

1.1. Controller-Pilot Data Link Communication (CPDLC)

CPDLC Build 1,¹⁶ is the first domestic controller-pilot data link implementation in the NAS, and is currently in use at Miami Center. This system was used as a model for the MACS DSR CPDLC implementation; however, many functions available at Miami Center are not supported by us. Another difference is the added DAG-related data link functions that are *not* part of the Build 1, including: support for pilot request downlinks, RTA uplinks, and trial plan or advisory clearance uplinks. Our implementation of these functions follows the syntax and format of existing Build 1 functionality as closely as possible. For example, frequency change functions (UH, UF) provided a model for RTA uplinks: HELD messages can be generated automatically for RTA-equipped aircraft when the STA is frozen, and sent automatically or released by the controller using a “UH [CID]” command. RTA uplinks can also be sent using the command “UR [CID]”.

Terminology and concepts key to this CPDLC implementation (e.g., “eligibility,” “status,” “transaction”) are defined in Table 3.8.

Table 3.8. CPDLC Terminology (from Miami Center’s CPDLC Build 1 implementation).

CPDLC	controller-to-pilot data link communication
downlink	a message sent down from the flight deck to the ground.
eligibility	sector can communicate with aircraft via CPDLC. Only one sector at a time has eligibility.
menu list	list of text messages that can be sent using “UM”. Can be turned on/off from the DC View.
status list	a list of ongoing transactions. Status list entries are sorted into 4 categories (held , positive , non-positive , downlink) and have 4 elements: (1) a “.” for selecting the transaction, (2) aircraft ID, (3) transaction specific info, (4) the transaction’s current status.
transaction	a CPDLC exchange (uplink and reply, downlink and reply) between flight deck and ground.
uplink	a message sent up from the ground to the flight deck.
transaction status types:	
closed	a “closed” transaction (status of NEG, UNA, AFF, WIL, ROG) is completed; no further actions are expected or possible. Closed, positive transactions (AFF, WIL, ROG) automatically drop off the list after 6 seconds. Closed non-positive transactions must be deleted by the controller.
held	held transactions (status of HLD) are found in the top status list category. There are two possible types of held transactions: transfer of communications, created when a handoff is accepted and TOC mode is MAN; and RTA uplink, created when an arrival aircraft crosses the freeze horizon. Held transactions are sent by the controller with the “UH” command.
nonpositive	“non-positive” transactions (status of TIM, NEG, UNA) are found in the third entry category in the the status list. A non-positive transaction may be open or closed .
open	an “open” transaction is waiting for a reply from the flight crew to the controller or from the controller to the flight crew. SNT, TIM and REQ are open states.
positive	“positive” transactions (WIL, AFF, ROG, NRR) comprise the second category in the status list. A positive transaction may be open or closed .
request	The last (fourth) transaction category are downlink requests, which may be open (REQ) or closed (AFF, UNA). Closed requests are automatically removed from the list after 6 seconds.

Section 3.6 describes methods for performing most of the operations supported by the AOL CPDLC implementation. Often there are several different methods for performing the same operation. Table 3.10, at the end of the section, provides a summary list of the 2-character keyboard methods for performing the basic AOL CPDLC functions.

