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Human Factors Minimum Operational Performance Standards for Controller Pilot Data Link Communications Systems: Build 1 and Build 1A

Draft Document

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Prepared by SC-194
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Foreword

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1. Purpose and Scope

1.1. Introduction

This document defines minimum human factors requirements and guidelines for air traffic services (ATS) data link communications between an air traffic specialist and a pilot utilizing the Aeronautical Telecommunications Network (ATN). The scope is the initial Controller-Pilot Data Link Communications (CPDLC) capabilities which comprise the Build 1 and Build 1A phases of the United States (US) implementation path.

In the US, initial CPDLC capabilities will be implemented in Air Route Traffic Control Centers (ARTCCs) and available to support ATS in the domestic en route airspace radar environment. Although there are some exceptions, the ARTCCs are typically responsible for airspace outside of the Terminal Control Area starting at 11,000 feet and extending through the Positive Control Area up to 60,000 feet. This airspace generally encompasses the transition and cruise phases of flight. The initial CPDLC capabilities, discussed in this document, will not be available in US en route oceanic airspace. An early (non-ATN compatible) CPDLC service has been available in US oceanic airspace since 1995. The second phase (Build 2) of the US CPDLC implementation path will field a common CPDLC service in domestic and oceanic en route airspace.

The operational CPDLC system includes an Aeronautical Telecommunications Network (ATN) interface, the Context Management Application (CMA), and CPDLC service requirements. CPDLC message assurance and addressing requirements are supported by the ATN protocols and the CMA, respectively. Key assumptions regarding the operational environment, the role of the ATN, the CMA application, and the CPDLC services in supporting the human factors requirements are presented in the following section.

Human factors considerations are an important element of CPDLC system performance. As illustrated in Figure 1-1, human factors requirements address many aspects of aircraft and ground system equipment, training, and procedures. These requirements will be used by designers, manufacturers, installers, and operators of the CPDLC flight deck and ground system equipment. To facilitate understanding and use of this document by these categories of readers, the requirements and guidelines are grouped into two sections: flight deck and ground system.

Compliance with these requirements is recommended as one means of assuring that the equipment will perform its intended functions satisfactorily under all conditions normally encountered in routine aeronautical operations. Any regulatory application of these standards is the sole responsibility of the appropriate governmental agencies.

Section 1.0 provides information on purpose and scope needed to understand the rationale for equipment characteristics and standards stated in the remaining sections. It describes typical equipment applications and operational goals as well as establishes the basis for the standards stated in Sections 2 and 3.

Section 2.0 contains standards for the flight deck equipment, equipment installation, and operations. This section also describes the equipment operational performance characteristics

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and defines conditions that will assure that flight crew operations can be conducted safely and reliably in the expected operational environment.

Section 3.0 contains standards for the air traffic service ground system equipment, equipment installation, and operations. This section also describes the equipment operational performance characteristics and defines conditions that will assure that air traffic service specialist (ATSS or controller) and airway facilities specialist (AFS) operations can be conducted safely and reliably in the expected operational environment.

The document contains seven appendices. Appendix A defines the acronyms and abbreviations used in this document. Appendix B defines the acronyms and abbreviations to be used in display formats of CPDLC messages. Appendix C defines the CPDLC Build 1/1A Message Set. Appendix D provides guidance on flight crew procedures and training. Appendix E provides guidance on ATS Specialist procedures and training. Appendix F provides guidance on the use of color. Appendix G provides guidance for controls.

Standards for the design and implementation of optional features, beyond those required for a minimum CPDLC capability, only apply if those features are implemented. This document also includes minimum requirements for the operational environment for which these requirements are appropriate.

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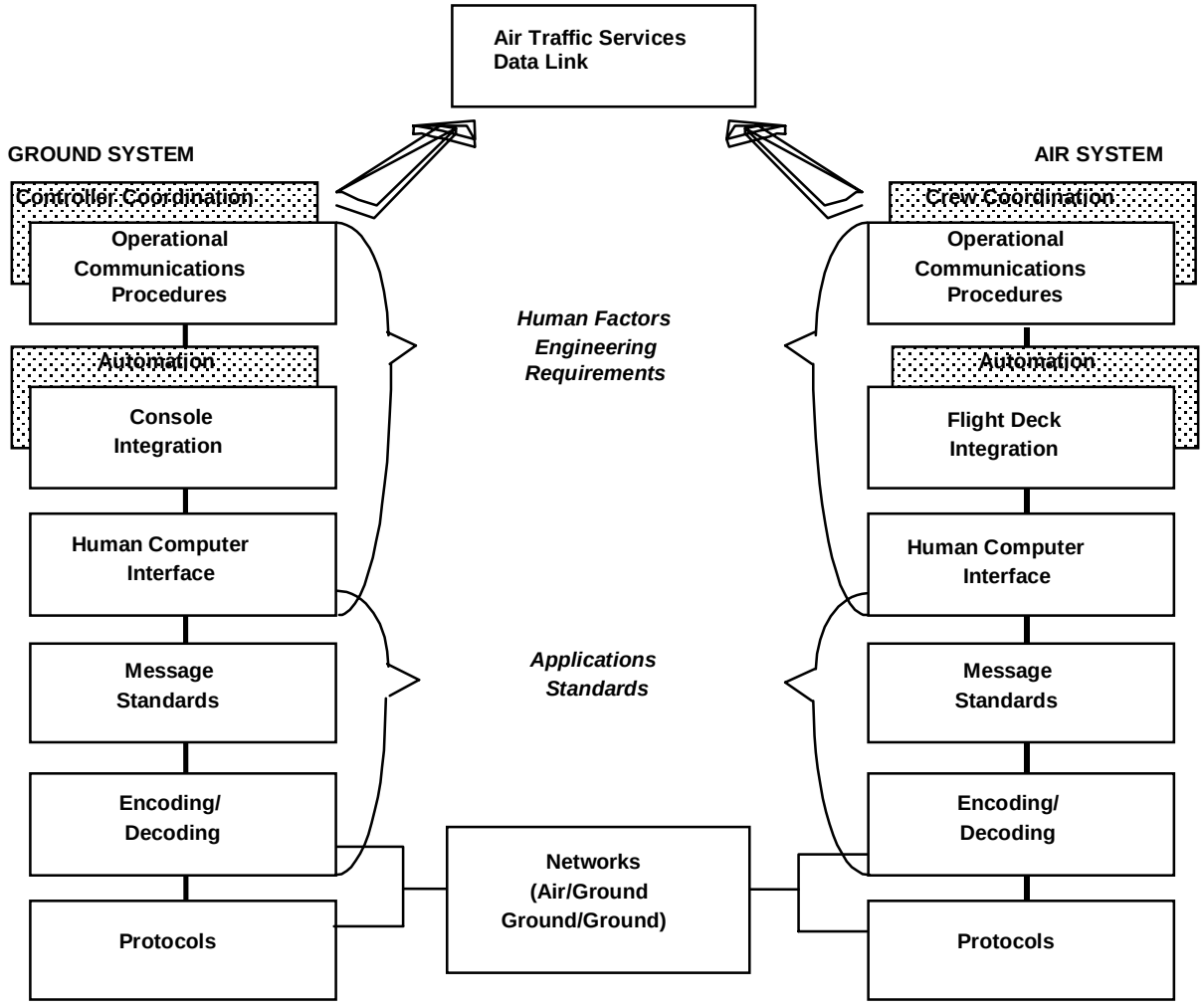

FIGURE 1-1 HUMAN FACTORS REQUIREMENTS IN THE CONTEXT OF GENERAL FUNCTIONAL REQUIREMENTS FOR DATA LINK COMMUNICATION

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1.2 System Overview

1.2.1 Current En Route CPDLC Implementation Path

The FAA's goal is to provide a full range of ATN-based CPDLC services in en route airspace. The currently accepted path provides for a phased-implementation of ATN-compatible CPDLC services, beginning with a key site evaluation of a limited set of services and maturing to a national deployment of a full set of services. To mitigate implementation risks, the FAA will develop CPDLC in four phases, with additional messages and capabilities supported for each build: CPDLC Build 1, CPDLC Build 1A, CPDLC Build 2, and CPDLC Build 3. It is assumed that transition to phases beyond Builds 1 and 1A will be contingent upon the success and "lessons learned" from these builds. That is, the evolutionary CPDLC acquisition process assumes that issues and improvements identified from initial operational use are fed into the ongoing development activities to facilitate deployment of increasingly mature baseline capabilities with each increment of new CPDLC capability.

CPDLC Build 1

CPDLC Build 1 is the first step in the development of the en route CPDLC program. CPDLC Build 1 will leverage the evolving capabilities of the existing National Airspace System (NAS) infrastructure, air/ground communication service providers, and avionics. It is planned that CPDLC will become operational in June of 2002.

The CPDLC Build 1 messages will be exchanged with data link-equipped aircraft using ARINC's Very high frequency Digital Link (VDL) Mode 2 air/ground communications subnetwork. Build 1 includes the CMA and a subset of CPDLC messages (see Appendix C) to perform the following services:

1. Transfer of Communication (TOC)
2. Initial Contact (IC)
3. Altimeter Setting (AS) and
4. An informational predefined message capability, which will be built by supervisory input and assigned to specified positions.

CPDLC Build 1A

CPDLC Build 1A will enhance ATS communications by increasing the message set to accommodate assignment of speeds, headings, and altitudes as well as a route clearance function (see Appendix C). A capability to handle pilot-initiated altitude requests will also be implemented. CPDLC Build 1A will continue to use the VDL Mode 2 air/ground communication subnetwork. CPDLC Build 1A is planned for a key site implementation in June 2003 with national deployment commencing thereafter.

CPDLC Build 2

CPDLC Build 2 will expand upon CPDLC Build 1A in terms of services and messages provided. CPDLC Build 2 will continue to use the VDL Mode 2 air/ground communication subnetwork, but will evolve the subset of the ATN CPDLC messages to support CPDLC

operations for several years. These messages will be coordinated across adjoining ICAO regions and will accommodate multi-part uplinks (e.g., crossings with time, speed, and altitude restrictions) and report instructions. The downlink capability for pilots to request clearances and respond to requests via CPDLC will be greatly enhanced.

CPDLC Build 2 will be fielded at a key site with national deployment commencing thereafter.

CPDLC Build 3

The deployment of CPDLC Build 3 is the last of the currently planned phases in the FAA's Aeronautical Data Link program. Details of the increased capabilities remain to be determined, but are likely to include additional messages from the ICAO Annex 10 CPDLC message set. CPDLC Build 3 is expected to use NEXCOM, a more robust air/ground communications subnetwork based upon VDL Mode 3 technology.

1.2.2 System Description

The CPDLC system provides the capability to establish, manage, and terminate a communication connection between an aircraft and a ground system air traffic control authority via the ATN. Once an appropriate connection is established the CPDLC system provides for a pilot to exchange messages with the eligible air traffic controller.

When a message is received, the CPDLC system decodes the data and determines the message urgency requirements, alerting requirements, and response requirements. These requirements then direct the CPDLC system concerning message display queuing, visual and aural alert coding, and response availability. CPDLC also provides the capability to compose a message and encode the message for transmission. Other features include message recall, system control capabilities and status indications.

1.3 Operational Overview

Initial CPDLC services will be used in the domestic en route airspace radar environment. The CPDLC messages correspond to phraseology employed in current US air traffic control procedures.

Controllers and pilots will use the initial CPDLC services to augment existing voice communications. CPDLC is expected to be used for routine or repetitive types of communications and it is not to be used in time-critical situations. Use of CPDLC by controllers and pilots is elective and will be based on their judgments concerning the appropriateness of the CPDLC system in the operational context (DO-Principles).

CPDLC tasking and procedures will ensure integrated flight crew and controller team functions, such as decision making, coordination, and task management. The distribution of responsibilities within flight crews and controller teams and the associated procedures will be defined by the operators and the FAA, respectively.

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1.4 Assumptions

1.4.1 Safety Assumptions

It is assumed that there will be no reduction in the overall level of safety related to the use of data communications, as measured by comprehensive testing and structured operational evaluation. Before implementation, comprehensive operational safety assessments will be conducted (DO-SPR). It is expected that the safety assessment process will consider the effects of flight crew (procedural) errors as determined by the pilot community. Based on experience with oceanic CPDLC, a government-industry interoperability team will need to be established prior to implementation and this team is expected to develop a plan for human factors data collection that defines human performance measures in addition to an engineering data collection plan.

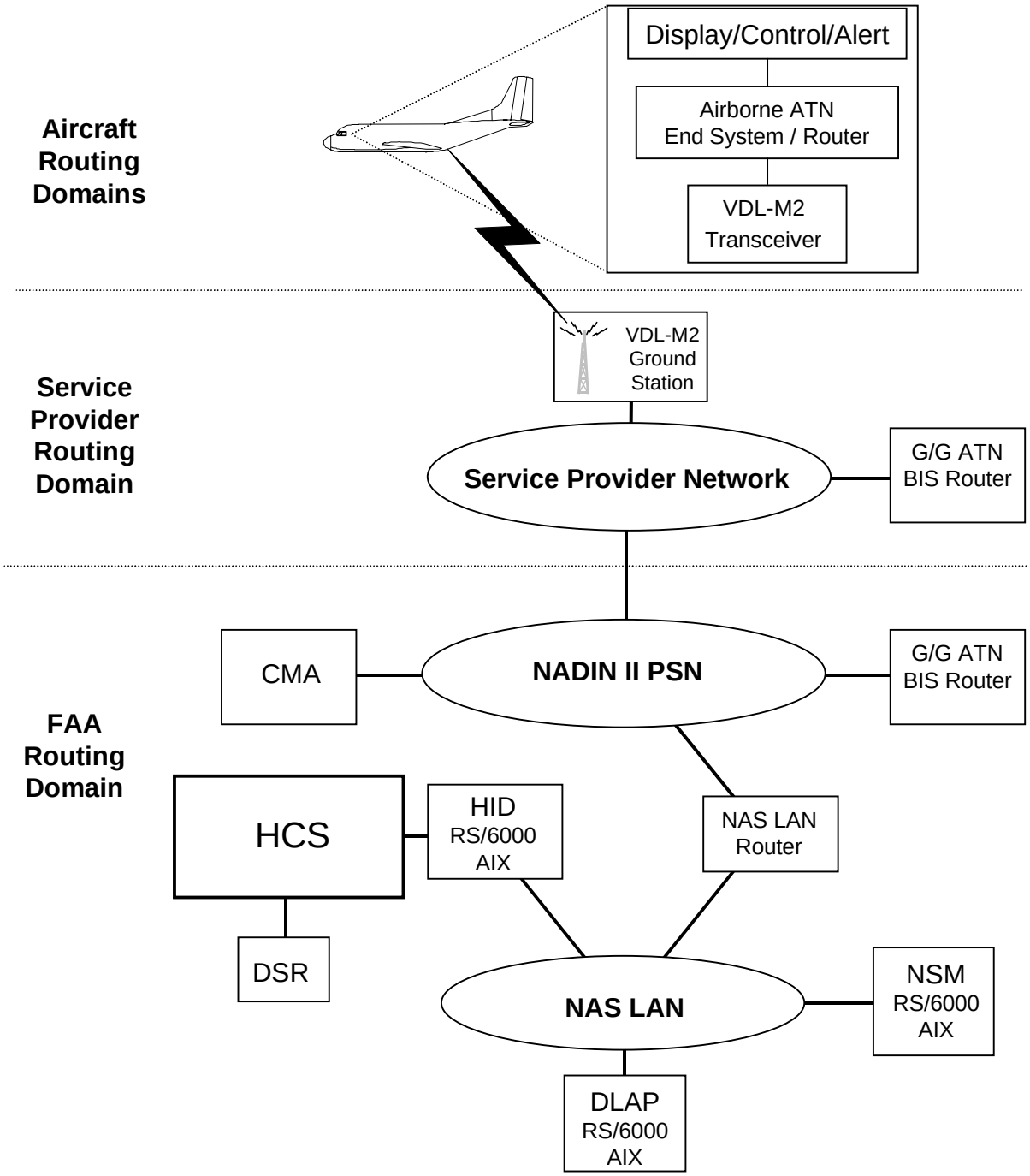
After implementation, the level of safety will continue to be monitored through ongoing in-service system assessment and evaluation activities including analyses of CPDLC performance data recorded automatically by the ground system and analysis of operational assessments obtained from controllers and pilots.

