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Controller-Pilot Data Link Communications Build 1 (CPDLC 1): Phase 1 Air Traffic Operational Effectiveness Test

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16. Abstract

This document presents the results of air traffic effectiveness testing that was conducted as part of the Phase 1 Operational Test (OT) of Controller-Pilot Data Link Communications Build 1 (CPDLC 1). Phase 1 effectiveness tests assessed CPDLC 1 from the perspective of the air traffic controller to ensure that it will effectively and suitably support Air Traffic Control (ATC) operations.

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EXECUTIVE SUMMARY

This report presents the results of air traffic effectiveness testing that was conducted as part of the Phase I Operational Test (OT) of Controller-Pilot Data Link Communications Build I (CPDLC I). Phase I effectiveness testing assessed CPDLC I from the perspective of the air traffic controller to ensure that it will effectively and suitably support Air Traffic Control (ATC) operations.

The objectives of effectiveness testing were to contribute to the resolution of five of the Critical Operational Issues (COI) that were identified for CPDLC I:

1. Can CPDLC be used without disruption or degradation to ATC operations? (COI 2)

2. Does CPDLC maintain at least the current level of efficiency and accuracy of communications between the controller and pilot? (COI 5)

3. Does CPDLC time performance allow for effective exchange of controller and pilot communications? (COI 6)

4. Does CPDLC Human Computer Interface (HCI) effectively support Air Traffic (AT), Airways Facilities (AF) and aircrew operations? (COI 7)

5. Is sufficient training provided for AT AF and aircrews to effectively operate the CPDLC system? (COI 8)

It should be noted that aspects of the COIs relevant to AT supervisors and AF personnel interactions with CPDLC I will be addressed during Phase 2 effectiveness testing.

Effectiveness testing was accomplished through a series of controller evaluations and high fidelity ATC simulations that were conducted in facilities of the Federal Aviation Administration (FAA) William J. Hughes Technical Center that were configured to emulate ATC operations in the airspace of the Miami Air Route Traffic Control Center (ARTCC). Eight Certified Professional Controllers from the Miami ARTCC acted as participants and evaluators.

The controllers first received instruction on the use of CPDLC I using the training program developed for operational implementation. Following 7 hours of simulation practice with the system they performed evaluations of the training program, the HCI, and CPDLC procedures. Subsequent full-scale simulation testing was conducted to determine the impact of CPDLC I on ATC operations and communications. The initial sequence of tests examined performance under nominal operating conditions, under conditions where CPDLC was disabled in adjacent sectors, and when major system failures occurred. A second series of tests was conducted to evaluate the effects of

increasing the number of CPDLC-equipped aircraft in the traffic sample and of degrading system transit time performance.

The results of effectiveness testing provided no evidence to suggest that CPDLC I will disrupt or degrade ATC operations at the Miami ARTCC. In addition, no adverse effects were observed as a result of system outages, selective disabling of the system at individual sectors, increasing CPDLC aircraft equipage to 40 percent of the traffic sample, or increasing one-way transit time by 50 percent. Controller and observer ratings of the effectiveness, accuracy, and timeliness of communications indicated that CPDLC I will not impair, and may slightly improve, each of these factors.

Controller evaluations and performance measures collected during testing indicated that the HCI will effectively support ATC operations. However, the design review identified six design modifications that were judged to be mandatory prior to field deployment. These included increasing the level of alerting provided when an incorrect initial contact (IIC) message is received, requiring a confirmatory input when deleting an IIC message, and provision of an unambiguous indication that the status list is suppressed/displayed at the sector. Six additional deficiencies in system functionality were identified by test personnel during system shakedown.

Evaluations of the CPDLC I training program indicated that the instruction and practice provided will be sufficient to allow controllers to effectively operate the system. However, the participants recommended several minor improvements to the Computer-Based Instruction (CBI), lecture, and simulation practice elements of the program.

1. INTRODUCTION.

1.1 PURPOSE.

This document presents the findings of air traffic operational effectiveness testing of Controller-Pilot Data Link Communications Build I (CPDLC I). Real-time, manned simulations and controller evaluations were employed to assess the impact of CPDLC I on Air Traffic Control (ATC) operations and on Air Traffic (AT) personnel.

2. BACKGROUND.

The Federal Aviation Administration (FAA) intends to field an International Civil Aviation Organization (ICAO)-compliant, en route Controller-Pilot Data Link Communications (CPDLC) capability in the National Airspace System (NAS) beginning in 2002. In its final form, CPDLC will provide controllers with the ability to uplink a variety of clearance and advisory messages to Data Link-equipped aircraft, and aircrews will be able to downlink reports and requests.

The national implementation of CPDLC will occur in a series of stages. In the initial stage, a subset of the end-state messages known as CPDLC I will be fielded at the Miami Air Route Traffic Control Center (ARTCC). After 1 year, an expanded message set known as CPDLC IA will be implemented throughout the NAS. Subsequent stages will further extend the message set and integrate CPDLC with future Decision Support Tools (DST).

CPDLC I will provide a capability for controllers to send the Transfer of Communication (TOC) message using Data Link, and for pilots to respond to the TOC by accepting or rejecting the message. As part of the acceptance reply, pilots will downlink an Initial Contact (IC) message containing the aircraft's assigned altitude as they enter a new en route sector. Upon receipt of the IC, the ATC system will automatically verify the altitude and alert the new controller if it fails to match the assigned, interim, or adapted altitude stored in the NAS database. CPDLC I also will provide a capability to send altimeter setting messages (ASM) to aircraft and to uplink predefined free-text messages (MTM) containing noncontrol information.

A commercial air-ground communications service provider (ARINC) will transmit the CPDLC I messages to properly equipped aircraft via a very high frequency (VHF) Data Link (VDL) Mode 2 network. Data Link aircrew interfaces and avionics, under development for use with VDL Mode 2, will be installed on the flight decks of commercial transport aircraft to support the airborne portion of the CPDLC I system. American Airlines will be the launch airline. On the ground, CPDLC I will be supported by the Host Computer System (HCS) and the Data Link Applications Processor (DLAP). CPDLC I functionality will be integrated with the display and input devices of the Display System Replacement (DSR) controller workstation that are currently operational at the Miami ARTCC.

1.3 OPERATIONAL EFFECTIVENESS TESTING.

Operational Test (OT) of CPDLC I is being conducted by ACT-350 at the FAA William J. Hughes Technical Center in advance of the single site field implementation. OT is assessing the readiness and operational acceptability of the FAA automation system and the ARINC sub-network to support the use of CPDLC I by the participating airlines. Testing is structured to ensure that all Critical Operational Issues (COI) are addressed and resolved. Formal OT encompasses Integration Testing, Operational Effectiveness Testing, and Suitability Testing.

CPDLC OT is occurring in two phases. The first phase included a production HCS software release and a prototype DLAP release (using the Pro-Aeronautical Telecommunications Network (ATN) product). The ATN and VDL-2 sub-network were simulated for this phase of OT. The second phase will update the DLAP to a production release. The ATN and VDL-2 sub-network will be tested in the second phase in a complete end-to-end environment.

This document presents the results of air traffic operational effectiveness testing conducted during the first phase of OT. Effectiveness testing examined CPDLC I from the perspective of the air traffic controller to ensure that CPDLC I will effectively and suitably support controller ATC operations. Testing focused on Air Traffic (AT) issues and addressed the controller's Human Computer Interface (HCI), controller training, the effects of CPDLC I on communications accuracy and efficiency, and its impact on AT operations. Effectiveness tests of Airways Facilities (AF) and ATC supervisory components of CPDLC I will be addressed in the second phase of OT.

2. TEST OBJECTIVES.

The objectives of the effectiveness tests were to help resolve the following COIs that have been identified for CPDLC I (Morfitt and Bigio 2000):

a. Can CPDLC be used without disruption or degradation to ATC operations? (COI 2)

b. Does CPDLC maintain at least the current level of efficiency and accuracy of communications between the controller and pilot? (COI 5)

c. Does CPDLC time performance allow for effective exchange of controller and pilot communications? (COI 6)

d. Does CPDLC HCI effectively support AT, AF, and aircrew operations? (COI 7)

e. Is sufficient training provided for AT AF and aircrews to effectively operate the CPDLC system? (COI 8)

It should be noted that the Phase 1 operational effectiveness test assessed AT controller issues. This test did not address aspects of the COIs relevant to AT supervisors, AF, or aircrew.

3. SUMMARY OF APPROACH.

Operational effectiveness testing was accomplished through a series of controller evaluations and high-fidelity ATC simulations that were used to evaluate the controller HCI, training, procedures, and the effects of CPDLC I on ATC system and communications performance. Test participants were controllers from the Miami ARTCC, and scenarios derived from actual operations in Miami ARTCC airspace were used in the ATC simulations. During these simulations, simulation pilots working at specialized workstations communicated with test controllers using voice and Data Link, and made inputs to maneuver aircraft targets presented on the controller's situation display. Simulation computers controlled CPDLC I transaction delays. The distribution of transaction delays experienced by controllers during primary test scenarios was based on the CPDLC I specifications for sub-network performance and on the results of prior flight simulation studies conducted to assess crew response times to CPDLC messages.

4. TEST CONDUCT.

4.1 TEST FACILITIES.

Testing was conducted in the Technical Center facilities configured to provide high-fidelity simulations of ATC operations in Miami ARTCC airspace. The operational test environment is illustrated in figure 1.

The DSR laboratory houses the en route controller workstations that were used for the ATC simulations. This facility is configured to duplicate a field installation, providing direct connection to the HCS. CPDLC communications to, and from, the HCS (via the DLAP) utilize the Host Interface Device/NAS Local Area Network (HNL).

The Target Generation Facility (TGF) was used to provide a dynamic simulation of the airborne environment. Trained simulation pilots working at TGF consoles controlled aircraft targets appearing on the DSR situation displays, and had the ability to communicate with controllers using voice and Data Link (via the HNL).

As shown in figure 1, the test environment also had the capability to add a high fidelity flight simulator to the air traffic provided by the TGF. It also permitted voice communications between controllers and flight simulator pilots and Data Link communications via a simulated sub-network. The VDL Mode 2 sub-network will be added to the system for the second phase of OT.

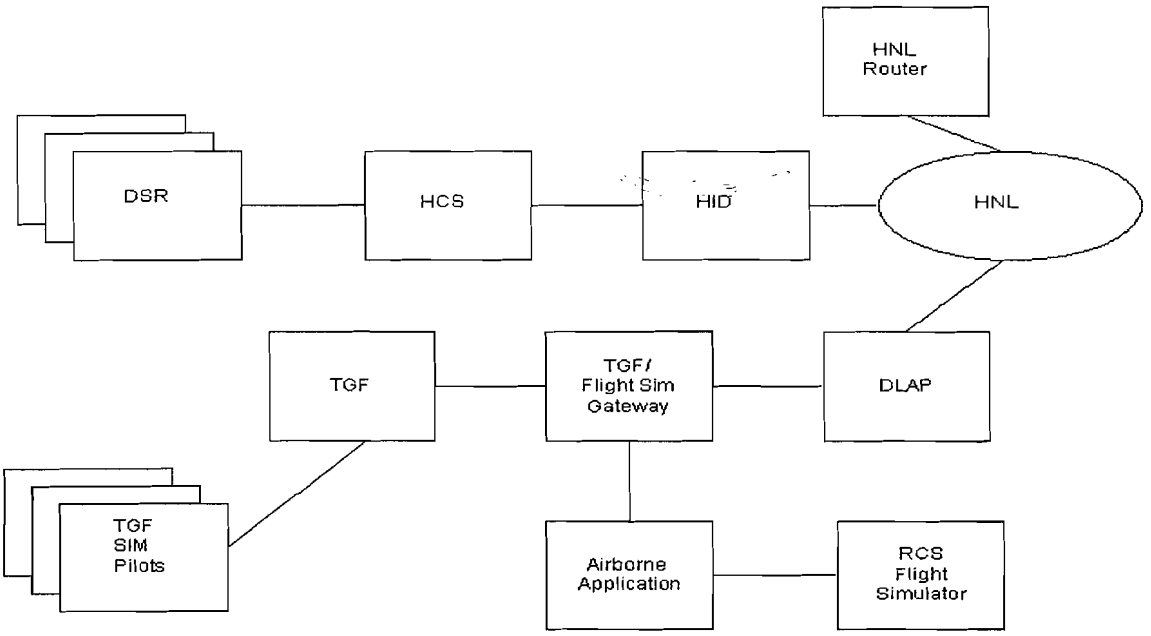

FIGURE 4.1-1. CPDLC I OPERATIONAL EFFECTIVENESS TEST ENVIRONMENT

4.2 CPDLC I SERVICES AND TRANSACTION DELAYS.

During testing, the four services comprising CPDLC I were available for use. These services are:

a. Transfer of Communication (TOC)

b. Initial Contact (IC)

c. Altimeter Setting (AS)

d. Menu Text Messages (MT)

Detailed descriptions of the functionality and the controller HCI associated with the services as they were tested are presented in appendix A as part of the controller design review materials.

In order to simulate the transaction delays that will be experienced by controllers in an operational environment, the simulation facilities included a computer system (TGF Flight Simulator Gateway) linked to the HNL through which CPDLC I traffic flowed. The computer controlled the time of arrival on the controller displays of all simulation pilot responses to Data Link messages by sampling from distributions of one-way transit times and pilot response times. These distributions were created using two sources of

data. The ATN-compliant, CPDLC I performance specification for the communications ground system and sub-network were used to define the one-way transit time distribution. This specification calls for one-way transmission times having a mean of 10 seconds, with 95 percent of messages delivered within 15 seconds and 99.99 percent delivered within 22 seconds.

A distribution of aircrew response latencies was approximated from data collected during a flight simulation study of CPDLC (Ferra and Reynolds, 2000). In the study, line pilots responded to CPDLC I messages in the context of normal en route flight operations using an HCI with a configuration similar to that chosen by the launch airline. The results showed that pilot response times ranged from a minimum of approximately 6 seconds to a maximum of approximately 50 seconds, with a mean value of approximately 23 seconds.

The specified one-way transit times and the pilot response time data were modeled by fitting them to gamma distributions using MATLAB software. During testing, each CPDLC total transaction time experienced by the test controllers was determined by sampling from the modeled one-way transit time and pilot response delay distributions.

4.3 TEST PARTICIPANTS.

The participants for effectiveness testing were eight Certified Professional Controllers (CPC) from the Miami ARTCC. The National Air Traffic Controller Association (NATCA) selected the controllers for participation. Four of the controllers were current specialists from Area 2. The remaining four were current specialists from Area 3.

4.4 TEST ACTIVITIES.

Effectiveness testing took place over an 8-day period. The first 4 days were devoted to training the participants to use CPDLC I, and to an assessment of the training program.

The remainder of the test period was used to evaluate the controller HCI and CPDLC procedures, and to conduct full-scale simulation tests to assess the effects of CPDLC I on the safety and effectiveness of the AT system.

Upon arrival at the Technical Center, the controllers received a briefing which outlined the objectives of the test, provided an overview of the test activities and schedule, and defined their roles and responsibilities as participants.

4.4.1 CPDLC I Controller Training And Training Evaluation.

FAA training specialists conducted the CPDLC I training program using materials, procedures, and documentation developed for field application. The training package included lecture materials and Computer-Based Instruction (CBI) lessons. It also included the specified series of Dynamic Simulation (DYSIM) practice and DYSIM evaluation problems at the DSR workstations.

Training occurred over a period of 4 days, with 7 hours devoted to DYSIM practice. In addition to training on the CPDLC I displays and inputs, the program provided instruction on air traffic CPDLC procedures that will govern its use. The training program contained end-of-lesson and end-of-course testing on CPDLC I displays, inputs, and procedures.

The controllers demonstrated the following skills and procedures during a final DYSIM evaluation. As noted, the controllers were required to demonstrate the skills at the Radar (R) and/or Radar Associate (D) positions.

4.4.1.1. Position Setup

a. Filter the Status List by service type. (R & D)

b. Filter the Status List by state. (R & D)

c. Move the Status List. (R)

d. Display / Suppress the Status List. (R)

e. Display / Suppress the Sector Settings List. (R)

f. Display / Suppress the Menu Text List. (R)

g Display / Suppress Menu Text List entries. (R & D)

h. Move the Menu Text List (R)

4.4.1.2 Data Link Management.

a. Manually establish a CPDLC session for an aircraft. (R & D)

b. Manually end a CPDLC session for an aircraft. (R & D)

c. (Procedure) Take appropriate action when manually terminating a session: (R & D):

   1. Inform flight crew
   2. Inform supervisor
   3. Inform next controller.

d. Acquire DL eligibility for a CPDLC aircraft, when already having track control. (R & D)

e. Acquire DL eligibility and track control for a CPDLC aircraft. (R & D)

f. Set TOC mode at the sector for all three modes (OFF, AUTO, & MAN). (R & D)

g. Delete entries from the Status List. (R & D)
(Procedure) Respond appropriately to the following status states: (R & D)

1. FAI - System generated when a CPDLC communication failure occurs, or if a session is terminated due to the aircraft track being dropped.

2. ERR - System generated when CPDLC cannot deliver an uplink or receives an error downlink element from the aircraft.

3. NEG - Pilot response of Negative.

4. UNA - Pilot response of Unable.

5. TIM - Pilot response not received within a specified amount of time (Pilot response Timeout).

h. (Procedure) Countermand a CPDLC uplink using appropriate phraseology. (R)

i. (Procedure) Brief required Data Link areas during transfer of position responsibility. (R & D) The required areas are:

1. Temporary MTM content
2. Data Link sector settings
3. Status of Data Link transactions

j. (Procedure) Inform the radar position of DL actions taken, when necessary. (D)

k. (Procedure) Steal eligibility only under the following conditions: (R & D)

1. Aircraft is within area of jurisdiction, or
2. After voice coordination, or
3. After both track control and voice communications have been established.

l. (Procedure) Do not initiate Data Link communications with aircraft, which are transitioning from a non-data link-equipped facility/sector until voice communications are established. (R & D)

m. (Procedure) Perform verbal coordination with pilot after deleting a transaction with a status state of TIM, SNT, FAI, or ERR (other than local). (R & D)

4.4.1.3 Altimeter Setting Message (ASM).

a. Manually uplink ASM. (R & D)

4.4.1.4. Initial Contact (IC).

a. Remove IC mismatch display. (R & D)

b. (Procedure) When presented with an IC mismatch, resolve via one of the following: (R & D)

1. Issue desired altitude clearance, or
2. No action required.

4.4.1.5. Menu Text Message (MTM).

a. Uplink MTM to a single aircraft. (R & D)
b. Uplink MTM to all eligible aircraft. (R & D)

4.4.1.6. Transfer of Communication (TOC).

a. Send TOC while in AUTO mode. (R & D)

b. Hold TOC while in Auto mode. (R & D)

c. Release a HLD TOC. (R & D)

d. Send Auto TOC while in Manual mode. (R & D)

e. Inhibit TOC in handoff message while in AUTO or MAN mode. (R & D)

f. Override the default frequency by: (R & D)

1. Using the optional U character
2. Manually entering the desired frequency

g. Uplink a frequency independent of track control. (R & D)

h. (Procedure) Ensure all potential conflicts for an aircraft in their area of jurisdiction are resolved prior to releasing/sending TOC. (R & D)

i. (Procedure) Take the following actions when advised that an adjacent sector's frequency has changed: (R & D)

1. Inform supervisor
2. Uplink alternate frequency or transfer communications via voice

j. (Procedure) Resume normal TOC operations when advised that the frequency table has been amended and record this information. (R & D)

k. (Procedure) Transfer eligibility to receiving controller prior to the sector boundary.

l. (Procedure) After having issued transfer of communications via voice, do not issue additional data link messages to that aircraft. (R & D)

4.4.1.7. Data Link Malfunctions.

a. CPDLC has failed for the facility. What specific actions should you take?