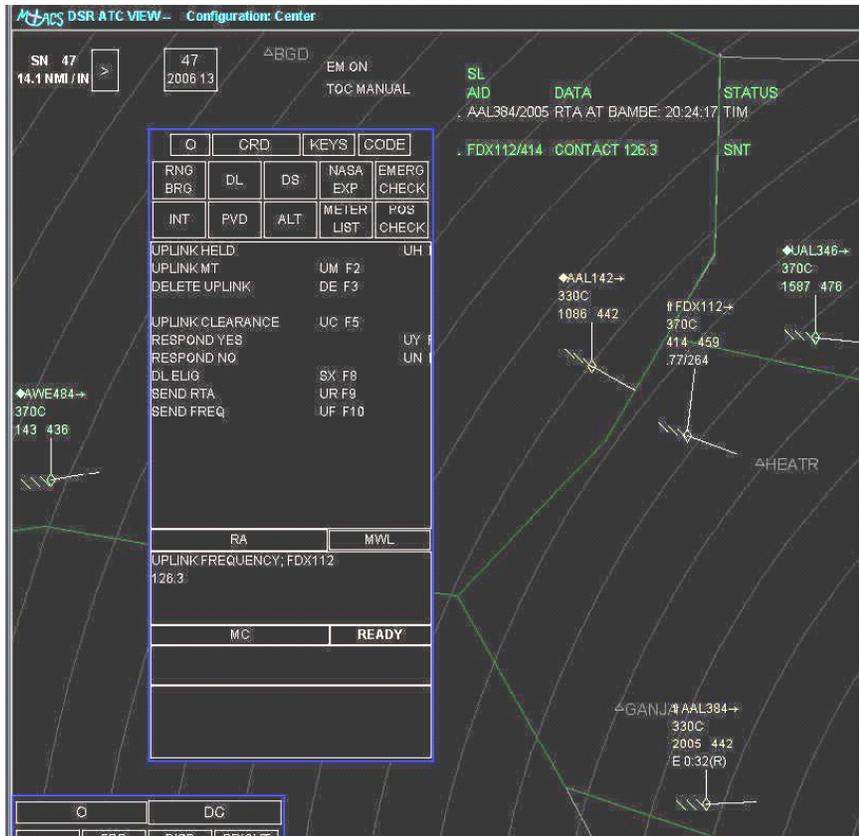


Figure 3.11. MACS DSR CPDLC example.

1.1.1. CPDLC Interface

The CPDLC interface includes several components in the DSR display: two R-CRD menus, some added buttons on the DC View, a CPDLC message “Status List”, a CPDLC “Menu Text” list, symbology in the flight data block, and a banner entry. Figure 3.7 illustrates most of these components within the full DSR display. Detailed descriptions of each element are provided below.

1.1.1.1 Data Block CPDLC Information

There are 5 different CPDLC data block symbols (illustrated in figure 3.11):

1. A down arrow (↓) indicates that a request has been “downlinked” from the flight deck. The color magenta is used to increase salience of this symbol and to uniquely identify request-related information (figure 3.14).
2. An up arrow (↑) indicates that a message has been “uplinked” from the controller to the aircraft. The uplink may be a clearance, frequency, or text message.
3. A filled diamond (◆) indicates that the sector has “elegibility”, and can send and receive messages to the aircraft. Data link eligibility usually accompanies track control, but the transfer mechanism is separate.

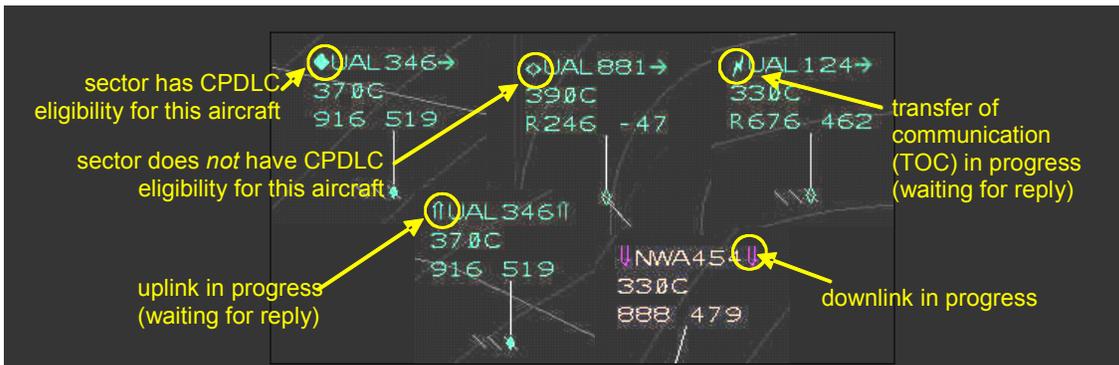


Figure 3.11. MACS DSR Data Block Information.

