Flight Deck Human Factors Issues for National Airspace System (NAS) En Route Controller Pilot Data Link Communications (CPDLC)

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
oz	ounces	28.35	grams	g
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
mL	milliliters	0.034	fluid ounces	fl oz
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
g	grams	0.035	ounces	oz
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	Kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

Preface

This report was prepared by the Aviation Human Factors Division of the Safety Management and Human Factors Technical Center at the John A. Volpe National Transportation Systems Center. It was completed with funding from the Federal Aviation Administration (FAA) Human Factors Division (ANG-C1) in support of the FAA Office of Flight Standards (AFS-470). We are thankful for our support from ANG-C1, including Dr. Sheryl Chappell and Dr. Paul Krois. We would like to thank our technical sponsors, Mark Patterson (AFS-470), Tom Kraft (AIR-100), and Dr. Kathy Abbott (AIR-100) for their support. We thank Andy Fry for his comments on an earlier draft.

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For questions or comments, please e-mail Dr. Kim Cardosi (kim.cardosi@dot.gov).

Contents

Acronyms and Abbreviations

ARTCC	Air Route Air Traffic Control Center
ATC	Air Traffic Control
CPDLC	Controller Pilot Datalink Communications
DM	Downlink Message
FAA	Federal Aviation Administration
FMC	Flight Management Computer
GOLD	Global Operational Data Link Manual
ICAO	International Civil Aviation Organization
MCP	Mode Control Panel
NAS	National Airspace System
SOP	Standard Operating Procedure
PF	Pilot Flying
PM	Pilot Monitoring
UM	Uplink Message

Executive Summary

Fundamental differences exist between transmissions of Air Traffic Control (ATC) clearances over voice and those transmitted via Controller Pilot Data Link Communications (CPDLC). It is imperative that flightcrew procedures are developed and implemented to capitalize on the strengths of CPDLC while minimizing the probability of error due to differences between CPDLC and voice. This paper provides flight deck human factors issues that apply to processing CPDLC messages in the en route environment. Consideration of these issues will help to inform the development of flightcrew procedures and training programs.

Voice communications allow both crewmembers to simultaneously hear the ATC clearance, independently form their own interpretation, and verify the interpretation with the other crewmember. With CPDLC, however, if one pilot were to read the clearance aloud before (or while) the second pilot reads it, the second pilot would be vulnerable to “reading” what the other pilot read aloud and missing any discrepancies between the actual clearance and what was heard. To ensure a common understanding of all clearances, it is recommended that both crewmembers silently and individually read each clearance and then confer before maneuvering the aircraft to comply with the clearance.

In the en route environment, it may not be feasible for both pilots to silently read each CPDLC message and then confer. The tempo of the operations and flightcrew workload will determine the degree to which this is appropriate. For simple messages that do not change the trajectory of the aircraft, the verification is less critical than for control messages. However, clearances that result in maneuvering the aircraft should always be independently assessed by each pilot before they are executed. In no case, should one pilot simply read and execute the clearance or read it to the other pilot to execute. Both pilots need to have an independent understanding of the clearance before it is executed.

A small subset of the CPDLC messages currently used in the oceanic environment are planned for initial domestic en route services. These include messages for altitude clearances, crossing restrictions, pilot requests (such as altitude changes and requests to go “Direct” to a waypoint on the route), re-route clearances, and emergency messages. There are important differences between existing oceanic CPDLC operations and planned domestic en route operations that flightcrew training will need to address. For example, pilots will not be able to send the same messages in the domestic en route environment that they use in the oceanic environment. Furthermore, in initial services, any free text message or message appended with free text will be rejected by the ground system and not be displayed to the controller. As CPDLC is implemented in the en route environment, both pilots and controllers will need to know what behavior to expect from the system and the person on the other side of the microphone.