1.4.2 Equipment Assumptions

Figure 1-2 depicts the FAA, service provider, aircraft equipment components, and system architecture that enable the initial CPDLC capability. As shown in the figure, the controller's CPDLC capability will be implemented in the Host Computer and Display System Replacement (DSR) system. This document assumes that the CPDLC Human Computer Interface (HCI) will comply with the HCI style of the DSR software and provide a common "look and feel". Procedures for preparing, sending, and receiving data link messages should be consistent with procedures for other DSR information handling tasks.

Ground system monitoring and control of FAA components of CPDLC will be conducted by airway facilities technicians using the Network System Manager (NSM) capability for Host Interface Device (HID) The HID controls the data link applications processor. The CPDLC application program and the software that manages connections to aircraft to the air/ground communications service provider reside in the data link applications processor. This document assumes that the HCI for CPDLC monitoring and control will comply with the HCI style of the NSM and provide a common "look and feel". Displays and procedures for checking and restoring the CPDLC system should be consistent with those used for monitoring other devices connected to the HID.

In the aircraft, the pilot's CPDLC capability will be implemented in the communications management unit, and will be integrated with control/display units, CPDLC message displays, and visual and aural alerting mechanisms available in the flight deck. The CPDLC HCI will vary based on the flight deck configuration and may undergo equipment changes from Build 1 to Build 1A.



ATN	Aeronautical Telecommunications Network	HCS	Host Computer System
BIS	Boundary Intermediate System	HID	Host Interface Device
CMA	Context Management Application	NADIN	National Airspace Data Interchange Network
DLAP	Data Link Application Processor	NSM	Network System Manager
DSR	Display System Replacement	PSN	Packet Switch Network
G/G	Ground/Ground	VDL-M2	Very High Frequency Digital Link-Mode 2

FIGURE 1-2 BUILD 1A SYSTEM ARCHITECTURE

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1.4.3 Communications System Assumptions

This document assumes that the CPDLC system complies with ICAO Standard and Recommended Practices (SARPS), Aeronautical Telecommunications, Annex 10 to the convention on International Civil Aviation, Volume III, Part I, *Digital Communications Systems*, Chapter 3, *Aeronautical Telecommunications Network (ATN).* It is assumed that the CPDLC system will comply with ICAO 9705-AN/956, the ATN SARPs, with the exception of Sections 2.2, 2.4, and 3. The CPDLC system will comply with the ATN SARPs Class I operation (Section 2.3.8). If the system does not comply with the ATN SARPS, additional requirements will apply.

1.4.3.1 ATN and Context Management Application Assumptions

The following assumptions have been made regarding ATN and context management.

The flight deck CPDLC system provides the capability to establish a connection with the appropriate ATS facility, using the context management application (CMA).

The CMA log-on process validates the aircraft address and uniquely identifies each flight before the connection is established.

After a connection is established, the system ensures that messages are correctly addressed.

After a connection is established, manual and automatic procedures will be used to ensure that messages are exchanged between the aircraft and the responsible ATS facility.

All times contained in the data link system will be referenced to Universal Coordinated Time.

1.4.3.2 CPDLC Service Assumptions

The following assumptions, from the ICAO SARPS, have been made regarding the contribution of the CPDLC services and message standards to human factors requirements.

Message Components

A CPDLC message is composed of a message header, and from one to five message elements. The message header for air-ground message exchange is composed of a message identification number, a message reference number if required, a timestamp, and an indication if a logical acknowledgement is required (optional).

Note: Initial CPDLC services should limit use of multi-element messages. In addition, the CPDLC ground system will prohibit multiple open transactions of the same type with an aircraft. For example, the controller may have only one open altitude message to an aircraft at a time.

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Message Identification Numbers

- Message identification numbers provided by a CPDLC ground system for messages to/from an aircraft have no relationship to the message identification numbers provided by the same ground system for another aircraft.

- Similarly, message identification numbers provided by an aircraft on a given CPDLC link for messages to/from a ground system have no relationship to the message identification numbers provided by the same aircraft with another ground system.

- The message identification number provided by the ground user will be different from any other message identification number currently in use with that particular aircraft.

- The message identification number provided by the avionics will be different from any other message identification number currently in use with that particular ground system.

- A message identification number will be deemed currently in use until: Scenario a): the message does not require a response: the message has been sent; or Scenario b): the message requires a response: the closure response has been received.

- Message identification numbers will be provided sequentially.

Message Reference Numbers

- All response messages will contain a message reference number.

- The message reference number will be identical to the message identification number of the initiating message to which it refers.

Message Attributes

Message attributes dictate certain message handling requirements for the CPDLC user receiving a message. Each CPDLC message has three attributes: urgency, alert and response attributes.

- *Urgency Attribute Levels*

The urgency (URG) attribute delineates the queuing requirements for received messages that are displayed to the end-user. Messages with the highest urgency will be placed at the beginning of the queue. There are four urgency levels from (1) distress, (2) urgent, (3) normal, and (4) low. CPDLC Build 1/1A messages have urgency attributes of (2) urgent (U) and (3) normal (N).

- *Alert Attribute*

The alert (ALRT) attribute delineates the type of alerting required upon message receipt. Alerting types include aural and visual annunciation of message presence. There are four types of alerting (1) high, (2) medium, (3) low, and (4) no alerting required. CPDLC Build 1/1A messages have an alert attribute of (2) medium (M).

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- *Response Attribute*

The response (RESP) attribute mandates response requirements for a given message element. CPDLC Build 1/1A uplink messages have response attributes of 1) WILCO, UNABLE, STANDBY (W/U), 2) AFFIRM, NEGATIVE, STANDBY (A/N), or 3) ROGER, STANDBY (R). CPDLC Build 1/1A pilot-initiated downlink messages have response attributes of 1) Yes (Y), or 2) No (N).

Note: The general convention throughout CPDLC documentation (e.g., SARPs) for abbreviating the response attributes leaves off the "S" for Standby. Thus, the "W/U" attribute denotes "W/U/S", "A/N" denotes "A/N/S", and "R" denotes "R/S".

Urgency, alert, and response attribute types are associated with each message element. When a message contains a single message element, the message attributes are the message element attributes. When a message contains multiple message elements, the highest precedence message element attribute type becomes the attribute type for the entire message. Message element attribute table entries are listed in order of precedence (i.e. a precedence value of 1 is highest, followed by 2, etc.). For example, this means that a message containing multiple message elements, where at least one element has a 1) W/U response attribute, the whole message then the whole message has the same (i.e., 1) W/U) response attribute.

Error Messages

The following two ERROR message elements may be provided to messages in Build 1/1A:

1. Unrecognizable message referent: This error message is sent when a response message is received and the original message referenced by the response has been deleted or cancelled.

2. Service Unavailable: This error message is sent in response to a message element which is not contained in the Build 1/1A message set.

Note: The CPDLC ground system also sends "service unavailable" message if the data link service is turned off in a sector. In addition to the ERROR message text, the CPDLC ground system will append additional free text to further explain the nature of the error, e.g., CPDLC is turned off.

Response Messages

- A message containing the ERROR message element will always be permitted as a response message.

- Any message that is considered a response message (i.e., it contains a message reference number) will have message urgency and alert attributes not less than the message to which it refers.

- If the CPDLC user sends a message containing the ERROR message element instead of the expected response message, the ERROR message will contain the initiating message identification number as the message reference number. This ERROR message will be a closure response message.

Logical Acknowledgement Messages

- The logical acknowledgement (LACK) was designed to provide a confirmation from a receiving system to the message originator that the message has been successfully received and is acceptable for display to the responsible person, if this is required. The logical acknowledgement in no way replaces any required operational response.

- A logical acknowledgement response message, if required, will be sent prior to sending another related response message(s), other than an ERROR message, if necessary.

- In Build 1A and beyond, a LACK will be enabled for uplinks and downlinks.

Note: Currently, the FAA Build 1 ground system will use LACKs only to monitor system performance. Under this approach, LACKs will be enabled on an intermittent basis and there will be no indication to controllers regarding LACKs.

1.4.3.3 Operational Dialogue Assumptions

The CPDLC message response attribute defines the allowable operational responses for each CPDLC message. In addition, the receipt or non-receipt of an allowable operational response will result in closure or non-closure of a CPDLC transaction (DO-Principles).

For all Build 1/1A messages, an operational response of STANDBY keeps a transaction open. For uplink instructions, clearance, and advisory messages, an operational response of WILCO, UNABLE, AFFIRMATIVE, NEGATIVE, or ROGER closes the transaction. In addition, a controller action to delete a message also closes that transaction For uplink report and confirmation messages, the downlink assigned or preferred level closes the transaction. For a downlink pilot request message, an operational response of UNABLE or an uplink clearance approving the request closes the transaction.

When a transaction is closed the controller or pilot has fulfilled all of the procedural requirements associated with it. Open transactions require additional action by the controller or pilot to complete the communication.

1.5 Definitions of Terms

This section contains a definition of terms used in this document that may have multiple meanings or that are not normally used in RTCA standards.

ATS MESSAGE: A clearance, instruction, or information message. Included in this category are messages associated with revisions to the clearance or route amendments. Also included are messages such as horizontal, vertical, or speed instructions, and messages associated with the transfer of communication, including radio frequency, initial contact reports, and altimeter information.

CONNECTION: An air/ground communications link between an aircraft and an ATS facility that enables CPDLC.

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CONTROL: An interface component with which users can interact (e.g., select an item, enter text, initiate an action).

CONTROLLER PILOT DATA LINK COMMUNICATIONS (CPDLC) SYSTEM: Digital telecommunications capability which supports ATS communication between airborne and ground-based computers and their operators.

CURRENT DATA AUTHORITY: The ATS facility that is communicating with an aircraft using CPDLC.

DEDICATED DISPLAY: A display surface that is used solely to present information related to a single function. Information related to any other function never appears on this display surface.

END-SYSTEM: System which originates a message or is designated as the recipient of a message.

EQUIPMENT: All components and features necessary for the system to properly perform its intended function(s).

ELIGIBILITY: CPDLC ground system function that limits data link communication with the aircraft to the single control position that has current responsibility for that aircraft and presents an aircraft eligibility indicator on the controller's display.

MUST: Items which are important, but are either duplicated somewhere else in the document as a "shall", or are considered outside the scope of this document.

OPERATIONAL DIALOGUE: The procedural protocol and cycle of ground- and air-initiated messages required for the full handshake that constitutes an information exchange between the controller and pilot. An exchange of one or more messages related to a dialogue is a transaction. For example, a typical transaction begins with an uplink message transmission by the controller and concludes with a downlink response constituting the operational acknowledgement or reply from the pilot.

OPERATOR: Human responsible for handling data link communications. The operator could be an aircraft flight crew member, an air traffic service specialist, or an airway facilities specialist.

SHALL: Indicates a requirement. An approved design must comply with every requirement, which can be assured by inspection, test, analysis, or demonstration.

SHARED DISPLAY: A display surface that is used for a variety of display functions such as presenting navigational routes, terrain data, and traffic information. The data may be presented in a single, integrated depiction, as layers where one data set overlays another, or the display may be switched from one function to another such that each data set is presented alone when it is selected.

SHOULD: Denotes a recommendation that would improve the CPDLC equipment, but does not constitute a requirement.

SUBNETWORK: One of the interoperable communications networks, such as VDL, HF, or satellite, that will support aeronautical data communications.

WILL: Identifies items which are essential, but because they appear in the assumptions section of the document or where use of the term "shall" is not appropriate.

1.6 Design Objectives

The control and display equipment for the both the flight deck and air traffic service ground system for CPDLC should apply the basic design objectives called out in ARP571, taking into consideration the functions, their frequency of use, and all operational and environmental conditions, so as to accomplish the following design objectives:

a) Simplify operations

b) Facilitate error-free operation

c) Maximize situation awareness

d) Minimize head-down/head-away time

e) Provide consistency of operation for common functions

f) Promote timely and accurate operation

g) Ensure that system failures do not degrade the operational capability of other systems with which they interact

h) Ensure intelligibility of messages throughout the wide range of ambient noise and visual conditions, concurrent speech and data link messages and other aural and visual signals

i) Provide for information redundancy to assist the flight crews and ATS/AF specialists in verification and error detection

j) Minimize nuisance alerts

The goal of these objectives, though not necessarily presented in order of importance, is to keep the operator workload at a level compatible with efficient operation.

1.7 References

Applicable Documents

The following publications form a part of this specification to the extent specified herein. The latest issue of all documents listed below, should apply. The documents are generally applicable to the subjects of flight deck and ATS workstation integration, human interface design, and procedures for data link.

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SAE Publications

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FAA-ER-130-006	*Display System Replacement System Specification*
FAA Order 7110.65	*Air Traffic Control*
FAA-RD-81-38	*Aircraft Alerting System Standardization Study: Volumes I, II, and III*
DLAP Ref.	**(Editors note: need reference HID/DLAP ref)**
TSO-C113	Technical Standard Order C113, *Airborne Multipurpose Electronic Displays*

RTCA Publications

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RTCA DO-Principles	*Guiding Principles for Air Traffic Services Provided via Data Communications Utilizing the Aeronautical Telecommunications Network, Builds 1 and 1A.*
RTCA DO-Plan	*U.S. National Airspace System Plan for Air Traffic Services Data Link (Phase 1, En Route CONUC Implementation)*
RTCA DO-219	*Minimum Operational Performance Standard for Two-Way Data Link Communications.* *Note: DO-219 is a historical reference but the contents have been superceded by the ICAO SARPS*
RTCA DO-SPR	*Safety and Performance Requirements for Air Traffic Services supported by Data Communications*

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ICAO 8400/4	*ICAO Abbreviations and Codes*
ICAO 9705-AN/956	*Standards and Recommended Practices (SARPs) for the Aeronautical Telecommunications Network (ATN)*
ICAO 9694	*Manual of ATS Data Link Applications*

Other Publications

Bouma, H. (1971). Visual recognition of isolated lower-case letters. *Vision Research,* Vol. 11, pp.459-474.

Bouma, H. (1979). Perceptual functions. In John A. Michon, Eg G. J. Eijkman, & Len F. W. de Klerk, (Eds.*), Handbook of psychonomics:* Vol. 1 (pp. 427-531). New York NY: North-Holland Publishing Co.

Defense Information Systems Agency (February 1998*). Department of Defense User Interface Specifications for the Defense Information Infrastructure(*DOD CM-400-18-05),.

Department of Defense Military Standard (MIL STD) 1472E (1996). *Department of Defense Design Criteria Standard: Human Engineering*. U.S. Army Aviation and Missile Command, Hunstville, Al.

Lockheed Martin, Air Traffic Management (July 26, 1999). *Display System Replacement Air Traffic Controller User Manual* (Document Number: TI 6160.50, CDRL Item: DPU07).

Smith,S.L. and Mosier,J.N.*(*1986). *Guidelines for Designing User Interface Software(ESD0TR086-278).* USAF Electronic Systems Center, Hanscom AFB.

Van Ness, F. L. and Bouma, H. (1980). On the legibility of segmented numerals. *Human Factors*, 22(4), pp.463-475.

2.0 Flight Deck Requirements

2.1 Equipment Performance and Design Requirements

This section contains requirements and guidelines for the design of flight deck equipment, hardware and software, that may be used for CPDLC. Guidance presented in Section 2.0 is relevant for all builds, but does not comprehensively address builds beyond 1A. For builds beyond 1A additional requirements will apply. This section also describes the equipment installation requirements and operational performance characteristics and defines conditions

that will assure that flight crew operations can be conducted safely and reliably in the expected operational environment.