4. An unfilled diamond (◇) indicates that the sector does not have “eligibility” (i.e., cannot communicate with this aircraft via CPDLC).
5. A lightning bolt (⚡) indicates that a transfer of communication (and transfer of eligibility) is in progress. The process is completed when the flight crew accepts the frequency change (TOC) uplink message.

1.1.1.2 R-CRD menus

Figure 3.12 shows the “DL Category Menu” on the R-CRD, accessed from the R-CRD’s “DL” key. The AOL implementation includes 5 of the 9 CPDLC Build 1 operations (UPLINK HELD, UPLINK MT, DELETE UPLINK, DL ELIG, SEND FREQ), and 4 custom DAG-TM operations (UPLINK CLEARANCE, RESPOND YES, RESPOND NO, SEND RTA). These operations can be initiated by several different methods:

- PICK the R-CRD menu entry, (or)
- type the two-character code shown in column 2 (e.g., “UC” for UPLINK CLEARANCE), (or)
- use the function key listed in column 3 (F5 for UPLINK CLEARANCE)

A second CPDLC menu, the “DS Category Menu,” is accessed using the “DS” key. This menu is used to configure or suppress the status and menu text lists on the DSR display. Ours is a subset of Miami Center’s Build 1 menu. The three supported operations are also available from the DC View.

1.1.1.3 Status List

The Status List (figure 3.13) provides the controller a list of ongoing transactions for his or her sector. There are several methods for toggling display of the list: from the

O		CRD	KEYS	CODE
RNG BRG	DL	DS	NASA EXP	EMERG CHECK
INT	PVD	ALT	METER LIST	POS CHECK
UPLINK HELD			UH	F1
UPLINK MT			UM	F2
DELETE UPLINK			DE	F3
UPLINK CLEARANCE			UC	F5
RESPOND YES			UY	F6
RESPOND NO			UN	F7
DL ELIG			SX	F8
SEND RTA			UR	F9
SEND FREQ			UF	F10
RA		MWL		
UPLINK CLEARANCE ; REROUTE TO UKW / FL310; AAL 168				
ROUTE AMENDED: IND. / ,341549N/0993029W, ,335041N/0992915W, ,UKW				
MC		READY		

Figure 3.12. R-CRD Data Link Menu

DC View (DL key), from the R-CRD DS category menu, or by typing “DL ON” / “DL OFF” in the R-CRD. The first line of the Status List is its label (“SL”). The second line labels the list’s three columns. The first column, “AID,” for aircraft ID; “DATA” identifies the transaction and includes transaction-specific information; and “STATUS” shows the transaction’s current status.

The Build 1 Status List sorts entries into three categories based on status: (1) held, (2) non-positive (open or closed), (3) positive (open or closed). The AOL implementation adds a 4th category for “pilot request” downlinks, which can be highlighted in cyan or magenta (Table 3.8). Handoffs cannot be initiated for an aircraft that has either “open” or “non-positive” entries

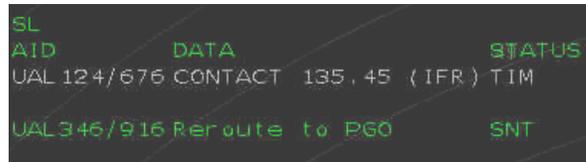


Figure 3.13. CPDLC Status List with 2 entries (one non-positive, one positive). This example has no entries in the held or downlink categories. See text and table 3.5 for a description of Status List elements and categories.

remaining in the status list; the controller must manually delete these entries using the “DE...” or “DE /OK...” commands.

1.1.2. CPDLC Operations

Four different types of communications are supported by CPDLC: transfer of communication, uplink messages, uplink clearances, and downlink requests.

