International Civil Aviation Organization

The Fourth Meeting of the Regional Airspace Safety Monitoring Advisory Group (RASMAG/4)

Bangkok, Thailand, 25 – 28 October 2005

Agenda Item 3: Airspace safety monitoring documentation and regional guidance material

GUIDANCE MATERIAL - DATA LINK GROUND EQUIPMENT

(Presented by Japan and New Zealand)

SUMMARY

This paper provides, for review by the meeting, preliminary guidance material in relation to the procurement, deployment and implementation of integrated data link systems.

1. INTRODUCTION

1.1 In recognizing the lack of suitable guidance material in relation to the procurement, deployment and implementation of integrated data link systems (including AFN, ADS, CPDLC and AIDC), RASMAG had commenced work towards drafting suitable regional guidance material in this respect.

2. DISCUSSION

2.1 The initial work in drafting appropriate guidance material has commenced since RASMAG/3 (June 2005), with focus on three primary areas:

a) System procurement processes;
b) Implementation of systems; and
c) The integration of data link systems.

2.2 Preliminary drafts of guidance material addressing these areas have been included as **Attachments A, B and C**, for review by the meeting. In reviewing the drafts, the meeting is invited to provide feedback for consideration by the primary authors in Japan and New Zealand. Moreover, the meeting is invited to consider a suitable final structure for a guidance material document that incorporates the three discrete areas under review. This may take the form of a fully integrated and combined document or a generic initial section with the three attachments included as separate appendices dealing with the specific sub sections.

3. ACTION BY THE MEETING

3.1 The meeting is invited to review and provide feedback on the attached draft documentation, including proposed structures for the final guidance material document.

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Guidance for ADS/CPDLC/AIDC System Procurement Process

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1 GENERAL

1.1 OBJECTIVES OF THE GUIDANCE

User organization of ADS/CPDLC/AIDC system should play many important roles in planning and deployment, especially in Service Operation Requirement Analysis and Total System Operation Test. This guidance will show the roles to be played and actions to be taken by user organization from planning to operational transfer. The guidance will be referred by user organization to improve its critical communication with vendors for successful deployment of the system such as:

- Clear definition of ATS Service Operation Requirements for proper work of the system in real operational environment,
- Application of proper interface standards for connection with avionic systems, adjoining ATS facilities or related ATS systems,
- Timely approval of design or specification change for reducing the impact to vendor work schedule and system quality, and
- Provision of proper test cases and exact data based on real operational environment for Total System Operation Test to certify the system is operational.

1.2 GENERAL FEATURE OF "SYSTEM"

1.2.1 Complexity of system

The word "system" is defined as "a group of units so combined as to form a whole and to operate in unison". ADS/CPDLC/AIDC system consists of airborne equipment, satellite, ground communication equipments, networks, information processing and display equipments, software and human beings, controllers and pilots. If one of the units of a system forms a lower level system, it is called as subsystem. A huge and complex system usually has a hierarchy of several layers of subsystems.

Every system or subsystem has its inputs, processes and outputs, and is controlled by external events, time conditions or certain time durations. Interface is defined as datum or controls between the units, subsystems or the system itself to/from outside. System functionalities are defined by the items mentioned above. According to this structure, system is very complex and almost unable to test all the cases of combinations with these items.

1.2.2 System Life Cycle Management

Every system has its life cycle from the planning to the end of operation, similar with the birth and the death of a human being. Total life cycle cost, including the operational and maintenance cost, is more important than the initial procurement cost, and is called as Total Cost of Ownership (TCO). Typical system life cycle consists of the following phases:

a) Conceptual Phase,

b) Validation Phase,

c) Development Phase,

d) Production Phase,

e) Installation and Test Phase,

f) Operation and Support Phase, and

f) Termination Phase.

Conceptual Phase and Validation Phase are included in planning, and are done by both user organization and vendors. Development Phase and Production Phase are mainly done by vendors, but some activities such as design review and provision of test cases are done by user organization. Installation and Test Phase is also done by both user organization and vendors.

If the ATS facility is going to buy a ready-made system with no modification, phase a) and phase d) would be skipped in user side. In case of modification, the phases from a) to d) should be followed briefly.

1.2.3 Project Management

Many kinds of human resources, equipments, tools, money and time are managed in a system planning, design and development. Standard methodologies are used in management of project. The Project Manager plans, follows, checks and corrects the project progress by work definition, resource requirement analysis, scheduling, quality management and cost control. Program Evaluation and Review Technique (PERT) chart shows its critical paths, time minimum path and cost minimum path of the project activities.

User organization should understand the methodology used in the project, involve the project management planning and follow the project management processes as one of the most important members of the project.

1.3 ELEMENTS OF SYSTEM QUALITY

Total system quality is defined as the results of multiplexing accumulation with Design Quality, Production Quality and Operation Quality. To improve system quality, these three quality elements should be improved simultaneously. Design Quality is based on both proper operational requirements from user organization and system design skills of the vendor. Production Quality depends on vendors. Operation Quality mainly depends on user organization. As the results of this quality structure, a good understanding and well organized cooperation between user organization and vendors are essential for better quality of total system.

Example:	1.0 x 1.0 x 1.0 = 1.000	(Ideal case)
	0.7 x 1.0 x 1.0 = 0.700	(Design Quality is poor)
	1.0 x 0.7 x 1.0 = 0.700	(Production Quality is poor)
	1.0 x 1.0 x 0.7 = 0.700	(Operation Quality is poor)
	0.7 x 0.7 x 0.7 = 0.343	(All quality elements are poor)

Note: Three Elements of System Quality

Design Quality is an index to express how properly the operational requirements are reflected to technical specifications through the design work.

Production Quality is an index to express how exactly the products are made according to the technical specifications through production quality control.

Operational Quality is an index to express how accurate the system is operated to realize the service objectives through operation management.

1.4 ROLES AND RESPONSIBILITIES OF USER ORGANIZATION

User organization is responsible for successful system deployment. Do not depend everything to vendors, but involve in critical processes of the system deployment.

1.4.1 Responsibility of user organization

ADS/CPDLC/AIDC system, or any system, is very complex and hard to test whether the system meets service operational requirements or not. Vendor is responsible only to develop a specific system according to the requirements from user organization, or produce standard systems according to its marketing based specification. User organization is responsible to define service operational requirements, help vendor(s) to design and system development properly, and to confirm the system meets the operational requirements.

Clearly defined Operational Requirements and well designed Total System Operation Test are the most important Key Success Factors (KSF) for successful ADS/CPDLC/AIDC system deployment.

1.4.2 Roles of user organization in development

If the ADS/CPDLC/AIDC system will be newly designed or modified from existing standard system, user organization should involve the design and development process. Understanding when and what to involve in development process is very important. Typically, a new system is developed according to the following steps;

a) Basic Design,

b) Preliminary Design Review,

c) Detail Design,

d) Critical Design Review,

e) Program Coding & Module Checkout,

f) Program Test,

g) System Integration & Quality/Verification Tests,

h) System Test & Evaluation (Simulated environment in factory),

i) Installation, and

j) Total System Operation Test (In real operational environment).

User organization should play main roles in Preliminary Design Review and Total System Operation Test. User organization also should help vendors in Basic Design, Detail Design, Critical Design Review and System Test & Evaluation.

2 PLANNING PROCESSES

Planning process of ADS/CPDLC/AIDC is very important to determine what kind of system the user organization needs and how to use it in its current and future service operation. It is recommended to go on steady step-by-step process to clarify the requirement, possible solutions and best combination of them as follows:

a) Case Studies on working systems,
b) ATS Service Operation Requirement Analysis,

c) Technical Feasibility Study,
d) Conceptual System Design, and
e) Preliminary Design Review.

2.1 CASE STUDIES ON EXISTING SYSTEMS

Case studies on real working ADS/CPDLC, ATC/ATM and AIDC systems/subsystems before start planning, as much as possible, are strongly recommended. The purpose of case studies is to understand how the system works in real ATS operational environment and lessons learnt in their valuable experiences, not only success stories. In general, the possible ways of case study on existing operating ADS/CPDLC/AIDC systems are as follows;

a) Visit an ATS facility to see real ADS/CPDLC/AIDC system operation,
b) Learn by lectures from experienced controllers, engineers and managers, or
c) Gather reference information on both operational and technical.