In general, a flight deck CPDLC system should notify the pilot of incoming messages, maintain a queue of pending (open) messages, display messages to the pilot, provide message response and compositions capabilities, and maintain a history log of messages that have been closed, including the associated pilot or controller responses where applicable.

2.1.1 Controls

This section contains general control requirements. Additional recommendations and guidance on designing controls is in appendix G.

1. Operations that occur frequently should be executable with a minimum number of actions.

Note: Frequently used operations for Builds 1 and 1A include: view a message, select a response--WILCO, UNABLE, STANDBY, ROGER, AFFIRMATIVE, NEGATIVE, and SEND a message. The number of actions may be reduced through the use of dedicated controls and the use of quick access menus.

2. Dedicated keys should be provided if non-alphanumeric special characters or functions are used (e.g.. space, slash or oblique (/), plus (+), minus (-), "clear" and "delete", etc.).

2.1.2.1 Layout of Controls

1. Controls that are normally adjusted in flight **shall** be readily accessible to the flight crew (FAR 25.777c).
2. If there are controls that do not require adjustment during flight (e.g., ground maintenance functions) those controls should be positioned to avoid inadvertent activation.
3. Line select function keys should align with adjacent text.
4. CPDLC controls should be arranged so that they do not obscure other controls or displays.
5. To the extent possible, controls should be organized according to the following principles:
   - Collocate the controls with associated displays.
   - Partition the controls into functional groups.
   - Place the most frequently used controls in the most accessible locations.
   - Arrange the controls according to the sequence of use.

2.1.2.2 Operation of Controls

1. The equipment **shall** be designed so that controls intended for use during flight cannot be operated in any position, combination or sequence that would result in a condition detrimental to the reliability of the equipment or operation of the aircraft.
2. Controls **shall** provide feedback when operated.

Note: tactile and visual cues are acceptable forms of feedback.

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3. The data link system **shall** echo pilot alphanumeric inputs within 0.2 s and respond to pilot inputs within 0.5 s, either by completing the processing or by providing feedback that the input is being processed, to prevent slowing tasks down and inducing entry errors such as multiple entries (Smith and Mosier, 1986).

4. Controls **shall** be resistant to inadvertent activation (See Appendix G).

Note: This may be achieved by employing adequate control size, height, resistance, displacement, and spacing or guards between controls.

5. Controls should be usable in the full range of turbulence conditions.

6. Control operating pressure should be light enough not to impede rapid sequential use (See Appendix G).

7. Controls designed to be used in flight **shall** be operable with one hand.

8. Activation or use of a control **shall** not require simultaneous use of two or more controls in flight (e.g., pushing two buttons at once).

9. If a control can be used for multiple functions, the current function **shall** be indicated and discriminable in all environmental conditions (e.g., lighting, ambient noise, turbulence).

10. The CPDLC function **shall** be accessible by a no more than three actions.

Note: Fewer actions are preferred. However, current Multifunction Control Display Units are not designed to allow CPDLC access in a single pilot action.

11. If the CPDLC function is active and an open message is not currently displayed, the pilot **shall** not be required to take more than two actions to view the message.

Note: It is recommended that no more than three pilot input actions be required to view a message, regardless of system configuration.

12. Labels for controls should be on or adjacent to controls they identify.

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2.1.2.3 Shared Control Considerations

If the controls used as the input device for data link operations are not dedicated (e.g., the flight management system keypad is used also to interface with the data link functionality), the following criteria apply.

1. Scratchpad data associated with a non-CPDLC function, but not yet entered into the non-CPDLC function, **shall** be cleared from the scratchpad area when the device is switched to the CPDLC function.

Note: The above requirement may result in a CPDLC system which operates in a manner which is inconsistent with other flight deck functions, e.g., Flight Management System or MCDU. Consistency of operations needs to be traded against the need to minimize errors when designing the CPDLC human computer interface.

2. If a non-CPDLC function is suspended by switching to CPDLC mode, the pilot **shall** be able to resume the suspended function and recover any associated data at the point at which it was suspended.
3. If CPDLC is suspended by switching to a non-CPDLC function, the pilot **shall** be able to resume the suspended function and recover any associated data at the point at which it was suspended.
4. When the pilot resumes the suspended function, an indication should be provided of where the pilot is in the suspended function.
5. If multiple units of the same control device are installed in the flight deck, use of one control device for CPDLC **shall** not restrict the use of another control device for any of its other (i.e., non-CPDLC) functions.
6. Conversely, the use of one control device for any of its functions except CPDLC **shall** not restrict use of any other CPDLC control device for CPDLC.

2.1.2.4 Menu Items and Menu Logic

1. Menu organization should support specific pilot tasks e.g., responding to controller-initiated messages and composing and sending messages.
2. If an option is never available to the pilot (e.g., a maintenance function), the option **shall** not be in the menu displayed to the pilot.
3. If an option is temporarily unavailable, it should be displayed in the menu with an indication that it is unavailable.
4. When hierarchic menus are used, only one action should be required to return to the next higher level.
5. When hierarchic menus are used, only one action should be required to return to the CPDLC menu at the top level.
6. The pilot should not be required to traverse more than three levels in a menu structure, and no more than two levels for frequently performed tasks.
7. Prompts, menu options, and error message should indicate the action to be executed.

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2.1.3 Display Features

2.1.3.1 Symbology

1. Symbols **shall** be discriminable at a nominal viewing distance of 29 inches, a minimum viewing distance of 10 inches and a maximum viewing distance of 40 inches under all flight deck lighting conditions (SAE AIR 1093).
2. Symbols **shall** be used for a single purpose within the CPDLC system.
3. Symbols used for one purpose in one flight deck system should not be used for another purpose with another system.
4. Symbols for graphic presentation should be consistent within the flight deck.

2.1.3.2 Display Characteristics

1. The operating range display luminance and contrast **shall** be sufficient to ensure display readability through the full range of normally expected flight deck illumination levels.
2. Redrawing/refresh of the display should be neither distracting nor detract from the utility of the display.
3. The contrast of all symbols and text against the background **shall** be no less than 3:1.

Note: The American National Standards Institute (ANSI) recommends a contrast ratio of 7:1 for alphanumeric characters, and cites 3:1 as a minimum (ANSI, 1988). The International Civil Aviation Organization (ICAO, 1993) recommends a contrast ratio of 8:1 for items (such as data blocks) that need to be read. For details that do not need to be read, such as maps and range rings, a contrast ratio of 3:1) is typically acceptable.

4. The display should be readable through a horizontal viewing angle 30 degrees either side of a line normal to the display surface, and through a vertical angle 20 degrees above and 5 degrees below a line normal to the display surface. (from in "Human Factors for Flight Deck Certification Personnel" DOT/FAA/RD-93-5)

Note: These parameters do not ensure that the equipment will be suitable for installation in all aircraft. It is recommended that the view angle be maximized to the increase the flexibility of the equipment for installation.

5. The CPDLC display area **shall** be capable of displaying the following information: an uplink message, message identifier, and message status, an indication of pending (open) message(s), the current data authority (ATS facility), connection status (active or failed), and data link avionics status.
6. CPDLC up-linked air traffic service messages **shall** be displayed in a consistent location on the flight deck.
7. Except during emergency situations (e.g., engine fire), CPDLC **shall** have a dedicated display or dedicated display area for uplinked air traffic service messages (e.g., a separate screen or part of a screen).

Note: The above requirement is a minimum requirement for Builds 1A and beyond, but does not apply to Build 1.

2.1.3.3 Display of Data Across Multiple Pages or Windows

1. When the requested data exceed the capacity of a single display frame, the pilot should have an easy means to move back and forth over displayed material. (e.g., by paging or scrolling).
2. In scanning through a multi-page display the pilot should be able to go forward or backward at will (e.g., the pilot should not be forced to cycle through an entire display series to reach a previous page).
3. If several windows are displayed at once, the pilot **shall** have a means to shift among them to select which window will be active.
4. If several windows are displayed concurrently, the system **shall** indicate which is the active window.

2.1.3.4 Shared Display Considerations

This section addresses issues associated with a CPDLC implementation that is on a shared or multi-function display with other data, such as flight management system data or airline operational control data.

Note: Although CPDLC must have a dedicated display area for uplink messages, CPDLC may share a display for message composition and response functions which require data entry.

Note: If pilots report problems using a shared CPDLC display during Build 1, then Build 1A may be impacted by pilots not using the shared display system.

Standards and guidance in this section apply to both integrated displays (with multiple applications integrated in a single display screen) and non-integrated stand-alone displays where the pilot can toggle between the various display applications (e.g., navigation only, traffic only, etc.). The standards below are not intended to be an exhaustive or comprehensive list of requirements and guidelines for a shared or multi-function display.

1. Where information on the shared display is inconsistent, the inconsistency should be obvious or annunciated, and should not contribute errors in information interpretation.
2. Data input formats for CPDLC should be consistent with data input formats used in the same flight deck. Examples may be inconsistencies in entering a flight ID, or a lat/long.
3. Non-CPDLC data on the display should be located in a consistent location and should not interfere with the usability of the CPDLC data.

2.1.3.5 Labels

1. CPDLC **shall** use an alphanumeric font of a sufficient thickness and size to be readable when user are seated at the normal viewing distance from the screen. Sans serif fonts are recommended. At a minimum, character height should be 1/200 of viewing distance (e.g., a

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viewing distance of 36 inches requires a .18 inch character height on the screen) (DoD, 1998, pp12-1).

Notes: The size of numbers and letters required to achieve acceptable readability may depend on the display technology used. Stroke width between 10 and 15% of character height appears to be best for word recognition on text displays and extensions of descending letters (p,q) and ascending letters (b, d) should be about 40% of letter height. This information is available in: Bouma (1971) Vision Research, 11, 459-474; Bouma (1979) In Handbook of Psychonomic, Vol 1 Chapter 8 pp 427-531; Van Ness and Bouma (1980) Human Factors,463-475.

2. All labels **shall** be readable at a viewing distances of 29 inches under all anticipated lighting conditions.(SAE/AIR 1093).
3. Labels **shall** be used to identify the functions of all CPDLC controls.
4. The spatial relationships between labels and the objects that they reference should be clear, logical, and consistent.
5. Label terminology and abbreviations should be consistent with Appendix B.
6. Data fields **shall** include the units of measurement or labels for the displayed data (Smith & Mosier, 1986).
7. If symbols are used to label data, CPDLC **shall** use appropriate symbols for degrees, minutes, and seconds to improve readability (DoD, 1998, pp 12-2).
8. Numeric message fields shall include a display of labels or units of measure for altitude, heading, and speed.
9. Labels **shall** be located sufficiently close to be associated with the data field but separated from the data field by at least one space (Smith & Mosier, 1986).
10. Soft control labels (e.g., response options) should be displayed in a consistent location on all CPDLC screens.
11. Soft control labels **shall** be unambiguously associated with the control they label (e.g., either through location or through an indicator of which control is associated with the label).
12. If the CPDLC system dynamically labels controls to indicate message response options, then response options that accept the message (e.g., WILCO, AFFIRMATIVE) on one screen **shall** not be presented in the same location as responses that reject the message (e.g., UNABLE, NEGATIVE) on another screen.

2.1.3.6 Color

Government guidelines and industry standards describing requirements and conventions in the use of color on flight deck displays are available for reference. These include: 14 CFR 23.1322 and 14 CFR 25.1322, AC 25-11, AC 23.1311a, DOT/FAA/RD-95.1, DOT/FAA/AR-99/52, SAE ARP4032, and SAE ARP 4102, DoD/CM-400-18-05 (see also Appendix F). These standards are the basis for the following guidelines.

1. Whenever color is used to code information, it **shall** be used redundantly with another means of coding information.

Note: This means that there should be some indication, other than color, about the information that the color is to convey. All information conveyed by color coding should also be available under a monochrome presentation.

2. No more than six colors should be used for color coding on the display. See ARP4032 and Appendix F for color guidelines.

Notes:

1) Use of additional colors for other purposes should not detract from the ability to identify each of the colors used for coding.

2) Color has been successfully used primarily as an aid for visual search or for perceptual grouping of information

3. The use of all colors must be consistent with commonly accepted aviation practice (AC 25-11; AC 23.1311). The accepted practice for the use of red and amber is consistent with 14 CFR 23.1322 and 25.1322 as follows:

   (a) Red **shall** be used only for indicating a hazard that may require immediate corrective action.

   Note: Since red text can be difficult to read, the legibility of specific red text should be tested before implementation.

   (b) Amber **shall** be used for indicating the possible need for future corrective action.

   (c) Any other color may be used for aspects not described in paragraphs a and b of this section, providing the color differs sufficiently from the colors prescribed in paragraphs a and b of this section to avoid possible confusion.

4. If color is used for information coding, the selected color set **shall** be absolutely discriminable (i.e., can be identified) under the full range of normally expected ambient light conditions.

5. Color-coding should be consistent across all CPDLC system displays and controls.

6. When colors are assigned a meaning, each color should have only one meaning.

7. Pure (e.g., "royal") blue should not be used for text, small symbols, other fine detail, or as a background color (See DOT/FAA/AR-99/52).

8. Saturated red and blue should never be presented in close proximity to avoid a false perception of depth.

9. Yellow and white are confusable and only one of them should be used to code text or small symbols.

10. Bright, highly saturated colors should be used sparingly and only be used for critical and temporary information so they are not visually distracting.

2.1.4 Self-Test

1. The capability should be provided for a self-test of the CPDLC avionics.

2. The test should detect and indicate failures in its operation during the self-test.

2.1.5 System Status, Mode Awareness & System Failure

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1. If the system has the ability to operate in different modes, that system **shall** continuously indicate what operating mode the system is in.
2. The flight crew **shall** be able to manually enter or manually override any information that is automatically entered for the logon.

Notes:

1) The initial crew-initiated system logon is to the context management application.

2) Required logon information consists of ATS facility identifier, the flight identifier (up to 7 alphanumeric characters), flight origin, and flight destination.

3) It is desirable to for the system to automatically fill in as much of the logon information as possible.

4) The CPDLC Ground system initiates the establishment of a CPDLC connection without pilot action

3. The CPDLC system logon interface **shall** indicate the type and format of input data expected.
4. The flight crew **shall** be notified of either a successful or an unsuccessful logon.
5. The CPDLC application **shall** check the facility identifier code in the logon request downlink against the uplinked CDA identifier and provide an alert to the crew if they are different.
6. On the CPDLC display(s), there **shall** be a continuous indication of the CDA (ATS facility identifier) with which the aircraft has a connection.
7. The system shall display the status of the data communications system (e.g. loss of data communications connection).
8. The flight crew **shall** have the capability to send a test message to verify that they can communicate with the ATS facility via data link.
9. This test message **shall** verify the path between avionics and controller workstation and require either a LACK or a controller response.

Note: The LACK response is preferred.

10. There **shall** be a means for the flight crew to terminate (abort) a CPDLC connection.
11. The CPDLC system **shall** indicate functions or responses that are available. For example, applicable response options may be indicated when a specific message is selected by the pilot.

2.1.6 Alerting

1. All uplinked CPDLC messages **shall** be annunciated by an aural and a unique visual alert.

Notes:

1) The intent of this alerting requirement is to uniquely identify the presence of a CPDLC message and direct the crew's attention to the CPDLC message display. If the aircraft does not have a centralized alerting system, which groups alerts for comparison, or the capability to display a unique visual alert a unique aural alert must be provided.

2) Use of a two-tone aural alert is recommended to minimize the risk of a missed alert.

2. A visual alert **shall** be displayed until all open transactions have been closed.
3. A visual alert **shall** be cleared once all open transactions have been closed.
4. Aural alerts indicating the receipt of a data link message **shall** be suspended during takeoff and landing.
5. CPDLC alerts should be integrated into the aircraft's existing alerting scheme.
6. If the CPDLC system generates a visual alert when sending data to the printer, the pilot **shall** have the ability to manually clear that alert notification.
7. The loss of a connection to the current data authority (ATS facility) **shall** be annunciated by a visual alert.
8. An indication of the data link avionics failure **shall** be displayed.
9. The failure to receive a successful response to a logon request **shall** be annunciated by a visual alert.

