AERONAUTICAL TELECOMMUNICATIONS NETWORK PANEL

WORKING GROUP 3 MEETING

Munich, 24-28 June 1996

Agenda Item 6: Air-Ground Applications SARPs

PROPOSED ATNP/2 WP -

'OVERVIEW OF CPDLC APPLICATION SARPS AND GUIDANCE MATERIAL'

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SUMMARY

This paper briefly outlines the development of the CPDLC SARPs since ATNP/1. It recommends that the attached SARPs be baselined as Version N.0

1. INTRODUCTION

1.1 The concept of using data link as a major medium for ATS communications arose from the deliberations of the two phases of the ICAO Special Committee for Future Air Navigation Systems which met between 1985 and 1992. Controller Pilot Data Link Communications (CPDLC) is one of the four early applications of an air/ground Air Traffic Management (ATM) data link system envisaged by the Automatic Dependent Surveillance Panel (ADSP), the others being Context Management (CM), Automatic Dependent Surveillance (ADS) itself, and Flight Information Services (FIS).

1.2 The ADSP is one of the ICAO operational Panels. It is charged with developing Operational Requirements for ATM data link applications, both air/ground and ground/ground, but it is not required to develop the necessary technical Standards and Recommended Practices (SARPS) - this responsibility has been delegated by ICAO to the Aeronautical Telecommunications Network Panel (ATNP), in some instances using material developed earlier by the Secondary Radar and Collision Avoidance Systems Panel (SICASP).

1.3 The ATNP established a number of Working Groups, of which Working Group 3 was responsible for developing, inter alia, SARPS and Guidance Material (GM) for the four air/ground applications noted in paragraph 1.1 above. WG 3 convened a Subgroup specifically for the purpose of developing SARPS material for the four air/ground applications, taking into account a limited set of the funtionalities identified by the ADSP, constrained by the need to achieve early implementation of the applications by 1998, this timescale being established by the requirements of the Industry.

1.4 The proposed CPDLC Standards and Recommended Practices are attached at Appendix A to this paper.

2. OPERATIONAL CONCEPT

2.1 In an ATS data link environment, CPDLC is expected to be used as the main means of communication of routine messages between a controller and the aircraft he/she is controlling. It is essentially a one-to-one link, with no broadcast facility, and only one controller exercising control over an aircraft at any one time. There are very limited facilities to allow an aircraft to contact another control authority for the purposes of obtaining specific information for a future part of the flight, but the general concept is one on one.

2.2 CPDLC will take over from voice communications for the great majority of controller pilot dialogues, and to this end a set of standard messages has been developed, covering the whole spectrum of normal operating procedures. These messages, their format and intent, are based on the relevant ICAO documentation, in particular Doc 4444, Procedures for Air Navigation and Rules of the Air (PANS/RAC). The format and content of the messages includes new message elements developed by the ADSP on the basis of operational experience, and specific messages related to the data link technology.

2.3 The use of data link is not as flexible as voice, and a set of rules has had to be developed indicating, for example, how a dialogue is opened and closed, how a particular sequence of messages within a dialogue is ended, and what are permitted replies to requests, clearances, information etc. However, the intention is that this should be as automatic as possible, with an apparently seamless line of communication between end users. The extent of the automation will ultimately be the responsibility of the system designers, both from the engineering and operational aspects.

3. DEVELOPMENT OF THE CPDLC SARPS.

3.1 The two root documents from which the SARPs have been developed are the Draft ICAO Manual of ATS Data Link Applications, submitted to the 2nd Meeting of the ADS Panel in September 1996, and the RTCA Document 219, Minimum Operating Performance Standards for ATC Two-way Data Link Communications, initially published in August 1993, and recently updated to bring it into line with the SARPs material.. The former laid down the high level operating requirements, while the latter specified operating concepts in some detail. In addition, ICAO had specified that CPDLC should conform to the ATN protocols for its data link operations.