2.2 DEFINITION OF SERVICE REQUIREMENTS

2.2.1 Confirmation of Service Environments

The purpose of service requirement analysis is to clarify the current ATS service status and define the baseline of functions and performance for Conceptual System Design. Items regarding to the service operation environments to be confirmed in the phase are as follows:

a) Airspace Structure and Major Airports;

b) Sector Configuration and VHF/Radar Coverage;

c) Traffic Flows (Routes, Number, Flight Levels, etc.);

d) ATS Procedures (Separation; and,

e) Related ATS facilities:

2.2.2 Requirement Analysis

Items to be analyzed in the service requirements definition phase are as follows:

(1) Required service operation functions for ADS/CPDLC and ATC/ATM

(2) Required performance (ex. Area and number of aircrafts to display)

(3) Required sector layout and geographic constraints

2.3 TECHNICAL FEASIBILITY STUDY

2.3.1 Possible Cases

The purpose of studies is to evaluate technical feasibilities of possible ways of ADS/CPDLC/AIDC system deployment based on the Service Operation Requirements, functionalities and performance of existing systems in the current market, and budget limitation. In general, there would be the following three possible cases;

Case-1: Ready-made standard system

Case-2: Modification from ready-made standard system

Case-3: Order–made system (Development from scratch)

2.3.2 Evaluation Criteria

Evaluation Criteria of the technical feasibility studies on existing systems in the current market are as follows;

a) Functions are met to the requirements?

b) Performance is enough to handle future traffic?

c) User operation is easy and acceptable by users?

d) Reliability is enough in future service conditions?

e) Connection with related systems/facilities is easy?

f) Required standards are applied?

2.4 CONCEPTUAL SYSTEM DESIGN

2.4.1 Purpose and Base

The purpose of Conceptual System Design is to describe conceptual outline of system by both ATS service operation point of view and holistic technical feasibility, referencing existing cases. The design would be based on the results of the Case Studies, Service Operation Requirement Analysis and Technical Feasibility Studies.

2.4.2 Expected Results

Expected results of the design would be documented with descriptions, diagrams and tables. Conceptual System Design results shall include the following;

a) Functions needed in ATS service (ex. ADS Reports, Traffic Display)

b) Performance goal needed in the targeted airspace

c) Physical configuration and layout (ex. Sectors and its combination)

c) Service procedures how to use ADS reports in ATS service

e) System operation procedure (ex. 24 Hours x 7 Days, Automatic Recovery)

f) Standards to be applied (ex. ARINC-745, RTCA DO-219, DO-258)

g) Interface specification with related ATS facilities

h) Data-link Service Provider and its interface

i) Human Machine Interface (ex. Font size & color)

2.5 PRELIMINARY DESIGN REVIEW

2.5.1 Purpose and Methodologies

The purpose of Preliminary Design Review is to confirm and correct the results of Conceptual System Design based on both Service Operation and Technical Feasibility points of view. Review shall be done by a combined team including users, engineers, managements, System Analysts and System Designers, and by one of the following methodologies:

a) Walk through of Conceptual Design documents; or

b) Logic and performance simulation (On-desk and/or computer simulation).

2.5.2 Expected Results

Expected results of the preliminary design review are as follows;

a) Adaptability to Service Operation Requirement

b) Connectivity with Related Systems

c) Issues on System Requirement

d) Issues on Service Operation Requirement

3 REQUEST FOR PROPOSAL (RFP)

3.1 OBJECTIVES

Request for Proposal (RFP) is a document to ask vendors to submit their proposal according to the specified way for easy and fair comparison based on the same contents and conditions. RFP is submitted in Validation Phase based on Requirement Analysis, definition of Functional Baseline, Conceptual Design and technical trade-off's. Usually, rough cost estimation is also requested by RFP. Items to propose, calculation method to estimate and form to submit are specified for easy and fair comparison. Vendors should follow the conditions specified in the RFP in their proposal. If they can not meet any item, they can propose some alternative way, counter proposal, to achieve the request.

3.2 CONTENTS AND PROCEDURES

RFP shall contain the following information for vendors to be met in the proposal;

a) Proposal Preparation Instruction

b) Model Contract

c) Attached documents and References

3.2.1 Proposal Preparation Instruction

Proposal Preparation Instruction in RFP should include the following items:

- Objectives
- Table of Contents
- Due Date
- Number of copies
- Contacts
- Questions and Answers, etc.

3.2.2 Model Contract

Model Contract in RFP should include the following items according to the government procurement process:

- Subject,
- Scope
- Due date
- Terms and Conditions, etc.

3.2.3 Attached Documents and References

The following Documents and References should be asked to attach to the RFP:

- Statement of Work (SOW)
- Function/Performance Specification
- List of Applied Standards
- Work Breakdown Structure (WBS)
- Engineering Instructions
- Education and training requirements

Note: Education and training requirements, such as number of personnel, subjects, contents, duration and number of times, should be clearly defined in the RFP.

3.2.4 Applied Specifications or Standards

If a standard ready made system is proposed, mismatching of interface or difference of standard is very critical to connect with related systems. Or if assumed ATC service procedure is different, you should change the procedure. Ro prevent these difficulties, applied specifications or standards should be confirmed or coordinated with related ATS facilities or existing system vendors before submitting the RFP;

Examples:

a) The latest standards applied for ADS/CPDLC/AIDC (ex. RTCA DO-258)

b) Interface specification with related ATC facilities

c) ATC service procedures how to use ADS reports

d) Data-link Service Provider and its interface

3.3 EVALUATION OF PROPOSALS

3.3.1 Fairness and Traceability

Evaluation of proposal in Vendor Selection process shall be fair and traceable. Evaluation should be based on approved documents and documented records of evidences, such as RFP, Proposal and Cost Estimation, Selection Criteria and Record of Evaluation.

3.3.2 Evaluation Team

Evaluation Team shall include users (Controllers), engineers, managements, System Analysts and System Designers.

3.3.3 Evaluation Criteria

Evaluation Criteria for Vendor Selection shall be clearly defined by the evaluation team before starting the selection process based on the RFP.

3.3.4 Selection Process

Vendor Selection Process shall also be clearly defined by the evaluation team according to the government procurement regulations before start.

3.3.5 Negotiation with vendors

Negotiation with vendors on detail conditions may be done in case of need, such as minor change of specification, trade-offs of technical alternatives and cost reduction.

4 SUPERVISION AND INSPECTION

4.1 ORGANIZATION AND TIMETABLE

Supervision and Inspection Plan, including what, when, by whom and how to supervise, shall be negotiated with vendor first, and then documented and approved before start of deployment. Supervision and Inspection may be done by team work, if the system is large and complex. Supervisor(s) shall not be the same person(s) of Inspector(s) for fair achievements of each responsibility.

4.2 PROCEDURES AND CRITERION

Standards and criteria to be applied in Supervision and Inspection shall also be clearly defined in the Supervision Plan and approved before the start. Acceptance Test may be major part of Inspection. Confirmation of vendor test results and quality management records may be assumed as parts of inspection.

4.3 RECORDING AND CORRECTIVE ACTION

Results of Supervision activities shall be recorded and reported periodically. If the progress is not in time, the revised schedule and proper actions shall be negotiated. If the results don’t meet specified standards or criteria, the facts, possible reason and corrective actions to be taken shall be recorded and reported as soon as possible.

5 PREPARATION FOR OPERATION

Most of preparation works for ADS/CPDLC/AIDC service operation are user's role. The basic requirements shall be clearly specified in RFP, and details will be proposed by vendors. After Vendor Selection, user organization shall negotiate the details of preparations with the vendor and define the roles and responsibilities of both parties. Some of the preparations will take so long time and so many human resources of user organization that special workload consideration shall be planned.

5.1 STANDARDIZATION OF SERVICE AND SYSTEM OPERATION

5.1.1 Service Operation

ATS Service Operation Manual shall be prepared and educated to the key users before Total System Test, and be confirmed of its validity in the test. The Service Operation manual shall include exceptional and emergency procedures as follows:

a) Weather deviation;

b) Route change;

c) Lost communication;

d) Emergency descent;

e) Confliction; and

f) System familiar.

5.1.2 System Operation

System operation procedures should be clearly defined in operation manual which contains emergency procedures such as system failure and recovery. System Operation Manual shall be prepared and educated to the system operators before the Total System Test, and be confirmed of its validity in the test.