2.1.7 Message Handling

2.1.7.1 Message Queue and Display Precedence

1. If all pending messages are not displayed, information **shall** be provided to notify the pilot of the existence of a queue of these messages.
2. The message queue display should indicate the number of pending messages.
3. When multiple ATS data link messages are waiting, the system **shall** display messages by order of urgency first and age second.
4. Within levels of urgency, messages should be displayed in order of oldest to newest, based on sending time.
5. A new message should not automatically cover and displace a message currently being displayed.

2.1.7.2 Message Display and Formatting

1. For each CPDLC message, the unique message identifier **shall** be available for display.
2. Lines of text **shall** be broken only at spaces or other natural delimiters.
3. Parameters associated with text **shall** be adjacent to and grouped with their descriptive or explanatory text or labels, and on the same page.
4. Conditions and restrictions associated with parameters and text **shall** be adjacent to and grouped with their descriptive or explanatory text or labels.
5. Message data **shall** be available in a directly usable form. If altitude is required in meters or feet, then both values should be available without requiring the pilot to convert displayed data.

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6. If the complete message cannot be presented on the same page, there **shall** be a clear indicator to the pilot that the message continues.
7. The data link message display should present all message text and parameters in a uniform size, font, and style and without emphasis coding of individual data fields upon initial display, to allow flight crew processing and interpretation of the full message content.
8. Data link message formats should be concise, to ensure that an uplink requires a minimum number of pages.
9. Consistent formats should be used to present messages on all CPDLC displays.
10. Standard locations and formats for data should be used to facilitate data entry and error checking and reduce the time and errors associated with reading the data.
11. Complete words should be displayed in preference to abbreviations and acronyms unless the abbreviations or acronyms are more commonly used than the words they replace (see Appendix B).
12. If an error message element is received, the display of the error message **shall** also include associated downlink message.
13. An ATS message should be displayed until it is acknowledged or the flight crew selects another message or display format.

2.1.7.3 Message Composition & Response

1. In preparing messages, pilots should enter, review, and change data on an organized display with field labels.
2. The CPDLC system **shall** indicate the pilot-initiated downlink messages that are supported in a particular airspace by a given ground system.

Note: This requirement does not apply to Build 1.

3. If messages require data entry, the system **shall** provide a preview of all ATS messages as they are composed, and before they are sent by the pilot.
4. The system **shall** support editing of pilot-composed messages
5. For messages that require a pilot response, the data link system **shall** indicate the set of appropriate response options.
6. For messages that require a pilot response, the data link system **shall** label the set of appropriate response options according to the response attributes as established in the SARPS, e.g., WILCO, UNABLE, STANDBY.
7. It should not be possible to respond positively to a message (i.e., WILCO, ROGER, or AFFIRMATIVE) so soon after it appears that it could not have been read; a 2 s delay between when the message appears and when a response is enabled should be implemented (DOT/FAA/CT-96-1).
8. All of the message **shall** be displayed before a positive (e.g., WILCO, ROGER, or AFFIRMATIVE) response is allowed.
9. A means should be provided for the flightcrew to clear uplink messages from the display after a response has been sent.

2.1.7.4 Message Status

1. The system **shall** maintain and clearly display message status information to the pilot, including but not limited to whether the message is pending, accepted, or rejected (see Table 2-1 for examples of one implementation of message status information).
2. If a connection is lost, each open transaction **shall** have an indication associated with the message that the connection has been lost.
3. To support pilot monitoring of transactions, transaction status information should be presented in close proximity to message displays. If messages are displayed in alphanumeric message and history lists, status information should be associated with the message text.
4. A positive, attention getting indication **shall** be presented to depict error and failed message statuses.
5. An indication should be provided when a LACK is not received within a specified time parameter.

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TABLE 2-1 MESSAGE STATUSES

Uplink	Description
NEW	A pending uplink message that has not been viewed.
OPEN	A pending uplink message that has been viewed, but to which no direct response has been sent. Note: Messages responded with STANDBY remain in this state. Or, if the uplink does not require a response and no additional reports are required to close out the message, the status will immediately become CLOSED.
ACCEPTED	An uplink message that has been responded to with a WILCO, ROGER, AFFIRM, or a specific response other than WE CANNOT ACCEPT (82).
REJECTED	An uplink message that has been responded to with either an UNABLE, NEGATIVE, or WE CANNOT ACCEPT (82). This message is no longer pending and is considered closed.
CLOSED	A uplink message that has had all elements of the message responded too; Or, a message that does not require a response.
FAILED	An uplink message was pending when all connections were terminated.
Downlink	**Description**
PENDING	A downlink message that has not been responded to by the ground ATC facility (No Logical Acknowledgement) Or, if no LACK's are required the message is immediately placed at OPEN..
OPEN	A pending downlink for which a Logical Acknowledgement has been received from the ground (if required) but no direct response to the message has been received.
CLOSED	A downlink message that may or may not have been viewed; And, has either been responded to by the ground ATC facility; Or for which no such response is required.
ERROR	A downlink message that caused an Error message to be generated from the ground.
FAILED	A downlink message that was open or pending and awaiting response when all connections were terminated.

2.1.7.5 Message Recall and History

1. The CPDLC system **shall** provide the capability to store, recall and display not less than the last 75 messages that were received and sent.

Note: On the flight deck data link display it may be desirable to provide a quick display of the most recent ATC clearances.

2. CPDLC messages **shall** be stored in non-volatile memory until cleared at the origination of the next flight.
3. Once the message log is full, new messages shall overwrite existing messages from oldest to newest (e.g., first-in is first-out).
4. All open data link messages **shall** be located at the top of the history log until they are closed.
5. Displayed history messages **shall** be distinguishable from pending messages.
6. If a history log list is displayed, the list **shall** be order by message age.
7. Message age **shall** be based on the time that the message was sent.
8. If a response has been initiated for the message both the message and response **shall** be displayed.

Note: Not all CPDLC messages require a response.

9. The time that the message was sent **shall** be available for display.
10. The time that a response was sent **shall** be available for display.
11. Message send and message response time display formats **shall** include hours, minutes, and seconds (Universal Coordinated Time).
12. ATS messages should be displayed so that each message is distinguishable.
13. In the history log, the status of each message should be displayed together with the message.
14. Data maintained in the history log **shall** not be available for direct entry into the flight guidance system in a single action.
15. History log data **shall** be clearly marked by means of visual coding to prevent the crew from interpreting it as new information.
16. The system should alert the flight crew when message storage is not possible.

2.1.8 Error Detection, Prevention and Recovery

1. The data link system should be designed to detect and trap errors (e.g., out-of-range values, invalid alphanumerics) as the pilot inputs are entered.
2. Out-of-range or invalid flight crew entries **shall** prompt an error message from the system to assist the pilot in determining the nature of the error and how to correct it.

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3. If the data link system detects the receipt of an out of sequence message, the out-of-sequence message(s) **shall** be indicated in the message display and message log along with an explanation of the problem.

2.2 Equipment Installation and Operations Requirements

Note: The term pilot as used in this section applies to the pilot in command and first officer.

2.2.1 Accessibility

1. To support team operations, system controls **shall** be manipulable by the pilot in command and first officer from their normal seated positions.

2.2.2 Display Visibility

1. The display and the visual alert **shall** be positioned such that the angle between the ray extending forward from the pilot's eye reference point to any point on the display surface and the normal to the display surface **shall** not exceed the maximum preferred viewing angles of the display. The maximum preferred viewing angles are +/- 35 degrees horizontal, and +/- 20 degrees vertical relative to the normal visual angle, which is 15 degrees declined from the design eye reference point.
2. Reflectance of the CPDLC display **should** not interfere with the readability of other displays.

2.2.3 Failure Protection

1. CPDLC messages **shall** be stored in non-volatile memory to preclude the loss of data during power loss.

2.2.4 Associated and/or Integrated Equipment or Systems

1. If more than one ATS data link system is active on an aircraft, all ATS data link systems **shall** operate consistently and use the same style interface for alerting, sending, receiving, displaying, printing, and storing ATS messages that meets the requirements in accordance with this document.
2. If more than one ATS data link system is active on an aircraft, there **shall** be a continuous indication on the data link system display of which system is in use.
3. The CPDLC HCI should be consistent with the crew interface and flight deck design of the particular aircraft in which the CPDLC system is installed.

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4. Data link systems should be designed to facilitate sharing of information with other associated flight deck systems.
5. The aural alert for data link messages **shall** be integrated with the flight intercom system.
6. The pilot should not be required to enter the same information multiple times into different flight deck equipment.
7. In order to minimize crew reentry of data, the data link system should be integrated with associated flight deck equipment including airborne flight management, control, and information systems.
8. If the CPDLC system has the ability to transfer data to other flight deck subsystem, i.e., the Flight Management System, it should be clearly indicated on the flight deck data link display which parts of a message can be transferred to other functions. All transferable parts of the message must have been displayed before the transfer can occur.
9. Data link installations should not prevent the pilot from performing other high priority tasks by either requiring full devotion of the pilot's attention resources or by tying up the equipment needed for the other tasks with data link functions.

2.2.4.1 Printer

1. If a CPDLC message is sent to the printer, the CPDLC system should have an indication of the printer status.
2. The printer should be located in a position which does not require either of the pilots to leave their seats to access information.
3. The data link printer should be able to be serviced without lengthy distraction from other pilot tasks.
4. A means should be provided for the flightcrew to selectively print any displayed or stored message.
5. The printer quality should be equivalent to at least an ARINC 740 printer.
6. The printer should accommodate the maximum length message.
7. The paper capacity should preclude the need for frequent in-flight servicing.
8. If message printing capability is provided, the system should alert the flightcrew when printing is not possible.

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3.0 Air Traffic Service (ATS) Ground System Requirements

This section contains standards for the air traffic service ground system equipment, equipment installation, and operations. This section also describes the equipment operational performance characteristics and defines conditions that will assure that air traffic service specialist (ATSS or controller) and airway facilities specialist (AFS) operations can be conducted safely and reliably in the expected operational environment. Guidance presented in Section 3.0 is relevant for all builds but does not comprehensively address builds beyond Build 1A. Additional requirements will be developed for builds beyond Build 1A.

3.1 Air Traffic Service Specialist (ATSS) Requirements

It is critical to the overall usability of the controller's system that the available software tools provide a human-computer interface with a common appearance and behavior so that controllers can interact effectively with any tools resident in the system. HCI commonality is particularly important as controllers are provided the capability to interact with a variety of complex, multi-windowed tools within in a single system. The benefits to be gained from a common HCI are increased controller productivity, reduced training requirements, and improved system reliability.

3.1.1 System Performance and Design Requirements

3.1.1.1 General

1. The system should provide cues (e.g., prompts, display formats) that encourage controllers to perform appropriate operations and prevent them from performing incorrect operations, rather than relying on error messages to inform them that an error has been made (DoD, 1998, pp 8-13).
2. Controller management of communications information and related tasks, such as flight data updates, for equipped and unequipped aircraft should be consistent.
3. Computer updates associated with voice and data link communications should not require different data entry forms and procedures.
4. As new data link services are developed in builds beyond Build 1A, implementation of these services should be compatible with established design conventions and promote predictable controller actions.

3.1.1.2 Interactive Control

1. The system **shall** execute an action only in response to explicit controller input.
2. An explicit controller input **shall** be required to authorize transmission of a message or to select an automatic transmission mode for a specific type of message (e.g., TOC).
3. The system **shall** echo controller alphanumeric inputs within 0.2 s and respond to controller inputs within 0.5 s, either by completing the processing or by providing feedback that the input is being processed, to prevent slowing tasks down and inducing entry errors such as multiple entries.

4. When a control entry, such as closing a window, deleting a message or turning off the data link system, will cause a loss of data, the CPDLC system HCI **shall** display an advisory message and require a confirmation action before implementing the entry.
5. Operations that occur most often should be executable with a minimum number of control operations. The number of operations may be reduced through the use of dedicated controls, automated changes that anticipate controller requirements, and the use of quick access menus.
6. If the system uses software controls (e.g., text boxes, list boxes, radio buttons), to select CPDLC system parameters, the controls **shall** provide continuous feedback on the selected parameters.
7. If the controller may only select a single item from a list, the available selection method should be limited to this type of action.
8. The system should allow the controller to suspend ongoing data link functions (e.g., composing, reviewing, or responding to a message) to access other functions at any time, and resume the suspended function at the point at which it was suspended.
9. When the controller resumes a suspended function, an indication **shall** be provided of where the controller is in the suspended function.

3.1.1.2.1 Layout of Data Link Keys

1. To the extent possible, data link keys should be organized according to the following principles:
   - Partition the keys into functional groups
   - Place the most frequently used keys in the most accessible locations
   - Arrange the keys according to the sequence of use

Notes:

1) *Dedicated keys should be used for frequently used functions.*
2) *Frequent data link functions are those that select, compose, and transmit data link messages.*

3.1.1.2.2 Interchangeability Between Input Devices

1. Frequently performed CPDLC functions should be able to be accomplished using either the trackball or keybord commands.
2. The system **shall** not force controllers to change input devices repeatedly when performing data link functions.

3.1.1.2.3 User-Computer Interaction Conventions

1. The system **shall** clearly indicate functions that are available for use from those that are not available based on the current context of the system or message status.

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2. The D controller keyboard and input device **shall** be capable of interactive data link functions, including message composition, response, and transmission.

3. CPDLC displays **shall** be consistent at R and D controller positions.

3.1.1.2.4 Menu Items and Menu Logic

1. When hierarchic menus are used, only one action should be required to return to the next higher level.

2. When hierarchic menus are used, only one action should be required to return to the CPDLC menu at the top level.

3. Menu organization should support specific controller tasks e.g., sending messages and responding to pilot-initiated messages.

4. Menu options **shall** indicate the action to be executed.

5. The controller **shall** not be required to traverse more than three levels in a menu structure for infrequently performed tasks, and no more than two levels for frequently performed tasks.

6. If an option is never available to the controller, the option **shall** not be presented in the menu.

7. If an option is temporarily unavailable, it should be displayed in the menu with an indication that it is unavailable.

8. Menu options **shall** be organized in logical or functional groupings with clear titles.

9. If similar options are in different menus, the options **shall** be ordered in a consistent manner.

3.1.1.3 Characteristics of Displayed Information

1. CPDLC **shall** use an alphanumeric font of a sufficient thickness and size to be readable when users are seated at the normal viewing distance from the screen.

Note: Sans serif fonts are recommended.

2. At a minimum, character height and symbol size should be 1/200 of viewing distance (e.g., a viewing distance of 36 inches requires a .18 inch character height on the screen) (DoD, 1998, pp12-1).

3. The contrast of all symbols and text **shall** be no less than 3:1.

Note: The American National Standards Institute (ANSI) recommends a contrast ratio of 7:1 for alphanumeric characters, and cites 3:1 as a minimum (ANSI, 1988). The International Civil Aviation Organization (ICAO,1993) recommends a contrast ratio of 8:1 for items (such as data blocks) that need to be read. For details that do not need to be read, such as maps and range rings, a contrast ratio of 3:1 is acceptable.

4. If symbols are used to label data, CPDLC **shall** use appropriate symbols for degrees, minutes, and seconds to improve readability (DoD, 1998, pp 12-2).

5. Labels **shall** be located sufficiently close to be associated with the data field but separated from the data field by at least one space (Smith & Mosier, 1986).
6. Symbols **shall** be used for a single purpose within the CPDLC system.
7. Use of symbols in the CPDLC system **shall** be consistent with the use of symbols in the legacy ground system.

3.1.1.3.1 Color

1. Whenever color is used to code information, it **shall** be used redundantly with another means of coding information. This means that there should be some indication, other than color, about the information that the color is to convey.
2. Color-coding should be consistent throughout the CPDLC system and should be consistent across all of the displays a controller team will use.
3. When colors are assigned a meaning, the colors should be readily identifiable and each color should have only one meaning.