1. Broadcast message on voice frequency
2. Ensure FAI uplinks in status list are resolved

b. Host has failed for the facility. What actions should you take?

1. As soon as practical, use any available information to resolve/verify outstanding CPDLC transactions.

c. If a pilot reports a CPDLC malfunction, what specific actions should you take?

1. Request report from second aircraft
2. Issue advisory when appropriate
3. Notify supervisor when appropriate

d. If a HOST startover occurs, what actions should you take regarding CPDLC?

1. Use all available information to verify/update CPDLC states and/or information.

Written controller evaluations of the training content, materials and pacing were interspersed among the lecture, CBI and DYSIM activities (see appendix A). In addition, a final evaluation was performed after completion of the training course. Forms used to obtain the written evaluations are contained in appendix A.

4.4.2 Service, Procedures, and Human - Computer Interface Design Review.

As described in section 4.4.1, the DYSIM practice and evaluation activities conducted during the training program required the controllers to thoroughly exercise all components of the CPDLC I HCI, experience CPDLC I errors and non-normal events, and carry out mitigating procedures. These experiences were used as a basis for the controllers to perform an initial design review of CPDLC I. The design review addressed the following (Measures of Effectiveness (MOE) and the Measure of Suitability (MOS) assigned to CPDLC I:

a. Are CPDLC I procedures adequate to prevent interference with ATC operations? (MOE 2.11)

b. Does the controller HCI support accurate CPDLC I data entry? (MOE 7.3)

c. Does the controller HCI provide effective display of CPDLC I information? (MOE 7.4)

d. Is the HCI acceptable to controllers? (MOS 7.5)

Each participant performed an independent evaluation of the service functionality, HCI, and proposed procedures for CPDLC I by completing the questionnaire items contained in a design review booklet (see appendix A). The booklet structured the controller evaluations around six primary topics: (1) Data Link Full Data Block and Status List Displays; (2) TOC inputs and displays; (3) MTM inputs and displays; (4) IC displays; (5) AS inputs and displays; and (6) CPDLC I procedures.

The booklet used descriptive text and graphics to present the inputs and displays for CPDLC I, the functionality provided for each service, and the procedures. For each of the covered topics, the controllers were asked to answer detailed questions regarding the acceptability of individual aspects of the Data Link designs for the R and D positions. In addition, they were asked to provide an overall evaluation of each service design and to record any required CPDLC I design modifications.

In order to facilitate the evaluations, the design review exercise was conducted in the DSR laboratory while the participants were seated at the display consoles. A low traffic scenario was presented on the displays that permitted the controllers to exercise the functions under evaluation to assist in their assessments.

It should be noted that the participants had a second opportunity to address the adequacy of the controller HCI in a debriefing and questionnaire scheduled as the final activity of the test.

4.4.3 Full-Scale Simulation Testing.

Full-scale simulation testing was conducted using the production CPDLC I ground software in the NAS operational mode and the full aircraft simulation capabilities of the TGF. The objectives of the testing were to determine the impact of CPDLC I on ATC operations and communications. In addition, the simulation runs permitted evaluation of special conditions not addressed during the training evaluation.

4.4.3.1 Airspace and Test Scenarios.

The four controllers from Area 3 of the Miami ARTCC controlled traffic in test scenarios derived from two contiguous airspace sectors. Sector 47 is a low altitude sector adjacent to the Miami Terminal Radar Approach Control Facility (TRACON) that controls airspace from 10,000 feet up to, but not including, Flight Level (FL) 240. Traffic in sector 47 includes arrivals, departures, and overflights as well as high/low military traffic. Sector 64 is a high altitude sector (FL 240 and above) that primarily controls departures from the Miami TRACON after passing through sector 47.

While the Area 3 controllers tasking focuses on departure traffic from the Miami terminal area, the traffic handled by the four controllers from Area 2 emphasized arrival traffic. Sector 2 is a high altitude sector that feeds arrivals to the low altitude sector 20 where the controller's primary responsibility is the sequencing of arrival traffic inbound to the South Florida area.

The sectors described above were selected for effectiveness testing because they provided an opportunity to fully exercise the primary TOC and IC messages under the most demanding conditions at the Miami ARTCC. In addition, the departure and arrival traffic streams passing through these sectors are expected to include significant numbers of CPDLC I-equipped aircraft operated by the launch airline at Miami.

Air traffic scenarios for testing were created from recent historical System Analysis Recording (SAR) tapes provided by the Miami ARTCC. ARTCC personnel selected SAR tapes that contained traffic representative of typical departure and arrival rushes. In order to permit comparisons of ATC system performance among test scenarios, no tapes were selected which reflected unusual conditions such as high winds.

During the high-fidelity simulation test runs, two controllers staffed each of the four test sectors.

4.4.3.2 Testing Objectives.

The full-scale simulation tests were used to address the following MOEs and the MOS assigned to CPDLC I:

a. Can controllers effectively perform ATC duties when CPDLC I services are used? (MOE 2.8)

b. Can controllers maintain current margin of safety when CPDLC I services are used? (MOE 2.9)

c. Can CPDLC I failures, outages, and errors be accommodated, without adverse effects on ATC operations? (MOE 2.10)

d. Are CPDLC I procedures adequate to prevent interference with ATC operations? (MOE 2.11)

e. Are CPDLC I total transaction times short enough to permit effective communications and prevent interference with ATC operations? (MOE 6.2, MOE 2.12)

f. Does CPDLC I maintain at least the current accuracy of communications? (MOE 5.5)

g. Does CPDLC I maintain at least the current efficiency of communications? (MOE 5.6)

h. Does the controller HCI support accurate CPDLC I data entry? (MOE 7.3)

i. Does the controller HCI provide effective display of CPDLC I information? (MOE 7.4)

j. Are controller training tools and methods, including DYSIM usable? (MOE 8.2)

k. Does training permit controllers to safely use CPDLC I service during actual ATC operations? (MOE 8.3)

l. Is the CPDLC I HCI acceptable to controllers? (MOS 7 7.5)

4.4.3.3 Nominal, Sector On/Off and System Outage Tests.

The initial sequence of full-scale simulation test runs was conducted to assess the effects of CPDLC I: (1) during normal expected operating conditions; (2) under conditions where aircraft must be transitioned to, or from, sectors where CPDLC is not available or disabled; and (3) when system failures occur.

Six 45-minute test runs were completed with 20 percent of the aircraft in a scenario equipped to conduct CPDLC communications. The test conditions and controller assignments for each of the departure and arrival sector pairs are shown in tables 4.4.3.3-1 AND 4.4.3.3-2 :

TABLE 4.4.3.3.-1. TEST SERIES 1 AREA 3 CONTROLLER ASSIGNMENTS

Run No.	Scenario	Sector DL Condition	Sector 47 R Pos.	Sector 47 D Pos.	Sector 64 R Pos.	Sector 64 D Pos.
1.	1	ON/ON	A	B	C	D
2.	1	ON/OFF	C	D	A	B
3.	1	OFF/ON	D	C	B	A
4.	2	ON/ON	A	C	B	D
5.	2	ON/OFF	B	A	D	C
6.	2	OFF/ON	D	B	C	A

TABLE 4.4.3.3-2. TEST SERIES 1 AREA 2 CONTROLLER ASSIGNMENTS

Run No.	Scenario	Sector DL Condition	Sector 02 R Pos.	Sector 02 D Pos.	Sector 20 R Pos.	Sector 20 D Pos.
1.	1	ON/ON	E	F	G	H
2.	1	ON/OFF	G	H	E	F
3.	1	OFF/ON	H	G	F	E
4.	2	ON/ON	E	G	F	H
5.	2	ON/OFF	F	E	H	G
6.	2	OFF/ON	H	F	G	E

The designations A – D and E – H in the tables refer to the four controllers from Areas 3 and 4, respectively. Two 45-minute test runs were conducted for each of the three unique sector test conditions in order to permit each controller within an area to experience the condition at both an R and a D position at one of the sectors.

a. Nominal System Test

As shown in the tables, for each of the two areas, runs 1 and 4 were conducted under normal conditions with both of the adjacent sectors having CPDLC enabled. These test runs constituted an evaluation of the system under normal operating conditions in which aircraft enter the Miami ARTCC from adjacent non-CPDLC facilities (MIA and Jacksonville ARTCC (JAX)), are transferred between active CPDLC sectors, and transition into non-CPDLC facilities.

b. Sector On/Off/On and Off/On/Off Test

CPDLC I procedures will permit controllers to disable CPDLC at individual sectors. The sector on/off test assessed the impact of exercising this option on ATC operations in both the sector electing not to use CPDLC and in adjacent sectors. In runs 2 and 5, sector 47 receiving departures from MIA Approach Control had CPDLC enabled, but the high altitude sector 64 had CPDLC disabled. Sector 02, receiving inbound traffic from JAX had CPDLC enabled, while the low altitude sector 20 had CPDLC disabled. In runs 3 and

6, sectors 47 and 02 had CPDLC disabled, and sectors 64 and 20 had CPDLC enabled.

Test runs 2, 3, 5, and 6 were also used to assess any unique effects of transferring between groups of three ARTCC sectors in various CPDLC enabled/disabled configurations. Within each run, one CPDLC-equipped aircraft was an FAA systems check flight. The flight plans for these aircraft were designed to require departure from MIA or arrival from JAX entering sectors 47 or 02, respectively. The aircraft were transferred to sector 64 or sector 20, but then reversed course and reentered sector 47 or 02. Thus, within each departure or arrival scenario, it was possible to observe aircraft transitioning through a CPDLC sector ON/OFF/ON scenario and a sector OFF/ON/OFF scenario.

c. System Outage Test

The requirement to evaluate the effect of CPDLC message errors and failures, as well as the adequacy of procedures for dealing with these events, was primarily addressed during DYSIM test runs designed to evaluate CPDLC training during the first week of testing. However, those evaluations did not assess the impact of major system failures and outages affecting all CPDLC connections within the facility. For this reason, major system outages were inserted at unpredictable times during the second one-half of the six test runs that were conducted with each of the sector pairs. These tests assessed the impact of four system failures: (1) Failure of the HNL; (2) Failure of the DLAP; (3) HCS Switchover; and (4) HCS Startover. The objective of the tests was to assess the adequacy and effectiveness of recovery procedures. In addition to the metrics described in section 4.4.4.6, observers assessed the time needed to recover from each outage and any impact on ATC operations.

4.4.3.4 High Equipage and Extended Transaction Time Tests.

During the period that CPDLC I will be operational at the Miami ARTCC, the expected number of aircraft that will be equipped to communicate using CPDLC will be relatively small. For this reason, most air traffic scenarios used during effectiveness testing contained only the largest number of equipped aircraft that can be expected to be operating simultaneously in a test sector at Miami (approximately 20 percent of the total number of aircraft in a scenario). Since the services provided by CPDLC will be carried over to future system builds, testing was needed to determine their effectiveness and usability under higher loading conditions. In this test, CPDLC equipage was increased to 40 percent of the aircraft in the scenario.

In addition, testing included a group of runs in which system time performance was degraded at both high and nominal equipage levels. During degraded performance

testing the one-way transit time was increased to 150 percent of that currently predicted for the actual operational system.

The transaction time and equipage variables for these tests were combined in a 2x2 factorial design with two replications in order to permit each of the participants to control traffic at an R and a D position within their area under each test condition.

The controllers were rotated through the sectors and control positions in a manner that assured that no controller acted as the R controller at the same sector more than one time under the same test scenario. In addition, the rotation sequence prevented a controller from manning a D position immediately after acting as the R controller at the same sector under the same scenario. The controller assignments for each of the eight test runs are shown in tables 4.4.3.4-1 and 4.4.3.4-2.

TABLE 4.4.3.4-1. TEST SERIES 2 AREA 3 CONTROLLER ASSIGNMENTS

Run No.	Scenario	Transit Time	Aircraft DL Equipage	Sector 47 R Pos.	Sector 47 D Pos.	Sector 64 R Pos.	Sector 64 D Pos.
1.	3	Normal	20%	A	C	B	D
2.	4	Normal	40%	D	B	C	A
3.	3	150%	20%	C	A	D	B
4.	4	150%	40%	B	D	A	C
5.	3	Normal	40%	B	D	A	C
6.	4	Normal	20%	C	A	D	B
7.	3	150%	40%	D	B	C	A
8.	4	150%	20%	A	C	B	D

TABLE 4.4.3.4.-2. TEST SERIES 2 AREA 2 CONTROLLER ASSIGNMENTS

Run No.	Scenario	Transit Time	Aircraft DL Equipage	Sector 02 R Pos.	Sector 02 D Pos.	Sector 20 R Pos.	Sector 20 D Pos.
1.	3	Normal	20%	E	G	F	H
2.	4	Normal	40%	H	F	G	E
3.	3	150%	20%	G	E	H	F
4.	4	150%	40%	F	H	E	G
5.	3	Normal	40%	F	H	E	G
6.	4	Normal	20%	G	E	H	F
7.	3	150%	40%	H	F	G	E
8.	4	150%	20%	E	G	F	H

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4.4.3.5 Procedures Test.

A controller procedures test was embedded within each of the test runs shown in the tables above. For this test, the Reconfigurable Cockpit Simulator (RCS) at the Technical Center was linked to the TGF in order to fly as part of the arrival and departure scenario traffic streams. The RCS is a fixed-base flight simulator with full outside-the-cockpit imagery. The RCS was equipped with avionics and a CPDLC pilot interface that emulated the system to be used by the launch airline at the Miami ARTCC.

During the runs, aircrews flew the simulator and communicated with participating controllers via voice radio and CPDLC. Selected atypical events were scripted for the aircrews that required the controllers to exercise mitigating procedures. These events included: (1) Aircraft connected by CPDLC but not voice radio as a result of mistuning the frequency; (2) Requirement to countermand a TOC; and (3) Voice radio handling of an incorrect IC downlink.

4.4.3.6 Measures of Performance (MOP).

The MOEs for the full-scale simulation test runs were addressed using objective measures of communications activity and observations recorded during the simulation runs, and with controller ratings and evaluations performed after each run. The observers were a CPC en route controller and an operations supervisor from the Miami ARTCC, and two additional CPC controllers currently assigned to the FAA Academy and FAA Headquarters. All four observers had participated in CPDLC development and testing at the Technical Center and were thoroughly familiar with the system. The following MOPs were collected during or following each test run:

a. Observer ratings of controller performance on sector duties during CPDLC I full-scale simulation scenarios. (MOP 2.8.1)

b. Controller perceived workload ratings following CPDLC I full-scale simulation scenarios. (MOP 2.8.2, MOP 7.5.2)

c. Operational errors (airspace violations and aircraft conflicts) observed during CPDLC I full-scale simulation scenarios. (MOP 2.10.1, MOP 8.3.1)

d. Observer and controller ratings of the margin of safety observed during CPDLC I simulation scenarios (baselined to equivalent control periods at home facility). (MOP 2.9.1, MOP 8.3.2)

e. Observer ratings of handoff timeliness observed during CPDLC I full-scale simulation scenarios. (MOP 2.12.2)

f. Controller review of adequacy of failure alerts and mitigating procedures. (MOP 2.11.1)

g. Observer ratings of detected/undetected data entry errors observed during CPDLC I full-scale simulation scenarios. (MOP 7.3.1)

h. Input error counts obtained from Host computer records recorded during CPDLC I full-scale simulation scenarios. (MOP 7.3.2)

i. Detection of alerts of nonmatching initial contact altitude downlinks sent during CPDLC I full-scale simulation scenarios. (MOP 7.4.1)

j. Ability to discriminate CPDLC I equipage/eligibility indicators as measured by attempts to send messages to noneligible/equipped aircraft during CPDLC I full-scale simulation scenarios. (MOP 7.4.2)

k. Detection of CPDLC I failure alerts and time-out indicators during CPDLC I full-scale simulation scenarios. (MOP 7.4.3)

l. Degree of CPDLC I usage by controllers during full-scale simulation exercises. (MOP 2.12.1)

m. Controller ratings of communications effectiveness, accuracy, and timeliness following full-scale simulation scenarios. (MOP 6.2.2, MOP 5.5.1, MOP 5.6.1)

The following paragraphs present detailed descriptions of the techniques that were used to collect these MOPs. All evaluation instruments and questionnaires discussed below are contained in appendix A.

4.4.3.6.1 ATC System Performance – Flight Safety.

Two measures were used as primary criteria for determining whether the ATC activities and aircraft operations observed during a test run were accomplished in a safe fashion.

a. Observer Safety Evaluation

When working in the en route ATC control room, operations supervisors who are familiar with all aspects of sector operation monitor controller actions and air traffic activity to ensure operational safety. The supervisor uses expert judgment to make determinations of unsafe conditions and to take measures to correct the problem.

This operational assessment technique was employed in the present study in the form of a comprehensive judgment for each test run. The observers assigned to each area indicated his/her judgment after observing the test run by completing an item on the questionnaire. If a test run was judged unsafe, the observer was asked to record explanatory remarks. As part of the safety evaluation, the observers also reported any airspace violations that occurred during the run and made a determination of cause.

b. Controller Safety Evaluation

In addition to supervisory monitoring, it is common practice in field ATC operations for controllers to identify potentially unsafe conditions that they encounter while staffing a sector. This evaluation was formalized for the present test using a comprehensive controller safety judgment corresponding to the overall observer's judgment. Following a test run, each controller on the participating team completed a safety evaluation. If any of the team members judged the run as unsafe, the controller was asked to record explanatory remarks.

4.4.3.6.2 Controller Performance and Workload.

a. Observer Ratings of Controller Performance Factors

During each test run, the observers monitored several controller performance factors believed to underlie their expert evaluations of work in the field. Because of numerous mitigating factors, subjective evaluations must be used to measure these variables with the observer acting as an "expert filter." During the test runs, the observers were asked to maintain a count of the frequency with which each of the following events occurred:

1. Errors or Omissions in Required Flight Strip Marking

2. Descending Arrival Aircraft Early Rather than Permitting Fuel Efficient Descents

3. Climbing Departure Aircraft Late Rather than Permitting Fuel Efficient Climbs

4. Untimely Issuance of Clearance

5. Failure to Comply with Letters of Agreement

6. Early Handoff Offers

7. Late Handoff Offers

8. Delayed Handoff Acceptance

Following the test run, the observers were asked to make judgments of the significance of their observations. For each of the above, the questionnaire permitted the observer to indicate that the event (1) never occurred, (2) occurred, but within normal limits of operational acceptability, (3) occurred more often than normal for this sector at this time of day, or (4) occurred unacceptably often. They were also asked to comment on perceived causes for any negative judgment.

In addition to these general ATC performance assessments, the observers completed specific questionnaire items designed to evaluate controller responses to the system failure, sector on/off, extended transaction time, and increased aircraft equipage conditions that were exercised during selected full-scale simulation test runs.

b. Controller Workload Ratings

Controller workload was assessed using two subjective workload rating scales that were completed after each test run.