5.1.3 System Management

System management procedures should be clearly defined in management manual, maintenance guide, trouble reporting procedure and recording system. System Management Guide shall be prepared and educated to the system managers before the Total System Test, and be confirmed of its validity in the test.

5.1.4 Automatic Tools

Automatic system operation, monitoring and management tools are very effective, reliable and efficient, especially for communication subsystem.

5.2 EDUCATION AND TRAINING

5.2.1 Controllers Training

Controllers should be educated with good knowledge of functions, performance, limitations, operational and emergency procedures of the system before start of training. Controllers should be familiar enough through training with system operations and service procedures using the system before start of real operation.

5.2.2 Operators/Managers Training

Operators/Managers also need to be educated and trained before start of real operation. System Operators/Managers should have detail knowledge of configuration, functions, performance, limitations, operational and emergency procedures.

5.2.3 Operation Manual

Operators should be trained to work according to authorized operation manual which contains emergency procedures such as system failure and recovery. Managers also should be trained to work according to system operation manual, maintenance guide, trouble reporting procedure and recording system.

5.2.4 Education and Training Plan

Basic Education and Training requirements for service operation, system operation and management are specified in RFP, and details will be proposed by the vendors. User organization shall plan details of education and training, including target audience, time and duration, objectives, goal to achieve, course contents and materials. Training shall include real-time simulator based training, using real ATS service operation cases in targeted airspace environment with peak traffic.

5.2.5 Simulator based Training

Simulator based controller training is very effective and shall include possible exceptional and emergency cases such as overload traffic situation, weather deviation, route change, emergency descent, confliction and system failar.

5.3 TOTAL SYSTEM TEST AND REHEARSAL OF TRANSFER

5.3.1 Test Components

Total System Operation Test is the final and only one way to certify the system is proven in real ATS service operational environment in targeted airspace from controller to pilot. The test should be planned to confirm that the deployed ADS/CPDLC/AIDC system meets the ATS Service Operation Requirements by the user's point of view. The test should include the following tests:

a) Function Test

b) Performance Test (Including overload test)

c) Reliability Test

d) Failure and Recovery Test

e) Simulated Operation Test

5.3.2 Test Bench

Proven test bench for Simulated Operation Test of ADS/CPDLC would be available by commissioning to aircraft manufacturers.

5.3.3 Test Plan

The test plan shall be based on the assumption that every designed function was already tested and performance goal was confirmed by the vendor before the test.

5.3.4 Resources

The preparation and test itself will take a certain long time and need huge hours of human resources. User organization shall consider special assignment of controllers.

5.3.5 Evaluation Criteria

Evaluation criteria to GO/NOGO for several milestones shall be determined in the test plan. In case of NOGO, the system shall be returned to the vendor to fix or improve.

6 OPERATIONAL TRANSFER

6.1 PRINCIPLE OF TRANSFER

Operation transfer process from current ATS service operation to ADS/CPDLC/AIDC based service operation shall be planned carefully by safety first principle. In general, there are two typical transfer scenarios as follows:

a) Phased Approach

Start small and then extend coverage such as operation hours, functions and airspace.

b) Parallel Operation

Operate new ADS/CPDLC/AIDC system/subsystem with the current system or manual operation simultaneously. More human resources are needed for the redundant operation.

6.2 GO/NOGO CRITERIA

Evaluation criteria to GO/NOGO shall be clearly defined in advance. If the transfer is planned in step-by-step phased approach, GO/NOGO is decided at each milestone. In case of trouble, the service operation shall be resumed to current system or to the last successful step according to predefined contingency plan.

6.3 PREPARATION

Prior coordination in detail with related facilities, education and training of controllers and operators/managers, manuals preparation and transition rehearsals should be done before starting operation transition.

Prior rehearsal of operational transition to new system is mandate. Phases and steps of transition, data integrity, prerequisite knowledge and readiness of personnel should be confirmed in the rehearsal. Experience is the most important key for safe transition of mission-critical system such as ADS/CPDLC/AIDC.

6.4 CONTINGENCY

Initial troubles of new system are inevitable and to be overcome properly. Trouble tendency of a system looks like a bath tab, high at the beginning, low during middle and high again at the end. This is called as Bath Tab Model.

a) Parallel Services Operation

Parallel Service Operation is to maintain service operation with both old and new systems simultaneously. It needs extra service resources according to the duplicated operations in this case. In case of trouble in the new system, the service will be covered by the old proven system.

b) Phased Transition

Step-by-step functional expansion, operational hour expansion or operational sector expansion are also typical ways of sound transition. In case of troubles in the new phase or step, the service will be covered by going back to one step before.

6.5 TROUBLE ANALYSIS

If a disorder of the system is found, it is important to classify the reasons as production, programming error (bug), specification mismatch or insufficient requirement. Trouble recording and statistic analysis is an effective way to estimate the possible errors unfound. Do not ignore any small trouble or question.

6.6 PERFORMANCE ANALYSIS

ADS/CPDLC system shall have automatic Performance Data Collection and Performance Data Analysis function to monitor the system performance level. The required data format and algorithm of analysis shall be specified in RFP. The following statistics shall be reported to Central Reporting Agency monthly, and the first month report should be one of the most important GO/NOGO criteria;

Delay time for Round Trips

Delay time for Downlinks

Number of lost messages

Unavailability of systems

Connection success and failure

GUIDANCE MATERIAL FOR IMPLEMENTING ADS - CPDLC - AIDC SYSTEMS

1 INTRODUCTION

This material has been developed under an initiative of the Regional Airspace Safety Monitoring Advisory Group (RASMAG) of the Asia Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG) to assist ATS providers with the implementation of ADS/CPDLC/AIDC systems.

The material covers two main aspects of implementation: specification and deployment.

Technical systems must be well specified in both the technical and operational aspects, and at the right level of detail: enough to ensure that the requirements are met, but not so much as to shut out good solutions.

The deployment of a new system involves a number of vital steps, such as testing, training, integrating and commissioning.

This material offers guidance, rather than solutions, with the emphasis on specifying ADS/CPDLC/AIDC systems.

2 SCOPE

This material is intended to cover ADS, CPDLC and AIDC systems. It does not include other ATM automation systems such as flight data processing systems (FDPS) and flow management systems, though these may, of course, be integral with the ADS/CPDLC/AIDC system.

For brevity, the ADS/CPDLC/AIDC system will be simply referred to as “the System”, except where a full reference is necessary for clarity.

3 SPECIFICATION

The development of the specification should, wherever possible, be a team effort, with operational and technical personnel working together to achieve the optimum result. Specifications produced by technical personnel often concentrate on technical features at the expense of operational suitability, when the whole purpose of the system is to support operational activities!

In developing a specification for any technical system, it is important to achieve the right level of detail. Too little detail leaves the purchaser at the mercy of potential suppliers, while too much may preclude suppliers from offering very suitable equipment. In general, it is probably appropriate to specify requirements in great detail only where those requirements are essential to the operation, and otherwise to leave the supplier a reasonable amount of freedom. An off-the-shelf system can be expected to be less expensive than one that is custom-designed.

It is also important to get the specification right. Proposals will be priced on the specification, and any changes required later, particularly after the contract is signed, will be costly in terms of price and completion time.

This section on specification covers the system configuration, its interfaces with other systems, its functionality, human factors implications, system parameters and recording and data analysis tools.

3.1 CONFIGURATION

The system configuration depends upon the operational environment. In specifying the configuration, a number of issues must be considered:

- Is it to be a stand-alone ADS/CPDLC/AIDC system, part of an integrated system or interfaced with a separate ATM system?
- How many sectors are required?
- How many workstations are required per sector? If more than one, why?
- What contingency configuration is required?
  - Complete duplication of the system?
  - Main/standby computers and independent contingency workstation(s)?
  - Duplication of communications bearers? If so, which ones?
- Assuming the normal operational configuration is one workstation per sector, how many contingency workstations are required?

3.2 INTERFACES

The System must have a number of interfaces to send and receive data; some of these are essential, others may be useful or just nice to have. This section concentrates on the essential and the useful.

3.2.1 Communications Service Provider

In the current FANS 1/A environment, ADS and CPDLC messages are passed between aircraft and the System using the ACARS data messaging system. ACARS was developed by the communication service providers (CSP) to pass information between the airline operating centre (AOC) and the aircraft. ADS and CPDLC required an air-ground datalink and, in the absence of the Aeronautical Telecommunication Network (ATN), the ACARS system was used.