Note: The number of colors assigned a different meaning should be limited to the number of colors shown to be able to be accurately identified on the chosen background (e.g., six colors on a black background), so that the colors, and their meanings, are not likely to be confused. Using a background color other than black is likely to decrease the number of usable colors (i.e., those to which can be assigned a meaning) to less than six.

4. The color red should only be used as an alert or warning, that is, when immediate controller action is required.

Note: This does not mean that alerts must be red, only that whenever red is used, it should be used only to convey critical information. Since red text can be difficult to read, the legibility of specific red text should be tested before implementation.

5. Green should be used only to indicate (or when it is compatible with) an "OK" status.
6. Pure (e.g., "royal") blue should not be used for text, small symbols, other fine detail or as a background color.

Note: Desaturated (i.e., "light") blue or cyan is usable on a black background or as a background color and very dark blue is usable on a light background or as a background color.

7. Yellow and white are easily confusable and only one of them should be used to code text or small symbols.
8. Bright, saturated colors should be used sparingly and only be used for critical and temporary information so they are not visually distracting.
9. Saturated red and blue should never be presented in close proximity to avoid a false perception of depth.

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3.1.1.4 System Status, Mode Awareness &System Failure

1. An unambiguous indication of system and function operational status and mode that affect operational procedures **shall** be provided to all controllers
2. The system **shall** display information associated with the aircraft position symbol/data block to indicate (1) which aircraft have a data link capability, (2) which aircraft have active data link connections with the facility, and (3) which aircraft are eligible to receive data link communications from the controller's sector.
3. If an aircraft has a data link connection but loses or terminates it, the controller **shall** have a positive indication of change in the aircraft's CPDLC system state. This means that the indication presents information and does not simply remove information from the display.
4. The system **shall** provide information needed to determine 1) which aircraft have a data link capability, 2) which aircraft have active data link connections with the facility, and which aircraft are eligible to receive data link communications from the controller's sector.
5. Data link system connectivity **shall** be established and displayed only when the aircraft has the capability to receive and process all data link services provided by the controller.
6. Indications of an aircraft's data link connection status (i.e. connection, and eligibility) **shall** be spatially associated with the aircraft's data block.
7. If the ground system or the controller switches to a back-up radar processing (Direct Access Radar Channel [DARC]) system and the CPDLC system is operational, the controller **shall** have access to CPDLC system status information.
8. For each open transaction that was open when a switch to the back-up radar processing system occurred, the controller **shall** have access to the flight identity associated with the transaction, message type and content, and the status at the time of the switch.
9. Pilot-initiated test messages should not be presented to the controller.

3.1.1.5 Alerting

1. The alerting function for pilot-initiated messages **shall** be distinguishable from any other alerts presented at the controller's workstation.
2. Alert coding **shall** be consistent with the message's alert attribute (i.e., medium).
3. A visual alert **shall** be displayed until all open pilot-initiated downlinks have been closed.
4. A visual alert **shall** be cleared once all open pilot-initiated downlinks have been closed.

3.1.1.6 Message Handling

3.1.1.6.1 Message Queue & Display Precedence

1. When multiple data link messages are waiting, the system **shall** facilitate responses by order of urgency first and age second.
2. Within levels of urgency, messages **shall** be displayed in order of oldest to newest, based on sending time.

3. Within levels of urgency, if a data link system detects an out of sequence situation, the controller **shall** be notified.
4. The system **shall** provide a controller capability to select a pending message for display without requiring the controller to respond to the message.
5. All incoming pilot-initiated messages **shall** be retained in the message queue until they are closed.
6. Data link message precedence mechanisms **shall** be consistent across the various services and types of messages available. That is, more urgent messages always have display precedence over the less urgent, and alerting schemes must handle the variety of priorities correctly.
7. On the controller's workstation, aircraft with pending pilot-initiated data link messages **shall** be identified by a visual indication.
8. The controller's workstation **shall** maintain a pending message queue to store open pilot-initiated data link transactions for aircraft within the controller's jurisdiction.
9. The system **shall** provide a controller capability to display the pending message queue for all aircraft or for a specified aircraft.
10. If all pending messages in the queue are not displayed, a visible indicator **shall** be provided to notify the controller that messages exceed the space available.

3.1.1.6.2 Message Display and Formatting

1. For each pilot-initiated message, a unique message identifier **shall** be available for display.
2. An indication of message send time or age, based on send time, must be available for display on the message display to help controllers estimate data validity and for coordination.
3. Lines of text **shall** be broken only at spaces or at the end of words.
4. Parameters associated with text, labels, or symbols **shall** be adjacent to and grouped with their descriptive or explanatory text, labels or symbols, and on the same page.
5. If the complete message cannot be presented in the display area, there **shall** be an indicator to the controller that the message continues.
6. Displays of pilot-initiated messages **shall** present text of the message as specified in the SARPS, including the units of measurement and/or labels (e.g., knots, mach, altitude, flight level, heading) for the displayed data (Smith & Mosier, 1986).
7. For ground system display of pilot-initiated messages, the CPDLC system **shall** display complete words in preference to abbreviations unless the abbreviations or acronyms are more commonly used than the words they replace.
8. The CPDLC system should not abbreviate words or generate acronyms that produce ambiguous abbreviations or acronyms. Abbreviations should be defined for data link information that are consistent with abbreviations in use on the flight deck or in the ATC environment (see Appendix B).
9. If it is necessary to define abbreviations, a simple rule should be followed. Abbreviation by truncation is the best choice except when word endings convey important information or

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when truncation causes ambiguity. When a truncation rule is used, abbreviations are easy for a designer to derive and easy for to decode.

10. If abbreviations are used, a glossary should be available for reference.

3.1.1.6.3 Message Response

1. If the system allows the controller to select a downlink message from a list, the list **shall** be frozen from moving when the cursor is over the message.
2. Only the applicable response options **shall** be indicated when a specific message is selected by the controller.
3. For clearance requests, the data link system **shall** automatically generate and present an appropriate clearance for the controller to review and uplink.
4. It should not be possible to send a response to a message so soon after it is displayed that it could not have been read; the system **shall** provide a minimum 2 s delay between when the response to one message is sent and when the response to the next message can be accepted.
5. The system **shall** not allow a positive response until all of the message has been displayed.

3.1.1.6.4 Message Composition and Transmission

1. The data link system **shall** provide capabilities for controller message composition such as the following:
   - Form-filling - either controller entry or retrieval of stored parameters to fill in predefined message templates
   - Selection of predefined messages and elements from a menu
   - Entry of commands or use of function keys to quickly format messages
   - Transmission of computer generated message data
2. Any unrecognized or unreasonable entry **shall** prompt an error message from the system.
3. No data changes **shall** result from any erroneous message entry condition.
4. The error message **shall** provide the information needed to assist the controller in determining the nature of the error and how the error could be corrected
5. The HCI should clearly indicate the type and format of data expected.
6. Routine or default data, data already known by the ground system and data that can be computed by the system should be automatically entered whenever possible.
7. The HCI **shall** allow the controller to enter numbers from either the keyboard or the numeric pad.
8. The controller's HCI **shall** facilitate message composition by providing quick access to a limited set of frequently used messages tailored to the position's operation.

9. If controller message displays contain symbols or abbreviations, a full readout of the message **shall** be available.
10. If the system allows the controller to select a message or an aircraft from a list, the list **shall** be frozen from moving when the cursor is over the list.
11. If the HCI allows the controller to select the addressee of a message from an aircraft list, the HCI **shall** lock the list from moving when the cursor is over the aircraft list.
12. When an aircraft is selected for message transmission, the selected aircraft **shall** be emphasized in the controller's situation display and in the message composition area before the message is sent.
13. Where appropriate, controller transmission of a ATS messages **shall** update the ground system data base and associated displays.
14. The system **shall** provide a preview of controller-entered data as it is entered.
15. Before a controller-composed message is sent, the system **shall** display a preview of the message that will be sent.
16. When a clearance contains a constraint or condition such as "AT FIX", the constraint or condition should be displayed sufficiently close so that it is associated with the clearance data (e.g., on the same line).
17. Controllers **shall** have the capability to fix errors by editing individual characters rather than having to erase and retype the entire text string.
18. A new pilot-initiated message **shall** not automatically cover and displace a message currently being displayed. Disruption due to automatic overwriting of a message being processed by the controller should not be possible, and errors due to the association with a new message of a response intended for an old message should not be possible.

3.1.1.6.5 Message Status

1. Message status information for controller-initiated messages **shall** be available in a status list and/or in the aircraft's data block.
2. For each message in the status list, a unique message identifier **shall** be available for display.
3. For each uplink message, the system **shall** display the flight identification, the message content and status information, including but not limited to, whether the message is pending or whether the flight crew has acknowledged the message with a positive (WILCO, AFFIRMATIVE) or non-positive (UNABLE, NEGATIVE) response, whether an error message was received, or whether there was a problem in delivering the message.
4. Messages in the status list should be displayed so that each message is distinguishable.
5. In the status list, status information should be associated with the message text.
6. The content and status of messages containing clearances that alter an aircraft's trajectory (speed, heading, altitude) should be spatially associated with the position symbol/data block.

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7. For messages that do not have a data block presentation of content and status., an indication of an open transaction should be spatially associated with the aircraft's position symbol/data block.

Note: CPDLC research has consistently shown that certain types of information must be presented in focal vision to ensure detection, avoid interruption of the controller's scan of the situation display, and ensure effective controller performance. Message content and status information presented in the data block support controllers using a data link communications system in which there is a noticeable delay between sending a message and receiving a response. These displays maintain and even improve their efficiency by sending a message, going on to other aircraft, and then returning during the scan to check the status of the message. The content is also needed for key clearances because the time delay and intervening tasks require a display to remind the controller of what was sent. If these data are available only in a peripheral message list (status list), the scan is interrupted and using Data Link becomes a burden rather than an aid.

8. A positive, attention getting indication **shall** be presented to depict the following non-positive statuses: 1) an open transaction for an aircraft with a lost connection (FAIL), 2) an uplink message that generated an error message (ERROR), 3) a negative/unable (NEG/UNA) crew response, 4) a reminder of a late response (TIMEOUT) or if applicable, nonreceipt of a logical acknowledgement, and 5) a downlinked assigned level report (IC) which does not match the ground system's assigned level for the aircraft.
9. When a non-positive status is detected, the rejected messages and the status indicator **shall** be highlighted on the controller's display until the controller takes the appropriate action and clears the display.
10. The primary alert code for the non-positive status of messages containing clearances that alter an aircraft's trajectory (speed, heading, altitude) should be spatially associated with the position symbol/data block.
11. After a parameter time has elapsed, the system **shall** automatically clear status indications for transaction that have been closed with a positive response.
12. To support controller monitoring of transactions, transaction status information **shall** be located sufficiently close to be associated with message displays.

3.1.1.6.6 Message Recall and History

1. The controller's workstation **shall** maintain a message history log to store closed data link transactions.

Note: This requirement does not apply to Build 1.

2. A message history log should contain at least the last five messages that were sent to each aircraft.
3. The system **shall** provide a controller capability to display messages for that sectors log and for a specified aircraft.

Note: This requirement does not apply to Build 1.

4. Displayed history messages **shall** be distinguishable from pending messages.
5. If a history log list is displayed, the list **shall** be ordered by message age.

6. Message age **shall** be based on the time that the message was sent.
7. The send time **shall** be generated by the controller's action to transmit the message.
8. If a response has been sent for the message both the message and response **shall** be displayed in the history list.

Note: Not all CPDLC messages require a response.

9. Responses **shall** be located sufficiently close to be associated with the message data but separated from the data field by at least one space (Smith & Mosier, 1986).
10. The time that the message was sent **shall** be available for display.
11. The time that a response was sent **shall** be available for display.

3.1.1.7 Error Detection and Recovery

1. If an error is detected, the system **shall** notify the controller with an informative, diagnostic error message that explains the nature of the error.
2. The data link system should be designed to detect and trap errors (e.g., out-of range values) before uplink to an aircraft.

3.1.1.8 Offline Message Composition Capability (Menu Build)

The CPDLC Menu Build function provides the interface that allows the creation of Menu Text messages for controller uplink. These messages may be tailored to meet the specific needs of individual centers and their sectors and are created by the area supervisor. In addition to the message text, the supervisor creates a short descriptive label that appears in the controller's menu list and assigns a message referent that the controller may enter to select a message for uplink. This section contains requirements and guidelines for the design of the Menu Build interface. In addition to the requirements listed in this section, the Menu Build function should conform to the requirements in sections 3.1.1.2 through 3.1.1.4. Some of these requirements are repeated in this section for emphasis.

31.1.8.1 Interactive Control

1. The system **shall** echo alphanumeric inputs within 0.2 s and respond to supervisor inputs within 0.5 s, either by completing the processing or by providing feedback that the input is being processed, to prevent slowing tasks down and inducing entry errors such as multiple entries.

2. When a control entry, such as closing a window, will cause the loss of data, display an advisory message and require a confirmation action before implementing it.

3.1.1.8.2 Menu Message Data Display

1. The contrast of all symbols and text **shall** be no less than 3:1.

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Note: The American National Standards Institute (ANSI) recommends a contrast ratio of 7:1 for alphanumeric characters, and cites 3:1 as a minimum (ANSI, 1988). The International Civil Aviation Organization (ICAO,1993) recommends a contrast ratio of 8:1 for items (such as data blocks) that need to be read. For details that do not need to be read, such as maps and range rings, a contrast ratio of 3:1 is acceptable.

2. The Menu Build function **shall** use an alphanumeric font of a sufficient thickness and size to be readable when user are seated at the normal viewing distance from the screen.

Note: Sans serif fonts are recommended.

3. At a minimum, character height and symbol size should be 1/200 of viewing distance (e.g., a viewing distance of 36 inches requires a .18 inch character height on the screen) (DoD, 1998, pp12-1).

4. Symbols used for **shall** be used for a single purpose within the CPDLC system.

3.1.1.8.3 Menu Message Composition

1. Menu options **shall** be organized in logical or functional groupings with clear titles.
2. When a pop-up menu appears, it appears near the element it is associated with.
3. Menu options **shall** indicate the action to be executed.
4. On-screen instructions should be adequate for performing the actions required by each menu.
5. The supervisor **shall** not be required to traverse more than three levels in a menu structure for infrequently performed tasks, and no more than two levels for frequently performed tasks.
6. Any unrecognized or unreasonable entry **shall** prompt an error message from the system.
7. No data changes **shall** result from any erroneous message entry condition.
8. The error message **shall** provide the information needed to assist the supervisor in determining the nature of the error and how the error could be corrected
9. The system should clearly indicate the type and format of data expected.
10. If message displays contain symbols or abbreviations, a full readout of the message **shall** be available.
11. The system **shall** provide a preview of data as it is entered.
12. Before a message is saved, the system **shall** display a preview of the message that will be sent.
13. The supervisor **shall** have the capability to fix errors by editing individual characters rather than having to erase and retype the entire text string.
14. When composing free text messages, the message text should consist of complete words in preference to abbreviations unless the abbreviations or acronyms are more commonly used than the words they replace.

15. Free text messages should not abbreviate words or generate acronyms that produce ambiguous abbreviations or acronyms.
16. Abbreviations should be defined for data link information that are consistent with abbreviations in use on the flight deck or in the ATC environment (see Appendix B).
17. If it is necessary to define abbreviations, a simple rule should be followed. Abbreviation by truncation is the best choice except when word endings convey important information or when truncation causes ambiguity. When a truncation rule is used, abbreviations are easy for a designer to derive and easy for to decode.
18. If abbreviations are used, a glossary should be available for reference.
19. Aids should be provided indicating formats and standard abbreviations and acronyms for use in creating the full message text and summaries for display in the Status and Menu Text Lists.

3.1.1.8.4 Modifying/Creating Menu Entries

1. The CPDLC system **shall** permit the simultaneous reviewing of menu entries from multiple workstations.
2. The CPDLC system **shall** prohibit the simultaneous editing of the same menu build entry from multiple workstations.
3. The CPCDLC system **shall** permit the simultaneous editing of different menu entries from multiple workstations.
4. The CPDLC system **shall** provide the capability to create and store messages without assigning a referent or assigning the message to a sector.