1. Introduction

There are several fundamental differences between transmissions of Air Traffic Control (ATC) clearances over voice and those transmitted via Controller Pilot Data Link Communications (CPDLC). Voice communications are fast, but transient (that is, when the controller finishes the transmission, the opportunity to process that message is over); written CPDLC messages are persistent, but can also be more time consuming. The pilot can refer to a single CPDLC transmission as often as needed, but the message requires more time to access and read than does recognizing one's call sign on the voice frequency and listening to the transmission. Transmission of a clearance via CPDLC precludes the possibility of a pilot erroneously accepting the clearance intended for another aircraft and reduces congestion on the voice frequencies, but neither pilots nor controllers can be expected to respond to a CPDLC message as quickly as they respond to a voice transmission. It is critical that flightcrew procedures are developed and implemented to capitalize on the strengths of CPDLC while minimizing the probability of error due to differences between CPDLC and voice.

There will also be differences between CPDLC operations in the oceanic environment and those in the domestic en route environment that is serviced by Air Route Air Traffic Control Centers (ARTCCs). After a brief review of human factors issues related to all operational environments, we provide a description of flight deck human factors issues that apply specifically to pilots processing CPDLC messages in the en route environment. Consideration of these issues will help to inform the development of flightcrew procedures and training programs.

2. Human Factors Issues Common to All Operational Environments

One key difference between voice communications and CPDLC is that voice transmissions offer both crewmembers the opportunity to simultaneously hear the clearance, independently form their own interpretation, and then verify the interpretation with the other crewmember. Cross-verification is a critical safety net in flight operations. For example, a significant reduction in "altitude busts" was credited to the introduction of a procedure in which one pilot would readback an altitude clearance while entering it into the Mode Control Panel (MCP), while the other pilot verified that the correct altitude was entered by pointing to it; this insures a common understanding of the altitude clearance between both pilots and that the correct (or at least commonly understood) altitude is entered on the flight deck. It is this safety net of a common crew understanding of the correct clearance that needs to be carried into the future CPDLC environment.

With CPDLC, if one pilot were to read the clearance aloud before (or while) the second pilot reads it, the second pilot would be vulnerable to "reading" what the other pilot read aloud and missing any discrepancies between the actual clearance and what was heard. To ensure an independent understanding of all clearances, it is recommended that both crewmembers *silently* and *individually* read each CPDLC clearance and then confer before maneuvering the aircraft to comply with the clearance. The validation part of the procedure ensures that both crewmembers have the same independent interpretation that voice affords. This silent read can be accomplished simultaneously or sequentially, depending on factors such as the equipment available and other concurrent duties. In some cases, the CPDLC message may need to be accessed before it can be viewed (i.e., via one or more button presses), and it may not be convenient or appropriate for both pilots to read it at the same time. This procedure for crew verification of a CPDLC clearance is commonly referred to as the "silent read" or "GOLD procedure", since it was published as a recommended Standard Operating Procedure (SOP) in the *Global Operational Data Link Document* (2010; 2013). The same guidance is in Document 10037, the *Global Operational Data Link Document (GOLD) Manual* from the International Civil Aviation Organization [ICAO] (2016).

The *GOLD* states:

> 4.1.2.3 Each flight crew member (e.g. pilot flying and pilot monitoring) should individually review each CPDLC uplink message [i.e., a message sent from ATC to flight crew] prior to responding to and/or executing any clearance, and individually review each CPDLC downlink message [i.e., a message sent from the flight crew to ATC] prior to transmission. Reading a message individually is a key element to ensuring that each flight crew member does not infer any preconceived intent different from what is intended or appropriate. Reading the message aloud would bias the other flight crew member and could lead to the error of 'reading' what was read aloud as opposed to what was actually displayed.
>
> 4.1.2.4 Some uplink messages, such as complex or conditional clearances, require special attention to prevent the flight crew from responding to a clearance with WILCO, but not complying with that clearance. To minimize errors, when responding to a clearance with WILCO, each flight crew member should read the uplink message individually (silently) before initiating a discussion about whether and how to act on the message.
>
> (*ICAO GOLD*, 2016; text in brackets added)

It should be noted that the *GOLD* Manual addresses current (not future) operations. As such, the guidance applies to controller-pilot communications in oceanic airspace where direct voice is not available. However, the recommended procedure for the flight crew's processing of CPDLC messages will help mitigate errors in all environments. That is, each pilot should silently read the message, then confer before a clearance is executed. While it would be appropriate for one pilot to say, "we have an altitude clearance", or "we got a reroute", each pilot should review the specific altitude or route before acting on the clearance.