The first scale required a relative rating of workload. The controllers were asked to rate the previous test run in comparison to a corresponding busy work period at the test position in the appropriate sector at the Miami ARTCC. The test run workload was rated as (1) much lower than usual, (2) somewhat lower than usual, (3) about the same, (4) somewhat higher than usual, or (5) much higher than usual.

The second scale required the controller to make a binary judgment regarding the impact of the workload experienced during a test run. Controllers indicated whether the workload was "acceptable and presented no threat of performance failure" or "unacceptable and threatened to, or actually did, affect the quality of my performance."

4.4.3.6.3 Communications Performance.

The following measures were used to determine the impact of CPDLC I on the accuracy and effectiveness of ATC communications.

a. Number and Content of Data Link Uplinks Sent

The number and content of Data Link messages sent by controllers was assessed by analyzing the SAR tapes from the test runs. Messages were tabulated by message category. These categories included: (1) transfer of communication messages; (2) altimeter messages (automatic and manual); and (3) informational messages sent using the MTM service.

b. Controller Ratings Of Communications Effectiveness

Following each test run, the controllers completed a rating form to evaluate the impact of CPDLC on the accuracy, timeliness, and effectiveness of ATC communications. The questions focused on identifying any negative effects of CPDLC on normal voice communications, and on any situations in which the use of CPDLC resulted in untimely communications or confusion requiring resolution by voice radio.

4.4.3.6.4 HCI Effectiveness.

In addition to the controller design review conducted during the first week of testing and the overall measures of system/controller performance described above, the CPDLC I

HCI was assessed using observer and controller observations and focused measures of input accuracy and display effectiveness. As a part of the observers' post-run questionnaire they were asked to evaluate the frequency with which controllers at the sector made Data Link input errors that were detected and mitigated, as well as whether they observed errors that were not detected by the controllers. The controllers also completed a questionnaire to report any HCI problems experienced during each test run.

In addition, the Host SAR tapes were analyzed to tabulate the number of keyboard errors made during CPDLC I data entries. In order to assess the effectiveness of CPDLC I displays, the system recorded the frequency with which controllers attempted to send Data Link messages to nonequipped aircraft. Finally, the observers recorded any significant delays in controller detection of message failure alerts, initial contact mismatch alerts, and time-out indicators.

4.4.4 Post Test Questionnaire and Debriefing.

Following the completion of all simulation testing, the controllers completed a post-test questionnaire and participated in a structured group debriefing. The questionnaire items and debriefing topics focused on issues defined by the COIs and related MOEs assigned to the Air Traffic Effectiveness Test (MOP 2.12.3, MOP 6.2.3, MOP 5.5.2, MOP 5.6.2, MOP 7.3.3, MOP 7.5.3 MOP 8.3.3). These included: (1) A retrospective assessment of the design of the services and the HCI; (2) A retrospective assessment of the adequacy of CPDLC I training; (3) The impact of CPDLC I on ATC operations; (4) The impact of CPDLC I on safety, efficiency, and controller workload; (5) The adequacy of CPDLC I procedures; and (6) The effects of CPDLC I on communications accuracy and efficiency.

5. RESULTS.

5.1 CONTROLLER TRAINING.

FAA training specialists conducted the 4-day controller training for CPDLC I. The training program included lecture, CBI, and DYSIM components, as well as a discussion/reinforcement component that followed each CBI and DYSIM element. Controllers completed an individual assessment form following every training component (see appendix A). Controllers also completed additional "problem forms" following the DYSIM performance check and a scenario designed to simulate a sector "push" condition. The responses and comments from the assessment and problem forms and comments noted during discussion periods were used to derive the results presented below.

5.1.1 Training Evaluations.

5.1.1.1 Lecture (Introduction and Procedure).

No major areas of concern were noted in student questionnaire responses to either the Introductory or the Procedures lecture. They indicated that each lesson held their interest and that lesson teaching aids and examples supported lesson content, and added that ample opportunity was provided for questions to be asked and answered. Controllers also responded that lesson pacing was good although the Procedures lecture (including breaks) lasted approximately 4.5 hours.

5.1.1.2 Computer Based Instruction (CBI).

Three CBI modules, covering basic and advanced CPDLC I topics, were presented to the controllers. Topics for the basic module included an introduction to CPDLC I, TC, IC/AS, MT, deleting, and two drills (Delete and CPDLC entries, designed to build speed and competency while using CPDLC commands). Topics for the two advanced modules included TC override, UH override, UF, advanced MT, CPDLC sessions and eligibility, filtering lists, and each also included the entries drill. Controller responses on all three post CBI assessment forms were very positive. They responded that overall, the content, instruction, and format of the lessons were good and that the lessons were adequate to teach the objectives. Further, they indicated that both drills were helpful preparation for the DYSIM practice scenarios. Controllers also agreed that the post CBI discussion sessions were essential for reinforcing and clarifying the lesson.

However, while controller responses indicated no major areas of concern with the lesson format and quality of content, six of eight controllers commented that the Basic CBI contained so much information that they felt hurried. They also indicated that more emphasis was needed on instruction for eligibility transfer and IC mismatch. Additionally, CBI context realism could be improved by clarifying the instruction when D side responses are required and by correcting inconsistent and unrealistic CBI interactive and background graphics.

5.1.1.3 DYSIM.

CPDLC I DYSIM training consisted of seven problems integrated with the CBI components to reinforce CPDLC concepts. The problems progressed from simple nose to tail problems run without headsets designed to build confidence and proficiency with CPDLC commands to scenarios running "typical traffic" incorporating both voice and CPDLC. The last two scenarios were the performance check and a "push" scenario simulating a peak traffic time for the Miami en route center. Controller questionnaire responses to all DYSIM scenarios were uniformly positive. Some comments throughout indicated that more opportunities could be provided for activity and repetition. Several comments indicated that the Performance Check was a little slow. Comments regarding the push scenario indicated that the pace was good and that the training had prepared them to handle the traffic.

5.1.2 Recommended Enhancements.

Controller responses indicated that the training program was acceptable and no mandatory changes were required for deployment. However, the following improvements were suggested.

a. To address the length and amount of information contained in the Basic CBI it was recommended that this CBI component be split into two segments.

b. Increase the emphasis in Basic CBI instruction and associated discussion sessions on transfer of eligibility and IC mismatch.

c. Include the importance of scanning the Status List in lecture, CBI, and DYSIM instruction to address problems such as late TOC release and timely non-normal status detection.

d. Correct inconsistent and unrealistic CBI graphics.

e. Add content regarding the operational implications of CPDLC to discussion sections.

f. Clarify CBI instructions when a D side response is required.

g. Provide students with an estimated time for completion of CBI components.

h. In response to controller comments regarding the pace of the DYSIM scenarios, add a note to the DYSIM instructor's checklist allowing the flexibility to provide more instruction/activity for the student as necessary or as time permits.

i. Reduce the size of the controller reference cards to accommodate sector space problems.

j. Provide a card for sector posting that includes correct phraseology for non-normal conditions as required by the procedures order.

5.2 HUMAN COMPUTER INTERFACE.

The findings presented below are a synthesis of the inputs that were obtained from the independently written controller HCI design reviews and the structured group debriefings that were conducted immediately after the individual reviews and at the end of full-scale simulation testing. The design reviews and debriefings focused on identifying aspects of the design that must be changed to ensure safety and user acceptance during the single site deployment of CPDLC I at the Miami ARTCC. A secondary objective was to identify modifications to the designs for the TOC, MT, and IC and AS services that the participants indicated could be deferred to CPDLC IA.

5.2.1 Mandatory Design Modifications.

The displays and inputs provided by the HCI were judged to be functionally complete and usable. However, the group identified six areas of concern regarding the HCI that should be resolved prior to field deployment:

a. Incorrect Initial Contact (IIC) Alert

The delivered HCI provided an alert when an uplinked message was in a non-normal status that could require controller action. Specifically, the status field for the message entry in the status list changed to indicate the non-normal status (e.g., FAI, ERR, TIM, IIC) and the entire entry was displayed in white.

While the test participants indicated that these alerts were adequate for other non-normal states, they determined that a higher level of alerting will be required for initial contact messages in the IIC status to ensure timely controller detection and action. Potential solutions generated by the group included flashing the status list entry or display of the entry at twice the brightness level of other entries with non-normal status.

When selecting an appropriate method for improving the alerting qualities of the IIC indication, it should be noted that this issue was addressed in two previous simulation studies of CPDLC I (Darby and Shingledecker, 1999, 2000.) The results of the first study showed that the non-normal status abbreviations (NEG, UNA, FAI, ERR, TIM, IIC) provided in the status list were not sufficiently obvious to reliably alert the controller and prompt any needed action. The second study examined two options for increasing the alerting value of these indications in CPDLC I. In the first option, the message entry in the status list blinked (on/off) at a 1.5 second rate when a message had an atypical status. In the second option, the status list entries were displayed in yellow at twice the intensity of other entries in the list.

The blink alert was found to be more effective than the double bright display in drawing the controller's attention to the status list. However, some controllers indicated that the blinking display was distracting and was difficult to read because the text was available for only 50 percent of the viewing time. The effectiveness of a blinking alert as well as the distraction effect is likely to be attributable to the fact that controllers typically position the status list near the edges of the display screen to avoid interference with viewing aircraft tracks and FDBs. Thus, when focusing on air traffic, the status list was presented in the peripheral visual field where the visual system is most sensitive to movement and variations in light intensity.

Two potential solutions were suggested to minimize required viewing time and reduce distraction. In one of these, the controller would have the ability to cancel the blinking by a trackball input to the status list entry. In the second solution, flashing (dim/bright) would be used as an alternative to blinking in order to distinguish the alert from higher priority alarms and to make the display continuously readable. It is

recommended that one or both of these options be considered for implementation in the CPDLC I HCI delivered to the Miami ARTCC.

b. IIC Delete Action

The HCI permitted controllers to cancel an IIC indication (and delete the status list entry) by entering the same command used to delete all other messages in a "closed" nonpositive status. The participants concurred that a confirmatory step should be added to this entry to discourage accidental deletion prior to resolving the altitude mismatch with the aircrew.

c. Status List Indication of "ERR"

The ERR status for a CPDLC I message indicates that an application error occurred as the system attempted to uplink a message. In the delivered HCI, the data field of the status list entry for a message having an ERR status presented a brief description of the type of application error that had occurred.

The participants noted that this descriptive data was not useful and that it replaced the original data field, making it impossible to determine the type and content of the message that the system had attempted to send. The group concurred that a status list entry with an ERR status should continue to display the original data field content.

d. Controller Eligibility to Change TOC Mode

The tested HCI permitted entries to change the TOC mode (MAN/AUTO/OFF) from both the Radar Controller and Radar Associate Controller (D-side) keyboards. To ensure the Radar controller's awareness of the active TOC mode at all times, the participants indicated that these inputs should be possible only at the Radar position.

e. Indication of Status List On/Off

The HCI provided controllers with the ability to suppress the status list. However, unless messages were currently being displayed in the status list, it was not clear whether the status list was turned on (and empty) or suppressed. In such a situation the controller would be required to call up the sector settings list to determine whether the status list was turned on or off.

The controller participants noted that a clear indication of whether the status list is on or off should be provided on the situation display at all times when CPDLC is on at the sector. Two solutions were suggested. In the first, the header for the status list "SL" would be displayed whenever the status list was turned on. Alternatively, the SL pick area in the DL section of the DC view would be highlighted whenever the status list was turned on.

f. Beacon Code List Overwrites Sector Settings Display

The HCI provided an ability to display the current settings for CPDLC I functions in the Computer Readout Display (CRD) view of the DSR. Upon making the appropriate entry, these sector settings would be displayed for an adjustable time parameter. However, because the sector settings shared the CRD with the Beacon Code List, the settings display was often replaced while the controllers attempted to examine it.

The participants indicated that the sector settings display was needed primarily during initial sector setup and when doing a transfer of position responsibility briefing. Consequently, they determined that this problem could be remedied without software changes. Specifically, the controllers recommended that local procedures be modified to require the current status of CPDLC settings be manually entered on sector briefing boards used at the Miami ARTCC.

5.2.2 Recommended Design Enhancements for CPDLC IA.

The four design issues described below also were identified during the debriefings. However, because of the short duration of the CPDLC I implementation and low levels of aircraft equipage, the participants indicated that the resolution of these issues could be safely deferred to CPDLC IA.

a. Cue Compensation for Silent Initial Contact

In discussions following full-scale simulation testing, the controllers noted that the "silent" check-in associated with CPDLC's automated initial contact service results in the loss of a cue to required action that is inherent to non-CPDLC operations. When using voice radio, the call from the pilot reporting his assigned altitude appears to act as a prompt to the controller signaling that any clearance that should be issued as soon as the aircraft is on frequency can be sent. Such cueing may play a role when, for example, the controller must give a climbing aircraft a new altitude as it enters the sector.

Under CPDLC operations this alerting cue is lost. Some indication is provided by the appearance of the data block indication of CPDLC eligibility (which should also be associated with voice radio availability). However, the visual cue may not be sufficiently effective as a replacement. It should also be noted that the effectiveness of the data block symbol change might improve with controller experience, increased CPDLC equipage levels, and the transition to CPDLC IA where more messages will be sent using the Data Link system.

b. History List

In agreement with controllers who participated in the Data Link en route benefits study (Data Link Benefits Study Team, 1994), the effectiveness test controllers

indicated that a history list should be provided. This list should be available on command for each aircraft and present the last message sent for each message type. The controllers noted that the history list would be required where control teams rather than a single controller staffs a sector. In these situations, the history list would resolve any question of whether a message had been sent by a team member, eliminate unnecessary discussion, and prevent instances where a message is sent to an aircraft twice to ensure its receipt.

c. Automatic Menu Text Uplinks

The participants recommended an enhancement to the Menu Text capability that would permit automated uplinks of routine messages such as weather reports and SIGMETS. Such uplinks would be triggered upon confirmation of a correct initial contact downlink from an aircraft as it enters a sector.

d. Opaque Status List

The status list delivered in CPDLC I is a standard HCS list which overlays text on a transparent background. The test participants noted that the readability of the list can be impaired if it is positioned over an area of the situation display that contains map lines, symbology, or aircraft data blocks. Test personnel explained that all CPDLC lists will be converted to DSR views for CPDLC IA. (DSR offers controllers the option to display views with an opaque or transparent background). The problem was judged to be tolerable for the CPDLC I implementation.

5.2.3 Additional Measures of HCI Effectiveness.

5.2.3.1 Entry Errors and Attempts to Send to Ineligible Aircraft.

A total of 1,445 CPDLC messages was sent during the 14 full-scale simulation test runs. HCS SAR tape recordings made during the runs identified 63 keyboard entry errors. Three of the errors (.02 percent of total messages sent) were attempts to send a message to an aircraft that did not have a Data Link session in progress. Eleven errors (.07 percent) were attempts to send messages to aircraft that had an active session, but the sector did not have eligibility for CPDLC communications. Of these, seven were attempts to send messages to aircraft whose Data Link eligibility had been transferred to the next sector immediately prior to the entry error.

Twenty-two inappropriate inputs (1.5 percent of the total messages sent) occurred under circumstances in which the controller had CPDLC eligibility. These errors included: (1) attempts to start a session with an aircraft; (2) attempts to handoff an aircraft with outstanding messages; (3) attempts to send messages to an aircraft while a handoff was in progress; and (4) attempts to send a message when another message of the same type was outstanding. The remaining 27 errors were cases in which the input message was appropriate, but the controller failed to make the entry using the correct format.

Overall, analysis of the relatively small number of keyboard errors committed during testing revealed no consistent pattern suggesting ineffectiveness of the Full Data Block symbols used to indicate Data Link session/eligibility or specific problems with the design of the CPDLC keyboard commands.

5.2.3.2 Post-Run CPDLC HCI Problem Reports.

Following each test run, the controllers completed a rating form to report any problems that they had experienced in using the CPDLC HCI. A total of 96 post-run observations were obtained for each of 12 potential HCI problem areas. These are listed below in order of the number of problems reported:

Problem Area	Number of Reports	Percent of Observations
Detecting status list alerts	7	7.3
Monitoring transaction status	6	6.2
Remembering message content or whether it had been sent	6	6.2
Making keyboard entries	5	5.2
Establishing a CPDLC session	5	5.2
Reading CPDLC displays	3	3.1
Coordinating actions of R and D controllers	3	3.1
Distinguishing between eligible and ineligible aircraft	1	1.0
Sending TOC	1	1.0
Sending MTM	0	0
Sending ASM	0	0
Managing CPDLC lists	0	0

Of the 1,152 post-run observations, 37 (3 percent) yielded an HCI problem report. As shown in the list, 13 problem reports were associated with detecting status list alerts or monitoring transactions in the status list. Subsequent debriefings revealed that these reports referred to the controllers' concerns that insufficient alerting was provided in the

status for an incorrect initial contact (IIC) and that the status list data field was overwritten when a message received an error (ERR) status. As discussed in section 5.2.1, both of these issues were identified as mandatory changes to the HCI for CPDLC I implementation.

Six reports identified problems with remembering the content of a message after it had been removed from the status list, or with remembering whether a message had been sent or not. The problem was not considered sufficiently serious to impact CPDLC I operations; however, the provision of a history list was recommended for the CPDLC IA implementation (see section 5.2.2).

The remaining HCI areas in the list that received at least one problem report did not result in mandatory design changes for CPDLC I or recommended changes for CPDLC IA. Examination of the distribution of these reports over the test runs shows that of the 18 problems experienced, 16 were reported during the first series of 6 test runs, and only 2 during the last series of 8 test runs. Therefore, it is likely that these reports of problems with using CPDLC were a result of inexperience with the system, and not fundamental inadequacies in the HCI.

5.3 PROCEDURES.

5.3.1 Controller Review of CPDLC I Procedures.

During the training phase of the test, the participants received instruction on a draft CPDLC procedures order (7110.XX) developed for use in normal operations and when system failures and errors occur. They were also required to exercise each procedure during a DYSIM performance evaluation at the end of the training course. As part of the subsequent design review, each controller provided an evaluation of procedural responsibilities associated with (1) flight progress strip marking, (2) countermanding an uplink, (3) commanded termination, (4) altimeter setting, (5) IC mismatch, (6) communications transfer, (7) stealing/establishing Data Link eligibility, (8) malfunctions/ shutdowns, (9) startover messages from the HCS, (10) transfer of position responsibility, and (11) sector team responsibilities. The full text of the procedures are included as part of the review booklet in appendix A.

The results of the review showed that the test controllers were unanimous in their judgment that the draft procedures would be effective and that there would be no operational or acceptance problems associated with implementing them at the Miami ARTCC.

5.3.2 Simulation Testing of Procedures.

5.3.2.1 System Outages.

Major system failures causing loss of CPDLC throughout the facility were inserted at unpredictable times during five of the full-scale simulation test runs to assess controller

usage of trained procedures and their effectiveness. Observer evaluations of a failure of the HNL indicated that controllers correctly switched to voice communications, successfully recovered from the event, and that there was no impact on safety. On a failure of the DLAP, three of four sectors issued the appropriate voice broadcast of a CPDLC failure. The fourth controller did not immediately remember the implications of a DLAP outage, but made the correct announcement when told that it created a loss of CPDLC. Observer reports indicated that recovery was successful in all cases and that there was no impact on safety.

An HCS switchover event was successfully resolved by all sectors. Controllers issued the announcement of the CPDLC outage, reviewed the status of CPDLC messages, and resolved any outstanding transactions that required action. The controllers also recovered successfully from two extended HCS startover events. Appropriate broadcasts of the phraseology defined in the procedures order were made and no safety impact was observed.