Note: This capability is needed to allow for rapid reconfiguration of controller menu to include messages that are used frequently but on a temporary basis.

5. The Menu Build function shall provide the capability to select all sectors with a single entry.

3.1.1.8.5 Menu Build Procedures

1. Procedures should be developed to prevent supervisors from editing messages not assigned to sectors in their areas.
2. Procedures should be developed to prevent supervisors from modifying temporary messages. The Supervisor should create a new temporary message with a new referent when one is needed.

3.1.2 Controller Workstation Integration and Operations Requirements

1. To support team operations, visual display information should be located within the forward field of view of all controllers, and system controls **shall** be accessible to all controllers.

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2. To support access to data link functions by the associate radar controller, data link displays and input capabilities should be available on the Data (D)-position display and keyboard.

3. Data link installations should not prevent the controller from performing other high priority tasks by either requiring full devotion of the controller's attention resources or by tying up the equipment needed for the other tasks with data link functions.

4. The data link prioritization scheme **shall** be compatible with all workstation functions, and inclusive of all functions that may generate workstation messages.

5. Data link systems **shall** not preclude access to other functions or unduly conflict with higher priority operations.

6. Symbols for graphic presentation **shall** be consistent within the controller's workstation.

7. If data link operations share display and control equipment with other functions, one controller's use of data link functions should not impede another controller's use of other equipment functions, particularly if there is only one of the equipment at the workstation.

3.2 Airway Facilities (AF) Specialist Requirements

AF operations for the CPDLC system are performed by AF specialists (technicians). It is critical to the overall usability of the technician's monitoring and control system that the available software tools provide a human-computer interface with a common appearance and behavior so that technician can interact effectively with any of the devices monitored by the system. HCI commonality is particularly important as technicians are provided the capability to interact with a variety of complex, multi-windowed tools within in a single system. The benefits to be gained from a common HCI are increased technician productivity, reduced training requirements, and improved system reliability.

3.2.1 System Performance and Design Requirements

3.2.1.1 General

This section contains requirements and guidelines for the design of ATSS ground system equipment, hardware and software, that may be used for CPDLC monitoring and control. The control and display equipment used by AF specialists should incorporate the basic guidance called out in DOT/FAA/CT-96-1. Guidance presented in the General section is relevant for all builds but does not comprehensively address builds beyond Build 1A. Additional requirements will be developed for builds beyond Build 1A.

1. The CPDLC monitoring and control system should provide cues (e.g., prompts, display format) that encourage technicians to perform appropriate operations and prevent them from performing incorrect operations, rather than relying on error messages to inform them that an error has been made (DoD, 1998, pp 8-13).

2. Procedures for performing the technician's tasks related to CPDLC monitoring and control, such as checking the status of the data link applications processor, should be

consistent with the procedures used for performing the same tasks on other systems attached to the HID and monitored through the NSM.

3. There should be a high degree of consistency throughout the HCI in maintenance automation programs and subsystems. (DOT/FAA/CT-96-1)
4. The HCI as well as hardware and software subsystems should reflect an obvious logic based on human-centered task needs and capabilities. (DOT/FAA/CT-96-1)
5. The HCI should represent the simplest design consistent with functions and tasks of the users of the operational and maintenance subsystems. (DOT/FAA/CT-96-1)
6. Information presented to the user should accurately reflect system and environment status in a manner so that the user rapidly recognizes, easily understands, and easily projects system outcomes in relation to system and user goals. (DOT/FAA/CT-96-1)
7. Automated maintenance subsystems should help the users accomplish their system functions and tasks. Information and data should be presented in easy-to-use intuitive formats and control capabilities should account for the range of safe actions. (DOT/FAA/CT-96-1)

3.2.1.2 Controls

Controls should be designed to maximize usability and minimize workload and technician errors. Operations that occur frequently should be executable with a minimum number of actions. The number of actions may be reduced through the use of dedicated controls and the use of quick access menus.

3.2.1.2.1 Layout of Controls

To the extent possible, controls should be organized according to the following principles:

- Collocate the controls with associated displays
- Partition the controls into functional groups
- Place the most important controls in the most accessible locations
- Place the most frequently used controls in the most accessible locations
- Arrange the controls according to the sequence of use
- Arrange the controls so they do not obscure other controls or displays
- Arrange sets of controls that perform similar functions consistently

3.2.1.2.2 Operation of Controls and Input Devices

1. Controls **shall** provide feedback when operated.

Note: Tactile and visual cues are acceptable forms of feedback.

2. Controls **shall** be resistant to inadvertent activation. (See appendix F)

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3. Activation or use of a control **shall** not require simultaneous use of two or more controls (e.g., pushing two buttons at once).
4. If a control can be used for multiple functions, the current function **shall** be indicated and discriminable in all environmental conditions (e.g., lighting, ambient noise).
5. The response of a display to movements of its associated control **shall** be consistent, predictable, and compatible with the technician's expectations. (DOT/FAA/CT-96-1)
6. The delay between the movement of a control and the response to that movement on the display **shall** be minimized (DOT/FAA/CT-96-1)

3.2.1.2.3 Interactive Control

1. The system **shall** execute an action only in response to explicit technician input.
2. The system **shall** echo technician alphanumeric inputs within 0.2 s and respond to technician inputs within 0.5 s, either by completing the processing or by providing feedback that the input is being processed.
3. If several windows are displayed at once, AF specialist **shall** have an easy means to shift among them to select which window is currently active.
4. If several windows are displayed at once, the system **shall** indicate which is the active window.
5. In scanning through a multi page display, AF specialist should be able to scroll forward or backward at will.
6. The AF specialist should not be forced to cycle through an entire display series to reach a previous page.
7. When a control entry, such as closing a window, deleting a message or turning off the data link system, will cause a loss of data, the CPDLC monitoring and control system **shall** display an advisory message and require a confirmation action before implementing the entry.
8. If the system uses software controls (e.g., text boxes, list boxes, radio buttons), to select CPDLC monitoring and control system parameters, the controls **shall** provide continuous feedback on the selected parameters.
9. If the technician may only select a single item from a list, the available selection method should be limited to this type of action.
10. The technician **shall** be able to suspend ongoing monitoring functions to access other functions at any time, and resume the suspended function at the point at which it was suspended.
11. An indication **shall** be provided of where the technician is in the suspended function.
12. Technicians **shall** not be forced to change input devices repeatedly when performing data link functions.
13. The system **shall** clearly indicate functions that are available for use from those that are not available based on the current context of the system status.
14. The amount of keying required should be minimized. (MIL-STD-1472E, 1996, 5.15.2.2.7)

15. The system should provide an explicitly labeled confirm functions key, different from the enter key for confirmation of control and data entries.
16. Fixed function keys (e.g., ENTER) should be used for time-critical, error-critical, or frequently used control inputs. (MIL-STD-1472E, 1996, 5.15.2.3.1)

3.2.1.2.4 Display of Menu Items and Menu Logic

1. If an option is never available to the technician, the option **shall** not be in the menu.
2. When hierarchic menus are used, only one action should be required to return to the next higher level.
3. When hierarchic menus are used, only one action should be required to return to the general menu at the top level.
4. The technician should not be required to traverse more than three levels in a menu structure, and no more than two levels for frequently performed tasks.
5. Menu organization should support specific technician tasks.
6. Prompts and menu options should indicate the action to be executed.
7. If an option is temporarily unavailable, it should be displayed in the menu with an indication that it is unavailable.
8. Options to perform opposing actions **shall** not be place adjacent to each other.
9. Menu options **shall** be organized in functional groupings with clear titles.
10. Menu options **shall** be arranged with the most frequently used options at the top.
11. If there is no functional grouping, the options **shall** be arranged in alphabetical order.
12. If similar options are in different menus, the options **shall** be ordered in a consistent manner.
13. Cascading sub-menus should appear to the right of the parent menu. If space to the right is limited, the sub-menu appears below the parent menu.
14. When a popup menu appears, it should appear near the associated element.

3.2.1.2.5 Characteristics of Displayed Information

1. The CPDLC monitoring and control system **shall** use an alphanumeric font of a sufficient thickness and size to be readable when user are seated at the normal viewing distance from the screen.

Note: Sans serif fonts are recommended.

2. At a minimum, character height and symbol size should be 1/200 of viewing distance (e.g., a viewing distance of 36 inches requires a .18 inch character height on the screen) (DoD, 1998, pp12-1).
3. The CPDLC monitoring and control system **shall** display complete words in preference to abbreviations unless the abbreviations or acronyms are more commonly used than the words they replace.

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4. The CPDLC monitoring and control system should not abbreviate words or generate acronyms that produce ambiguous abbreviations or acronyms. *Editor's Note: cite appendix A and B* Abbreviations should be defined for data link information that are consistent with abbreviations in use in the technician's workstation.
5. If abbreviations are used, a dictionary should be available for reference.
6. Labels **shall** be located sufficiently close to be associated with the data field but separated from the data field by at least one space (Smith & Mosier, 1986).
7. Labels **shall** be provided (1) to locate and identify controls and displays, (2) to interpret and follow procedures, and/or (3) to avoid hazards. (DOT/FAA/CT-96-1)
8. The selection and use of terminology in labels **shall** be consistent.
9. If controls and displays must be used together (as, for example, in certain adjustment tasks), appropriate labels **shall** indicate their functional relationship. (DOT/FAA/CT-96-1)
10. To the extent possible, a symbol should be (1) an analog of the object it represents, (2) in general use and well known to the users, or (3) based on established standards or conventional meanings. (DOT/FAA/CT-96-1)
11. Symbols **shall** be used for a single purpose within the CPDLC monitoring and control system.
12. Use of symbols in the CPDLC monitoring and control system **shall** be consistent with the use of symbols in the other monitored HID systems.
13. Symbols for graphic presentation **shall** be consistent within the CPDLC monitoring and control system.

3.2.1.2.5.1 Color

1. Whenever color is used to code information, it **shall** be used redundantly with another means of coding information. This means that there must be some indication, other than color, about the information that the color is to convey.
2. Color-coding should be consistent throughout the CPDLC monitoring and control system and should be consistent across all of the displays a single technician will use.
3. When colors are assigned a meaning, the colors should be readily identifiable and each color should have only one meaning.
4. Whenever color is used to code information, no more than five colors shall be assigned a meaning in the CPDLC monitoring and control system .

Note: The number of colors assigned a different meaning should be limited to the number of colors shown to be able to be accurately identified on the chosen background (e.g., six colors on a black background), so that the colors, and their meanings, are not likely to be confused Using a background color other than black is likely to decrease the number of usable colors (i.e., those to which can be assigned a meaning) to less than six.

5. The color red should only be used as an alert or warning, that is, when immediate technician action is required.

Note: This does not mean that alerts must be red, only that whenever red is used, it should be used only to convey critical information. Since red text can be difficult to read, the legibility of specific red text should be tested before implementation.

6. Green should be used only to indicate (or when it is compatible with) an "OK" status.
7. Pure (e.g., “royal”) blue should not be used for text, small symbols, other fine detail or as a background color.

Note: Desaturated (i.e., “light”) blue or cyan is usable on a black background or as a background color and very dark blue is usable on a light background or as a background color.

8. Yellow and white are easily confusable and only one of them should be used to code text or small symbols.
9. Bright, saturated colors should be used sparingly and only be used for critical and temporary information so they are not visually distracting.
10. Saturated red and blue should never be presented in close proximity to avoid a false perception of depth.

3.2.1.2.6 Alerting

1. The alerting function for CPDLC errors and faults **shall** be distinguishable from any other alerts presented at the technician’s workstation.
2. Alarm/alert coding for CPDLC **shall** be consistent with the alerting scheme for other HID systems monitored by the NSM.
3. Alert and alarm features (including any applicable automated aiding) associated with CPDLC maintenance systems should:
   a) ensure that the operator’s attention is directed by an alarm to the fact that a facility, system, subsystem, or process has failed or is operating in an out-of-tolerance condition;
   b) inform the operator of the priority and nature of any deviation;
   c) guide the operator’s initial responses;
   d) be able to confirm in a timely manner that the operator’s action corrected the deviation;
   e) be as simple and unambiguous as possible so that the operator can understand and verify its rationale and processes,
   f) if applicable, employ trend information to alert responsible humans of pending problems and to increase their confidence in the alarm system; and
   g) if response time will permit, provide quick means for operators to evaluate the validity of alarm signals. (DOT/FAA/CT-96-1)
4. Alarm signals and messages **shall** be distinctive and consistent for each class of event. (DOT/FAA/CT-96-1)

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5. A system or application **shall** provide users a means of acknowledging critical and noncritical alarms, and of turning off alarm signals once the alarms have been acknowledged or the condition generating the alarm has been corrected.
6. The procedures for acknowledgment and termination should not decrease the speed and accuracy of operator reaction to the alerting situation. (DOT/FAA/CT-96-1)
7. Users **shall** be provided informative feedback for actions that trigger alarms and alerting signals. If necessary, users should be able to request help and related information for the operation and processing of critical and noncritical alarms, messages, and signals. (DOT/FAA/CT-96-1)
8. A system or application **shall** provide users with a simple means for turning off an auditory alarm without erasing any displayed message that accompanies the auditory signal. (DOT/FAA/CT-96-1)

3.2.1.2.7 System Status, Mode Awareness &System Failure

1. The data link monitoring and control system **shall** provide a display of current operational status of connection to the A/G communication service provider and the status of the CPDLC and CM applications.

2. A positive indication of failures of the data link system, the system hardware components, the loss of a data link connection, and the failure to successfully send or receive a message **shall** be provided.

3. Control automation itself **shall** never fail silently or passively.

4. The HCI **shall** indicate functions that are available for use from those that are not, based on the current context of the system status.

5. When warranted by system complexity, status displays should incorporate graphical representations that integrate the status, flow, and coverage information most needed by AF technicians. The following are examples of features that should be considered for display:

    - continuously operative communications system status displays that can show options for normal, degraded, backup, and emergency operations;

    - communications routing status that show displays where failures have caused automatic switching to backup capabilities, or where manual or automatic rerouting is in effect;

    - alerting and alarm indications as to the location of the problem communications equipment and the nature of the problem;

    - failure of components that are transparent to users;

    - periodic manual or automated communications checking results; and

    - supportive historical and diagnostic information available for specific components. (DOT/FAA/CT-96-1)

3.2.1.2.8 Error Management

1. Any unrecognized or unreasonable entry **shall** prompt an error message from the system.
2. No data changes **shall** result from any erroneous message entry condition.
3. The error message **shall** provide the information needed to assist the technician in determining the nature of the error and how the error could be corrected.
4. The system **shall** permit correction of individual errors without requiring re-entry of correctly entered commands or data elements (MIL-STD-1472E, 1996, 5.15.8.1).
5. The system **shall** indicate the type and format of data expected.
6. Within the CPDLC monitoring and control system, standard locations and formats and coding of data should be used to facilitate data entry and error checking and reduce the time and errors associated with reading the data.
7. When a user signals for system log-off, or application exit or shutdown, the system should check pending transactions to determine if data loss seems probable. If so, the computer should prompt for confirmation before the log-off command is executed. (MIL-STD-1472E, 1996, 5.15.1.6)

3.2.1.2.9 Test Messages

1. The system **shall** provide the capability to verify communications with avionics via data link.

Note: The avionics used in this test will not be with an airborne aircraft.

2. Each test message **shall** be uniquely identifiable.

3.2.1.2.9.1 Test Message Status

1. A positive, attention getting indication **shall** be presented to depict failed test message statuses.

2. If a connection is lost, each open test transaction **shall** be closed and have an indication associated with the message that the connection has been lost.

3.2.1.2.10 Maintenance Message Display

Maintenance messages may be displayed through several special purpose message windows. These include request windows, error message windows, information message windows, confirmation message windows, warning message windows, and "working" message windows.