In the en route environment, it may or may not be feasible for both pilots to silently read each CPDLC message and then confer. The tempo of the operations and flightcrew workload will determine the degree to which this is appropriate. For simple messages that do not change the trajectory of the aircraft (such as a frequency change), the verification is less critical than for control messages. In no case, however, should one pilot simply read and execute (or read to the other pilot to execute) a clearance to change the trajectory of the aircraft. In the oceanic environment, pilots need to be particularly attentive to conditional clearances (such as "AT [time] CLIMB and MAINTAIN [altitude]" and "expect" messages (as in" EXPECT [altitude] at [time]"), to ensure appropriate action.

A recent review of SOPs across seven carriers found that only one carrier instructed their flightcrews to follow the "silent read" procedure recommended in the *GOLD* Manual (Lennertz & Cardosi, 2015). Two carriers recommended the problematic practice that the message should be read out loud by the Pilot Monitoring (PM) and verified by the Pilot Flying (PF). Four of the seven carriers did not specify a procedure.

Company SOPs should address handling of CPDLC messages in the different operational environments and address the roles of each crewmember in this process. For example, departure clearances sent via CPDLC should be processed while at the gate or while the aircraft is stopped in the non-movement area. Ideally, the departure clearance would be entered and verified before pushback. Simple revisions of departure clearances (e.g., change in squawk code) that are received after pushback (blockout) but require minimal heads-down time and distraction can often be accomplished while taxiing. To help prevent runway incursions, however, heads-down activities should *not* be conducted while taxiing in close proximity to an active runway. As with other complex tasks, revised departure clearances that require substantial data entry (e.g., those involving a runway change) should be processed while the aircraft is stationary with the parking brake set.

In the domestic en route environment, when CPDLC services become available, flightcrew response time should be consistent with the operational tempo. For most messages, the flightcrew will have adequate time to silently read the clearance, confer, and respond to the message within one minute. If additional time is needed, the flightcrew should send a "STANDBY" response. Then, as soon as practical, the flightcrew should send a closure response (e.g., WILCO, UNABLE). In accordance with the "sterile cockpit rule", CPDLC messages will typically not be sent or received below 10,000 feet unless they are critical to the safety of the flight and the voice frequency is not a viable option.

In addition to the risk associated with maneuvering the aircraft before both pilots have independently read and conferred on the clearance, there are specific human factors issues common to all environments. These include issues with the use of a printer, risks associated with responding before the entire message is read, and responding to a multi-element clearance when it is only possible to comply with part of the clearance.

Use of the printer. Printers may not produce an exact replica of the message on the flight deck display, and may, in fact, produce corrupted data. For example, pages may print out of order or the last page may fail to print. For these and other reasons, the message must be reviewed on the appropriate flight deck display approved for that purpose before it is acted upon.

Display of large messages. Large messages, which often contain loadable route information, may not be shown in their entirety on the message display. Two of the airlines reviewed (Lennertz & Cardosi, 2015) provide the flightcrew with guidance on the additional steps (e.g., button presses) that are needed to review a large and/or loadable message, and one of these airlines further suggests that large messages may be reviewed in their entirety when printed. (Again, note that printers should not be used as the primary means to review a long message). Another helpful practice for the display of long clearances is to have the CPDLC message on one pilot's display while reviewing the modified route on the other.

Response options. Flightcrew interface designs differ. In some designs, the response options (i.e., ACCEPT, REJECT) are only shown after all message pages have been reviewed, which helps to ensure that the flightcrew views the entire message before responding. Other designs, however, do not prevent the pilot from responding before the last page (i.e., entire message) has been viewed. Pilots also need to be aware of how the response options available to them (which vary by manufacturer) are translated to ATC depending on the content of the message (e.g., "ACCEPT" can translate to WILCO, ROGER, or AFFIRMATIVE; and "REJECT" can translate to UNABLE or NEGATIVE). A pilot must REJECT/UNABLE a clearance if any part of the clearance cannot be complied with. For example, with the CPDLC message "CROSS (*position*) AT (*altitude*) AT (*speed*)" the clearance must be rejected if the position cannot be crossed at *both* the specified altitude *and* speed.