5.3.2.2 Non-Normal Events.

Recovery from non-normal CPDLC events was tested in the final eight simulation test runs. These events were inserted by test personnel or created by cooperating aircrews flying the RCS flight simulator. A total of 20 non-normal transaction states (TIM, UNA, ERR, FAI, IIC) were presented to the controllers for resolution. In addition, they were required to follow procedures for countermanding a CPDLC message using voice radio four times, and deal with an aircraft that had mistuned a radio frequency after receiving a Data Link TOC three times.

Observer reports showed that the non-normal transaction states were detected in a timely fashion in all cases. The report also indicated that the procedures dictated by the order were followed in all but one case where the controller failed to delete a transaction in a TIM state and caused a delay in transferring CPDLC eligibility to the next sector. The observers rated the procedures as effective in all instances.

5.4 EFFECTS OF CPDLC ON ATC OPERATIONS.

The impact of CPDLC on ATC Operations was analyzed separately for the different operating conditions that were examined during full-scale simulation testing. The following sections present the findings for these effects under nominal system operations, when some sectors had CPDLC disabled, when aircraft equipage levels were increased, and when system transit time performance was degraded.

5.4.1 Nominal System.

Eight of the 14 test runs were conducted with scenarios in which 20 percent of the aircraft were equipped for CPDLC communications and with CPDLC time performance set at a level that met system specifications. Measurements of performance on sector

duties, safety, and controller workload were used as indices of the effects of CPDLC on ATC operations.

5.4.1.1 Sector Duty Performance.

During each test run, the observers judged each control team on eight factors indicative of degraded sector performance. A 5-point rating scale ranging from 1 "never occurred" to 5 "occurred unacceptably often" was used to quantify the judgments.

Ratings on each dimension for eight test runs averaged across the four observers are summarized in table 5.4.1.1-1. As shown in the table, none of the average ratings exceeded the midpoint (3 - "within normal limits for the sector during this duty period") on the 1 to 5 scale. Although flight progress strip marking appeared to receive the poorest average ratings overall, none of these indicated that omissions or errors were greater than normal.

TABLE 5.4.1.1-1. SECTOR DUTY PERFORMANCE UNDER NOMINAL CPDLC OPERATIONS

Performance Factor	Mean Rating
Errors/Omissions FS Marking	2.16
Inefficient Descents	1.38
Inefficient Climbs	1.71
Late/Early Clearances	1.33
Compliance with LOA	1.13
Early Hand Off	1.46
Late Hand Off	1.33
Late Hand Off Acceptance	1.50

Of the 24 sector test run observations made under nominal system conditions, the overall effectiveness and efficiency of the controllers' performance were rated as either "effective with a high degree of efficiency" or effective with acceptable efficiency" in 23 cases. One sector team's performance was rated "ineffective and inefficient" during one test run. This rating was attributed to problems with simulation pilot responsiveness to voice clearances, and did not implicate the CPDLC system.

5.4.1.2 Safety.

Controller and observer ratings of the margin of safety achieved during each test run were made on a 4-point scale (1 – "Greater than normal", 2 – "Typical operations with acceptable margin of safety", 3 – "Safety not compromised, but had concerns", 4 – "Unsafe and unacceptable"). The mean observer rating under nominal system performance and loading conditions was 2.0. The corresponding mean controller safety rating for these test runs was 1.96.

5.4.1.3 Controller Workload.

Controllers rated their perceived workload for each test run relative to normal, non-CPDLC operations at the sector on a scale ranging from 1 – "Much lower than usual" to 5 – "Much higher than usual". They also provided an absolute binary rating to indicate whether the experienced workload was acceptable or unacceptable.

The mean rating of relative workload for the 48 observations was 3.27, indicating that controllers perceived their workload to be 3 – "About the same as usual" or 4 – "Somewhat higher than usual". Overall, 46 of the 48 binary ratings indicated that the level of workload experienced by the controllers was acceptable, and did not affect their ability to control traffic safely and effectively. Two ratings of unacceptable workload were obtained from a single sector team who reported that poor simulation pilot responsiveness and simulation system performance problems during one test run had raised their workload. These controllers did not attribute the increased workload to CPDLC.

5.4.2 Sector On/Off Effects.

Four test runs were conducted with CPDLC disabled in one of the arrival and one of the departure sectors. Observer reports revealed no performance problems or apparent confusion associated with controller teams who had CPDLC disabled or who received aircraft from, or handed aircraft off to, other sectors that had CPDLC disabled.

These observations were corroborated by post-run ratings completed by the controllers which indicated that no problems were experienced when dealing with aircraft received from, or going to, a sector with Data Link turned off.

5.4.3 Increased Equipage and Extended Transaction Delays.

The final series of eight test runs were primarily conducted to assess the effects of increasing the number of aircraft equipped to conduct CPDLC I communications and of degraded CPDLC one-way transit time performance. Test runs were completed with both the expected 20 percent of aircraft in a scenario equipped for CPDLC and with 40 percent equipage. At each of these equipage levels, one-way transit times were manipulated to provide both expected system time performance and transit times extended by 50 percent.

5.4.3.1 Total Transaction Times.

Figures 5.4.3.1-1 and 5.4.3.1-2 present the frequency distributions of the total transaction delays that were experienced by the controllers during testing under expected system performance conditions and degraded performance conditions. Total transaction time (TTT) is the elapsed time between an entry to send a CPDLC message to the receipt of a response from the flight deck. It includes the uplink transit time, the aircrew response time, and the downlink transit time.

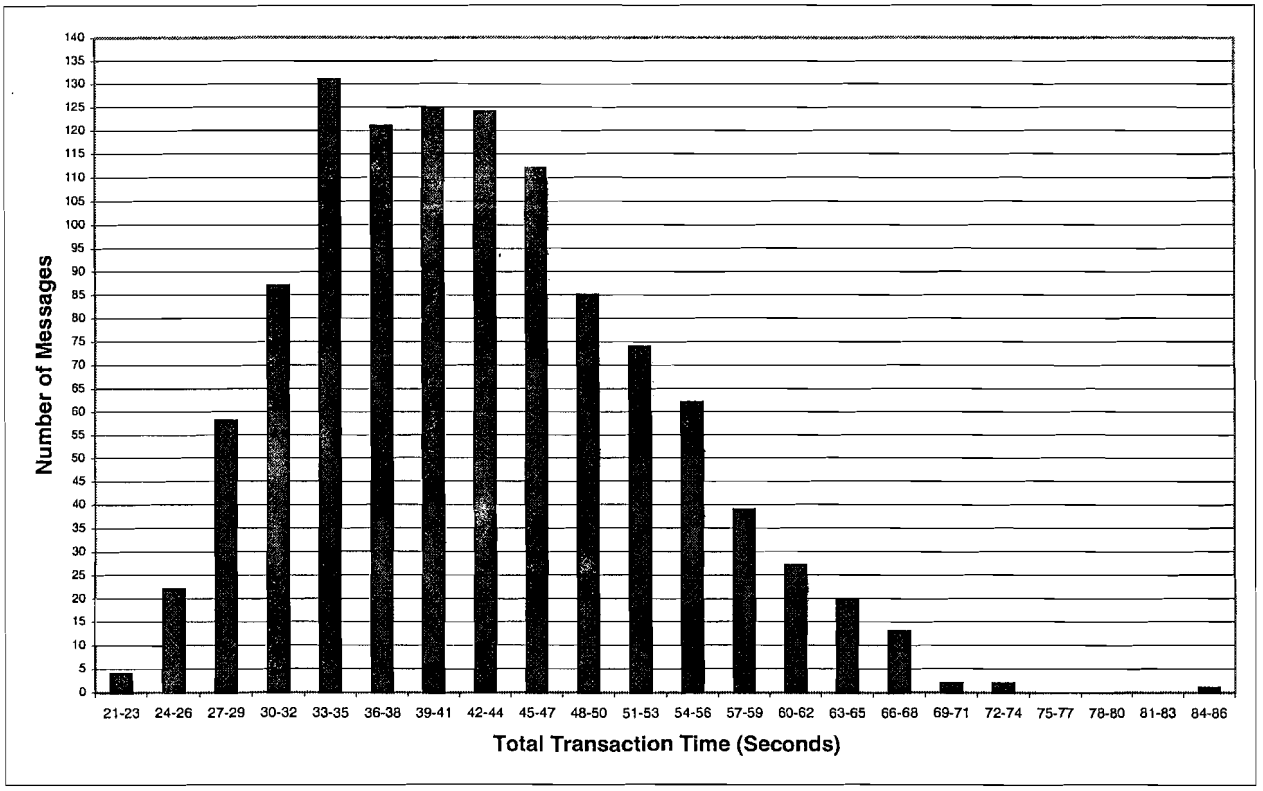

FIGURE 5.4.3.1-1. TOTAL TRANSACTION TIMES DURING NORMAL SYSTEM PERFORMANCE TESTING

Figure 5.4.3.1-1 shows the distribution of TTTs of all messages sent during test runs in which uplink and downlink transit times were drawn from a distribution based on a model of one-way transit times that met the CPDLC I performance specification. Figure 5.4.3.1-2 shows the distribution of TTTs of all messages sent during test runs in which the one-way transit times were based on a model in which performance was degraded to increase the delay by 50 percent. As described in section 4.2, aircrew response times under both conditions were based on a distribution modeled after data collected during a flight simulation study which used a pilot HCI configuration similar to that chosen by the CPDLC I launch airline.

As shown in figure 5.4.3.1-1, the mean TTT experienced by the controllers under normal system performance conditions was approximately 43 seconds. TTTs ranged from a minimum of 21 seconds to a maximum of 86 seconds. The mean extended TTT experienced under degraded system performance was approximately 54 seconds (figure 5.4.3.1-2). The minimum TTT increased to 23 seconds, while the maximum increased to 89 seconds.

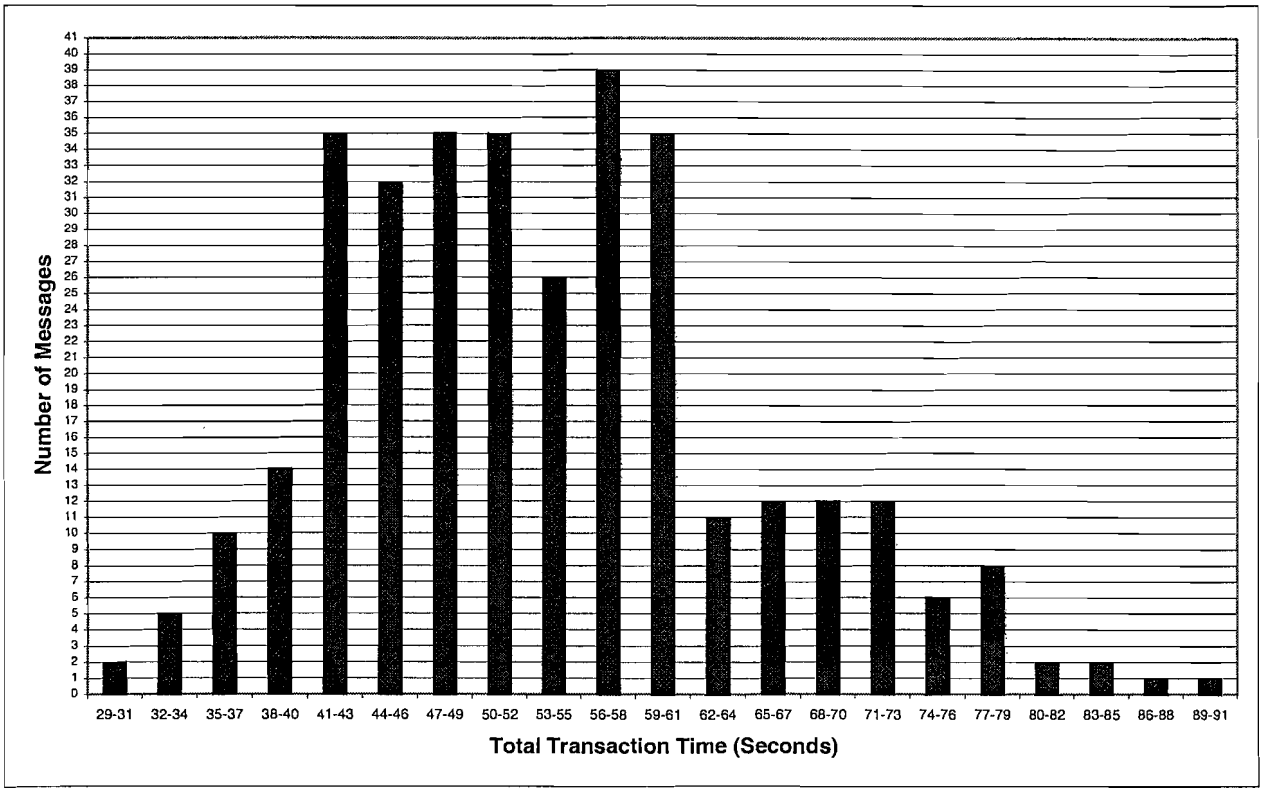

FIGURE 5.4.3.1-2. TOTAL TRANSACTION TIMES DURING DEGRADED SYSTEM PERFORMANCE TESTING

5.4.2.3 Total Transaction Time and Aircraft Equipage Effects.

Table 5.4.2.3-1 presents the average observer ratings on eight sector performance factors as a function of the test conditions. As shown in the table, a majority of the mean ratings indicate that performance deficiencies either (1 – "Never occurred") or (2 – "Rarely occurred") under all of the transit delay and equipage combinations. In agreement with the nominal system test results presented in table 5.4.1.1-1, ratings of errors and omissions in flight progress strip marking were somewhat poorer than those of the other factors. However, none of the ratings indicated that performance on this task exceeded a value of 3 ("Occurred, but within limits of operational acceptability").

Observer and controller ratings of the margin of safety associated with each of the transit delay and equipage combinations are shown in table 5.4.2.3-2. Both ratings were made on an identical four-point scale (1 – "Greater than normal", 2 – "Typical

TABLE 5.4.2.3-1. SECTOR DUTY PERFORMANCE UNDER EXTENDED TRANSACTION DELAYS AND INCREASED EQUIPAGE

Performance Factor	Norm./20%	Norm./40%	Ext./20%	Ext./40%
Errors/Omissions FS Marking	2.13	2.00	1.75	2.13
Inefficient Descents	1.38	1.13	1.25	1.13
Inefficient Climbs	1.50	1.13	1.00	1.13
Late/Early Clearances	1.13	1.25	1.25	1.13
Compliance with LOA	1.13	1.00	1.00	1.00
Early Hand Off	1.38	1.38	1.25	1.25
Late Hand Off	1.25	1.25	1.25	1.25
Late Hand Off Acceptance	1.38	1.38	1.25	1.50

operations with acceptable margin of safety", 3 – "Safety not compromised, but had concerns", and 4 – "Unsafe and unacceptable"). While the observer ratings were somewhat more favorable than the controller ratings, none indicated a reduced margin of safety associated with increased equipage or degraded transit time.

TABLE 5.4.2.3-2. SAFETY RATINGS UNDER EXTENDED TRANSACTION DELAYS AND INCREASED EQUIPAGE

Rater	Norm./20%	Norm./40%	Ext./20%	Ext./40%
Controller	2.00	2.00	2.00	2.00
Observer	1.88	1.63	1.75	1.75

Mean controller workload ratings as a function of the transit time and equipage variables are presented in table 5.4.2.3-3. These ratings were made on a scale ranging from 1 – "Much lower than usual" to 5 – "Much higher than usual." As shown in the table, mean workload ratings clustered around a rating of 3 indicating that they perceived their workload to be "About the same as usual." None of the binary ratings indicated that the workload experienced under any of the test conditions was unacceptable.

TABLE 5.4.2.3-3. CONTROLLER WORKLOAD RATINGS UNDER EXTENDED TRANSACTION DELAYS AND INCREASED EQUIPAGE

Controller	Norm./20%	Norm./40%	Ext./20%	Ext./40%
Radar	3.00	2.75	2.50	3.12
Data	2.88	3.0	3.0	3.12

Post-run controller questionnaires corroborated the safety and workload findings. None of the controllers reported that they had experienced problems in dealing with too many CPDLC-equipped aircraft or with transaction delays that were too long.

5.5 EFFECTS OF CPDLC ON COMMUNICATIONS.

The overall effects of CPDLC I on the quality of ATC air-ground communications were assessed by the controllers and observers following each test run. Ratings of effects of CPDLC on the effectiveness, accuracy, and timeliness of communications were made on the 5-point scale below:

a. Communications Rating Scale:

1 – Large Improvement
2 – Some Improvement
3 – No Effect
4 – Some Decrease
5 – Unacceptable Decrease

Table 5.5-1 presents the mean controller and observer ratings on each communications dimension as a function of transit time and level of CPDLC equipage. Examination of the results for all dimensions shows that the impressions of both the observers and controllers were that CPDLC I either had no effect on the effectiveness, accuracy, and timeliness of ATC communications or produced some improvement, regardless of the level of aircraft equipage or transit time.

While these results clearly indicate that CPDLC I had no detrimental effects on ATC communications during effectiveness testing, examination of trends in the data provided some insight into factors that may affect the level of benefit that will be derived from the use of CPDLC.

In order to facilitate analysis of the effects of aircraft equipage and transit time, the third column of the table shows the mean ratings across observers and controllers for each dimension. Inspection of these data shows no consistent or large differences between ratings for test runs conducted using normal and extended transit times. However, ratings of effectiveness, accuracy, and timeliness were consistently more favorable following the test runs conducted with 40 percent of the aircraft equipped with CPDLC than with only 20 percent of the aircraft capable of communicating via Data Link. This finding suggests that the beneficial effects of CPDLC will be accrued when aircraft equipage levels reach a point that make Data Link a routine mode of ATC communication.

TABLE 5.5-1. MEAN RATINGS OF THE EFFECTS OF CPDLC I ON ATC COMMUNICATIONS

Communications Effectiveness

Transit Time/ Equipped A/C	Observer	Controller	Mean
Normal/20%	2.63	2.38	2.51
Normal/40%	2.63	2.00	2.32
Extended/20%	2.50	2.50	2.50
Extended/40%	2.38	1.88	2.13

Communications Accuracy

Transit Time/ Equipped A/C	Observer	Controller	Mean
Normal/20%	2.63	2.44	2.54
Normal/40%	2.13	2.13	2.13
Extended/20%	3.00	2.50	2.75
Extended/40%	2.50	2.25	2.38

Communications Timeliness

Transit Time/ Equipped A/C	Observer	Controller	Mean
Normal/20%	2.75	2.75	2.75
Normal/40%	2.38	2.50	2.44
Extended/20%	2.75	2.88	2.82
Extended/40%	2.63	2.44	2.54

5.6 OTHER EFFECTIVENESS TEST FINDINGS.

In addition to formal test results, system shakedown activities, and observations made by test personnel and controllers during the effectiveness test revealed a group of deficiencies in the delivered system. The following are the primary problems that were identified for resolution:

a. Initial Eligibility Assignment

When initial CPDLC eligibility is assigned to a sector within the facility, the system assigns it to the sector with track control. This design could create a situation where one sector is communicating with the aircraft via CPDLC, while the other sector (outside the facility) is still communicating with it by voice. The recommended modification was to add the requirement that initial eligibility be assigned to the sector with track control only if the aircraft is within the facility's airspace.

b. Altimeter Uplinks

Two situations were discovered in which altimeter setting messages were automatically sent to aircraft when they should not have been. Against system requirements, the software sent messages to aircraft descending below FL 180. In addition, if an altimeter was manually sent to an aircraft outside the sector boundary, a second altimeter was automatically uplinked when the aircraft crossed the boundary.

c. Altimeter Not Sent

Test observers noted that when an altimeter setting is not automatically uplinked because the sector does not have track control, the system does not inform the controller. To ensure safety, a modification was recommended to provide a specific alerting message for this event.

d. CPDLC Shutdown

Failure testing of the Host Interface Device (HID) and the Data Link Application Processor (DLAP) showed that although CPDLC was properly shutdown when these failures occurred, aircraft session and eligibility symbols persisted on the situation display. Creation of a hard shutdown message was recommended to clear all CPDLC symbols and lists.

e. Status List Following HOST Start Over

In accordance with requirements, after an extended HOST start over which causes CPDLC to fail, a recovered status list was displayed with all transactions showing an "FAI". During the effectiveness test, it was recognized that an IIC present prior to the start over would not be displayed after the event, thereby creating a safety hazard if the controller had not noticed it earlier. It was determined that the problem would be resolved if the system sent a message to the Flight Progress Strip Printer when any IIC occurred at a sector.

f. *ALL Status List Display

The tested system failed to meet requirements for status list entries when a Menu Text message is sent to all aircraft (*ALL). Separate entries were not generated for each aircraft responding with Standby (SBY). In addition, *ALL entries with the time out status (TIM) were not highlighted.