1. Message windows should contain (1) a title, (2) an indication of the type of message, (3) the message itself, and (4) the applicable response options. (DOT/FAA/CT-96-1)
2. The messages in message windows should use language that is meaningful to users and should require no further documentation or translation. (DOT/FAA/CT-96-1)

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3. Critical messages warning users of destructive consequences of actions should be displayed in warning message windows, and processing should be suspended until a user responds. (DOT/FAA/CT-96-1)
4. Message urgency should be conveyed (e.g., highlight, border color, or some other visual and/or auditory coding technique) to facilitate recognition of urgency and the appropriate response time.
5. If the processing time resulting from a user action will exceed 2 seconds, the system **shall** display a "working" message window that does not interrupt processing and is removed automatically when processing is completed. (DOT/FAA/CT-96-1)

3.2.1.2.10.1 Maintenance Message Recall and History

1. The AF Specialist workstation **shall** maintain a message history log to store closed data link transactions.
2. The system **shall** provide a technician capability to display recalled log messages for all aircraft or for a specified aircraft.
3. Alerting and alarm events or automatic switching events **shall** be logged and presented through status displays to notify the individuals monitoring the system. (DOT/FAA/CT-96-1)
4. When a person monitoring the system makes any control, diagnostic, or switching actions that affect the performance of the CPDLC system, these human control actions should be entered into a log automatically.

3.2.1.2.11 The Maintenance Manual

1. One or more maintenance manuals **shall** be provided to instruct technicians on how to perform all required operating and maintenance procedures.
2. A proceduralized instruction **shall** include all of the following supporting information that is applicable:
    a. An applicability statement that specifies the equipment or systems to which the procedure applies and its purpose;
    b. Any initial setup or input conditions required for the procedure;
    c. A list of tools or test equipment required;
    d. A list of materials and mandatory parts required;
    e. A list of support equipment required;
    f. If more than one, the minimum number of personnel required;
    g. A system preparation checklist; and,
    h. A list of any special environmental conditions required (for example, ventilation, lighting, temperature, noise level, electromagnetic interference, cleanliness, and humidity). (DOT/FAA/CT-96-1)
3. A proceduralized instruction **shall** apply to a single task and present instructional information as a series of steps. A lengthy or complicated procedure may be divided into a

series of related subtasks as long as each subtask accomplishes a distinct, recognizable objective. (DOT/FAA/CT-96-1)

4. Proceduralized instructions **shall** include a level of detail that is appropriate to the intended users. (DOT/FAA/CT-96-1)
5. Each proceduralized instruction **shall** contain all the steps and supporting information required to successfully complete the task. (DOT/FAA/CT-96-1)
6. A proceduralized instruction **shall** be organized in a hierarchical, logical, consistent manner that is apparent to the user. (DOT/FAA/CT-96-1)
7. A proceduralized instruction **shall** have a title that uniquely identifies the task to be performed. (DOT/FAA/CT-96-1)
8. If a proceduralized instruction contains distinct parts, each part **shall** have a heading. (DOT/FAA/CT-96-1)
9. Steps **shall** be numbered in a way that provides useful information to users without being overly complex. (DOT/FAA/CT-96-1)
10. Warnings, cautions, and notes **shall** be included in proceduralized instructions, as appropriate. (DOT/FAA/CT-96-1).

Note: Warnings are provided whenever a step or procedure or the failure to perform a step or procedure correctly might result in personal injury to, or loss of life of, the maintainer or anyone else. Cautions are provided whenever a step or procedure or the failure to perform a step or procedure correctly might result in damage or destruction of equipment or systems. Notes are provided whenever it seems appropriate to call the reader's attention to something or to provide additional information. (DOT/FAA/CT-96-1)

11. Warnings, cautions, and notes **shall** not themselves contain procedural steps. (DOT/FAA/CT-96-1)
12. Information that is important and useful but not easily incorporated into a procedure should be presented in an appendix or attachment to the procedure. However, the use of appendixes and attachments should be minimized. (DOT/FAA/CT-96-1)

3.2.2 Technician Workstation Integration and Operations Requirements

1. Use of the CPDLC monitoring and control system **shall** not preclude access to other monitoring functions or conflict with higher priority operations.

3.2.2.1 Equipment Access

1. The controls and equipment for maintenance of CPDLC system components **shall** be readily accessible to technicians.
2. Arm and hand access. Openings provided for access to interior equipment **shall** be sized to permit the required adjustment or handling and **shall** provide an adequate view of the item being manipulated. (MIL-STD-1472E, 1996, 5.9.9.5.1).
3. Access openings **shall** be large enough to permit operation of tools for maintenance of the equipment reached through the access. (MIL-STD-1472E, 1996, 5.9.9.5.1.3).

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4. Where visual access is required, the opening **shall** provide a visual angle sufficient to view all required information at the normal operating or maintenance position (MIL-STD-1472E, 1996, 5.9.9.6)

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Appendix A: Abbreviations and Acronyms

AF	Airway Facilities
AFS	Airway Facilities Specialist
ANSI	American National Standards Institute
ARTCCs	Air Route Traffic control Centers
AS	Altimeter Setting
ATN	Aeronautical Telecommunications Network
ATS	Air Traffic Service
ATSS	Air Traffic Service Specialist
BIS	Boundary Intermediate System
CMA	Context Management Application
CPDLC	Controller-Pilot Data Link Communications
D	Data
DLAP	Data Line Application Processor
DSR	Display System Replacement
G/G	Ground/Ground
HCI	Human Computer Interface
HCS	Host Computer System
HID	Host Interface Device
IC	Initial Contact
ICAO	International Civil Aviation Organization
MFD	Multi-Function Display
N	Normal
NADIN	National Airspace Data Interchange Network
NAS	National Airspace System
NSM	Network System Manager
PSN	Packet Switch Network
SARPS	Standard and Recommended Practices
TMC	Technical Management Committee
TOC	Transfer of Communication
U	Urgent
URG	Urgency
US	United States

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VDL	Very high frequency Digital Link
VDL-M2	Very High Frequency Digital Link-Mode 2

Appendix B: Design Guidance for Abbreviations and Acronyms in CPDLC Displays

Editor's Note: This Appendix is under development by Working Group 3

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Appendix C: Controller–Pilot Data Link Communications Build 1/1A Message Set

Uplink Messages

The uplink messages for CPDLC-I/IA are presented in this section. For a description of message attributes (i.e., URG, ALRT, RESP), refer to the ATN SARPs section 2.3.7.

TABLE C-1 RESPONSES/ACKNOWLEDGMENTS (UPLINK)

	Message Intent/Use	Message Element	URG	ALRT	RESP
0	Indicates that ATC cannot comply with the request.	UNABLE	N	M	N
1	Indicates that ATC has received the message and will respond.	STANDBY	N	L	N
3	Indicates that ATC has received and understood the message.	ROGER	N	L	N

TABLE C-2 VERTICAL CLEARANCES (UPLINK)

	Message Intent/Use	Message Element	URG	ALRT	RESP
19	Instruction to maintain the specified level.	MAINTAIN *(level)*	N	M	W/U
20	Instruction that a climb to a specified level is to commence and once reached the specified level is to be maintained.	CLIMB TO *(level)*	N	M	W/U
23	Instruction that a descent to a specified level is to commence and once reached the specified level is to be maintained.	DESCEND TO *(level)*	N	M	W/U

Note: Wherever the variable (level) is specified, the message can specify either a single level or a vertical range, i.e., block level.

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TABLE C-3 CROSSING CONSTRAINTS (UPLINK)

	Message Intent/Use	Message Element	URG	ALRT	RESP
46	Instruction that the specified position is to be crossed at the specified level. This may require the aircraft to modify its climb or descent profile.	CROSS (*position*) AT (*level*)	N	M	W/U
47	Instruction that the specified position is to be crossed at or above the specified level.	CROSS (*position*) AT OR ABOVE (*level*)	N	M	W/U
48	Instruction that the specified position is to be crossed at or below the specified level.	CROSS (*position*) AT OR BELOW (level)			
51	Instruction that the specified position is to be crossed at the specified time.	CROSS (*position*) AT (*time*)	N	M	W/U
52	Instruction that the specified position is to be crossed at or before the specified time.	CROSS (*position*) AT OR BEFORE (*time*)	N	M	W/U
53	Instruction that the specified position is to be crossed at or after the specified time.	CROSS (*position*) AT OR AFTER (*time*)	N	M	W/U
55	Instruction that the specified position is to be crossed at the specified speed and the specified speed is to be maintained until further advised.	CROSS (*position*) AT (*speed*)	N	M	W/U
61	Instruction that the specified position is to be crossed at the specified level and speed, and the level and speed are to be maintained.	CROSS (*position*) AT AND MAINTAIN (*level*) AT (*speed*)	N	M	W/U

TABLE C-4 ROUTE MODIFICATIONS (UPLINK)

	Message Intent/Use	Message Element	URG	ALRT	RESP
74	Instruction to proceed directly from the present position to the specified position.	PROCEED DIRECT TO *(position)*	N	M	W/U
80	Instruction to proceed via the specified route.	CLEARED *(route clearance)*	N	M	W/U
190	Instruction to fly on the specified heading.	FLY HEADING (degrees)	N	M	W/U

TABLE C-5 SPEED CHANGES (UPLINK)

	Message Intent/Use	Message Element	URG	ALRT	RESP

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	Message Intent/Use	Message Element	URG	ALRT	RESP
106	Instruction that the specified speed is to be maintained.	MAINTAIN *(speed)*	N	M	W/U
108	Instruction that the specified speed or a greater speed is to be maintained.	MAINTAIN *(speed)* OR GREATER	N	M	W/U
109	Instruction that the specified speed or a lesser speed is to be maintained.	MAINTAIN *(speed)* OR LESS	N	M	W/U

TABLE C-6 CONTACT/MONITOR/SURVEILLANCE REQUESTS (UPLINK)

	Message Intent/Use	Message Element	URG	ALRT	RESP
117	Instruction that the ATS unit with the specified ATS unit name is to be contacted on the specified frequency.	CONTACT *(unit name)* *(frequency)*	N	M	W/U
120	Instruction that the ATS unit with the specified ATS unit name is to be monitored on the specified frequency.	MONITOR *(unit name)* *(frequency)*	N	M	W/U

TABLE C-7 REPORT/CONFIRMATION REQUESTS (UPLINK)

	Message Intent/Use	Message Element	URG	ALRT	RESP
135	Instruction to confirm and acknowledge the currently assigned level.	CONFIRM ASSIGNED LEVEL	N	L	Y
231	Instruction to indicate the pilot's preferred level.	STATE PREFERRED LEVEL	L	L	Y

TABLE C-8 AIR TRAFFIC ADVISORIES (UPLINK)

	Message Intent/Use	Message Element	URG	ALRT	RESP
213	ATS advisory that the specified altimeter setting relates to the specified facility.	*(facility designation)* ALTIMETER *(altimeter)*	N	L	R
157	Notification that a continuous transmission is detected on the specified frequency. Check the microphone button.	CHECK STUCK MICROPHONE *(frequency)*	U	M	N

TABLE C-9 SYSTEM MANAGEMENT MESSAGES (UPLINK)

	Message Intent/Use	Message Element	URG	ALRT	RESP
159	A system generated message notifying that the ground system has detected an error.	ERROR *(error information)*	U	M	N
160	Notification to the avionics that the specified data authority is the Next Data Authority. If no data authority is specified, this indicates that any previously specified Next Data Authority is no longer valid.	NEXT DATA AUTHORITY *(facility)*	L	N	N
162	Notification that the ground system does not support this message.	SERVICE UNAVAILABLE	L	L	N
227	Confirmation to the aircraft system that the ground system has received the message to which the logical acknowledgment refers and found it acceptable for display to the responsible person.	LOGICAL ACKNOWLEDGMENT	N	M	N
233	Notification to the pilot that messages sent requiring a logical acknowledgment will not be accepted by this ground system.	USE OF LOGICAL ACKNOWLEMENT PROHIBITED	N	M	N

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TABLE C-10 ADDITIONAL MESSAGES (UPLINK)

	Message Intent/Use	Message Element	URG	ALRT	RESP
165	Used to link two messages, indicating the proper order of execution of clearances/instructions.	THEN	L	N	N
183		*(free text)*	N	M	N
196		*(free text)*	N	M	W/U
203		*(free text)*	N	M	R
205		*(free text)*	N	M	A/N

Note: Free text message elements have no associated message intent. The capability to send a free text message with any of the attribute combinations already used in the message set have been provided for in the technical requirements of the ATN (Annex 10, Volume III, Part I, Chapter 3).

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Downlink Messages

The Downlink messages for CPDLC-I/IA are presented in this section.

TABLE C-11 RESPONSES (DOWNLINK)

	Message Intent/Use	Message Element	URG	ALRT	RESP
0	The instruction is understood and will be complied with.	WILCO	N	M	N
1	The instruction cannot be complied with.	UNABLE	N	M	N
2	Wait for a reply.	STANDBY	N	M	N
3	Message received and understood.	ROGER	N	M	N
4	Positive pilot response.	AFFIRM	N	M	N
5	Negative pilot response.	NEGATIVE	N	M	N

TABLE C-12 VERTICAL REQUESTS (DOWNLINK)

	Message Intent/Use	Message Element	URG	ALRT	RESP
6	Request to fly at the specified level.	REQUEST *(level)*	N	L	Y

TABLE C-13 REPORTS (DOWNLINK)

	Message Intent/Use	Message Element	URG	ALRT	RESP
38	Read-back of the assigned level.	ASSIGNED LEVEL *(level)*	N	M	N
106	Notification of the preferred level.	PREFERRED LEVEL *(level)*	L	L	N

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Table C-14. System Management Messages (Downlink)

	Message Intent/Use	Message Element	URG	ALRT	RESP
62	A system generated message that the avionics has detected an error.	ERROR *(error information)*	U	L	N
63	A system generated denial to any CPDLC message sent from a ground facility that is not the current data authority.	NOT CURRENT DATA AUTHORITY	L	L	N
99	A system generated message to inform a ground facility that it is now the current data authority.	CURRENT DATA AUTHORITY	L	L	N
107	A system generated message sent to a ground system that tries to connect to an aircraft when a current data authority has not designated the ground system as the NDA.	NOT AUTHORIZED NEXT DATA AUTHORITY	L	L	N
100	Confirmation to the ground system that the aircraft system has received the message to which the logical acknowledgment refers and found it acceptable for display to the responsible person.	LOGICAL ACKNOWLEDGMENT	N	M	N

APPENDIX D: GUIDANCE FOR FLIGHT CREW PROCEDURES AND TRAINING

This appendix contains guidance related to procedures and training for controller pilot data link communications systems, as described in section 1 (system overview). The focus of the guidance is on lessons learned from currently fielded data link systems, such as oceanic CPDLC. The objective is to provide a high level description of topic areas that should be addressed by operators in their training and/or procedure development. The topic areas recommended pertain to the subset of issues related to human performance or human computer interaction. It is anticipated that the operator will supplement what has been suggested below with additional content and topic areas.

General Information

CPDLC procedures are envisioned to be common for CPDLC, regardless of the interface. The procedures described below are undergoing development by a team of air traffic controllers and pilots, and support organizations.

CPDLC Build 1/1A is meant to be used in the en route environment, in conjunction with standard VHF voice radio communications. It is meant for non-time critical situations. When data link is used for ATS communications, the pilot is required to monitor the appropriate ATS frequency and revert to voice whenever appropriate. While pilots and controllers are encouraged to use data link to the maximum extent practicable, at any time, pilots or controllers may terminate the use of data link for any reason.

Log-on

Before flight, the aircrew should initiate (logon) all airborne systems required to support their Build 1/1A data link capabilities. This typically occurs before departure when the pilot logs on to the context management application. The pilot logon provides the ATS facility, the flight identification (up to 7 alphanumeric characters), and the departure and destination airports. The ground system checks this information against the filed flight plan and if the logon information is correct a system logon is established. The pilot logon informs the ATS system that the pilot desires to participate in CPDLC with all equipped ATS facilities.