3. Description of Planned CPDLC En Route Services

The FAA plans to implement CPLDC en routes services in two stages. Initial services are scheduled to begin in 2019. Full services are scheduled to begin in 2022. Here, we address messages that will be available during initial services. Initial services will allow controllers to issue altimeter settings, altitude clearances, crossing restrictions, and route clearances. Specific message elements that will be available in initial services are listed in the Appendix.

Altitudes. In initial services, the controller will be able to issue instructions to climb to, descend to, or maintain a single – but not a block – altitude. The controller will also be able to append "AT PILOTS DISCRETION", "EXPEDITE" or "IMMEDIATELY" to the altitude clearance. Note that appending "EXPEDITE" to a clearance to "DESCEND" results in the message "EXPEDITE DESCEND TO (*altitude*)". The message element "AT PILOTS DISCRETION" gives the pilot the option to start the climb or descent when the pilot wishes, authorizes the pilot to conduct the climb or descent at any rate, and to temporarily level off at any intermediate altitude as desired. Once the aircraft has vacated an altitude, however, it may not return to that altitude.

Crossing restrictions. Two crossing restriction message elements will be available to the controller during initial services. These messages instruct the flightcrew to cross a specific fix at a specific altitude and, if desired, at a specific speed; for example, "CROSS *(position)* AT AND MAINTAIN *(altitude)* AT *(speed)*".

Pilot requests. In addition to specific altitudes, pilots will be able to request to proceed direct to a position that is already on the cleared route; requests to proceed direct to a position that is not on the cleared route should be handled via voice. Pilots can append "DUE TO WEATHER" or "DUE TO AIRCRAFT PERFORMANCE" to any request or "UNABLE" response. In the initial implementation, appending free text to any message, however, will result in the ground system rejecting the message and, in this case, the controller would never see it.

If a controller does not respond to a request, flightcrew should *not* repeat the request. If necessary, the flightcrew can contact the controller by voice. An exception to this is if a pilot request is followed by an instruction to contact a new Center (e.g., to contact New York Center while leaving Boston Center), then the request should be made with the next Center; pilot requests can be transferred between sectors within a Center, but do not get transferred to the next Center.

In the oceanic environment, some pilots are trained to follow up on a request using a "WHEN CAN WE EXPECT…" message or a free text message – as this will avoid having two identical open messages (Lennertz & Cardosi, 2015). This procedure would not work in the National Airspace System (NAS) en route environment for two reasons. First, the pilot cannot send "WHEN CAN WE EXPECT…" or free text messages to an en route center; doing so would result in the message being rejected by the ground system and a "MESSAGE NOT SUPPORTED" response. Second, when a message from a pilot is waiting to be displayed to the controller, or if the controller has responded with STANDBY, there is no indication to the controller that an additional message is waiting to be displayed.

Emergency messages. In initial services, pilots will be able to send the following emergency messages:
Downlink Message (DM) 55 PAN PAN PAN
DM56 MAYDAY MAYDAY MAYDAY
DM57 [remaining fuel] OF FUEL REMAINING AND [remaining souls] SOULS ON BOARD
DM58 CANCEL EMERGENCY
DM59 DIVERTING TO [position] VIA [route clearance]
DM60 OFFSETTING [distance offset] [direction] OF ROUTE
DM61 DESCENDING TO [altitude]
DM68 [freetext]
DM80 DEVIATING [distance offset] [direction] OF ROUTE

Error Messages. The error messages to be used in the en route environment were still being finalized at press time. These messages will be an important part of pilot training. It is necessary for pilots to understand the conditions that will generate the error messages and the appropriate pilot response to the error message.

4. Human Factors Issues Specific to the En Route Environment

There will be differences in the way the system operates in the NAS en route environment than the way the same system operates in the oceanic environment. Pilots who fly in both environments will need to be mindful of these differences. Here, we outline specific human factors issues associated with initial services in the en route environment that may be incorporated into flightcrew training and the development of en route flightcrew procedures.