Access to the ACARS datalink is available only from the CSPs; ARINC and SITA are the major CSPs; they provide global coverage and complete management of the signal between the ATSU and the aircraft, including selection of most appropriate datalink path (VHF, satellite or HF). There are also some national or regional CSPs, such as AVICOM Japan.

It is essential therefore to specify the appropriate interface port(s) to connect to the chosen CSP. This is typically an RS232 serial port, but the exact requirement should be confirmed with the CSP.

3.2.2 ATN

It is intended that the ADS and CPDLC functions will eventually be carried by the ATN. The purpose of the ATN is to "provide data communication services and application entities in support of the delivery of air traffic services (ATS) to aircraft; the exchange of ATS information between ATS units; and other applications such as aeronautical operational control (AOC) and aeronautical administrative communication (AAC)." *[Annex 10, Vol III, 3.3]*

It is important, therefore, that any new system should either include provisions for, or have a defined upgrade path to provide, interfacing with the ATN.

ICAO Doc 9705 - Manual of Technical Provisions for the Aeronautical Telecommunication Network (ATN) is the appropriate source of interface data for the ATN.

At present, the ATN is under development and trials are being carried out in several ICAO Regions.

3.2.3 AFTN/AMHS

At present, the AFTN is the carrier for ground-ground messaging between ATC units and carries AIDC messages in the FANS 1/A environment. The AHMS (Aeronautical Message Handling System) is the ground-ground messaging application of the ATN. The AMHS is also referred to as the ATSMHS (ATS Message Handling System).

AIDC messages will be passed via the AFTN until the ATN is operational. However, AFTN/AMHS gateways will increasingly be used to provide a transition between the AFTN and ATN. These gateways transpose AFTN messages into AMHS format and vice versa.

Any new system should include at least one AFTN/AMHS gateway. AIDC messages generated in AMHS structure can then be transmitted via the AFTN and incoming messages from the AFTN will be transposed to AMHS structure. After the ATN becomes operational and the AFTN is no longer used, the gateway can be removed.

3.2.4 ATS systems

In many cases, interfaces to other ATS systems will be necessary. This may be because an ADS/CPDLC system will use the flight data or other processing capability of an another system or because the new system will be directly connected to another system.

3.2.4.1 Flight Data Processing System

Where an ADS/CPDLC system is to rely on an existing system to provide flight data, the interface required will depend on the data to be passed. The ADS/CPDLC system may have no flight data processing capability and merely require flight plan information for identification purposes, or it may have some capability to up-date flight plans received from the other system and return the up-dated information.

In either case, the interface may need to transform data formats between the 2 systems. It is therefore essential that the data formats used by the existing system are detailed in the specification so that they are allowed for in proposals; otherwise, costly contract variations may be required.

3.2.4.2 Radar Data Processing System

Data imported from a separate radar data processing system will take the form of track data or possibly plot data. As with interfaces for flight data, it is most important to detail the radar data formats in the specification.

If ADS data is to be exported to a separate radar data processing system or display system, the formats required by those systems also must be detailed.

3.2.4.3 Direct Connection between Systems

When a full system (with FDPS and perhaps RDPS as well as ADS/CPDLC/AIDC) is to be connected directly to an existing system for full data interchange, details of all the data formats of the existing system should be included in the specification.

3.2.5 Radar Data

If the System is to receive direct radar feeds from existing radars, the output data format of each radar must be detailed.

Most new systems are designed around the ASTERIX radar data formats; specifying ASTERIX where possible will allow the greatest flexibility for the future. Information on ASTERIX may be found at:
http://www.eurocontrol.int/asterix/public/subsite_homepage/homepage.html

The “Regional Supplement to the ASTERIX Interface Control Document (ICD) for the Asia/Pac Region” gives details of location-specific ASTERIX coding.

Inputs from military radars may be non-standard or require additional processing; any available details should be included.

3.2.6 Meteorological Data

Many modern systems make provision for the use of meteorological data for updating predicted waypoint times in near-real time. However, this type of prediction may require very large amounts of data and may not be justified if experience shows that weather variations have very little effect on the routes concerned or where the weather patterns are such that occasional manual input would suffice.

If there is a requirement for regular automatic data input, the available sources of data should be investigated and the appropriate formats should be specified.

3.3 CORE APPLICATIONS

This section covers the core applications of the system, ADS, CPDLC and AIDC, and their supporting functions, AFN and ACF.

3.3.1 ADS

ADS is a means of surveillance in which an aircraft reports its current position, intent and other pertinent information via the datalink function to an ATSU. ADS is detailed in ARINC 745-2.

The ADS reporting rate and the types of data to report are determined by ADS contract requests from an ATSU. An aircraft can report to up to four ATSUs simultaneously.

There are three types of ADS contract: the periodic contract, the event contract and the demand (“one-shot”) contract.

3.3.1.1 Periodic Contract

The ATSU sets up a periodic contract with the aircraft to obtain regular position reports; the contract specifies to the aircraft the reporting rate, any optional data groups be added to the basic ADS report, and the frequency at which the optional groups are to be included in the reports.

Only one periodic contract can be established between an ATSU end system and a particular aircraft at any one time. The periodic contract normally remains in effect until the contract is cancelled by the ATSU.

The system must be capable of pre-defining the reporting rate as a system parameter and of allowing the controller to change the rate, on a case by case basis, to meet operational requirements.

The system must also allow the controller to include any of the permissible additional data groups in a periodic contract request.

Some systems have the capability of automatically changing the reporting rate from one area to another; however, this could increase system cost and complexity.

3.3.1.2 Event Contract

An event contract specifies a request for reports whenever a defined ‘event’ occurs. Only one event contract can be established between a ground system and a particular aircraft at any one time; however, the event contract can contain multiple event types. There are four event types

- The Vertical Rate Change Event is triggered when the aircraft's vertical rate is either less than or greater than a parameter defined in the contract.
- The Lateral Deviation Change Event is triggered when the aircraft's actual position exceeds a lateral distance parameter from the aircraft's expected position on the active flight plan.
- The Altitude Range Change Event is triggered when the aircraft's altitude exceeds the altitude ceiling or floor defined in the contract by the ground system.

Once a vertical rate, lateral deviation or altitude range event trigger has occurred, a recurrence of this event no longer triggers an event report. If required, a new event contract must be initiated each time one of these specific events occurs.

- The Waypoint Change Event is triggered by a change to the next or the next-plus-one waypoints. Such a change normally occurs due to routine waypoint sequencing. However, it will also be triggered by occurrences such as a change to a non-ATS waypoint entered by the pilot for operational reasons, or execution of a new route affecting the next or next-plus-one waypoints. Unlike the other event contracts, the waypoint change event trigger remains in effect for all waypoint changes.

Once an event contract has been established, it remains in effect until the specific event requests are fulfilled, or it is cancelled by the ground system.

The system must be capable of pre-defining the event trigger parameters and of allowing the controller to change the event parameters as required.

3.3.1.3 Demand Contract

The demand contract is a "one-off" request from the ground system for an ADS report containing specific data as defined in the request. A demand contract can be requested by the ground system at any time. The demand contract request does not affect any existing contracts.

The system must allow the controller to initiate a demand contract, including optional data fields.

3.3.1.4 Emergency Mode

The emergency mode can only be activated by the pilot and is normally cancelled by the pilot. While it is possible for some ground systems to cancel the emergency mode status, most ground systems do not have this capability although some ground systems allow the controller to modify the "display" of the emergency mode status.

The system must recognise the emergency flag and display the emergency status to the controller.

3.3.2 CPDLC

CPDLC provides a two-way message system between controller and pilot. It comprises an number of pre-defined up-link and down-link messages, some of which are complete in themselves, while others require data (such as time flight level, etc) to be added. There are also two free-text messages available in each direction, one reserved for emergency use.

To send a message, the controller selects the required message and enters any required data. (Options for selecting messages and entering data are discussed below under Human-Machine Interface.) The system then automatically codes the message in bit-oriented format and presents it for transmission.

On reception of a down-link message, the CPDLC application decodes the message and presents it to the controller.

The current message set is detailed in the FOM, and the system must provide the complete up-link message set and be capable of accepting and decoding the complete down-link message set.

Some message sequences require "closure":

- A message requiring a response remains open until a referenced response is received.
- A message is closed when either a response is not technically required, or after a referenced response other than STANDBY or REQUEST DEFERRED has been received.