The pilot logon does not establish a CPDLC connection to an ATS facility. The CPDLC connection is initiated automatically by the ground system when the flight approaches the ATS facility airspace.

> *Note: The pilot logon procedure is still under development. This material reflects the current state of the knowledge but is subject to change as the procedure is finalized. Comments have been left in this version of the material but will be incorporated or revised as the procedure is developed.*

1. The pilot should initiate a new logon when any of the following information changes:
   - Flight Identification (i.e., Call Sign)
   - Departure Airport
   - Destination Airport
2. If the pilot makes the decision to not use CPDLC prior to entering CPDLC operational airspace, the pilot should not logon. Since a valid logon is a prerequisite for CPDLC

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service this will prevent inadvertent use of CPDLC by the controller for that individual airplane.

Termination/Reestablishment of an active CPDLC connection

1. When the pilot has an CPDLC connection, but elects not to use CPDLC, the pilot should 1) respond to all open uplinks, 2) terminate the CPDLC connection and 3) coordinate verbally with ATC.

Example pilot phraseology:

"[ATC facility name] [Callsign] Terminating CPDLC. Reverting to voice."

1. When the pilot desires to reestablish CPDLC, the pilot should coordinate verbally with ATC so that ATC can take the appropriate action.

Example pilot phraseology:

"[ATC facility name] [Callsign] Request CPDLC connection."

Non-positive data link transactions

Note: A non-positive data link transaction includes unable or error responses and failures.

1. Data link procedures should provide guidance to use voice communication in non-positive situations.
2. Pilots should notify the ATS facility of CPDLC failures on the flight deck.

UNABLE Pilot Response

1. When the pilot responds "UNABLE" to a data link clearance, the pilot should also coordinate verbally with ATC.

Error Messages / Failed Status in Response to a Downlink

Note: Current error message text is provided in the SARPs: Unrecognized message reference number, service not available. Final error message text is TBD.

1. The pilot should coordinate verbally with ATC regarding receipt of an error message, unless the controller has previously coordinated regarding this message.

   The pilot should coordinate verbally with ATC regarding receipt of any Failed status on a downlink.

2. When the system generates an error message as a result of a pilot response (e.g., WILCO) to a data link clearance, the pilot should continue to operate in a manner consistent with the response that was sent.

*Note: This means if the pilot Wilco's a Climb to FL350, and that response is returned with an error from the ground system, the Pilot **shall** continue to the climb to FL350. The controller, in issuing the uplink in the first place, has already "cleared" the airspace for the pilot's expected acceptance of the clearance. The error, of course, is discussed on voice radio.*

Note: The above procedure will be documented in the AIM for the flight crew and in the FAA7110.65 for the controllers.

Verbal Coordination to Clarify Data Link Clearances

1. When an ATC voice or data link clearance is in question for any reason, the pilot should coordinate verbally with ATC.
2. When coordinating verbally with ATC regarding a message, the pilot should refer to the message unambiguously based on both its operational content and Message Identification Number (MIN).

Note: The MIN feature will not be available until CPDLC Build 1A.

- Example – CPDLC Build 1: "Center, XXX123 is unable to climb to FL350."
- Example - CPDLC Build 1A and on: "Center, XXX123 is unable to climb to FL350 as cleared in message 53."

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Operational Procedures

1. The pilot should use voice for urgent communications and when voice communications will enhance operational safety or reduce workload.
2. The pilot should attend to voice and data link communications with respect to the following relative priorities (1 – highest, 3 – lowest):
    1. ATC Voice Communications
    2. CPDLC Communications
    3. AOC Communications
3. Pilots should not be required to respond or send messages redundantly over both communication media.
4. The pilot should close ATC transactions on the same communications medium (i.e., voice or data link) on which they were initiated.

Note: The intent of this requirement is to close out data link messages that are in OPEN status. If an uplink is received, the pilot should respond with either WILCO or UNABLE to change the status to CLOSED.

5. The pilot should respond to data link messages in the order they were sent.
6. The flight crew should verify clearance acceptability, before sending a WILCO/UNABLE response to an uplinked clearance.

Note: This procedure may require the crew to send a STANDBY response

7. Unless otherwise coordinated verbally with ATC, the pilot should operate with the understanding that the most recent ATC clearance received, via voice or data link, overrides a previous clearance.
8. If a voice communication countermands an open data link transaction, voice communications will prevail until pilot and controller mutually agree to resume data link communications.

Flight Crew Coordination

Note: The distribution of responsibilities will be the operator's purview. This section contains recommendations to assist operators in development of detailed procedures.

1. In general, the pilot not flying (PNF) will handle all communications tasks, including CPDLC, ATC voice, and company communications. The pilot flying (PF) will fly and navigate the aircraft according to standard company procedures.
2. The flight crew should routinely cross check and update one another on the operational content of CPDLC messages and their responses in accordance with company Crew Resource Management (CRM) procedures.
3. Flight crew coordination of the message intent should be effected before the pilot CPDLC response is sent.
4. Flight crew coordination of the message intent should be effected before entering/executing the message data into a flight deck system.

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5. For any clearance that affects the trajectory of the aircraft both crew members should read the uplink.

Note: Oceanic CPDLC experience showed that it was advantageous to have both crew members READ the uplink themselves before they responded.

6. The flight crew should confirm that aircraft performance/configuration is as expected following the transfer (manual or automatic) of CPDLC uplinked data into a flight guidance system.
7. The flight crew should coordinate to ensure that aircraft trajectory changes indicated in CPDLC messages occur at the appropriate time or point as directed.

Training

Note: Flight Crew training and currency requirements are developed in AC-xx/Handbook Bulletin (HBAT).

1. Data link training should emphasize the importance of a timely crew response to uplink ATS messages.
2. Training should emphasize the appropriate allocation of flying tasks and communication tasks.
3. Training on data link procedures should emphasize that data link operations should not require the simultaneous visual attention of both pilots.
4. If abbreviations are used, a glossary should be available during training.
5. Pilots should receive cross operational (e.g., controller CPDLC procedures, issues, and problems) training.

Currency of Training

1. Training for CPDLC should be recent, prior to commencing CPDLC operations.

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APPENDIX E: Guidance for Air Traffic Specialist Procedures and Training

This appendix contains guidance related to procedures and training for controller pilot data link communications systems, as described in section 1 (system overview). The focus of the guidance is on lessons learned from currently fielded data link systems, such as oceanic CPDLC. The objective is to provide a high level description of topic areas that should be addressed by the FAA in their training and/or procedure development. The topic areas recommended pertain to the subset of issues related to human performance or human computer interaction. It is anticipated that the FAA will supplement what has been suggested below with additional content and topic areas.

General Information

CPDLC Build 1/1A is meant to be used in conjunction with standard VHF voice radio communications. It is meant for non-time critical situations. When data link is used for ATS communications, the pilot is required to monitor the appropriate ATS frequency and revert to voice whenever appropriate. While pilots and controllers are encouraged to use data link to the maximum extent practicable, at any time, pilots or controllers may terminate the use of data link for any reason.

The procedures described below are undergoing development by a team of professional air traffic controllers and airline pilots, and support organizations.

ATS Specialist Procedures

Note: ATSS CPDLC procedures will be documented in a revision to the controller's handbook, FAA 7110.xx.

1. In general, the Radar (R) controller will handle voice and data link communication tasks. The R controller may delegate data link communication tasks to the Radar Associate (D) controller.

Transfer and Assumption of Position Responsibility

1. When a controller transfers position responsibility (e.g., performs a position relief briefing), the status of the data link system, settings, and all open transactions should reviewed with the controller who is assuming responsibility.

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Turning on/off data link

1. When the controller has CPDLC connections, but elects not to use CPDLC, the controller should 1) wait for closure or clear any open uplink transactions, 2) turn off CPDLC, and 3) coordinate the turn-off verbally with pilots.
2. When the controller desires to conduct CPDLC operations, the controller should take explicit action to again enable CPDLC operations. The controller should coordinate verbally or via data link with pilots that CPDLC operations are acceptable at this time.

Non-positive data link transactions

1. Data link procedures should provide guidance on how to conduct communication in non-positive situations(i.e., failures, errors, unable/negative responses, late response [timeout], or inconsistent assigned level reports[IC mismatch]), including error responses and failures.
2. Controllers should notify affected parties of any system failures that could affect the communications capability.
3. Transactions with a non-positive status, should require controller action to clear status indications.
4. Voice communications should be used to resolve non-positive data link transactions.
5. The controller should coordinate verbally with the pilot regarding receipt of any Failed status on a uplink.

UNABLE Controller Response

6. When the controller responds “UNABLE” to a clearance request, the controller should also coordinate verbally with the pilot.

Verbal Coordination to Clarify Data Link Clearances

1. When an ATC voice or data link clearance is in question for any reason, the controller should coordinate verbally with the pilot.
2. When coordinating verbally with the pilot regarding a data link message, the controller should refer to the message unambiguously based on both its operational content and Message Identification Number (MIN).

Operational Procedures

1. Controller should use voice for urgent communications and when voice communications will enhance operational safety or reduce workload.
2. Explicit controller action should be required to approve transmission of data link messages containing control instructions and clearances.

Note: The action to select an automatic mode for the transfer of communication message would be consistent with this procedure.

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3. Controllers should not be required to send or respond to messages redundantly over both voice and data link communication media.
4. The controller should close ATC transactions on the same communications medium (i.e., voice or data link) on which they were initiated.
5. To ensure proper coordination of ground and air data link systems, if a data link message has been responded to by voice, the corresponding data link response should also be completed.
6. If the age or context of the message makes its validity suspect, the controller should verify the validity of that message by contacting the pilot on voice before acting upon it.
7. Controllers should not use data link to issue conditional clearances that are executed outside of their control jurisdiction (airspace).
8. When a clearance contains instructions to be executed sequentially, it should be constructed with a corresponding word (message element) order.

Note: This procedure should apply to the controller when composing messages in real time and to the supervisor when composing messages offline to build controller menus of predefined messages.

Controller Team Procedures

1. Where appropriate, procedures should include cross checking between controllers of data link messages and responses.
2. New procedures and training should be developed to accommodate reallocation of controller team tasks.
3. Controller team members should verbalize changes made to CPDLC system settings and parameters.
4. When appropriate, controller team members should verbalize the flight and type of data link communications initiated and responses received.

Training

Note: ATSS training materials and currency requirements are being developed by the FAA Academy.

1. Data link training should emphasize the importance of a timely controller response to downlink ATS messages.
2. If abbreviations are used in CPDLC displays and operations, a glossary should be available for controller reference.
3. Initial training for CPDLC should be recent, prior to commencing CPDL operations.
4. Controllers should receive cross operational (e.g., flight crew CPDLC procedures, issues, and problems) training.

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APPENDIX F: Guidance for the Use of Color

Potential Issues and Limitations

The various uses of color come with a number of limitations that restrict the extent to which color should be depended upon for object identification or differentiation.

The extreme brightness that is possible within the flight deck can washout and drastically alter the appearance and discriminability of color. Differences among individuals concerning how colors are perceived are quite large. Research indicates that regions of relatively high color confusion exist between red and magenta, magenta and purple, yellow and amber, and cyan and green. An ideal color set would not include these pairs.

The size of colored symbols has been found to interfere with the color discrimination for small visual fields. Also, normal aging of the eye can reduce the ability to sharply focus red objects or differentiate between blue and green.

In, general no more than six or seven colors should be used for symbols on electronic displays with high information content. In addition, gray, brown, or blue may be used for fill-in colors. Caution should be taken to ensure that colors used for background or fill applications do not interfere with the detection or recognition of adjacent color-coded symbols. (Editors note: talk about problems with using blue text on a black background)

Display colors must be highly distinct if they are to be correctly identified by all flight crews under the likely range of flight deck illumination.

Conventions

A well-researched color set commonly recommended for flight deck applications includes: red, tan/brown, amber, yellow, green, cyan, blue, magenta, and white.

It is acceptable for the following display features to be coded as follows (or with similar colors), provided that the display can produce distinctive and recognizable renditions of the chosen colors:

Fixed reference symbols and current data values	white
Selected data values/normal status	green/cyan or white
Selected heading	magenta or white
Active route/flight plan	magenta
Warnings	red
Cautions/abnormal conditions	yellow/amber

For additional detail concerning the use of color with electronic displays the designer should refer to SAE ARP4032, AC 25-11, and AC 23.1311.

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Recommendations

The colors that are used for attention getting and alerting **should** be identifiable through the full range of normally expected flight deck illumination conditions.

Blue **should** not be used to present small, detailed symbols.

Red and blue **should** not be presented adjacent to each other more than momentarily.

Adjacent colors should not be equal in luminance when discrimination of edges or detail is important.

The colors and brightness of the display **should** not interfere with the readability of other flight deck instrumentation.

APPENDIX G: Design Guidance For Controls

Appendix F contains design guidance for controls that is intended to maximize their usability and to minimize the probability of inadvertent activation, especially during turbulence. Tables F-1 and F-2 present design aspects for various types of control devices, including center-to-center (C-C) spacing recommendations for the same type of control. Table F-3 contains minimum edge-to-edge spacing requirements between the same and different types of controls. These spacing values are for single finger operation. If it is not possible to meet the spacing guidelines, then mechanical interlocks or barriers are recommended.

The tables do not contain guidance for touch sensitive display devices. Touch sensitive display devices used in flight have shown resistance to inadvertent activation (e.g. in turbulence conditions) when data entry is made upon release of the finger from the surface rather than the imposition.

TABLE F-1 DESIGN GUIDANCE FOR ROTARY KNOBS AND KEYBOARDS

	Rotary Knob	Concentric Inner Knob	Concentric Outer Knob	Keyboard
Minimum Diameter	10 mm	22 mm	13 mm	10 mm
Minimum Height	13 mm	13 mm	16 mm	NA
Minimum Displacement	NA	NA	NA	1.3 mm
Minimum C-C Spacing	25 mm	25 mm	25 mm	19 mm
Setting Separation	15 degrees	15 degrees	15 degrees	NA
Minimum Resistance	1.1 N	1.2 N	1.2 N	0.25 N
Maximum Resistance	3.3 N	1.7 N	1.7 N	1.5 N
Movement Direction	Clockwise to increase	Clockwise to increase	Clockwise to increase	NA
Desirable Features	Serrated or knurled edge	Serrated edge	Serrated edge	Provide feedback

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Note: For keyboards, the preferred resistance, or force required to press each key, is between 0.5 N and 0.6 N.

TABLE F-2 DESIGN GUIDANCE FOR PUSH BUTTONS AND TOGGLE OR ROCKER SWITCHES

	Push Button	Push-Pull Button	Toggle Switch	Rocker Switch
Minimum Diameter	9.5 mm	6 mm	3 mm	6 mm
Minimum Length	6.4 mm	19 mm	13 mm	13 mm
Minimum Displacement	2 mm	13 mm	17 degrees	30 degrees
Minimum C-C Spacing	19 mm	25 mm	13 mm	19 mm
Minimum Resistance	2.8 N	2.8 N	2.8 N	2.8 N
Maximum Resistance	11 N	18 N	11 N	11 N
Desirable Features	Provide feedback	Push to activate	Vertical Orientation	Vertical Orientation
	Concave or friction surface	Increase length if dual use	Arm guard Up for on	Upper wing for on

TABLE F-3 MINIMUM EDGE-TO-EDGE SPACING BETWEEN DIFFERENT TYPES OF CONTROLS

Type of Control	Toggle Switches	Push Buttons	Continuous Rotary	Rotary Selector	Discrete Thumbwheel
Toggle Sw.	See Note	13 mm	19 mm	19 mm	13 mm
Push Button	13 mm	13 mm	13 mm	13 mm	13 mm
Cont. Rotary	19 mm	13 mm	25 mm	25 mm	19 mm
Rotary Select	19 mm	13 mm	25 mm	25 mm	19 mm
Disc. Thumb.	13 mm	13 mm	19 mm	19 mm	10 mm

Note: Use 19 mm for standard toggle switches and 25 mm for lever lock toggle switches.

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