3.2 The initial development of the SARPs was conceptually relatively uncomplicated. After initial contact was made, and a dialogue opened, pilot or controller could send and receive messages via the data link. Appropriate replies had to be made, and one objective was that any dialogue should be closed correctly - aborting a connection should only happen in the event of some fault in the system. A pilot would only be able to correspond through one data link connection to his/her current data authority, and automatic procedures were developed to allow an easy hand-over to the next data authority, exactly analogous with current voice operations.

3.3 As in voice dialogue, a message to an end user could contain several items of information, (not always totally related to the same topic), or it might only contain a brief acknowledgement of a previous message. It was decided operationally that a maximum of five different items of information could be included in one message. Two sets of message items ('message elements') were developed, an uplink set for use by the controller, and a downlink set for use by the pilot. There are also some messages relating to system performance which are only generated by the system itself. In addition, 'free text' messages are permitted, where an element of free text is limited to a maximum of 256 characters taken from the International Alphabet No. 5 (IA5) character set.

3.4 In the course of the development of these SARPs, the concept has become more complicated. In particular, the ADSP identified a need for the pilot to open up a limited dialogue with a data authority which was not his/her current data authority, in order to obtain a clearance for a part of the route which the aircraft was going to fly at some later time. This is termed a 'Downstream Clearance' (DSC), and applies particularly, but not exclusively, to aircraft entering the North Atlantic Region.

3.5 Also there was an implicit requirement in the ADSP material to be able to exchange CPDLC type data link messages between adjacent ATSUs. ATNP WG 3 considered that, within the timecale available, it would be unable to develop a suitable set of Inter Centre Communications SARPs to

enable this functionality. It therefore decided to include an element of ground/ground message forwarding in the CPDLC functionality.

3.6 Both the DSC and the ground/ground functionality were seen by some WG 3 members as having a limited applicability. States would not be willing to incur the costs of implementing a complete system if they only ever intended to use certain elements of the application. In addition, they would want to be involved in a validation programme for parts of SARPs for which they would have no future need. On the basis of these arguments, therefore, the WG agreed to try to separate out the functionalities to enable part implementation and part validation, whilst still retaining the interoperability required by the ICAO Standards. This has led to the development of subsetting rules, and the identification of conformant configurations.

3.7 The Subgroup of Working Group 3 which has been responsible for the production of the draft CPDLC SARPs material has worked very closely with the relevant Working Groups of the ADSP, to ensure that the development of both the operational concepts, and the technical means of achieving them keep in step with each other. However, the ADSP is generally looking at a longer timescale than the current ATNP initial implementation programme, and this will inevitably mean that some elements of their work has not been incorporated into the present SARPs.

4. OVERVIEW OF THE CONTENTS OF THE MATERIAL

General

4.1 Due to the complexities of the documentation, and the repetitive nature of some of the material, none of the Air-Ground Applications SARPs are stand-alone documents. For example, there are no formal list of acronyms, definitions or references - these are all in Part 1. Likewise, conventions for expressing requirements, system performance parameters common to all air-ground applications, and the whole description of the Application Layer structure, with its finite and abstract concepts and its basis within ISO specifications, is also outwith this material.

4.2 Also, to the extent possible, the CPDLC SARPs are a Controlled Document. This means that, once they were initially baselined (at the WG 3/4 meeting in October 1995) all changes have been documented through defect reporting and a configuration control procedure. Some reports are little more than a one line entry, invoking near-global changes agreed by a meeting of WG 3, whereas others may be technically complex, raised by an organisation responsible for developing prototype implementations. All defect reports are reviewed by Subgroup 2, acting as a Configuration Control Board , the necessary remedial action put in place, and the results presented to WG 3 for acceptance and approval. Traceability of actions is provided by means of the Configuration Sheet at the front of the SARPs.

4.3 All the Air-Ground SARPs are produced to a standard format of eight chapters, and all chapter headings are the same. This has greatly helped the maintenance of document stability, commonality and presentation. CPDLC SARPs are no different in basic layout from all other air-ground applications SARPs.

Chapter 1 - Application overview

4.4 This introductory chapter gives a very brief, high level description of CPDLC, as an application allowing data link communications both between air traffic controllers and pilots and also between two ATC ground systems, for the purposes of forwarding a CPDLC message.