The system must manage message closure protocols in accordance with the requirements of the FOM.

3.3.3 ACF

ADS and CPDLC both operate on bit-oriented data, while ACARS is character-oriented. The ACARS Convergence Function converts the bit-oriented data of ADS and CPDLC to the character-oriented data used by ACARS, and *vice versa*.

If the system is to operate over ACARS, the ACF must be specified as an essential requirement.

(The ACF is not required where the ATN is the carrier.)

3.3.4 AFN

The AFN function provides the transfer of information required to support the initiation of datalink connectivity between an aircraft and an ATSU. The AFN is a character-oriented application.

Because it is essential to ADS and CPDLC operation over ACARS, the AFN function as detailed in ARINC 622-4 must be a requirement of the system specification.

3.3.5 AIDC

The AIDC application supports information exchanges for notification, coordination, and the transfer of communications and control functions between automated ATS systems located at different ATSUs.

The AIDC message set is defined in the Regional Interface Control Document (ICD) for ATS Interfacility Data Communications (AIDC). This message set was based on ICAO agreed methods and messages wherever possible; elsewhere, new messages used existing ICAO field definitions to the extent possible.

3.4 HUMAN MACHINE INTERFACE

3.4.1 Displays

One or more displays are required to handle the ADS, CPDLC and AIDC messages. Most systems now incorporate message handling into the situation display.

Modern displays use LCD technology and may be as large as 600 x 600mm, with typical resolution of 2048 x 2048 pixels. Smaller displays may be more appropriate for some uses, particularly if there are 2 displays at a controller position: a second display is often used for flight data handling. However, the arrangement of displays will largely depend on the extent to which the new system is to be integrated with existing systems.

While colour displays offer great advantages in differentiating between different categories of data, the choice of colours for the various categories can be very contentious. If colour displays have not been used before, it is strongly recommended that colour allocation is not arbitrarily decided, but is based upon the experience of other users. Controllers at units with colour displays will be able to provide useful information on colour choices. “Ownership” is an important reason why engineers should not specify colours!

Symbols for ADS tracks should differ from radar track symbols: there should probably be separate symbols for ADS only tracks and for ADS + radar tracks. Using track symbols to indicate CPDLC status will probably lead to a confusing number of symbols; CPDLC status is best included in the track label.

3.4.2 Information Processing

Specific – menus, message sets,

The language for all menus and message sets should be English: English is the *de facto* language for radiotelephony within the Asia-Pacific Region. While it may seem attractive for menus and CPDLC messages to be displayed in a local language, this will inevitably lead to loss of English language proficiency and so will work against the new ICAO language proficiency provisions in Annexes 1, 6, 10 and 11. These require that from March 2008, pilots, aeronautical station (radio) operators and air traffic controllers shall demonstrate the ability to speak and understand the language used for radiotelephony communications to specified levels.

3.4.3 Input Devices

The controller input devices include the text input device and the pointing device.

The text input device is normally a keyboard and there are various types of keyboard (standard, ergonomic, etc). The type should be specified if it is considered important; however, it is worth noting that controllers do not have to input large amounts of text in an ADS/CPDLC system. Touch panels may be offered instead of keyboards.

The mouse is the most common and probably most flexible pointing device; others include the track-ball and the light pen. It is difficult to locate a track-ball and keyboard so that they are well-placed for both left- and right-handed people, and light pens have been poorly received by many controllers.

Wireless connections for the input devices will reduce the clutter on the workstation working surface and allow more freedom of movement for the pointing devices. However, electro-magnetic compatibility with nearby equipment must be carefully considered.

3.5 CONTROLLER TOOLS

Controller tools include such items as

3.6 CAPACITY

Don't over-specify capacity, but allow for growth. At 10% per annum, traffic will double in 7.5 years. Typical life of a system is 5-7 years.

But allow for traffic peaks (daily, seasonal).

3.7 PARAMETERS

3.8 RECORDING AND DATA ANALYSIS

The system should record all incoming and outgoing ADS, CPDLC and AIDC messages for use in incident and accident investigations. It is imperative that all recordings are time-stamped. Messages are typically recorded onto a tape cartridge or DVD, and the system should allow change-over of the cartridge or DVD with no interruption to the recording.

In accordance with the FANS Operations Manual, data message recordings should be retained for at least 15, and preferably 30, days for accident/incident investigation purposes, and should allow replaying of the situation and identification of messages were sent or received by the system .

Provision should also be made for recording data for use by the agencies monitoring RNP, RVSM and datalink performance. These are the Safety Reporting Agency (SMA), the Regional Monitoring Agency (RMA) and the Central Monitoring Agency (CRA) respectively. Generally, the data required by RMAs and SMAs is captured by the FDPS.

To meet CRA requirements, the specification should include a requirement for datalink performance monitoring tools and analysis software. The analysis software should, at the least, be capable of extracting time-stamps, addressees and message types from all incoming and outgoing messages.

The table below shows the datalink monitoring requirements for ATS providers taken from the “Guidance Material for End-to-End Safety and Performance Monitoring of ATS Datalink Systems in the Asia Pacific Region”.

3.8.1 Local Data Collection

Requirements	Who/What
Operational Procedures	Time stamped ATS messages with identification and reference numbers
	Message Assurance
	Anomaly event report
Performance	Availability
	Transit times
Safety (i.e. operational, performance, interoperability requirements which are used to mitigate the effect of a failure condition)	Time stamped ATS messages with identification and reference numbers/MAS
	Anomaly event reports
Interoperability	Time stamped ATS messages with identification and reference numbers/MAS

4 DEPLOYMENT

Deployment of the new system includes the acceptance testing, controller and technician training and, finally, commissioning the new system into service. It is essential that these phases are carefully planned, particularly with regard to staffing.

During the various phases of the deployment, staff will need to be taken away from their normal duties for training and acceptance testing and, during the commissioning phase, for parallel operations. This will place a heavy demand on resources, and may necessitate hiring controllers or technicians (or both) on a short-term basis to operate the existing system while permanent staff carry out these project duties. It is imperative that permanent staff are used for project duties, as they will provide the core of experience for the future. If temporary staff are required, the recruitment planning should include training time for them to become familiar with the existing system.

4.1 ACCEPTANCE TESTING

New systems normally undergo acceptance testing both at the factory and after installation on site; it is generally the responsibility of the supplier to bear the cost of correction of problems identified during these tests.

The factory acceptance test (FAT) provides the opportunity to identify any problems before the system is shipped while the supplier has all its resources available. The site acceptance test (SAT) is the last opportunity to identify problems before the system is accepted. It is not always practical to fix every problem before acceptance, and the acceptance documents will normally contain a schedule of outstanding issues to be addressed by the supplier.

The supplier will normally provide a test schedule well in advance of the test, and this should cover all the operational functions and technical requirements. However, this should not prevent the purchaser’s staff from adding extra tests either before or during the FAT or SAT.

Both FAT and SAT should be carried out by personnel familiar with the system specification, and it is most important that both operational and technical staff are actively involved. These personnel must be carefully selected: they will inevitably become the core group of specialists because of the good practical knowledge of the system gained during the testing process.

Any problems identified or unexpected results obtained during testing should be recorded in detail, reported at once to the supplier’s staff and tests repeated to confirm the problem and the steps leading to it.

4.2 TRAINING

The supplier will carry out the initial training, and training staff should be included in the earliest courses, which should be completed before the FAT. Technical training will normally be good, because the supplier's engineers have designed the system. For controller training, while the supplier's staff can explain and demonstrate the functions, they may not understand how each function is used operationally. The supplier's course would thus provide the basis for the purchaser's training staff to develop an operational training programme.

4.2.1 Operational Training

Controllers must, of course, know how to operate all the functions available to them. They should also be given an appreciation of the basic processes of the system and its interfaces. As noted above, it is most unlikely that the supplier will be able to provide full operational training, which requires detailed knowledge of the specific operational environment.

4.2.2 Technical Training

Technical training must, of course, encompass the technical details of the system and the normal operating and maintenance processes. However, for a computer-based system, it is essential that the training covers system changeover and recovery procedures: computer crashes are almost inevitable and staff must know how to bring the system back into operation quickly and safely. They must also be properly trained in system back-ups, parameter changes, loading new software and software fixes, and in dumping system data for fault tracing.