1.1.2.1 Transfer of Communication

Transfer of communication for CPDLC aircraft is an automation-assisted process for transferring both radio communications & data link eligibility from transferring to receiving sector after the handoff of track control is complete. This process includes either a manual or automatic uplink of the receiving sector's radio frequency, depending on the selected "TOC mode." TOC mode can be changed from the DC View. Transfer of communication is described in Table 3.9.

Table 3.9. Transfer of Communications Procedure

1.	Sector handoff is initiated by transferring controller. <u>A handoff cannot be initiated while open or non-positive transactions for the aircraft remain in the status list.</u>
2.	Handoff accepted. Depending on whether TOC mode is MANUAL or AUTO, a frequency uplink message is either: (a) automatically sent to the aircraft (TOC AUTO), or (b) automatically created and "HLD" in the status list (TOC MANUAL). When ready, the transferring controller sends the message to the aircraft with the "UH" function.
3.	the data block on both sectors has a lightning bolt ("⚡") next to the call sign indicating a TOC in progress.
4.	thepilot receives the message, tunes the new frequency, and responds via CPDLC to the uplink message (WIL).
5.	CPDLC eligibility transfers to the next sector as soon as the "WILCO" is received.
6.	The data link symbol in the data block reflects the transfer of eligibility: "◇" (hollow diamond) for transferring controller, "◆" (filled diamond) for receiving controller.
7.	The flight crew will check in by voice if the message was "CONTACT...". They will <i>not</i> check in by voice if the uplink message told them to "MONITOR...". In DAG-TM simulations, controller managed (IFR) aircraft received "CONTACT" messages for TOC, while autonomous/free flight (AFR) aircraft received "MONITOR" messages.

1.1.2.2 Uplink Clearances & Messages

Uplink clearances currently supported in the AOL CPDLC implementation include RTA, altitude and speed clearances (speeds based on meter-fix speed advisories), and route modification clearances. These require a CPDLC reply (“wilco”, “unable”) from the flight deck. Text messages (e.g., “Check stuck mike”) may also be sent; these may or may not require a response.

1.1.3. Downlink Requests

Route modification requests can be downlinked from the flight deck and are presented to the controller as trial plan proposals (Figure 3.14). The controller may either accept or reject these requests. No mechanism is currently provided for sending a modified ‘alternative’ proposal as part of the same transaction.

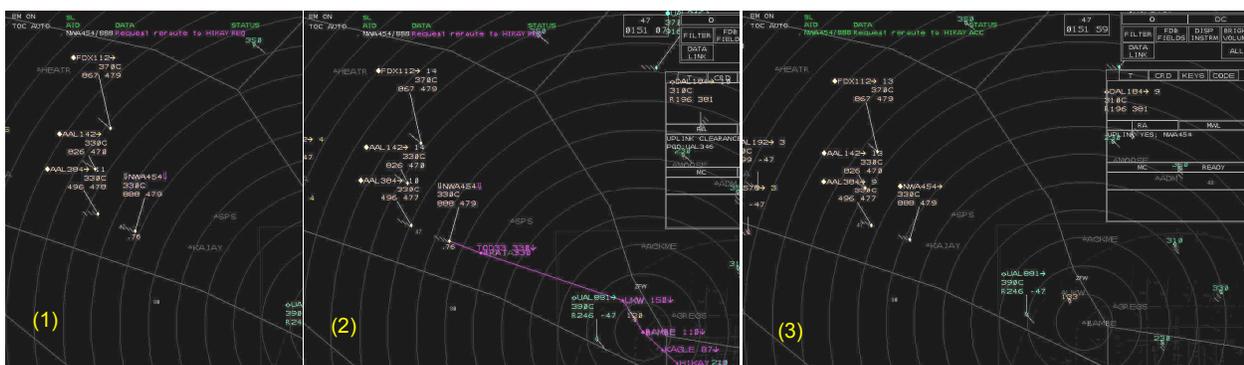


Figure 3.14. MACS/DSR downlink request interface:

- (1) Ground automation has received a donwlink request from AAL384.Magenta ontroller cues shown in datablock and status list.
- (2) Route request accessed by clicking on the magenta arrow is displayed with ground automation feedback (as in trial plan).
- (3) The controller has approved the request (“ACC” uplink sent to flight crew).