4.5 This chapter also contains an outline description of the functions which the application provides, namely:

a. **The Controller-Pilot Message Exchange Function**

This defines a method for the controller and pilot to exchange messages via data link

b. **The Transfer of Data Authority Function**

This provides the capability for the Current Data Authority (CDA) to designate another ground system as Next Data Authority (NDA). A CPDLC dialogue can be opened with or by the NDA at a time before becoming the CDA.

c. **The Downstream Clearance Function**

This provides the capability for an aircraft to contact an Air Traffic Service Unit (ATSU) which is not the CDA for the purposes of receiving a Downstream Clearance (DSC).

d. **The Ground Forward Function**

This provides the capability for a ground system to forward information received in a CPDLC message to another ground system.

4.6 Finally, chapter one contains a brief resume of the contents of the other chapters.

4.7 Since this chapter contains no information directly relation to the stipulation of specific Standards, it is written as series of informative notes.

Chapter 2 - General requirements

4.8 This chapter contains information and high level requirements for the maintenance of Backward Compatibility and Error Processing. Throughout these SARPs great emphasis is placed on the end users being kept informed of the state of the system.

Chapter 3 - The Abstract Service

4.9 This chapter defines the abstract service interface for the CPDLC application. The CPDLC-Application Service Element (CPDLC-ASE) abstract service is described from the viewpoint of the CPDLC-air-user (the pilot and the aircraft systems), the CPDLC-ground-user (the controller and the ATSU ground system facilities) and the CPDLC-service-provider (the providers of the communications media, routing and switching facilities).

4.10 In this chapter the static behaviour, (i.e. the format) of the CPDLC abstract service is described. Its dynamic behaviour (i.e. how it is used) is described in chapter 7. In order to clarify some of the concepts inherent in the abstract service, an outline diagram and informative notes are provided as an introduction. There is of course no requirement to implement the CPDLC-ASE abstract service in a CPDLC product: however, it is necessary to implement the ground based and air based system in such a way that it will be impossible to detect (from the peer system) whether or not an interface has been built. This emphasises the implementation impartiality of the SARPs, which retaining the need for the provision of interoperability.

4.11 The CPDLC-ASE abstract service shall consist of a subset of the following services (permissible subsets are described in chapter 8), the rules and requirements of which are described in detail:

a. CPDLC-start service

b. DCS-start service

c. CPDLC-message service

d. CPDLC-end service

e. DSC-end service

f. CPDLC-forward service

g. CPDLC-user-abort service, and

h. CPDLC-provider-abort service

4.12 Each service contains a number of primitives and parameters - parameter values, where required, conforming to the Abstract Syntax Notation .One (ASN.1) syntax as given in Chapter 4.

Chapter 4 - Formal Definition of Messages

4.13 This chapter describes the contents of all permissible CPDLC messages through definition of the CPDLC ASN.1 abstract syntax. All possible combinations of message parameters and their range of values are detailed. Any messages not included in this chapter may be sent using the 'Free Text' option, subject to the restrictions outlined in para 3.3 above.

4.14 Parameter ranges and resolutions, where applicable, have been obtained from the ADSP documentation - any changes in these will be reflected in this chapter through the means of defect notes.

Chapter 5 - Protocol Definition

4.15 This chapter is effective split up into three parts - sequence diagrams for the services given in chapter 3, protocol descriptions and error handling for the CPDLC-Air- and Ground-ASEs, and State Tables.

4.16. The sequence diagrams define the valid sequence of primitives that are possible to be invoked during the operation of the CPDLC application. They show the relationship in time between the service request and the resulting indication, and, if applicable, the subsequent response and resulting confirmation. With the exception of the abort primitives, only the sequence of primitives described in the diagrams shall be permitted. (Abort primitives may interrupt and terminate any of the normal message sequences.)

4.17 In order to guarantee message sequencing in normal operations, the CPDLC-air-ASE and the CPDLC-ground-ASE shall process primitives in the order in which they are received.