In accordance with requirements, *ALL transactions that resulted in a TIM did not generate individual entries for each applicable aircraft. However, testing indicated that such entries were needed to permit the controller to resolve them with the pilots when necessary.

6. CONCLUSIONS AND RECOMMENDATIONS.

The results presented in section 5 of this report warrant the following conclusions and related recommendations regarding the five Critical Operational Issue (COI) that were addressed during effectiveness testing of Controller-Pilot Data Link Communication Build 1 (CPDLC I).

6.1 ATC OPERATIONS (COI 2).

Full-scale simulation testing provided no evidence to suggest that the use of CPDLC I will disrupt or degrade air traffic control (ATC) operations. Testing under nominal system performance conditions with CPDLC-equipped aircraft comprising 20 percent of the traffic sample indicated that CPDLC did not increase perceived controller workload or impair performance on key sector duties. In addition, controller and observer ratings revealed no reduction in the margin of safety associated with CPDLC usage. No negative effects of selectively disabling CPDLC in contiguous sectors were observed.

Major system outages injected into the test runs resulted in successful recoveries with no impact on safety. Furthermore, individual transaction errors and failures as well as other non-normal transaction states and events were detected in a timely fashion and successfully ameliorated using CPDLC procedures.

Testing conducted with 40 percent aircraft equipage and one-way transit time performance degraded by 50 percent detected no reduction in sector duty performance or safety and no increase in controller workload.

6.2 ATC COMMUNICATIONS (COI 5, COI 6).

Test results show that CPDLC I maintains at least the current level of accuracy and efficiency in ATC communications and that time performance of the system permitted effective exchange of information. Controller and sector observer ratings of communications effectiveness, accuracy, and timeliness indicated that each of these dimensions were unchanged or slightly improved with CPDLC I. These ratings were not affected by a 50-percent increase in one-way transit time. It should be noted, however, that the level of time performance shown to be acceptable for the limited message set of CPDLC I may not be sufficient for CPDLC IA when clearances that alter an aircraft's trajectory are added to the set.

6.3 HUMAN COMPUTER INTERFACE (COI 7).

Controller design reviews and performance measures collected during full-scale simulation testing showed that the controller Host Computer Interface (HCI) for CPDLC I will effectively support Air Traffic (AT) operations. However, the design reviews yielded six areas of concern that should be resolved. It is recommended that these HCI issues documented in section 5.2.1 be addressed prior to CPDLC 1 implementation. It is further recommended that six additional problems with system functionality be resolved.

These problems were identified by test personnel and are documented in section 5.5. Finally, the controller participants identified four design enhancements that should be addressed for CPDLC IA.

6.4 TRAINING (COI 8).

Controller evaluations of the CPDLC I training program, as well as satisfactory controller performance in subsequent simulation testing, indicated that the training will be sufficient to allow controllers to effectively operate the system. However, the controllers suggested several improvements to the Computer-Based Instruction (CBI), lecture and Dynamic Simulation (DYSIM) components. It is recommended that the modifications documented in section 5.1 be incorporated into the training program.

7. REFERENCES.

Darby, E.R. and Shingledecker, C.A. *Controller Evaluation of CPDLC Services Implemented on the Display System Replacement (DSR) Workstation: Study 1. Initial Assessment of Services Transitioned from the PVD and Design Development for Additional Services.* FAA William J. Hughes Technical Center, DOT/FAA/CT-TN99/11, 1999.

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Data Link Benefits Study Team, *User Benefits of Two-Way Data Link ATC Communications: Aircraft Delay and Flight Efficiency in Congested En Route Airspace.* Final Report, FAA Technical Center, DOT/FAA/CT-95/4, February 1995.

Morfitt, G. and Bigio, R. *Controller Pilot Data Link Communications Build I (CPDLC I) Operational Test Plan (Phase 1)*, Federal Aviation Administration, William J. Hughes Technical Center, ACT-350, May 25, 2000.

8. ABBREVIATIONS AND ACRONYMS.

AF	Airways Facilities
ARINC	Aeronautical Radio, Inc.
ARTCC	Air Route Traffic Control Center
AS	Altimeter Setting
ASM	Altimeter Setting Message
AT	Air Traffic
ATC	Air Traffic Control
ATN	Aeronautical Telecommunications Network
CBI	Computer-Based Instruction
CPC	Certified Professional Controller
CPDLC IA	CPDLC Build IA
CPDLC	Controller-Pilot Data Link Communication
CPDLC I	CPDLC Build I
COI	Critical Operational Issue
CRD	Computer Readout Device
DLAP	Data Link Applications Processor
DSR	Display System Replacement
DST	Decision Support Tools
DYSIM	Dynamic Simulation
FAA	Federal Aviation Administration
FL	Flight Level
HCI	Human Computer Interface
HCS	Host Computer System
HNL	Host Interface Device/NAS Local Area Network
IC	Initial Contact
ICAO	International Civil Aviation Organization
IIC	Incorrect Initial Contact
JAX	Jacksonville ARTCC
LAK	Logical Acknowledgement
MOE	Measure of Effectiveness
MOP	Measure of Performance
MOS	Measure of Suitability
MTM / MT	Menu Text Messages
NAS	National Airspace System
NATCA	National Air Traffic Controller Association
OT	Operational Test
RCS	Reconfigurable Cockpit Simulator
SAR	System Analysis and Recording
SBY	Standby
TGF	Target Generation Facility
TIM	Time Out Status
TOC	Transfer of Communication
TRACON	Terminal Radar Approach Control Facility
TTT	Total Transaction Time
VDL	VHF Data Link
VHF	Very High Frequency

APPENDIX A

EVALUATION INSTRUMENTS

Student Assessment of Classroom Instruction

Course _____ Lesson _____
Name _____ Date _____
(optional)

Check one box for each question below as follows:

Yes = Basically there were no problems in this area.
NI = Needs improvement - a couple of problems in this area appear in spots (please specify in your comments below what the problem was and where it is located in the training materials).
No = Problems in this area are present throughout most or all of the lesson - please describe the problem.

Check One Yes	NI	No	Area of Consideration	Comments (If NI or No, briefly explain and include lesson page number.)
☐	☐	☐	1. The lesson objectives were clear.	
☐	☐	☐	2. The instructor's presentation was clear.	
☐	☐	☐	3. The lesson handouts/materials were relevant and easy to read and understand.	
☐	☐	☐	4. The graphics were easy to read and understand.	
☐	☐	☐	5. Lesson overheads or other visuals were clear and supported the teaching points.	
☐	☐	☐	6. Examples (when used) clearly illustrated the lesson content.	
☐	☐	☐	7. The lesson was sequenced logically and well organized.	
☐	☐	☐	8. The activities and/or exercises were helpful in learning the material.	
☐	☐	☐	9. Opportunities were provided to ask questions and questions were answered adequately.	
☐	☐	☐	10. The lesson held my interest.	
☐	☐	☐	11. The pacing of instruction was comfortable.	
☐	☐	☐	12. Overall, the lesson(s) is/are adequate to teach the objective(s).	

Student Assessment of CBI Instruction

Course _____ Lesson _____

Name _____ Date _____ (optional)

Check one box for each question below as follows:

Yes = Basically there were no problems in this area.
NI = Needs improvement - a couple of problems in this area appear in spots (please specify in your comments below what the problem was and where it is located in the training materials).
No = Problems in this area are present throughout most or all of the lesson - please describe the problem.

Check box Yes	NI	No	Area of Consideration	Comments (If NI or no, briefly explain and include screen reference)
☐	☐	☐	1. The objectives /goals of the lesson were clear.	
☐	☐	☐	2. I could easily tell where I was in the lesson at all times.	
☐	☐	☐	3. Instructions on what to do were clear.	
☐	☐	☐	4. The pacing of instruction was comfortable.	
☐	☐	☐	5. CBI controls / navigation were easy to locate and use.	
☐	☐	☐	6. The lesson content and instruction were good quality.	
☐	☐	☐	7. Information was presented logically and was well organized.	
☐	☐	☐	8. The examples (when used) were clear.	
☐	☐	☐	9. Audio and narration were clear and supported the teaching points.	
☐	☐	☐	10. Text information was easy to read and understand.	
☐	☐	☐	11. Graphics were easy to understand and clearly illustrated the teaching points.	
☐	☐	☐	12. The activities and exercises (including drills) were adequate and appropriate to teach the material.	

☐	☐	☐	13. Feedback in the exercises was clear and adequate.
☐	☐	☐	14. Handouts / support materials were easy to use and were helpful.
☐	☐	☐	15. The test items were well written and appropriate for the level of the lesson.
☐	☐	☐	16. The discussion following the CBI clarified the concepts taught in the CBI.
☐	☐	☐	17. Overall, the lesson(s) is/are adequate to teach the objective(s).

Use the back of this form to write any additional comments you may have.

Student Assessment of DYSIM Design

Course: _____ Participant: _____ Scenario # or name: ____ Date _____

Please consider each of the following aspects of the scenario you just completed.

	Yes	No
	(Check one)	
1. Was the pace of the scenario appropriate? If no, please explain and/or suggest an improvement.	☐	☐
2. Were the type, number, and/or sequence of events adequate? If no, please explain and/or suggest an improvement.	☐	☐
3. Were instructor demonstrations of how to perform tasks adequate? (Mark "N/A" if demonstrations were not a part of the scenario.) If no, please explain and/or suggest an improvement.	☐	☐
4. Did you receive useful feedback from the instructor on your performance? If no, please explain and/or suggest an improvement.	☐	☐
5. Was the scenario practice adequate to learn the skills being taught in that scenario? If no, please explain and/or suggest an improvement.	☐	☐

Problems During DYSIM

The questions below ask you to describe any learning or performance problems you had during the final scenario, such as:

- I performed a procedure or operation incorrectly.
- I forgot to perform a procedure or operation.
- I couldn't remember how to perform a procedure or operation.
- I got confused.
- I got overwhelmed and was forced to stop or delay performing a procedure or operation.

Describe each problem and where/when it occurred in the scenario in the box below. Be as specific as possible. Then answer the questions about the problem. Use additional problem sheets as necessary.

Problem Description:

a. How often did you experience the problem? (circle one) Once Twice Numerous times

	Yes	No
b. Did the problem occur during previous scenarios?	☐	☐
c. If the problem were to occur while you are on position, could it compromise safety? If yes, please explain.	☐	☐
d. If the problem were to occur while you are on position, could it reduce operational effectiveness or efficiency? If yes, please explain.	☐	☐

Which **one** of the following was the main cause of the problem you experienced? (check one box)

- ☐ Skill or knowledge not taught
- ☐ Not enough practice
- ☐ Too much time between practice and testing
- ☐ Test scenarios were too difficult

Use Additional Problem Sheets as Necessary

Course Effectiveness

What is your overall assessment of the training? (Complete after the final scenario)

		Yes	No
6.	**Overall, was the CBI adequate preparation for the simulation practice?** If no, please indicate which skills should receive additional emphasis to better prepare you for simulation practice. (Mark "N/A" if there was no CBI.)	☐	☐
7.	Overall, was the simulation practice adequate preparation for the performance check? If no, please indicate which skills should receive additional emphasis to better prepare you for testing. . (Mark "N/A" if there was no performance check.)	☐	☐
8.	Overall, did the ***simulation*** adequately prepare you to do your job? If no, please indicate which skills should receive additional emphasis to better prepare you for the job.	☐	☐
9.	Overall, did the ***course*** adequately prepare you to do your job? If no, please indicate what areas require additional instruction and/or practice to better prepare you for the job.	☐	☐

10. Do you have any other comments concerning any part of the course?

Please hand in this questionnaire when you have completed it. There will be a short discussion period to make sure your comments are understood.

Problem Continuation Sheet

Problem Description:

a. How often did you experience the problem? (circle one) Once Twice Numerous times

	Yes	No
b. Did the problem occur during previous scenarios?	☐	☐
c. If the problem were to occur while you are on position, could it compromise safety? If yes, please explain.	☐	☐
d. If the problem were to occur while you are on position, could it reduce operational effectiveness or efficiency? If yes, please explain.	☐	☐

Which **one** of the following was the main cause of the problem you experienced? (check one box)

- ☐ Skill or knowledge not taught
- ☐ Too much time between practice and testing
- ☐ Not enough practice
- ☐ Test scenarios were too difficult
- ☐ Other (please describe) _____

Recommendation for addressing problem:

FAA Aeronautical
DATA LINK

CPDLC I

HUMAN-COMPUTER INTERFACE AND PROCEDURES

CONTROLLER DESIGN REVIEW BOOKLET

This booklet contains a series of questions that will permit you to independently review and evaluate the CPDLC I Human-Computer Interface (HCI) and associated operational procedures. The primary goals of the review are to:

1. Ensure that the service designs and procedures are acceptable for field deployment at the Miami ARTCC.

2. Determine whether there are any changes to the designs that <u>must</u> be made for CPDLC I to ensure safety and operational acceptance.

Please answer all of the questions in this booklet and carefully record your comments and any recommendations. Explain your reasons for suggesting any changes.

Reviewer's Name _____

Instructions

This booklet is divided into seven parts that will permit you to make a detailed evaluation of the functionality provided by CPDLC I, the controller HCI, and procedures. Each part begins with a design description. Read these descriptions carefully before answering the associated questions and recording your comments.

NOTES ON CONVENTIONS USED IN THE SERVICE DESCRIPTIONS

- Data as shown in a display or entered on the keyboard are presented in quotation marks. When spaces are required, they are included within the quotation marks. The quotation marks are not part of the display or entry.

- All spaces included within quotation marks for keyboard entries are mandatory. For example, "MT ON" should be interpreted as typing MT, a space, and ON.

- Input commands printed in bold italics refer to a DSR keyboard category, soft function, or hard function key, or a "key" in the R-CRD Category Selection Area (e.g. ***DL, DS, F1***).

- Two trackball keys are used. Trackball ENTER (middle key) is used to complete a command sequence. Trackball SELECT (left key) is used to identify an item in the R-CRD text area or the status list and to identify lists for moving them on the display.

- FLID refers to any NAS command for identifying a flight including:

  . The Aircraft Identification Call Sign (AID)

  . The Computer Identification Number (CID)

  . The Beacon Code

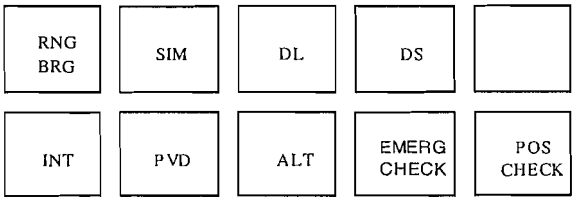
  . Positioning the trackball cursor over the data block and pressing trackball ENTER

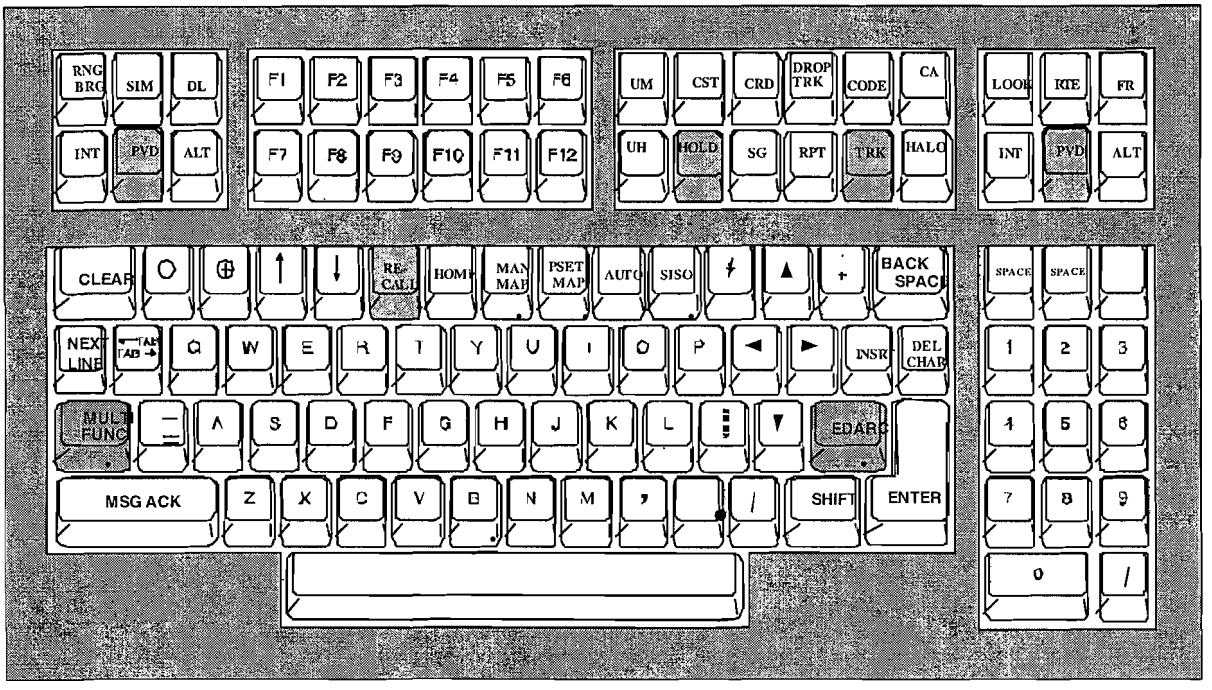
All keyboard entries must be followed by a keyboard ENTER or a trackball ENTER to complete the command sequence.

CPDLC Keys

The CPDLC I HCI for DSR uses three dedicated keyboard keys and two "pick" keys in the R-CRD category selection area. The **Data Link (*DL*)** keyboard and pick keys are used to send some messages, delete messages, transfer eligibility, and initiate or terminate a Data Link session with an aircraft. The **Data Link Settings (*DS*)** pick key is used to modify current sector Data Link settings, and to select or modify the contents of Data Link lists. The two remaining keyboard keys are used to uplink a transfer of communication message in the "held" status (***UH***), and to send a message contained in the menu text list (***UM***).