Table 3.10. Summary of CPDLC Keyboard Commands

<i>Transfer of Communications:</i>		
uplink frequency:	UH [cid]	send held message (keyboard)
	UH (slew & ENTER on ".")	send held message (trackball)
	UF [cid]	send default frequency (sector with eligibility)
	UF [frequency] [cid]	send specified frequency
	UF [sector ID#] [cid]	send default frequency for specified sector
transfer eligibility:	SX [cid]	transfers eligibility to sector with track control
	SX /OK [cid]	transfers eligibility to sector <i>without</i> track control
change TOC mode:	"TOC mode" button in DC View	"TOC Manual" to "TOC Auto" to "TOC Off"
<i>Status List Management:</i>		
delete message:	DE [cid]	delete all closed messages for specified aircraft.
	DE (slew & ENTER on ".")	delete selected (closed) message.
	DE /OK ...	over-ride for deleting open messages (must specify message or aircraft)
turn on/off SL display:	SL ON (or) SL OFF	
	"DL" button in DC View	
<i>Uplink Clearances:</i>		
uplink RTA:	UH [cid]	send held message (keyboard)
	UH (slew & ENTER on ".")	send held message (trackball)
	UR [cid]	uplink current RTA to specified aircraft
uplink speed advisories:	UC [cid]	uplink advised speeds to specified aircraft
uplink route clearance:	UC [cid]	uplink advised trial plan route to specified aircraft
<i>Reply to Downlink Request:</i>		
Affirmative, approved:	UY [cid]	sends positive (approved) response to flight deck
Negative, unable:	UN [cid]	sends negative (denied) response to flight deck

1.1.4. CPDLC and Autonomous Operations

CPDLC supports autonomous operations by greatly reducing the need for controller interaction with AFR aircraft. For most sectors, in fact, controller communications with AFR aircraft is minimal to none. The controller or pilot can initiate contact at any time, however, since the flight crew is required to monitor the radio frequency of the airspace that they are flying through. Transfer of radio (and CPDLC) communication is handled from the ground completely through the automation, with no controller involvement.

CPDLC also permits RTA assignment to AFR flights for TRACON (managed airspace) entry to be handled automatically without controller involvement.

CPDLC Differences – AOL vs. CPDLC-1 Version

MSP Walkthrough, June 22-24, 2005

DL Category Key Menu

Press DL Category Key to display DL Menu

Use Trackball to display DL Menu

Miami Center...

0	CRD	KEYS	CODE
RNG BRG	SIM	DL	DS
INT	PUD	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

0	CRD	KEYS	CODE
RNG BRG	SIM	DL	DS
INT	PUD	ALT	EMERG CHECK
			POS CHECK
UPLINK HELD		UH	F1
UPLINK MT		UM	F2
DELETE UPLINK		DE	F3
UPLINK CLEARANCE		UC	F5
RESPOND YES		UY	F6
RESPOND NO		UN	F7
DL ELIG		SX	F8
UPLINK RTA		UR	F9
SEND FREQ		UF	F10

Section 6: Message Entry Options
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1: "DL Category Menu" on R-CRD [from CBI Lesson 1]

The screensnap was taken from a CBI (computer-based instruction) course developed for the CPDLC-1 service currently used at Miami Center. Miami Center's CPDLC (controller-pilot data link) implementation served as the model for our Airspace Operation Laboratory (AOL) CPDLC. However, many functions available in the full Miami Center CPDLC version are not supported by us. We have also added DAG-related datalink functions that are not part of the Miami Center system, including: support for pilot request downlinks, RTA uplinks, and trial plan/ clearance/ advisory uplinks. These differences are indicated by **orange** or **highlighted text**.