Use of Free text. The use of free text will not be supported in initial services. Any message sent by the pilot that contains free text will be rejected by the ground system (and so, never displayed to the controller) and result in the pilot receiving “MESSAGE NOT SUPPORTED BY THIS ATC UNIT”.

Receipt of “STANDBY. Another way in which pilots should expect different behavior in the NAS en route environment than in the oceanic environment, concerns the use of “STANDBY”. For example, one Part 121 carrier informs their pilots that if ATC responds to a request with “STANDBY”, they can expect a response within 10 minutes. If a response is not received within 10 minutes, pilots are instructed to send an inquiry to ATC (such as “WHEN CAN WE EXPECT…”) but not duplicate the request (Lennertz & Cardosi, 2015). In order to realize the expected benefits of the use of CPDLC, the timing of pilot and controller responses will need to be in keeping with the operational tempo. Pilots who are experienced with CPDLC in the oceanic environment will also need to know that the “WHEN CAN WE EXPECT…” messages will *not* be supported in the en route environment and that any questions regarding the request should be conveyed via voice.

Altitudes. In initial services, the controller will be able to issue instructions to climb to, descend to, or maintain a single – but not a block – altitude. As with current oceanic US operations, the controller will also be able to append “AT PILOTS DISCRETION”, “EXPEDITE” or “IMMEDIATELY” to the altitude clearance.

Crossing restrictions. The controller will be able to use two crossing restriction message elements to instruct the flight crew to cross a specific fix at a specific altitude and, if desired, at a specific speed. This is a subset of the crossing messages available in the oceanic environment.

Pilot requests. Pilots will be able to request specific altitudes (but not block altitudes), route clearances, and direct to a position. The controller will be able to issue clearances to address each of these requests.

Pilots can append “DUE TO WEATHER” or “DUE TO AIRCRAFT PERFORMANCE” to any request or “UNABLE” response. If a message is appended with free text, as is common in the oceanic environment, it will result in an error: the ground system will reject the message. In this case, the controller will never see it and an error message (e.g., “MESSAGE NOT SUPPORTED BY THIS ATC UNIT”) will be sent to the flightcrew.

Flightcrews should be aware of the difference in how route requests will be handled in the en route environment: the ground system will revise a route request based on the aircraft present position. The request that the controller sees will be a logical interpretation of the request based on the aircraft's position, rather than the actual request.

Emergency messages. Controllers will only be able to respond to emergency messages via voice or with one of the supported messages, such as "CONTACT [name] [frequency]"

5. Summary of Differences on use of CPDLC in the en route and oceanic environments from a pilot's perspective

As CPDLC is implemented in the en route environment, both pilots and controllers need to have a common understanding of the usable messages and what behavior to expect from the other side of the microphone. Airlines will need to add or revise their current CPDLC training and materials to include the use of CPDLC in domestic en route airspace. This will provide an opportunity to reinforce procedures recommended in the oceanic environment, such as both pilots independently reading the CPDLC message and conferring before a clearance is executed, and not relying solely on a printed CPDLC clearance (i.e., always view the clearance on the appropriate flight deck display).

For pilots who are accustomed to using CPDLC in the oceanic environment, some degree of 'negative transfer of training' is to be expected. That is, pilots cannot use CPDLC in the en route environment the same way they do in the oceanic environment. Pilots will need to learn the differences between how the system operates in the two environments. Below is a summary of the key differences.

UNABLE. As in the oceanic environment, pilots must respond "REJECT/UNABLE" to any CPDLC transmission that contains an instruction that cannot be executed or a restriction that cannot be met. In the case of a multi-element clearance, such as a crossing restriction with an altitude and speed, the pilot must REJECT/UNABLE the clearance if any portion of the clearance cannot be complied with. In the en route environment, however, pilots should immediately contact the controller by voice in conjunction with the REJECT/UNABLE response. Note that even if the pilot has informed the controller by voice that they cannot accept the clearance, an UNABLE response will need to be sent to close out the transaction.

Use of free text. The use of free text will not be supported in initial services. Any message sent by the pilot, other than an emergency message, that contains free text will be rejected by the ground system (and so, never displayed to the controller) and result in an error message such as "MESSAGE NOT SUPPORTED BY THIS ATC UNIT".