The locations for these keys and the displays that are presented in the R-CRD category selection area when the ***DL*** or ***DS*** keys are pressed are shown in the following diagrams:





DL CATEGORY MENU

T	CRD		KEYS	CODE
RNG BRG	SIM	DL	DS	
INT	PVD	ALT	EMERG CHECK	POS CHECK

UPLINK HELD	UH	F1
UPLINK MT	UM	F2
DELETE UPLINK	DE	F3
DYSIM RESPONSE	JU	F4
START SESSION	SD	F5
DYSIM MENU	JN	F6
SEND END SERV	ED	F7
DL ELIG	SX	F8
SEND FREQ	UF	F10

RA	MWL

- RESPONSE AREA -
(4 LINES)
ACCEPTS/READOUTS

MC	READ

- MESSAGE COMPOSITION AREA -
(6 LINES)

- PREVIEW AREA -
(2 LINES)

- FEEDBACK AREA -
(4 LINES)
FOR ERROR MESSAGES

UPLINK HELD: Sends a held TOC shown in the status list.
UPLINK MT: Sends a menu text message.
DELETE UPLINK: Deletes a transaction shown in the status list.
DYSIM RESPONSE: Training function.
START SESSION: Manually initiates a data link session with an aircraft.
DYSIM MENU: Training function.
SEND END SERV: Manually terminates a data link session with an aircraft.
DL ELIG: Sends eligibility to another sector that has track control. Transfers eligibility to your sector if you have track control.
SEND FREQUENCY: Sends a frequency to an aircraft independent of a TOC.

DS DISPLAY

T	CRD		KEYS	CODE
RNG BRG	SIM	DL	DS	
INT	PVD	ALT	EMERG CHECK	POS CHECK

TOC MODE	AT	F1
MENU TEXT LIST	MT	F2
SUPP/RECALL MT	MS	F3
SECTOR SETTINGS	SN	F7
SL SERVICES	SV	F8
STATUS LIST	SL	F9
SL STATES	SZ	F10

RA	MWL

- RESPONSE AREA -
(4 LINES)
ACCEPTS/READOUTS

MC	READ

- MESSAGE COMPOSITION AREA -
(6 LINES)

- PREVIEW AREA -
(2 LINES)

- FEEDBACK AREA -
(4 LINES)
FOR ERROR MESSAGES

TOC MODE: Cue to the Host command/function key used to set TOC Mode to Man, Auto or Off.
MENU TEXT LIST: Cue to the Host command/function key used to turn he MT list On or Off at the sector.
SUPP/RECALL MT: Cue to the Host command/function key used to display/suppress individual menu items.
SECTOR SETTINGS: Cue to the Host command/function key used to display the current sector settings
SL SERVICES: Cue to the Host command/function key used to filter the Status List by service type.
STATUS LIST: Cue to the Host command/function key used to turn the Status List On or OFF at the sector.
SL STATES: Cue to the Host command/function key used to filter the Status List by message status.

CPDLC I Key
Evaluation

1. Are the locations of the Data Link keys on the keyboard (***DL, UM, UH***) and in the R-CRD "pick" area (***DL, DS***) acceptable for the functions that they serve?

   Yes _____ No _____

   If "No", explain why:

2. Are the abbreviations used to label the Data Link keys meaningful and not susceptible to confusion with other key designations used in DSR?

   Yes _____ No _____

   If "No", explain why:

3. Are the Data Link functions appropriately grouped under the ***DL*** and ***DS*** keys?

   Yes _____ No _____

   If "No", explain why:

4. Are the items shown on the R-CRD when the ***DL*** and ***DS*** keys are pressed unambiguous and do they adequately indicate the functions that they will perform?

   Yes _____ No _____

   If "No", explain why:

Overall Evaluation of CPDLC keys:

_____ THE DESIGN IS ACCEPTABLE FOR CPDLC I – NO CHANGES ARE NEEDED FOR INITIAL DEPLOYMENT AT THE MIAMI ARTCC

_____ THE DESIGN IS ACCEPTABLE, BUT THE FOLLOWING CHANGES ARE NEEDED FOR THE NATIONAL DEPLOYMENT OF CPDLC IA:

_____ THE DESIGN IS UNACCEPTABLE FOR CPDLC I – THE CHANGES DESCRIBED BELOW MUST BE IMPLEMENTED ASSURE SAFETY AND OPERATIONAL ACCEPTANCE AT MIAMI:

Full Data Block and Status List

- Function

The Full Data Block (FDB) provides unique graphic characters which indicate that an aircraft is equipped to receive Data Link messages and has an active Data Link session, and whether the observing control position is eligible to uplink messages to the aircraft. The FDB also provides limited information about the status of ongoing Data Link transaction.

The status list is a Host situation display tabular list that contains full information about the content and current status of ongoing Data Link transactions. The status list does not appear on the D position display.

- Full Data Block Equipage and Eligibility Indicators

Data Link equipage/session and eligibility are indicated by graphic characters located in the first position of the first line of the FDB. When no special character is displayed in this position the aircraft is not capable of communicating via Data Link or does not have an active Data Link session. An open diamond indicates that the aircraft is Data Link equipped and has an active session, but that the viewing sector position is ineligible to communicate with it. A filled diamond indicates that the aircraft is equipped with an active session, and that the viewing sector is eligible.

Data Link sessions with aircraft are normally established and terminated by automation. The controller can manually establish an active session with an aircraft that has logged-on to the Data Link system by entering ***DL F5,*** or typing "SD", followed by the FLID. A session can be terminated by entering ***DL F7,*** or typing "ED", followed by the FLID.

- Status List Format

The status list is identified by "SL" displayed in the header area of the list. Each line of the list contains information about one ongoing transaction. A line has three data fields displaying 1) the aircraft identification, 2) an abbreviated version of the content of the uplinked message, and 3) and an indication of the current status of the transaction.

For example, "UAL172 123.125/CAL SNT" would indicate that the controller had uplinked a message to switch radio frequencies to UAL 172 along with a Confirm Assigned Level request, and that the message is in the sent status.

- Status List Abbreviations of Transaction Status

The third field of a status line presents the following abbreviations to indicate the current status of the transaction:

"SNT" - Sent: A controller input or system event has initiated the uplink.

"HLD" - Held: A transfer of communication message containing the radio frequency of a new airspace sector, which the aircraft will enter, has been prepared and is ready for uplink when the sending controller makes an appropriate input.

"ROG - Roger
"AFF" - Affirmative
"WIL" - Wilco: The system has received a downlink from the flight deck indicating that the pilot has received the message / agrees with / or will comply with the uplinked message.

"NEG" - Negative
"UNA" - Unable: The system has received a downlink from the flight deck indicating that the pilot has received the uplinked message, but does not agree with / is unable to comply.

"SBY" - Standby: The system has received a downlink from the flight deck indicating that that the pilot has received the uplinked message and will subsequently reply with a positive or negative response.

"TIM"- Time Out: A timer initiated when the uplinked message was sent has expired. This is an adaptable time parameter nominally set at 40 seconds. The time out status is an indication to the controller of an unusually lengthy delay for receipt of a response from the aircraft. The transaction remains open, and a subsequent response will be accepted by the system.

"FAI" - Failed: Indicates that the Data Link session with the intended receiving aircraft has been aborted. The transaction is closed.

"ERR"-Error: Indicates that an application error has occurred in attempting to send the message. The ERR status closes the transaction.

All list entries that have a non-positive status are displayed in white to alert the controller. All states that close a transaction with a positive response (ROG, WIL, AFF) will delete the relevant line on the status list after an adjustable time parameter (nominally 6 seconds) has expired. Messages in any other

transaction state must be manually deleted using inputs described in succeeding sections of this booklet.

- Full Data Block Indications for CPDLC I Services and Status

FDB indicators are correlated with the status list indicators, but vary depending upon the service involved. They are described in detail under succeeding sections devoted to each service.

- Inputs to Move the Status List

The status list can be moved to any position on the situation display by pressing ***PVD*** "L", slewing to the desired position, and pressing the trackball ENTER key.

- Inputs to Suppress or Retrieve the Status List

The status list can be suppressed by typing "SL OFF" (or ***DS F9*** "OFF"). The list is retrieved to the situation display by typing "SL ON" (or ***DS F9*** "ON"). These entries cannot be made from the D position.

- Selecting Message Types for Display in the Status List

The status list will display information on all four types of messages included in CPDLC I. However, the Radar controller can selectively suppress status list content by message category. The following table presents the commands used to selectively suppress and retrieve each message type.

Transfer of Communication	"SV TC OFF" or "SV TC ON"
Menu Text	"SV MT OFF" or "SV MT ON"
Altimeter Setting	"SV AS OFF" or "SV AS ON"
All Message Types	"SV OFF" or "SV ON"

It is also possible to display or suppress multiple message types in a single command (e.g. SV "TC MT OFF"). Note that pressing ***DS F7*** or "SN" ENTER will display the active Data Link Sector Settings for suppressed status list services.

Any transaction that results in a negative response, FAI, ERR or a TIM will be automatically forced to appear in the status list even if that message type is suppressed.

- Selecting Message States for Display in the Status List

The Radar controller also can determine the messages that will appear in the status list by their respective states. The following table presents the commands used to selectively suppress and retrieve the display of messages in five states. Messages with any other status cannot be suppressed.

SENT	"SZ SNT OFF" or "SZ SNT ON"
ROGER	"SZ ROG OFF" or "SZ ROG ON"
WILCO	"SZ WIL OFF" or "SZ WIL ON"
AFFIRMATIVE	"SZ AFF OFF" or "SZ AFF ON"

Note that pressing ***DS F7*** or "SN" ENTER will display the active Data Link Sector Settings for suppressed message states.

Full Data Block and Status List
Evaluation

1. Do the Full Data Block symbols provide unambiguous information regarding Data Link equipage/active session and eligibility?

   Yes _____ No _____

   If "No", explain why:

2. Are the Full Data Block symbols readable and can they be easily distinguished from one another?

   Yes _____ No _____

   If "No", explain why:

3. Are the transaction status abbreviations (SNT etc.) used in the status list sufficiently clear and easy to understand?

   Yes _____ No _____

   If "No", explain why:

4. Are the "abnormal" status indications (NEG, UNA, FAI, ERR, TIM) in the status list adequate to catch the controller's attention?

   Yes _____ No _____

   If "No", explain why:

5. Does the design provide an adequate capability to control (filter) the contents of the status list (i.e. by message type and status)?

   Yes _____ No _____

   If "No", explain why:

6. Are the inputs and displays for accomplishing functions under the Data Link Settings menu acceptable for managing the contents of Status List?

   Yes _____ No _____

   If "No", explain why:

Overall Evaluation of Full Data Block and Status List Displays/Inputs:

_____ THE DESIGN IS ACCEPTABLE FOR CPDLC I – NO CHANGES ARE NEEDED FOR INITIAL DEPLOYMENT AT THE MIAMI ARTCC

_____ THE DESIGN IS ACCEPTABLE, BUT THE FOLLOWING CHANGES ARE NEEDED FOR THE NATIONAL DEPLOYMENT OF CPDLC IA:

_____ THE DESIGN IS UNACCEPTABLE FOR CPDLC I – THE CHANGES DESCRIBED BELOW MUST BE IMPLEMENTED ASSURE SAFETY AND OPERATIONAL ACCEPTANCE AT MIAMI:

Transfer of Communication (TOC)

- Function

The Data Link transfer of communication message is automatically prepared when the receiving controller accepts a sector handoff for an equipped aircraft. The sending controller has the option to send the new frequency automatically when the handoff is accepted, or to send the message manually at a later time.

- Inputs to Set the Transfer of Communication Mode

Transfer of communication can be set to the automatic mode by typing "AT AUTO" (or ***DS*** "AUTO"). The manual mode is selected by typing "AT MAN" or ***DS***"MAN". TOC can be turned off at the sector by typing "AT OFF" or ***DS*** "OFF". The selected mode for TOC is shown in a banner on the situation display.

- Automatic and Manual Send Inputs

When in the automatic mode, the transfer of communication message will uplink the default frequency for the receiving sector with no additional action by the sending controller when the receiving sector accepts the handoff.

When in the manual mode, acceptance of the handoff will store the message for later transmission. The message will appear in the status list in the "HLD" status. The controller can send the message by a trackball slew/ENTER to the "dot" preceding the appropriate line in the status list or by pressing the ***UH*** key followed by the FLID, or by typing "UH" or ***DL*** followed by the FLID.

- Changing the Default Frequency

Frequencies other than the primary default frequency for the receiving sector can be sent when using CPDLC for the transfer of communication. When making the entries to handoff the aircraft, typing "U" after the sector number will substitute a predefined alternate frequency (e.g. "22 U TWA254"). Typing a numeric radio frequency value in the same position will send that frequency if adapted for the facility. To change the frequency for a TOC in the held status, press the ***UH*** key, type "UH" or ***DL,*** "U" or the desired frequency number, and the FLID (e.g. "UH 126.9 AAL123 ENTER"

- Status List and Full Data Block Displays on Transfer of Communication

The status list entry for a transfer of communication transaction presents the AID, the uplinked frequency, and the current transaction status message. When in a

manual mode, the "HLD" status message is displayed until the controller completes the slew action or keyboard entry to send the message. In the automatic mode, the status line appears in the "SNT" state immediately after acceptance of the handoff.

In either mode of operation, when the transfer of communication message is sent, a "lightning bolt" symbol replaces the Data Link equipage/eligibility indicator in the first position of the first line of the Full Data Block. This symbol will appear at all sectors displaying the aircraft's FDB. When the wilco is received from the flight deck, the "lightning bolt" symbol is replaced by the filled diamond in the receiving sector and by the open diamond in all other sectors.

- Unable and Time Out Displays for Transfer of Communication and Controller Responses.

If the flight deck responds to a transfer of communication message with an unable, "UNA" is displayed in the status field of the status list. If the flight deck fails to downlink a response within 40 seconds (adaptable), "TIM" is displayed in the status field.

The unable conditions also will cause the "lightning bolt" symbol in the first position of the first line of the sending controller's Full Data Block to revert to the filled diamond symbol indicating that Data Link eligibility remains at the sending sector. All other sectors will display the open diamond.

- Deleting Transfer of Communication Transactions

The controller can close the transaction and delete "HLD", "UNA", "ERR", or "FAI" indicators by typing ***DL F3*** "TC" and the FLID or "DE TC" and the FLID. If the controller chooses to delete a transaction in the "SNT", "SBY" or "TIM" states "/OK" must be included in the command sequence prior to "TC" (e.g. ***DL F3*** "/OK TC USA219").

A closed transaction can also be deleted by eliminating "TC" in the command and using the trackball to select the dot preceding the appropriate line in the status list.

- Sending an Automatic Transfer of Communication When in Manual Mode

While working in the manual mode, the controller can selectively choose to send the message automatically to an individual aircraft by adding a single keystroke to the normal sequence used to offer a handoff.

The transfer of communication message will be sent automatically upon handoff acceptance if the controller offers the handoff by typing the two-digit receiving

sector number, "T", and the FLID (e.g. "22 T USA435"). Alternate frequency options may be included in the command. Only one aircraft may be designated in the message. Adding the "T" to a single handoff command will not affect other subsequent aircraft handoffs, and the selected mode will remain manual.

- Holding a Transfer of Communication When in Automatic

While working in the automatic mode, the controller can selectively choose to hold the message for an individual aircraft by adding a single keystroke to the normal sequence used to offer a handoff.

The transfer of communication message will be put into the held status upon handoff acceptance if the controller offers the handoff by typing the two-digit receiving sector number, "M", and the FLID (e.g. "22 I USA435"). Alternate frequency options may be included in the command. Only one aircraft may be designated in the message. Adding the "M" to a single handoff command will not affect other subsequent aircraft handoffs, and the selected mode will remain automatic.

- Acquiring and Transferring Data Link Eligibility Without a Handoff

A single command is used either to acquire Data Link eligibility or transfer it to another sector. If a controller has track control for an aircraft, Data Link eligibility can be acquired from another sector in the absence of a completed handoff by typing ***DL F8*** or "SX", followed by the FLID. This action does not uplink the acquiring sector's radio frequency to the aircraft. (Track control and Data Link eligibility can be acquired from another sector in the absence of a handoff by typing "/OK D" and the FLID).

If another sector has track control of an aircraft, Data Link eligibility can be transferred to that sector with the same command (***DL F8*** or "SX", followed by the FLID.)

- Sending a Radio Frequency to an Aircraft Without a Handoff

A controller who has acquired Data Link eligibility in the absence of a handoff can send his/her sector's radio frequency to the aircraft by typing ***DL F10*** or "UF", followed by the FLID.

Frequencies other than the primary default frequency for the sector can be substituted. Typing "UF U" or ***DL F10*** "U", followed by the FLID will substitute a predefined alternate frequency. Typing a numeric radio frequency value, rather than "U", will send that frequency if adapted for the facility.

When a frequency is sent in this manner, the message will instruct the pilot to "monitor" the new frequency. If "C" is inserted, the message will instruct the pilot to "contact" the controller on the new frequency (e.g. "UF C NWA899").

- Initiating a Handoff Without Preparing a Transfer of Communication Message

An aircraft with an ongoing Data Link session can be handed off without preparing or sending a transfer of communication message by typing the receiving sector's number, "O" and the FLID (e.g. "22 O USA219").

Transfer of Communication Evaluation

1. Are the available input options for sending a "held" transfer of communication message adequate for the R and D controllers?

   Yes _____ No _____

   If "No", explain why:

2. Are the Full Data Block indicators along with the status list adequate for monitoring an ongoing transfer of communication transaction?

   Yes _____ No _____

   If "No", explain why:

3. Are the inputs for temporarily changing the transfer of communication mode (auto/manual) for a single aircraft acceptable?

   Yes _____ No _____

   If "No", explain why:

4. Are the inputs used to "steal"/acquire Data Link eligibility acceptable?

   Yes _____ No _____

   If "No", explain why:

5. Are the inputs used to send a voice radio frequency in the absence of a hand off acceptable?

   Yes _____ No _____

   If "No", explain why:

6. Will the options to substitute an alternate frequency in the hand off message ("U", typed frequency) and to inhibit the preparation of a TOC message ("O") adequately support the controller's operational requirements?

   Yes _____ No _____

   If "No", explain why:

Overall Evaluation of Transfer of Communication Displays/Inputs:

_____ THE DESIGN IS ACCEPTABLE FOR CPDLC I – NO CHANGES ARE NEEDED FOR INITIAL DEPLOYMENT AT THE MIAMI ARTCC

_____ THE DESIGN IS ACCEPTABLE, BUT THE FOLLOWING CHANGES ARE NEEDED FOR THE NATIONAL DEPLOYMENT OF CPDLC IA:

_____ THE DESIGN IS UNACCEPTABLE FOR CPDLC I – THE CHANGES DESCRIBED BELOW MUST BE IMPLEMENTED ASSURE SAFETY AND OPERATIONAL ACCEPTANCE AT MIAMI:

Initial Contact (IC)

- Function

This service substitutes the initial radio call from the flight deck after a transfer of communication with a downlink report of assigned altitude. Under normal conditions, the initial contact procedure is automatic and transparent, and requires no controller interaction.

- Initial Contact Procedure

An assigned altitude request message is automatically appended to the radio frequency assignment message that is uplinked during transfer of communication. The flight deck responds to the transfer of communication and confirm assigned level uplink by downlinking a wilco along with a report of assigned altitude to the receiving controller.

