discussed here is in the application level routing. Some of the information required to perform this function will be static, for example, the address of a particular ATC centre. Other information will be dynamic, for example, the logical CPDLC connection between an ATC centre and an aircraft. The dynamic routing tables that control the routing of messages will require management. Some items will require changing, and some will require monitoring.

A data link application server will require a number of queues for messages, for example, messages arriving and message due to be transmitted. These queues will have to be monitored to avoid congestion.

Data link application servers will be required to maintain statistics on usage. This will not only be for audit purposes for accident investigation, but also for accounting purposes, if the service is charged for by use.

The management of the server will also require the system to detect faults and subsequently alert an operator. Faults could be, line faults, network faults, congestion, protocol errors or hardware failure.

9. TECHNICAL ISSUES

The main technical function of a data link application server is that of routing messages from the aircraft to the appropriate ground system, and vice versa. This will require a dynamic routing function to keep track of the various connections. It is necessary for the applications to contain the information required to perform the necessary routing. In order to maintain these dynamic tables, the data link application server must keep information on routing for all current connections. It must also act as the CM server, keeping information on the addresses that any aircraft sends it through a CM logon request.

Once a connection with an aircraft is established, the routing for that connection will be recorded and routing of subsequent messages will not be an issue.

All ground initiated connections will have to occur after the aircraft has performed a CM logon request. Therefore the data link application server will have the necessary routing information.

For air initiated connections, analysis must be performed on a case by case basis. Table 9-1 shows an analysis of all functions that result in an air initiated connection request.

Application	Function	Analysis
CM	CM-logon	The data link application server must act as the CM server, and therefore there is no issue concerning routing.
CPDLC	CPDLC-start initiated from the aircraft	In the CPDLC start request PDU there is an indication of the destination for the message in the CPDLC-start parameter "called peer identifier". This parameter must be passed to the ground system through A-ASSOCIATE AE-Title parameter. This is not done under the current specification.
		Even if the called peer identifier were passed to the ground system, the CPDLC SARPs do not state any use for this parameter in the ground system, and it is not passed to the CPDLC-ground-user in the CPDLC-start indication.
		Thus the information to route the CPDLC-start is not available in the ground system.
	DSC-start	The same issue exists for a DSC-start request.
FIS	Contract request	The ATIS contract request (the only one defined so far) contains an indication of the airport for which information is sought. This can be used as the basis for routing.

Table 9-1: Analysis of functions that result in an air initiated connection request

In addition to the function of routing messages and providing a simpler transfer mechanism, there are a number of other functions that could be provided:

- The data link application server could provide a smooth transfer of data authority without the need to break the air-ground connection. This needs careful thought and a redefinition of the ACM requirement.

- The data link application server could provide a different method of obtaining down stream clearance. For example, it could recognise a downstream clearance request as and forward it to the appropriate ground system. This would not meet the requirements of the current SARPs.

- When several ATC systems establish similar ADS contracts with the same aircraft, the data link application server could establish a single ADS contract with the aircraft which satisfies the needs of all ATC systems.

- When several aircraft establish similar FIS contracts with the same FIS service, the data link application server could establish a single FIS contract that satisfies the needs of each aircraft. It should be noted that the savings from such a system may not be high.

One of the technical issues that arise from the concept of a data link application server is that the applications of several ATSUs will have the same NSAP address. When implementations of both air and ground systems are made, this fact must not give rise to any artificial constraints. For example, an aircraft should be able to accept contracts from two different ground systems with the same network address.

If the concept of a data link application server is to be pursued, one of the main issues to be tackled is that of defining the requirements specification. This must cover:

- the nature of the link to the ATC system, for example, an RPC mechanism over a locally defined network infrastructure; this is a issue for the local implementation, but an open specification is needed if a public service is to be offered;

- the functionality of the routing mechanism;

- any additional functionality such as performing a smooth CPDLC transfer of data authority;

- the systems management functionality that is required.

Aspects such as the required level of performance are implementation specific, and will have to be defined on an implementation by implementation basis, provided that they match the required communication performance (RCP).

10. FINANCIAL ISSUES

There are financial benefits that could arise from the concept of a data link application server. Financial benefits arise from:

- lower development costs for ATSU software

- lower maintenance costs for ATSU software

- lower hardware costs at each ATSU

- lower validation costs for each ATSU system

- lower air/ground communications costs through reducing the number of times connections are opened and closed

- lower air/ground communications costs through the use of single contracts to cover multiple air/ground contracts

Financial costs arise from:

- provision of data link application server hardware

- development or procurement of data link application server software

- validation costs for the data link application server

- maintenance of data link application server software

In order to understand fully the financial benefits deriving from a data link application server, a full cost benefit study should be performed. However, it is clear that the financial benefits are a function of the number of ATSUs that use the server, whereas the costs are fixed. Therefore, given sufficient ATSUs participating in the use of a data link application server, it is likely that financial benefits will result.

11.   CONCLUSIONS

In the development of data link, the concept of a data link application server has not been widely considered so far. This paper has highlighted the following benefits of the concept, which are potentially financially beneficial:

- benefits relating to the simplification of transfer between sectors,

- benefits relating to ATSU equipment being much simpler.

In order to determine if this concept is worth pursuing further, an initial cost benefit analysis should be carried out.

The ORD definitions of the ACM and DSC services have some underlying assumptions about the architecture of the systems providing the service. These need to be re-examined in the light of the concept of a data link application server.

The technical evaluation has shown that it is not possible to route the CPDLC and DSC connections that are initiated in the aircraft to the appropriate ground system. If these connections are to be permitted, then changes would have to be made to the Upper layer and CPDLC SARPs.

Should the CBA show a genuine cost benefit, and the issues raised here be solved, the next step is to write an initial specification for a data link application server, and produce a prototype for experimental purposes.