STANDBY. Pilots need to be aware of the tempo of CPDLC communications (e.g., transmission times) and how it relates to air traffic operations. For example, the use of "STANDBY" is recommended in the oceanic environment whenever additional time is needed before pilots can respond to a message. In the en route environment, there will be times when a "STANDBY" response will not be operationally appropriate and the pilots should revert to voice. However, dialogs initiated on CPDLC need to be finished on CPDLC; the CPDLC dialog will need to be closed out with an "ACCEPT" or "REJECT" response, even if a verbal response has been given. Pilots will also need to know that the "WHEN CAN WE EXPECT…" messages will *not* be supported in the en route environment and that any questions regarding the request should be conveyed via voice.

Pilot Requests. As with the use of free text alone, appending any request with free text will result in the ground system rejecting the message and sending an error message to the pilot.

Emergency Messages. Controllers will only be able to respond to emergency messages via voice or with one of the supported messages, such as "CONTACT [name] [frequency]". "

Error Messages. The conditions that will generate an error message will be different in the en route environment than in the oceanic environment. Pilots will need to understand what will generate an error message and the appropriate responses to the error messages.

6. References

ICAO (2016). *Document 10037 Global Operational Data Link Document (GOLD) Manual*.

Lennertz, T., & Cardosi, K. (2015). *Flightcrew procedures for Controller Pilot Data Link Communications.* DOT-VNTSC-FAA-15-12.

Appendix: CPDLC Message Set for Initial En Route Services

Uplink Message Elements

UM0 UNABLE

UM1 STANDBY

UM3 ROGER

UM117 CONTACT *(icao unit name) (frequency)*

UM120 MONITOR *(icao unit name) (frequency)*

UM153 ALTIMETER *(altimeter)*

UM20 CLIMB TO AND MAINTAIN *(altitude)*

UM23 DESCEND TO AND MAINTAIN *(altitude)*

UM19 MAINTAIN *(altitude)*

UM38 IMMEDIATELY CLIMB TO *(altitude)*

UM39 IMMEDIATELY DESCEND TO *(altitude*

UM36 EXPEDITE CLIMB TO (altitude)

UM37 EXPEDITE DESCENT TO (altitude)

UM166 DUE TO TRAFFIC

UM167 DUE TO AIRSPACE RESTRICTION

UM79 CLEARED TO (*position*) VIA (*route clearance*)

UM80 CLEARED (*route clearance*)

UM83 AT (position) CLEARED (*route clearance*)

UM135 CONFIRM ASSIGNED ALTITUDE

UM49 CROSS *(position)* AT AND MAINTAIN *(altitude)*

UM61 CROSS *(position)* AT AND MAINTAIN *(altitude)* AT *(speed)*

UM159 ERROR *(error information)*

UM161 END SERVICE

UM169 MESSAGE NOT SUPPORTED BY THIS ATC UNIT

UM177 AT PILOTS DISCRETION

Downlink Message Elements

DM0 WILCO
DM1 UNABLE
DM2 STANDBY
DM3 ROGER
DM6 REQUEST *(altitude)*
DM9 REQUEST CLIMB TO *(altitude)*
DM10 REQUEST DESCENT TO *(altitude)*
DM65 DUE TO WEATHER
DM66 DUE TO AIRCRAFT PERFORMANCE
DM63 NOT CURRENT DATA AUTHORITY
DM38 ASSIGNED ALTITUDE *(altitude)*
DM30 DESCENDING TO *(altitude)*
DM61 DESCENDING TO (*altitude*) [which the FAA system recognizes as an emergency message]
DM59 DIVERTING TO *(position)* VIA *(route clearance)*
DM60 OFFSETTING *(distance offset) (direction)* OF ROUTE
DM80 DEVIATING *(deviation offset) (direction)* OF ROUTE
DM20 REQUEST VOICE CONTACT
DM55 PAN PAN PAN
DM56 MAYDAY MAYDAY MAYDAY
DM57 *(remaining fuel)* OF FUEL REMAINING AND *(remaining souls)* SOULS ON BOARD
DM58 CANCEL EMERGENCY

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