4.18 The protocol descriptions and error handling part of the chapter presents requirements for the CPDLC-air and ground-ASEs in specific states. If no actions are described for a CPDLC service primitive when the ASE is in a specific state, then the invocation of that primitive shall be prohibited while the ASE is in that state. Likewise, should the unexpected happen when an ASE is in a specific state, then exception handling procedures shall apply.

4.19 The state tables are a tabular description of the protocol rules earlier in the chapter. However, if the state tables conflict with any textual statements made elsewhere in the SARPs, the textual statements take precedence.

4.20 In the state tables, the statement 'cannot occur' means that if the implementation conforms to the SARPs, it is impossible for this event to occur. If the event does occur, this implies that there is an error in the implementation. If such a situation is detected, it is suggested that the ASE aborts , giving an indication of an unrecoverable system error. The statement 'not permitted' means that the implementation must prevent this event from occurring through some local means. If the event does occur, this implies that there is likewise an error in the implementation. However, if such a situation is detected in this case, it is suggested that the ASE performs a local rejection of the request, rather than aborting the dialogue.

Chapter 6 - Communication Requirements

4.21 This short chapter specifies the use of Packed Encoding Rules (PER) to encode/decode the ASN.1 message structure, Dialogue Service requirements, including Quality of Service (QOS), and stipulates the IA5 character string used as the Application Entity qualifier for the CPDLC application.

4.22 In this initial version of the CPDLC application, there are only limited QOS requirements - these will be expected to become more strongly defined in later versions.

Chapter 7 - User Requirements

4.23 This chapter contains requirements imposed on the CPDLC-user concerning CPDLC messages and interfacing with the CPDLC-ASEs. In this chapter, CPDLC-user implies both the air and ground user. It is also written in slightly less formal language. This in this chapter the term 'CPDLC message', 'message', 'uplink message' and 'downlink message' are used interchangeably, and equate to a CPDLC message. Then the terms 'send' and 'transmit' are used, this means that the CPDLC user has invoked a CPDLC service request or response primitive. When the term 'receive is used, this means that a CPDLC indication or confirmation primitive parameter containing a CPDLC message has been provided by the CPDLC service.

4.24 This chapter also specifies CPDLC message generation requirements, indicating whether or not a response is required, how a response is matched to a transmitted message (message reference numbers), and how a sequence of messages in terminated (closure response). Detailed requirements for message composition are given, including the minimum contents for both air-ground and ground-ground messages. Unacceptable combinations of messages are also expressly covered.

4.25 Each CPDLC message can have up to three attributes, which dictate certain message handling requirements for the CPDLC user receiving a message - these attributes relate to Urgency, Alert and Response. Both the Urgency and Alert Attribute values apply to air-ground and ground-ground messages - the Response attribute only applies to air-ground messages.

4.26 This chapter contains the CPDLC message set, presented in plain language, giving an explanation of the intent and use for each message element. The actual information exchanged between aircraft and ground peer (or ground and ground peer) CPDLC applications is defined in chapter 4, but that chapter does not mandate any particular method for presenting this information.

4.27 The presentation of information to the controller and the aircraft crew is a matter for local implementation. The message presentation recommendations contained in this chapter are one possible means of presenting the information. These recommendations are generally consistent with current ICAO practices for displaying ATC information.

Chapter 8 - Subsetting Rules

4.28 This chapter specifies conformance requirements which all implementations of the CPDLC protocol obey. The protocol options are tabulated, and indication is given as to whether mandatory, optional or conditional support is required to ensure conformance to the SARPs.

4.29 There are just two CPDLC-air-ASE conformant configurations, namely supporting the core functionality, or the core functionality plus a DSC capability. (Thus, the core CPDLC functionality for air-ground is everything except DSC.) The ground user has several permissible combinations.

4.30 These subsetting rules will permit applications to be tailored to suit individual ground implementations, commensurate with the underlying task, while still maintaining an acceptable level of interoperability.

5. RECOMMENDATION

5.1 The Panel is recommended to approve the attached CPDLC Standards and Recommended Practices for review by the Air Navigation Commission for inclusion into the relevant ICAO documentation.