Receipt of the wilco response transfers Data Link eligibility to the receiving sector. In addition, the reported assigned altitude is automatically checked against the aircraft's assigned altitude, interim altitude, or adapted altitude recorded in the NAS database. If the aircraft's reported downlinked assigned altitude matches the database value, nothing is displayed at the sending or receiving sectors, and no additional controller action is required.

Note that the transfer of communication message will normally instruct the pilot to "monitor" the new frequency. If the new sector is not equipped for Data Link, it will instruct the pilot to "contact" the controller at the new frequency and no altitude request will be sent.

- Discrepancy Between Reported and Assigned Altitudes

If the reported assigned altitude fails to match the assigned or interim altitude contained in the NAS database, the downlinked value followed by "I" will appear the first four positions of the second line of the Full Data Block. This will timeshare every 1.5 seconds with the database value followed by the altitude conformance indicator. If the Mode C altitude had been displayed in this field when the timesharing began, the Mode C altitude will be shifted to the right of the second line to make it continuously viewable.

In addition to the FDB display, a status list entry will be created displaying the AID, the NAS data base altitude, and the downlinked altitude. The down linked altitude will be right justified in the data field of the status list. The status field will show "/IIC" (e.g. "TWA515 240 340/IIC") in white to alert the controller.

The Data Link eligible receiving controller with track control can resolve the mismatch by contacting the flight deck via voice radio. The error displays may be cleared by deleting the IC status list entry (***DL F3*** "IC" and the FLID or "DE IC" and the FLID).

Initial Contact
Evaluation

1. Are the timeshared FDB display and the status list indicator sufficient to alert the controller of an initial contact downlink of an altitude that fails to match the NAS database?

   Yes _____ No _____

   If "No", explain why:

2. Are the options for deleting an IC mismatch acceptable?

   Yes _____ No _____

   If "No", explain why:

Overall Evaluation of Initial Contact Displays/Inputs:

_____ THE DESIGN IS ACCEPTABLE FOR CPDLC I – NO CHANGES ARE NEEDED FOR INITIAL DEPLOYMENT AT THE MIAMI ARTCC

_____ THE DESIGN IS ACCEPTABLE, BUT THE FOLLOWING CHANGES ARE NEEDED FOR THE NATIONAL DEPLOYMENT OF CPDLC IA:

_____ THE DESIGN IS UNACCEPTABLE FOR CPDLC I – THE CHANGES DESCRIBED BELOW MUST BE IMPLEMENTED ASSURE SAFETY AND OPERATIONAL ACCEPTANCE AT MIAMI:

Menu Text

- Function

The Menu Text function permits the controller to uplink non-safety critical messages by selecting them from a predefined menu list. Menus can be tailored to meet the specific requirements of individual airspace sectors.

- Menu Format

The menu is a Host situation display tabular list identified by "ML" in the header area of the list. Each line of the menu contains one message preceded by an identifying menu referent used to select the message. The menu referent must begin with an alphabetic character. Up to ten messages can be displayed in the menu list. A sample menu is shown below:

A	WRI ILS OUT RWY 6 / 24
B	BAD WEATHER WARN
MIC	CHECK STUCK MIC
CALL	CALL COMPANY

- Inputs to Send a Menu Text Message

To send a menu text message, press the ***UM*** key (or type "UM" or ***DL F2***), the menu item referent, and the FLID (e.g. ***UM*** "A USA456").

The message can be sent to all aircraft that are Data Link eligible for the sector by substituting " *ALL " for the FLID in the keyboard command.

- Full Data Block and Status List Displays on Menu Text Uplink

When a menu text message is uplinked, an up-arrow symbol replaces the filled diamond in the first position of the first line of the Full Data Block at all positions displaying the Full Data Block. The up-arrow is removed when the message receives the appropriate positive or negative response from the flight deck or when it is deleted from the status list.

For all messages sent from the menu, the status list will display the AID followed by the menu item referent, and the current status of the transaction (e.g. "AA231 CALL SNT"). The status list line is deleted when the appropriate positive or negative response from the flight deck is received, or when the controller deletes it from the status list.

When a message is sent to all aircraft, a single line is created in the status list with "ALL" appearing the FLID field. The status line is deleted when all of the aircraft respond with the appropriate positive response. A separate line is

created in the status list for each negative aircraft response to an all message, or if a transmission error occurs ("ERR", "FAI").

- Deleting Menu Text Transactions

The controller can close the transaction and delete "UNA","ERR", "FAI", or "NEG" indicators by typing ***DL F3*** "MT" and the FLID or "DE MT" and the FLID. If the controller chooses to delete a transaction in the "SND", "SBY" or "TIM" states, "/OK" must be included in the command sequence prior to "MT" (e.g. ***DL F3*** "MT /OK USA219"). The transaction can also be deleted by eliminating the "MT" and FLID in the command and using the trackball to select the dot preceding the appropriate line in the status list. If the trackball is not used for this command, all MT transactions for the aircraft that are displayed in the status list will be deleted.

- Controlling Menu Text List Content

A menu build function will be used by supervisory personnel to create sector-tailored menus. However, the controller will have the capability to determine whether the menu list will be displayed, and to selectively display or suppress individual items. Messages continue to be available for uplink when suppressed from the display.

The menu list can be suppressed by typing "MT OFF" (or ***DS F2*** "OFF"). The list is retrieved to the situation display by typing "MT ON" (or ***DS F2***"ON"). These entries cannot be made from the D position.

Suppression of the individual messages in the menu is accomplished by typing "MS *menu referent* OFF" or ***DS F3*** "*menu referent* OFF". A message can be retrieved by substituting "ON" in the command sequence.

Up to five messages can be suppressed or retrieved in a single command by separating the menu referents with spaces.

- Inputs to Move the Menu

The menu text list can be moved to any position on the situation display by pressing ***PVD*** "T", slewing to the desired position, and pressing the trackball PICK ENTER key.

Menu Text
Evaluation

1. Are the available input options for sending a menu text message adequate for the R and D controllers?

   Yes _____ No _____

   If "No", explain why:

2. Are the FDB indicators along with the status list adequate for monitoring an ongoing menu text transaction?

   Yes _____ No _____

   If "No", explain why:

3. Are the options for suppressing/retrieving items in the menu text list acceptable?

   Yes _____ No _____

   If "No", explain why:

4. Are the inputs and displays for accomplishing functions under the Data Link Settings menu acceptable for managing the contents of the Menu Text List?

   Yes _____ No _____

   If "No", explain why:

Overall Evaluation of Menu Text Displays/Inputs:

_____ THE DESIGN IS ACCEPTABLE FOR CPDLC I – NO CHANGES ARE NEEDED FOR INITIAL DEPLOYMENT AT THE MIAMI ARTCC

_____ THE DESIGN IS ACCEPTABLE, BUT THE FOLLOWING CHANGES ARE NEEDED FOR THE NATIONAL DEPLOYMENT OF CPDLC IA:

_____ THE DESIGN IS UNACCEPTABLE FOR CPDLC I – THE CHANGES DESCRIBED BELOW MUST BE IMPLEMENTED ASSURE SAFETY AND OPERATIONAL ACCEPTANCE AT MIAMI:

Altimeter Setting (AS)

- Function

This Data Link message uplinks an altimeter setting to the flight deck. Normally, the uplink will be accomplished automatically in accordance with procedures and directives. An altimeter setting can also be manually uplinked by the controller.

- Manual Uplink of Altimeter Setting

An altimeter setting can be manually uplinked by pressing ***CRD,*** typing the designator for the station providing the local altimeter setting, "S" and the FLID.

- Full Data Block and Status List Displays for Altimeter Setting Messages

When an altimeter setting message is uplinked either automatically or manually, an up-arrow symbol replaces the hourglass in the first position of the first line of the Full Data Block at all positions displaying the FDB. The up-arrow is removed when the message receives a "ROG" or "UNA", or is deleted from the status list.

For all altimeter messages, the status list will display the AID followed by the station designator and the altimeter setting, and the current status of the transaction (e.g. "AAL231 DCA 2997 SNT"). The status list line is deleted when a "ROG" is received. Messages in any other transaction state must be manually deleted.

- Deleting Altimeter Setting Transactions

The controller can close the transaction and delete "UNA" or "ERR" indicators by typing ***DL F3*** "AS" and the FLID or "DE AS" and the FLID. If the controller chooses to delete a transaction in the "SND", "SBY" or "TIM" state "/OK" must be included in the command sequence prior to "AS" (e.g. ***DL F3*** "/OK AS USA219"). The transaction can also be deleted by eliminating the "AS" and FLID in the command and using the trackball to select the line in the status list. If the trackball is not used for this command, all AS transactions for the aircraft that are displayed in the status list will be deleted.

Altimeter Setting
Evaluation

1. Are the inputs for sending an altimeter setting message adequate for the R and D controllers?

   Yes _____ No _____

   If "No", explain why:

2. Are the Full Data Block indicators along with the status list adequate for monitoring an ongoing altimeter setting transaction?

   Yes _____ No _____

   If "No", explain why:

3. Do you feel that the Full Data Block and Status List indicators are adequate for detecting an error or failure in an altimeter setting message that has been sent automatically?

   Yes _____ No _____

   If "No", explain why:

Overall Evaluation of Altimeter Setting Displays/Inputs:

_____ THE DESIGN IS ACCEPTABLE FOR CPDLC I – NO CHANGES ARE NEEDED FOR INITIAL DEPLOYMENT AT THE MIAMI ARTCC

_____ THE DESIGN IS ACCEPTABLE, BUT THE FOLLOWING CHANGES ARE NEEDED FOR THE NATIONAL DEPLOYMENT OF CPDLC IA:

_____ THE DESIGN IS UNACCEPTABLE FOR CPDLC I – THE CHANGES DESCRIBED BELOW MUST BE IMPLEMENTED ASSURE SAFETY AND OPERATIONAL ACCEPTANCE AT MIAMI:

CPDLC I Procedures
Evaluation

The following procedures have been excerpted from the current draft of Order 7110.XX *Air Traffic Control Procedures for Domestic Controller Pilot Data Link Communications (CPDLC) ZMA Build I ATN.*

Read each of the procedures, and answer the questions that follow.

FLIGHT PROGRESS STRIP MARKING

When using flight progress strip markings on FAA Form 7230-19:

a. Write the control information symbol "D" after the radar identification "R" in space 26.

b. Place a single horizontal line through the "D" when the data link session is terminated or lost.

1. Are the CPDLC conventions for strip making clearly described?

   Yes _____ No _____

   If "No", explain why:

2. Are there any operational or controller acceptance problems associated with implementing this procedure?

   Yes _____ No _____

   If "Yes", explain why:

COUNTERMANDING A CPDLC UPLINK

a. Use voice communications when amending/canceling a CPDLC message.

PHRASEOLOGY-
"(Aircraft I.D.), DISREGARD CPDLC (message content or type) MESSAGE(S)," if necessary, "UNTIL FURTHER ADVISED," and *(issue the desired clearance/instruction).*

EXAMPLE-
"AAL12, disregard CPDLC frequency change messages until further advised, remain on this frequency."

NOTE-
The pilot should send a non-positive response to terminate the uplink message on the flight deck.

(1) When using the phrase *"UNTIL FURTHER ADVISED"*, controllers shall:

(a) Coordinate with the succeeding sector, or

(b) Verbally instruct the aircraft when to resume normal CPDLC operation.

EXAMPLE-
"AAL12, resume normal CPDLC operations."

b. Verbally coordinate with the aircraft prior to deleting SNT, TIM, SBY, or FAI messages.

1. Is the phraseology used to countermand a CPDLC uplink clear and unambiguous?

Yes _____ No _____

If "No", explain why:

2. Are there any operational or controller acceptance problems associated with implementing this procedure?

   Yes _____ No _____

   If "Yes", explain why:

COMMAND TERMINATION

The command termination action discontinues an individual data link connection between the ground system and an aircraft. It may be invoked by a controller or pilot as appropriate

a. When invoking a command termination action with an aircraft:

(1) Advise the flight crew via voice communications the reason for data link termination.

EXAMPLE-
"AAL 1313, your CPDLC session is terminated because of unreliable air traffic control message reception."

(2) Advise the operations supervisor as soon as practical.

(3) Recommend that this information be entered in the flight plan remarks.

b. In lost communications situations and when CPDLC remains operational, controllers shall avoid invoking command termination actions.

1. Are the required procedures for invoking Command Termination clearly described?

Yes _____ No _____

If "No", explain why:

2. Are there any operational or controller acceptance problems associated with implementing this procedure?

Yes _____ No _____

If "Yes", explain why:

ALTIMETER SETTING MESSAGES

a. Whenever practicable, issue current altimeter settings using the ASM function, unless:

   1. A non-positive response has been received to an ASM uplink to that aircraft, or

   2. The current altimeter is missing, or

   3. The ASM was rejected by the en route host automation system, or

   4. The aircraft's data block is in a coast status.

NOTE-
1. *When sector settings permit current/adapted ASM uplinks, the requirement to issue the altimeter setting to aircraft operating in your area of jurisdiction is satisfied.*

2. *Sector SOPs' shall reflect the primary and secondary altimeter stations assigned to that sector's fix posting area (FPA)/status information area (SIA).*

b. When providing approach control services, use voice communications to issue the altimeter setting for the landing airport.

c. Advise the operational supervisor when you become aware of any altimeter reading in excess of 31.00".

1. Are the four exceptions regarding satisfaction of the requirement to issue an altimeter setting when ASM is active clearly described?

   Yes _____ No _____

   If "No", explain why:

2. Are there any operational or controller acceptance problems associated with implementing these procedures for altimeter settings?

Yes _____ No _____

If "Yes", explain why:

IC MISMATCH

When an IC mismatch is displayed, evaluate the reason for the alert without delay and take action as appropriate.

The computer entry of a message removing the IC mismatch display constitutes acknowledgment of the alert and signifies that appropriate action has been, or will be, taken.

1. Are the controller responsibilities following an IC mismatch clearly defined?

   Yes _____ No _____

   If "No", explain why:

2. Are there any operational or controller acceptance problems associated with implementing the procedure for responding to an IC mismatch?

   Yes _____ No _____

   If "Yes", explain why:

COMMUNICATIONS TRANSFER OF CPDLC AIRCRAFT

CPDLC eligibility shall be transferred at or before an aircraft enters the receiving controller's area of jurisdiction, unless otherwise coordinated or specified by a letter of agreement or a facility directive.

> **NOTE:** Controllers should consider aircraft proximity to the receiving controller's boundary to ensure that the transfer of communication is accomplished prior to an aircraft entering the receiving controller's airspace.

When a sector has issued a transfer of communications to an aircraft via voice, that sector shall not issue any additional CPDLC messages to that aircraft.

> **NOTE:** Controllers should consider this before uplinking to *ALL.

When a sector has issued a transfer of communications via CPDLC, that sector shall not issue any control instructions via voice without countermanding the TOC.

TOC AUTO

> Initiate an automated handoff only after eliminating any potential conflict with other aircraft for which you have separation responsibility.

TOC MANUAL

> Release a held TOC only after eliminating any potential conflict with other aircraft for which you have separation responsibility.

1. Are controller responsibilities for timely transfer of communications adequately defined?

   Yes _____ No _____

   If "No", explain why:

2. Are the prohibitions against sending CPDLC messages or voice control instructions after issuing a transfer of communications clearly stated?

   Yes _____ No _____

   If "No", explain why:

3. Is the need to eliminate potential aircraft conflicts prior to initiating a handoff (AUTO TOC) or releasing a held TOC (MANUAL TOC) clearly stated?

   Yes _____ No _____

   If "No", explain why:

4. Are there any operational or controller acceptance problems associated with implementing the procedures for transferring communications ?

   Yes _____ No _____

   If "Yes", explain why:

STEALING OR ESTABLISHING CPDLC ELIGIBILITY WITHIN A CPDLC FACILITY

Unless a controller has track control *and* established voice communications with an aircraft, or the aircraft is within their area of jurisdiction, verbal coordination shall be accomplished prior to stealing or establishing CPDLC eligibility.

1. Does the order clearly define the conditions under which verbal coordination is required when stealing or establishing CPDLC eligibility?

   Yes _____ No _____

   If "No", explain why:

2. Are there any operational or controller acceptance problems associated with implementing the procedure for stealing/establishing CPDLC eligibility?

   Yes _____ No _____

   If "Yes", explain why:

CPDLC MALFUNCTIONS/SHUTDOWNS

When CPDLC shutdown begins, the controller shall advise the pilot(s) with the following phraseology,

> *"ATTENTION ALL AIRCRAFT* (Facility ID*) CPDLC PLANNED SHUTDOWN IN PROGRESS. CONTINUE NORMAL PROCESSING OF CURRENT MESSAGES."*

When CPDLC has failed for the facility, the controller shall advise the pilot(s) with the following phraseology,

> *"ATTENTION ALL AIRCRAFT* (Facility) *CPDLC OUT OF SERVICE."*

When the HOST computer fails, or CPDLC malfunctions, controllers shall take action to resolve all CPDLC transactions for which they are responsible.

When an aircraft reports a possible CPDLC system malfunction, take the following actions:

- Request a report from a second aircraft.

- If the second aircraft reports normal operations, continue use and inform the first aircraft.

- If the second aircraft confirms the malfunction, or in the absence of a second aircraft, advise the operational supervisor.

When CPDLC is returned to service, the controller shall advise the pilot(s) with the following phraseology,

> *"ATTENTION ALL AIRCRAFT,* (Facility ID) *CPDLC RETURNED TO SERVICE."*

1. Is the phraseology to be used when a planned shutdown or facility failure occur clear and unambiguous?

   Yes _____ No _____

   If "No", explain why:

2. Are the actions to be taken after a Host failure or CPDLC malfunction clearly stated?

   Yes _____ No _____

   If "No", explain why:

3. Are the steps to be taken when an aircraft reports a possible CPDLC malfunction clearly defined?

   Yes _____ No _____

   If "No", explain why:

4. Are there any operational or controller acceptance problems associated with implementing the procedures dealing with CPDLC shutdowns/failures?

   Yes _____ No _____

   If "Yes", explain why:

STARTOVER MESSAGES RECEIVED FROM THE EN ROUTE AUTOMATION SYSTEM (HOST)

When a startover message is received from the en route automation system (HOST), controllers shall verify that the information displayed in the status list is current/valid, and that transactions in progress at the time of the interruption are completed, re-sent, or otherwise resolved.

1. Are the actions to be taken after a Host startover clearly stated?

   Yes _____ No _____

   If "No", explain why:

2. Are there any operational or controller acceptance problems associated with implementing the procedures dealing with Host startovers?

   Yes _____ No _____

   If "Yes", explain why:

TRANSFER OF POSITION RESPONSIBILITY

Briefing shall include:

- Temporary MTM content.
- CPDLC sector settings.
- Status of CPDLC transactions.

1. Are the items to be included in the transfer of position briefing clearly stated?

   Yes _____ No _____

   If "No", explain why:

3. Are there any operational or controller acceptance problems associated with implementing the procedures for transfer of position responsibility?

   Yes _____ No _____

   If "Yes", explain why:

EN ROUTE SECTOR TEAM POSITION RESPONSIBILITIES

At the direction of the Radar Controller, the Radar Associate and Radar Coordinator controllers shall assist the radar position by initiating CPDLC messages which are necessary for the continued smooth operation by the sector. They shall ensure that the radar position is informed, as necessary, of any action taken.