4.3 COMMISSIONING

APPENDIX A GLOSSARY

ACARS	Aircraft Communications Addressing and Reporting System
ACAS	Aircraft Collision Avoidance System (ICAO
ADS	Automatic Dependent Surveillance
AEEC	Airline Electronic Engineering Committee
AFN	ATS Facilities Notification
AFTN	Aeronautical Fixed Telecommunication Network
AIDC	ATC Inter-Facility Data Communications
AIP	Aeronautical Information Publication
AMHS	Aeronautical Message Handling System
AOC	Airline Operational Communications
APANPIRG	Asia/Pacific Air Navigation Planning and Implementation Regional Group
ARINC	Aeronautical Radio Incorporated
ATC	Air Traffic Control
ATM	Air Traffic Management
ATN	Aeronautical Telecommunication Network
ATS	Air Traffic Services
ATSMHS	ATS Message Handling System
ATSU	ATS unit
AVICOM	AVICOM Japan Co. LTD
CAA	Civil Aviation Authority
CNS	Communications, Navigation, Surveillance
CPDLC	Controller Pilot Data Link Communications
CRA	Central Reporting Agency (for datalink)
CRC	Cyclic Redundancy Check
DL	Downlink message
EUROCAE	European Organisation for Civil Aviation Equipment
FANS	Future Air Navigation System
FIR	Flight Information Region
FIT	FANS Interoperability Team (IPACG, ISPACG) FANS Implementation Team (FIT-BOB, FIT-SEA)
FMC	Flight Management Computer
FMS	Flight Management System
GES	Ground Earth Station (satellite)
GPS	Global Positioning System (USA)
HF	High Frequency (3-30 MHz)
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
IFATCA	International Federation of Air Traffic Controllers Associations
IFALPA	International Federation of Air Line Pilots' Associations
IPACG	Informal Pacific ATC Coordinating Group
ISPACG	Informal South Pacific ATS Coordinating Group
MAS	Message Assurance (data message)
MCDU	Multipurpose Control Display Unit (ACARS & FMC)
MU	Management Unit (ACARS)
NDA	Next Data Authority
NOTAM	Notice To AirMen

RASMAG	Regional Airspace Safety Monitoring Advisory Group
RMA	Regional Monitoring Agency (for RVSM)
RNP	Required Navigation Performance
RTCA	RTCA Inc.
RVSM	Reduced Vertical Separation Minima
SATCOM	Satellite Communication
SATVOICE	Satellite Voice Communication
SITA	Société Internationale de Télécommunications Aéronautiques
SMA	Safety Monitoring Agency (for RNP)
SR&O	System Requirements and Objectives (FANS-1 document)
TCAS	Traffic Alert and Collision Avoidance System (USA)
TMU	Traffic Management Unit
UL	Uplink message
VHF	Very High Frequency (30-300 MHz)

APPENDIX B REFERENCES

Annex 10, Volume III, Communication Systems		ICAO
Manual of Technical Provisions for the Aeronautical Telecommunication Network (ATN)	Doc 9750	ICAO
Basic Air Navigation Plan – Asia and Pacific Regions	Doc 9673	ICAO
Asia/Pacific Regional Plan for the new CNS/ATM Systems		ICAO Asia Pacific Office
FANS 1/A Operations Manual		
Interoperability Requirements for ATS Applications using ARINC 622 Data Communications	DO-258 / ED-100	RTCA and EUROCAE
Minimum Operational Performance Standards for ATC Two-Way Data Link Communications	DO-219	RTCA
Air-Ground Character-Oriented Protocol Specification	618-5	ARINC
Data Link Ground Systems Standard and Interface Specification (DGSS/IS)	620-5	ARINC
ATS Data Link Applications Over ACARS Air-Ground Network	622-4	ARINC
Aircraft Communications Addressing Reporting System (ACARS)	724B-5	ARINC
Regional Supplement to the ASTERIX Interface Control Document (ICD) for the Asia/Pac Region		ICAO Asia Pacific Office
Asia/Pacific Regional Interface Control Document (ICD) for ATS Interfacility Data Communications (AIDC)		ICAO Asia Pacific Office
Guidance Material for End-to-End Safety and Performance Monitoring of ATS Datalink Systems in the Asia Pacific Region		ICAO Asia Pacific Office

APPENDIX C PERFORMANCE CRITERIA

Criteria	Definition	Values
Performance	End to end round trip time for uplinks. (from sending of the uplink until reception of the MAS)	Round trip time of 2 minutes, 95% of the messages. Round trip time of 6 minutes, 99% of the messages.
	End to end one way time for downlinks. (comparison of message time stamp and receipt time)	One way time of 1 minute, 95% of the messages. One way time of 3 minutes, 99% of the messages
	Uplink messages only: Undelivered messages will be determined by: • Message assurance failure is received. After trying both VHF and SATCOM. Depending on reason code received, the message might, in fact, have made it to the aircraft. • No message assurance or flight crew response is received by ATSU after 900 seconds	Less than 1% of all attempted messages undelivered
Availability	The ability of the network data link service to perform a required function under given conditions at a given time: The maximum allowed time of continuous unavailability or downtime should be declared (MTTR) ∗	99.9% TBD
Reliability	The ability of a data link application/system to perform a required function under given conditions for a given time interval: it can be expressed in MTBF (Mean Time Between Failure) *	TBD
Integrity	The probability of an undetected failure, event or occurrence within a given time interval.	10^{-6}/hour

∗ Availability = MTBF x 100/(MTBF+MTTR)

Note: RTCA SC189/EUROCAE WG 53 is defining the performance requirements for specific operational environments.

Recommended Requirements for Integrated Data-link Systems

1. General Requirements

1.1 General

1.1.1 Integrated ATS data-link systems (hereinafter refer to 'ATS data-link systems') shall have the capabilities of AFN, ADS, CPDLC, AIDC.

1.1.2 ATS data-link systems should be integrated with other automated systems. FDP system provides the flight plan data of aircraft, such as registration number, flight identification, flight path. In return, ATS data-link systems feed back the current aircraft positions to FDP system to update the flight data.

1.1.3 ATS data-link systems should be linked with a data-link communication service provider.

1.1.4 ATS data-link systems shall be capable of transmitting and receiving AFN, ADS, CPDLC and AIDC messages complying with Doc 9694.

1.1.5 ATS data-link systems shall be capable of ACARS Convergence Function (ACF) to convert the messages of character-oriented data to/from bit-oriented data on ADS and CPDLC.

1.1.6 ATS data-link systems should provide air traffic controllers with:

a. presentation of message exchanges on ATC screen
b. updated aircraft positions coincident with the maps on ATC screen
c. tools for measuring separation in distance
d. information on aircraft flight status
e. HMI tools for making messages
f. conflict probe, and resolution capability if available
g. (electronic) flight progress strips if required
h. presentation of emergency status for both air and ground
i. other pertinent information to ATC operations

1.1.7 ADS/CPDLC system capacity should be determined taking the airspace characteristics into consideration, including such factors as:

a. operational policy and procedures planned to be applied
b. traffic density at the peak hours
c. airspace size
d. number of FANS capable aircraft operating in the airspace
e. growth of FANS operation in future

1.1.8 ATS data-link systems shall be capable of cyclic redundancy check (CRC) on each downlink message.

1.1.9 ATS data-link systems shall be capable of format and various validity checks appropriate to the message.

1.1.10 Notification of Error Message
Controllers should be notified when ATS data-link systems detected;
a. message error
b. message sequence error
c. duplicate message identification number

1.2 Time Stamps and Timers

1.2.1 AFN Logon, CPDLC and AIDC messages are time-stamped, however the forms of timestamp are actually set differently from specified in Doc 9694. For example, time used in ADS report consists of minute/second/ millisecond instead of hour/minute/second specified in Doc 9694.

1.2.2 By setting/deactivating various timer values for receiving messages responded to transmitted messages, the ATS data-link systems should monitor that aircraft responses arrive within a specified time limit.

1.2.3 Timers are prepared differently depending on the operational requirements of each ATSU. However, the timers for sending messages relating automatic transfer of connection or air traffic service shall be set according to the letter of agreement between both ATSUs.

1.2.4 A timer file should be prepared in ATS data-link systems for;
a. timeout settings for delayed response
b. timing to initiate actions in ADS/CPDLC operations for;
-1- connection request (CR)
-2- ADS Periodic, event and demand requests
-3- automated transfer of connection to the next ATSU
* sending NDA (Next Data Authority) message
* sending FN_CAD (AFN Contact Advisory): at least 30 minutes prior to FIR boundary message
* sending End Service message before the aircraft crossing FIR boundary (e.g. 5 minutes before)
c. timer to trigger actions for sending AIDC messages

d. timer for re-transmission of the message when no response received within a specified time
e. detection of overdue aircraft, and
f. detection of potential conflicting status of traffic

1.3 Industry Standards

The industry standards for data-link function are described in ARINC 622 (end-to-end) and RTCA DO-258 (Interoperability requirements), ARINC 620 (ground-to-ground), ARINC 619 (airborne), ARINC 429 (DITS), ARINC 758 (ACARS CMU).

a. ARINC 622: Supplement 1 and 2, ATS Data-link Applications over ACARS Air-Ground Network
b. RTCA DO-258: Interoperability Requirements for ATS Applications Using ARNC 622 Data Communications
c. ARINC 620: Supplement 1, Data-link Ground System Standard and Interface Specification
d. ARINC 619: Supplement 1, ACARS Protocols for Avionics End Systems
e. ARINC 429: Supplement 13, Mark 33 Digital Information Transfer System
f. ARINC 745: Supplement 2, Automatic Dependent Surveillance
g. ARINC 753: Supplement 2, HF Data-link Protocols

1.4 Data Recordings

The contents and timestamps of all messages shall be recorded at ATSUs. The facility shall be available to retrieve, display and printout the recorded data.

Note 1: The Processes for Uplink Messages by CSP System

-1- An ATS data-link systems sends a message to a CSP.

-2- The CSP sends message, ACK, to ATSU. [The CSP returns the message with reason if the uplink cannot be formatted].

-3- The CSP breaks the message into 'blocks' if necessary, then uplink these blocks to Airborne Communication Management function (CMU).

Messages greater than 220 characters are termed 'mult-block' messages, which are divided into 'blocks' not greater than 220 characters in size. Generally, the size of ADS messages is greater than others.

-4- The CMU sends 'ACK's to the CSP for each block received. When failed, it sends 'NAK'.

-5- The CMU re-assembles the blocks if the message is a multi-block message, then sends LDU to the aircraft. If the uplink was undeliverable, it sends a reject message to the CSP.

-6- The airborne application system sends the link layer ACK to the CMU, if the airborne application system sends 'NAK' if the CRC fails or if the message is greater than 2 LDUs,

-7- The CSP sends 'MAS' to the ATSU after all blocks are ACK'd by the CMU. The CSP returns the NAK message to ATSU with reason if uplink was undeliverable.

Note 2: Process for Downlink Message by ATS Data-link Systems

-1- An airborne application system breaks the message into LDUs if necessary, then sends LDU to the CMU.

-2- The CMU sends link layer 'ACK' to the airborne application system. It sends 'NAK' if the CRC fails.

-3- The CMU combines LDUs if necessary, divides the message into blocks, then sends these block(s) to the CSP. It continues to send the message until CSP responds.

-4- The CSP sends 'ACK' to the aircraft. The CSP sends 'NAK' or no response if block check sequence (BCS) fails.

-5- The CMU sends the network ACK to the airborne application system when ACK for last block received.

-6- The CSP sends the message to the ATS data-link systems.

-7- ATS data-link systems sends 'ACK' to the CSP.

CMU may retry a message if NO ACK timer expires. The timer is programmed differently, depending on VHF or SATCOM, and depending on CSPs.

2. DLIC (Data-link Initiation Capability)

2.1 AFN Logon fuctions

2.1.1 AFN logon functions provide the necessary information to enable ADS and CPDLC communications between ATS data-link systems and aircraft avionics systems with the following functions:

a. Logon
b. Update
c. Contact
d. Logon information forwarding to the next ATSU

Note: DLIC(Data-link Initiation Capability) functional capabilities are prepared in Part 2 (Data-link initiation capability) of Doc 9694.

2.1.2 Capacity for AFN logons should be determined with the operational requirements, such as estimated number of FANS aircraft at the peak hours and future growth of FANS aircraft.

2.1.3 ATS data-link systems shall have the capability of responding messages of accepting or rejecting the AFN logon request made by aircraft.

2.1.4 ATS data-link systems should be linked with FDP and enable to correlate the AFN logon data automatically with the flight plan of the aircraft.

2.1.5 The capability of displaying or presenting the following data should be prepared for controller's workstation.

a. address and version number of the aircraft, if required
b. response from the aircraft with timestamp
c. status of correlation of the aircraft with its stored flight plan
d. indication of 'Acceptance' or 'Rejection' to the logon request from aircraft

2.1.6 The capability for sending following information to aircraft should be prepared by ATS data-link systems;

a. name, address and version number
b. applications supported by the system
c. message of 'Acceptance' or Rejection' with reason when rejected.

2.2 Use of AIDC for Forwarding AFN Message

ATS data-link systems is required of sending FANS application message (FAN) to the next ATSU that is capable of ADS/CPDLC and AIDC according to the Asia/Pacific regional Interface Control Document (ICD).

3 CPDLC

3.1 General

3.1.1 Capacity of the CPDLC function should be determined taking account the operational policy and procedures and airspace characteristics, such as the number of FANS capable aircraft, airspace size and number of ATC waypoint, necessary communications in ATS operations, and estimation of future growth of FANS operation.

3.1.2 ATS data-link systems should be capable of processing the specified number of message exchange with each of the aircraft.

3.1.3 ATS data-link systems shall have the capability of ACARS Convergence Function (ACF) to convert the bit-oriented data of CPDLC messages to the character-oriented data, and vice versa.

3.1.4 Down-linked CPDLC messages shall be provided for controllers by displaying them on the ATC screen with HMI consideration.

3.1.5 HMI (Human Machine Interface) tools to make uplink messages should be developed for controllers with using the message set prepared in Appendix A to Chapter 3 of Manual of ATS Data-link Applications (Doc 9694) and FANS 1/A Operations Manual.

Note: Size of free text field is limited to 80 characters instead of 256 for a specific type of aircraft.

3.1.6 CPDLC position reports are recommended to be processed automatically for updating the aircraft positions on ATC screens with map, if no ADS report was available.

3.1.7 ATS data-link systems shall have the capability of terminating CPDLC connection with the aircraft.

3.2 CPDLC Requirements

3.2.1 ATS data-link systems should allow exchanging messages in the manner prescribed in ICAO Doc 9694 and FANS 1/A Operations Manual.

3.2.2 Next Data Authority Notification (NDA)

3.2.2.1 NDA should be designated by ATS data-link systems.

3.2.2.2 NDA link should be established with the aircraft by ATS data-link systems.

3.2.2.3 Transfer of CPDLC in relation to the transfer of voice communication should be available.

3.2.3 Transfer of CPDLC between ATC Sectors

ATS data-link systems should allow transfer of CPDLC between sectors of an ATSU without changing the data authority with same CPDLC link.

3.2.4 CPDLC Message Exchange Requirements

3.2.4.1 ATS data-link systems shall be capable of handling the message set and standardized free text messages defined in the FOM, and free text as well.

3.2.4.2 ATS data-link systems should allow controllers to review the uplink messages prior to sending.

3.2.5 Message Handling Order

3.2.5.1 Messages should be handled in order of priority.

3.2.5.2 Messages with the same priority should be processed in the time order of receipt.

3.2.5.3 Unsuccessful receipt of the required response in the specified time nor MAS should be informed to the controller.

3.2.6 Responses

3.2.6.1 ATS data-link systems shall allow controllers to send any response messages linking with the reference number of the message received.

3.2.6.2 Relationship between the message and its intent and response requirement is defined in the FOM.

3.2.6.3 With the closure response message, the dialog is closed and the ATS data-link systems shall reject any further attempt to send a response message.

3.2.7 Message Closure

3.2.7.1 CPDLC dialogue should not be closed until an appropriate closure response for that message with same reference number is received.

3.2.7.2 The capability of closing a CPDLC message, independent of CPDLC closure message receipt, should be prepared.

4. ADS

4.1 General

4.1.1 Capacity of the ADS function should be determined taking account the operational policy and procedures and airspace characteristics, such as number of FANS capable aircraft, periodic reporting rate, airspace size, waypoint event report frequency if applicable, usage of event and demand contract, and possible increase of FANS aircraft in the future.

4.1.2 ATS data-link systems shall have the capability of ACARS Convergence Function (ACF) to convert the bit-oriented data of received ADS reports to the character-oriented data, and vice versa for uplink request messages.

4.1.3 ATS data-link systems shall be capable of initiating the periodic, event and demand contract.

4.1.4 ATS data-link systems should be able to support a demand, an event and a periodic contract simultaneously with each aircraft.

4.1.5 ATS data-link systems should apply cyclic redundancy check (CRC) to each ADS message.

4.1.6 ATS data-link systems should apply the validation check on incoming data in relation to time, altitude, direction and geographical point which consist of the basic and fix intent data referring flight data of the aircraft.

4.1.7 ATS data-link systems should be capable of processing ADS reports to display the aircraft positions, tracks and altitude on ATC screen. The aircraft positions should be updated by calculating with ADS data and displayed automatically on ATC screen every specified interval (e.g. one minute).

4.1.8 Air and earth data of ADS reports are requested if necessary, and are provided for controllers if required.

4.1.9 The quality of ATC operation depends on the functionality, capability and performance of ADS data processing and display functions prepared for controllers, such as (3.2, Doc 9689):

a. basic update rate
b. display accuracy
c. ADS contract parameters
d. sensor accuracy
e. system reliability, and

f. end-to-end-communications time capabilities (e.g. trip time of a message)

4.2 Periodic Contract

4.2.1 Only one periodic contract can be established with a particular aircraft at any one time.

4.2.2 ATS data-link systems shall be capable of initiating a periodic contract to specify the responding rate, to request that the operational data groups be added to the basic report, and to specify the frequency at which the operational groups are to be included.

4.2.3 ATSU should limit the reporting rate to not more frequency than 5 minutes. (Appendix 1, Doc 9689)

4.2.4 ATS data-link systems should make a periodic contract remain in effect until the contract is cancelled by the ATSU, the flight crew turns off, or the flight completed.

4.2.5 Periodic reporting rate is specified in accordance with the separation standards being applied (Doc 9689).

Note: For example, with RNP10 for 50NM longitudinal separation using ADS-based surveillance, the maximum reporting period requires 27 minutes when calculated with the collision risk model.
With RNP 4, the maximum reporting period for 30NM longitudinal separation requires 14 minutes, and 50NM separation requires 32 minutes. (4.2 Appendix 1, Doc 9689)

4.3 Event Contract

4.3.1 ATS data-link systems should be capable of event contracts specifying the request for report whenever a defined ‘event’ occurs.

4.3.2 Only one event contract can be established with a particular aircraft at any one time. However, an event contract can contain multiple event types.

4.3.3 Vertical Event Contract

ATS data-link systems should be capable of triggering an event contract, when the aircraft’s vertical rate is either less than or greater than a parameter defined in the contract (feet per minute)

4.3.4 Lateral deviation Change Event

ATS data-link systems should be capable of triggering an event contract when the aircaft's actual position exceeds a lateral distance parameter from the planed route (nautical mile).

4.3.5 Altitude Range Change Event

ATS data-link systems should be capable of triggering an event contract when the aircraft's altitude exceeds the altitude ceiling or floor defined in the contract by ATS data-link systems (feet).

4.3.6 Waypoint Change Event

ATS data-link systems should be capable of triggering an event contract for changing the next or the next-plus-one waypoints.

4.3.7 Change of Reporting Frequency When Event Occurs

Reporting intervals could be changed by shortening periodic report rate, if necessary, when an event occurred. (e.g. 5 min.)

4.4 Demand Contract

Demand contract is a 'one-off' request from ATS data-link systems and can be requested at any time. Demand contract request will not affect any existing contracts.

Note: Use of Demand Contract (Example)

If a periodic position report is not received within a specified time (e.g. 3 minutes) it is due, a one-off ADS demand contract will be initiated by the ATSU manually or automatically.

If ADS surveillance cannot be re-established within further period of time (e.g. 5 minutes), the ATSU must commence immediate action to establish some alternative form of separation (2.1, Appendix 5, Doc 9689).

4.5 Message Handling

4.5.1 ADS messages should be processed by ATS data-link systems in the following order:

a. ADS emergency mode
b. demand/event reports
c. periodic report

4.5.2 Messages should be handled in the order received, when message is queued in each categories of the above, 4.5.1.

4.5.3 Notification of errors to controllers

a. message validation error
b. message sequence error detected with time stamp
c. time-out of ADS report in response to request
d. periodic and waypoint report failure

5 AIDC

5.1 General

5.1.1 The general descriptions on AIDC applications, requirements, functional capabilities, and message contents are provided in Manual of ATS Data-link Applications (Doc 9694) and Asia/Pacific ICD.

5.1.2 AIDC application exchanges ATC information between ATSUs in support of ATC functions.

5.1.3 AIDC application requires:

a. that messages are generated and sent in the time-ordered sequence; and
b. that messages are delivered in the order they are sent.

5.1.3 When an ATSU queues received messages, messages with the highest urgency type will be placed at the beginning of the queue. Messages will be assigned one of the following attributes:

a. normal
b. urgent, or
c. distress

5.1.5 The time used in AIDC application should be accurate to within 1 second of UTC.

5.1.6 A timestamp should be the time when the message is dispatched and should consist of the date (YYMMDD) and time (HHMMSS).

5.1.7 Every AIDC message should contain a reference to a previously sent message. This reference shall contain the ID of the referenced message.

5.2 Asia/Pacific Interface Control Document (ICD)

5.2.1 The Asia Pacific Regional Interface Control Document for AIDC provides the standardized procedures for the interfacility message exchanges.

5.2.2 The purpose of Asia/Pacific Regional Interface Control Document (ICD) for AIDC is to ensure that the interfacility message exchanges between ATSUs equipped with automated ATS systems in the Asia/Pacific Region is harmonized to a common based standard.

5.2.3 Until ATN becomes available, the engineering details needed to implement the exchange of messages in Appendix A of Asia/Pacific ICD will need to be agreed to bilaterally.

5.3 Message Header

5.3.1 Every message shall contain an AFTN header. AFTN IA-5 message header including the use of the Optional Data Field defined in Annex10 will be employed for the exchange of data. AFTN priority indicator FF shall normally be used for all data exchanges.

5.3.2 A message header consists of the *optional data field (ODF)*, *addressing, message/data identification number, reference information, time stamp,* and *cyclic redundancy check (CRC)*.

5.4 Timers

In order to guarantee the uniqueness of the message identification number, and yet allow for the efficient reuse of the numbers in the pool, two (2) timers are required for each message unit requiring confirmation: accountability and reuse.

a. *Accountability Timer* determines the maximum period of time for the responding application to confirm receipt of a given message unit.
b. *Reuse Timer* function employs two (2) timers that determine the minimum period of time.

Reuse timer A shall be set for exchanges not involving dialogues between processors. The range shall be from 1 to 30 minutes, in one minute increments. The default value shall be 5 minutes or as agreed by the concerned administrations.

Reuse timer B shall set for exchanges where a dialogue is involved in the exchange. The range for timer shall be 2 to 90 minutes, in one minute increments. The default value shall be 10 minutes or as agreed by the concerned administrations.

In the event of system failure, the accountability and reuse timers should be reset and resume timing upon completion of system recovery.

5.5 ATS Coordination Messages

AIDC provides the means by which data is exchanged between and within ATSU, during the *notification* of flights approaching FIR boundary, *coordination* of boundary crossing conditions, *transfer* of ATC services. AIDC also exchanges the information of *emergency*, *track definition*, as well as the information on *application management* and *surveillance data transfer.*

5.6 Detailed Information Provided in ICD

The following appendixes for Asia/Pacific ICD describe the details.

a. ATS coordination messages (Appendix A)
b. Error codes (Appendix B)
c. ATM application naming conventions (Appendix C)
d. Implementation Guidance Material – IGM (Appendix D) and
e. Relationship to ICAO AIDC messages (Appendix E)

5.7 Performance requirements

5.7.1 The performance requirements for the trip time of messages need to be specified and agreed to by neighboring ATSU to ensure effective use of AIDC. Recommended performance figures are specified in Appendix D of ICD. (ICD 3.3)

5.7.2 The methodology for monitoring AIDC performance is prepared in the Appendix A of the Guidance Material for End-to-End Safety and Performance Monitoring of ATS Data-link Systems in the Asia/Pacific Region.

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