1. Does this procedure clearly define the responsibilities of the sector team when using CPDLC?

   Yes _____ No _____

   If "No", explain why:

2. Are there any operational or controller acceptance problems associated with the use of CPDLC by a sector team?

   Yes _____ No _____

   If "Yes", explain why:

CPDLC I AT Effectiveness Testing

Controller Test Run Evaluation

Name _____

Test Condition _____

Run No. _____ Sector _____ Position _____

Date _____ Time _____

Part I. Workload Evaluation

Use the items below to describe the level of workload that you experienced at your position during this test run. These should be ratings of your personal perception of how hard you feel you had to work to perform your duties -- not an estimate based on overall sector loading or traffic count.

1. In comparison to a corresponding traffic period at this sector at Miami ARTCC, my workload during this test run was:

   _____ Much Lower Than Usual

   _____ Somewhat Lower Than Usual

   _____ About The Same

   _____ Somewhat Higher Than Usual

   _____ Much Higher Than Usual

2. Overall, the level of workload that I experienced during this test run was:

   _____ ACCEPTABLE -- did not affect my ability to control traffic safely and effectively.

   _____ UNACCEPTABLE -- either threatened to, or actually did, impair my ability to control traffic safely and effectively.

Please describe any factors that you feel may have influenced your perceived workload:

Part II. Controller's Operational Assessment

Safety

Based on your experience with actual operations at this sector under these traffic conditions at the Miami ARTCC, use the scale below to make an overall operational assessment of ATC safety during this test run prior to any overall system failures that may have been injected for test purposes:

a) _____ The margin of safety was greater than normal for operations at this sector at the Miami ARTCC.

b) _____ Operations were typical, with an acceptable margin of safety.

c) _____ Operational safety was not compromised, but I had safety concerns.

d) _____ Operations were unsafe, and unacceptable.

If you checked c. or d., please explain your rating below. Describe the incidents or factors which influenced your judgment.

Part III. Effects of CPDLC on ATC Operations (COMPLETE THIS SECTION ONLY IF CPDLC WAS ON AT YOUR SECTOR FOR THIS TEST RUN)

Evaluate the effects of CPDLC on ATC operations using the scale below:

Large Improvement	Some Improvement	No Effect	Some Decrease	Unacceptable Decrease
a. _____	b. _____	c. _____	d. _____	e. _____

1. Did the use of CPDLC have any effect on the margin of safety observed during this test run?

   a. _____ b. _____ c. _____ d. _____ e. _____

2. Did the use of CPDLC have any effect on your ability to control aircraft efficiently during this test run?

   a. _____ b. _____ c. _____ d. _____ e. _____

Large Improvement	Some Improvement	No Effect	Some Decrease	Unacceptable Decrease
a. _____	b. _____	c. _____	d. _____	e. _____

3. Did CPDLC have any effect on the effectiveness of communications during this test run?

a. _____ b. _____ c. _____ d. _____ e. _____

4. Did CPDLC have any effect on the accuracy of communications during this test run?

a. _____ b. _____ c. _____ d. _____ e. _____

5. Did CPDLC have any effect on the timeliness of communications during this test run?

a. _____ b. _____ c. _____ d. _____ e. _____

Part IV. CPDLC Usage Problems (COMPLETE THIS SECTION ONLY IF CPDLC WAS ON AT YOUR SECTOR FOR THIS TEST RUN)

Use the scale below to indicate the severity of PROBLEMS that you experienced in performing *CPDLC tasks during this test run:*

No Problems	Some Problems	Unacceptable Problems	Did Not Perform This Task
a. _____	b. _____	c. _____	d. _____

1. Making accurate CPDLC keyboard entries.

a. _____ b. _____ c. _____ d. _____

2. Reading CPDLC displays.

a. _____ b. _____ c. _____ d. _____

3. Detecting CPDLC alerts in the status list (FAI, ERR, TIM, IIC, UNA etc.)

a. _____ b. _____ c. _____ d. _____

No Problems	Some Problems	Unacceptable Problems	Did Not Perform This Task
a. _____	b. _____	c. _____	d. _____

4. Distinguishing between data block symbols for CPDLC eligible and ineligible aircraft.

a. _____ b. _____ c. _____ d. _____

5. Monitoring the status of ongoing CPDLC transactions.

a. _____ b. _____ c. _____ d. _____

6. Sending Transfer of Communications messages.

a. _____ b. _____ c. _____ d. _____

7. Sending Menu Text Messages.

a. _____ b. _____ c. _____ d. _____

8. Sending Altimeter Setting Messages.

a. _____ b. _____ c. _____ d. _____

9. Coordinating CPDLC actions between R and D controllers.

a. _____ b. _____ c. _____ d. _____

10. Following CPDLC procedures for handling non-normal events.

a. _____ b. _____ c. _____ d. _____

11. Managing CPDLC lists and menu.

a. _____ b. _____ c. _____ d. _____

12. Remembering the content of a sent CPDLC message or whether it was sent.

a. _____ b. _____ c. _____ d. _____

13. Establishing a CPDLC session with an aircraft.

a. _____ b. _____ c. _____ d. _____

14. Stealing or forwarding CPDLC eligibility.

a. _____ b. _____ c. _____ d. _____

No Problems	Some Problems	Unacceptable Problems	Did Not Perform This Task
a. _____	b. _____	c. _____	d. _____

15. Dealing with aircraft received from, or going to, a sector with Data Link turned OFF.

a. _____ b. _____ c. _____ d. _____

16. Dealing with too many CPDLC equipped aircraft.

a. _____ b. _____ c. _____ d. _____

17. Dealing with CPDLC transaction delays that were too long.

a. _____ b. _____ c. _____ d. _____

If you checked c. (Unacceptable Problems) for any of these items please explain your rating below. Describe the incidents or factors that influenced your judgment.

CPDLC I AT Effectiveness Testing

Observer Test Run Evaluation

Test Condition _____

Run No. _____ Sector _____

Date _____ Time _____

Part I. Performance Ratings

Evaluate the ATC operations observed during this test run on the following factors using the scale below:

Never Occurred	Rarely Occurred	Occurred, But Within Limits of Operational Acceptability	Occurred More Often Than Normal	Occurred Unacceptably Often
a. _____	b. _____	c. _____	d. _____	e. _____

1. Errors or omissions in required flight strip marking.

a. _____ b. _____ c. _____ d. _____ e. _____

2. Gave Arriving Aircraft Inefficient (Early) Descent.

a. _____ b. _____ c. _____ d. _____ e. _____

3. Gave Departing Aircraft Inefficient (Late) Climb.

a. _____ b. _____ c. _____ d. _____ e. _____

4. Issued Clearances Later or Earlier Than Appropriate.

a. _____ b. _____ c. _____ d. _____ e. _____

5. Failed to Comply with Letters of Agreement.

a. _____ b. _____ c. _____ d. _____ e. _____

6. Offered Hand-Offs Earlier Than Appropriate.

a. _____ b. _____ c. _____ d. _____ e. _____

7. Offered Hand-Offs Later Than Appropriate.

a. _____ b. _____ c. _____ d. _____ e. _____

8. Accepted Hand-Offs Later Than Appropriate.

Never Occurred	Rarely Occurred	Occurred, But Within Limits of Operational Acceptability	Occurred More Often Than Normal	Occurred Unacceptably Often
a. _____	b. _____	c. _____	d. _____	e. _____

Part II. Overall Operational Assessment

Safety

Use the scale below to make an overall operational assessment of ATC safety during this test run prior to any overall system failures that may have been injected for test purposes:

a) _____ The margin of safety was greater than normal.

b) _____ Operations were typical, with an acceptable margin of safety.

d) _____ Operational safety was not compromised, but I had safety concerns.

d) _____ Operations were unsafe, and unacceptable.

If you checked c. or d., please explain your rating below. Thoroughly describe the incidents or factors which influenced your judgment.

Control Effectiveness and Efficiency

Use the following scale to make an overall operational assessment of the efficiency and effectiveness with which aircraft were handled during this test run:

a) _____ **Aircraft were handled effectively and with a high degree of efficiency.**

b) _____ Aircraft were handled effectively, with an acceptable level of efficiency.

c) _____ Aircraft were handled effectively, but efficiency was poor.

d) _____ ATC performance was ineffective and inefficient.

Part III. Effects of CPDLC on ATC Operations

Evaluate the effects of CPDFLC on ATC operations using the scale below:

Large Improvement	Some Improvement	No Effect	Some Decrease	Unacceptable Decrease
a. _____	b. _____	c. _____	d. _____	e. _____

1. Did the use of CPDLC appear to have any effect on the margin of safety observed during this test run?

a. _____ b. _____ c. _____ d. _____ e. _____

2. Did the use of CPDLC appear to have any effect on the controllers' ability to control aircraft efficiently during this test run?

a. _____ b. _____ c. _____ d. _____ e. _____

3. Did CPDLC appear to have any effect on the effectiveness of communications during this test run?

a. _____ b. _____ c. _____ d. _____ e. _____

4. Did CPDLC appear to have any effect on the accuracy of communications during this test run?

a. _____ b. _____ c. _____ d. _____ e. _____

5. Did CPDLC appear to have any effect on the timeliness of communications during this test run?

a. _____ b. _____ c. _____ d. _____ e. _____

Part IV. CPDLC Usage

1. Did you observe any input errors in selecting or entering Data Link messages?

   a) _____ I did not notice any input errors.

   b) _____ I noticed a few errors.

   c) _____ The controllers made several errors.

2. If you observed Data Link entry errors, how were they handled? (Check all that apply)

   a) _____ Errors were detected by the controllers during the input process and corrected before sending.

   b) _____ The controllers noticed the error in the FDB or Status List Display after sending the message. The error was corrected by voice radio using correct procedures.

   c) _____ The error was detected only by noticing an unintended outcome or voice radio contact by aircraft.

   d) _____ The error was never detected by the controllers.

Part V. Sector On/Off Effects (Test Series 1)

1. During this test run CPDLC was: ON _____ OFF _____ at this sector.

2. Describe any apparent controller or pilot confusion or problems associated with CPDLC aircraft passing to or from this sector.

Part VI. System Outage (Test Series 1)

1. Which system outage occurred during this test run?

2. Recovery time _____

3. Describe the controllers' response to the failure.

4. How successful was the recovery?

5. Describe any impact on safety.

Part VII. Non-normal Event Recovery (Test Series 2)

1. Which non-normal Data Link events occurred during this test run?

   _____ No non-normal message states occurred

   _____ ERROR

   _____ FAIL

   _____ IIC

   _____ Pilot Mistuned frequency after a CPDLC TOC

   _____ Controller countermanded a CPDLC TOC

2. Were these detected in a timely fashion?

3. Were appropriate procedures followed?

4. Were the procedures effective?

Part VII. Transaction Time and Equipage Effects (Test Series 2)

1. CPDLC transaction delays for this test run were:

   Normal _____ Longer than Normal _____

2. The number of CPDLC equipped aircraft in this test run was:

   Normal _____ Larger than Normal _____

3. Describe any problems attributable to the number of CPDLC equipped aircraft in this test run.

CONTROLLER POST TEST QUESTIONNAIRE

Name: _____

Based on your ATC background and the experience that you have had with CPDLC during this test, carefully evaluate each of the following statements. Place an "X" in the space that indicates your level of agreement with each statement on the 1 to 5 scale

Strongly Disagree		Neutral (No Opinion)		Strongly Agree
1	2	3	4	5

I. Training

1. The CBI components of the training program will be adequate for controllers.

   1 _____ 2 _____ 3 _____ 4 _____ 5 _____

2. The lecture components of the training program will be adequate for controllers.

   1 _____ 2 _____ 3 _____ 4 _____ 5 _____

3. The DYSIM components of the training program will be adequate for controllers.

   1 _____ 2 _____ 3 _____ 4 _____ 5 _____

4. The procedures that I learned to use when dealing with CPDLC errors, failures and negative pilot responses were effective.

   1 _____ 2 _____ 3 _____ 4 _____ 5 _____

5. After training was completed, I was fully prepared to use CPDLC.

   1 _____ 2 _____ 3 _____ 4 _____ 5 _____

II. Displays

6. The size of the CPDLC data block symbols is adequate, even when the smallest font size is selected.

   1 _____ 2 _____ 3 _____ 4 _____ 5 _____

7. The "up arrow" and "lightning bolt" symbols are easy to see.

   1 _____ 2 _____ 3 _____ 4 _____ 5 _____

8. Whether a diamond is open or filled is immediately noticeable.

   1 _____ 2 _____ 3 _____ 4 _____ 5 _____

Strongly Disagree		Neutral (No Opinion)		Strongly Agree
1	2	3	4	5

9. The CPDLC data block symbols were easy to distinguish from one another.

1	2	3	4	5

10. It is clear when the CPDLC sector settings have been successfully adjusted.

1	2	3	4	5

11. It is easy to tell when a data link message has been sent to an aircraft.

1	2	3	4	5

12. It is easy to tell when, for whatever reason, a data link message has NOT been sent to an aircraft.

1	2	3	4	5

13. It is clear when a hand-off will (and will not) result in an automatic transfer of communication.

1	2	3	4	5

14. It is easy to determine that a CPDLC message was received by the intended aircraft.

1	2	3	4	5

15. The error messages provided make it easy to know what the error is and what should be done about it.

1	2	3	4	5

16. It is easy to tell whether a message is pending, sent, accepted or rejected.

1	2	3	4	5

17. The meanings of all abbreviations and acronyms used in CPDLC are clear.

1	2	3	4	5

18. It is easy to tell whether the flight crew has acknowledged a controller's message with a positive (Wilco, Affirmative) or a negative (Unable, Negative) response.

1	2	3	4	5

Strongly Disagree		Neutral (No Opinion)		Strongly Agree
1	2	3	4	5

19. It would be easy to tell if a data link message was received by an aircraft OTHER than the one the message was intended for.

1	2	3	4	5

20. CPDLC status list alerts (e.g. IIC, ERR, FAI, NEG/UNA) were effective at getting my attention.

1	2	3	4	5

21. Overall, CPDLC displays were clear and easy to interpret.

1	2	3	4	5

III. Inputs

22. The risk of making unrecoverable input errors and sending erroneous messages with CPDLC is low.

1	2	3	4	5

23. When I made input errors with CPDLC, the system either prevented the uplink OR I caught the errors myself before sending.

1	2	3	4	5

24. I never attempted to send CPDLC messages to non-equipped or non-eligible aircraft and failed to notice that the message had not been sent.

1	2	3	4	5

25. It is easy to remember which data link key performs which function.

1	2	3	4	5

26. The data link function keys are located in a logical fashion.

1	2	3	4	5

27. Data link entries are quick and easy to make.

1	2	3	4	5

Strongly Disagree		Neutral (No Opinion)		Strongly Agree
1	2	3	4	5

28. It is easy to tell when I have made an error in a data link command.

1	2	3	4	5

29. The data link settings are easy to adjust.

1	2	3	4	5

30. It is easy to filter the status list by service type and message state.

1	2	3	4	5

31. It is easy to display the current sector settings.

1	2	3	4	5

32. It is easy to suppress/display all messages in the menu text list.

1	2	3	4	5

33. The steps required to clear an initial contact altitude mismatch error are easy to remember.

1	2	3	4	5

34. The steps required to clear an error message are easy to remember.

1	2	3	4	5

35. It is clear what needs to be done after a message in an open state has been deleted.

1	2	3	4	5

36. It is clear what needs to be done after a pilot response of "NEG" or "UNA".

1	2	3	4	5

37. It is clear what needs to be done after a return message of "ERR.

1	2	3	4	5

38. It is clear what needs to be done after a return message of "TIM".

1	2	3	4	5

Strongly Disagree		Neutral (No Opinion)		Strongly Agree
1	2	3	4	5

39. Overall, making CPDLC inputs was easy.

1	2	3	4	5

IV. Effects of CPDLC on ATC

40. CPDLC did not interfere with ATC operations during testing.

1	2	3	4	5

41. CPDLC did not impair the accuracy of communications during testing.

1	2	3	4	5

42. I had no trouble switching between voice radio and CPDLC as required to get the job done most efficiently.

1	2	3	4	5

43. CPDLC did not impair the efficiency with which communications were conducted during testing.

1	2	3	4	5

44. The turnaround time for CPDLC transactions during the test was acceptable for sending Transfer of Communication (TOC) messages.

1	2	3	4	5

45. The turnaround time for CPDLC transactions during the test was acceptable for sending Menu Text Messages.

1	2	3	4	5

46. The turnaround time for CPDLC transactions during the test was acceptable for sending Altimeter Setting Messages.

1	2	3	4	5

47. Timely communications by voice radio and CPDLC were achieved during testing.

1	2	3	4	5

48. CPDLC did not significantly increase my workload.

1	2	3	4	5

Strongly Disagree		Neutral (No Opinion)		Strongly Agree
1	2	3	4	5

49. CPDLC did not reduce the margin of safety in ATC operations.

1	2	3	4	5

50. CPDLC did not reduce my ability to control traffic effectively.

1	2	3	4	5

51. CPDLC did not reduce my ability to control traffic efficiently.

1	2	3	4	5

52. CPDLC did not interfere with my ability to monitor traffic and make control decisions.

1	2	3	4	5

53. Using CPDLC does not distract me from other aspects of the radar situation (that is, it does not reduce my situational awareness).

1	2	3	4	5

54. CPDLC is well-integrated with other DSR functions.

1	2	3	4	5

55. There are no incompatibilities between CPDLC and other DSR functions.

1	2	3	4	5

56. CPDLC is sufficiently integrated with other functions so that the same data does not need to be entered more than once.

1	2	3	4	5

57. CPDLC does not tie up equipment or resources needed for other, more immediate, tasks.

1	2	3	4	5

58. CPDLC helps by simplifying the task of sending routine, repetitive messages.

1	2	3	4	5

59. CPDLC should reduce controller-pilot communication errors.

1	2	3	4	5

Strongly Disagree		Neutral (No Opinion)		Strongly Agree
1	2	3	4	5

60. The margin of safety in ATC operations will be increased with CPDLC.

1	2	3	4	5

61. CPDLC will reduce the number of pilot requests for retransmissions (repeats) of messages sent by controllers.

1	2	3	4	5

62. The CPDLC controller will have more time to coordinate and plan with others during busy work periods.

1	2	3	4	5

63. CPDLC permits controllers to better distribute their workload and avoid having too many things to do at one time during busy work periods.

1	2	3	4	5

64. Controllers will experience less stress during busy traffic rushes when CPDLC is implemented.

1	2	3	4	5

65. CPDLC makes the voice channel more available when it is needed for a time-critical clearance.

1	2	3	4	5

66. CPDLC will reduce minor communications errors that can lead to inefficiencies and flight delays.

1	2	3	4	5

67. Lost communications, stolen clearances, and readback errors are important safety problems that CPDLC will help to solve.

1	2	3	4	5

68. Having aircraft equipped with CPDLC will make frequency outages and stuck mics easier to handle and less dangerous.

1	2	3	4	5

Please answer A. and B. below and briefly explain your answers:

A. Did the simulation environment and traffic used in this test provide a sufficiently realistic replication of operations in your area of the Miami ARTCC?

_____ YES NO _____

If NO, Why Not?

B. Do you feel that the conditions of this test provided for fair assessments of a controller's ability to use CPDLC and of the effectiveness of the system?

_____ YES NO _____

If NO, Why Not?

Please add any comments regarding CPDLC or this test that you would like to express: