NextGen Flight Deck Data Comm: Auxiliary Synthetic Speech Phase II

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Data Comm—a text-based controller-pilot communication system—is expected to yield several NextGen safety and efficiency benefits. With Data Comm, communication becomes a visual task, and may potentially increase head-down time on the flight deck as crews interact with the display. This study examined the feasibility of supplementing Data Comm with synthetic speech in commercial, en-route operations. To this end, 32 air-transport pilots (16 flightcrews) flew two experimental conditions in a Boeing 737-800 fixed-base simulator. In one condition, Data Comm was implemented with a text-only display, and, in the other it was implemented with a text display and synthetic speech that annunciated each message (text+speech). Results indicated that the text+speech display aided the performance of flightcrews compared to text only, without introducing additional complications. Relative to the text-only display, the text+speech display yielded less head-down time. Flightcrews did not delay opening or acknowledging a text+speech message when the party line was active. The majority of pilots reported that the text+speech display was easy to use, helpful, and not distracting; however, this acceptance was attenuated in major-airline pilots. Taken together, these results provide preliminary guidance for aircraft certification regarding the use and implementation of synthetic speech on the flight deck.

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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)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		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)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		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)**

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Acronyms and Abbreviations

AC	Advisory Circular
ADS-B	Automatic Dependent Surveillance - Broadcast
ANOVA	Analysis of Variance
ATC	Air Traffic Control
CDTI	Cockpit Display of Traffic Information
CDU	Control Display Unit
CLE	Cleveland Hopkins International Airport
CPDLC	Controller Pilot Data Link Communications
CRM	Crew Resource Management
Data Comm	Data Communications
FMS	Flight Management System
GA	General Aviation
GGA	Global Positioning System Fix Data
GOLD	Global Operational Data Link Document
GPWS	Ground Proximity Warning System
GPS	Global Positioning System
ICAO	International Civil Aviation Organization
IM	Interval Management
ITP	In-Trail Procedure
JFK	John F. Kennedy International Airport
MCDU	Multifunction Control Display Unit
MCP	Mode Control Panel
MFD	Multi-function Display
MS	Microsoft
MSG	Message
NAS	National Airspace System
NextGen	Next Generation Air Transportation System
NG	Next Generation
NM	Nautical Miles
NMEA	National Marine Electronics Association
NRC	National Research Council
OTW	Out The Window
PF	Pilot Flying
PM	Pilot Monitoring
RMC	Recommended Minimum Specific GPS/Transit Data
SC	Special Committee
SD	Standard Deviation
SELCAL	Selective Calling
SOP	Standard Operating Procedures

TCAS	Traffic Alert and Collision Avoidance System
TOD	Top of Descent
UM	Uplink Message
VNAV	Vertical Navigation
WILCO	Will Comply
WX	Weather

Preface

This report was prepared by the Aviation Human Factors Division RVT-35 of the Safety Management and Human Factors Technical Center at the John A. Volpe National Transportation Systems Center. The Federal Aviation Administration (FAA) Human Factors Division (ANG-C1) funded this project. We thank our FAA program manager, Dan Herschler, for his guidance and feedback. This work was conducted in support of the Office of Aviation Safety (AVS), Aircraft Certification Service, Systems and Equipment Branch (AIR-130). Thanks to Katherine Lemos, Christophe Hamel, and Cathy Swider for their guidance. Note, however, that the data collected, the observations made, and any conclusions drawn are sole responsibility of the authors.

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For questions or comments, please e-mail Tracy Lennertz at tracy.lennertz@dot.gov

Executive Summary

Data Comm—a digital, text-based communication system between pilots and controllers—is expected to yield several safety and efficiency benefits in the Next Generation Air Transportation System (NextGen). It is hoped to alleviate frequency congestion, reduce problems associated with speech rate and accent, reduce call-sign confusions, reduce pilots' reliance on memory, and reduce errors and workload by allowing some clearances to be loaded into the Flight Management System (FMS) with the push of a button or two.

A potential challenge associated with the use of Data Comm on the flight deck is the increased visual task load. Data Comm transfers communicating from an auditory to a visual task, and this may yield an operationally relevant increase in head-down time. To avoid such unintended consequences, the National Research Council (NRC) suggested that Data Comm should "[e]mploy redundant voice synthesis…operated in parallel with the visual (text and graphics) display of the message" (Wickens, Mavor, Parasuraman, & McGee, 1998, p.251).

The current study builds on the Volpe Center's past research addressing the questions raised in the NRC recommendations (see Phase I; Lennertz, Bürki-Cohen, Sparko, Macchiarella, Kring, Coman, Haritos, & Alvarado, 2012a). The Phase I research compared the effects of a custom-made Data Comm display with text only to a Data Comm display with text and synthetic speech on single-pilot crews in the terminal environment. The current study (i.e., Phase II) extends this comparison to two-pilot crews communicating with Air Traffic Control (ATC) in the en-route environment.

Thirty-two current air-transport pilots (16 flightcrews) flew a Boeing Next-Generation 737-800 fixed-base research simulator in two experimental conditions. In one condition, communication with ATC was via a text-only Data Comm display. In the other condition, communication with ATC was via the Data Comm display with synthetic speech (i.e., text+speech); synthetic speech was played aloud on the flight deck. In both conditions, an aural (e.g., chime) and visual indication announced the receipt of a new Data Comm message on the flight deck. Participants responded to messages via the Control Display Unit (CDU).

Results indicated that a synthetic speech display aided the performance of two-pilot flightcrews in the en-route environment compared to a text-only display, replicating many of the results from Phase I (Lennertz et al., 2012a). Concurrent head-down time for both the Captain (Pilot Flying) and First Officer (Pilot Monitoring) showed that while flightcrews looked down more often in the text+speech condition than in the text-only condition, the duration of these glances was shorter with the synthetic speech display and thus less disruptive of pilots' scans. There was no difference in the number of messages that were printed or reviewed between the two conditions. Pilots' response to the receipt of a new text+speech message was not affected by simultaneous party-line communications. Flightcrews in both conditions tended to respond correctly to a Data Comm clearance that was countermanded by ATC before it arrived on the flight deck. Subjective responses indicated the majority of pilots reported the text+speech display was easy to use, helpful, and not distracting. These preferences, however, may have been moderated by flightcrew experience. In sum, the results indicate that the implementation of a text+speech Data Comm display, relative to a text-only display, may yield safety and efficiency benefits on the flight deck without introducing negative consequences. Taken together, these results provide preliminary guidance for aircraft certification regarding the use and implementation of synthetic speech on the flight deck. Note, however, that the data collected, the observations made, and any conclusions drawn are sole responsibility of the authors.

1. Introduction

The implementation of the Next Generation Air Transportation System (NextGen) introduces new applications to the flight deck. One such application is Data Comm. In Data Comm, flightcrews communicate with Air Traffic Control (ATC) using a digital, text-based data communication system. Data Comm allows the exchange of written messages directly between controllers and a specific flightcrew.

NextGen is intended to reduce delays and fuel emissions by allowing aircraft to fly more efficient routes or altitudes (*NextGen Implementation Plan*, 2013). For example, flightcrews may use the In-Trail Procedure (ITP), based on Automatic Dependent Surveillance-Broadcast (ADS-B), to climb or descend over the ocean to an altitude typically blocked by procedural separation standards (RTCA DO-312, 2008). Similarly, crews may use Interval Management (IM) from the en-route to the approach flight phase to maintain a stable distance to a leading aircraft (RTCA DO-328, 2011). These applications may translate not only into fuel efficiency, but also into safety enhancements—as pilots gain access to less turbulent altitudes and receive more accurate information about nearby aircraft on the flight deck (*NextGen Implementation Plan*, 2013).

Such NextGen applications will, however, introduce new complexities to the flight deck. For ITP, the flightcrew must use a display to review speed and distance information about similarly-equipped nearby aircraft [Advisory Circular (AC) 90-114, *Automatic Dependent Surveillance-Broadcast (ADS-B) Operations*, 9/21/12]. With IM, the new information about the distance of the leading aircraft can be shown on both a Cockpit Display of Traffic Information (CDTI) and an indicator in the pilots' primary field of view (cf. Bone & Penhallegon, 2007; Penhallegon & Battiste, 2011). Crews may need to use both displays to review relevant information about similarly-equipped nearby traffic during the application.

In this environment of increased cognitive load, Data Comm is considered an enabling technology, offering several benefits affecting the safety and efficiency of operations. Data Comm can be expected to reduce frequency congestion (cf. Kerns, 1999), thereby opening up the frequency for time-critical communications and promoting full read back of clearances (Kerns, 1991). With written Data Comm messages there are also fewer requests for clarification that require repeated transmissions (Hinton & Lohr, 1988; Kerns, 1991; 1999; Talotta et al., 1990). Difficulties understanding messages due to speech rate or accent no longer occur.

Pilots and controllers can select commonly used messages from a menu without having to manually enter the entire text. This promotes the use of standard phraseology. Data Comm also alleviates the flightcrew's reliance on memory. In the voice environment, messages from ATC must be remembered or written down. With Data Comm, messages are stored in a log—pilots and controllers can retrieve previous messages. In simulation studies, use of Data Comm is associated with fewer memory errors than voice communications, and this benefit is most pronounced with long and complex instructions (DeMik, 2009; Wickens, Goh, Helleberg, Horrey, & Talleur, 2003). Long and complex instructions are anticipated to become more prevalent in the NextGen environment. Moreover, Data Comm enables some clearances to be loaded into the Flight Management System (FMS) with the push

of a button or two, alleviating the need to manually enter the information. This has the potential to reduce data entry errors, workload, and flightcrew response time to a clearance.[1]

The introduction of Data Comm may also entail some unintended consequences. Data Comm may exacerbate the potential increase in head-down visual and manual tasks on the flight deck generated by other NextGen applications. Data Comm requires pilots to interact with a display [typically on the Control Display Unit (CDU)] to access and respond to messages. This increase in looking at the Data Comm display may come at the expense of not looking elsewhere on the flight deck, for example, at the instrument panel, out the window (OTW) or at other NextGen displays. Any disruption of pilots' scan carries potential safety implications. In addition, communication becomes a primarily visual (rather than auditory) task (Wickens et al., 2003). These factors may yield a decrease in flight performance (e.g., vertical tracking performance; Wickens et al., 2003) or an increase in perceived workload in single-pilot operations (two-pilot crews typically do not report an overall increase in communication workload; Kerns, 1999; 1991).

To mitigate such unintended consequences of a text-only Data Comm display, the National Research Council (NRC) recommended that Data Comm should "[e]mploy redundant voice synthesis of uplink messages as a design option, operated in parallel with visual (text and graphics) display of the message" (Wickens, Mavor, Parasuraman, & McGee, 1998, p. 251). With such a text and synthetic speech (text+speech) system, the communication task would be shared by the visual and the historically familiar auditory domain. This may reduce both the frequency and duration of gazes at the Data Comm display, leaving more visual resources for OTW and instrument scans (for a discussion of multiple resource theory, see Wickens, 2002). The benefits of text-only Data Comm—affecting both safety and efficiency—such as the availability of a message log and the selection of pre-formatted messages, would be preserved. The work presented and its earlier proof-of-concept study described in the next paragraph are part of the FAA's compliance with a congressional mandate to "address the problems and concerns raised by the National Research Council…[and] respond to the recommendations" (Title 49 United States Code Section 44516).

The current study builds on the Volpe Center's past research addressing the questions raised in the NRC recommendations (i.e., Phase I; Lennertz, Bürki-Cohen, Sparko, Macchiarella, Kring, Coman, Haritos, & Alvarado, 2012a; for a shorter version see Lennertz et al., 2012b). The Phase I research compared the effects of a custom-made visual Data Comm display with text only (text only) with a Data Comm display with text and synthetic speech (text+speech) on single-pilot crews in the terminal environment. The current study (i.e., Phase II) addresses the same questions by comparing the performance of two-pilot crews communicating with ATC in the en-route environment. Again, they are either using a text-only Data Comm or a text+speech Data Comm display, this time implemented on the CDU following a standard industry model. Of interest is whether the Data Comm text+speech condition yields decreased head-down time relative to the text-only condition, without introducing additional complications. The next section discusses the existing evidence regarding the effect of supplementing

[1] See, however, the issue of partial "autoload" (i.e., push to load) when loadable and unloadable instructions are combined in the same message, discussed in Section 4.2 Limitations and Future Research.

visual Data Comm with speech, including our earlier Phase I study. This is followed by a summary of the key features of the current study and the main concerns and expectations to be studied.

1.1 Does an Auxiliary Synthetic-Speech Display Help or Harm?

Here, we ask whether an auxiliary synthetic-speech display can reduce the challenges associated with Data Comm in two-pilot operations without introducing additional complications. Early investigations of Data Comm with an auxiliary synthetic-speech display, all using fixed-based research simulators with an OTW view, have obtained mixed results.

In several studies, a text-only display for Data Comm has been associated with better performance compared to a speech-only or text+speech display, at least for single-pilot operations. Helleberg and Wickens (2003) varied whether General Aviation (GA) pilots received Data Comm messages from ATC with a text-only display, a synthetic-speech-only display, or both modalities (text+speech) in an en-route environment. Along numerous measures, pilots performed best with the text-only display. In particular, with text-only communication, pilots flew more precisely and detected traffic faster than with synthetic-speech only or text+speech. Comparing the two remaining displays, performance was better with the text+speech display than with the speech-only one. Both the text-only and text+speech displays were associated with increased OTW scanning and fewer readback errors relative to the speech-only display (Helleberg & Wickens, 2003). Similar results were obtained by Steelman, Talleur, Carbonari, Yamani, Nunes, and McCarley (2013): In a series of single-pilot GA flying scenarios comprised of take-off to descent, ATC messages presented as text only or text+speech tended to yield better performance (i.e., lower perception of workload, better altitude tracking) than speech alone.

Yet, along some measures, a text-only display was associated with poorer performance relative to text+speech or speech-only displays. In particular, during single-pilot GA operations in the en-route environment, Lancaster and Casali (2008) found that the use of a text-only display was consistently associated with decreased performance compared to the synthetic-speech-only and the redundant (text+speech) displays. Specifically, pilots were more likely to rate workload with the text-only display as "high" or "dangerous" than for the speech-only display and redundant display. The speech-only and the redundant display ratings did not differ from each other. Textual presentation also yielded the most head-down time, which again did not differ for the remaining presentation modes. In a GA environment, Steelman et al. (2013) likewise observed that the speech-only display yielded the least head-down time compared to the text-only and text+speech displays. In a similar simulation, Lu, Wickens, Sarter, Thomas, Nikolic, and Sebok (2012) compared air-carrier pilot performance to Data Comm messages that were presented as text-only or text+speech. In this study, the participant acted as the Pilot Monitoring (PM) from 5,000 feet to the Top of Descent (TOD) and presumably, as the pilot interacting with and responding to the Data Comm interface; during this time, a confederate acted as the Pilot Flying (PF). Interestingly, no difference in accuracy (defined as noticing the message and entering the correct setting on the flight deck) was observed between the two conditions (which may be due to a ceiling effect). Pilots however, responded faster to the message when it was presented as text+speech compared to text only (e.g., an average of 5.6 seconds vs 9.9 seconds). Here, response time was defined as the time

between the receipt of the message and when the pilot pressed “ACCEPT” or entered the corresponding setting on the flight deck, whichever came first.

Mixed results were also obtained with a speech-only display. In a study by McCarley, Talleur, and Steelman-Allen (2010), instrument-rated commercial pilots communicated with ATC using a text-only display, a synthetic-speech-only display, or a text+speech display. The speech-only condition elicited the longest OTW dwell time. This benefit, however, did not translate into improved flight precision. Tothe contrary,altitude tracking performance (a measure of flight precision) was lowest in the speech-only condition, compared to all other conditions.

In an initial proof-of-concept study, Lennertz et al. (2012; Phase I) examined the feasibility of supplementing a visual Data Comm display with synthetic-speech annunciations for GA pilots in the terminal environment. In general, results indicated that supplementing visual Data Comm with synthetic speech may mitigate some of the potential risks associated with text-only Data Comm without introducing new complications for the single pilot. In particular, pilots spent less total time looking down at the Data Comm display when the messages were annunciated by synthetic speech (similar to Lancaster & Casali, 2008). The addition of synthetic speech also may have helped pilots to remember to act on a conditional clearance at a future position (e.g., “AT [location] CLIMB TO [altitude]”). Although pilots sometimes took longer to acknowledge a message [i.e., reply WILCO (i.e., Will Comply) or UNABLE] when it was annunciated by synthetic speech (likely, because they waited for the speech to finish before responding), this had no effect on their time to initiate or comply with instructions from ATC. Unlike McCarley et al. (2012), Lennertz et al. (2012) did not observe an interaction between head-down time and flight precision; in fact, preliminary analyses did not yield a difference in flight precision between text+speech and text only. The speech also did not increase errors related to similar-sounding call signs heard on the party line (i.e., a shared frequency between the controller and flightcrews in a particular airspace) or to a Data Comm clearance that was countermanded via voice before it arrived on the flight deck. Pilots found the text+speech Data Comm display helpful, easy to use, and not distracting. Moreover, pilots expressed a preference for text+speech Data Comm over Data Comm with text alone.

While previous research demonstrates several performance advantages for redundant (text+speech) displays when compared to text-only or speech-only displays (Helleberg & Wickens, 2003; Lancaster and Casali, 2008; Lennertz et al., 2012a; Lu et al., 2012; Steelman et al., 2013), redundant displays may also yield some disadvantages. For example, redundant displays tend to elicit longer response times than text-only ones—listening to and understanding an annunciated Data Comm message was found to take longer than simply reading it (Lennertz et al., 2012a; Rehmann & Mogford, 1996). Moreover, pilots may check both modalities before responding (Hilborn, 1972). While this redundancy may aid message comprehension, it may take longer to respond. In a recent meta-analysis comparing performance with visual-only or audio-only tasks (e.g., communicating with ATC, obstacle detection, responding to driving alerts) with redundant (i.e., audio-visual) tasks, Lu, Wickens, Prinet, Hutchins, Sarter, and Sebok (2013) found a cost in response time for redundant tasks, but also a gain in accuracy. Specifically, for communication tasks, the meta-analysis yielded a performance gain (i.e., combined response time and accuracy) for redundant displays, under high but not low workload conditions. However, the performance gain for the redundant displays also likely depends on the speech quality; low-quality speech—especially for pilots who are unfamiliar with it—may prolong response time

(Diehl, 1975). An aural display may also disrupt pilots' attention from other tasks; the temporal nature of aural information does not necessarily allow for efficient task management (Latorella, 1998).

Table 1 summarizes past results. It shows that previous studies have documented that the addition of synthetic speech displays to text-displays may yield several safety and efficiency benefits. In particular, that addition of synthetic speech may help to decrease head-down time (Lancaster & Casali, 2008; Lennertz et al., 2012a), yield lower ratings of workload (Lancaster & Casali, 2008), and aid memory for clearances (i.e., the conditional clearance in Lennertz et al., 2012a). The addition of synthetic speech displays to text-displays, however, may come at a cost to flight precision and traffic detection (Helleberg & Wickens, 2003). With regard to the time to acknowledge a Data Comm message, the results are contradictory—pilots can be slower to acknowledge a message with the addition of synthetic speech (Lennertz et al., 2012a; Lu et al., 2013; but see Lu et al., 2012, for opposite results). In addition, a decrease in head-down time is not consistently associated with an increase in flight precision (McCarley et al., 2010). Of interest is whether the advantages for redundant Data Comm displays outweigh the potential costs. Past research has not clearly demonstrated that this is the case, particularly for multi-crew operations in an en-route environment.

The current study addresses the time to acknowledge a message and head-down time for multi-crew operations. Moreover, it will address additional questions such as the interaction between auxiliary synthetic speech and information heard on the party line. Finally, it will shed light on the review process for Data Comm messages adopted by the flightcrews.

Table 1. A summary of past results.

GA operations		
Study	**Conditions**	**Main findings**
Helleberg & Wickens (2003)	- Text only - Speech only - Text+speech	- Increased flight precision and faster traffic detection with text only compared to other conditions. - Increased OTW scanning and fewer readback errors for text only and text+speech compared to speech only.
Lancaster & Casali (2008)	- Text only - Speech only - Text+speech	- Lower workload ratings and less head-down time with speech-only and text+speech compared to text only.
Lennertz et al. (2012)	- Text-only - Text+speech	- Less head-down time with text+speech compared to text only. - No difference in time to initiate/comply with instructions or response to a countermanded clearance between text only and text+speech.
Steelman et al. (2013)	- Text only - Speech only - Text+speech	- Lower perception of workload and better altitude tracking for text only and text+speech compared to speech only. - Less head-down time with speech only compared to text only and text+speech.

GA operations		
Air-carrier operations		
Study	**Conditions**	**Main findings**
Lu et al. (2012)	- Text only - Text+speech	- Faster response time for text+speech compared to text only. - No difference in accuracy (i.e., entering the correct flight deck setting) between text only and text+speech.
McCarley et al. (2010)	- Text only - Speech only - Text+speech	- Lower altitude tracking performance for speech only compared to text only and text+speech - Less head-down time with speech only compared to text only and text+speech.

1.2 The Current Study

Building on the results of Lennertz et al. (Phase I, 2012) that examined the effects of a dedicated Data Comm display with and without speech for single pilots flying in the terminal environment, the current study (Phase II) examined the effects of a Data Comm display with and without speech for a two-pilot crew in the en-route environment. The purpose of the work is to provide FAA aircraft certification with data regarding the potential impact of such systems. Although recommendations for the specific design of such systems are beyond the scope of this work, the implementation decisions taken for the two phases of this work may provide some preliminary guidance.

The current study differs along a number of dimensions from the previous study and was designed to more realistically represent anticipated initial Data Comm implementation. Phase I was designed as a proof-of-concept study, with several characteristics that might have offered an advantage to text+speech over text-only presentation of Data Comm compared to the current study. These characteristics are listed below and contrasted with the current study.

- Lacking a co-pilot monitoring and communicating, the single pilots in Phase I may have benefitted from the presence of auxiliary synthetic speech more than the multi-crew pilots in the current study. This is because with text+speech, the pilot in Phase I did not need to take his or her eyes off the instruments or the OTW view to read the clearance and maneuver the aircraft.
- Pilots in the Phase I study were flying without any autopilot capability, which may have given the text+speech condition an additional advantage compared to the current study, where pilots exclusively flew with autopilot.
- Phase I pilots interacted with a dedicated Data Comm display designed with human-factors principles in mind (a single-function touch-screen tablet with color-coded response options). In the current study, the Data Comm interface was implemented on a Multi-function Control Display Unit (MCDU) on the FMS and shared with other applications as in some initial air-carrier Data Comm implementations.
- The earlier study tested the text+speech Data Comm concept using tactical instructions (e.g., radar vectors for approach) in the terminal environment, which required the pilots to react to

the clearance in a timely manner, while hand flying the aircraft. The current study used Data Comm for routine instructions only.

- In Phase I, synthetic-speech annunciations did not overlap with other communications. Such overlaps could frequently occur in real and especially multi-crew operations, distracting pilots from listening to the party line or interrupting their within-crew coordination.

There was at least one characteristic in Phase I that could have favored the text-only display, namely the fact that the participants were students at an aviation university and presumably highly proficient in texting. The participants in the current study were drawn from a cross-section of operators ranging from corporations to major airlines and may have included more pilots using more traditional means of communication.

As in the first study, our main questions were whether the addition of speech 1) introduced harmful effects on flight safety and efficiency, and 2) offered safety and efficiency benefits. Crews flew a single scenario in two experimental conditions: In one condition, communication with ATC was via the text-only Data Comm display; in the other condition, communication with ATC was via the text with synthetic speech (text+speech) Data Comm display. Crews received several Data Comm messages from ATC while monitoring the party line over headphones. Data Comm messages comprised routine clearances of varying length (e.g., transfer of communications, speed, altitude, crossing constraints). All messages were sampled from the draft (i.e., 2013) RTCA Special Committee (SC)-214/EUROCAE WG-78 message set (see also RTCA DO-350, 2014).

1.2.1 Do No Harm

The addition of speech to a visual Data Comm display may yield some unintended consequences—consequences that may impact the overall safety and efficiency of the system. Thus, one of the primary goals of this study was to examine any potentially harmful impacts of a text+speech display relative to a text-only one. In particular, with a two-pilot crew in a glass cockpit, there is concern that the synthetic speech would add to the auditory clutter and interfere with vital on-board and off-board crew, ATC, or company communications or auditory announcements generated by the equipment. Message annunciations, which are automatically triggered when the message is opened, may "step on" live ATC communications. This could impact safety, for example, if critical voice communications are missed due to the addition of auditory clutter, or efficiency, for example, if flight crews must request information from ATC or repeat on-board communications. Our experimental conditions provided flightcrews with several such instances to see if crews would delay opening a Data Comm message when they hear voices on the party line, or fail to open or respond to and/or comply with Data Comm messages (see Section 2.4.3 for a description of the party line). Crews were also asked whether they perceived the message annunciations as distracting.

With Data Comm, it is also possible that the controller may need to countermand via voice a Data Comm clearance that was sent to—but not yet viewed by—the flightcrew. To investigate whether pilots comply with such voice instructions, each crew received one Data Comm message that was countermanded by a live controller, in either the text-only or text+speech Data Comm condition. The live voice countermand occurred thirty seconds before the Data Comm message was received on the flight deck (see Figure 1 for the timeline of the countermanded clearance). Crews may be more likely to

ignore the countermand in the text+speech condition—at least if the delayed erroneous Data Comm message was more powerful in overriding the earlier voice countermand when it was presented both visually and aurally. This unintended potential negative consequence of implementing a synthetic-speech Data Comm display, however, was not observed in Phase I when testing the same question.

Lastly, we were interested whether communicating with a text+speech display would impact crews' perceived workload compared to communicating with a text-only display. In particular, we expected that auxiliary synthetic speech would not affect crews' ratings of communications workload.

1.2.2 Help, If You Can

A second goal of the current study was to examine whether the addition of synthetic speech to the Data Comm display would improve safety and efficiency of operations. We predicted that the text+speech display would help crews to spend less time looking down at the CDU (i.e., reduce head-down gaze-dwell time) than in the text-only condition (replicating the Phase I results) since the message will be heard by both pilots at the same time, thus improving pilots' scan. We also predicted that pilots would have to review (i.e., scroll through the message pages) and print the message less often in the text+speech condition than in the text-only condition, because the additional verbal cue would enhance memory for instructions.

It is also possible that the presence of synthetic speech annunciating ATC messages aloud would relieve some of the potentially time-consuming standard operating procedure (SOP) recommended for text-only Data Comm [cf. the International Civil Aviation Organization (ICAO) Global Operational Data Link Document (GOLD), 2013], thereby improving efficiency. This SOP specified in the GOLD is intended to safeguard pilots from misreading the Data Comm message by recommending that both pilots silently and individually read the message and discuss it—before they act on it. When communicating with text+speech, only the PM would have to read the message, thus simplifying flightcrew procedures and reducing head-down time for the pilot flying. This may also lead to faster response times. Note, this prediction differs from our findings in Phase I, where we observed that pilots responded *faster* with text only compared to text+speech, supposedly because reading was faster than listening to the annunciated message, but the ICAO GOLD SOP did not apply with the one-person crews of Phase I.

Similar to Phase I, we further expected pilots to find the text+speech condition acceptable and easy to use. We also expected crews to prefer to communicate with text+speech compared to text only (replicating Phase I results). Yet, these subjective perceptions may depend on the nature of pilots' airline operations and their prior experience.

A summary of the main concerns and predictions regarding the effects of the addition of synthetic speech on safety and efficiency is provided in Table 2.

Table 2. A summary of the main predictions.

Do no harm	
Variable	**Main Concerns**
	Compared to text only…
Step ons	Crews in the text+speech condition may delay opening or acknowledging messages that were received when the party line is active.
Response time	Crews in the text+speech condition may be slower to acknowledge a Data Comm message via the CDU because they wait for the voice to finish the message before responding.
Countermanded clearance	Crews in the text+speech condition may be more likely to respond incorrectly to the countermanded clearance.
Perceived communications workload	Auxiliary synthetic speech may affect crews' communications workload.
Help, if you can	
Variable	**Main predictions**
	Compared to text only…
Head-down time	Crews in the text+speech condition will spend less time looking down at the CDU.
Printing	Crews in the text+speech condition will be less likely to print messages.
Message review (i.e., back-paging)	Crews in the text+speech condition will be less likely to review the message (i.e., back-page).
Usability & acceptability	Pilots will prefer to communicate using the text+speech display compared to the text-only display. Pilots will find the text+speech display helpful, easy to use, and not distracting.

2. Method

2.1 Participants

Thirty-two (31 male, 1 female)[2] current Boeing 737/757 air-transport pilots participated in exchange for compensation for their time and travel expenses. Participants were medically qualified to exercise the privileges of their pilot certificates in accordance with FAA Part 61. A majority (N = 21) of participants reported being right-handed, with 3 being left-handed, and 8 being ambidextrous (of whom 2 were left-hand dominant and 6 were right-hand dominant). Participants self-reported an average total flight time of 13,089 hours.[3] Participants also self-reported an average of 3,699 hours in a Boeing 737). Participants represented ten different air carriers. Eight were from non-major carriers (i.e., corporate, charter, and small airlines) with an average of 12,763 total flight hours . The remaining 24 were from major carriers with an average of 13,202 total flight hours. Detailed information regarding the experience of the participants is shown in Table 3. Sixteen of the participants were current First Officers and 17 of the participants were Captains (one participant reported being both a current Captain and First Officer).

Eleven participants reported experience with Data Comm from either the military or from flying in the North Atlantic or Pacific. Of these, 73% (8 pilots) reported that their carrier specified procedures for Data Comm (e.g., that both pilots must confirm messages or not be heads down at the same time) and 64% (7 pilots) reported that they typically printed Data Comm messages for review.

Participants were run in pairs (i.e., Captain and First Officer); 50% of the crews consisted of participants from the same air carrier. The entire experiment took about six hours. Informed consent was obtained from all participants (see Appendix A).

Table 3. Participant Data

Variable	n	Average (hrs)	SD	Range	
				Minimum	Maximum
Total Flight Time	32	13,089.	5,719	3,900	25,000
- Major Carriers	24	13,202	4,662	4,350	23,500
- Non-major Carriers	8	12,763.	8,467	3,900	25,000
Time in B737 (excluding simulator time)	32	3,699	3,258	0	13,000

[2] This gender bias emerged naturally from the recruiting process, which was contracted out to a third party. According to a CNN story from March 2011 (http://www.cnn.com/2011/TRAVEL/03/18/female.airline.pilots/) it roughly corresponds, with 3.13 percent female pilots, to the 5 percent female members of the Air Line Pilots Association.

[3] One participant reported a total flight time of 280,000 hours; this datum was excluded from the analysis of total flight time.

2.2 Materials

2.2.1 Experiment Scenario

Each crew flew a single simulated scenario in the two experimental conditions: text only and text+speech. The scenario was approximately 60-minutes long and began with takeoff from John F. Kennedy International Airport (JFK) and ended just prior to contact with Cleveland approach control for a flight that was planned to the Cleveland Hopkins Airport (CLE). The flight traversed both New York (e.g., New York Departure, New York Center) and Cleveland (e.g., Cleveland Center) sectors. The scenario was designed to impose moderate workload, taking place at night[4] in busy en-route centers. In the scenario, the flightcrew deviated around hazardous weather. Numerous aircraft were heard on the party line; a party-line transmission occurred approximately every 21 seconds. Three aircraft on the party line (i.e., Delta 761, Delta 715, and United 751) had similar-sounding call signs to the participants' ownship (i.e., Delta 751).

Data Comm was primarily used for communication en-route (the first Data Comm message occurred eight minutes after departure). While the actual flying was identical in both experimental conditions, the presentation of Data Comm messages was varied. In one condition—the text-only condition—ATC instructions were issued via a Data Comm text display. In the other condition—the text+speech condition—instructions were issued via a Data Comm text display and annunciated by a synthetic voice. In each condition, live-voice ATC instructions and some transmissions on the party line overlapped with the annunciation of the synthetic speech on the flight deck. Flightcrews did not receive any communications from company dispatchers, nor could flightcrews compose Data Comm messages (e.g., requests) to send to ATC in either experimental condition.

As shown in Table 4, the scenario script contained mainly routine Data Comm messages sampled from the draft RTCA SC-214/EUROCAE WG-78 message set (see RTCA DO-350, 2014; i.e., transfer of communications, speed, altitude, crossing constraints).

As in Phase I, participants experienced one Data Comm instruction that was countermanded by (a recording of) a "live" controller. One half of the participants (*N* = 16) experienced the live controller countermanding a previous instruction in the text-only Data Comm display condition. The other half (*N* = 16) experienced the countermand in the text-and-synthetic-voice Data Comm display condition. A 30-second delay was implemented between the live countermand of the Data Comm message and the receipt of the message on the flight deck (see Figure 1 for a timeline of events).

In both conditions, an experimenter acting as air traffic controller (one of the ATC voices heard on the party line) was available to respond to crews' questions while flying. The experimenter who acted as the simulated controller followed a scripted checklist to ensure the crew complied with all instructions (all experimenter checklists are provided in Appendix E). If a flightcrew made an error, the controller provided an appropriate, standardized reply to ensure that the crew was corrected back on course (see Error Mitigation Strategies script in Appendix D). The scenario script for both conditions is provided in Appendix D and the experimenter checklists, including pre-experiment, training, during-experiment, and

[4] Note data collection occurred during the day.

post-experiment checklists, are provided in Appendix E. Appendix E also contains the counterbalancing scheme to control any sequence effects from the order of presentation of the experiment scenarios.

Table 4. A description of the Data Comm messages in the experimental condition.

Uplink message (UM)	Synthetic speech duration (s)	Expected downlink response	Corresponding UM in draft SC-214/WG-78 Set
PROCEED DIRECT TO CANDR	1	WILCO	74R
CLIMB TO FL230 CONTACT NEW YORK CENTER 127.85	8	WILCO	20, 117R
DUE TO CROSSING TRAFFIC CROSS CANDR AT OR ABOVE FL250 CLIMB TO FL260	9	WILCO	166, 47R, 20
SQUAWK 5342	3	WILCO	123
CONTACT NEW YORK CENTER 134.5	4	WILCO	117R
CLIMB TO FL280	3	WILCO	20
HAZARDOUS WEATHER CONVECTIVE SIGMET 55C VALID UNTIL 0155 FOR ERN OH WRN PA WRN NY LINE TSTMS 40 NM WIDE MOVG NE AT 35KTS HAIL TO 2 IN PSBL	19	ROGER	275
DUE TO CROSSING TRAFFIC CLIMB TO REACH FL320 BEFORE TIME 0130Z	11	WILCO	166, 26
DUE TO WEATHER CLEARED TO KCLE AIRPORT VIA DIRECT BURNI EWC YNG CXR2	7	WILCO	169 (free text), 79R
MAINTAIN M.78 OR GREATER FOR SPACING	3	WILCO	108, 169 (free text)
CONTACT CLEVELAND CENTER 132.22	5	WILCO	117R
CLEARED TO DEVIATE UP TO 20 MILES SOUTH OF ROUTE DIRECT EWC WHEN ABLE	5	WILCO	82R, 74R, 247
PROCEED DIRECT TO YNG	3	WILCO	74R
DESCEND TO FL240 MAINTAIN 280KTS OR GREATER (countermanded clearance)	6	WILCO	23, 108
CONTACT CLEVELAND CENTER 123.75	6	WILCO	117R
EXPECT LOWER AT TIME 0152Z	5	ROGER	9
DESCEND TO FL200	3	WILCO	23
DESCEND TO 11000 FT CROSS YNG AT OR;BELOW 14000 FT CLEVELAND ALTIMETER 30.12	10	WILCO	23, 48R, 153/213R
CLEVELAND HOPKINS ATIS C	2	ROGER	158R/212R
CROSS YNG AT OR BELOW 14000 FT CROSS CXR AT AND;MAINTAIN 9000 FT AT CXR CONTACT CLEVELAND APPROACH 126.55	13	WILCO	48R, 46R, 19, 118R

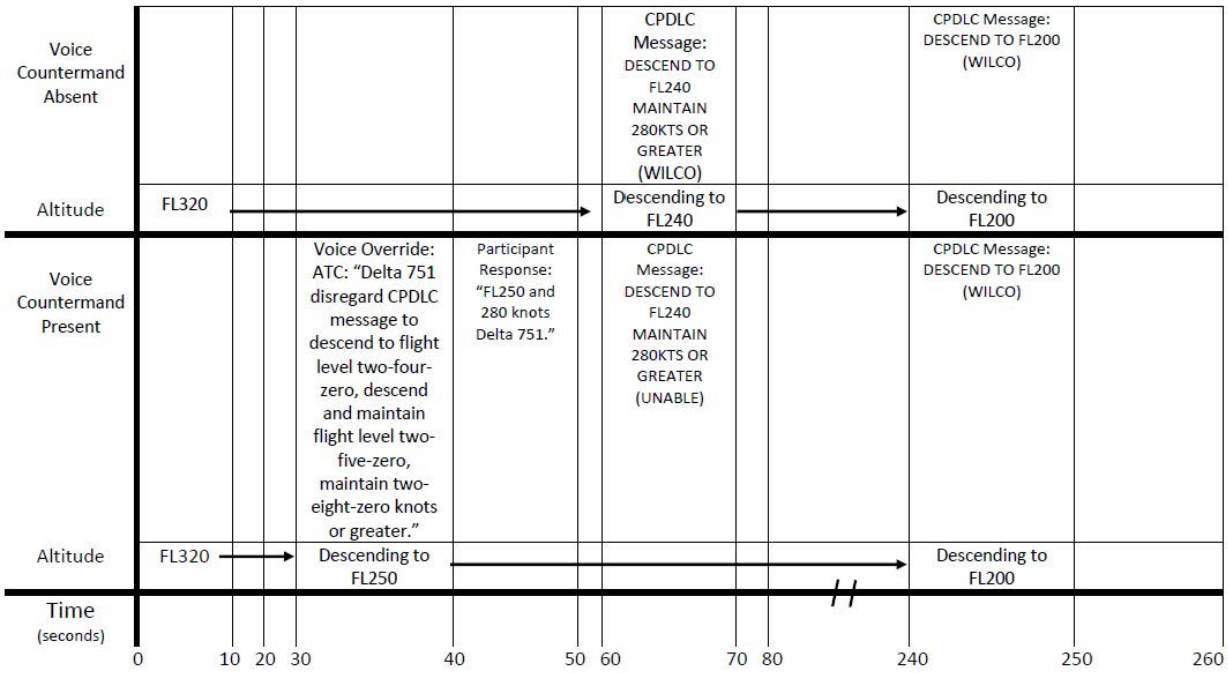

Figure 1. Timeline of countermanded clearance.

2.2.2 Practice Scenario

Prior to each experimental condition, participants flew a 15-minute practice scenario in Boston airspace (i.e., mostly terminal and some en-route airspace). Just as in the actual experiment, the practice scenario had two Data Comm conditions: text-only and text+speech. Participants completed the practice scenario as many times as necessary to feel comfortable in the simulator. Before moving onto the experimental condition, participants demonstrated proficiency by successfully replying to a series of Data Comm messages without assistance from the experimenter.

2.2.3 Questionnaires

Each participant completed three questionnaires: one after each experimental condition and a final post-experiment questionnaire after having experienced both conditions. Post-condition questionnaires focused on workload, perception of head-down time, flightcrew procedures and user acceptability. The post-experiment questionnaires addressed user preference between the Data Comm displays (i.e., text only vs. text+speech). Prior to taking part in the experiment, participants completed a background questionnaire detailing their flying experience (see Appendix B for the background questionnaire and experiment questionnaires). Questionnaires were completed online and each took no longer than 20 minutes to complete.

2.2.4 Flight Briefing and Flight Deck Materials

Participants received a flight briefing package that included the flight plan, necessary charts, and weather information before each experimental condition (see Appendix C for the flight briefing). Crews

were instructed to familiarize themselves with the route as normal, and perform before and after take-off checklists (appropriate checklists were provided on the flight deck). A notepad and flight deck printer were provided for the crewmembers to use as desired. The experimenter programmed the FMS and configured the simulator prior to the start of each experimental condition.

2.3 Special Instructions

The recommended SOPs for Data Comm differed depending on the Data Comm modality. When communicating with text-only Data Comm, participants were instructed to follow the procedure recommended in the GOLD, that is, for each pilot to read the message silently, then discuss it, before executing any clearance. When communicating with text+speech Data Comm, both participants heard the message simultaneously, so both pilots were not required to read the message before discussing it (see Section 1.2.2 for considerations on how these different procedures may impact operational efficiency). In each practice condition (but not experimental condition), flightcrews were reminded of the recommended Data Comm procedures.

Participants were instructed to remain on autopilot for the entire scenario. The PM (i.e., the First Officer) was in charge of communicating (using the Data Comm interface) while the PF (i.e., the Captain) navigated.

2.4 Equipment

2.4.1 Simulator

Crews flew the Volpe Center's Boeing 737-800/NG ("Next Generation") fixed-base simulator shown in Figure 2. The simulator's visual display included three medium-resolution 42-inch plasma displays (with a 120-degree horizontal and 30-degree vertical field of view). The OTW visuals were provided by Microsoft (MS) Flight Simulator X (See Figure 2). The aircraft modeling was a combination of MS Flight Simulator and Sim Avionics. The simulator did not have control loading.

Figure 2. The Volpe Center's Boeing 737-800/NG fixed-base simulator.

2.4.1.1 Simulator Limitations

The B737-800/NG simulator had several limitations. Crews were briefed on each of these limitations prior to flying (see briefing in Appendix C). In most cases, the limitations were unlikely to adversely affect the flight; in cases where this was a possibility, crews were provided with an alternative action. Each limitation and corresponding alternative action, where appropriate, is explained, in turn, below.

- The Multi-function Display (MFD; adjacent to the CDU) could not be tailored by the flightcrew for use (e.g., for display of auxiliary engine gauges); it was used to display a system clock for data collection purposes.
- The weather (WX) radar button was inoperative. During the practice and experiment scenarios, a radar weather image (i.e., an image of a thunderstorm) was programmed to be shown on the display at a specific time, and pressing the WX radar button would override the programmed image.
- The size of the radar weather image could not be scaled independently on the First Officer and Captain Navigation Displays. The software used to display the image did not differentiate between the two displays. Crews were briefed that the weather display should be considered accurate at the 80 nautical mile (NM) range and that any decisions regarding the weather should be based on this range (see Figure 3).
- Due to the simulator's inconsistent Vertical Navigation (VNAV) performance (e.g., inconsistencies in calculating the top of descent point), VNAV was considered inoperative. Crews were instructed to control the airplane via Level Change or Vertical Speed, autothrottle, and Speed on the Mode Control Panel (MCP). Crews were also instructed that restrictions could still be entered on the LEGS page of the FMS as a reminder (but, that they will be ignored by the FMS without VNAV).
- The simulator had an unrealistic acceleration rate after lift-off when the flaps were extended; crews were instructed to reduce the climb rate or retract the flaps "off-schedule" as needed.
- Lastly, the Traffic Alert and Collision Avoidance System (TCAS) was inoperative in the current study, as the location of nearby traffic could not be precisely controlled. A Ground Proximity

Warning System (GPWS) was also not implemented. This may have removed some of the normal auditory clutter on the flight deck compared to real operations, avoiding some of the potentially negative impacts of the text+speech display.

Crews were able to fly the simulator during the practice session, and observe each of these limitations, prior to the experiment scenarios.

Figure 3. The size of the radar weather image on the ND at the 80 NM, 160 NM, and 320 NM range remained constant (from left to right).

2.4.2 Data Comm Interface

The Data Comm interface presented pilots with visual or text-only and text+speech displays dependent on the condition. In one condition, the press of a button called up the visual display of the message only, in the other, a synthetic voice read the message "aloud" in conjunction with its visual presentation. The detailed implementation is described below.

The left and right CDUs were configured with a Data Comm interface (see Figures 4-9) which was created using an "overlay" provided by the simulator manufacturer. The software received and recorded pilot responses and sent text messages to the FMS CDU. The software also prompted the synthetic speech—provided by Microsoft's "Anna"—to annunciate the text messages sent by the software to the cockpit. Flightcrew interactions with the Data Comm interface (i.e., button-presses) were recorded by the CDU software and time-stamped.

To access the Data Comm page from within the CDU required a series of steps. In the simulated interface, the pilot typically pressed at least three keys to access the Controller Pilot Data Link Communications (CPDLC) Menu screen, from which a new message could then be opened or a previous message could be reviewed (described in detail below). While this implementation was cumbersome, it represents a realistic worst-case scenario in which multiple keypresses are required to access a message.

The design of the CDU Data Comm pages was based on an implementation developed by a major manufacturer. Figure 4 shows that the CPDLC Menu REQUESTS and REPORTS keys were inactive in the current implementation (typically, the REQUESTS page would be used to downlink requests to ATC,

and the REPORTS pages would be used to send reports, for example, on position, speed or heading to ATC). Pilots were briefed on inactive CDU functions prior to the experiment. The SPEECH ON/OFF toggle key on the CPDLC Menu allowed the pilot to turn the synthetic speech annunciations on or off for the entire flight scenario; pilots were instructed not to use this function (its purpose was to indicate the speech status to experimenters).

On the bottom right of the CPDLC Menu (Figure 4) and all subsequent pages, an "*ATC MSG" (i.e., ATC message) indication appeared when a Data Comm message was open. The crew was alerted to a new message by an audible chime (similar to the Selective Calling, or SelCal, "ding-dong") and another visual "*ATC MSG" that appeared on the Engine-Indicating and Crew-Alerting System (EICAS; as shown in Figure 5). To read or hear a Data Comm message, the crew pressed the "*ATC MSG" key on the CDU. Pressing this key called up the Data Comm message screen, displaying the Data Comm message via text (see Figure 6) and, in the text+speech condition, automatically triggering the synthetic speech.

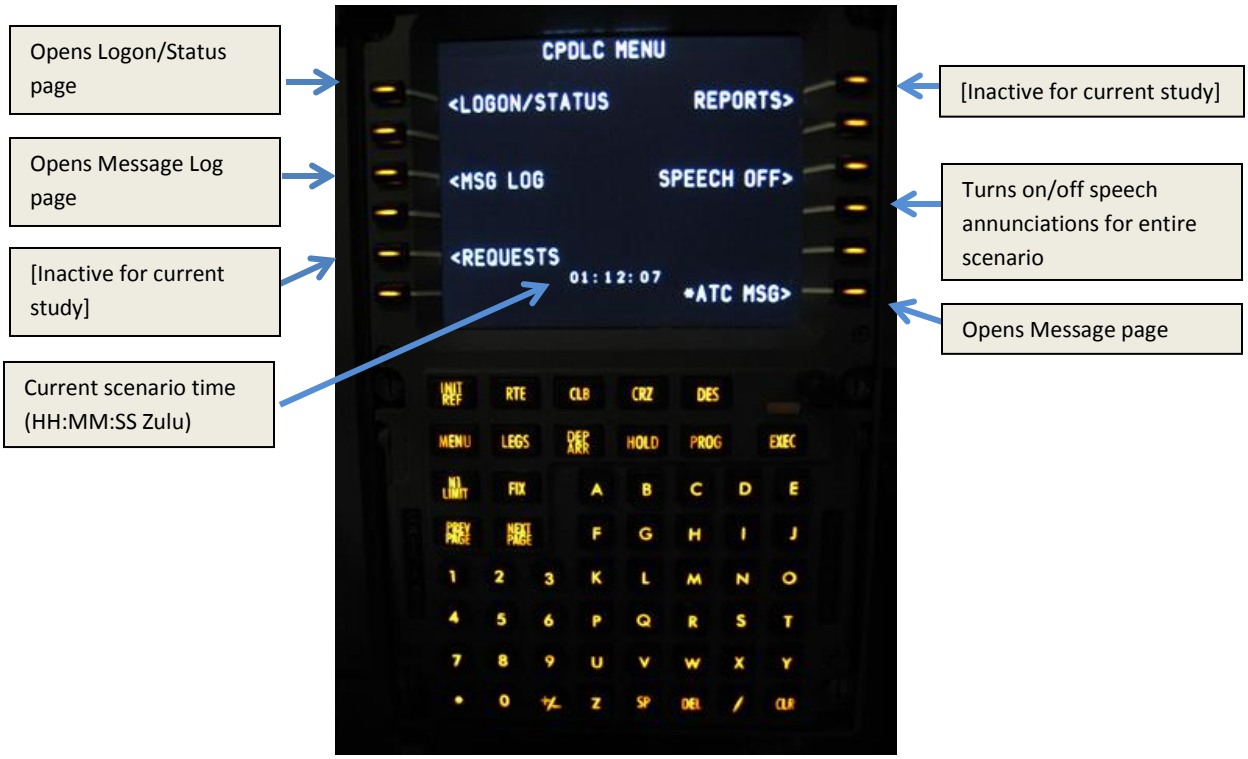

Figure 4. The CPDLC Menu page on the CDU.

Figure 5. The EICAS display with ATC message notification.

Figure 6 shows an "open" Data Comm Message screen. The CPDLC message (e.g., "CLIMB TO 12000") and status (e.g., "OPEN") are displayed on the top left and right, respectively. The available responses are shown at the bottom, along with additional message options. (When the message spans more than one page, the responses are located on the first page of the clearance, but to prevent premature responses, only after pilots have paged to the end of the message and then paged back again.) For the current study, the possible responses were WILCO\ROGER or UNABLE.

If the pilot selected the WILCO key, the current screen updated the response to "**WILCO**," as shown in Figure 7. If the pilot selected the UNABLE key, a new Reject page (Figure 8) opened to allow the pilot to select and send a reason for the UNABLE [e.g., due to WX (weather), AC PERF (aircraft performance), etc.], and the previous screen (the Message page, in Figure 7) would update the response to "**UNABLE**" and show the selected reason.

For the current study (i.e., unlike the industry model), a MUTE/SPEAK toggle key was added to the Message page. When a message was being annunciated by the synthetic voice, the MUTE/SPEAK toggle key read MUTE; pressing the MUTE key muted the current synthetic-speech annunciation for the current message (all future messages were still annunciated, unless MUTE was selected again). When a message was being annunciated, the same key would read SPEAK (as in Figure 6); pressing the SPEAK key would replay the message that was currently selected (see Section 2.4.3 for a description of audio controls on the flight deck). A PRINT option (on the lower left of the message screen) allowed the crew to print stored Data Comm messages on a small footprint printer (manufactured by Seiko, with a Bluetooth interface) installed in the flight-deck pedestal (see Figure 9). On all instantiations of the Data Comm message page and the message log (e.g., Figures 6-8; 10), a RETURN key brought the pilot back to the CPDLC menu page.

Figure 6. An "open" Data Comm message with respective response keys.

Figure 7. A "closed" Data Comm message with WILCO response.

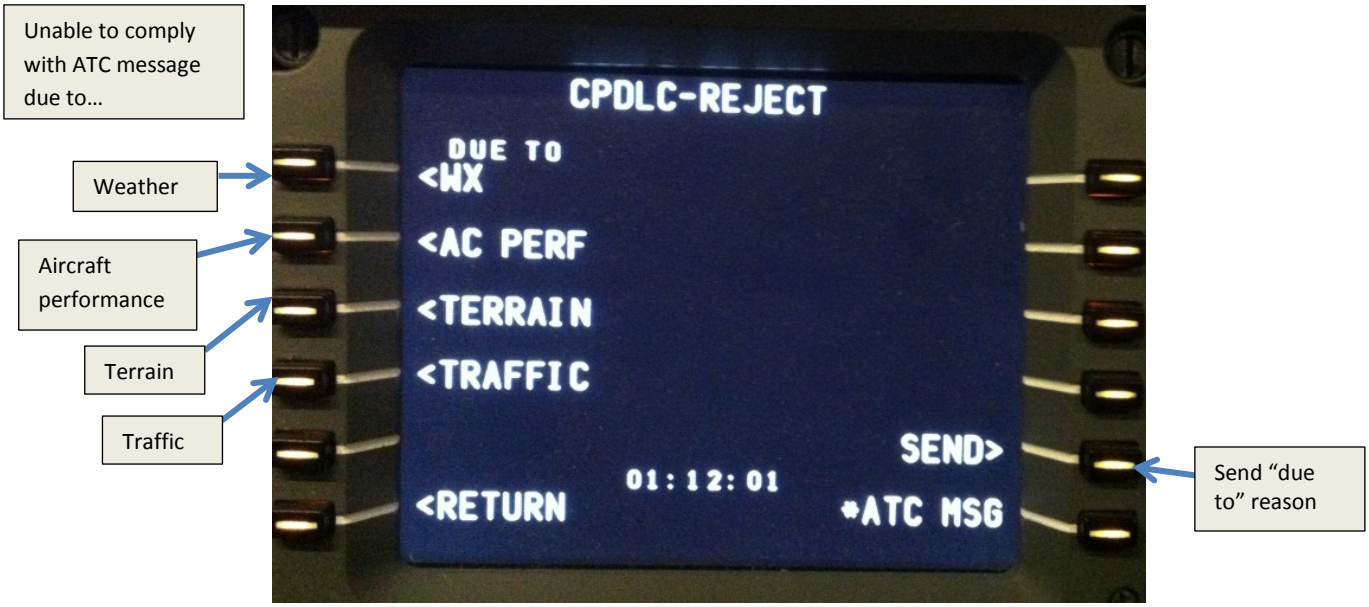

Figure 8. The REJECT page with possible reasons for an UNABLE response.

Figure 9. The flight deck printer.

Figure 10 shows the MSG LOG page, which was accessible via the CPDLC Menu page shown in Figure 4. The Log held a truncated list of all messages received along with message status (e.g., OPEN/WILCO/REJECT), with newest messages on top. At any time, the crew could open any message for review, regardless of message status, via the Message Log: Pressing the key next to a message opened that message's Message page (e.g., Figure 6 and Figure 7).

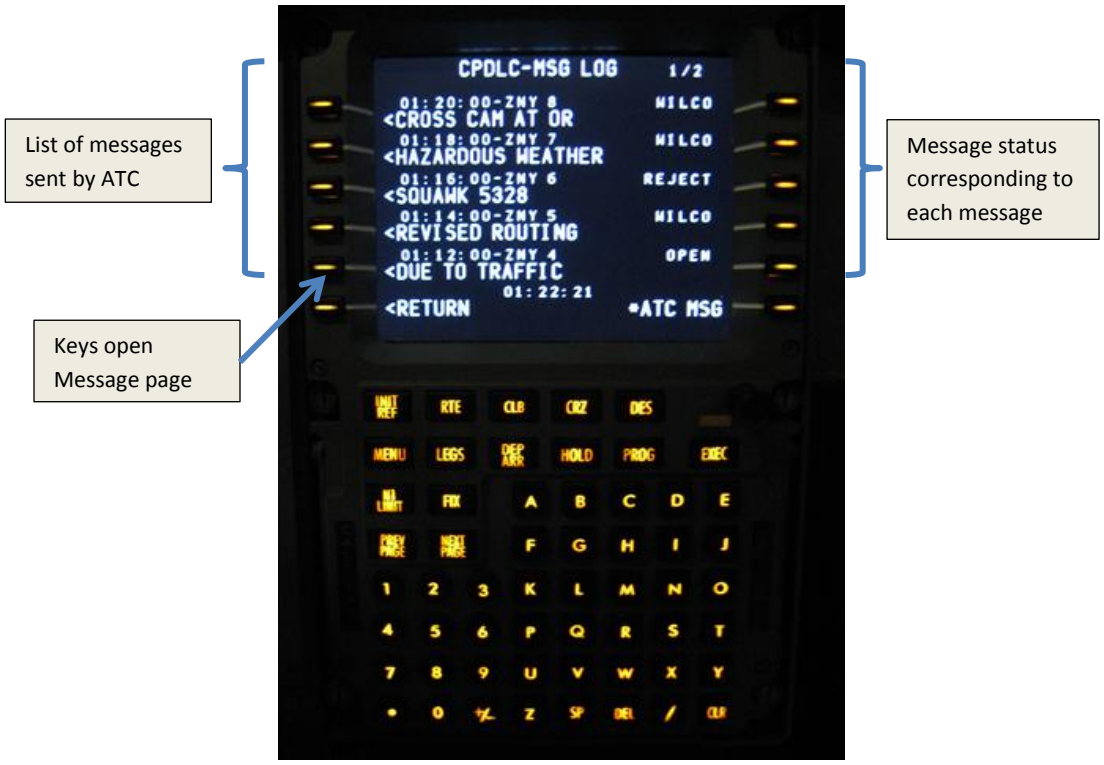

Figure 10. The Data Comm message log.

2.4.3 Synthetic Voice and Audio Recordings

A highly-intelligible 16 kHz synthesized female voice, "Anna," developed by Microsoft, was used for the aural Data Comm display.[5]

The experiment scenario included a pre-recorded party line and pre-recorded instructions from the controller to ownship (meant to seem as if they were occurring in real time, i.e., "live") and synthetic speech annunciations.[6] The party line chatter was scripted for the current study, and a transmission occurred an average of every 21 seconds (SD = 25 seconds, range = 5 – 140 seconds). The script included 25 other aircraft and ATC (other aircraft heard on the party line were communicating with the appropriate ATC facility for the sector they were flying through). Three aircraft on the party line (i.e., Delta 761, Delta 715, and United 751) had similar-sounding call signs to the participants' ownship (i.e., Delta 751). Traffic on the party line was recorded via laptop by Volpe Center employees. The ATC voices on the party line were recorded by the experimenter who typically acted as ATC during the experiment (See Appendix D for the party line script).

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[5] In a comparison of six ATC clearances (e.g., "American one twenty seven climb and maintain flight level three one zero"), Microsoft's Anna and AT&T Crystal (used in Phase I; Lennertz et al., 2012a) yielded similar ratings of acceptability and intelligibility from 11 listeners.

[6] An example of a synthetic speech annunciation can be found here: Sigmet55C_large.wav

The party line and "live" ATC instructions were presented over customized single-ear Panasonic airline style boom-microphone headsets (similar to the Telex Airman 750). The synthesized voice was played aloud on the flight deck, on a separate channel from the one used for the ATC communications provided via voice and party line so that the synthetic voice could be replayed and/or muted without interfering with other audio. Pilots could adjust the volume on the radio [party line, "live" ATC, and intercom (own speech to other crew member and/or ATC over microphone)], but not the synthetic speech (which could be muted).[7] Five of the sixteen flightcrews requested minor adjustments[8] to the volume of the radio heard over the headset; these adjustments were made during the practice session.

2.5 Experimental Design

The experimental design involves one main independent variable—Data Comm modality. To test the effects of Data Comm modality, participants flew the same scenario twice, differing only in the presentation of Data Comm; in one condition, participants communicated with ATC using text-only Data Comm and, in the other condition, they communicated with ATC using text+speech Data Comm. Thus, all variables that were examined with respect to Data Comm modality—response time, gaze-dwell time, printing, message reviewing, perceived communications workload, and perceived usability and acceptability—represented a within-subjects design. There were two exceptions: The first exception was the effect of Data Comm modality with regard to the countermanded clearance, which represented a between-subjects design. Participants experienced one countermanded clearance in *either* the text-only *or* the text+speech condition. To avoid order effects, presentation of the countermanded clearance (i.e., in the text-only or the text+speech condition) and the order of the Data Comm conditions (i.e., text only first or text+speech first) were counterbalanced across participants (see Appendix E for the counterbalancing scheme). The second exception was the effect of aural step-ons, which only occurred in the text+speech condition, and were examined with a between-subjects design.

Both quantitative and qualitative data were collected as described below.

2.5.1 Quantitative Data Collection

Quantitative dependent data included: a) crew inputs to the CDU Data Comm page, b) aircraft-state variables recorded from the simulator, and c) video and audio recordings.

[7] The lack of volume control for the synthetic speech was due to a constraint in setting up the simulator and is not necessarily a design recommendation. Indeed, it may be beneficial to implement a system with volume control, as the noise levels on the flight deck may vary by aircraft, phase of flight, and environment (e.g., weather conditions).

[8] For one crew, the volume setting was not recorded.

2.5.1.2 *Data from the CDU Data Comm Page Inputs*

Data from the CDU Data Comm page included, for each message, the following:

a) the time it was uplinked by ATC,
b) the time it was opened by the crew and by whom,
c) the time it was acknowledged (WILCO/ROGER or UNABLE) and by whom,
d) the time(s) that each page was accessed (for messages that span more than one page),
e) the time(s) that each message was muted (when applicable),
f) the time(s) when the synthetic speech annunciation was replayed (when applicable), and
g) the time(s) when the message was printed (when applicable).

The CDU Data Comm page data were used to analyze response times and crew interactions with the Data Comm interface, using the uplink times as the basis of the calculations.

2.5.1.3 *Flight Data Recording*

A stream of 1 Hz Global Positioning System (GPS) standard National Marine Electronics Association (NMEA) Recommended Minimum Specific GPS/TRANSIT and GPS fix data [Recommended Minimum Specific (RMC) and Global Positioning System Fix Data (GGA), respectively] messages were collected in a text file that included simulation time, aircraft position (i.e., latitude and longitude), altitude, track (i.e., heading), and groundspeed. These data could be used to analyze the crew's compliance with ATC instructions and to calculate the time it took the crew to initiate and complete ATC instructions.

2.5.1.4 *Audio/Video Data*

A Geovision GV-1480 DVR equipped computer recorded four video and two audio sources. The video sources comprised:

a) Captain,
b) First Officer,
c) CDU, and
d) a wide field-of-view of the flight deck, including MCP and flightcrew interactions.

Video cameras recorded the Captain's and First Officer's gaze behavior to calculate pilots' gaze-dwell time and location (e.g., at the CDU, MCP, or OTW).

The dependent and independent audio data comprised:

a) "ambient flight deck audio" that captured crew voice, synthetic speech, and flight deck sounds and warnings,
b) "intercom/radio audio" that captured crew voice, party line, and ATC.

Video and audio recordings served as additional data sources.

2.5.2 Qualitative Data Collection

Qualitative data (all dependent) included:

a) two post-scenario questionnaires (one after each experimental condition) for pilots to share their opinions on each condition,

b) one post-experiment questionnaire for pilots to compare their perceptions of the two conditions, and
c) experimenter observations.

The experimenter recorded his or her observations of crew compliance (e.g., inputs to the MCP, CDU, and transponder; see Appendix E for a description of the observer roles). Any notes that participants took during each experimental condition were also collected.

2.5.3 Statistical Analysis and Presentation

The majority of the data were examined using Wilcoxon matched-pairs signed rank tests (S) that compared (within-subjects) flightcrews' or individual pilots' responses between Data Comm conditions. Gaze-dwell time was examined using paired t-tests or Analysis of Variance (ANOVA). Data that were examined between-subjects were examined using chi-square tests or median tests. Additional details about the statistical analyses are provided in Appendix F.

Much of the data are graphed using box plots to show the distribution of responses. An example box plot is shown in Figure 11. Each box contains 50% of the data, with the lower boundary of the box representing the 1st quartile, or 25% of the data, and the higher boundary representing the 3rd quartile, or 75% of the data; the middle line is the median, or 50% of the data. The whiskers denote the minimum and maximum of the distribution. The mean is represented by an X. Note that when the data are symmetrical, the mean and median should be similar. When the data are asymmetrical, the median may be the best parameter for interpreting the results of our statistical tests.

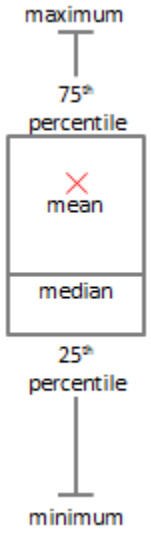


Figure 11. Example box plot.

2.6 Procedure

Upon arrival, participants were given an introductory presentation (see Appendix C) that included the objective of the experiment, an overview of the simulator, and special instructions (e.g., flight deck roles and recommended SOPs).

After completing the pre-experiment questionnaire, participants were taken to the simulator to practice their first experimental condition. Following the practice, participants reviewed the flight briefing materials. After review of the briefing materials, participants flew the first experimental condition, and then completed the post-scenario questionnaire.

Following a lunch break, participants flew the second practice condition, again reviewed the flight briefing materials (which were identical to the first session), and flew the second experimental condition. Participants then completed a post-scenario questionnaire, and a final post-experiment questionnaire. Finally, participants engaged in an informal debriefing session, and were encouraged to ask any questions. The whole procedure took no more than six hours.

3. Results

3.1 Do No Harm

3.1.1 Step-Ons

We predicted that flightcrews may delay opening or acknowledging Data Comm messages when the party line "steps on" (is heard at the same time as) the synthetic speech annunciation of a message. In this study we refer to two types of step-ons between the synthetic speech and the party-line voice frequency: (1) unintentional step-ons, in which communications heard over the party line started while a message was already being annunciated (i.e., the party line stepped on the synthetic speech), and (2) intentional step-ons, in which the flightcrew opened the message page to read the message text (thus triggering the annunciation) while communications were already being heard over the party line (i.e., the speech stepped on the party line). The occurrence of an intentional step-on indicated that the flightcrew did not wait for party-line communications to cease before opening a message. A chi-square (χ^2) test was used to examine whether there was a significant difference between the number of times flightcrews caused an intentional step-on and the number of times flightcrews waited for the party line to cease before opening a message (i.e., avoided a step-on). These data are shown in Figure 12. The results showed that flightcrews caused a step-on significantly more often than they avoided one, $\chi^2 = 20.55$, $p < .001$. That is, contrary to our expectation, potential step-ons from the party line did not delay flightcrews in opening Data Comm messages in the text+speech condition.

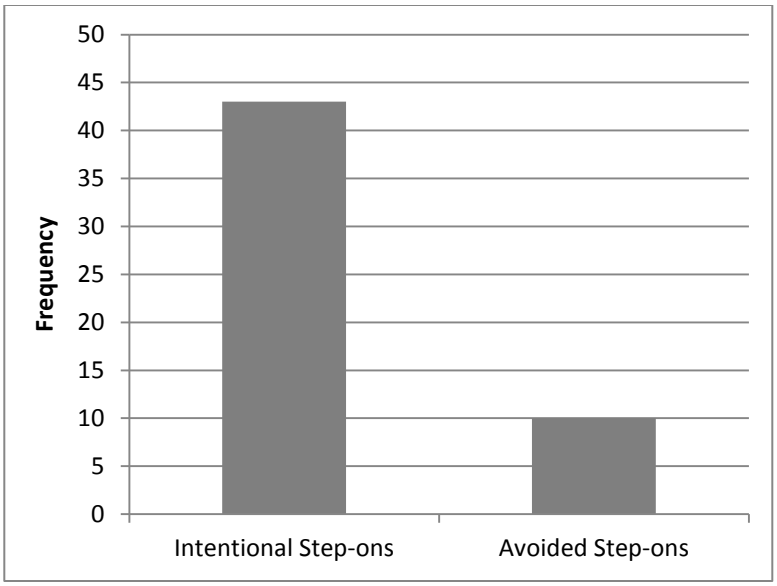


Figure 12. Number of intentional step-ons vs. avoided step-ons.

We also predicted that flightcrews would delay acknowledging a message (i.e., responding WILCO or UNABLE on the Data Comm display) when step-ons occurred. A median test (represented by the χ^2 symbol) was used to examine whether the median time to acknowledge a message was significantly different when a step-on occurred vs. when a step-on did not occur. A second median test examined only the step-on data, and compared the median time to acknowledge a message between intentional and unintentional step-ons. The median response times associated with these two tests are depicted in Figure 13 and Figure 14, respectively.

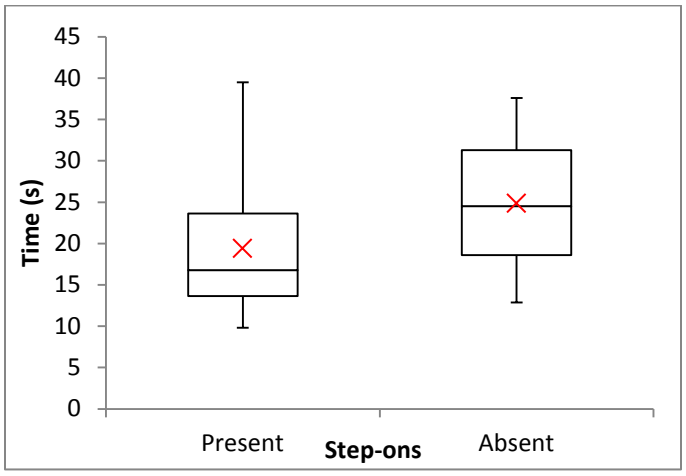


Figure 13. Time to acknowledge messages during step-ons vs. no step-ons.

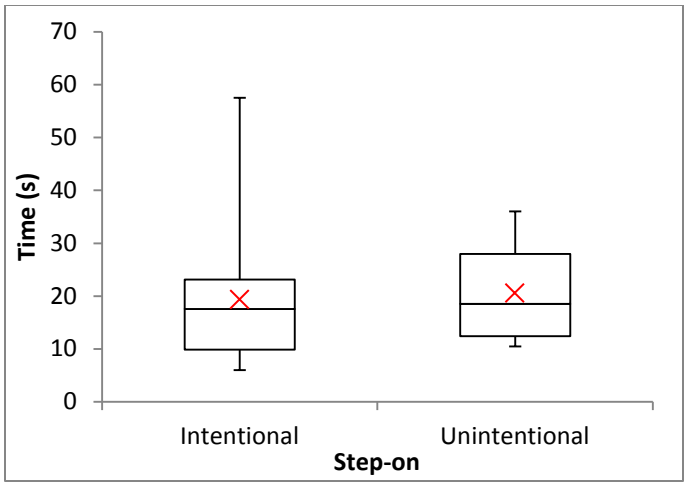


Figure 14. Time to acknowledge messages during intentional vs. unintentional step-ons.

Contrary to our prediction, the results showed that the occurrence of a step-on (either intentional or unintentional) had no significant influence on flightcrews' time to acknowledge a message, $\chi^2(1) = 1.13$, $p = .29$, and there was no difference in flightcrews' response times to intentional vs. unintentional step-ons, $\chi^2(1) = .34$, $p = .56$. Another indication that step-ons did not influence flightcrews' ability to communicate with text+speech Data Comm is that there was only one instance of a flightcrew muting the synthetic speech.[9] Without consulting the PF, the PM muted a 19-second message (the longest in our message set) that provided information about hazardous weather (note: the flightcrew was not required to take any actions beyond acknowledging the message). There were no overlapping party-line or intracrew communications. The PM muttered "shut up" as he muted, suggesting that he found the voice to be annoying. The flightcrew did not WILCO this message. When they noticed less than a minute later, the PM commented that he hit MUTE instead of the WILCO button.

Given these results, we considered whether pilots were even paying attention to the party line—that is, if they were ignoring information on the party line because they did not consider it useful. However, a check of the video and observation data showed that pilots did listen to and acknowledge information on the party line. Three examples drawn from the text+speech condition are provided in the following tables: [10]

[9] Another way to examine how step-ons influenced communication would be to count the number of times flightcrews pressed the "speak" button to replay the synthetic speech annunciation of the message. These data were not included in the report due to resource limitations.

[10] A thorough video analysis of both conditions could not be performed due to resource limitations, and for the text-only condition, no anecdotal evidence of party line acknowledgement was observed.

Table 5. Example 1: Discussion of turbulence information on the party line.

Speaker	Dialogue
Party line	Cleveland Center United 8734 with you at flight level three-seven-zero, smooth.
First Officer (FO)	Cleveland Center Delta seven-fifty-one
ATC	Go ahead
FO	Where was that United reported smooth?

Table 6. Example 2: Discussion of nearby traffic on the party line.

Speaker	Dialogue
Party line	Cleveland, American five-eighty-two with you descending to flight level two-four-zero.
Captain	She's 280 or less.
FO	She's 280 or—OH, she's two-eighty or less [points behind].
Captain	The American behind us
FO	Yeah
Captain	On the arrival, to direct Elwood City two eighty or less
FO	Yeah
Captain	Then they turn direct Youngstown

Table 7. Example 3: Discussion of traffic with a similar-sounding call sign on the party line.

Speaker	Dialogue
Party line	United seven-fifty-one climb and maintain flight level three-two-zero.
FO	United seven-fifty-one.
Captain	Yeah, we gotta be careful about that.
FO	Yeah yeah, listening for that one. Yeah they're flying at three-twenty as well.
Captain	Mmm.

3.1.2 Response Times

Flightcrews were expected to respond to Data Comm messages faster in the text-only condition than in the text+speech condition because, in the text+speech condition, they may listen to the entire message before responding. Pilots may be able to read the text message faster than the synthetic speech can annunciate it.

Two types of response times were analyzed for each flightcrew: 1) time to open Data Comm messages, and 2) time to acknowledge messages after opening them. Differences in response times by Data Comm condition were examined using Wilcoxon matched-pairs signed-rank tests (S). The results of the statistical test confirmed our prediction, showing that flightcrews were significantly faster opening messages with text-only Data Comm than with text+speech Data Comm, $S = -41$, $p < .05$. Figure 15 shows the time to open messages for flightcrews who were faster in the text-only vs. the text+speech condition. The majority of flightcrews (n = 12) were faster opening the message with text-only Data Comm, and did so with a median time of 6.65 seconds. The four flightcrews who opened the message faster with text+speech did so with a median time of 7.55 seconds.

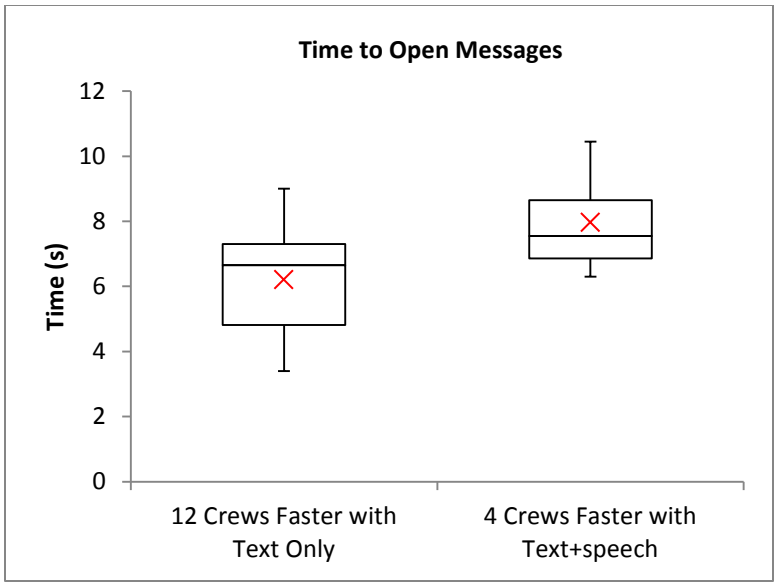


Figure 15. Time to open messages by faster Data Comm condition.

Flightcrews were also marginally faster to acknowledge messages with text only Data Comm than with text+speech Data Comm, S = -35.5, p = .0672. Figure 16 shows the time to acknowledge messages for flight crews who were faster in the text-only vs. the text+speech condition. There were 12 flightcrews who acknowledged the message faster with text-only Data Comm, compared to 4 who were faster to acknowledge with text+speech (note that these were not the same 4 flightcrews who opened the message faster with text+speech). The flightcrews who acknowledged faster with text only did so with a median time of 19.08 seconds; those who acknowledged faster with text+speech did so with a median time of 17.48 seconds.

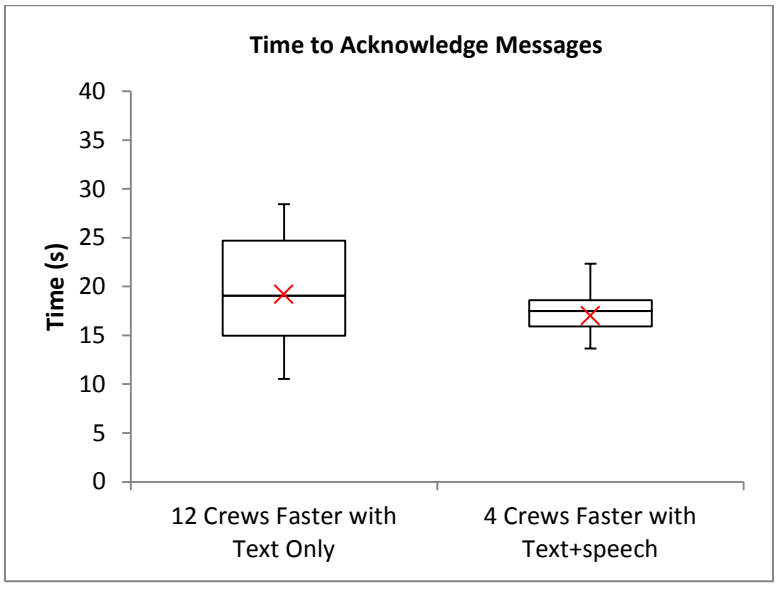


Figure 16. Time to acknowledge messages by faster Data Comm condition.

3.1.3 Countermanded Clearance

With Data Comm, a controller may countermand a clearance via voice before it is viewed on the CDU. In this experiment, one of the two scenarios contained a pre-recorded countermand ("Delta 751 disregard CPDLC message to descend to flight level two-four-zero, descend and maintain flight level two-five-zero, maintain two-eight-zero knots or greater"; see Figure 1, p. 25) issued by the "live" controller (i.e., recorded in the voice of the live controller) before the countermanded clearance had arrived on the CDU. To respond correctly, the flightcrew must reply "UNABLE" to the countermanded clearance. The flightcrew may also acknowledge the countermand via voice (e.g., "Maintain two-five zero"). It was predicted that pilots may be more likely to ignore the countermand and thus erroneously obey the countermanded clearance when the Data Comm message was displayed both visually and via voice.

An inspection of flightcrew errors (measured via experimenter observations) determined that only one flightcrew failed to respond correctly to the countermanded clearance, and this occurred in the text+speech condition.[11] A chi-square (χ^2) test did not yield a significant difference between the experimental conditions, χ^2 (1) = 1.07, p = .30.

3.1.4 Perceived Communications Workload

Pilots' perceived communications workload was measured in the post-scenario questionnaires by asking pilots to rate their agreement with two statements:

1) Communicating with a *live controller* was easy
2) Communicating with a *text display [and computer-generated speech]* was easy.

Pilots were given five levels of agreement to choose from: Strongly Disagree, Disagree, Undecided, Agree, or Strongly Agree.

We predicted that communicating with a live controller in the text+speech Data Comm condition would be as easy as communicating with a live controller during the with text-only condition, replicating Phase I results. Perceived communications workload was analyzed using a Wilcoxon matched-pairs signed rank test. As expected, there was no significant difference in pilots' ratings of the ease of communication with a *live controller* between Data Comm conditions, $S(1) = 0.00$, $p = 1.00$ (see Figure 17). The majority of pilots (n=23) perceived no difference in their workload between conditions when it came to communicating with a live controller.

[11] Experiment circumstances may have influenced the flightcrew's failure to respond correctly to the countermanded clearance. For this crew, there was a mismatch in the controller voice for the "live" countermanded clearance and the controller voice that responded to flightcrew queries. It is possible that the flightcrew did not listen closely to the countermand since it was not from the voice they were expecting to receive instructions from. For most other flightcrews, the same voice was heard on the party line for both the countermanded clearance and real-time queries.

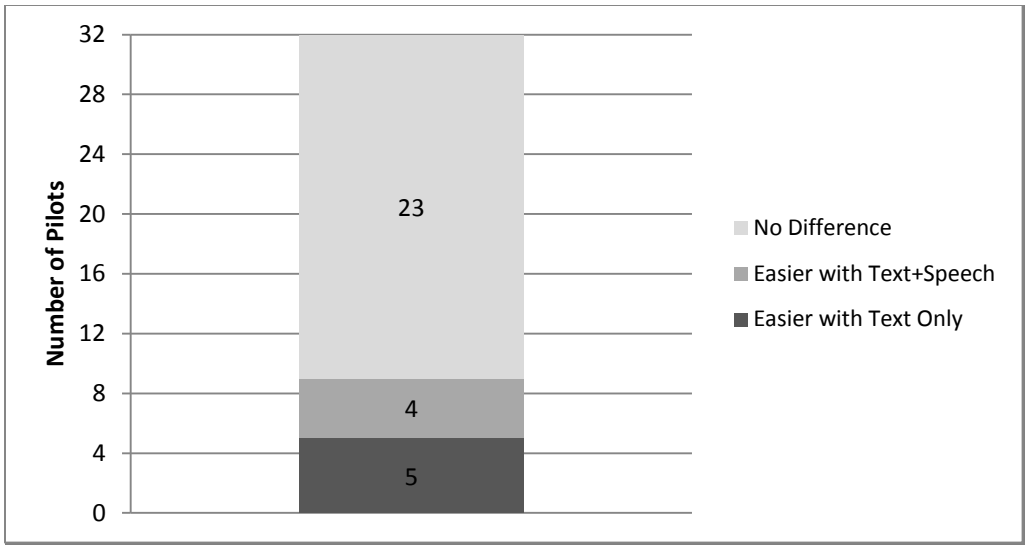


Figure 17. Number of pilots who agreed that communications with a live controller was easier with text-only vs. text+speech Data Comm.

We also predicted that communicating with the text+speech display *in general* would be as easy as communicating with the text-only display. Pilots were significantly more in agreement with the statement that it was easy to communicate with the text+speech display than with the statement that it was easy to communicate with the text-only display, $S = -44.5$, $p < .05$. This result is illustrated in Figure 18. Note that about half of the pilots (n=15) perceived no difference in *general* communications workload between conditions. Of those pilots that did perceive a difference, 13 agreed that communicating with the text+speech display was easier than communicating with the text-only display and only 4 agreed that communicating with the text-only display was easier than communicating with the text+speech display.

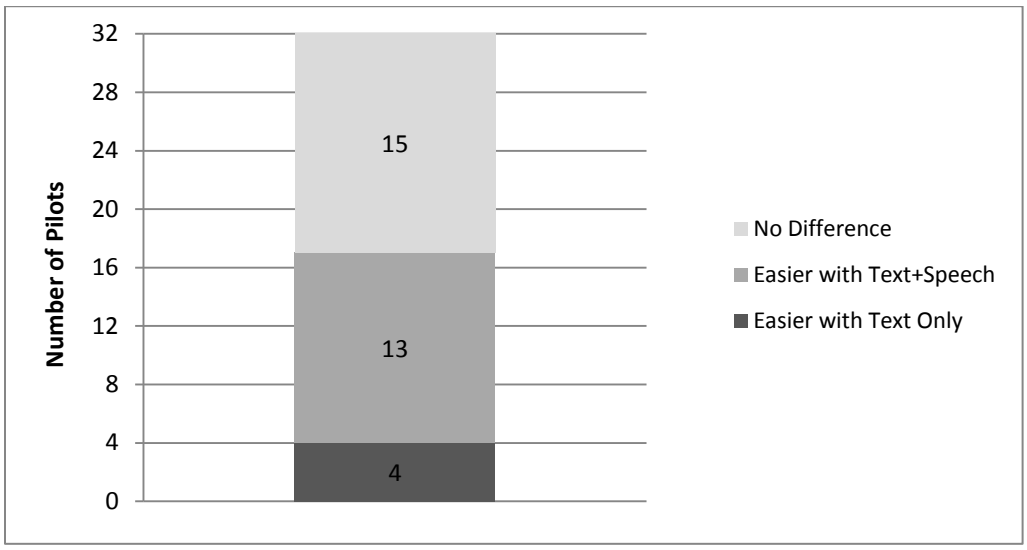


Figure 18. Number of pilots who agreed that communications with the Data Comm display was easier with text-only vs. text+speech Data Comm.

Figure 19 shows the number of pilots who provided each rating by Data Comm condition. Note that the ratings were generally high for both conditions—that is, pilots generally agreed or strongly agreed that communication with the Data Comm display was easy. There were a few exceptions for the text-only display: five pilots were undecided and one pilot strongly disagreed. We were interested to see whether these pilots were from major airlines, because major airline pilots may be less accepting of the addition of an auxiliary synthetic speech Data Comm display on the flight deck than pilots that are not from major airlines (e.g., commuter, contract, etc.). Nearly all pilots that reported previous experience with Data Comm were also from a major airline.

Two separate Wilcoxon matched-pairs signed-rank tests were run separately on pilots from major airlines and pilots not from major airlines. The results showed that major airline pilots did not perceive a difference in their communications workload between conditions, but non-major airline pilots gave significantly higher ratings for the text+speech condition than for the text-only condition, $S = -14$, $p < .05$.

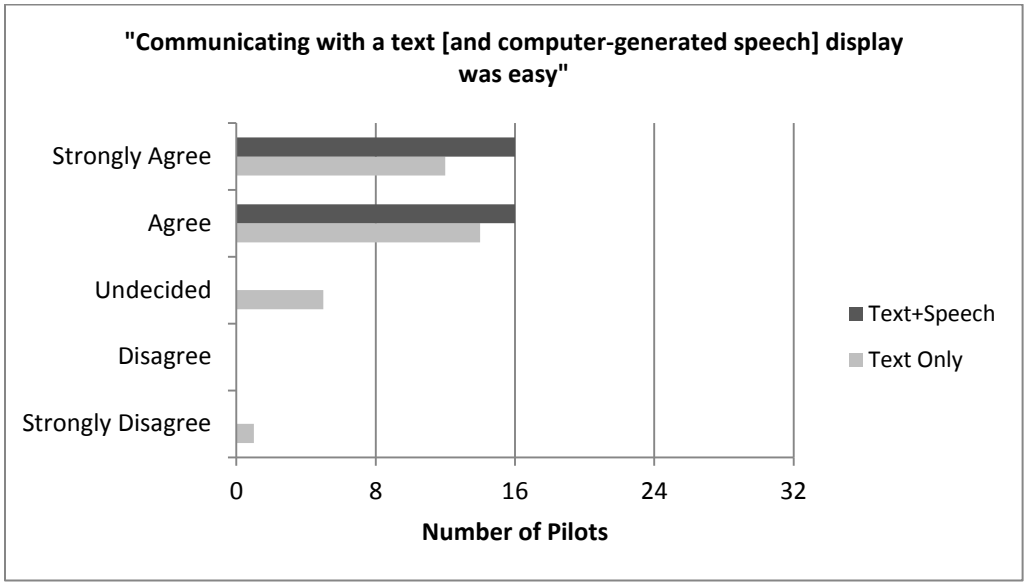


Figure 19. Pilot ratings of communications workload

3.2 Help, If You Can

3.2.1 Gaze-Dwell Time

3.2.1.1 Quantitative

Gaze-dwell time was defined as the time the pilot was looking at the CDU and measured in number of looks, per-look duration, and total duration. Two cameras—one mounted in front of each pilot (above the instrument panel)—captured pilots' gaze-dwell time. A primary coder, blind to the experimental conditions, measured participants' gaze-dwell time on the CDU by silently viewing the video recordings of all experiment scenarios. A second coder, also blind to the conditions, analyzed a

subset of the data (i.e., 4 out of the 16 crews) to establish inter-rater reliability. Pearson correlations indicated a high inter-rater reliability between coders (see Appendix F for calculation details and statistical values). Data from the primary coder were used for the quantitative dwell time analysis.

Gaze-dwell time was measured with Noldus Observer XT software. Coders measured the PM (typically the First Officer) gaze-dwell time in its entirety for each scenario, and then measured the subset of PF (typically the Captain) gaze-dwell time on the CDU that was concurrent to the First Officer's gaze-dwell time on the CDU.[12]

We predicted that flightcrews generally would spend less time gazing down at the CDU in the text+speech condition, relative to the text-only condition, because both pilots would not necessarily have to look down to read the message (recall the SOP for text+speech where it was recommended that the PM read the message to verify its content). Of primary interest was concurrent gaze-dwell time—that is, when both the PF and the PM were looking at the CDU at the same time. Gaze-dwell time was measured in three ways: (1) total number of looks, (2) average duration per look, and (3) total gaze-dwell time across the scenario. The data were analyzed using a paired t-test.

Figure 20 shows the average number of looks down at the CDU across the whole scenario by Data Comm condition. The figure is separated into concurrent looks (by the PM and PF) and looks by the pilot communicating (PM) only (consisting of PMs concurrent and "solitary" looks). Pilots looked down concurrently significantly more often in the text+speech condition than in the text-only condition, $t(15) = 2.25$, $p < .05$. There was no significant difference for the PMs alone, which is not surprising since we recommended that the PM read the message in both conditions, $t(15) = -.72$, $p = .48$.

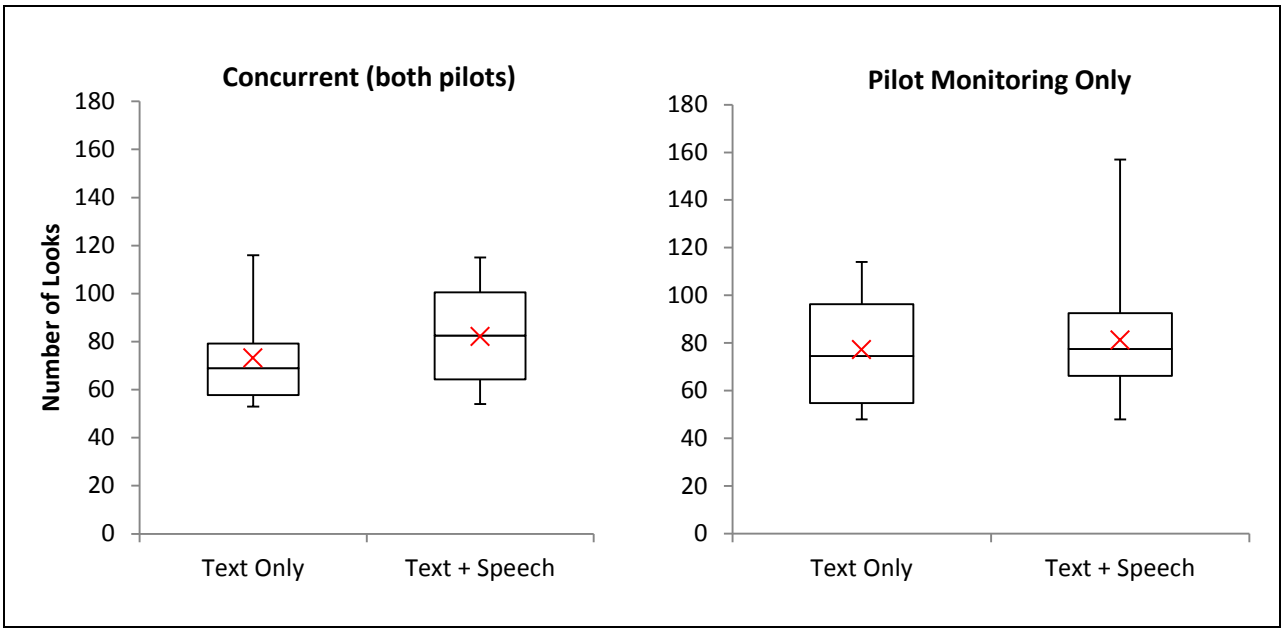


Figure 20. Number of looks by Data Comm condition.

[12] Note that eye-tracking had been considered for Phase I and Phase II and rejected as too costly, cumbersome, and inaccurate with the available equipment.

The average *duration* of each look by Data Comm condition is presented in Figure 21 for concurrent and PM only. There was a significant difference between Data Comm conditions for concurrent gaze-dwell time, $t(15) = 2.72$, $p < .05$. When both pilots were looking down at the CDU, they looked for an average of .92 seconds longer per look in the text-only condition than in the text+speech condition. There was no significant difference in looking duration for PMs only, $t(15) = .27$, $p = .79$

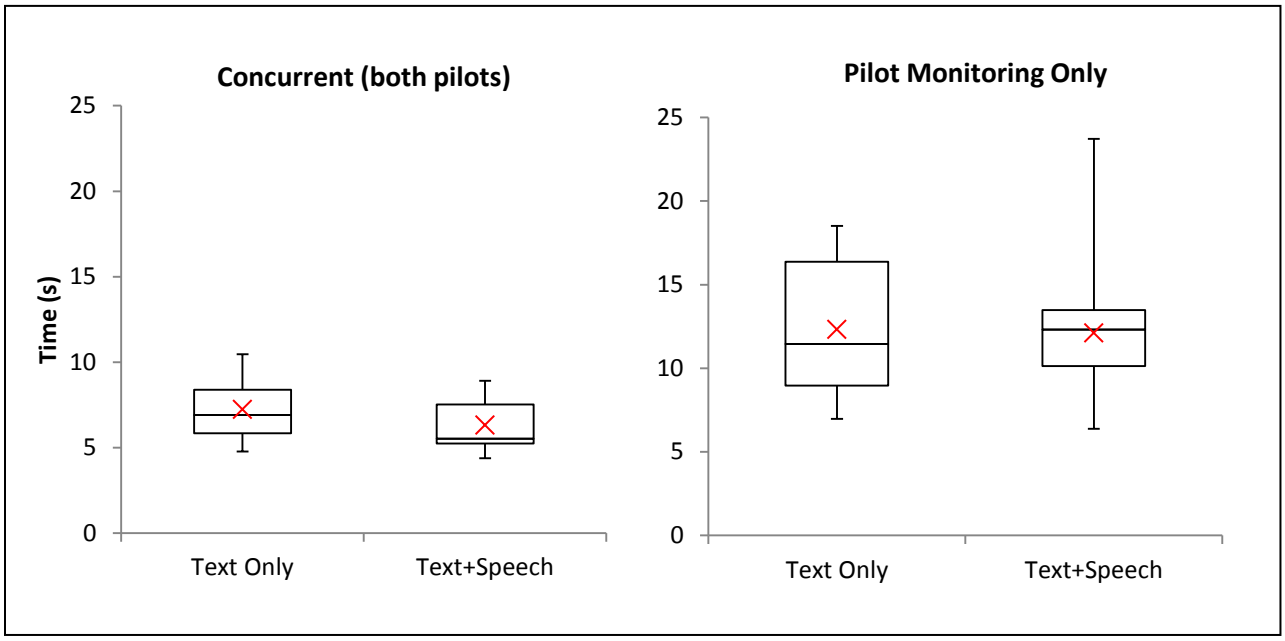


Figure 21. Average duration per look by Data Comm condition.

Figure 22 shows the average total gaze-dwell time across the entire scenario by Data Comm condition for concurrent and the PM only. There were no significant differences in total gaze-dwell time duration for concurrent, $t(15) = .62$, $p = .54$, or the PM only, $t(15) = -.74$, $p = .47$.

Using total dwell time and total scenario time, we also calculated the percentage of time that pilots spent looking down at the CDU for each condition. On average, both pilots looked down at the CDU concurrently for 7% of the time in both conditions (i.e., there was no difference). PMs alone spent 13% of their time looking down at the CDU in both conditions.

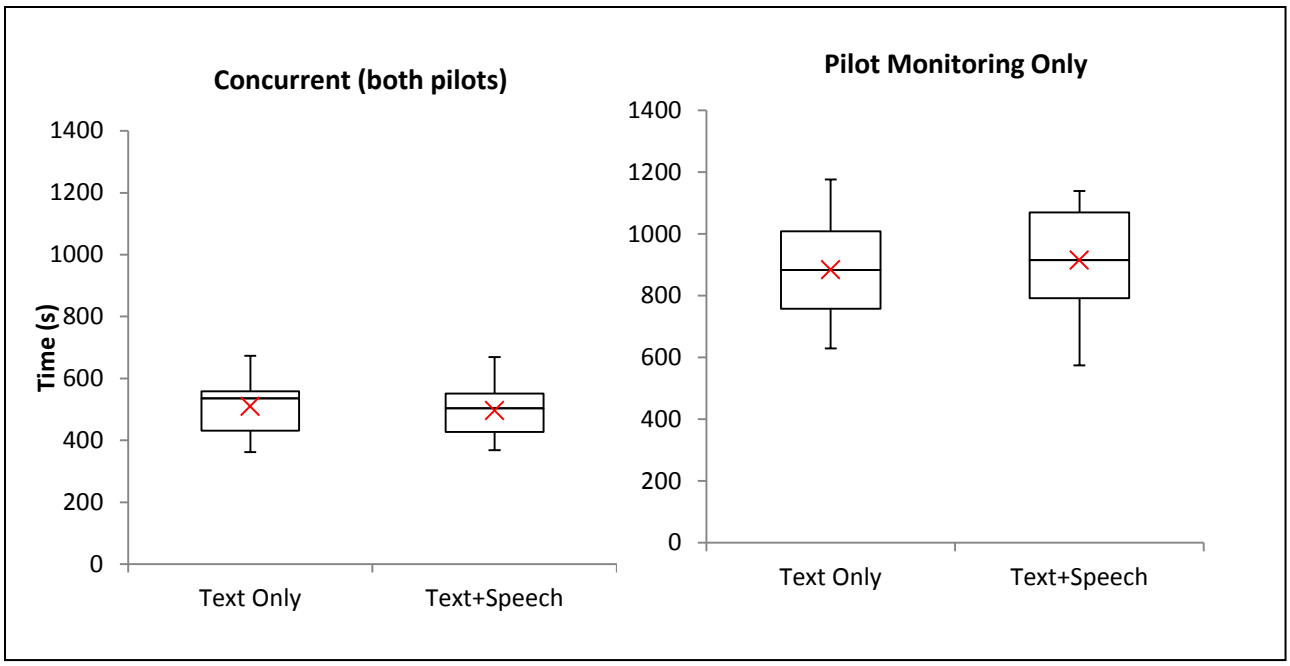
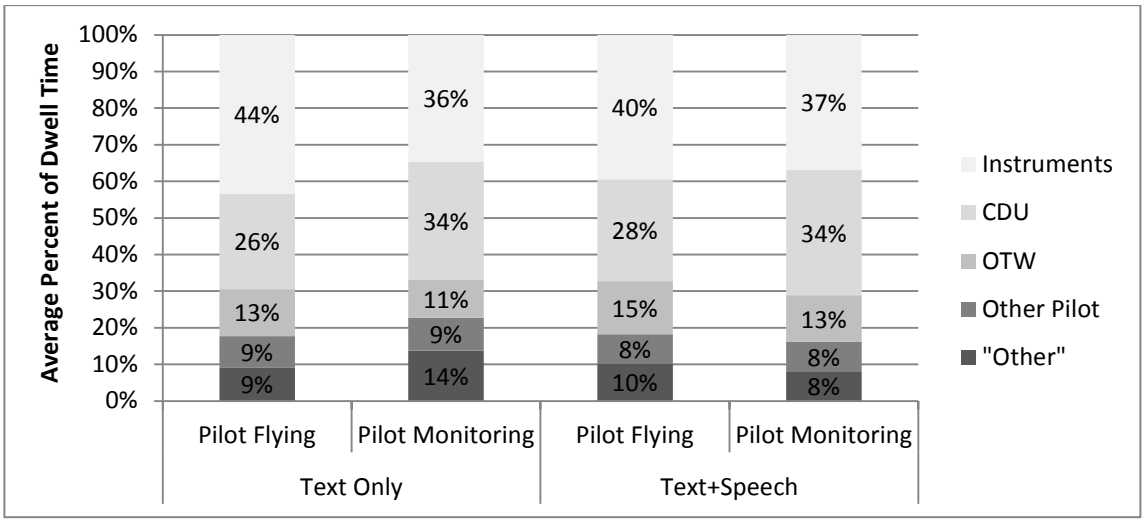


Figure 22. Average total gaze-dwell time across the scenario by Data Comm condition.

3.2.1.2 Qualitative Perceptions

Pilots were asked to estimate the percentage of time they spent looking at various locations within the flight deck, including OTW, at their instruments, CDU, their crewmember, or "other." Pilots' average estimated dwell times at each looking location (e.g., OTW, instruments) are shown in Figure 23 by Data Comm condition and pilot role. Dwell times at each looking location were analyzed using ANOVA that tested for main effects and interactions of Data Comm condition and pilot role. The Bonferroni correction was applied to the p-values to counteract the increased risk of Type I error with the use of multiple tests. The ANOVA found no significant main effects or interactions of Data Comm condition or pilot role on estimated dwell time at the CDU, or at other locations within the flight deck. Comparing pilots' actual total gaze-dwell time to their estimates, however, shows that pilots overestimated the time they spent looking down at the CDU (recall that PMs alone actually looked down 13% of the time in both conditions). In both Data Comm conditions, PFs and PMs estimated they spent the most time looking at their flight instruments, followed by the CDU, then OTW. Pilots estimated they spent the least amount of time looking at the other pilot in their flightcrew and at "other."



Note that percentages may not add up to 100 because some pilots' estimates did not add up.

Figure 23. Pilot estimates of percent dwell time by Data Comm condition and flight deck location.

3.2.2 Data Comm Procedures

Flightcrews were asked to follow recommended SOPs for Data Comm, which differed by condition: During the text-only condition, it was recommended that flightcrews follow the procedure described in the GOLD—that is, for both pilots to silently read the Data Comm message and then agree on the appropriate action before initiating a response. During the text+speech condition, we recommended that flightcrews follow a simplified version of the GOLD procedure, in which both pilots listened to the message—but only the PM would need to read it—before agreeing on the appropriate action.

The SOP for text-only Data Comm is considered necessary to safeguard pilots against misreading Data Comm messages. We expected pilots to agree that this SOP was necessary for avoiding misinterpretation of the message, but we were also interested in whether they followed it throughout the scenario. The SOP for text+speech Data Comm was expected to simplify inter-crew communication (but this was difficult to measure objectively), and we expected pilots to find this procedure feasible and acceptable.

Flightcrew opinions on the SOPs were obtained from the post-experiment questionnaire.

3.2.2.1 Text only

With regard to SOPs for the text-only condition, pilots were asked to provide feedback on the following questions or statements:

- With a text display ONLY, it is operationally necessary for both crewmembers to silently and individually read the Data Comm message and reach consensus to avoid misinterpretation [Response options included: Strongly Disagree, Disagree, Undecided, Agree, Strongly Agree]
- How often did you use the GOLD procedure (silent and individual read, confer, then respond) during the TEXT-only condition? [Response options included: Never, Rarely, Sometimes, Often, Always]

Pilots' ratings of the necessity of the GOLD procedure are shown in Figure 24. As predicted, most pilots agreed or strongly agreed that the procedure was necessary when communication was with text-only Data Comm.

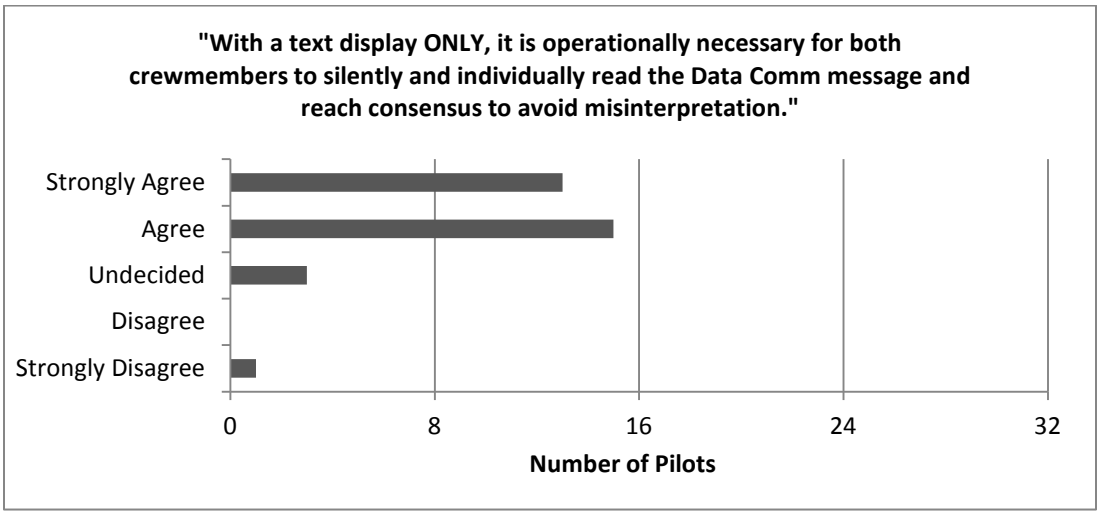


Figure 24. Pilot ratings of the necessity of the GOLD procedure for text-only Data Comm.

Pilots' feedback on their use of the GOLD procedure is shown in Figure 25. Most pilots reported using the GOLD procedure often or always.

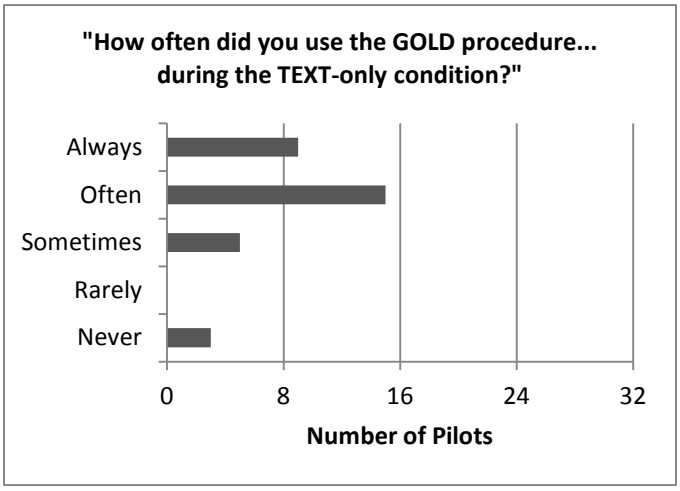


Figure 25. Pilot ratings of use of the GOLD procedure for text-only Data Comm.

If pilots did not always use the GOLD procedure, they were asked to "describe why." Pilots provided their answers via free response. Common answers are paraphrased below:

- Distracted and/or busy (n=3)
- Read the message out loud (n=7), sometimes unintentionally (n=4; the other 3 did not say whether it was intentional or not)
- Prefer to communicate about the message verbally (n=4)

The last bullet seems to be related to Crew Resource Management (CRM); these pilots preferred to read/interpret the Data Comm messages as a team rather than first read them individually. An example of this type of comment is provided below:

> "Thought it was better to work as a team to determine the intent of the message. I think as the system becomes more ingrained with experience the GOLD procedure might be more common, but until then I think CRM is better served doing together as much as feasible."

Pilots were also asked to describe, via free response, how they communicated with their crewmember about the Data Comm message when they did not use the GOLD procedure. Most pilots commented that they read the Data Comm messages out loud and/or discussed them instead of reading silently. A few examples are provided below:

- "I read the message aloud to him, then confirmed that he understood the message"
- "Communicated actions after/as reading the message"
- "Verbally. Reading/Verifying together"

3.2.2.2 Text+speech

With regard to procedures for text+speech Data Comm, pilots were asked to rate their agreement with the following statement: "With computer-generated speech AND a text display, it is operationally acceptable for only one crewmember to read the text message after both crewmembers listen to the computer-speech message before taking action." Pilot ratings are shown in Figure 26. As the figure shows, most pilots agreed or strongly agreed that the SOPs for text+speech Data Comm were acceptable, but there were also several pilots who were undecided or disagreed.

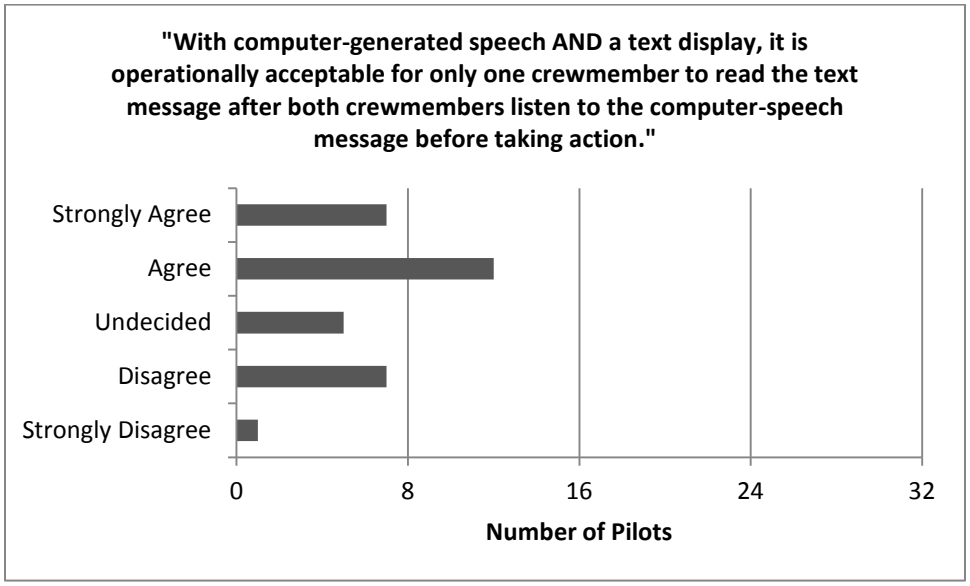


Figure 26. Pilot ratings of the acceptability of SOPs for text+speech Data Comm.

We were interested to see if the pilots who disagreed were from major airlines or not, since pilots from major airlines may have more extensive CRM training programs. Ratings are shown in Figure 27 by major airline experience. There were thirteen pilots who did not agree that the simplified SOPs

were acceptable, and all but one (n=12) of these pilots were from major airlines. Of these 12 pilots, 6 (50%) also had Data Comm experience. Five of the thirteen crews provided comments about why they felt the SOP was not acceptable; comments indicated that pilots felt both crewmembers should read and/or verify the content of the spoken message.

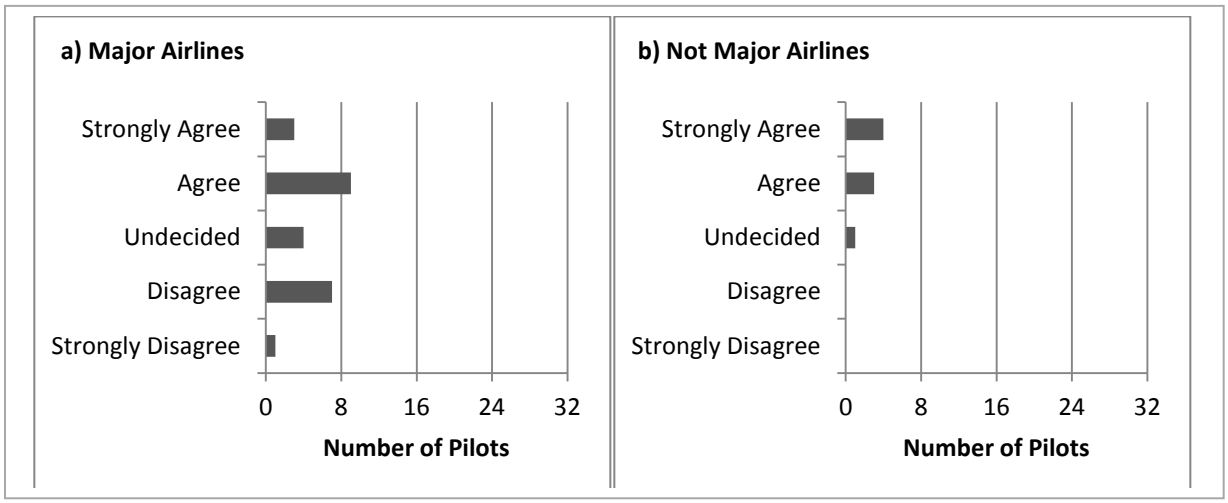


Figure 27. Pilot ratings of text+speech SOPs by major airline experience.

3.2.3 Back-Paging

When Data Comm messages are long and span multiple pages on the CDU, flightcrews may need to go back to previous pages ("back-page") and reread the content in order to remember the clearance before responding. It was predicted that flightcrews would back-page less often in the text+speech condition than in the text-only condition, because the addition of speech would help crews to remember the clearances. Back-paging was defined as the number of times the flightcrew *re*opened a message page before acknowledging (e.g., Wilco) the message, and was only calculated for messages that spanned more than one page. A Wilcoxon matched-pairs signed-rank test yielded no difference in the amount of back-paging between conditions.

3.2.4 Printing

The crew members could print messages on the flight deck as needed. Some crews were previously trained by their carrier to print each Data Comm message for review and/or reference. Here, it was expected that crews would print less often in the text+speech condition than in the text-only condition because the speech would provide an additional memory cue. A Wilcoxon matched-pairs signed-rank test revealed no significant difference in the amount of printing by Data Comm condition. On average, crews printed five (of twenty) messages in both conditions. There were no significant differences in printing between messages. It should be noted that flightcrews in this study may have been accustomed to printing as part of their company SOPs. Nine crews had at least one crewmember with Data Comm experience and of these, six crews had a crewmember who indicated he or she typically printed Data Comm messages for review (but note that there was no difference in printing between conditions for crews with Data Comm experience or crews without Data Comm experience). It

may take time for flightcrews to overcome ingrained printing procedures and to adjust to the novel text+speech technology. With more practice, flightcrews may realize that they need to print less with text+speech Data Comm than with text-only Data Comm.

3.2.5 Usability and Acceptability

Pilot opinions regarding usability and acceptability were gathered from the post-scenario and post-experiment questionnaires. It was expected the pilots would find the text+speech Data Comm system easy to use, helpful, and not distracting. (Note that "easy to use" differs from the topic of communications workload described earlier, which focused specifically on the ease of *communicating* with the display.) Pilots were also expected to prefer text+speech Data Comm over text-only Data Comm. This section concludes with some very preliminary, indirectly derived design considerations.

3.2.5.1 Easy to Use

Information about the ease of using the system was gathered from the post-scenario questionnaires, which were filled out twice—once after the text-only scenario and once after the text+speech scenario. Using a five-point scale with endpoints "strongly disagree" and "strongly agree," pilots were asked to rate the following statements:

- I imagine that most people would learn to use the system quickly
- I found the system easy to use
- I trusted the system

Figure 28, Figure 29, and Figure 30 show pilots' ratings for each question by Data Comm condition. In the figures, the y-axis shows each rating (e.g., "strongly agree") and the x-axis shows the number of pilots who provided each rating. As the figures show, most pilots agreed or strongly agreed that both systems were easy to learn and use, and that they trusted the systems. Wilcoxon matched-pairs signed rank tests found no significant differences between pilots' ratings of the two systems, S(1) ranged from -13 to -18, all $p > 10$.

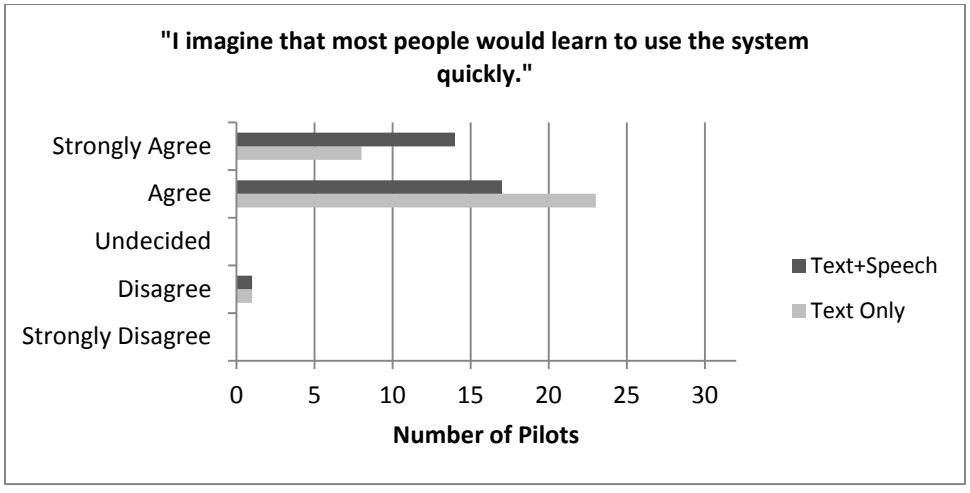


Figure 28. Pilot ratings of learning to use the Data Comm system by condition.

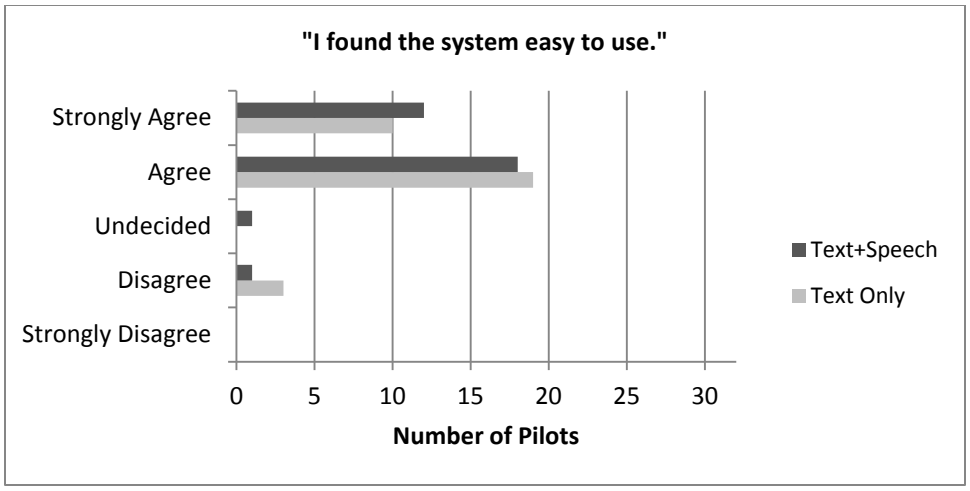


Figure 29. Pilot ratings of Data Comm system ease-of use by condition.

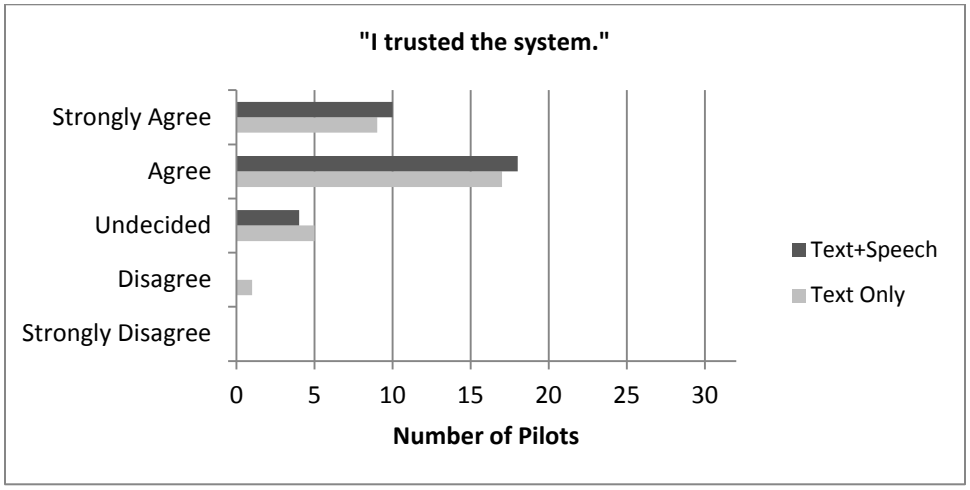


Figure 30. Pilot ratings of trust in the Data Comm system by condition.

3.2.5.2 Helpful

Information about the helpfulness of the Data Comm systems was obtained from the post-experiment questionnaire, which was filled out after both scenarios were completed. Using the same five-point rating scale as above ("strongly disagree" to "strongly agree"), pilots rated the following two statements:

- The text display is helpful
- The computer-generated speech in addition to the text display is helpful

The ratings of each Data Comm display are shown in Figure 31. A Wilcoxon matched-pairs signed rank test found no significant difference between pilots' ratings of the text-only vs. text+speech display, $S(1) = 5$, $p = .81$. Pilots generally agreed or strongly agreed that both displays were helpful.

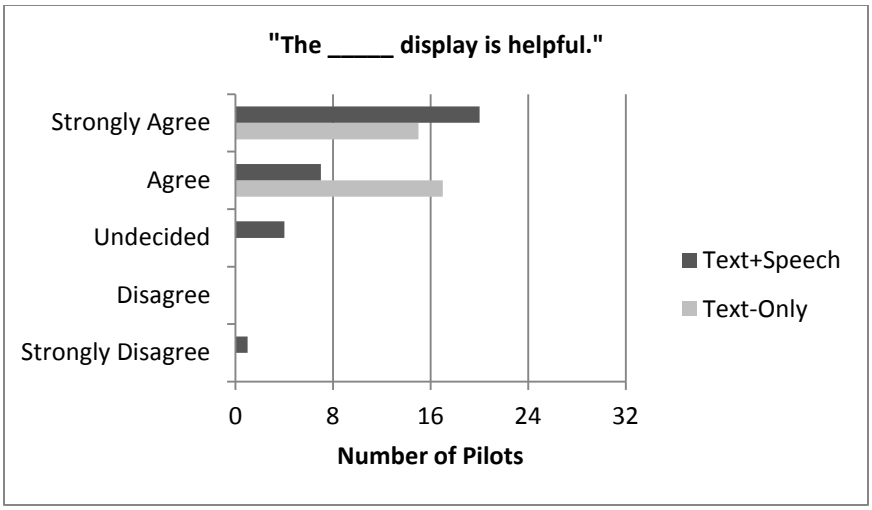


Figure 31. Pilot ratings of the helpfulness of the Data Comm display by condition.

Note that there were five pilots who did not agree that the text+speech display was helpful (four who were "undecided" and one who "strongly disagreed"). We wondered whether it was the major-airline pilots who did not find the text+speech display helpful, maybe because of their familiarity with text-only Data Comm. Another reason could be a general resistance to increasing aural stimuli in the already crowded acoustic environment on an advanced flight deck. Figure 32 shows the ratings for major and non-major airline pilots (in the figure, parts a and b, respectively). As the figure demonstrates, the five pilots who did not think the text+speech display was helpful were indeed pilots from major airlines. Three of these five pilots (60%) also had Data Comm experience. To further examine differences in ratings by major airline experience, we conducted two additional Wilcoxon matched-pairs signed rank tests: one on major airline pilots and one on non-major airline pilots. The results of both tests were nonsignificant, indicating that neither group found one Data Comm display to be more helpful than the other. That is, even though some major airline pilots did not agree that the text+speech display was helpful, the opinions of these pilots were not enough to influence the overall opinion of the entire group.

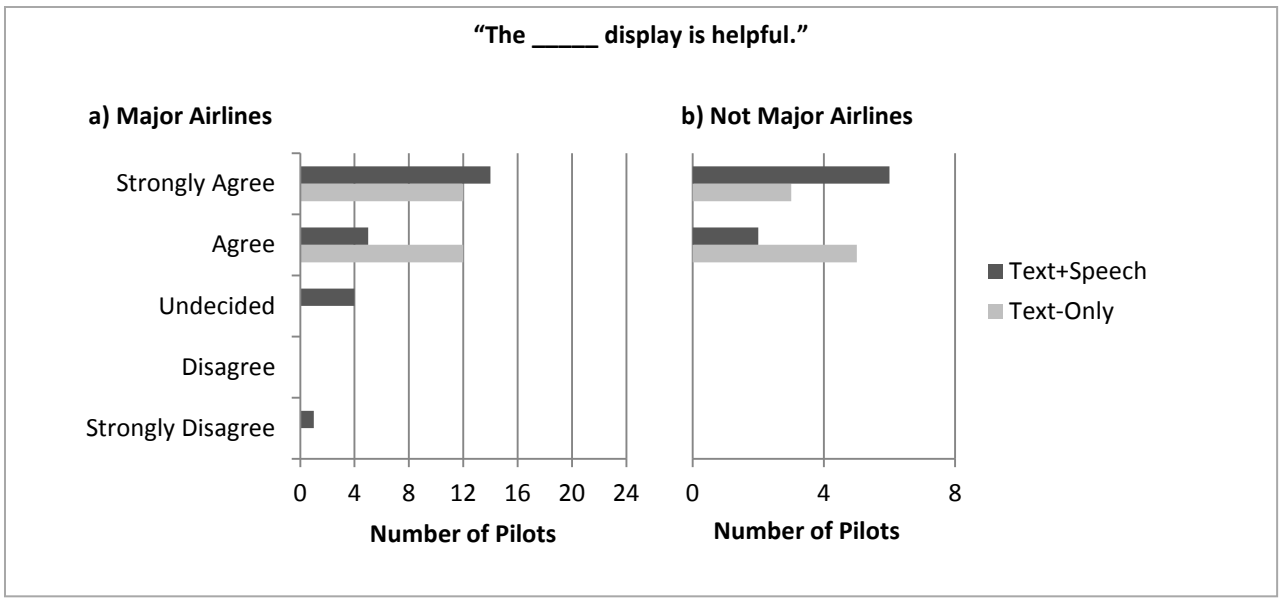


Figure 32. Pilot ratings of the helpfulness of the Data Comm display by condition and major airline experience.

3.2.5.3 Not Distracting

On the post-experiment questionnaire, pilots were asked to rate their agreement with the statement, "The computer-generated speech in addition to the text display is distracting." Pilots' ratings are shown in Figure 33. As the figure shows, most pilots disagreed or strongly disagreed with this statement, indicating that they did not find the speech to be distracting.

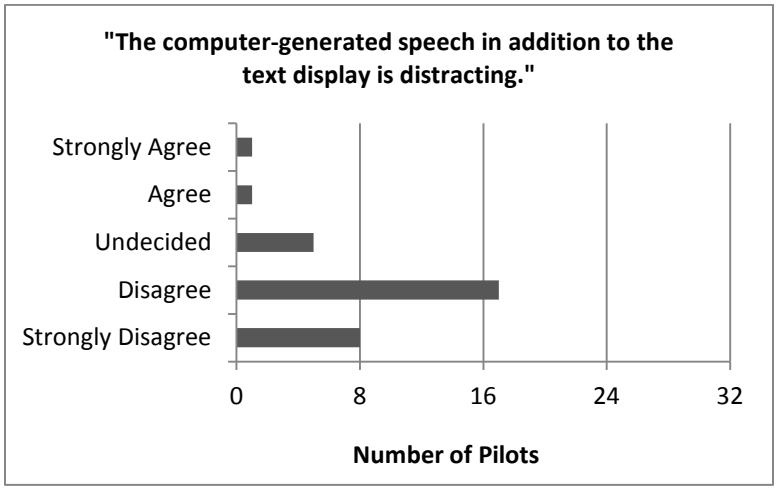


Figure 33. Pilot ratings of whether the synthetic speech was distracting.

Note that there were again some pilots who did *not* disagree that the speech was distracting (five were undecided, one agreed, and one strongly agreed), and we were interested in whether these pilots were from major airlines or not. The ratings from major airline pilots and non-major airline pilots are shown separately in Figure 34 (parts a and b, respectively). The figure shows that the five pilots who were undecided about whether the synthetic speech was distracting included both major (n=3) and non-

major (n=2) airline pilots. These pilots also had a mix of Data Comm experience; 2 of the 3 major airline pilots and 1 of the 2 non-major airline pilots had experience with Data Comm. The two pilots who felt that the speech was distracting (providing a rating of “agree” or “strongly agree”) were both major airline pilots, one of which had Data Comm experience.

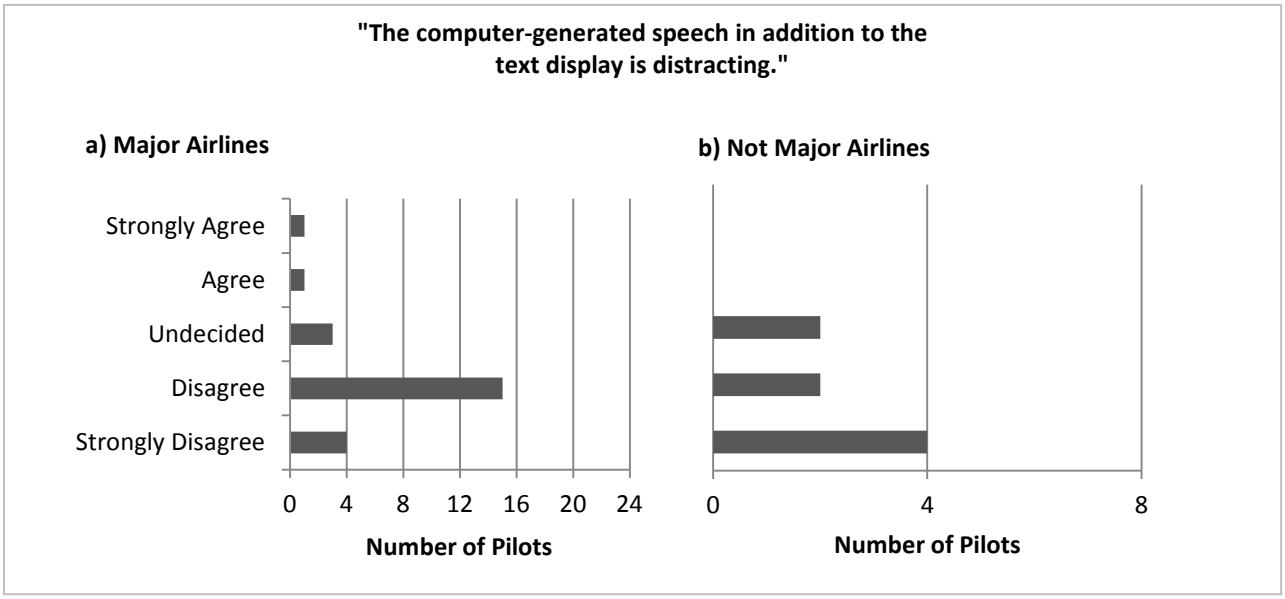


Figure 34. Pilot ratings of whether the synthetic speech was distracting by major airline experience.

3.2.5.4 Pilot Preferences

Pilots were asked about their preferences for the Data Comm displays on the post-experiment questionnaire. They were asked about their preferences in three ways:

- Whether they preferred the text display or the synthetic speech alone (e.g., a preference for the text-only or an imagined speech-only display)
- Whether they preferred either display (text-only and/or text+speech) over a live controller
- Overall preference for communicating with ATC

To obtain pilot preferences of the text display and speech alone, pilots were asked to rate their agreement with two statements:

- I prefer the text display only, without the computer-generated speech
- I would prefer the computer-generated speech only, without the text display

Pilot ratings of these statements are provided in Figure 35 and Figure 36, respectively. As the figures show, the majority of pilots disagreed or strongly disagreed with a preference for the text display alone and for the synthetic speech alone.

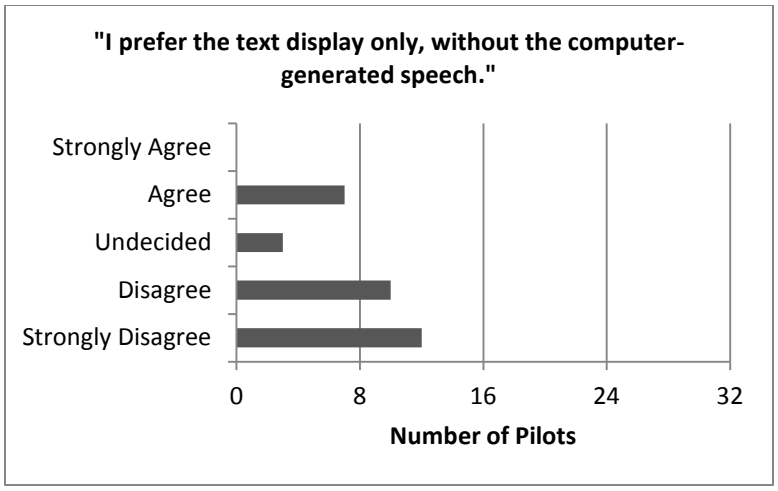


Figure 35. Pilot ratings of a preference for the text display only.

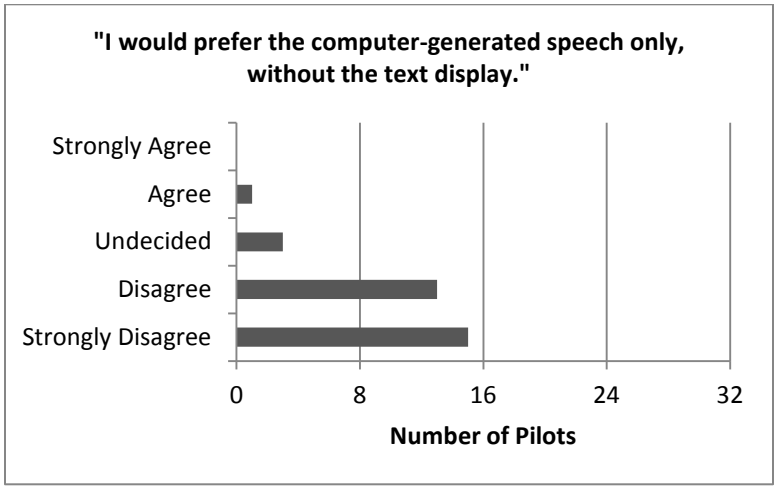


Figure 36. Pilot ratings of a preference for the synthetic speech only.

Note that there were 10 pilots who did *not* disagree with a preference for text only (7 agreed and 3 were undecided) and 4 pilots who did *not* disagree with a preference for the synthetic speech only (1 agreed and 3 were undecided). As in the previous sections, we were interested in classifying the ratings by major and non-major airline pilots. The preference ratings are shown by airline type in Figure 37 for the text-only display and Figure 38 for the fictitious synthetic-speech-only display. The figures show that for both the text display and the synthetic speech, the pilots who did not disagree (i.e., were undecided or did show a preference) were major airline pilots. Of the 10 major airline pilots who did not disagree with a preference for text only, 4 (40%) had Data Comm experience.

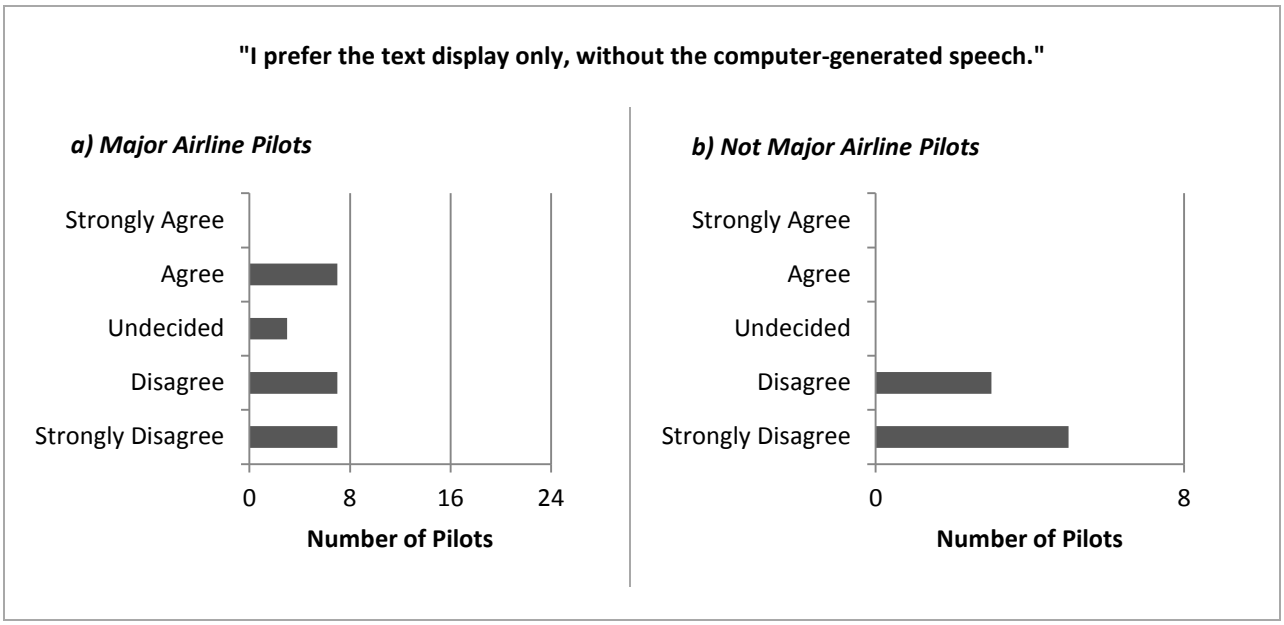


Figure 37. Pilot ratings of a preference for the text display only by major airline experience.

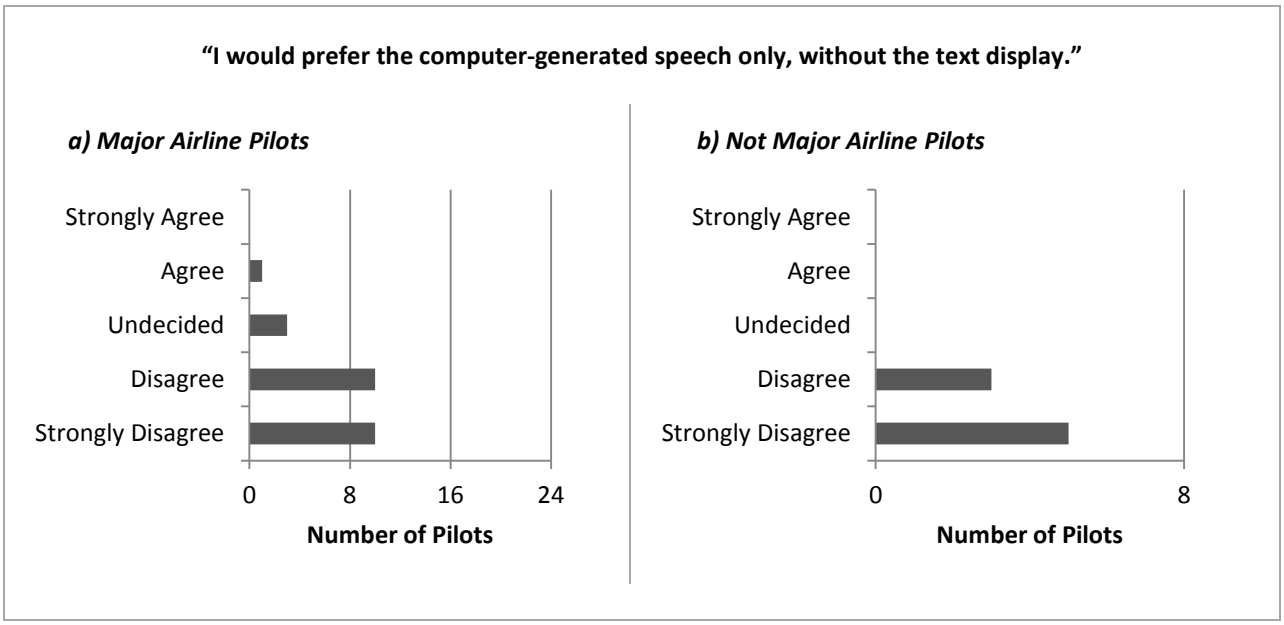


Figure 38. Pilot ratings of a preference for the synthetic speech only by major airline experience.

After rating their preferences for the text display and the synthetic speech individually, pilots were asked to rate their preferences for each Data Comm display, text only or text+speech, compared to communicating with a live controller. The following statements were rated using the five-point agreement scale:

- Compared to a live controller, I prefer to communicate with ATC using ONLY the text display WITHOUT the computer-generated speech
- Compared to a live controller, I prefer to communicate with ATC using the text display AND the computer-generated speech

The ratings for these statements are provided in Figure 39. As the figure shows, pilots' preferences varied. There were 15 pilots—all from major airlines—who either preferred text-only Data Comm or had no preference; 6 of those 15 (40%) had Data Comm experience. As for text+speech, there were 20 pilots—17 from major airlines—who either did not prefer text+speech or had no preference, 8 of whom (40%) had Data Comm experience. A Wilcoxon signed rank test revealed that the more favorable comparison of text+speech with live ATC communications vs. the comparison with text only was marginally significant, $S(1) = -49.5$, $p = .08$. We also ran Wilcoxon tests separately on ratings by major airline pilots and ratings by non-major airline pilots. The results showed no significant differences in preferences from major airline pilots, $S(1) = -10.5$, $p = .61$. As can be seen in Figure 40, pilots' ratings from major airlines varied in their preferences for both text-only and text+speech Data Comm. The same figure shows that the results for non-major airline pilots were more consistent, with a higher preference for text+speech compared to live ATC than for text-only Data Comm, $S(1) = -7.5$, $p = .06$.

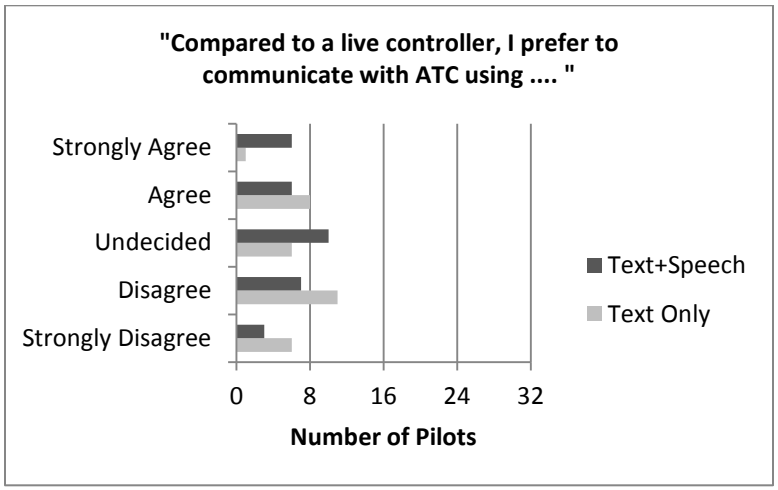


Figure 39. Pilot ratings of Data Comm preferences compared to communicating with live ATC.

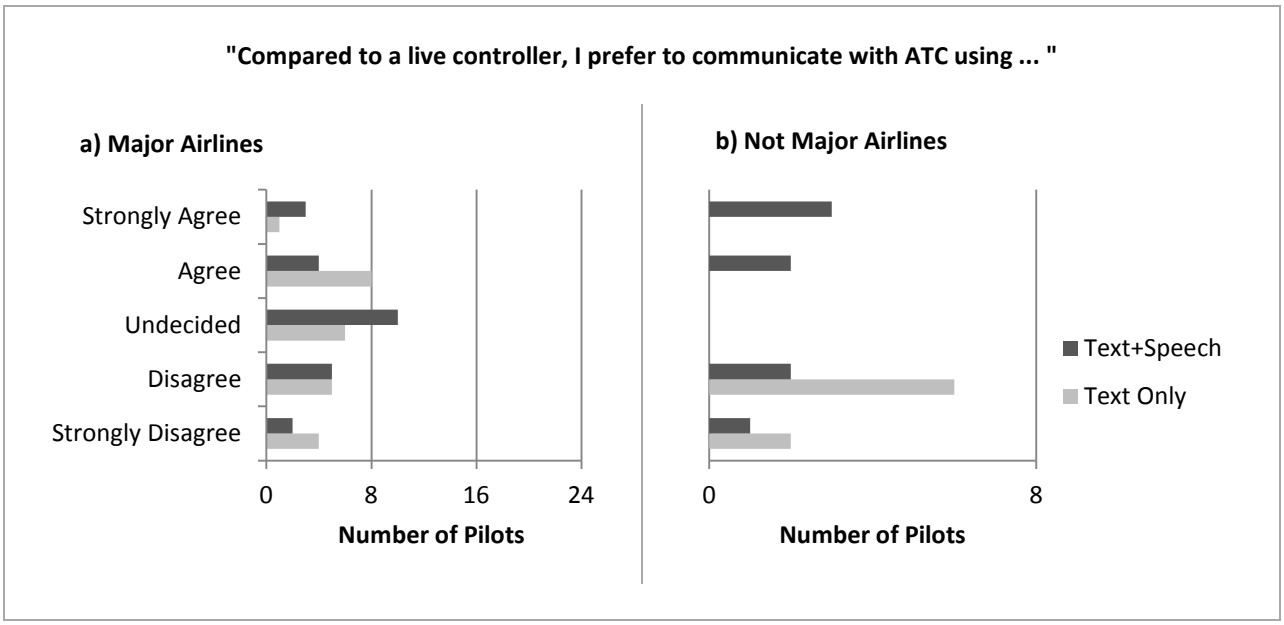


Figure 40. Pilot ratings of Data Comm preferences compared to communicating with live ATC by major airline experience.

Lastly, pilots were asked to provide their overall preference for communicating with ATC by completing the statement, "If I had to choose one way to communicate with ATC, I would prefer...". Pilots could pick between one of four response options:

- A live controller only
- The Data Comm text-only display ONLY (with a live controller as needed)
- The Data Comm computer-generated speech display ONLY (with a live controller as needed)
- The Data Comm text AND computer-generated speech display (with a live controller as needed)

Pilots' ratings are provided in Figure 41. The majority of pilots preferred to communicate with ATC using text+speech Data Comm.

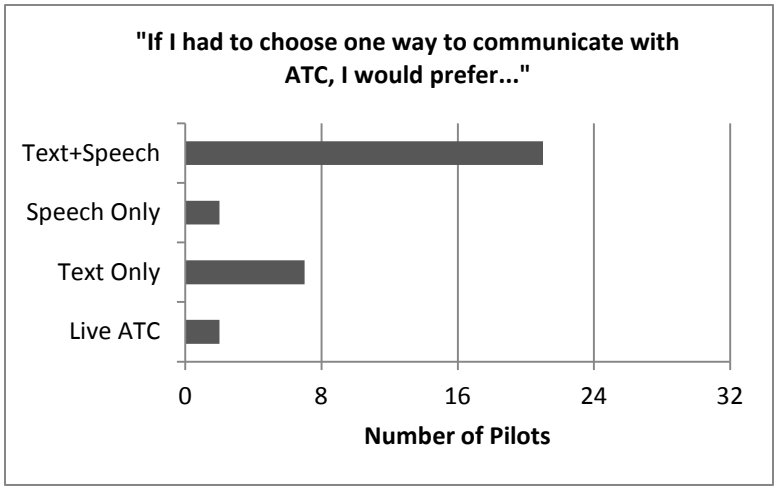


Figure 41. Pilots' overall preferences for communicating with ATC.

Note also that seven pilots said they preferred communicating with text-only Data Comm. We were again interested to see which pilots—those from major or non-major airlines—had preferences for text-only vs. text+speech Data Comm. Figure 42 show preferences by airline type. As in previous sections, all seven pilots who preferred text-only Data Comm were pilots from major airlines. Four of these seven pilots also had Data Comm experience. Even with the preferences of these seven pilots, the overall preference for text+speech predominated for the major airline pilots as well as the non-major airline pilots. Additional questionnaire data are provided in Appendix G.

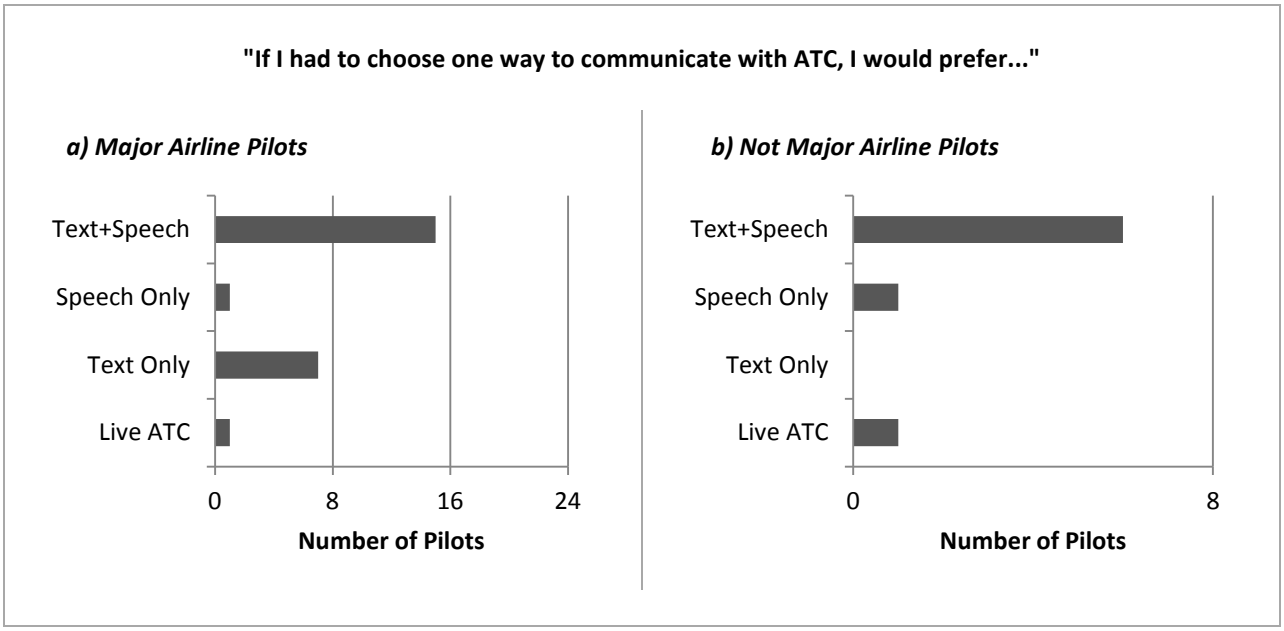


Figure 42. Pilots' overall preference for communicating with ATC by major airline experience.

3.3 Participant Observations on System Implementation

The combined results of the two phases of research showed high acceptance and potentially beneficial effects of adding synthetic speech to text Data Comm, regardless of whether the system was implemented on a dedicated, custom-designed display or a legacy multi-function CDU. Despite the somewhat clumsy but realistic implementation on the CDU requiring multiple keypresses in Phase II, acceptance of the system was still high (note, however, that this may depend on the availability of a pilot communicating). Moreover, the results of the current study seem to indicate that the presence of synthetic speech may give some relief from potentially cumbersome procedures requiring both pilots to read messages independently and silently before discussing and then acting on them, with most pilots feeling that a simplified procedure was acceptable for the text+speech condition. Finally, several pilots commented on the desirability of an on/off button affording the choice of (de)selecting the synthetic speech for all or part of a flight. One pilot specifically commented that he would reserve synthetic speech for flights involving crew fatigue. Other crews commented that text+speech may be helpful during periods of low workload (e.g., during cruise) but should be turned off during periods of high

workload (e.g., descent) because it could become a distraction (see Appendix G: Additional questionnaire data for the full set of pilot comments).

4. Discussion

4.1 Summary of Results

Data Comm is expected to yield several safety and efficiency benefits in the National Airspace System (NAS): it may alleviate frequency congestion, reduce problems associated with speech rate and accent, reduce call-sign confusions, reduce pilots' reliance on memory, and reduce errors and workload by allowing some clearances to be loaded into the FMS with the push of a button or two. Data Comm may also facilitate the communication of complex information in other NextGen applications.

The success of Data Comm, however, likely depends on its implementation. Given that Data Comm requires pilots to interact with a display (typically outside one's primary field of view), this may yield an operationally significant increase in head-down time, with potentially negative consequences for both safety and efficiency. Here, we examined the feasibility of implementing an auxiliary synthetic speech display in the en-route environment with a two-person flightcrew. Our main interest was whether such a display may mitigate some of the challenges associated with Data Comm. Specifically, we examined whether a text+speech display, compared to a text-only display, aids two-pilot crew performance (e.g., reducing head-down time) without introducing additional complications (e.g., disrupting other on-board communications).

In general, the results indicated that an auxiliary synthetic speech display aided the performance of two-pilot crews compared to a display with text only, replicating many of the results from past research (Lancaster & Casali, 2008; Lennertz et al., 2012a-Phase I). Recall our expectation that crews in the text+speech condition would spend less time looking down at the CDU, since the message was annunciated. An examination of concurrent head-down time for both the Captain (i.e., PF) and First Officer (i.e., PM) showed that while crews looked down more often in the text+speech condition than the text-only condition, the duration of these glances was shorter with the auxiliary synthetic speech display. This suggests that while the presence of speech initially draws pilots' attention to the display, pilots required shorter glances to comprehend the message. A similar benefit for single pilots was observed in Phase I (A comparision of Phase I and Phase II results is shown in Table 8).

When crews spend more time interacting with the CDU to communicate with ATC, they likely spend less time looking at the instrument panel or out the window. In the NextGen environment, Data Comm is one of many displays and applications that will compete for pilots' attention. NextGen flight decks may be equipped with a CDTI that is used to perform new applications such as ITP or IM. It is envisioned that these applications may occur simultaneously with Data Comm. How the flightcrew will allocate their limited resources across such applications remains an open question. Hence, any additional time spent looking at the CDU for Data Comm, rather than elsewhere on the flight deck, is operationally relevant.

Importantly, the auxiliary synthetic speech display did not appear to harm crew performance in the en-route environment. Crews in both Data Comm conditions tended to respond correctly to the

countermanded clearance (replicating Phase I). The presence of the auxiliary synthetic speech display may, however, have affected intracrew communication and coordination. Compared to the text-only condition, crews in the text+speech condition tended to be about two seconds slower to acknowledge a Data Comm message via the CDU. This delay may have occurred because the flightcrews waited for the speech to finish before acknowledging the message (as was observed in Phase I).[13] It is unlikely, however, that this difference in response time between the two conditions would have a detrimental effect on safety or efficiency.

Surprisingly, the presence of the party line did not impact crews' responses to the receipt of a new text+speech message. Crews did not delay opening or acknowledging a text+speech message when the party line was active. In many instances, crews intentionally stepped on the party line by activating the synthetic speech. This might have suggested that crews were ignoring the chatter on the party line. However, several crews commented on relevant information such as weather, turbulence, or the routing of nearby traffic heard on the party line (e.g., "…there was a report of moderate turbulence, is that along our route?" and "Where was that United reported smooth?").[14] Given that our experiment scenario was flown in the en-route environment using autopilot, we did not expect an immediate change to the flight path based on a Data Comm message. Consequently, flight compliance data were not examined.

Contrary to our expectation, crews in the text+speech condition were just as likely to print and review messages as crews in the text-only condition. This may, however, be due to the novelty of the display and/or the need to document communication with ATC (several crews mentioned that they printed messages as a record of communication, possibly due to an SOP required by their company).

Lastly, subjective data indicated that the presence of auxiliary synthetic speech did not affect crews' communications workload, and in some cases, crews preferred to communicate with the text+speech display compared to text only. Crews did not express difficulty communicating with a live controller in either condition; rather crews reported communicating with a live controller was easy in both conditions. In general, crews also reported that it was easier to communicate with text+speech than with text only, but agreed that communication was easy in both conditions. Moreover, the majority of pilots reported the text+speech display was easy to use, helpful, and not distracting[15]—replicating Phase I results. These preferences, however, may have been a function of flightcrew experience. Pilots from major carriers were less likely to rate the text+speech display as helpful and not distracting; about 50% of these pilots had Data Comm experience. These results suggest pilots from major airlines may be more resistant to the addition of a new text+speech application on the flight deck. This resistance may be due to prior Data Comm experience, differences in operations or demographics.

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[13] This result is contrary to Lu et al. (2012), and may be attributed to differences in recommended procedures for the receipt of a Data Comm message.

[14] A full analysis of crews' use of meaningful information heard on the party line is beyond the scope of this paper.

[15] In fact, as one pilot stated, voice communications may help keep flightcrews alert on long or uneventful flights (which has potential safety implications). One negative consequence of text-only Data Comm is that the silent communication from ATC may remove this alerting benefit, while implementation of a text+speech Data Comm display may preserve it (see Section 4.2 Limitations and Future Research).

Beyond the original scope of the project, the combined phases provide some indications with regard to the implementation of text+speech Data Comm systems, which may help FAA aircraft certification with the evaluation of systems. High acceptance and potentially beneficial effects of the text+speech system were observed, regardless of implementation on a dedicated, custom-designed display or a legacy multi-function CDU. Moreover, the results of the current study suggest that the presence of synthetic speech may offer some relief from potentially cumbersome procedures requiring both pilots to read messages independently and silently before discussing and then acting on them. Most pilots felt that a simplified procedure was acceptable for the text+speech condition. Finally, several pilots commented that synthetic speech should be selectable for all or part of a flight. One pilot commented that he would reserve synthetic speech for flights involving crew fatigue. Other crews commented that text+speech may be helpful during periods of low workload (e.g., during cruise) but should be turned off during periods of high workload (e.g., descent) because it could become a distraction (see Appendix G for the full set of pilot comments).

In sum, the results offer several indications that the implementation of a text+speech Data Comm display, relative to a text-only display, may yield safety and efficiency benefits on the flight deck (e.g., reduced head-down time), without introducing negative consequences (e.g., a delay in acknowledging a message, or disrupting on- and off-board communications). Note, however, that the data collected, the observations made, and any conclusions drawn are sole responsibility of the authors.

Table 8. A comparison of the Phase I and Phase II results.

Do no harm			
Variable	**Main concerns**	**Phase I results**	**Phase II results**
	Compared to text only…		
Step ons	Crews in the text+speech condition will delay opening or acknowledging messages that are received when the party line is active.	n/a	Not confirmed.
Response time	Crews in the text+speech condition will be slower to acknowledge a Data Comm message via the CDU because they wait for the voice to finish the message before acknowledging.	Confirmed.	Confirmed.
Countermanded clearance	Crews in the text+speech condition will be more likely to respond incorrectly to the countermanded clearance.	Not confirmed.	Not confirmed.

Perceived communications workload	Auxiliary synthetic speech will not affect crews' communications workload.	Confirmed.	Confirmed.
Help, if you can			
Variable	**Main predictions**	**Phase I results**	**Phase II results**
	Compared to text only…		
Head-down time	Crews in the text+speech condition will spend less time looking down at the CDU.	Confirmed.	Confirmed.
Printing	Crews in the text+speech condition will be less likely to print messages.	n/a	Not confirmed.
Message review (i.e., back-paging)	Crews in the text+speech condition will be less likely to review the message (i.e., back-page)	n/a	Not confirmed.
Usability & acceptability	Pilots will prefer to communicate using the text+speech display compared to the text-only display. Pilots will find the text+speech display helpful, easy to use, and not distracting.	Confirmed. Confirmed.	Confirmed. Confirmed.

4.2 Limitations and Future Research

In several ways, the current study broadened the possible application of the Phase I results to presumably more imminent Data Comm implementations. Here, commercial (rather than GA) pilots flew on autopilot (rather than by hand) in a realistic en-route (rather than terminal) environment. Participants interacted with Data Comm using a legacy display on the CDU, and unlike Phase I, this display was not a touch screen and did not include color-coded response keys.

Nonetheless, the current study had several inherent biases, some of which may have caused pilots to favor text+speech compared to text only. First, we did not include a baseline voice-only condition (representing current-day operations with a live controller). We assumed that Data Comm will indeed replace voice for non-time critical communications in the NextGen en-route environment (making the baseline comparison less relevant).[16] The lack of a baseline condition, however, may have

[16] In addition, past research has compared flightcrew performance with a live controller condition to a (text-only) Data Comm condition. See Lennertz et al. (2012) for a review.

biased crews to favor text+speech due to its similarity with voice-only operations. Counter to this argument stands the fact that the less experienced non-major airline pilots who should be less vested in voice communications showed an even stronger preference for text+speech than the major-airline pilots. It remains unclear how crew performance might differ between a live-voice-only and a text+speech environment.

Second, the recommended crew procedures may have also biased crews to favor text+speech compared to text only. Current guidance (e.g., GOLD, 2013) specifies that in a two-person crew, each pilot should silently read the Data Comm message before conferring and responding. We briefed crews on this procedure and recommended that they follow it for text-only messages. With text+speech, we recommended that both pilots listen to the message, and that the PM read the message to verify the content before conferring and responding. The presence of the synthetic speech thereby reduced the need for each pilot to read the message silently as the procedure was inherently simpler and more similar to current voice-only procedures. This similarity could have biased crews to prefer text+speech compared to text only. However it may also be reflective of a real advantage of text+speech.

Third, some aspects of our simulator may have influenced the flightcrew to favor text+speech compared to text only. Recall that our simulator did not include TCAS or GPWS—two flight deck systems that provide aural instructions to the crew. As such, compared to real operations, our flight deck was relatively quiet, and the text+speech Data Comm display was the only system that provided annunciations. This quiet environment may have biased crews to favor text+speech compared to text only, whereas the presence of additional aural stimuli might have tempered their preference for synthetic speech. Experience with TCAS and GPWS may also underlie some of the differences observed between pilots from major and non-major airlines. Pilots from major airlines, presumably more familiar with the full scope of auditory information on the flight deck, may be more apprehensive towards the addition of a new auditory system.

Some aspects of the study may have biased crews to favor Data Comm in general, regardless of the display mode (i.e, text+speech or text only). For example, crews never initiated data communication with ATC. Crews' use of Data Comm was limited to replying to ATC messages. In real operations, crews will use Data Comm to send messages to ATC, for example to request a higher altitude or a weather deviation. To send these messages, the crew must interact with the Data Comm display and will likely select the message from a categorized list (which may be time consuming). Since crews did not down-link messages in the current study, this may have biased pilots to favor Data Comm in general.

Other aspects of our study may have biased crews to disfavor Data Comm. In particular, it required a minimum of three keypresses to review a Data Comm message in our CDU implementation. While some current implementations do require a series of keypresses to access a message, our interface was less than ideal and it may have cautioned crews against Data Comm regardless of display mode. Indeed, such reservations were expressed in the final briefings.

We also encountered several limitations in our data analyses. For example, we were unable to systematically categorize all of the procedures that crews' adopted for the review of a text only and text+speech message. While we documented flightcrew procedures to the extent practicable, crews often responded subtly to the receipt of a Data Comm message, and for text-only messages, it was often not clear when one or both of the crew members were silently reading. Thus, we could not make a firm comparison between the recommended text-only and text+speech procedures, and it remains unclear

whether the addition of an auxiliary speech display did indeed simplify crew procedures for Data Comm. Subjective data, however, indicated that pilots generally agreed that the text-only SOP was necessary. Pilots also agreed that the text+speech SOP was acceptable.

Interestingly, we did observe that some crews had difficulty adopting the silent read procedure and often began reading the message aloud before shifting to reading it silently. In addition, the procedure that a crew used for the review of a message often differed from *message to message*—seemingly based on the workload and operational environment, as expected. Many crews tailored the recommended procedures to facilitate their use. For example, some pilots pointed to the message when reading it, non-verbally indicating to their crewmember that they were reviewing it. Some crews systematically organized the printed messages (e.g., placing the most recent message by the throttle) to help keep track of the instructions.

A full analysis of the video data was beyond the resources available for this study, and this may have affected our conclusions. For example, categorizing crew responses to similar call signs, crew queries to ATC, and ATC interventions (e.g., to correct an error) would have required reviewing all of the video data. A full analysis of the video data may also further determine the extent to which crews discussed or ignored meaningful information on the party line, mainly weather information.

In addition, an analysis of flight compliance data was not carried out. Given that our experiment scenario was flown in the en-route environment (with strategic clearances) and on autopilot, we did not expect an immediate change in the flight path of the aircraft based on a given Data Comm message. Therefore we did not examine flight compliance data. Such an analysis, however, could be carried out using the NMEA data.[17]

Another limitation concerns the prior experience of our participants. In particular, our crews came from 10 different carriers (including both major and non-major). Half of the crews in each of our experiment sessions consisted of pilots from the same carrier (e.g., both the Captain and First Officer were from the same airline). Crews comprising a Captain and First Officer from different carriers may have different SOPs, for example, regarding route entry into the FMS, or verifying that information was input correctly on the instrument panel. These differences may have impacted crews' performance with the Data Comm display, regardless of display mode.

Lastly, variability regarding our participants' experience with Data Comm may have impacted our results. About thirty percent of the pilots in our experiment had experience communicating with Data Comm (e.g., in the North Atlantic or South Pacific regions). Crews familiar with Data Comm may have adopted procedures that were previously prescribed by their carrier (e.g., print and save printed messages). Crews familiar with text-only Data Comm may prefer this implementation over text+speech due to their past experience.

Future work may control for some of these limitations and further analyze the data. Also, neither of our studies addressed the issue of "autoload" and the potential that only part of a clearance containing multiple instructions would be loadable, in fact increasing flightcrew workload and the potential for error (see Pepitone, Letsu-Dake, & Ball, 2013). Such cases could provide an additional role

[17] This decision was also based on resource restrictions. In addition to the effort required for the main analysis, NMEA data requires extensive reformatting before analysis.

for text+speech, where the speech may underscore the length of a clearance. This may also be an advantage for clearances that span several pages. On the other hand, there may be limits to the acceptable length of voice annunciations, especially when they contain longitudes and latitudes. Future research could explore the utility of using the synthetic speech for telling pilots what to look for (e.g., "New route clearance received in Data Comm"). The potential benefit of auxiliary speech in keeping crews alert on long flights could also be explored. One of the major-airline PMs in the study remarked that he may keep the voice off during day flights, but would always turn it on whenever either pilot reported fatigue and on "red-eye" flights. This further underscores the fact that the presence or absence of synthetic speech should be selectable, as implemented but not tested against the alternative in the current study.

Another avenue for future research is the interaction between major/non-major carriers and the implementation of a text+speech Data Comm display. Our preliminary results indicate that pilots from major carriers were *less likely* to rate the text+speech display as helpful and not distracting compared to pilots from non-major carriers. It appears that pilots from major carriers, and potentially those with prior Data Comm experience, may be more resistant to the implementation of a text+speech Data Comm display. Any future studies should be performed on a flight deck equipped with the appropriate aural alerting systems (e.g., TCAS and GPWS). On an additional methodological note, the use of an eye tracker (instead of video, explored in both phases but rejected due to unavailability of effective equipment) to code head-down time may permit further study of pilots' eye movements and scan patterns as a window to how synthetic speech affects their allocation of visual attention.

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6. Appendices

6.1 Appendix A: Participant Forms

Appendix A contains the:

- Informed Consent Form
- Withdrawal Form
- Debriefing Form

Informed Consent Form

Data Comm and Computer-Generated Speech Study
US Department of Transportation (DOT) Volpe Center

This study is being conducted by the John A. Volpe National Transportation Systems Center, United States Department of Transportation (USDOT), and is being led by Dr. Judith Bürki-Cohen. The USDOT Volpe Center is funded by the Federal Aviation Administration, Human Factors Division.

Purpose of Study. In the future, some of the voice-radio communications used by pilots and controllers today are going to be replaced by text messages. These text messages are called Data Comm. The design and procedures for Data Comm are still under development. This study explores the option of supplementing Data Comm text messages with computer-generated speech. In this experiment, you will fly scenarios in the Boeing 737 simulator. During the scenarios, you will receive and respond to Data Comm messages from ATC using the Data Comm page on the CDU. We will also ask you to fill out online questionnaires between flights in the simulator.

Procedure. The entire experiment is expected to take about six hours.

Discomfort and Risks. Overall risk involved with participating in this study is low. However, since the experiment takes place in a simulator, some participants may experience symptoms of "simulator sickness." You should immediately report any suspected adverse effects of completing the study to Dr. Bürki-Cohen (see contact information below).

Benefits to You. Participation provides you with the opportunity to aid in the development of recommendations for the design and implementation of Data Comm. We also hope that you will enjoy having a chance to experience one of the key enablers of the future Next Generation Air Traffic Management System.

Assurances and Rights of the Participant. Your participation in this experiment is completely voluntary. Your participation is strictly confidential, and no individual names or identities will be associated with any data or released in any reports. Only random numbers are used to identify pilots. We will be recording data from the simulator as well as your questionnaire responses. We will also be recording audio and video. The data will be used for experiment purposes only; we are not evaluating or judging your flight performance as a pilot. We are evaluating new systems and you are our test pilot. You may choose to terminate your participation in the study at any time. *Data provided until the point of termination will be stored and could potentially be used in the analysis*. Only individuals directly involved with the study will have access to the data.

Organization Responsible for this Study. This study is being conducted by the John A. Volpe National Transportation Systems Center, United States Department of Transportation (USDOT), and is being led by Dr. Judith Bürki-Cohen, whose contact information is below. The USDOT Volpe Center is funded by the Federal Aviation Administration, Human Factors Division. If you have any questions, please let us know. For further information about this study, please feel free to contact:

Judith Bürki-Cohen
US DOT Volpe Center, 55 Broadway, Cambridge, MA 02142
Judith.Bürki-Cohen@dot.gov (617) 494-2638

Statement of Consent. Please sign your name below so we have a record that you are voluntarily participating in this study. This document is stored separately from all other data you provide.

I have read this consent document. I understand its contents, and I freely consent to participate in this study under the conditions described.

Signature of participant _____ Date _____

Signature of experimenter _____ Date _____

Signature of witness _____

Withdrawal Form

Data Comm and Computer-Generated Speech Study

Statement of Withdrawal

I acknowledge that my withdrawal in this experiment is entirely voluntary and that I am choosing to do so. I understand that any data collected for this experiment will be deleted and in no way will I be associated with this experiment

Participant's name (please print):_____

Signature of Participant:_____ Date:_____

Experimenter:_____ Date:_____

Debriefing Form

Data Comm and Computer-Generated Speech Study

Summary

Thank you for participating in the study! Your participation will help the development and implementation of Data Communication between pilots and controllers. In the future, some voice communications will be replaced by Data Comm text messages. The purpose of this study is to examine whether the addition of computer-generated speech to the text message assists or encumbers the flight crew with their tasks.

Your participation will help to determine whether Data Comm with computer-generated speech is a viable option on the flight deck. It will also help to develop guidance for the design and implementation of Data Comm in general.

Please keep in mind that confidentiality is important to the validity of the experiment. Please do not discuss the details of this experiment with any other participants or your friends.

This study is being conducted by the John A. Volpe National Transportation Systems Center, United States Department of Transportation (USDOT), and is being led by Dr. Judith Bürki-Cohen. The USDOT Volpe Center is funded by the Federal Aviation Administration, Human Factors Division. If you have any questions or comments, please let us know.

For further information about this study, please feel free to contact:

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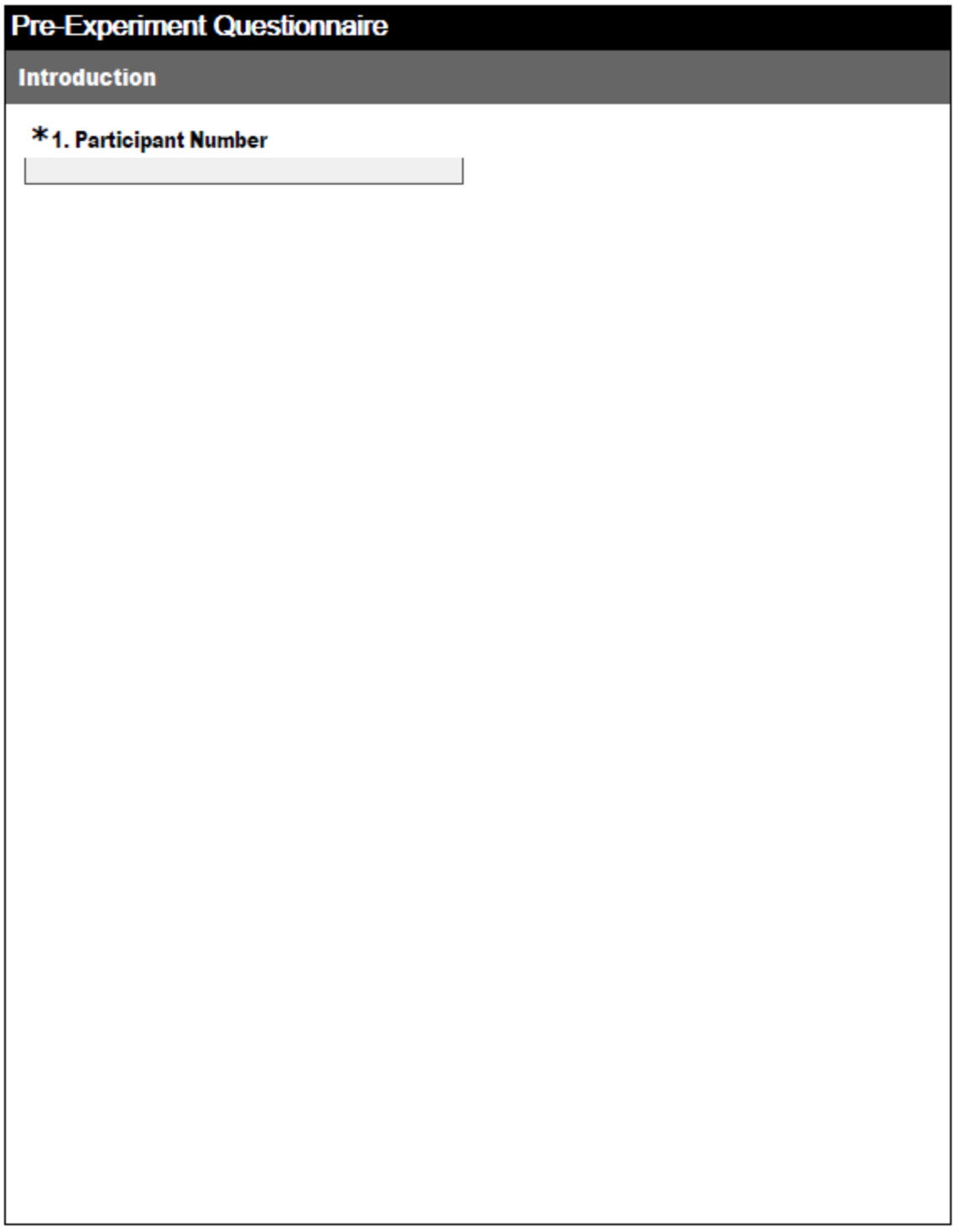
6.2 Appendix B: Questionnaires

Appendix B contains the four questionnaires administered to each participant.

- Pre-Experiment Questionnaire
- Post Text Only Questionnaire
- Post Text+Speech Questionnaire
- Post Experiment Questionnaire

Pre-Experiment Questionnaire



Pre-Experiment Questionnaire

Introduction

*1. Participant Number

Page 1

Pre-Experiment Questionnaire

Demographics

*2. What is your total flight time?

*3. How many hours do you have in a B737 (excluding simulator time)?

Page 2

Pre-Experiment Questionnaire

Current Experience

4. What air carrier do you currently fly for?

- ◯ AirTran
- ◯ American
- ◯ Delta
- ◯ FedEx
- ◯ Frontier
- ◯ JetBlue
- ◯ Southwest
- ◯ Spirit
- ◯ United
- ◯ UPS
- ◯ US Airways
- ◯ Virgin

Other (please specify)

5. Please select your current position.

- ☐ First Officer
- ☐ Captain

Other (please specify)

6. In addition to the B737, are you currently flying any other aircraft on the line?

Page 3

Pre-Experiment Questionnaire

Past Experience

7. Do you have any military experience?

- ◯ Yes
- ◯ No

Other (please specify)

Page 4

Pre-Experiment Questionnaire

Past Experience

8. If yes, please describe your past and/or current military experience.

Page 5

Pre-Experiment Questionnaire

Data Comm Experience

*9. Do you have any experience with Data Comm (e.g., FANS 1/A, ATN)?

- ◯ No
- ◯ Yes

If yes, please describe the aircraft and environment.

Page 6

Pre-Experiment Questionnaire

Data Comm Experience

***10. Does your carrier specify any procedures for Data Comm?**

- ◯ No
- ◯ Yes

If yes, please explain.

***11. Do you typically print Data Comm messages for review?**

- ◯ No
- ◯ Yes

Please share any comments.

Page 7

Pre-Experiment Questionnaire

Misc.

***12. When did you learn to speak English?**

- ☐ Before age 5
- ☐ After age 5

***13. Confirm that you have 20/20 vision or better by selecting one of the following options.**
(note, that if you hold a 1st or 2nd Class Medical Certificate you have at least 20/20 vision).

- ◯ 20/20 or better uncorrected
- ◯ 20/20 or better corrected with procedure (e.g., Lasik)
- ◯ 20/20 or better corrected with glasses
- ◯ 20/20 or better corrected with contact lenses

***14. Which of the following best describes your handedness?**

- ◯ Left-handed
- ◯ Right-handed
- ◯ Ambidextrous left-hand dominant
- ◯ Ambidextrous right-hand dominant
- ◯ Ambidextrous no dominance

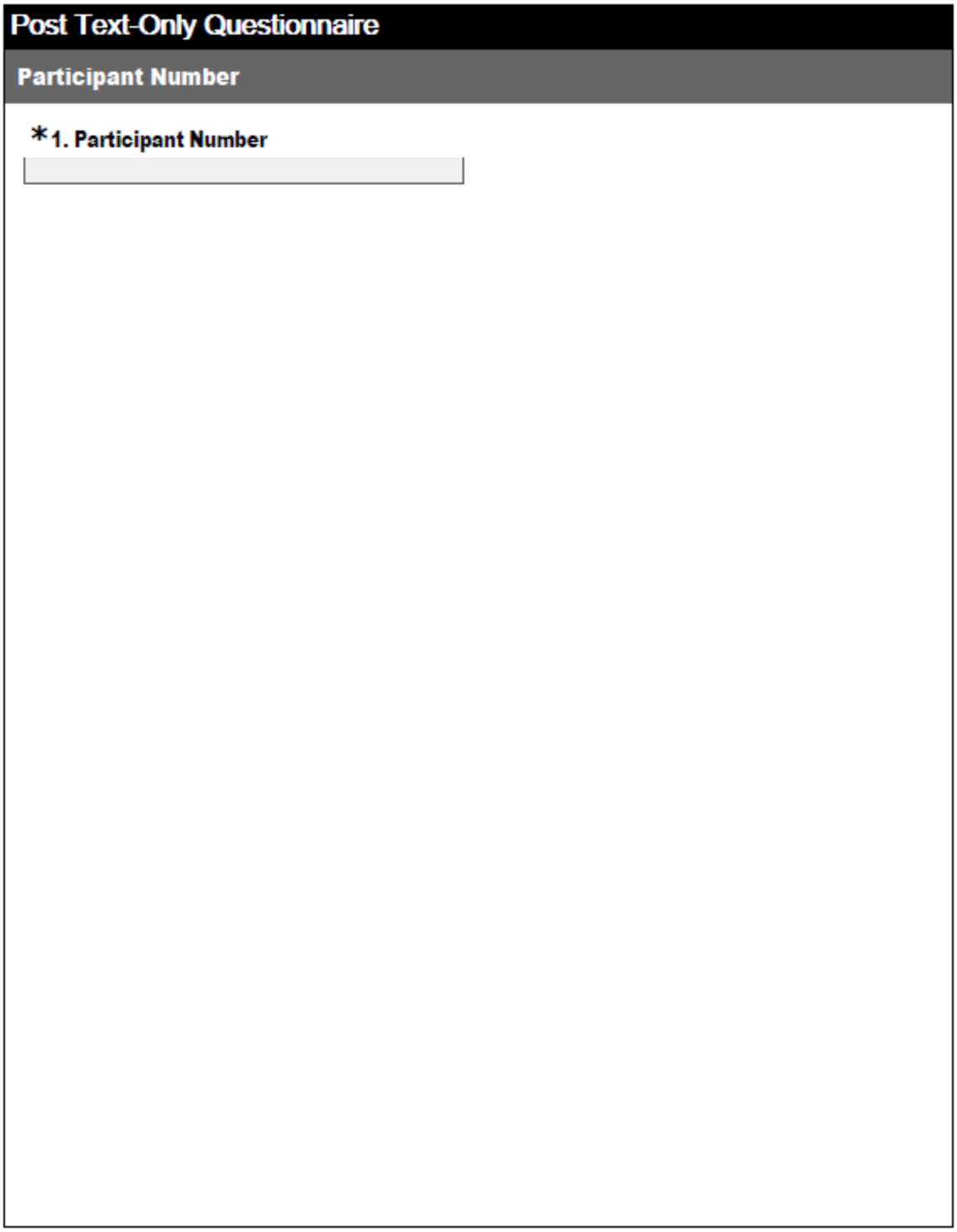
Pre-Experiment Questionnaire

Thank you!

Thank you for completing this survey. Please tell the experimenter you are finished.

Page 9

Post Text-Only Questionnaire



Post Text-Only Questionnaire

Participant Number

*1. Participant Number

Page 1

Post Text-Only Questionnaire

Background

***2. Please select your role on the flight you just completed.**

- ◯ Pilot Flying (Captain)
- ◯ Pilot Monitoring (First Officer)

Page 2

Post Text-Only Questionnaire

ATC Communications Workload

In this part of the survey, you will assess your EN ROUTE communications workload for the flight you just completed.

Please indicate the degree to which you agree or disagree using the scale below.

***3. The following statements relate to your ATC communications workload while flying EN ROUTE.**

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
A. Communicating (receiving and replying to instructions) with a LIVE CONTROLLER was easy.	◯	◯	◯	◯	◯
B. Communicating (receiving and replying to instruction) with a TEXT DISPLAY was easy.	◯	◯	◯	◯	◯

If you disagree with any of the above statements, please note your suggestions.

Page 3

Post Text-Only Questionnaire

Monitoring Pattern

In this part of the survey, we ask about your monitoring pattern during the flight you just completed. That is, what percent of your time you spent looking out the window, what percent of your time you spent looking at the flight instruments, and what percent of your time you spent looking at the Control Displays Unit (CDU) on the Flight Management System (FMS). Note, your responses need to add up to 100%.

***4. While EN ROUTE, what percent of time did you look at the Control Display Unit (CDU)?**

***5. While EN ROUTE, what percent of time did you look at the flight instruments?**

***6. While EN ROUTE, what percent of time did you look out the window?**

***7. While EN ROUTE, what percent of time did you look at the other pilot?**

***8. While EN ROUTE, what percent of time did you look at "OTHER" (that is NOT at the Control Display Unit, NOT at the flight instruments, NOT out the window, or NOT at the other pilot)?**

9. If you did look at "OTHER", please indicate what it was.

10. Please indicate any comments on questions 4-9 below.

Page 4

Post Text-Only Questionnaire

***11. Did Data Comm affect your monitoring pattern?**

- ◯ No
- ◯ Yes

If yes, please indicate how.

Page 5

Post Text-Only Questionnaire

Using the system

In this part of the survey, we seek your opinion about how easy it was to interact with the text-display system.

***12. The following statements relate to how easy it was to use the text-display system.**

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
A. I imagine that most people would learn to use the system quickly.	◯	◯	◯	◯	◯
B. I found the system easy to use.	◯	◯	◯	◯	◯
C. I trusted the system.	◯	◯	◯	◯	◯

If you disagree with any of the statements above, please note your suggestions.

***13. During the flight, did you use the Log on the CDU to review messages?**

◯ No

◯ Yes

If yes, please specify how you used the Log.

Page 6

Post Text-Only Questionnaire

***14. During the flight, did you use the printer?**

- ◯ No
- ◯ Yes

If yes, please briefly describe how you used the printer during flight.

***15. Please describe how you set up the two Control Display Units (CDUs) on the flight deck.**

***16. The set-up of the CDUs supported our tasks on the flight deck.**

◯ Strongly Disagree ◯ Disagree ◯ Undecided ◯ Agree ◯ Strongly Agree

If you disagree, please specify why.

Page 7

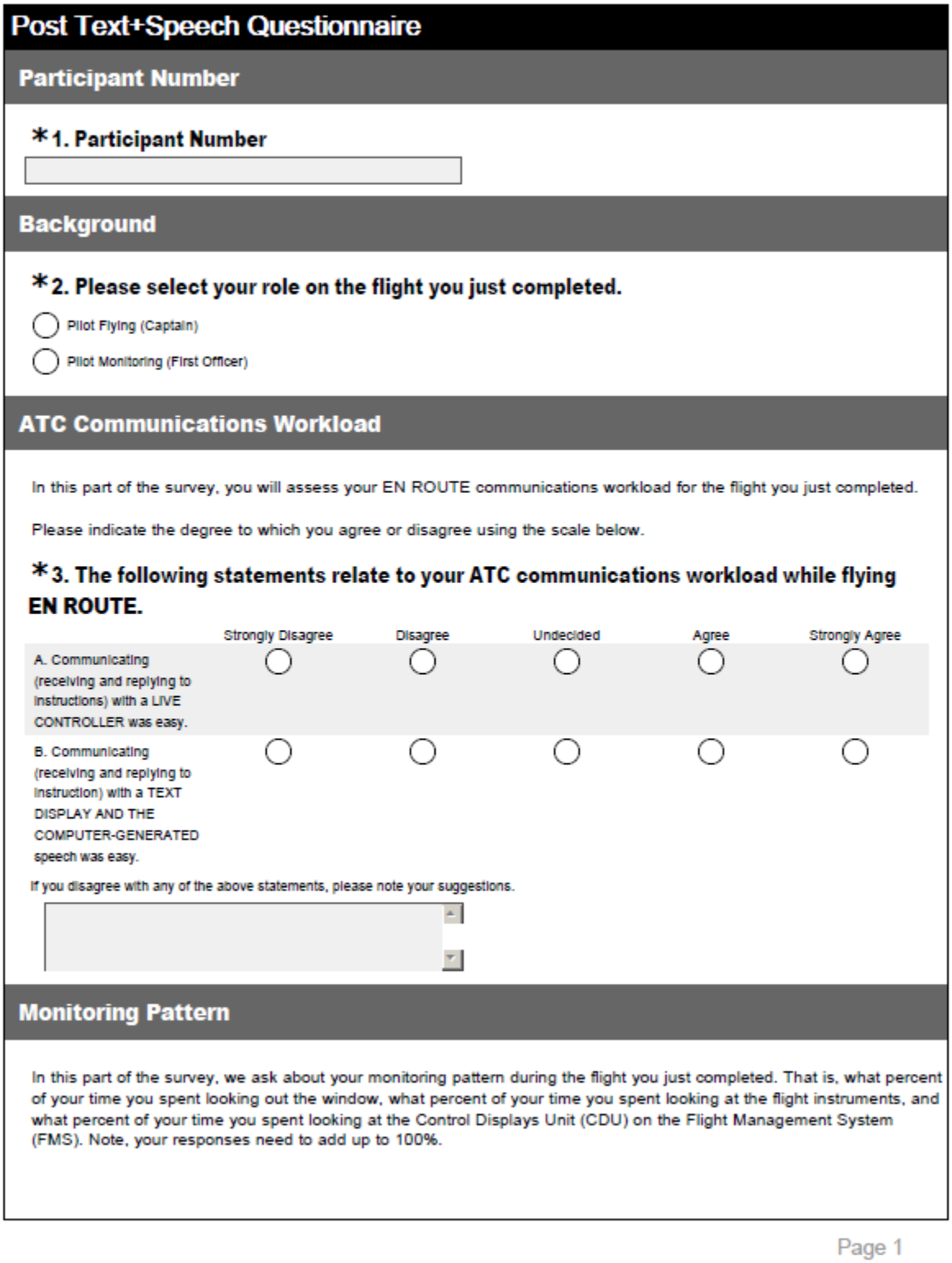
Post Text-Only Questionnaire

Thank you!

Thank you for completing this survey. Please tell the experimenter you are finished.

Page 8

Post Text+Speech Questionnaire



Post Text+Speech Questionnaire

Participant Number

***1. Participant Number**

Background

***2. Please select your role on the flight you just completed.**

- ◯ Pilot Flying (Captain)
- ◯ Pilot Monitoring (First Officer)

ATC Communications Workload

In this part of the survey, you will assess your EN ROUTE communications workload for the flight you just completed.

Please indicate the degree to which you agree or disagree using the scale below.

***3. The following statements relate to your ATC communications workload while flying EN ROUTE.**

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
A. Communicating (receiving and replying to instructions) with a LIVE CONTROLLER was easy.	◯	◯	◯	◯	◯
B. Communicating (receiving and replying to instruction) with a TEXT DISPLAY AND THE COMPUTER-GENERATED speech was easy.	◯	◯	◯	◯	◯

If you disagree with any of the above statements, please note your suggestions.

Monitoring Pattern

In this part of the survey, we ask about your monitoring pattern during the flight you just completed. That is, what percent of your time you spent looking out the window, what percent of your time you spent looking at the flight instruments, and what percent of your time you spent looking at the Control Displays Unit (CDU) on the Flight Management System (FMS). Note, your responses need to add up to 100%.

Page 1

Post Text+Speech Questionnaire

***4. While EN ROUTE, what percent of time did you look at the Control Display Unit (CDU)?**

***5. While EN ROUTE, what percent of time did you look at the flight instruments?**

***6. While EN ROUTE, what percent of time did you look out the window?**

***7. While EN ROUTE, what percent of time did you look at the other pilot?**

***8. While EN ROUTE, what percent of time did you look at "OTHER" (that is NOT at the Control Display Unit, NOT at the flight instruments, NOT out the window, or NOT at the other pilot)?**

9. If you did look at "OTHER", please indicate what it was.

10. Please indicate any comments on questions 4-9 below.

***11. Did Data Comm affect your monitoring pattern?**

- ◯ No
- ◯ Yes

If yes, please indicate how.

The computer-generated speech

In this part of the survey, we seek your opinion about the computer-generated speech you heard during the flight you just completed.

Post Text+Speech Questionnaire

For each statement, please indicate the degree to which you agree or disagree using the scale below.

***12. The following statements relate to the computer-generated speech heard during the flight you just completed.**

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
A. The loudness of the computer-generated speech relative to the party line is sufficient.	◯	◯	◯	◯	◯
B. The loudness of computer-generated speech on its own is sufficient.	◯	◯	◯	◯	◯
C. It is easy for me to understand the computer-generated speech.	◯	◯	◯	◯	◯
D. The computer-generated speech is neither too fast or too slow.	◯	◯	◯	◯	◯
E. I can easily tell the difference between the computer-generated speech and a human voice.	◯	◯	◯	◯	◯

If you disagree with any of the statements above, please note your suggestions.

Using the system

In this part of the survey, we seek your opinion about how easy it was to interact with the text-display and the computer-generated speech.

Page 3

Post Text+Speech Questionnaire

***13. The following statements relate to how easy it was to use the entire system (that is, the text display and the computer-generated speech).**

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
A. I imagine that most people would learn to use the system quickly.	◯	◯	◯	◯	◯
B. I found the system easy to use.	◯	◯	◯	◯	◯
C. I trusted the system.	◯	◯	◯	◯	◯

If you disagree with any of the statements above, please note your suggestions.

***14. During the flight, did you use the Log on the CDU to review messages?**

◯ No

◯ Yes

If yes, please specify how you used the Log.

Page 4

Post Text+Speech Questionnaire

***15. During the flight, did you use the printer?**

- ◯ No
- ◯ Yes

If yes, please briefly describe how you used the printer during flight.

***16. Please describe how you set up the two Control Display Units (CDUs) on the flight deck.**

***17. The set-up of the CDUs supported our tasks on the flight deck.**

◯ Strongly Disagree ◯ Disagree ◯ Undecided ◯ Agree ◯ Strongly Agree

If you disagree, please specify why.

Page 5

Post Text+Speech Questionnaire

***18. For each statement, please indicate the degree to which you agree or disagree using the scale below.**

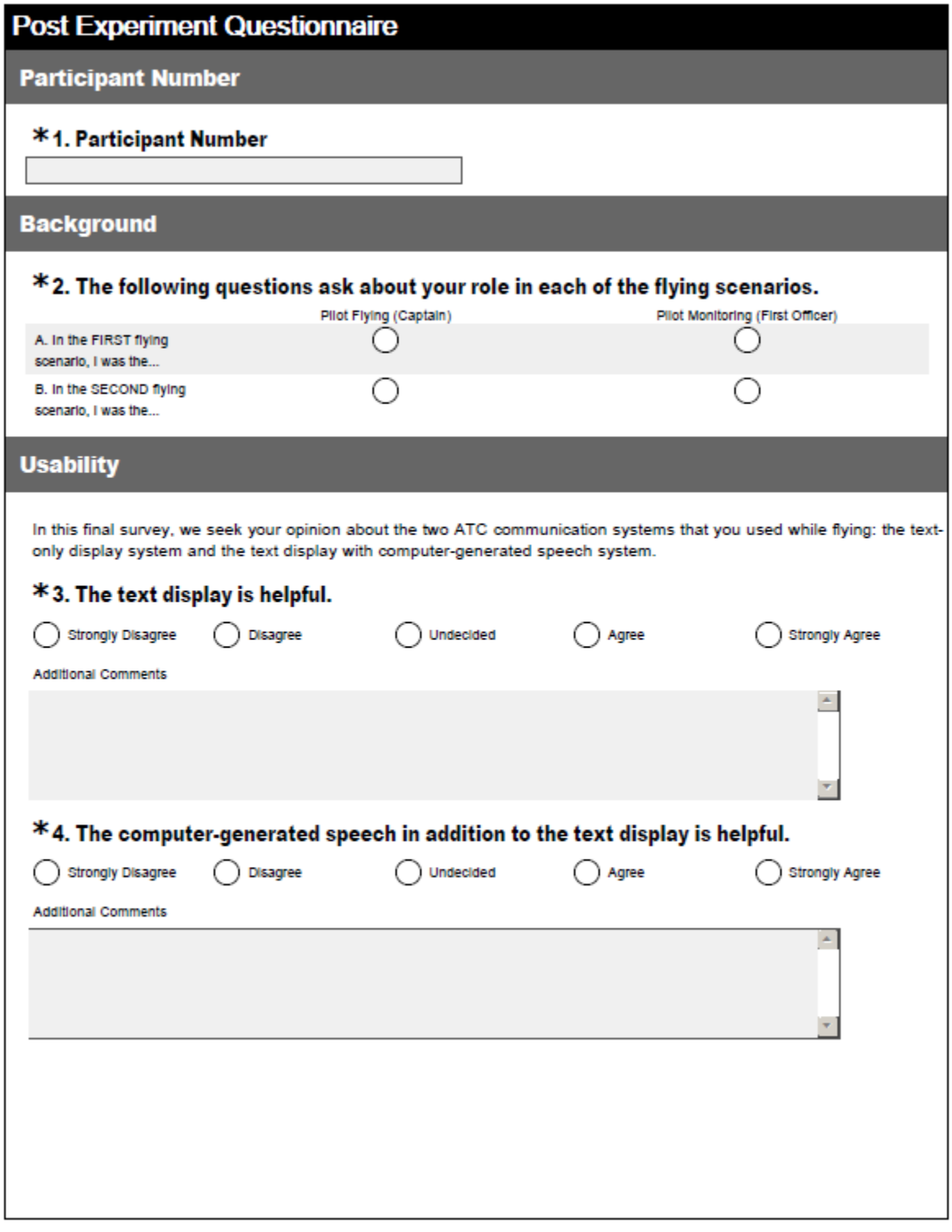
	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
A. I typically listened to all of the computer-generated speech before responding.	◯	◯	◯	◯	◯
B. I rarely muted the computer-generated speech before it was completed.	◯	◯	◯	◯	◯
C. I typically looked at the written text message at the same time as I listened to the synthetic speech.	◯	◯	◯	◯	◯
D. I typically replayed the message before responding.	◯	◯	◯	◯	◯
E. I rarely found the computer-generated speech to be distracting.	◯	◯	◯	◯	◯
F. I rarely found the computer-generated speech was confusable with voices heard on the party line.	◯	◯	◯	◯	◯

Please share your comments.

Thank you!

Thank you for completing this survey. Please tell the experimenter you are finished.

Post Experiment Questionnaire



Post Experiment Questionnaire

Participant Number

***1. Participant Number**

Background

***2. The following questions ask about your role in each of the flying scenarios.**

	Pilot Flying (Captain)	Pilot Monitoring (First Officer)
A. In the FIRST flying scenario, I was the...	◯	◯
B. In the SECOND flying scenario, I was the...	◯	◯

Usability

In this final survey, we seek your opinion about the two ATC communication systems that you used while flying: the text-only display system and the text display with computer-generated speech system.

***3. The text display is helpful.**

◯ Strongly Disagree ◯ Disagree ◯ Undecided ◯ Agree ◯ Strongly Agree

Additional Comments

***4. The computer-generated speech in addition to the text display is helpful.**

◯ Strongly Disagree ◯ Disagree ◯ Undecided ◯ Agree ◯ Strongly Agree

Additional Comments

Page 1

Post Experiment Questionnaire

***5. The computer-generated speech in addition to the text display is distracting.**

◯ Strongly Disagree ◯ Disagree ◯ Undecided ◯ Agree ◯ Strongly Agree

Additional Comments

***6. I prefer the text display only, without the computer-generated speech.**

◯ Strongly Disagree ◯ Disagree ◯ Undecided ◯ Agree ◯ Strongly Agree

Additional Comments

***7. I would prefer the computer-generated speech only, without the text display.**

◯ Strongly Disagree ◯ Disagree ◯ Undecided ◯ Agree ◯ Strongly Agree

Additional Comments

***8. Compared to a live controller, I prefer to communicate with ATC using the text display AND the computer-generated speech.**

◯ Strongly Disagree ◯ Disagree ◯ Undecided ◯ Agree ◯ Strongly Agree

Additional Comments

Page 2

Post Experiment Questionnaire

***9. Compared to a live controller, I prefer to communicate with ATC using ONLY the text display WITHOUT the computer-generated speech.**

◯ Strongly Disagree ◯ Disagree ◯ Undecided ◯ Agree ◯ Strongly Agree

Additional Comments

Crew procedures

***10. With computer-generated speech AND a text display, it is operationally feasible for both crewmembers to hear and understand the message at the same time.**

◯ Strongly Disagree ◯ Disagree ◯ Undecided ◯ Agree ◯ Strongly Agree

Additional Comments

***11. With computer-generated speech AND a text display, it is operationally acceptable for only one crewmember to read the text message after both crewmembers listen to the computer-speech message before taking action.**

◯ Strongly Disagree ◯ Disagree ◯ Undecided ◯ Agree ◯ Strongly Agree

Additional Comments

Post Experiment Questionnaire

***12. With a text display ONLY, it is operationally necessary for both crewmembers to silently and individually read the Data Comm message and reach consensus to avoid misinterpretation.**

◯ Strongly Disagree ◯ Disagree ◯ Undecided ◯ Agree ◯ Strongly Agree

Additional Comments

***13. How often did you use the GOLD procedure (silent and individual read, confer, then respond) during the TEXT-only condition?**

◯ Never ◯ Rarely ◯ Sometimes ◯ Often ◯ Always

Crew Procedures (2)

14. If you did NOT always use the GOLD procedure (silent and individual read, confer, then respond), please describe why:

15. If you did NOT always use the GOLD Procedure, how did you communicate with the other flight crew member about the Data Comm message?

Page 4

Post Experiment Questionnaire

***16. If I had to chose one way to communicate with ATC, I would prefer...**

- ◯ a live controller ONLY
- ◯ the Data Comm text-only display ONLY (with a live controller as needed)
- ◯ the Data Comm computer-generated speech display ONLY (with a live controller as needed)
- ◯ the Data Comm text AND computer-generated speech display (with a live controller as needed)

***17. I found the AURAL indication of an incoming Data Comm message (ding-dong) to be effective.**

◯ Strongly Disagree ◯ Disagree ◯ Undecided ◯ Agree ◯ Strongly Agree

Additional Comments

***18. I found the VISUAL indication of an incoming Data Comm message (".ATC MSG") on the EICAS display to be effective.**

◯ Strongly Disagree ◯ Disagree ◯ Undecided ◯ Agree ◯ Strongly Agree

Additional Comments

***19. I found the VISUAL indication of an incoming Data Comm message (" *ATC MSG") on the CDU to be effective.**

◯ Strongly Disagree ◯ Disagree ◯ Undecided ◯ Agree ◯ Strongly Agree

Additional Comments

Post Experiment Questionnaire

20. Please share any final comments.

Thank you!

Thank you for your time today. Please let the experimenter know you are finished.

Page 6

6.3 Appendix C: Flightcrew Briefing Materials

Appendix C contains all materials given to participants prior to flying the practice and experiment scenarios:

- Introductory Briefing Presentation
- Air Traffic Chart
- Normals Checklist Flow
- Runway Chart
- Terminal Procedures
- Dispatch Form

Introductory Briefing Presentation

Welcome to the Data Comm and Computer-Generated Speech Study

Last updated: 09 July 2013

Volpe The National Transportation Systems Center
Advancing transportation innovation for the public good

U.S. Department of Transportation
Research and Innovative Technology Administration
John A. Volpe National Transportation Systems Center

Informed Consent

- This study is being conducted by the USDOT Volpe Center for
  - FAA NextGen Human Factors Division
- Research team members
  - Judith Bürki-Cohen, **Andrea Sparko**, **Tracy Lennertz**
  - **Alan Yost**, **Drew Kendra**, Mike Zuschlag
  - **Amanda Mattson**, Emma Levitt

Informed Consent

Data Comm

- Controller-pilot datalink communication (CPDLC) via text
- Would it help to supplement Data Comm text messages with computer-generated speech?
- You will help determine Data Comm design/procedures

Informed Consent

- You will
  - Fly from JFK to CLE twice
  - Receive and respond to
    - Live-controller messages via your headsets
    - Data Comm (CPDLC) messages via the CDU CPDLC page
  - On one of the two flights
    - Read Data Comm Text messages
    - Read AND Hear Data Comm Text + (computer-generated) Speech messages
- Between scenarios, you will
  - Share your opinions

4

737-800/NG Simulator
(Next Generation)

- Fixed base
- Forward & overhead cameras
- Audio recording
- No food, drinks, gum, cell phone
- In dry weather, may need to remove shoes
  - To prevent static discharge—Sorry!

Informed Consent

- **Your participation is voluntary**
- All data will be completely de-identified
- We are not evaluating your performance as pilots, rather
  - You are test pilots helping us evaluate a new system
- Please sign two copies
  - One for us and one for you to keep

6

Logistics

- Restrooms
- Cafeteria/lunch options
- Briefing room
- Simulator room
- Emergency exits

Thank you for turning cell phones off in flight!

7

Time	Event	Location
0900	Intro Brief and Training	Briefing Room
0940	Pre-Experiment Questionnaire	Briefing Room
1000	Practice Session 1	Simulator Room
1030	Experimental Session 1	Simulator Room
1130	Post-Experimental Session 1 Questionnaire	Briefing Room
1145	*Lunch*	Cafeteria/Kendall Square
1300	Practice Session 2	Simulator Room
1330	Experimental Session 2	Simulator Room
1430	Post-Experimental Session 2 Questionnaire	Briefing Room
1445	Post-Experiment Questionnaire	Briefing Room
1500	Debrief	Briefing Room

8

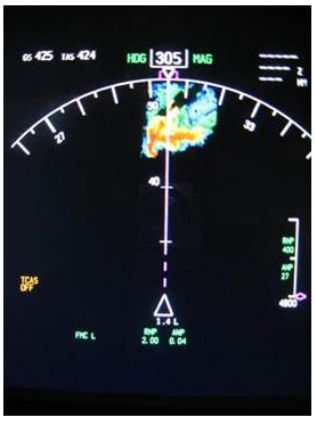
"Simisms"

- MFD inoperative
  - Shows system clock
- WX Radar
  - Inoperative: We use a 'canned' radar image that will display on the ND
  - Please do not press
- WX image on ND
  - Cannot be scaled independently for CA & FO
  - Is accurate at 80 nm (see next page)

9

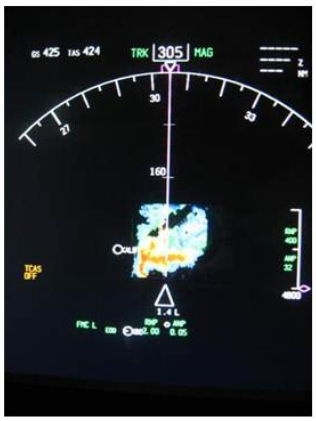
Weather image on ND

80 nmi range



160 nmi range

320 nmi range



"Simisms" cont.

- VNAV inoperative
  - Please control airplane via
    - Level Change or Vertical Speed
    - Autothrottle
    - MCP speed
  - You can enter restrictions on LEGS page as a reminder
    - FMS will ignore them without VNAV
- Simulator has an unrealistic acceleration rate after lift-off when flaps are extended
  - Reduce climb rate, or retract flaps "off-schedule"
- TCAS inoperative

Please let us know of any other simisms during the debrief

You are our experts

11

Night Flight from JFK to CLE

- Departure from JFK Runway 4L threshold
  - Fly until you transition into CLE airspace
- FMS is programmed & simulator configured
  - Familiarize yourself with the route as normal
  - Perform before/after takeoff checklist
  - All materials on flightdeck
    - Flight plan, Wx/NOTAMS, charts, checklists, notepad & pen
- When cleared for take-off,
  - Fly to 500-1000 ft
  - Engage autopilot
- ATC clearances will be via live voice and Data Comm
  - Data Comm Text + Speech (computer generated) on one of the two flights
- No off-nominal events

12

Data Comm Message Annunciations

ATC Message indication on EICAS

13

How to get to Data Comm page

From the PROGRESS or LEGS page, press MENU

How to get to Data Comm page

Then press SIM OPTIONS

And then NEXT PAGE

Data Comm Display

Opens Message Log page

Turns on/off speech annunciations

Current scenario time (HH:MM:SS Zulu)

Displays Message page (text or text+speech)

Indicates that the Line Select Key is Active.

16

Data Comm Display

Message arrival time and origin

Message text

Responds WILCO/ROGER

Prints message

Returns to CPDLC Menu page

Page 1 of 1

Message status

Responds UNABLE; Opens Reject page

Replays message annunciation (or mutes)

Indicates open message

17

Data Comm Display

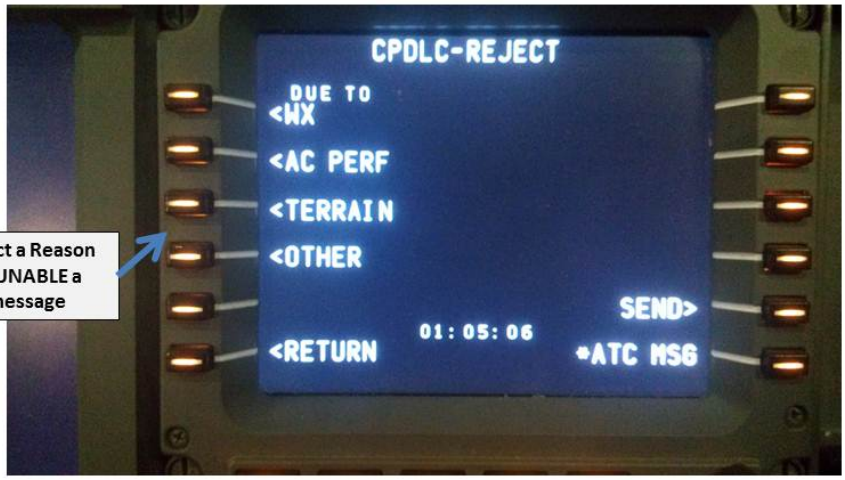
Indicates that the pilot has responded WILCO

18

Data Comm Display

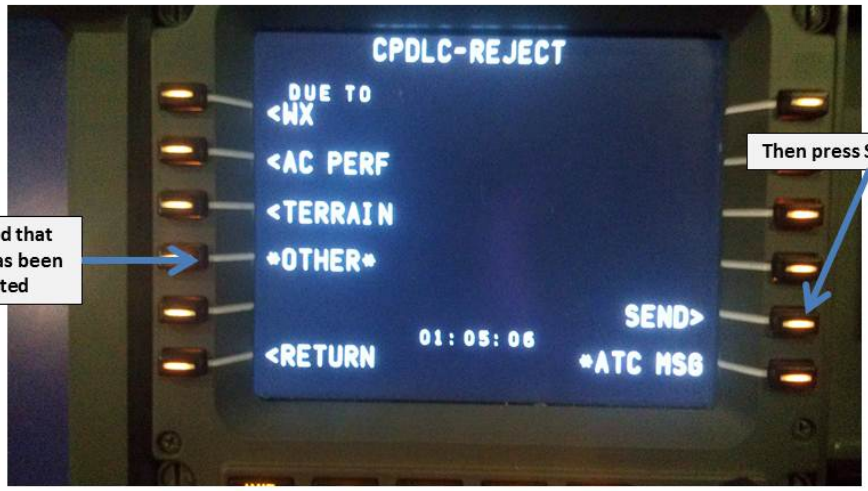
Responds UNABLE; Opens Reject page

Data Comm Display



Select a Reason to UNABLE a message

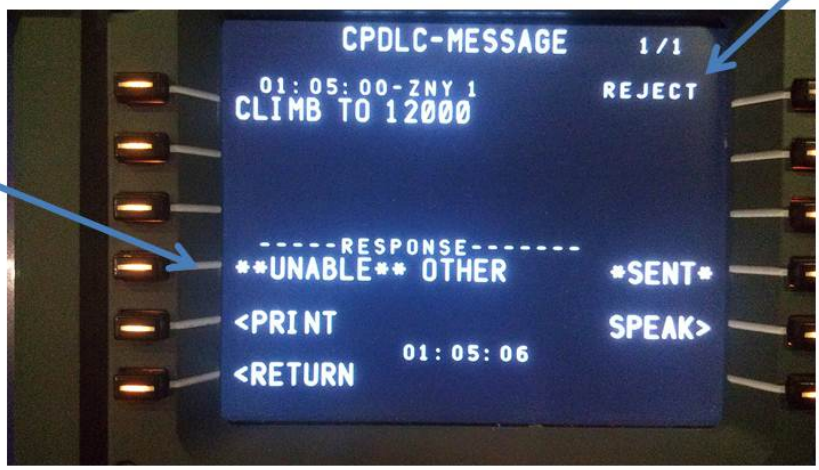
Data Comm Display



Indicated that OTHER has been selected

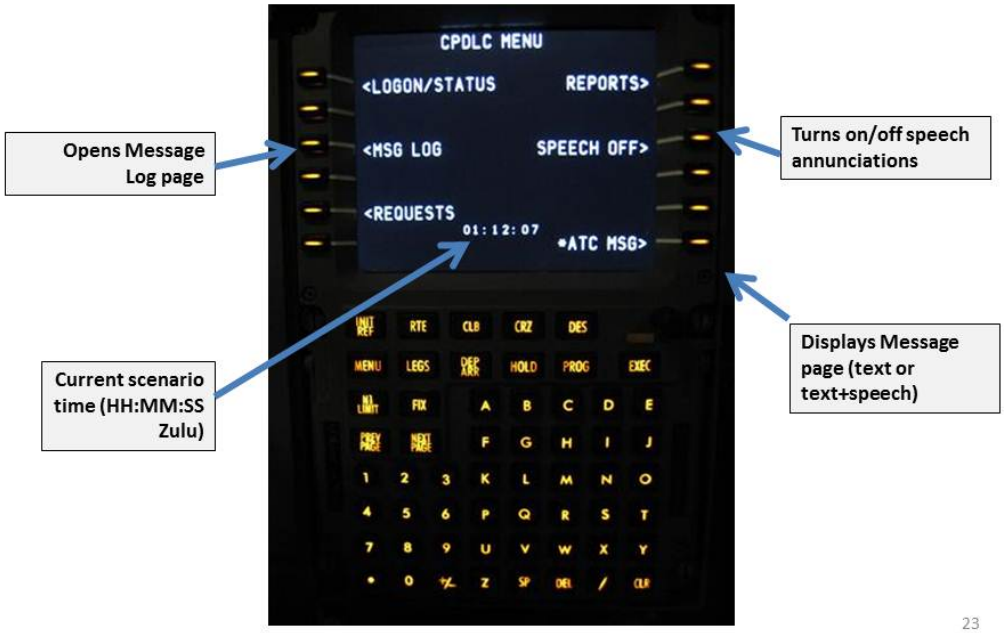
Then press SEND

Data Comm Display



Indicates that the pilot has responded UNABLE

Data Comm Display



23

Data Comm Display

- Message Log
- Messages FROM ATC only
- Messages to ATC limited to
  - Wilco/Roger
  - Unable/Reject

24

Data Comm Display

Return to Menu, then Message Log to respond to time-out message

25

Procedures for Data Comm: Text Only

1. SELCAL tone announces message
2. Before maneuvering,
   - Each pilot reads the message silently, then
   - Both pilots agree on response (Wilco/Unable)

   Pilots do not need to read the message at the same time
3. Pilot Monitoring responds "Wilco/Roger" or "Unable" as agreed

The GOLD Procedure: **To prevent misreading**

26

Procedures for Data Comm: Text+Speech

1. SELCAL tone announces message
2. Before maneuvering,
   - Pilot Monitoring reads message silently, then
   - Replays speech as needed
   - Pilots agree on the response (Wilco/Unable)
3. Pilot Monitoring responds "Wilco/Roger" or "Unable" as agreed

27

Other Data Comm Instructions

- Print Data Comm messages when necessary and check against Data Comm display
- Respond to Data Comm messages using the FMS buttons
- Respond to voice messages with voice
- Respond to Data Comm "CONTACT" (frequency change) messages
  1. With Data Comm
  2. By voice call on the appropriate Frequency
- Voice has priority over Data Comm

28

You are our test pilots

- Left seat is PF and right seat is PM and communicating with ATC
- Recommended default FMS pages
  - Pilot Flying: LEGS page
  - Pilot Monitoring: Progress Page
- Discuss any other procedures during your practice scenarios
- Perform normal flight plan monitoring duties (e.g., monitoring fuel, ETA, etc.)
- Please take and stay in your usual seat for both scenarios
  - If you are both Captains, the more recent one should be Pilot Monitoring
  - If you are both First Officers, the one with less left-seat or less military flight experience should be Pilot Monitoring

29

Pre-Experiment Questionnaire…

30

After the training you will know how to…

- access a message
- review a message that has multiple pages
- replay or mute a message
- respond to a message with WILCO or UNABLE (including messages that are timed out)
- use the printer
- use the recommended Data Comm procedures

31

Please take a short break prior to flying the training scenario…

32

Please review the materials for your next flight…

33

Post-Scenario Questionnaire - 1

34

Lunch

Post-Scenario Questionnaire - 2

36

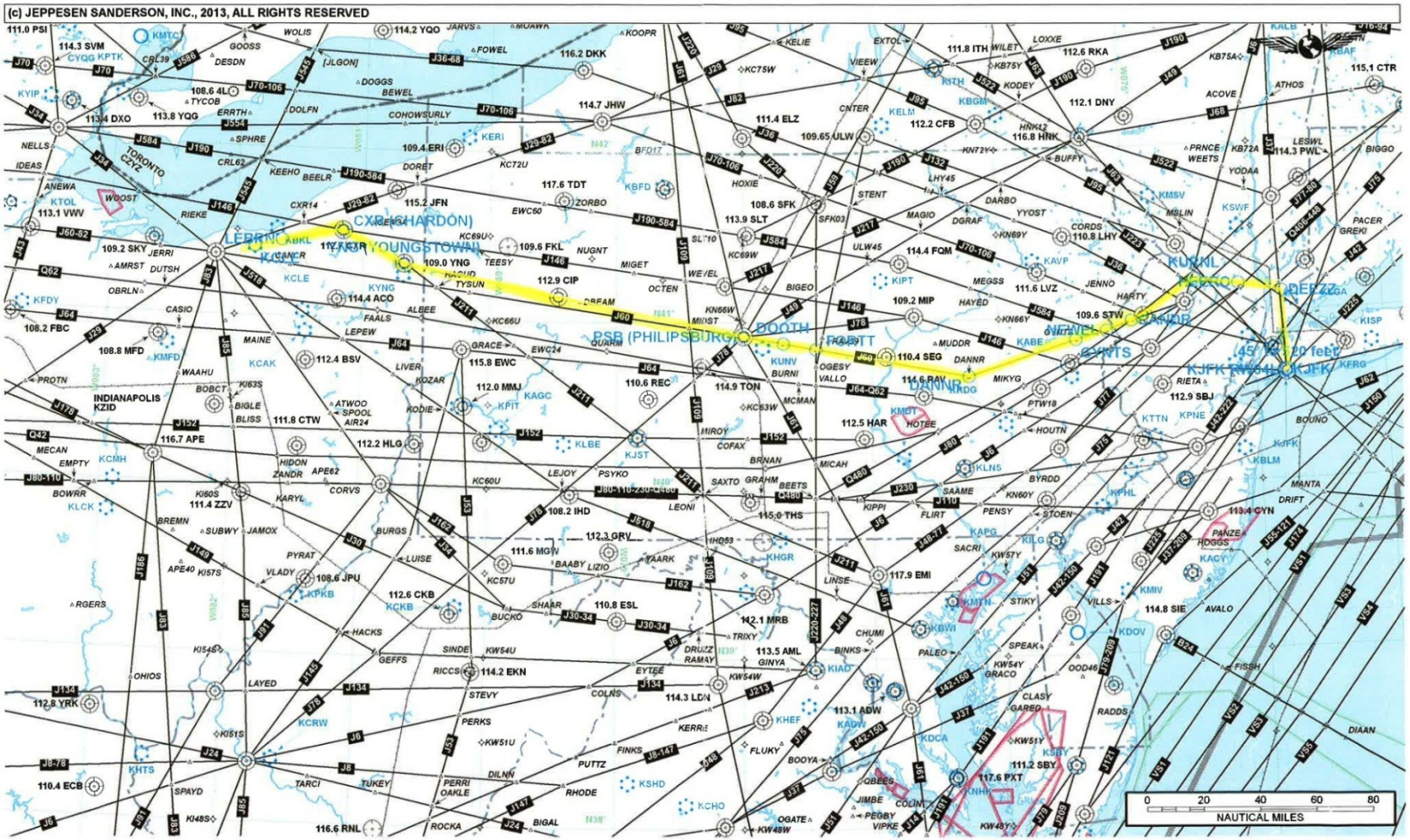
Post-Experiment Questionnaire

37

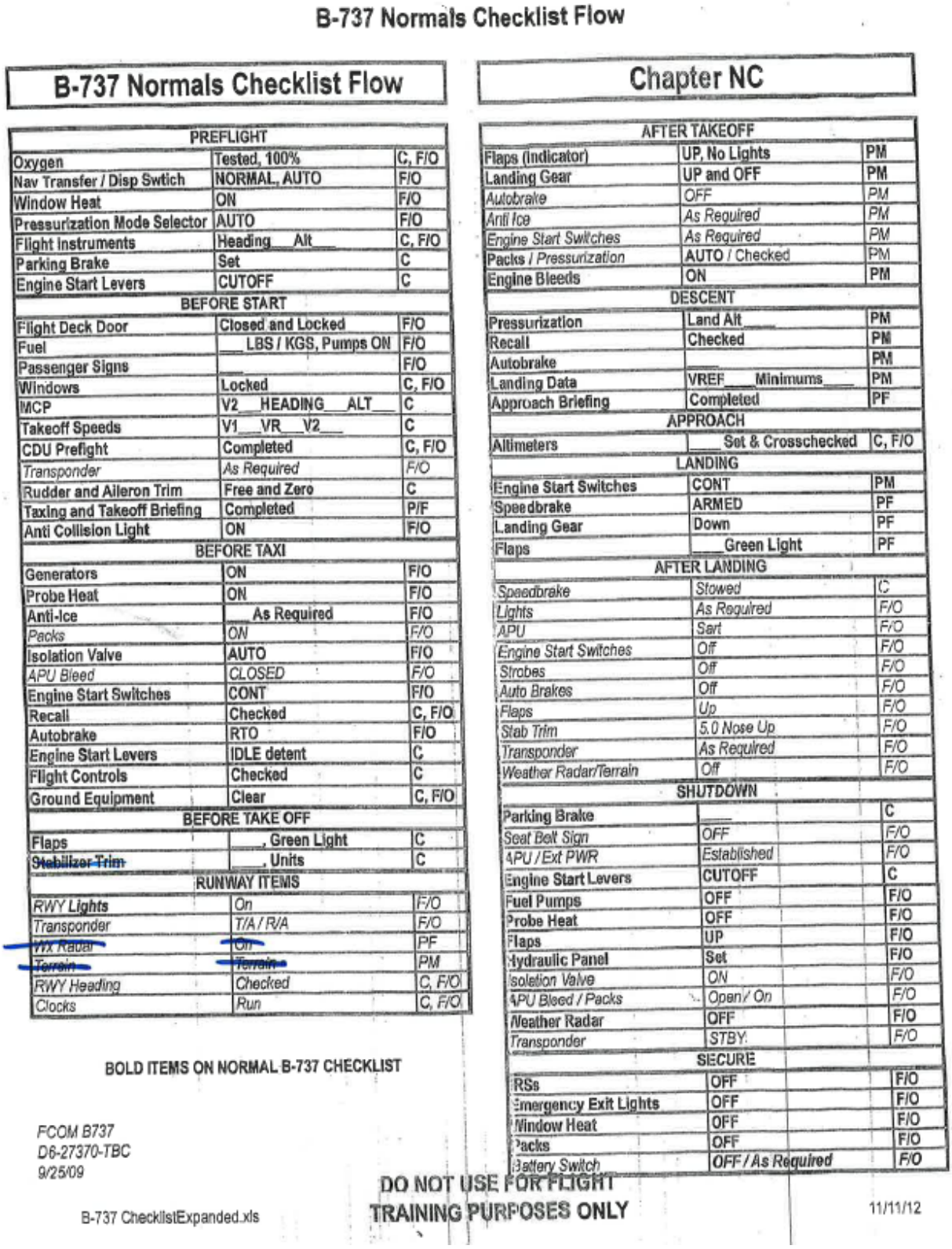
Debrief

38

Air Traffic Chart


(c) JEPPESEN SANDERSON, INC., 2013, ALL RIGHTS RESERVED
0 20 40 60 80
NAUTICAL MILES

Normals Checklist Flow



B-737 Normals Checklist Flow

B-737 Normals Checklist Flow

PREFLIGHT		
Oxygen	Tested, 100%	C, F/O
Nav Transfer / Disp Swtich	NORMAL, AUTO	F/O
Window Heat	ON	F/O
Pressurization Mode Selector	AUTO	F/O
Flight Instruments	Heading___Alt___	C, F/O
Parking Brake	Set	C
Engine Start Levers	CUTOFF	C
BEFORE START		
Flight Deck Door	Closed and Locked	F/O
Fuel	___LBS / KGS, Pumps ON	F/O
Passenger Signs	___	F/O
Windows	Locked	C, F/O
MCP	V2___HEADING___ALT___	C
Takeoff Speeds	V1___VR___V2___	C
CDU Preflight	Completed	C, F/O
Transponder	*As Required*	*F/O*
Rudder and Aileron Trim	Free and Zero	C
Taxing and Takeoff Briefing	Completed	P/F
Anti Collision Light	ON	F/O
BEFORE TAXI		
Generators	ON	F/O
Probe Heat	ON	F/O
Anti-Ice	___As Required	F/O
Packs	*ON*	*F/O*
Isolation Valve	AUTO	F/O
APU Bleed	*CLOSED*	*F/O*
Engine Start Switches	CONT	F/O
Recall	Checked	C, F/O
Autobrake	RTO	F/O
Engine Start Levers	IDLE detent	C
Flight Controls	Checked	C
Ground Equipment	Clear	C, F/O
BEFORE TAKE OFF		
Flaps	___, Green Light	C
~~Stabilizer Trim~~	___, Units	C
RUNWAY ITEMS		
RWY Lights	*On*	*F/O*
Transponder	*T/A / R/A*	*F/O*
~~*Wx Radar*~~	~~*On*~~	*PF*
~~*Terrain*~~	~~*Terrain*~~	*PM*
RWY Heading	*Checked*	*C, F/O*
Clocks	*Run*	*C, F/O*

Chapter NC

AFTER TAKEOFF		
Flaps (Indicator)	UP, No Lights	PM
Landing Gear	UP and OFF	PM
Autobrake	*OFF*	*PM*
Anti Ice	*As Required*	*PM*
Engine Start Switches	*As Required*	*PM*
Packs / *Pressurization*	AUTO / Checked	PM
Engine Bleeds	ON	PM
DESCENT		
Pressurization	Land Alt___	PM
Recall	Checked	PM
Autobrake	___	PM
Landing Data	VREF___Minimums___	PM
Approach Briefing	Completed	PF
APPROACH		
Altimeters	___ Set & Crosschecked	C, F/O
LANDING		
Engine Start Switches	CONT	PM
Speedbrake	ARMED	PF
Landing Gear	Down	PF
Flaps	___Green Light	PF
AFTER LANDING		
Speedbrake	*Stowed*	*C*
Lights	*As Required*	*F/O*
APU	*Sart*	*F/O*
Engine Start Switches	*Off*	*F/O*
Strobes	*Off*	*F/O*
Auto Brakes	*Off*	*F/O*
Flaps	*Up*	*F/O*
Stab Trim	*5.0 Nose Up*	*F/O*
Transponder	*As Required*	*F/O*
Weather Radar/Terrain	*Off*	*F/O*
SHUTDOWN		
Parking Brake	___	C
Seat Belt Sign	*OFF*	*F/O*
APU / Ext PWR	*Established*	*F/O*
Engine Start Levers	CUTOFF	C
Fuel Pumps	OFF	F/O
Probe Heat	OFF	F/O
Flaps	UP	F/O
Hydraulic Panel	Set	F/O
Isolation Valve	*ON*	*F/O*
APU Bleed / Packs	*Open / On*	*F/O*
Weather Radar	OFF	F/O
Transponder	*STBY*	*F/O*
SECURE		
RSs	OFF	F/O
Emergency Exit Lights	OFF	F/O
Window Heat	OFF	F/O
Packs	OFF	F/O
Battery Switch	OFF / As Required	F/O

BOLD ITEMS ON NORMAL B-737 CHECKLIST

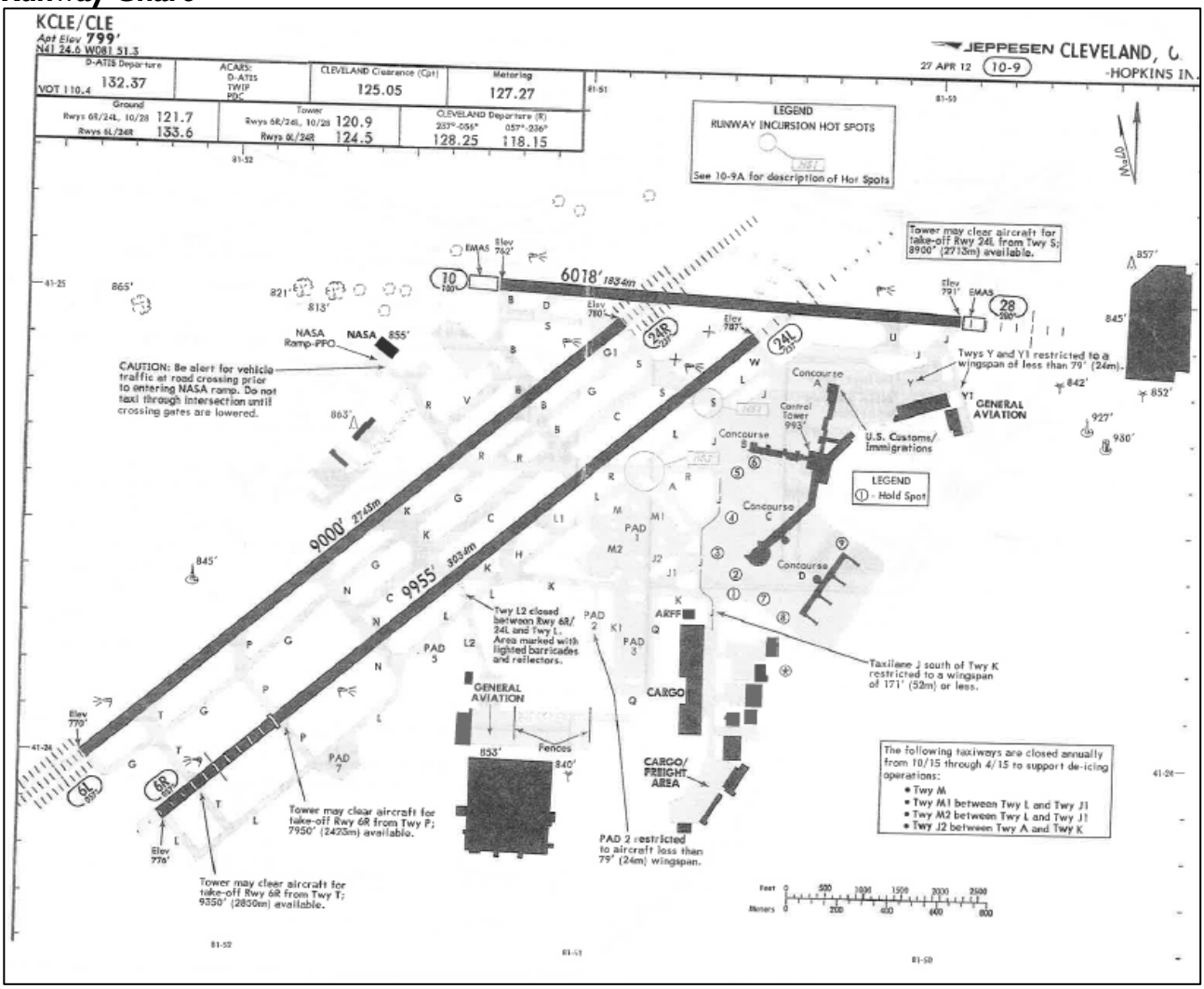
FCOM B737
D6-27370-TBC
9/25/09

DO NOT USE FOR FLIGHT
TRAINING PURPOSES ONLY

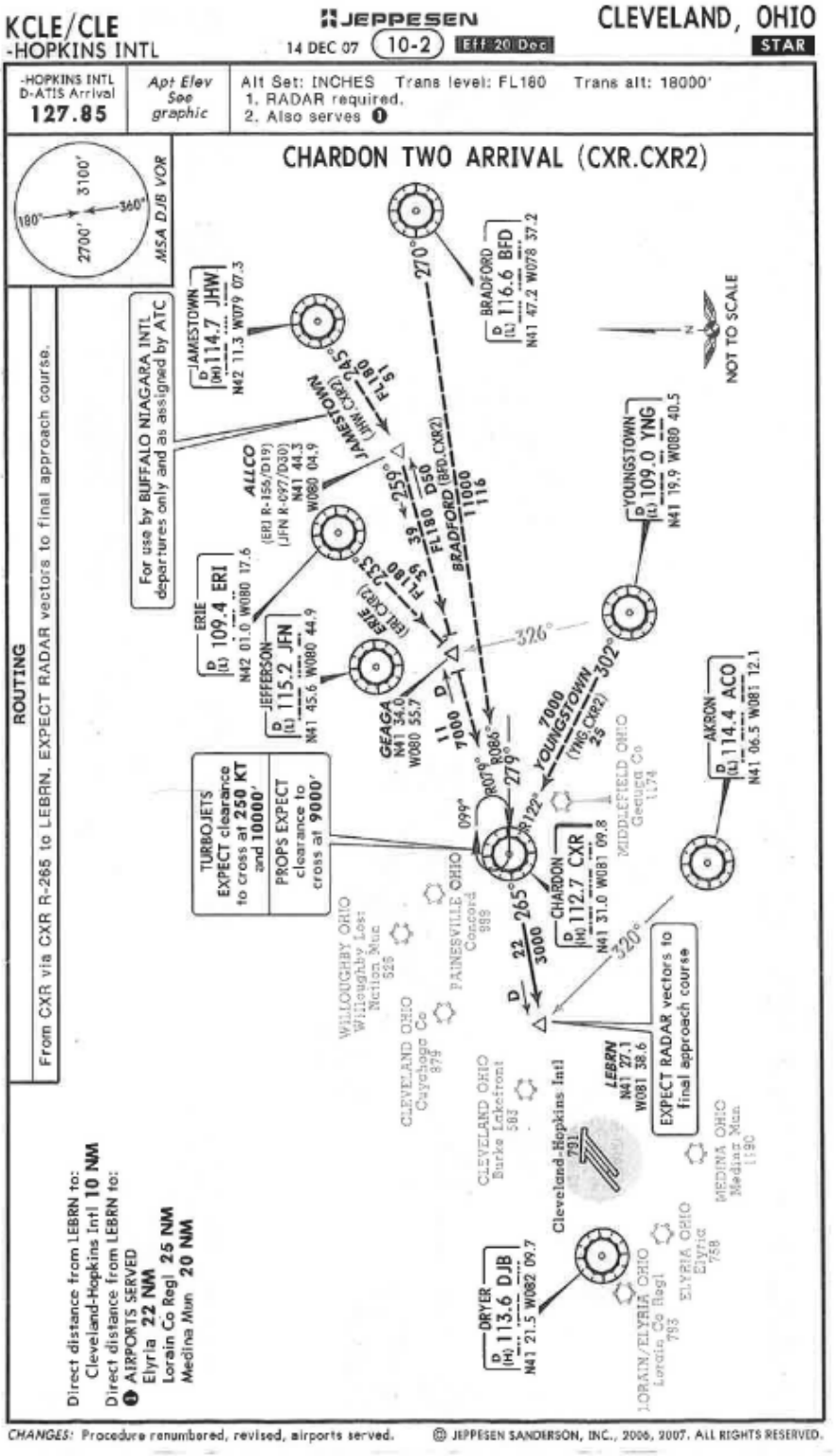
B-737 ChecklistExpanded.xls

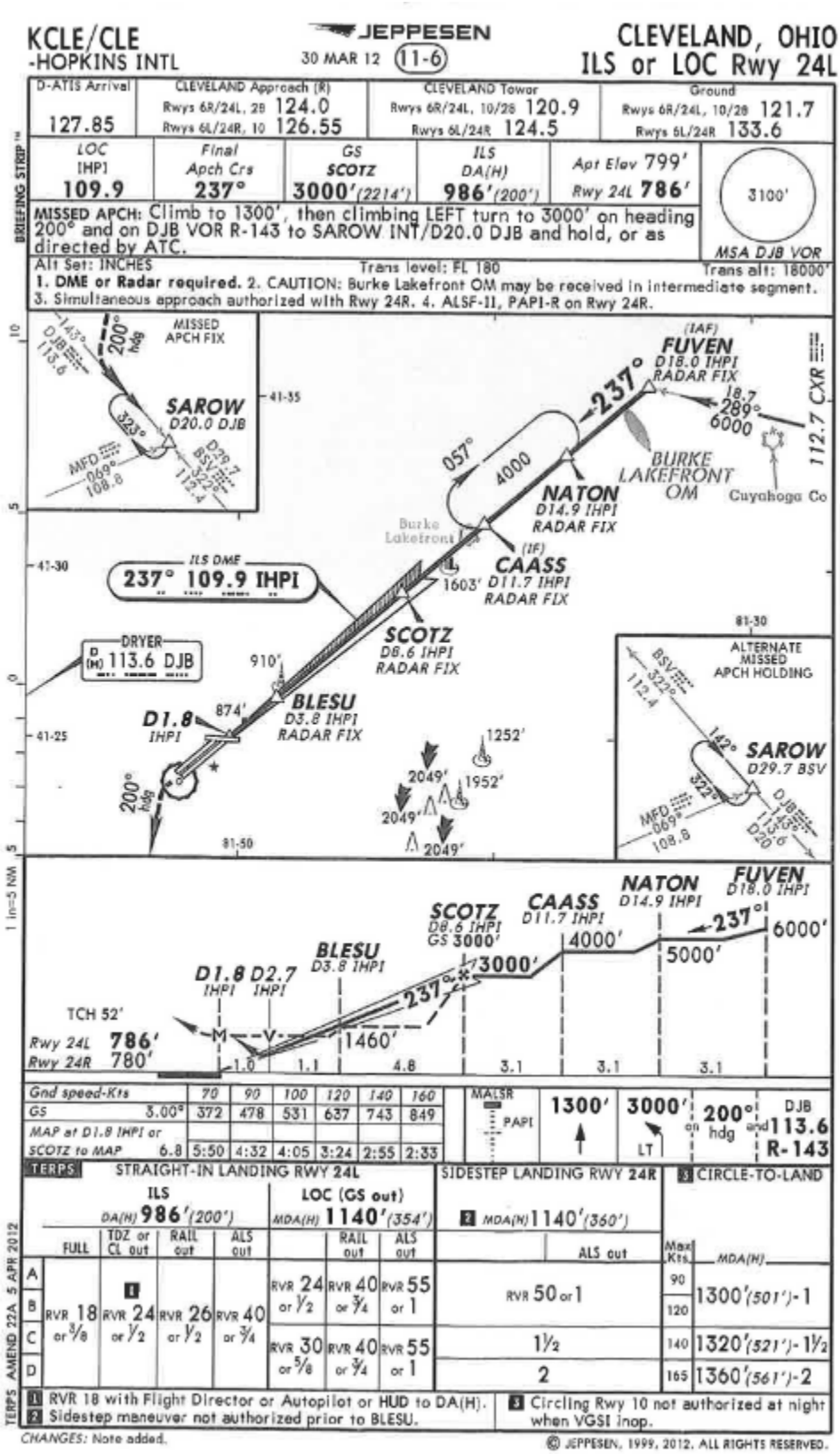
11/11/12

Runway Chart



Terminal Procedures




KCLE/CLE
-HOPKINS INTL
JEPPESEN
30 MAR 12
11-6
CLEVELAND, OHIO
ILS or LOC Rwy 24L
D-ATIS Arrival
127.85
CLEVELAND Approach (R)
Rwys 6R/24L, 28 124.0
Rwys 6L/24R, 10 126.55
CLEVELAND Tower
Rwys 6R/24L, 10/28 120.9
Rwys 6L/24R 124.5
Ground
Rwys 6R/24L, 10/28 121.7
Rwys 6L/24R 133.6
LOC IHPI 109.9
Final Apch Crs 237°
GS SCOTZ 3000'(2214')
ILS DA(H) 986'(200')
Apt Elev 799'
Rwy 24L 786'
3100'
MSA DJB VOR
MISSED APCH: Climb to 1300', then climbing LEFT turn to 3000' on heading 200° and on DJB VOR R-143 to SAROW INT/D20.0 DJB and hold, or as directed by ATC.
Alt Set: INCHES
Trans level: FL 180
Trans alt: 18000'
1. DME or Radar required. 2. CAUTION: Burke Lakefront OM may be received in intermediate segment.
3. Simultaneous approach authorized with Rwy 24R. 4. ALSF-II, PAPI-R on Rwy 24R.
BRIEFING STRIP™
MISSED APCH FIX
SAROW
D20.0 DJB
FUVEN
D18.0 IHPI
RADAR FIX
(IAF)
237°
289°
18.7
6000
112.7 CXR
057°
4000
BURKE LAKEFRONT OM
Cuyahoga Co
NATON
D14.9 IHPI
RADAR FIX
Burke Lakefront
(IF)
CAASS
D11.7 IHPI
RADAR FIX
1603'
ILS DME
237° 109.9 IHPI
SCOTZ
D8.6 IHPI
RADAR FIX
DRYER
D(M) 113.6 DJB
910'
BLESU
D3.8 IHPI
RADAR FIX
D1.8
IHPI
874'
200°
hdg
1252'
2049'
1952'
2049'
2049'
ALTERNATE MISSED APCH HOLDING
BSV 322° 112.4
142°
SAROW
D29.7 BSV
322°
MFD 069° 108.8
DJB 143° 113.6 D20.6
41-55
41-30
41-25
41-50
81-30
10
5
0
5
1 in=5 NM
SCOTZ
D8.6 IHPI
GS 3000'
CAASS
D11.7 IHPI
NATON
D14.9 IHPI
FUVEN
D18.0 IHPI
BLESU
D3.8 IHPI
D1.8 IHPI
D2.7 IHPI
237°
3000'
4000'
5000'
6000'
TCH 52'
Rwy 24L 786'
Rwy 24R 780'
1460'
1.0
1.1
4.8
3.1
3.1
3.1
Gnd speed-Kts 70 90 100 120 140 160
GS 3.00° 372 478 531 637 743 849
MAP at D1.8 IHPI or SCOTZ to MAP 6.8 5:50 4:32 4:05 3:24 2:55 2:33
MALSR
PAPI
1300'
3000'
LT
200° on hdg and DJB 113.6 R-143
TERPS
STRAIGHT-IN LANDING RWY 24L
ILS DA(H) 986'(200')
LOC (GS out) MDA(H) 1140'(354')
SIDESTEP LANDING RWY 24R
2 MDA(N) 1140'(360')
3 CIRCLE-TO-LAND
FULL
TDZ or CL out
RAIL out
ALS out
ALS out
Max Kts
MDA(N)
A
B
C
D
RVR 18 or 3/8
1 RVR 24 or 1/2
RVR 26 or 1/2
RVR 40 or 3/4
RVR 24 or 1/2
RVR 40 or 3/4
RVR 55 or 1
RVR 30 or 5/8
RVR 40 or 3/4
RVR 55 or 1
RVR 50 or 1
1½
2
90
120
140
165
1300'(501')-1
1320'(521')-1½
1360'(561')-2
1 RVR 18 with Flight Director or Autopilot or HUD to DA(H).
2 Sidestep maneuver not authorized prior to BLESU.
3 Circling Rwy 10 not authorized at night when VGSI inop.
TERPS AMEND 22A 5 APR 2012
CHANGES: Note added.
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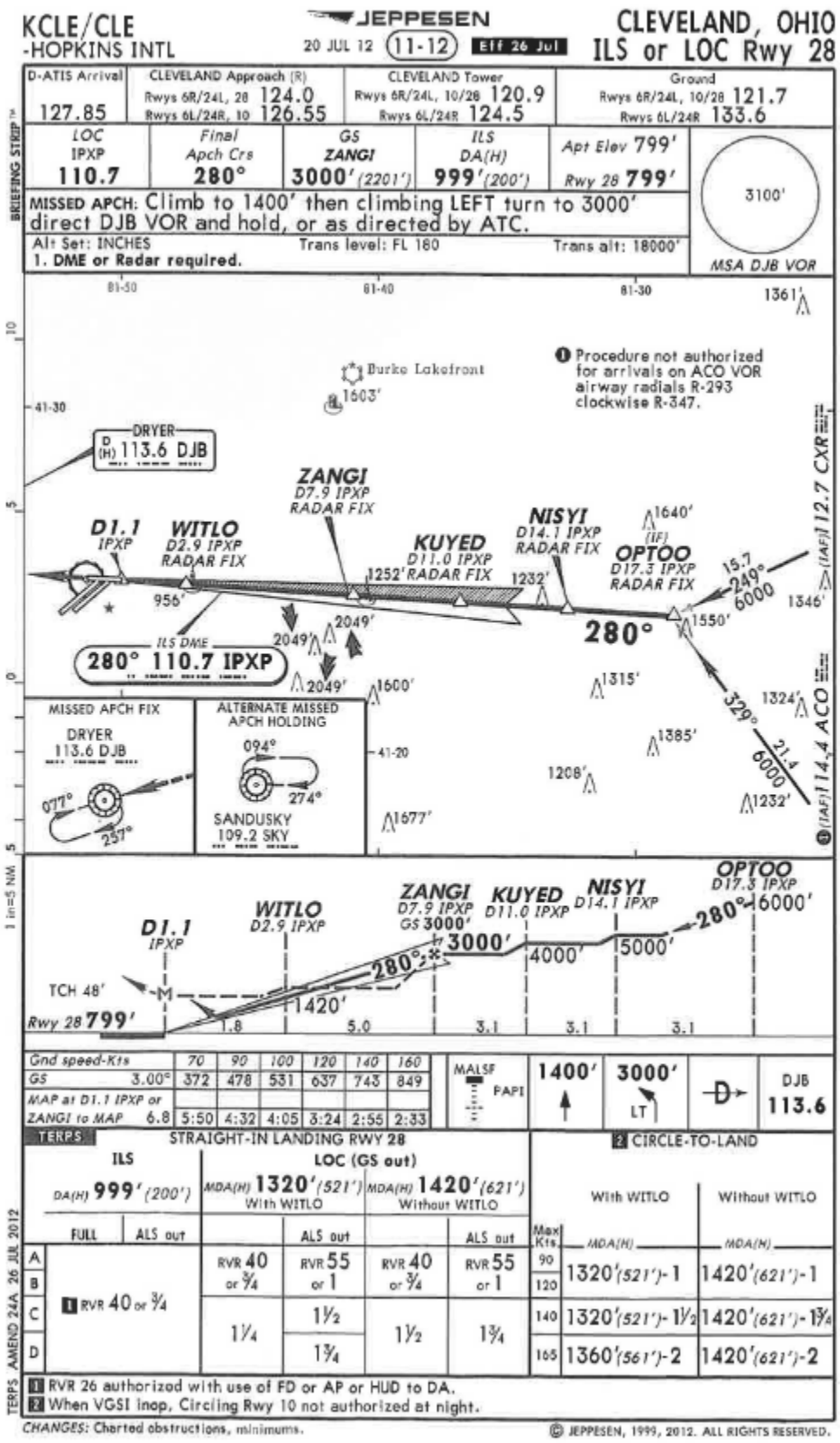
KCLE/CLE
-HOPKINS INTL
JEPPESEN
20 JUL 12 (11-12) Eff 26 Jul
CLEVELAND, OHIO
ILS or LOC Rwy 28
D-ATIS Arrival 127.85
CLEVELAND Approach (R) Rwys 6R/24L, 28 124.0 Rwys 6L/24R, 10 126.55
CLEVELAND Tower Rwys 6R/24L, 10/28 120.9 Rwys 6L/24R 124.5
Ground Rwys 6R/24L, 10/28 121.7 Rwys 6L/24R 133.6
LOC IPXP 110.7
Final Apch Crs 280°
GS ZANGI 3000' (2201')
ILS DA(H) 999' (200')
Apt Elev 799'
Rwy 28 799'
3100'
MISSED APCH: Climb to 1400' then climbing LEFT turn to 3000' direct DJB VOR and hold, or as directed by ATC.
Alt Set: INCHES
Trans level: FL 180
Trans alt: 18000'
1. DME or Radar required.
MSA DJB VOR
Burke Lakefront
1603'
1 Procedure not authorized for arrivals on ACO VOR airway radials R-293 clockwise R-347.
DRYER
D (H) 113.6 DJB
ZANGI
D7.9 IPXP
RADAR FIX
D1.1
IPXP
WITLO
D2.9 IPXP
RADAR FIX
KUYED
D11.0 IPXP
1252' RADAR FIX
NISYI
D14.1 IPXP
RADAR FIX
1640'
(IF)
OPTOO
D17.3 IPXP
RADAR FIX
15.7
249°
6000
(IAF) 12.7 CXR
1346'
1550'
280°
1232'
956'
ILS DME
280° 110.7 IPXP
2049'
1600'
1315'
329°
21.4
6000
(IAF) 14.4 ACO
1324'
1385'
1208'
1677'
MISSED APCH FIX
DRYER
113.6 DJB
077°
257°
ALTERNATE MISSED APCH HOLDING
094°
274°
SANDUSKY
109.2 SKY
1 in=5 NM
ZANGI D7.9 IPXP GS 3000'
KUYED D11.0 IPXP
NISYI D14.1 IPXP
OPTOO D17.3 IPXP
6000'
3000'
4000'
5000'
280°
TCH 48'
Rwy 28 799'
1420'
1.8
5.0
3.1
3.1
3.1
Gnd speed-Kts 70 90 100 120 140 160
GS 3.00° 372 478 531 637 743 849
MAP at D1.1 IPXP or ZANGI to MAP 6.8 5:50 4:32 4:05 3:24 2:55 2:33
MALSF PAPI
1400'
3000'
LT
DJB
113.6
TERPS
STRAIGHT-IN LANDING RWY 28
ILS
DA(H) 999' (200')
FULL
ALS out
LOC (GS out)
MDA(H) 1320' (521') With WITLO
MDA(H) 1420' (621') Without WITLO
ALS out
2 CIRCLE-TO-LAND
With WITLO
Without WITLO
Max Kts
MDA(H)
A
B
C
D
1 RVR 40 or ¾
RVR 40 or ¾
RVR 55 or 1
1¼
1½
1¾
90
120
140
165
1320' (521') - 1
1420' (621') - 1
1320' (521') - 1½
1420' (621') - 1¾
1360' (561') - 2
1420' (621') - 2
1 RVR 26 authorized with use of FD or AP or HUD to DA.
2 When VGSI inop, Circling Rwy 10 not authorized at night.
CHANGES: Charted obstructions, minimums.
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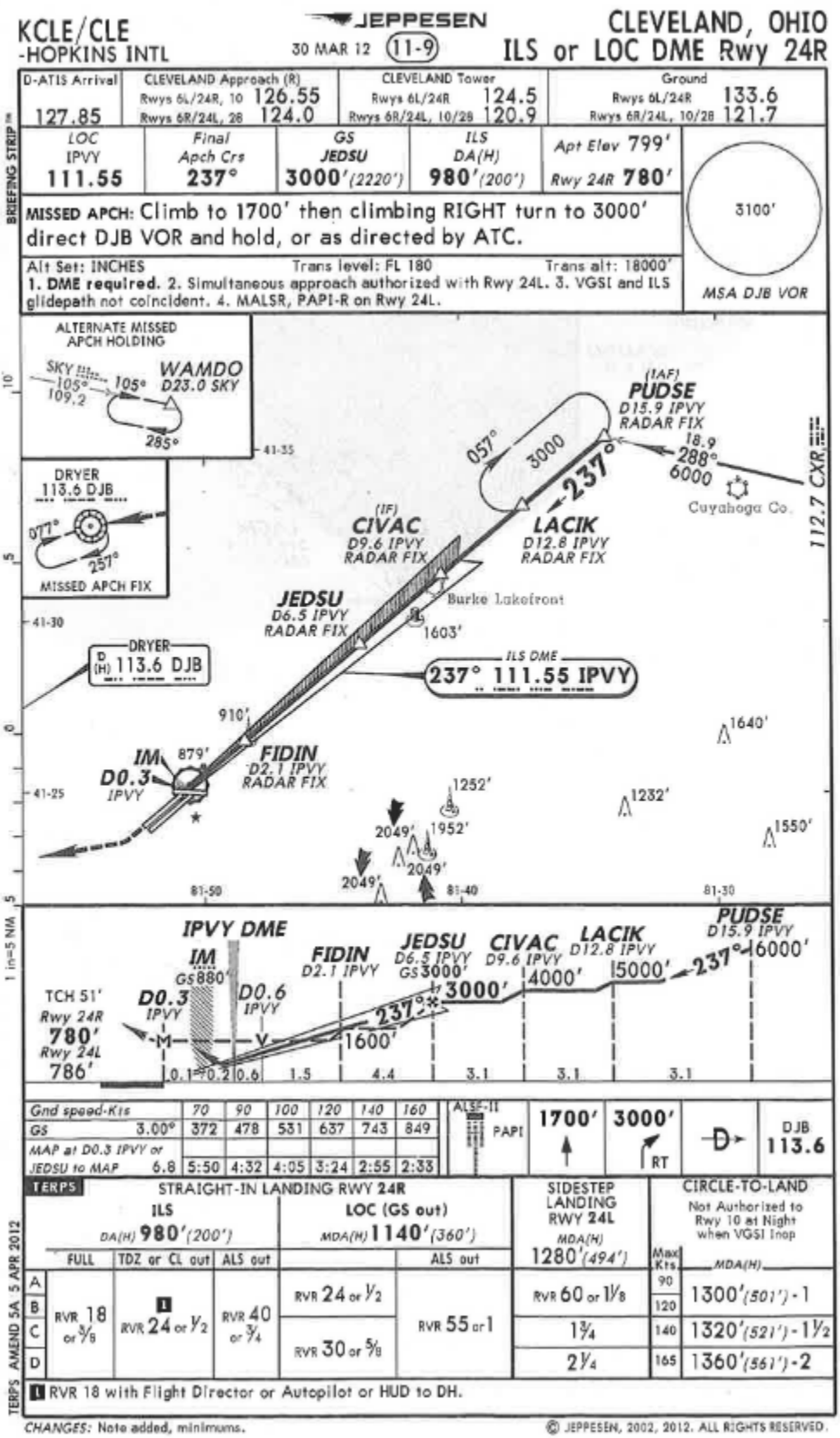
BRIEFING STRIP™
TERPS AMEND 24A 26 JUL 2012


KCLE/CLE
-HOPKINS INTL
JEPPESEN
30 MAR 12
11-9
CLEVELAND, OHIO
ILS or LOC DME Rwy 24R
D-ATIS Arrival
127.85
CLEVELAND Approach (R)
Rwys 6L/24R, 10 126.55
Rwys 6R/24L, 28 124.0
CLEVELAND Tower
Rwys 6L/24R 124.5
Rwys 6R/24L, 10/28 120.9
Ground
Rwys 6L/24R 133.6
Rwys 6R/24L, 10/28 121.7
LOC
IPVY
111.55
Final
Apch Crs
237°
GS
JEDSU
3000'(2220')
ILS
DA(H)
980'(200')
Apt Elev 799'
Rwy 24R 780'
MISSED APCH: Climb to 1700' then climbing RIGHT turn to 3000' direct DJB VOR and hold, or as directed by ATC.
Alt Set: INCHES
Trans level: FL 180
Trans alt: 18000'
1. DME required. 2. Simultaneous approach authorized with Rwy 24L. 3. VGSI and ILS glidepath not coincident. 4. MALSR, PAPI-R on Rwy 24L.
3100'
MSA DJB VOR
ALTERNATE MISSED APCH HOLDING
WAMDO
D23.0 SKY
105°
109.2
285°
DRYER
113.6 DJB
077°
257°
MISSED APCH FIX
(IAF)
PUDSE
D15.9 IPVY
RADAR FIX
18.9
288°
6000
Cuyahoga Co.
112.7 CXR
057°
3000
237°
(IF)
CIVAC
D9.6 IPVY
RADAR FIX
LACIK
D12.8 IPVY
RADAR FIX
JEDSU
D6.5 IPVY
RADAR FIX
Burke Lakefront
1603'
DRYER
D (H) 113.6 DJB
ILS DME
237° 111.55 IPVY
910'
IM
879'
D0.3
IPVY
FIDIN
D2.1 IPVY
RADAR FIX
1640'
1252'
1232'
1550'
2049'
1952'
2049'
2049'
41-35
41-30
41-25
81-50
81-40
81-30
IPVY DME
IM
GS 880'
D0.3
IPVY
D0.6
IPVY
FIDIN
D2.1 IPVY
JEDSU
D6.5 IPVY
GS 3000'
CIVAC
D9.6 IPVY
LACIK
D12.8 IPVY
PUDSE
D15.9 IPVY
6000'
TCH 51'
Rwy 24R
780'
Rwy 24L
786'
3000'
4000'
5000'
237°
1600'
0.1
0.2
0.6
1.5
4.4
3.1
3.1
3.1
Gnd speed-Kts 70 90 100 120 140 160
GS 3.00° 372 478 581 637 743 849
MAP at D0.3 IPVY or JEDSU to MAP 6.8 5:50 4:32 4:05 3:24 2:55 2:33
ALSF-II
PAPI
1700'
3000'
RT
DJB
113.6
TERPS
STRAIGHT-IN LANDING RWY 24R
ILS
DA(H) 980'(200')
LOC (GS out)
MDA(H) 1140'(360')
SIDESTEP LANDING RWY 24L
MDA(H) 1280'(494')
CIRCLE-TO-LAND
Not Authorized to Rwy 10 at Night when VGSI Inop
FULL
TDZ or CL out
ALS out
ALS out
Max Kts
MDA(H)
A
B
C
D
RVR 18 or 3/8
L RVR 24 or 1/2
RVR 40 or 3/4
RVR 24 or 1/2
RVR 30 or 5/8
RVR 55 or 1
RVR 60 or 1 1/8
1 3/4
2 1/4
90
120
140
165
1300'(501')-1
1320'(521')-1 1/2
1360'(561')-2
L RVR 18 with Flight Director or Autopilot or HUD to DH.
CHANGES: Note added, minimums.
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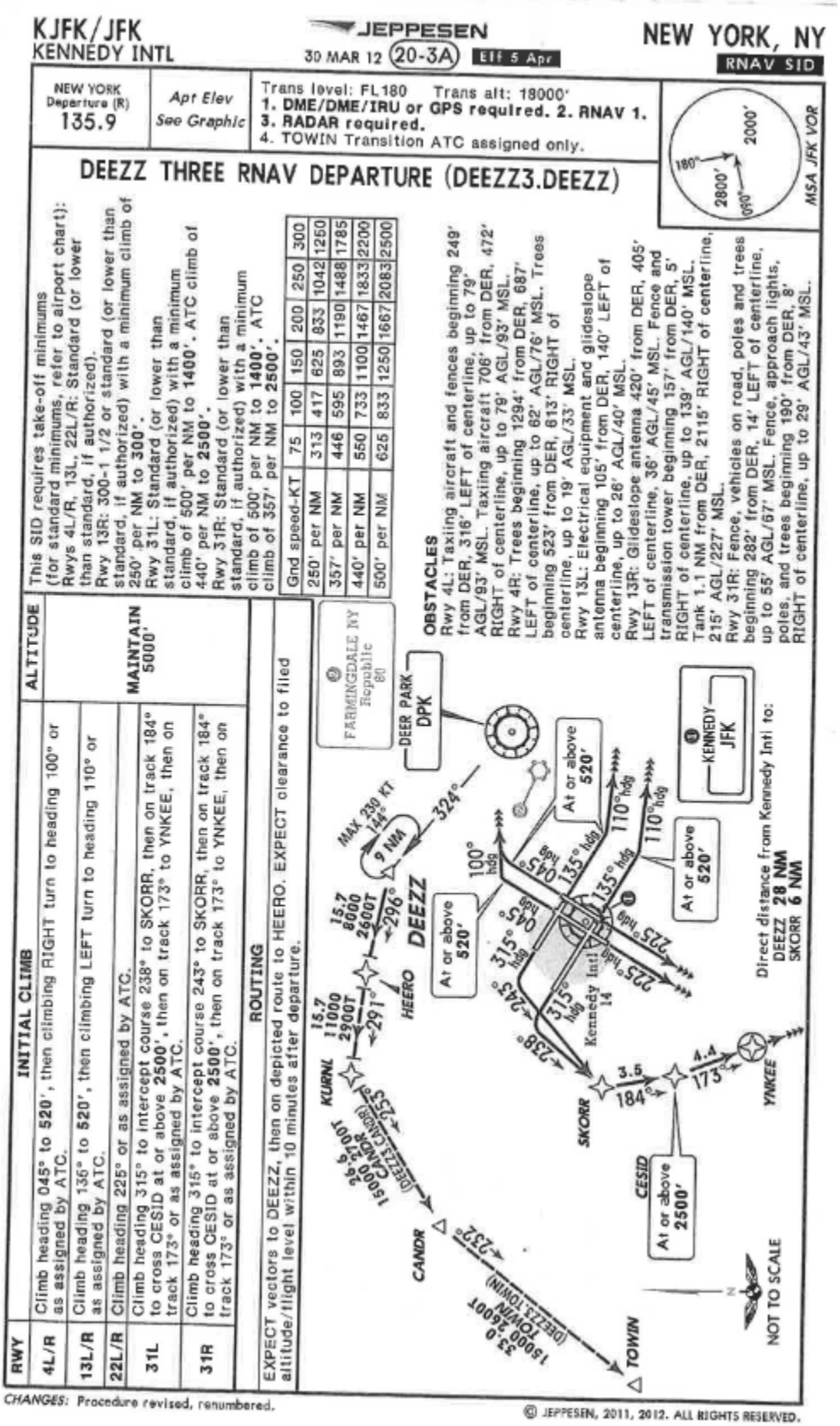
BRIEFING STRIP
TERPS AMEND 5A 5 APR 2012
1 in=5 NM


KJFK/JFK
KENNEDY INTL
JEPPESEN
30 MAR 12 (20-3A) Eff 5 Apr
NEW YORK, NY
RNAV SID
NEW YORK Departure (R) 135.9
Apr Elev See Graphic
Trans level: FL180 Trans alt: 18000'
1. DME/DME/IRU or GPS required. 2. RNAV 1.
3. RADAR required.
4. TOWIN Transition ATC assigned only.
DEEZZ THREE RNAV DEPARTURE (DEEZZ3.DEEZZ)
MSA JFK VOR
180° 2000' 2800' 090°
This SID requires take-off minimums (for standard minimums, refer to airport chart):
Rwys 4L/R, 13L, 22L/R: Standard (or lower than standard, if authorized).
Rwy 13R: 300-1 1/2 or standard (or lower than standard, if authorized) with a minimum climb of 250' per NM to 300'.
Rwy 31L: Standard (or lower than standard, if authorized) with a minimum climb of 500' per NM to 1400'. ATC climb of 440' per NM to 2500'.
Rwy 31R: Standard (or lower than standard, if authorized) with a minimum climb of 500' per NM to 1400'. ATC climb of 357' per NM to 2500'.
Gnd speed-KT 75 100 150 200 250 300
250' per NM 313 417 625 833 1042 1250
357' per NM 446 595 893 1190 1488 1785
440' per NM 550 733 1100 1467 1833 2200
500' per NM 625 833 1250 1667 2083 2500
RWY
4L/R
13L/R
22L/R
31L
31R
INITIAL CLIMB
Climb heading 045° to 520', then climbing RIGHT turn to heading 100° or as assigned by ATC.
Climb heading 135° to 520', then climbing LEFT turn to heading 110° or as assigned by ATC.
Climb heading 225° or as assigned by ATC.
Climb heading 315° to intercept course 238° to SKORR, then on track 184° to cross CESID at or above 2500', then on track 173° to YNKEE, then on track 173° or as assigned by ATC.
Climb heading 315° to intercept course 243° to SKORR, then on track 184° to cross CESID at or above 2500', then on track 173° to YNKEE, then on track 173° or as assigned by ATC.
ALTITUDE
MAINTAIN 5000'
ROUTING
EXPECT vectors to DEEZZ, then on depicted route to HEERO. EXPECT clearance to filed altitude/flight level within 10 minutes after departure.
OBSTACLES
Rwy 4L: Taxiing aircraft and fences beginning 249' from DER, 316' LEFT of centerline, up to 79' AGL/93' MSL. Taxiing aircraft 706' from DER, 472' RIGHT of centerline, up to 79' AGL/93' MSL.
Rwy 4R: Trees beginning 1294' from DER, 687' LEFT of centerline, up to 62' AGL/76' MSL. Trees beginning 523' from DER, 613' RIGHT of centerline, up to 19' AGL/33' MSL.
Rwy 13L: Electrical equipment and glideslope antenna beginning 105' from DER, 140' LEFT of centerline, up to 26' AGL/40' MSL.
Rwy 13R: Glideslope antenna 420' from DER, 405' LEFT of centerline, 36' AGL/45' MSL. Fence and transmission tower beginning 157' from DER, 5' RIGHT of centerline, up to 139' AGL/140' MSL. Tank 1.1 NM from DER, 2115' RIGHT of centerline, 215' AGL/227' MSL.
Rwy 31R: Fence, vehicles on road, poles and trees beginning 282' from DER, 14' LEFT of centerline, up to 55' AGL/67' MSL. Fence, approach lights, poles, and trees beginning 190' from DER, 8' RIGHT of centerline, up to 29' AGL/43' MSL.
FARMINGDALE NY Republic (8)
DEER PARK DPK
KENNEDY JFK
Direct distance from Kennedy Intl to:
DEEZZ 28 NM
SKORR 6 NM
MAX 230 KT
144°
9 NM
324°
296°
DEEZZ
15.7
8000
2600T
291°
HEERO
15.7
11000
2900T
KURNL
100° hdg
At or above 520'
At or above 520'
At or above 520'
At or above 2500'
135° hdg
110° hdg
045° hdg
315° hdg
225° hdg
243°
238°
Kennedy Intl 14
3.5
184°
SKORR
4.4
173°
YNKEE
CESID
CANDR
232°
(DEEZZ CANDR)
15000 2600T
(DEEZZ TOWIN)
15000 2600T
TOWIN
NOT TO SCALE
CHANGES: Procedure revised, renumbered.
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Dispatch Form

IFR DLA751 JFK CLE ALTN AKO
MIN T/O FUEL 15600 RLS FUEL 34400
TOT BRN 6200 PLAN ARR FUEL 28200 00HR/59MIN

ALTN RTE FL180 CLE.DCT.AKO
**********CRITICAL FLIGHT **********
FPL – DLA751_
-B738/M
-KJFK0100
-M080F320 DEEZZ3 CANDR J60 PSB YNG CXR2
-KCLE0100 KAKO

TO IDENT	FL	LAT WIND	LONG WCR	MC MH	MK TRR	GS TAS	TD I	SD TLDR	ST TTLT	SB TTLB
DEEZZ		N41.114	W73.777		 0008	250 250	0 0	0035 0387	0008 0008	0008 0008
HEERO		N41.169	W74.115	296		420 420	0 0	0016 0371	0002 0010	0002 0010
KURNL		N41.201	W74.458	291		420 420	0 0	0016 0355	0002 0012	0003 0013
CANDR	320	N40.970	W74.960	253	800	460 460	0 0	0027 0328	0004 0016	0007 0020
NEWEL	320	N40.917	W75.159	264	800	460 460	0 0	0010 0318	0001 0017	0001 0021
GYNTS	320	N40.868	W75.390	269	800	460 460	0 0	0011 0307	0001 0018	0001 0022
DANNR	320	N40.666	W76.240	266	800	460 460	0 0	0040 0267	0005 0023	0005 0027
FORTT	320	N40.840	W77.435	295	800	460 460	0 0	0055 0212	0007 0030	0007 0034
DOOTH	320	N40.875	W77.689	294	800	460 460	0 0	0012 0200	0001 0031	0001 0035
PSB	320	N40.916	W77.992	294	800	460 460	0 0	0014 0186	0002 0033	0002 0037
YNG	180	N41.331	W80.674	296	800	420 420	0 0	0129 0057	0016 0049	0016 0053
CXR	100	N41.517	W81.163	311		250 250	0 0	0025 0032	0003 0052	0001 0054
LEBRN	30	N41.452	W81.643	265		250 250	0 0	0022 0010	0005 0057	0001 0055
CLE	12	N41.409	N81855		1200			0010 0000	0002 0059	0001 0056

RWT 135600 PLD 10000

PLAN ARR FUEL 29500 0100

	ARPT	FUEL	TIME	DIST
ENRT BRN	CLE	5600	0059	0422

RSV		18800	
ALTN	AKO	6000	NM
HOLD		4000	

T/O Fuel 33800

TAXI JFK 600

TOTAL 34400

RLS FUEL JFK 34400

Remarks

VNAV --- Do not Use. Use Level Change only for theses tests.

Weight and Balance Data

EOW	91200	ZFW	101200
PSGR WT	8000	FUEL	34400
CGO WT	2000	RMP	135600
		TXI	600
		TOW	135000

Weather

JFK

METAR: 080100Z 04012KT 10SM CLR 09/M01 A3015

TAF: 071723Z 0818/0924 04010KT P6SM SCT250

CLE

METAR 080100Z 25010KT 15SM CLR 09/M01 A3012

TAF 071723Z 0818/0924 025010KT P6SM SCT250

SIGMET S

CONVECTIVE SIGMET 55C VALID UNTIL 0155 FOR ERN OH WRN PA WRN NY LINE TSTMS 40 NM WIDE MOVG NE AT 35KTS HAIL TO 2 IN PSBL

ATIS

JFK Information Alpha 0100Z Better than 5000 and 5 wind 040 at 12 temperature 15 dew point 05 altimeter 30.15 landing and departing runways 4L and 4R advise on initial contact you have information Alpha

Departure Clearance

Cleared to Cleveland Hopkins via DEETZ3 departure then as filed maintain 5000 departure frequency will be 135.9 Squawk 4671

6.4 Appendix D: Party Line Script and Mitigation Strategies

Appendix D contains the following:

- Party Line Script
- Flightcrew Error Mitigation Strategies

Party Line Script

Time	Live ATC	Party Line	Data Comm Message	Pilot Action
01:00:00	"Delta 751 cleared for takeoff"			
				"Delta 751 cleared for takeoff" (voice)
1 min after TO	"Delta 751 contact departure"			
				"Delta 751" (voice)
				"Departure Delta 751 out of [altitude] for 5,000" (voice)
Leaving 400 ft	"Delta 751 roger"			
Leaving 4,000 ft	"Delta 751 cleared direct DEETZ, climb and maintain 15,000"			
				"Direct DEETZ climb to 15,000 Delta 751" (voice)
				Proceeds direct to DEETZ (LEGS direct to)
				Climbs to 15,000 (MCP altitude)
01:03:00		New York Departure, American 582 with you out of 2,000 for 6,000		
01:03:07		American 582, radar contact continue heading one-zero-zero		
01:03:14		Heading one-zero-zero, American 582		
01:04:00		American 582 climb and maintain one-five-thousand		

Time	Live ATC	Party Line	Data Comm Message	Pilot Action
01:04:07		Up to one-five-thousand, American 582		
01:04:30		Jet Blue 281 contact New York Center 134.5		
01:04:37		Jet Blue 281		
01:05:00		United 723 climb and maintain one-five-thousand		
01:05:07		Up to one-five-thousand, United 723		
01:05:30		Southwest 6209 cleared direct Hartford, contact Boston Center 132.5		
01:05:37		Direct Hartford, Southwest 6209		
01:05:45		American 582, cleared direct DEETZ		
01:05:52		Direct DEETZ, American 582		
01:06:00		Departure, Jet Blue 283 with you out of 2,000 for 6,000		
01:06:10		Jet Blue 283 radar contact, climb and maintain one-five-thousand		
01:06:17		Climb to one-five-thousand, Jet Blue 283		
01:06:30		United 3215 climb and maintain flight level two-three-zero, contact New York on 127.85		

Time	Live ATC	Party Line	Data Comm Message	Pilot Action
01:06:40		Flight level two-three-zero contact New York, United 3215		
01:07:00		United 723 climb and maintain flight level two-three-zero, contact Boston Center on 132.5		
01:07:10		Climb to flight level two-three-zero, United 723		
01:07:30		Departure American 2375 with you out of 2,000 for 6,000		
01:07:37		American 2375 radar contact, continue heading one-zero-zero		
01:07:44		Heading one-zero-zero, American 2375		
01:08:00			**PROCEED DIRECT TO; CANDR;**	
				Listen/Confer/Reply (SOP)
				Replies WILCO/ROGER (CPDLC)
				Proceeds direct to CANDR (LEGS direct to)
01:08:30		Southwest 1204 contact New York Center on 127.85		
01:08:39		Southwest 1204		
01:09:00		Departure, Air Tran 284 with you out of 2,000 for 6,000		

Time	Live ATC	Party Line	Data Comm Message	Pilot Action
01:09:07		Air Tran 284 radar contact, climb and maintain one-five-thousand		
01:09:14		Climb to one-five-thousand, Air Tran 284		
01:10:00		Air Tran 284 cleared direct DEETZ		
01:10:07		Direct DEETZ, Air Tran 284		
01:11:00			**CLIMB TO FL230; CONTACT NEW YORK; CENTER 127.85;**	
				Listen/Confer/Reply (SOP)
				Replies WILCO/ROGER (CPDLC)
				Climbs to 23,000 ft (MCP altitude)
				Dials freq 127.85 (radio)
				"New York Center Delta 751 with you out of [altitude] for 230" (voice)
	"Delta 751 New York Center Roger"			
01:12:00		United 987 contact Cleveland on 132.22		
01:12:10		Thirty-two-twenty-two, United 987		
01:12:30		New York Center, American 2314 request higher		

Time	Live ATC	Party Line	Data Comm Message	Pilot Action
01:12:37		American 2314 expect flight level two-six-zero in five minutes, crossing traffic		
01:12:47		American 2314		
01:13:00			**DUE TO CROSSING; TRAFFIC CROSS CANDR; AT OR ABOVE FL250; CLIMB TO FL260;**	
				Listen/Confer/Reply (SOP)
				Replies WILCO/ROGER (CPDLC)
				Climbs to 26,000 ft (MCP altitude)
				Crosses CANDR at/above 25,000 ft (listen - restriction)
01:13:30		New York Center, American 582 with you out of one-eight-zero for flight level two-three-zero		
01:13:38		American 582 New York Center, ROGER, climb and maintain flight level two-six-zero		
01:13:48		Climb to flight level two-six-zero, American 582		
01:15:00			**SQUAWK 5342;**	
				Listen/Confer/Reply (SOP)

Time	Live ATC	Party Line	Data Comm Message	Pilot Action
				Replies WILCO/ROGER (CPDLC)
				Selects code 5342 (transponder)
01:15:00		American 2314 fly heading two-three-zero, climb and maintain flight level two-six-zero		
01:15:10		Heading two-three-zero climb to flight level two-six-zero, American 2314		
01:16:00			**CONTACT NEW YORK; CENTER 134.5**	
				Listen/Confer/Reply (SOP)
				Replies WILCO/ROGER (CPDLC)
				Dials freq 134.5 (radio)
				"New York Center Delta 751 with you out of [altitude] for 260"(voice)
	"Delta 751 New York Center Roger"			
01:16:00		Southwest 4578 contact Cleveland Center on 132.22		
01:16:10		Southwest 4578		
01:16:20		Center United 421		
01:16:25		United 421 go ahead		

Time	Live ATC	Party Line	Data Comm Message	Pilot Action
01:16:30		We'd like to deviate thirty left for weather and get flight level three-two-zero if it's smooth		
01:16:40		United 421 deviation left of course approved. Let me know when you can go back on course, flight level three-two-zero reported smooth		
01:16:55		Deviation approved and call you back on course, United 421		
01:17:00		Center United 751		
01:17:05		United 751 go ahead		
01:17:10		Where was that United, can he give us a ride report?		
01:17:15		About 50 miles west of you. United 421 how's your ride?		
01:17:22		Light to moderate chop, United 421		
01:17:27		United 751 did you copy?		
01:17:33		Affirmative, and we'd like three-two-zero as well		
01:17:40		United 751 Climb and maintain flight level three-two-zero		
				Nothing; Does not climb to 32,000 ft (MCP altitude)

Time	Live ATC	Party Line	Data Comm Message	Pilot Action
01:17:47		Climb to three-two-zero, United 751		
01:18:00			**CLIMB TO FL280;**	
				Listen/Confer/Reply (SOP)
				Replies WILCO/ROGER (CPDLC)
				Climbs to 28,000 ft (MCP altitude)
01:18:30	United 421 climb and maintain flight level three-two-zero			
01:18:37	Climb to flight level three-two-zero, United 421			
01:18:45	New York Center American 582 with you flight level two-six-zero			
01:18:52	American 582 New York Center ROGER, climb and maintain flight level three-two-zero. Smooth rides at three-two-zero.			
01:19:00			**HAZARDOUS WEATHER; CONVECTIVE SIGMET; 55C VALID UNTIL 0155; FOR ERN OH WRN PA; WRN NY LINE TSTMS; 40 NM WIDE MOVG; NE AT 35KTS; HAIL TO 2 IN PSBL;**	
				Listen/Confer/Reply (SOP)

Time	Live ATC	Party Line	Data Comm Message	Pilot Action
				Replies WILCO/ROGER (CPDLC)
01:19:05		American 582 climb to flight level two-three-zero, thanks.		
01:19:30		Center, United 421 can go back on course		
01:19:38		United 421 ROGER, cleared direct Pittsburg rest of route unchanged		
01:19:48		Direct Pittsburg, United 421		
01:20:00			**DUE TO CROSSING; TRAFFIC CLIMB TO; REACH FL320 BEFORE; TIME 0130Z;**	
				Listen/Confer/Reply (SOP)
				Replies WILCO/ROGER (CPDLC)
				Climb to 32,000 ft before 0130 (listen - restriction)
01:20:00		UAL751 Contact Cleveland center on 132.22		
				Nothing; Does not contact Cleveland (radio/voice)
01:20:09		Cleveland on thirty-two-twenty-two, United 751		
01:21:00		New York, US Air 128 with you at flight level two-eight-zero		

Time	Live ATC	Party Line	Data Comm Message	Pilot Action
01:21:07		US Air 128, New York Center ROGER		
01:21:30		Eagle 521 descend and maintain flight level two-three-zero, contact New York approach on 127.85		
01:21:45		Descend to flight level two-three-zero and call approach, EAGLE 521		
01:22:30		New York Center, United 940 with you at flight level two-niner-zero		
01:22:38		United 940 New York Center, ROGER		
01:23:00		New York Center, Delta 761 with you at flight level three-three-zero		
01:23:07		Delta 761 New York Center, ROGER		
				Nothing; Does not respond (voice)
01:24:00		Delta 761 for traffic descend and maintain flight level three-one-zero		
				Nothing; Does not respond (voice); Does not descent to 31,000 (MCP altitude)
01:24:07		Descend to flight level three-one-zero, Delta 761		

Time	Live ATC	Party Line	Data Comm Message	Pilot Action
01:25:00			**DUE TO WEATHER; CLEARED TO KCLE; AIRPORT VIA DIRECT; BURNI EWC YNG CX2;**	
				Listen/Confer/Reply (SOP)
				Replies WILCO/ROGER (CPDLC)
				Modifies route (LEGS direct to)
01:26:00		American 582 say your Mach speed		
01:26:07		Mach seven-eight, American 582		
01:26:14		American 582 maintain Mach .78 or less for spacing		
01:26:24		Maintain seven-eight or less, American 582		
01:27:30		US Air 128 descend and maintain flight level two-three-zero		
01:27:37		Descend to flight level two-three-zero, US Air 128		
01:28:00			**MAINTAIN M.78 OR; GREATER FOR SPACING;**	
				Listen/Confer/Reply (SOP)
				Replies WILCO/ROGER (CPDLC)
				Maintains M.78 or greater (speed)

Time	Live ATC	Party Line	Data Comm Message	Pilot Action
01:28:00		US Air 128 contact New York Approach on 127.85		
01:28:07		Twenty-seven-eighty-five, US Air 128		
01:29:00		Delta 715 new routing advise when ready to copy		
				Nothing; Does not contact ATC (voice)
01:29:10		Go ahead, Delta 715		
01:29:25		Delta 715 cleared to Atlanta via present position direct ROME, rest of route unchanged		
01:29:35		Direct ROME, rest of route unchanged, Delta 715		
01:30:00		Delta 715 contact Washington Center on 126.72		
				Nothing; Does not contact Washington Center (radio/voice)
01:30:07		Delta 715		
01:30:30		United 421 contact Cleveland Center on 132.22		
01:30:38		Cleveland on 132.22, United 421		
01:31:00		United 940 descend and maintain flight level two-three-zero		
01:31:07		Descend to flight level two-three-zero, United 940		

Time	Live ATC	Party Line	Data Comm Message	Pilot Action
01:32:00		New York Center Southwest 627 with you at flight level three-one-zero		
01:32:07		Southwest 627, New York Center, ROGER		
01:33:00		Southwest 627 turn 30 degrees left for traffic		
01:33:07		Thirty left, Southwest 627		
01:33:30		Southwest 627, traffic two o'clock, ten miles southeast bound an airbus at flight level three-two-zero		
01:33:40		Traffic in sight, Southwest 627		
01:34:00			**CONTACT CLEVELAND; CENTER 132.22;**	
				Listen/Confer/Reply (SOP)
				Replies WILCO/ROGER (CPDLC)
				Dials freq 132.22 (radio)
				"Delta 751 is with you out of [altitude] for 320" (voice)
	"Delta 751 Cleveland Center, Roger"			
01:35:30		United 940 contact New York approach on 127.85		
01:35:37		Twenty-seven-eighty-five, United 940		

Time	Live ATC	Party Line	Data Comm Message	Pilot Action
01:36:00		Southwest 627 cleared direct Rivet		
01:36:07		Direct Rivet, Southwest 627		
01:37:00	**CLEARED TO DEVIATE; UP TO 20 MILES SOUTH; OF ROUTE DIRECT EWC; WHEN ABLE;**			
				Listen/Confer/Reply (SOP)
				Replies WILCO/ROGER (CPDLC)
				Deviates south of route (no more than 20 mi) (MCP Heading)
				Proceeds direct to EWC (LEGS restriction) – will happen later
01:37:30		Cleveland Center, American 582 is with you at flight level three-two-zero, Mach seven-eight or less		
01:37:40		American 582 Cleveland Center ROGER area of weather at twelve o'clock, 60 miles, advise if you need to deviate		
01:37:52		Will advise, American 582		

Time	Live ATC	Party Line	Data Comm Message	Pilot Action
01:38:00		Cleveland Center United 8734 with you at flight level three-seven-zero, smooth		
01:38:07		United 8734 Cleveland Center, ROGER, should be a good ride		
01:38:30		American 237 descend and maintain flight level two-four-zero		
01:38:37		Descend to two-four-zero, American 237		
01:39:00		Cleveland American 582		
01:39:07		American 582, go ahead		
01:39:15		Looks like we need to deviate about 30 left for some weather ahead		
01:39:21		American 582, deviation left of course approved, direct Elwood City when able		
01:39:30		Deviate left and direct Elwood City when able, American 582		
01:41:00		American 237, contact Cleveland center on 123.75		
01:41:08		Twenty-three-seventy-five, American 237		

Time	Live ATC	Party Line	Data Comm Message	Pilot Action
01:42:00		Cleveland Center Jet Blue 174 with you at flight level three-two-zero		
01:42:07		Jet Blue 174, Cleveland Center ROGER, area of weather at your twelve o'clock 60 miles, let me know if you need to deviate		
01:42:20		WILCO, Jet Blue 174		
01:42:30		Southwest 627 contact Washington Center on 126.72		
01:42:37		Southwest 627		
01:43:00		Hello Cleveland, US Air 187 with you at flight level three-one-zero, light chop		
01:43:10		US Air 187 Cleveland Center ROGER, flight level three-three-zero reported smooth		
01:43:20		We'd like three-three-zero		
01:43:27		US Air 187, standby		
01:44:00			**PROCEED DIRECT TO; YNG;**	
				Listen/Confer/Reply (SOP)
				Replies WILCO/ROGER (CPDLC)

Time	Live ATC	Party Line	Data Comm Message	Pilot Action
				Proceeds direct to YNG (LEGS direct to)
01:44:30		US Air 187, climb and maintain flight level three-three-zero		
01:44:37		Climb to three-three-zero, US Air 187		
01:44:47		US Air 187, slight routing change, let me know when you are ready to copy		
01:45:00		US Air 187, go ahead		
01:45:07		US Air 187 cleared to the Kennedy airport via direct Delancy Kingston niner		
01:45:16		Direct Delancy Kingston nine, US Air 187		
The following is exclusive to the countermand condition				
01:45:30	Delta 751 disregard CPDLC message to descend to flight level two-four-zero, descend and maintain flight level two-five-zero, maintain two-eight-zero knots or greater			
				Replies “FL250 and 280 knots Delta 751” (voice)
				Descends to 25,000 ft (MCP altitude)
				Maintains 280 kt (speed)

Time	Live ATC	Party Line	Data Comm Message	Pilot Action
01:46:00			**DESCEND TO FL240; MAINTAIN 280KTS OR; GREATER;**	
				Listen/Confer/Reply (SOP)
				Replies UNABLE (CPDLC)
End of countermand exclusive section				
				Nothing else; Does not descend to 24,000 (MCP altitude)
01:47:00		Center, American 582 back on course to Elwood City		
01:47:10		American 582, proceed direct Youngstown, descend and maintain flight level two-four-zero, do not exceed two-eight-zero knots in the descent		
01:47:22		Direct Youngstown and descend to two-four-zero, two-eighty or less, American 582		
01:48:00		United 8374, contact New York Center on 134.5		
01:48:09		Thirty-four-five, United 8374		
01:48:30			**CONTACT CLEVELAND CENTER 123.75**	
				Listen/Confer/Reply (SOP)

Time	Live ATC	Party Line	Data Comm Message	Pilot Action
				Replies WILCO/ROGER (CPDLC)
				Dials freq 123.75 (radio)
				"Cleveland Center Delta 751 is with you at FL250" [or "out of (altitude) for FL250"] (voice)
	"DLA751 Cleveland Center roger"			
01:49:00		Cleveland, American 582 with you descending to two-four-zero		
01:49:10		American 582, Cleveland Center, ROGER		
01:49:30			**EXPECT LOWER AT TIME; 0152Z**	
				Listen/Confer/Reply (SOP)
				Replies WILCO/ROGER (CPDLC)
01:50:00			**DESCEND TO FL200;**	
				Listen/Confer/Reply (SOP)
				Replies WILCO/ROGER (CPDLC)
				Descends to 20,000 ft (MCP altitude)
01:51:00			**DESCEND TO 11000 FT; CROSS YNG AT OR; BELOW 14000 FT; CLEVELAND ALTIMETER; 30.12;**	

Time	Live ATC	Party Line	Data Comm Message	Pilot Action
				Listen/Confer/Reply (SOP)
				Replies WILCO/ROGER (CPDLC)
				Descends to 11000 ft (MCP altitude)
				Crosses YNG at/below 14000 ft (listen - restriction)
				Sets altimeter at 30.12 (altimeter)
01:51:30		American 582 descend to one-one-thousand, cross Youngstown at or below one-four-thousand, Cleveland altimeter three-zero-one-five.		
01:51:45		Down to one-one-thousand, cross Youngstown at or below one-four-thousand, American 582.		
01:52:00			**CLEVELAND HOPKINS; ATIS C;**	
				Listen/Confer/Reply (SOP)
				Replies WILCO/ROGER (CPDLC)
				Dials in ATIS freq on communications radio (radio)

Time	Live ATC	Party Line	Data Comm Message	Pilot Action
	"Cleveland ATIS Information Charlie Better than 5000 and 5 temperature 15 Dewpoint 10 wind 240 at 15 altimeter 30.12 Advise on initial contact you have information Charlie"			
01:53:00			**CROSS YNG AT OR; BELOW 14000 FT; CROSS CXR AT AND; MAINTAIN 9000 FT; AT CXR CONTACT; CLEVELAND APPROACH ON; 126.55;**	
				Listen/Confer/Reply (SOP)
				Replies WILCO/ROGER (CPDLC)
				Dials altitude 9,000 ft (MCP altitude)
				Dials freq 126.55 (radio)
				Crosses YNG at or below 14,000 ft (listen - restriction)
				Crosses CXR at 9,000 ft (listen – restriction)
				"Cleveland Approach DLA751 is with you at 9,000" (voice)
				END SCENARIO

Flightcrew Error Mitigation Strategies

Crew errors that occur during the experiment resulting from the use of CPDLC with and without speech are of course the primary interest of the study. We anticipate few of these, and those that do happen will likely be the result of errors in using the interface. The crew will be free to ask the experimenter to remind them how to navigate the CPDLC software to help avoid this type of error.

Our strategy for dealing with errors directly related to the *content* of the CPDLC messages will depend on the timing of the error in relation to the clearance given, whether or not the crew responded to the clearance, and whether or not the crew made the correct modifications to the FMS/Mode control panel to execute the clearance. The role of the live controller/'experimenter' will be to take each of these errors on a case by case basis.

In the event the crew fails to respond to the CPDLC message—e.g., no WILCO/UNABLE, but takes the correct action (e.g., modifies the flight path of the aircraft on the FMS or MCP):

- Give the crew time to notice a message is still open (which occurs when a new message is received)
- Query the crew whether or not they received a CPDLC clearance
- Restate the clearance via voice if necessary
- Assure the crew responds to the open message. This is important for data collection purposes.

In the event of an incorrect crew action to a CPDLC message—e.g., the crew enters an incorrect altitude/route into the MCP/FMS.

- If the mistake will not compromise the applicability of the next instruction in the script: Don't intervene.
- If the mistake will render the next instruction not applicable, the following actions may be appropriate:
- Query the crew as to the content of the CPDLC message
- Live controller/experimenter intervenes via voice to get pilots back on track. (e.g., DL751, confirm receipt of a CPDLC message to XXXXXXX)

All errors, whether they are errors in responding to the Data Comm system or flying errors, must be handled with the goal of ensuring that

a) the data captures the flightcrew's error; and
b) the remaining scenario is not compromised

6.5 Appendix E: Checklists and experimental scripts

Appendix E contains:

- Set-Up Checklist
- Pre-Experiment Checklist (Welcome and Initial Briefing)
- Training Run #1 Checklist
- Training Run #2 Checklist
- Instructions for Observer Checklist
- Experimental Scripts (1: text+speech, countermand present; 2: text only, countermand present; 3: text+speech, countermand absent; 4; text only, countermand absent)
- Post-Session 1 Checklist
- Post-Session 2 Checklist
- Simulator Support Checklist
- ATC/Trainer Checklist
- CPDLC Training that was Accomplished During Flight Checklist
- Counterbalancing Scheme

Set-Up Checklists (Before Participants Arrive)

	Action	☑	Notes
In general…			
	Observer enter: • Observer Name: _____ • Participant #'s: _____ & _____ • Crew #: _____ • Experiment Counterbalancing order: (1)_____ (2) _____ [e.g., (1) Text, (2) Text+speech] • Countermand condition: _____ • Date: _____ (See Counterbalancing Scheme)		
	Place "Quiet please, experiment in progress" signs on the front door, the door to the outside observer room, and the door to the simulator.		
In briefing room…			
	Place on briefing room table:		
	•-Informed Consent Forms (4)		
	•-Withdrawal Forms (2)		
	• Debriefing (2)		
	• Hard-copy questionnaires at workstations, in proper order (2 each)		
	•Hard-copy image of CPDLC Interface (1)		
	Launch briefing on large screen		
	Launch online questionnaires in proper order (see counterbalancing order)…		
	Enter Participant # in each questionnaire and click NEXT		
In outside observation room…			
	Sim Tech launched response time program		
	Observer places observer checklists at observer station (check counterbalancing scheme)		
In inside observation room…			
	Observer places CPDLC procedures printouts in observation room.		
	Observer places observer checklists at observer station (check counterbalancing scheme)		
	Observer places print-out envelopes at observer station		
In simulator cab…			
	Place notepads & pencils near each seat		
	Place headphones & cleaning wipes near each seat		
	Place flight briefing in cab		
	Check printer paper & fill if needed		

Welcome & Initial Briefing

	Action	☑	Notes
In briefing room…			
	Observer gives each participant 2 copies of informed consent form and talk through it w/ Briefing PPT		
	Observers obtain both participants' signatures on informed consent form and sign both copies		
	Observers give copies of consent form to participants		
	Observer files signed consent forms in filing cabinet (Andrea's office)		
	Observer/Briefer gives briefing		
	Participants fill out Pre-experiment Questionnaires		
	Short break… Crew determines pilot roles **Observer enter roles:** PF: _____ / PM: _____		
	Observer bring crew to simulator room for training		

Training Run #1

Action	☑	Notes
Observer enter: • Observer Name: _____ • Observer Location (inside/outside):_____ • Run 1 condition: _____ • Run 1 seat: L _____ R _____ [enter Pilot ID) • Time start: _____ • Date: _____		
In simulator cab…		
RUN 1		
Observer closes door to observer room		
Trainer/ATC briefs simisms…		
• VNAV is inoperative		
• TCAS is inoperative		
• Do not enable Wx display		
• Wx is not scaled		
• Do not select alternate MFD display		
Sim Tech tests party line volume. **Observer enter vol setting**: ____		
Sim Tech launched RUN 1 training scenario (incl. reset time, start CPDLC)		
Sim Tech dims light		
Trainer/ATC begins CPDLC training…		
• After takeoff: Menu Briefing		
o How to access CPDLC menu from NAV pages (MENU/SIM/NEXT PAGE)		
o Logon page (non-interactive)		
o MSG Log		
o Speech on/off → tell them not to change it		
o Other items – non-functional		
o *ATC MSG – LSK 12/Chime – EICAS Message – on all pages		
1. "Climb to 12000": CPDLC Message Page Briefing		
o Accessed via ATC MSG press or MSG Log		
o When speech is on, the message is annunciated upon access		
o Message header description		
o Current Message/Message Status description		
o WILCO/ROGER response		
o REJECT response		
o Speak/Mute button – demo use with live clearances		
o PRINT		
o RETURN		
2. "Proceed direct to GDM" – let message timeout – MSL LOG Page		
o Message timeout screen and EICAS/LSK 12 indications		
o List of all received messages		

	Action	☑	Notes
	o Latest message first		
	o Select MSG to open message and enable response to open message		
	3. Contact Boston on 132.22 –Practice UNABLE/REJECT		
	4. “Due to Traffic…” -- Multi Page Access		
	o Next button/ Back LSK		
	o Must read page 2 Response requirement		
	5. “Cleared to ALB…” - Practice		
	6. “SQUAWK 5328” – REJECT/UNABLE PAGE		
	o Select reason for reject		
	o Press SEND to send REJECT to ATC		
	7. “Hazardous Weather …” – Use of ROGER instead of WILCO		
	8. “CROSS CAMBRIDGE…” – Multipage practice – Notice WX display		
	Trainer/ATC tells crew that practice messages will begin – first 6 messages repeated 1 minute apart		
	Observer reminds pilots to practice procedures (use printout)		
	Crew is proficient with CPDLC interface (if not, continue practice) Proficiency = at least one message accepted, printed, timed-out and rejected without error/questions		
	Crew takes break for setup – 10 min bathroom etc.		
	Observer gives crew flight briefing materials to review.		

Training Run #2

Action	☑	Notes
Observer enter: • Observer Name: _____ • Observer Location (inside/outside):_____ • Run 2 condition: _____ • Run 2 seat: L _____ R _____ [enter Pilot ID) • Time start: _____ • Date: _____		
In observation room…		
Observer reminds crew of CPDLC procedures (use printout)		
In simulator cab…		
RUN 2		
Observer closes door to observer room		
Sim Tech launched RUN 1 training scenario (incl. reset time, start CPDLC)		
Sim Tech dims light		
Trainer/ATC tells crew what's different with CDPLC		
Crew practices until proficient with CPDLC interface (if not, continue practice) Proficiency = at least one message accepted, printed, timed-out and rejected without error/questions		
Crew takes break for setup – 10 min bathroom etc.		
Observer gives crew flight briefing materials to review (if they want them)		

Instructions for Observer Checklist

The observer will use the checklist to record the time (scenario time; in the "☑ / Time" column) when the crew and/or ATC completes each action. When it is not possible to record the time, the observer will only check off that the action was completed. Actions under the column "Pilot Actions" are the highest priority and the observer should aim to record time for these actions, if nothing else.

Pilot actions are monitored by watching over-the-shoulder (Observer 1; sim room) or via video (Observer 2; observation room) and via headphones. The table below categories pilot actions by type and provides descriptions of what the observer should see or hear when the pilot executes those actions. Note that although each action as attributed to either the first officer (FO) or the captain (Capt), either pilot may respond.

Action Type	Description
Voice	FO speaks to ATC via voice over radio.
CPDLC	FO responds to Data Comm message via the CDU (*ATC MSG will turn off when sent)
Data Comm procedures	Whether crew complies with procedures
MCP heading	Capt dials new heading on MCP: 1. Dials new heading 2. Presses "HDG SEL" (only when ATC assigns new heading)
MCP altitude	Capt dials new altitude on MCP: 1. Dials new altitude 2. Presses "Altitude Intervene" or "Level Change" button to execute (unless already in climb/descent) 3. (Throttles will go up)
LEGS - direct to	Capt enters "direct to" route into CDU Legs page: 1. Selects new fix 2. Presses top button to move fix to top (EXEC button lights up) 3. Presses EXEC button to execute
Restriction	Capt enters restriction in FMS: 1. Types in restriction (note: A=above/B=below) (EXEC button lights up) 2. Pressed EXEC button to execute And/or: Observer must listen to pilot conversation to determine if crew understood the restriction (example of restriction: "Cross CANDR at or above FL250")
Radio & ATIS	FO/Capt dial radio frequency on center console: 1. Dial freq 2. Press TRF (transfer button) 3. Freq shows up in left window
Transponder	FO dials transponder code on center console (beep-beep-beep when changed)
Airspeed	Whether crew complies with airspeed. 1. Airspeed shown on MCP and PFD. 2. Mach speed is on PFD (bottom left)
Altimeter	Crew changes altimeter setting using "STD" dial (both pilots have one) Also shows up on PFD (bottom right, "STD" is 29.92 or setting shown in yellow box)

Instructions for Observer Checklist (cont.)

On the checklist, in the Notes column, the observer should also record

1. When step-ons occur,
2. Pilot errors/non-compliance (see Pilot Error Mitigation Strategies)
3. Pilot queries to ATC/experimenter
4. Etc.

Notes: (1) Actions in quotation marks indicate phrases spoken over radio. (2) Pilot/Crew voice responses are suggested based on standard phraseology. The experimenter (ATC) will not intervene if the pilots use other phraseology. (3) Actions with ** are CPDLC messages. (4) Yellow-highlighted cells are messages to ownship.

Observer Roles

Observer-INSIDE

- Record inputs to the MCP (altitude, heading, airspeed)
- Record inputs to the radio (frequency changes, transponder entries)
- Record entries into CDU (route changes on LEGS page and CPDLC entries – CPDLC is redundant with sim data)
- Record flight crew interaction with live controller (typically Alan) (e.g., queries to ATC, ATC interventions)
- Record time of MCP entry and time of CDU entry, as possible

Observer-OUTSIDE

- Record all step-ons between text+speech and party line (assume no step ons with text-only)
- Record interaction between the flight crew (e.g., discussion of messages, especially understanding of restrictions & execution of Data Comm procedures, etc.).
- Record time of MCP entry and CDU entry, as possible

Summary:

Inside: Focus on entries to MCP

Outside: Focus on step-ons, crew interaction

Definition of a Step-on

Step-on definition: Occurrences in which the synthetic speech and party line occur at the same time

- INTENTIONAL Step on: Occurs when the flightcrew INTIATES the synthetic speech while the party line is also playing.
- UNINTENTIONAL Step on: Occurs when the party line chatter occurs AFTER the flightcrew has initiated the synthetic speech

TEXT+SPEECH, COUNTERMAND PRESENT

OBSERVER WRITE IN

OBSERVER NAME: _____LOCATION (inside/outside): _____

CREW ID: _____

SESSION (1/2): _____

DATE: _____ LOCAL TIME: _____

Inside: Did Sim Tech remind crew about not talking to ATC? _____

Outside: Is data collection working (red)? _____

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:00:00	"Delta 751 cleared for takeoff"		01:00:00	
		"Delta 751 cleared for takeoff" (voice)		
1 min after TO	"Delta 751 contact departure"			
		"Delta 751" (voice)		
		"Departure Delta 751 out of [altitude] for 5,000" (voice)		
Leaving 400 ft	"Delta 751 roger"			
Leaving 4,000 ft	"Delta 751 cleared direct DEETZ, climb and maintain 15,000"			
		"Direct DEETZ climb to 15,000 Delta 751" (voice)		
		Proceeds direct to DEETZ (LEGS direct to)		
		Climbs to 15,000 (MCP altitude)		
01:03:00	New York Departure, American 582 with you out of 2,000 for 6,000			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:03:07	American 582, radar contact continue heading one-zero-zero			
01:03:14	Heading one-zero-zero, American 582			
01:04:00	American 582 climb and maintain one-five-thousand			
01:04:07	Up to one-five-thousand, American 582			
01:04:30	Jet Blue 281 contact New York Center 134.5			
01:04:37	Jet Blue 281			
01:05:00	United 723 climb and maintain one-five-thousand			
01:05:07	Up to one-five-thousand, United 723			
01:05:30	Southwest 6209 cleared direct Hartford, contact Boston Center 132.5			
01:05:37	Direct Hartford, Southwest 6209			
01:05:45	American 582, cleared direct DEETZ			
01:05:52	Direct DEETZ, American 582			
01:06:00	Departure, Jet Blue 283 with you out of 2,000 for 6,000			
01:06:10	Jet Blue 283 radar contact, climb and maintain one-five-thousand			
01:06:17	Climb to one-five-thousand, Jet Blue 283			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:06:30	United 3215 climb and maintain flight level two-three-zero, contact New York on 127.85			
01:06:40	Flight level two-three-zero contact New York, United 3215			
01:07:00	United 723 climb and maintain flight level two-three-zero, contact Boston Center on 132.5			
01:07:10	Climb to flight level two-three-zero, United 723			
01:07:30	Departure American 2375 with you out of 2,000 for 6,000			
01:07:37	American 2375 radar contact, continue heading one-zero-zero			
01:07:44	Heading one-zero-zero, American 2375			
01:08:00	**PROCEED DIRECT TO; CANDR;**		01:08:00	
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Proceeds direct to CANDR (LEGS direct to)		
01:08:30	Southwest 1204 contact New York Center on 127.85			
01:08:39	Southwest 1204			
01:09:00	Departure, Air Tran 284 with you out of 2,000 for 6,000			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:09:07	Air Tran 284 radar contact, climb and maintain one-five-thousand			
01:09:14	Climb to one-five-thousand, Air Tran 284			
01:10:00	Air Tran 284 cleared direct DEETZ			
01:10:07	Direct DEETZ, Air Tran 284			
01:11:00	**CLIMB TO FL230; CONTACT NEW YORK; CENTER 127.85;**		01:11:00	
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Climbs to 23,000 ft (MCP altitude)		
		Dials freq 127.85 (radio)		
		"New York Center Delta 751 with you out of [altitude] for 230" (voice)		
	"Delta 751 New York Center Roger"			
01:12:00	United 987 contact Cleveland on 132.22			
01:12:10	Thirty-two-twenty-two, United 987			
01:12:30	New York Center, American 2314 request higher			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:12:37	American 2314 expect flight level two-six-zero in five minutes, crossing traffic			
01:12:47	American 2314			
01:13:00	**DUE TO CROSSING; TRAFFIC CROSS CANDR; AT OR ABOVE FL250; CLIMB TO FL260;**		01:13:00	
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Climbs to 26,000 ft (MCP altitude)		
		Crosses CANDR at/above 25,000 ft (listen - restriction)		
01:13:30	New York Center, American 582 with you out of one-eight-zero for flight level two-three-zero			
01:13:38	American 582 New York Center, ROGER, climb and maintain flight level two-six-zero			
01:13:48	Climb to flight level two-six-zero, American 582			
01:15:00	**SQUAWK 5342;**		01:15:00	Possible Step-on
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Selects code 5342 (transponder)		

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:15:00	American 2314 fly heading two-three-zero, climb and maintain flight level two-six-zero		01:15:00	
01:15:10	Heading two-three-zero climb to flight level two-six-zero, American 2314			
01:16:00	**CONTACT NEW YORK; CENTER 134.5**		01:16:00	Possible Step-on
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Dials freq 134.5 (radio)		
		"New York Center Delta 751 with you out of [altitude] for 260"(voice)		
	"Delta 751 New York Center Roger"			
01:16:00	Southwest 4578 contact Cleveland Center on 132.22		01:16:00	
01:16:10	Southwest 4578			
01:16:20	Center United 421			
01:16:25	United 421 go ahead			
01:16:30	We'd like to deviate thirty left for weather and get flight level three-two-zero if it's smooth			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:16:40	United 421 deviation left of course approved. Let me know when you can go back on course, flight level three-two-zero reported smooth			
01:16:55	Deviation approved and call you back on course, United 421			
01:17:00	Center United 751			
01:17:05	United 751 go ahead			
01:17:10	Where was that United, can he give us a ride report?			
01:17:15	About 50 miles west of you. United 421 how's your ride?			
01:17:22	Light to moderate chop, United 421			
01:17:27	United 751 did you copy?			
01:17:33	Affirmative, and we'd like three-two-zero as well			
01:17:40	United 751 Climb and maintain flight level three-two-zero			Similar Call Sign
		Nothing; Does not climb to 32,000 ft (MCP altitude)		
01:17:47	Climb to three-two-zero, United 751			
01:18:00	**CLIMB TO FL280;**		01:18:00	Possible Step on
		Listen/Confer/Reply (SOP)		

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
		Replies WILCO/ROGER (CPDLC)		
		Climbs to 28,000 ft (MCP altitude)		
01:18:30	United 421 climb and maintain flight level three-two-zero			
01:18:37	Climb to flight level three-two-zero, United 421			
01:18:45	New York Center American 582 with you flight level two-six-zero			
01:18:52	American 582 New York Center ROGER, climb and maintain flight level three-two-zero. Smooth rides at three-two-zero.			
01:19:00	**HAZARDOUS WEATHER; CONVECTIVE SIGMET; 55C VALID UNTIL 0155; FOR ERN OH WRN PA; WRN NY LINE TSTMS; 40 NM WIDE MOVG; NE AT 35KTS; HAIL TO 2 IN PSBL;**		01:19:00	
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
01:19:05	American 582 climb to flight level two-three-zero, thanks.			
01:19:30	Center, United 421 can go back on course			
01:19:38	United 421 ROGER, cleared direct Pittsburg rest of route unchanged			
01:19:48	Direct Pittsburg, United 421			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:20:00	**DUE TO CROSSING; TRAFFIC CLIMB TO; REACH FL320 BEFORE; TIME 0130Z;**		01:20:00	Possible step on
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Climb to 32,000 ft before 0130 (listen - restriction)		
01:20:00	UAL751 Contact Cleveland center on 132.22		01:20:00	Similar Call Sign
		Nothing; Does not contact Cleveland (radio/voice)		
01:20:09	Cleveland on thirty-two-twenty-two, United 751			
01:21:00	New York, US Air 128 with you at flight level two-eight-zero			
01:21:07	US Air 128, New York Center ROGER			
01:21:30	Eagle 521 descend and maintain flight level two-three-zero, contact New York approach on 127.85			
01:21:45	Descend to flight level two-three-zero and call approach, EAGLE 521			
01:22:30	New York Center, United 940 with you at flight level two-niner-zero			
01:22:38	United 940 New York Center, ROGER			
01:23:00	New York Center, Delta 761 with you at flight level three-three-zero			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:23:07	Delta 761 New York Center, ROGER			Similar Call Sign
		Nothing; Does not respond (voice)		
01:24:00	Delta 761 for traffic descend and maintain flight level three-one-zero			Similar Call Sign
		Nothing; Does not respond (voice); Does not descent to 31,000 (MCP altitude)		
01:24:07	Descend to flight level three-one-zero, Delta 761			
01:25:00	**DUE TO WEATHER; CLEARED TO KCLE; AIRPORT VIA DIRECT; BURNI EWC YNG CX2;**		01:25:00	
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Modifies route (LEGS direct to)		
01:26:00	American 582 say your Mach speed			
01:26:07	Mach seven-eight, American 582			
01:26:14	American 582 maintain Mach .78 or less for spacing			
01:26:24	Maintain seven-eight or less, American 582			
01:27:30	US Air 128 descend and maintain flight level two-three-zero			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:27:37	Descend to flight level two-three-zero, US Air 128			
01:28:00	**MAINTAIN M.78 OR; GREATER FOR SPACING;**		01:28:00	Possible Step-on
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Maintains M.78 or greater (speed)		
01:28:00	US Air 128 contact New York Approach on 127.85		01:28:00	
01:28:07	Twenty-seven-eighty-five, US Air 128			
01:29:00	Delta 715 new routing advise when ready to copy			Similar Call Sign
		Nothing; Does not contact ATC (voice)		
01:29:10	Go ahead, Delta 715			
01:29:25	Delta 715 cleared to Atlanta via present position direct ROME, rest of route unchanged			
01:29:35	Direct ROME, rest of route unchanged, Delta 715			
01:30:00	Delta 715 contact Washington Center on 126.72			Similar Call Sign
		Nothing; Does not contact Washington Center (radio/voice)		
01:30:07	Delta 715			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:30:30	United 421 contact Cleveland Center on 132.22			
01:30:38	Cleveland on 132.22, United 421			
01:31:00	United 940 descend and maintain flight level two-three-zero			
01:31:07	Descend to flight level two-three-zero, United 940			
01:32:00	New York Center Southwest 627 with you at flight level three-one-zero			
01:32:07	Southwest 627, New York Center, ROGER			
01:33:00	Southwest 627 turn 30 degrees left for traffic			
01:33:07	Thirty left, Southwest 627			
01:33:30	Southwest 627, traffic two o'clock, ten miles southeast bound an airbus at flight level three-two-zero			
01:33:40	Traffic in sight, Southwest 627			
01:34:00	**CONTACT CLEVELAND; CENTER 132.22;**		01:34:00	
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Dials freq 132.22 (radio)		

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
		"Delta 751 is with you out of [altitude] for 320" (voice)		
	"Delta 751 Cleveland Center, Roger"			
01:35:30	United 940 contact New York approach on 127.85			
01:35:37	Twenty-seven-eighty-five, United 940			
01:36:00	Southwest 627 cleared direct Rivet			
01:36:07	Direct Rivet, Southwest 627			
01:37:00	**CLEARED TO DEVIATE; UP TO 20 MILES SOUTH; OF ROUTE DIRECT EWC; WHEN ABLE;**		01:37:00	
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Deviates south of route (no more than 20 mi) (MCP Heading)		
		Proceeds direct to EWC (LEGS restriction) – will happen later		
01:37:30	Cleveland Center, American 582 is with you at flight level three-two-zero, Mach seven-eight or less			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:37:40	American 582 Cleveland Center ROGER area of weather at twelve o'clock, 60 miles, advise if you need to deviate			
01:37:52	Will advise, American 582			
01:38:00	Cleveland Center United 8734 with you at flight level three-seven-zero, smooth			
01:38:07	United 8734 Cleveland Center, ROGER, should be a good ride			
01:38:30	American 237 descend and maintain flight level two-four-zero			
01:38:37	Descend to two-four-zero, American 237			
01:39:00	Cleveland American 582			
01:39:07	American 582, go ahead			
01:39:15	Looks like we need to deviate about 30 left for some weather ahead			
01:39:21	American 582, deviation left of course approved, direct Elwood City when able			
01:39:30	Deviate left and direct Elwood City when able, American 582			
01:41:00	American 237, contact Cleveland center on 123.75			
01:41:08	Twenty-three-seventy-five, American 237			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:42:00	Cleveland Center Jet Blue 174 with you at flight level three-two-zero			
01:42:07	Jet Blue 174, Cleveland Center ROGER, area of weather at your twelve o'clock 60 miles, let me know if you need to deviate			
01:42:20	WILCO, Jet Blue 174			
01:42:30	Southwest 627 contact Washington Center on 126.72			
01:42:37	Southwest 627			
01:43:00	Hello Cleveland, US Air 187 with you at flight level three-one-zero, light chop			
01:43:10	US Air 187 Cleveland Center ROGER, flight level three-three-zero reported smooth			
01:43:20	We'd like three-three-zero			
01:43:27	US Air 187, standby			
01:44:00	**PROCEED DIRECT TO; YNG;**		01:44:00	
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Proceeds direct to YNG (LEGS direct to)		
01:44:30	US Air 187, climb and maintain flight level three-three-zero			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:44:37	Climb to three-three-zero, US Air 187			
01:44:47	US Air 187, slight routing change, let me know when you are ready to copy			
01:45:00	US Air 187, go ahead			
01:45:07	US Air 187 cleared to the Kennedy airport via direct Delancy Kingston niner			
01:45:16	Direct Delancy Kingston nine, US Air 187			
01:45:30	Delta 751 disregard CPDLC message to descend to flight level two-four-zero, descend and maintain flight level two-five-zero, maintain two-eight-zero knots or greater		01:45:30	Voice Countermand (recorded)
		Replies “FL250 and 280 knots Delta 751” (voice)		
		Descends to 25,000 ft (MCP altitude)		
		Maintains 280 kt (speed)		
01:46:00	**DESCEND TO FL240; MAINTAIN 280KTS OR; GREATER;**		01:46:00	Countermanded Clearance
		Listen/Confer/Reply (SOP)		
		Replies UNABLE (CPDLC)		
		Nothing else; Does not descend to 24,000 (MCP altitude)		

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:47:00	Center, American 582 back on course to Elwood City			
01:47:10	American 582, proceed direct Youngstown, descend and maintain flight level two-four-zero, do not exceed two-eight-zero knots in the descent			
01:47:22	Direct Youngstown and descend to two-four-zero, two-eighty or less, American 582			
01:48:00	United 8374, contact New York Center on 134.5			
01:48:09	Thirty-four-five, United 8374			
01:48:30	**CONTACT CLEVELAND CENTER 123.75**		01:47:00	Possible step on
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Dials freq 123.75 (radio)		
		"Cleveland Center Delta 751 is with you at FL250" [or "out of (altitude) for FL250"] (voice)		
	"DLA751 Cleveland Center roger"			
01:49:00	Cleveland, American 582 with you descending to two-four-zero			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:49:10	American 582, Cleveland Center, ROGER			
01:49:30	**EXPECT LOWER AT TIME; 0152Z**		01:49:30	
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
01:50:00	**DESCEND TO FL200;**		01:50:00	Possible step-on
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Descends to 20,000 ft (MCP altitude)		
01:51:00	**DESCEND TO 11000 FT; CROSS YNG AT OR; BELOW 14000 FT; CLEVELAND ALTIMETER; 30.12;**		01:51:00	
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Descends to 11000 ft (MCP altitude)		
		Crosses YNG at/below 14000 ft (listen - restriction)		
		Sets altimeter at 30.12 (altimeter)		

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:51:30	American 582 descend to one-one-thousand, cross Youngstown at or below one-four-thousand, Cleveland altimeter three-zero-one-five.			
01:51:45	Down to one-one-thousand, cross Youngstown at or below one-four-thousand, American 582.			
01:52:00	**CLEVELAND HOPKINS; ATIS C;**		01:52:00	
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Dials in ATIS freq on communications radio (radio)		
	"Cleveland ATIS Information Charlie Better than 5000 and 5 temperature 15 Dewpoint 10 wind 240 at 15 altimeter 30.12 Advise on initial contact you have information Charlie"			
01:53:00	**CROSS YNG AT OR; BELOW 14000 FT; CROSS CXR AT AND; MAINTAIN 9000 FT; AT CXR CONTACT; CLEVELAND APPROACH ON; 126.55;**		01:53:00	
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
		Dials altitude 9,000 ft (MCP altitude)		
		Dials freq 126.55 (radio)		
		Crosses YNG at or below 14,000 ft (listen - restriction)		
		Crosses CXR at 9,000 ft (listen – restriction)		
		"Cleveland Approach DLA751 is with you at 9,000" (voice)		
		END SCENARIO		

TEXT ONLY, COUNTERMAND PRESENT

OBSERVER WRITE IN

OBSERVER NAME: _____LOCATION (inside/outside): _____

CREW ID: _____

SESSION (1/2): _____

DATE: _____ LOCAL TIME: _____

Inside: Did Sim Tech remind crew about not talking to ATC? _____

Outside: Is data collection working (red)? _____

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:00:00	"Delta 751 cleared for takeoff"		01:00:00	
		"Delta 751 cleared for takeoff" (voice)		
1 min after TO	"Delta 751 contact departure"			
		"Delta 751" (voice)		
		"Departure Delta 751 out of [altitude] for 5,000" (voice)		
Leaving 400 ft	"Delta 751 roger"			
Leaving 4,000 ft	"Delta 751 cleared direct DEETZ, climb and maintain 15,000"			
		"Direct DEETZ climb to 15,000 Delta 751" (voice)		
		Proceeds direct to DEETZ (LEGS direct to)		
		Climbs to 15,000 (MCP altitude)		
01:03:00	New York Departure, American 582 with you out of 2,000 for 6,000			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:03:07	American 582, radar contact continue heading one-zero-zero			
01:03:14	Heading one-zero-zero, American 582			
01:04:00	American 582 climb and maintain one-five-thousand			
01:04:07	Up to one-five-thousand, American 582			
01:04:30	Jet Blue 281 contact New York Center 134.5			
01:04:37	Jet Blue 281			
01:05:00	United 723 climb and maintain one-five-thousand			
01:05:07	Up to one-five-thousand, United 723			
01:05:30	Southwest 6209 cleared direct Hartford, contact Boston Center 132.5			
01:05:37	Direct Hartford, Southwest 6209			
01:05:45	American 582, cleared direct DEETZ			
01:05:52	Direct DEETZ, American 582			
01:06:00	Departure, Jet Blue 283 with you out of 2,000 for 6,000			
01:06:10	Jet Blue 283 radar contact, climb and maintain one-five-thousand			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:06:17	Climb to one-five-thousand, Jet Blue 283			
01:06:30	United 3215 climb and maintain flight level two-three-zero, contact New York on 127.85			
01:06:40	Flight level two-three-zero contact New York, United 3215			
01:07:00	United 723 climb and maintain flight level two-three-zero, contact Boston Center on 132.5			
01:07:10	Climb to flight level two-three-zero, United 723			
01:07:30	Departure American 2375 with you out of 2,000 for 6,000			
01:07:37	American 2375 radar contact, continue heading one-zero-zero			
01:07:44	Heading one-zero-zero, American 2375			
01:08:00	**PROCEED DIRECT TO; CANDR;**		01:08:00	
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Proceeds direct to CANDR (LEGS direct to)		
01:08:30	Southwest 1204 contact New York Center on 127.85			
01:08:39	Southwest 1204			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:09:00	Departure, Air Tran 284 with you out of 2,000 for 6,000			
01:09:07	Air Tran 284 radar contact, climb and maintain one-five-thousand			
01:09:14	Climb to one-five-thousand, Air Tran 284			
01:10:00	Air Tran 284 cleared direct DEETZ			
01:10:07	Direct DEETZ, Air Tran 284			
01:11:00	**CLIMB TO FL230; CONTACT NEW YORK; CENTER 127.85;**		01:11:00	
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Climbs to 23,000 ft (MCP altitude)		
		Dials freq 127.85 (radio)		
		“New York Center Delta 751 with you out of [altitude] for 230” (voice)		
	“Delta 751 New York Center Roger”			
01:12:00	United 987 contact Cleveland on 132.22			
01:12:10	Thirty-two-twenty-two, United 987			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:12:30	New York Center, American 2314 request higher			
01:12:37	American 2314 expect flight level two-six-zero in five minutes, crossing traffic			
01:12:47	American 2314			
01:13:00	**DUE TO CROSSING; TRAFFIC CROSS CANDR; AT OR ABOVE FL250; CLIMB TO FL260;**		01:13:00	
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Climbs to 26,000 ft (MCP altitude)		
		Crosses CANDR at/above 25,000 ft (listen - restriction)		
01:13:30	New York Center, American 582 with you out of one-eight-zero for flight level two-three-zero			
01:13:38	American 582 New York Center, ROGER, climb and maintain flight level two-six-zero			
01:13:48	Climb to flight level two-six-zero, American 582			
01:15:00	**SQUAWK 5342;**		01:15:00	

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Selects code 5342 (transponder)		
01:15:00	American 2314 fly heading two-three-zero, climb and maintain flight level two-six-zero		01:15:00	
01:15:10	Heading two-three-zero climb to flight level two-six-zero, American 2314			
01:16:00	**CONTACT NEW YORK; CENTER 134.5**		01:16:00	
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Dials freq 134.5 (radio)		
		"New York Center Delta 751 with you out of [altitude] for 260"(voice)		
	"Delta 751 New York Center Roger"			
01:16:00	Southwest 4578 contact Cleveland Center on 132.22		01:16:00	
01:16:10	Southwest 4578			
01:16:20	Center United 421			
01:16:25	United 421 go ahead			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:16:30	We'd like to deviate thirty left for weather and get flight level three-two-zero if it's smooth			
01:16:40	United 421 deviation left of course approved. Let me know when you can go back on course, flight level three-two-zero reported smooth			
01:16:55	Deviation approved and call you back on course, United 421			
01:17:00	Center United 751			
01:17:05	United 751 go ahead			
01:17:10	Where was that United, can he give us a ride report?			
01:17:15	About 50 miles west of you. United 421 how's your ride?			
01:17:22	Light to moderate chop, United 421			
01:17:27	United 751 did you copy?			
01:17:33	Affirmative, and we'd like three-two-zero as well			
01:17:40	United 751 Climb and maintain flight level three-two-zero			Similar Call Sign
		Nothing; Does not climb to 32,000 ft (MCP altitude)		

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:17:47	Climb to three-two-zero, United 751			
01:18:00	**CLIMB TO FL280;**		01:18:00	
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Climbs to 28,000 ft (MCP altitude)		
01:18:30	United 421 climb and maintain flight level three-two-zero			
01:18:37	Climb to flight level three-two-zero, United 421			
01:18:45	New York Center American 582 with you flight level two-six-zero			
01:18:52	American 582 New York Center ROGER, climb and maintain flight level three-two-zero. Smooth rides at three-two-zero.			
01:19:00	**HAZARDOUS WEATHER; CONVECTIVE SIGMET; 55C VALID UNTIL 0155; FOR ERN OH WRN PA; WRN NY LINE TSTMS; 40 NM WIDE MOVG; NE AT 35KTS; HAIL TO 2 IN PSBL;**		01:19:00	
		Read Separately/Confer/Reply (SOP)		

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
		Replies WILCO/ROGER (CPDLC)		
01:19:05	American 582 climb to flight level two-three-zero, thanks.			
01:19:30	Center, United 421 can go back on course			
01:19:38	United 421 ROGER, cleared direct Pittsburg rest of route unchanged			
01:19:48	Direct Pittsburg, United 421			
01:20:00	**DUE TO CROSSING; TRAFFIC CLIMB TO; REACH FL320 BEFORE; TIME 0130Z;**		01:20:00	
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Climb to 32,000 ft before 0130 (listen - restriction)		
01:20:00	UAL751 Contact Cleveland center on 132.22		01:20:00	Similar Call Sign
		Nothing; Does not contact Cleveland (radio/voice)		
01:20:09	Cleveland on thirty-two-twenty-two, United 751			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:21:00	New York, US Air 128 with you at flight level two-eight-zero			
01:21:07	US Air 128, New York Center ROGER			
01:21:30	Eagle 521 descend and maintain flight level two-three-zero, contact New York approach on 127.85			
01:21:45	Descend to flight level two-three-zero and call approach, EAGLE 521			
01:22:30	New York Center, United 940 with you at flight level two-niner-zero			
01:22:38	United 940 New York Center, ROGER			
01:23:00	New York Center, Delta 761 with you at flight level three-three-zero			
01:23:07	Delta 761 New York Center, ROGER			Similar Call Sign
		Nothing; Does not respond (voice)		
01:24:00	Delta 761 for traffic descend and maintain flight level three-one-zero			Similar Call Sign
		Nothing; Does not respond (voice); Does not descent to 31,000 (MCP altitude)		
01:24:07	Descend to flight level three-one-zero, Delta 761			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:25:00	**DUE TO WEATHER; CLEARED TO KCLE; AIRPORT VIA DIRECT; BURNI EWC YNG CX2;**		01:25:00	
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Modifies route (LEGS direct to)		
01:26:00	American 582 say your Mach speed			
01:26:07	Mach seven-eight, American 582			
01:26:14	American 582 maintain Mach .78 or less for spacing			
01:26:24	Maintain seven-eight or less, American 582			
01:27:30	US Air 128 descend and maintain flight level two-three-zero			
01:27:37	Descend to flight level two-three-zero, US Air 128			
01:28:00	**MAINTAIN M.78 OR; GREATER FOR SPACING;**		01:28:00	
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Maintains M.78 or greater (PFD)		

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:28:00	US Air 128 contact New York Approach on 127.85		01:28:00	
01:28:07	Twenty-seven-eighty-five, US Air 128			
01:29:00	Delta 715 new routing advise when ready to copy			Similar Call Sign
		Nothing; Does not contact ATC (voice)		
01:29:10	Go ahead, Delta 715			
01:29:25	Delta 715 cleared to Atlanta via present position direct ROME, rest of route unchanged			
01:29:35	Direct ROME, rest of route unchanged, Delta 715			
01:30:00	Delta 715 contact Washington Center on 126.72			Similar Call Sign
		Nothing; Does not contact Washington Center (radio/voice)		
01:30:07	Delta 715			
01:30:30	United 421 contact Cleveland Center on 132.22			
01:30:38	Cleveland on 132.22, United 421			
01:31:00	United 940 descend and maintain flight level two-three-zero			
01:31:07	Descend to flight level two-three-zero, United 940			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:32:00	New York Center Southwest 627 with you at flight level three-one-zero			
01:32:07	Southwest 627, New York Center, ROGER			
01:33:00	Southwest 627 turn 30 degrees left for traffic			
01:33:07	Thirty left, Southwest 627			
01:33:30	Southwest 627, traffic two o'clock, ten miles southeast bound an airbus at flight level three-two-zero			
01:33:40	Traffic in sight, Southwest 627			
01:34:00	**CONTACT CLEVELAND; CENTER 132.22;**		01:34:00	
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Dials freq 132.22 (radio)		
		"Delta 751 is with you out of [altitude] for 320" (voice)		
	"Delta 751 Cleveland Center, Roger"			
01:35:30	United 940 contact New York approach on 127.85			
01:35:37	Twenty-seven-eighty-five, United 940			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:36:00	Southwest 627 cleared direct Rivet			
01:36:07	Direct Rivet, Southwest 627			
01:37:00	**CLEARED TO DEVIATE; UP TO 20 MILES SOUTH; OF ROUTE DIRECT EWC; WHEN ABLE;**		01:37:00	
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Deviates south of route (no more than 20 mi) (MCP Heading)		
		Proceeds direct to EWC (LEGS restriction) [may happen later]		
01:37:30	Cleveland Center, American 582 is with you at flight level three-two-zero, Mach seven-eight or less			
01:37:40	American 582 Cleveland Center ROGER area of weather at twelve o'clock, 60 miles, advise if you need to deviate			
01:37:52	Will advise, American 582			
01:38:00	Cleveland Center United 8734 with you at flight level three-seven-zero, smooth			
01:38:07	United 8734 Cleveland Center, ROGER, should be a good ride			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:38:30	American 237 descend and maintain flight level two-four-zero			
01:38:37	Descend to two-four-zero, American 237			
01:39:00	Cleveland American 582			
01:39:07	American 582, go ahead			
01:39:15	Looks like we need to deviate about 30 left for some weather ahead			
01:39:21	American 582, deviation left of course approved, direct Elwood City when able			
01:39:30	Deviate left and direct Elwood City when able, American 582			
01:41:00	American 237, contact Cleveland center on 123.75			
01:41:08	Twenty-three-seventy-five, American 237			
01:42:00	Cleveland Center Jet Blue 174 with you at flight level three-two-zero			
01:42:07	Jet Blue 174, Cleveland Center ROGER, area of weather at your twelve o'clock 60 miles, let me know if you need to deviate			
01:42:20	WILCO, Jet Blue 174			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:42:30	Southwest 627 contact Washington Center on 126.72			
01:42:37	Southwest 627			
01:43:00	Hello Cleveland, US Air 187 with you at flight level three-one-zero, light chop			
01:43:10	US Air 187 Cleveland Center ROGER, flight level three-three-zero reported smooth			
01:43:20	We'd like three-three-zero			
01:43:27	US Air 187, standby			
01:44:00	**PROCEED DIRECT TO; YNG;**		01:44:00	
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Proceeds direct to YNG (LEGS direct to)		
01:44:30	US Air 187, climb and maintain flight level three-three-zero			
01:44:37	Climb to three-three-zero, US Air 187			
01:44:47	US Air 187, slight routing change, let me know when you are ready to copy			
01:45:00	US Air 187, go ahead			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:45:07	US Air 187 cleared to the Kennedy airport via direct Delancy Kingston niner			
01:45:16	Direct Delancy Kingston nine, US Air 187			
01:45:30	Delta 751 disregard CPDLC message to descend to flight level two-four-zero, descend and maintain flight level two-five-zero, maintain two-eight-zero knots or greater		01:45:30	Voice Countermand (recorded)
		Replies “FL250 and 280 knots Delta 751” (voice)		
		Descends to 25,000 ft (MCP altitude)		
		Maintains 280 kt (MCP/PFD)		
01:46:00	**DESCEND TO FL240; MAINTAIN 280KTS OR; GREATER;**		01:46:00	Countermanded Clearance
		Read Separately/Confer/Reply (SOP)		
		Replies UNABLE (CPDLC)		
		Nothing else; Does not descend to 24,000 (MCP altitude)		
01:47:00	Center, American 582 back on course to Elwood City			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:47:10	American 582, proceed direct Youngstown, descend and maintain flight level two-four-zero, do not exceed two-eight-zero knots in the descent			
01:47:22	Direct Youngstown and descend to two-four-zero, two-eighty or less, American 582			
01:48:00	United 8374, contact New York Center on 134.5			
01:48:09	Thirty-four-five, United 8374			
01:48:30	**CONTACT CLEVELAND CENTER 123.75**		01:47:00	
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Dials freq 123.75 (radio)		
		"Cleveland Center Delta 751 is with you at FL250" [or "out of (altitude) for FL250"] (voice)		
	"DLA751 Cleveland Center roger			
01:49:00	Cleveland, American 582 with you descending to two-four-zero			
01:49:10	American 582, Cleveland Center, ROGER			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:49:30	**EXPECT LOWER AT TIME; 0152Z**		01:49:30	
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
01:50:00	**DESCEND TO FL200;**		01:50:00	
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Descends to 20,000 ft (MCP altitude)		
01:51:00	**DESCEND TO 11000 FT; CROSS YNG AT OR; BELOW 14000 FT; CLEVELAND ALTIMETER; 30.12;**		01:51:00	
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Descends to 11000 ft (MCP altitude)		
		Crosses YNG at/below 14000 ft (listen - restriction)		
		Sets altimeter at 30.12(altimeter)		

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:51:30	American 582 descend to one-one-thousand, cross Youngstown at or below one-four-thousand, Cleveland altimeter three-zero-one-five.			
01:51:45	Down to one-one-thousand, cross Youngstown at or below one-four-thousand, American 582.			
01:52:00	**CLEVELAND HOPKINS; ATIS C;**		01:51:00	
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Dials in ATIS freq on communications radio (radio)		
	"Cleveland ATIS Information Charlie Better than 5000 and 5 temperature 15 Dewpoint 10 wind 240 at 15 altimeter 30.12 Advise on initial contact you have information Charlie"			
01:53:00	**CROSS YNG AT OR; BELOW 14000 FT; CROSS CXR AT AND; MAINTAIN 9000 FT; AT CXR CONTACT; CLEVELAND APPROACH ON; 126.55;**		01:53:00	

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Dials altitude 9,000 ft (MCP altitude)		
		Dials freq 126.55 (radio)		
		Crosses YNG at or below 14,000 ft (listen - restriction)		
		Crosses CXR at 9,000 ft (listen – restriction)		
		"Cleveland Approach DLA751 is with you at 9,000" (voice)		
		END SCENARIO		

TEXT+SPEECH, COUNTERMAND ABSENT

OBSERVER WRITE IN

OBSERVER NAME: _____LOCATION (inside/outside): _____

CREW ID: _____

SESSION (1/2): _____

DATE: _____ LOCAL TIME: _____

Inside: Did Sim Tech remind crew about not talking to ATC? _____

Outside: Is data collection working (red)? _____

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:00:00	"Delta 751 cleared for takeoff"		01:00:00	
		"Delta 751 cleared for takeoff" (voice)		
1 min after TO	"Delta 751 contact departure"			
		"Delta 751" (voice)		
		"Departure Delta 751 out of [altitude] for 5,000" (voice)		
Leaving 400 ft	"Delta 751 roger"			
Leaving 4,000 ft	"Delta 751 cleared direct DEETZ, climb and maintain 15,000"			
		"Direct DEETZ climb to 15,000 Delta 751" (voice)		
		Proceeds direct to DEETZ (LEGS direct to)		
		Climbs to 15,000 (MCP altitude)		
01:03:00	New York Departure, American 582 with you out of 2,000 for 6,000			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:03:07	American 582, radar contact continue heading one-zero-zero			
01:03:14	Heading one-zero-zero, American 582			
01:04:00	American 582 climb and maintain one-five-thousand			
01:04:07	Up to one-five-thousand, American 582			
01:04:30	Jet Blue 281 contact New York Center 134.5			
01:04:37	Jet Blue 281			
01:05:00	United 723 climb and maintain one-five-thousand			
01:05:07	Up to one-five-thousand, United 723			
01:05:30	Southwest 6209 cleared direct Hartford, contact Boston Center 132.5			
01:05:37	Direct Hartford, Southwest 6209			
01:05:45	American 582, cleared direct DEETZ			
01:05:52	Direct DEETZ, American 582			
01:06:00	Departure, Jet Blue 283 with you out of 2,000 for 6,000			
01:06:10	Jet Blue 283 radar contact, climb and maintain one-five-thousand			
01:06:17	Climb to one-five-thousand, Jet Blue 283			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:06:30	United 3215 climb and maintain flight level two-three-zero, contact New York on 127.85			
01:06:40	Flight level two-three-zero contact New York, United 3215			
01:07:00	United 723 climb and maintain flight level two-three-zero, contact Boston Center on 132.5			
01:07:10	Climb to flight level two-three-zero, United 723			
01:07:30	Departure American 2375 with you out of 2,000 for 6,000			
01:07:37	American 2375 radar contact, continue heading one-zero-zero			
01:07:44	Heading one-zero-zero, American 2375			
01:08:00	**PROCEED DIRECT TO; CANDR;**		01:08:00	
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Proceeds direct to CANDR (LEGS direct to)		
01:08:30	Southwest 1204 contact New York Center on 127.85			
01:08:39	Southwest 1204			
01:09:00	Departure, Air Tran 284 with you out of 2,000 for 6,000			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:09:07	Air Tran 284 radar contact, climb and maintain one-five-thousand			
01:09:14	Climb to one-five-thousand, Air Tran 284			
01:10:00	Air Tran 284 cleared direct DEETZ			
01:10:07	Direct DEETZ, Air Tran 284			
01:11:00	**CLIMB TO FL230; CONTACT NEW YORK; CENTER 127.85;**		01:11:00	
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Climbs to 23,000 ft (MCP altitude)		
		Dials freq 127.85 (radio)		
		"New York Center Delta 751 with you out of [altitude] for 230" (voice)		
	"Delta 751 New York Center Roger"			
01:12:00	United 987 contact Cleveland on 132.22			
01:12:10	Thirty-two-twenty-two, United 987			
01:12:30	New York Center, American 2314 request higher			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:12:37	American 2314 expect flight level two-six-zero in five minutes, crossing traffic			
01:12:47	American 2314			
01:13:00	**DUE TO CROSSING; TRAFFIC CROSS CANDR; AT OR ABOVE FL250; CLIMB TO FL260;**		01:13:00	
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Climbs to 26,000 ft (MCP altitude)		
		Crosses CANDR at/above 25,000 ft (listen - restriction)		
01:13:30	New York Center, American 582 with you out of one-eight-zero for flight level two-three-zero			
01:13:38	American 582 New York Center, ROGER, climb and maintain flight level two-six-zero			
01:13:48	Climb to flight level two-six-zero, American 582			
01:15:00	**SQUAWK 5342;**		01:15:00	Possible Step-on
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
		Selects code 5342 (transponder)		
01:15:00	American 2314 fly heading two-three-zero, climb and maintain flight level two-six-zero		01:15:00	
01:15:10	Heading two-three-zero climb to flight level two-six-zero, American 2314			
01:16:00	**CONTACT NEW YORK; CENTER 134.5**		01:16:00	Possible Step-on
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Dials freq 134.5 (radio)		
		"New York Center Delta 751 with you out of [altitude] for 260"(voice)		
	"Delta 751 New York Center Roger"			
01:16:00	Southwest 4578 contact Cleveland Center on 132.22		01:16:00	
01:16:10	Southwest 4578			
01:16:20	Center United 421			
01:16:25	United 421 go ahead			
01:16:30	We'd like to deviate thirty left for weather and get flight level three-two-zero if it's smooth			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:16:40	United 421 deviation left of course approved. Let me know when you can go back on course, flight level three-two-zero reported smooth			
01:16:55	Deviation approved and call you back on course, United 421			
01:17:00	Center United 751			
01:17:05	United 751 go ahead			
01:17:10	Where was that United, can he give us a ride report?			
01:17:15	About 50 miles west of you. United 421 how's your ride?			
01:17:22	Light to moderate chop, United 421			
01:17:27	United 751 did you copy?			
01:17:33	Affirmative, and we'd like three-two-zero as well			
01:17:40	United 751 Climb and maintain flight level three-two-zero			Similar Call Sign
		Nothing; Does not climb to 32,000 ft (MCP altitude)		
01:17:47	Climb to three-two-zero, United 751			
01:18:00	**CLIMB TO FL280;**		01:18:00	Possible Step on
		Listen/Confer/Reply (SOP)		

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
		Replies WILCO/ROGER (CPDLC)		
		Climbs to 28,000 ft (MCP altitude)		
01:18:30	United 421 climb and maintain flight level three-two-zero			
01:18:37	Climb to flight level three-two-zero, United 421			
01:18:45	New York Center American 582 with you flight level two-six-zero			
01:18:52	American 582 New York Center ROGER, climb and maintain flight level three-two-zero. Smooth rides at three-two-zero.			
01:19:00	**HAZARDOUS WEATHER; CONVECTIVE SIGMET; 55C VALID UNTIL 0155; FOR ERN OH WRN PA; WRN NY LINE TSTMS; 40 NM WIDE MOVG; NE AT 35KTS; HAIL TO 2 IN PSBL;**		01:19:00	
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
01:19:05	American 582 climb to flight level two-three-zero, thanks.			
01:19:30	Center, United 421 can go back on course			
01:19:38	United 421 ROGER, cleared direct Pittsburg rest of route unchanged			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:19:48	Direct Pittsburg, United 421			
01:20:00	**DUE TO CROSSING; TRAFFIC CLIMB TO; REACH FL320 BEFORE; TIME 0130Z;**		01:20:00	Possible step on
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Climb to 32,000 ft before 0130 (listen - restriction)		
01:20:00	UAL751 Contact Cleveland center on 132.22		01:20:00	Similar Call Sign
		Nothing; Does not contact Cleveland (radio/voice)		
01:20:09	Cleveland on thirty-two-twenty-two, United 751			
01:21:00	New York, US Air 128 with you at flight level two-eight-zero			
01:21:07	US Air 128, New York Center ROGER			
01:21:30	Eagle 521 descend and maintain flight level two-three-zero, contact New York approach on 127.85			
01:21:45	Descend to flight level two-three-zero and call approach, EAGLE 521			
01:22:30	New York Center, United 940 with you at flight level two-niner-zero			
01:22:38	United 940 New York Center, ROGER			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:23:00	New York Center, Delta 761 with you at flight level three-three-zero			
01:23:07	Delta 761 New York Center, ROGER			Similar Call Sign
		Nothing; Does not respond (voice)		
01:24:00	Delta 761 for traffic descend and maintain flight level three-one-zero			Similar Call Sign
		Nothing; Does not respond (voice); Does not descent to 31,000 (MCP altitude)		
01:24:07	Descend to flight level three-one-zero, Delta 761			
01:25:00	**DUE TO WEATHER; CLEARED TO KCLE; AIRPORT VIA DIRECT; BURNI EWC YNG CX2;**		01:25:00	
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Modifies route (LEGS direct to)		
01:26:00	American 582 say your Mach speed			
01:26:07	Mach seven-eight, American 582			
01:26:14	American 582 maintain Mach .78 or less for spacing			
01:26:24	Maintain seven-eight or less, American 582			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:27:30	US Air 128 descend and maintain flight level two-three-zero			
01:27:37	Descend to flight level two-three-zero, US Air 128			
01:28:00	**MAINTAIN M.78 OR; GREATER FOR SPACING;**		01:28:00	Possible Step-on
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Maintains M.78 or greater (speed)		
01:28:00	US Air 128 contact New York Approach on 127.85		01:28:00	
01:28:07	Twenty-seven-eighty-five, US Air 128			
01:29:00	Delta 715 new routing advise when ready to copy			Similar Call Sign
		Nothing; Does not contact ATC (voice)		
01:29:10	Go ahead, Delta 715			
01:29:25	Delta 715 cleared to Atlanta via present position direct ROME, rest of route unchanged			
01:29:35	Direct ROME, rest of route unchanged, Delta 715			
01:30:00	Delta 715 contact Washington Center on 126.72			Similar Call Sign
		Nothing; Does not contact Washington Center (radio/voice)		

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:30:07	Delta 715			
01:30:30	United 421 contact Cleveland Center on 132.22			
01:30:38	Cleveland on 132.22, United 421			
01:31:00	United 940 descend and maintain flight level two-three-zero			
01:31:07	Descend to flight level two-three-zero, United 940			
01:32:00	New York Center Southwest 627 with you at flight level three-one-zero			
01:32:07	Southwest 627, New York Center, ROGER			
01:33:00	Southwest 627 turn 30 degrees left for traffic			
01:33:07	Thirty left, Southwest 627			
01:33:30	Southwest 627, traffic two o'clock, ten miles southeast bound an airbus at flight level three-two-zero			
01:33:40	Traffic in sight, Southwest 627			
01:34:00	**CONTACT CLEVELAND; CENTER 132.22;**		01:34:00	
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
		Dials freq 132.22 (radio)		
		"Delta 751 is with you out of [altitude] for 320" (voice)		
	"Delta 751 Cleveland Center, Roger"			
01:35:30	United 940 contact New York approach on 127.85			
01:35:37	Twenty-seven-eighty-five, United 940			
01:36:00	Southwest 627 cleared direct Rivet			
01:36:07	Direct Rivet, Southwest 627			
01:37:00	**CLEARED TO DEVIATE; UP TO 20 MILES SOUTH; OF ROUTE DIRECT EWC; WHEN ABLE;**		01:37:00	
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Deviates south of route (no more than 20 mi) (MCP Heading)		
		Proceeds direct to EWC (LEGS restriction) – may be later		

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:37:30	Cleveland Center, American 582 is with you at flight level three-two-zero, Mach seven-eight or less			
01:37:40	American 582 Cleveland Center ROGER area of weather at twelve o'clock, 60 miles, advise if you need to deviate			
01:37:52	Will advise, American 582			
01:38:00	Cleveland Center United 8734 with you at flight level three-seven-zero, smooth			
01:38:07	United 8734 Cleveland Center, ROGER, should be a good ride			
01:38:30	American 237 descend and maintain flight level two-four-zero			
01:38:37	Descend to two-four-zero, American 237			
01:39:00	Cleveland American 582			
01:39:07	American 582, go ahead			
01:39:15	Looks like we need to deviate about 30 left for some weather ahead			
01:39:21	American 582, deviation left of course approved, direct Elwood City when able			
01:39:30	Deviate left and direct Elwood City when able, American 582			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:41:00	American 237, contact Cleveland center on 123.75			
01:41:08	Twenty-three-seventy-five, American 237			
01:42:00	Cleveland Center Jet Blue 174 with you at flight level three-two-zero			
01:42:07	Jet Blue 174, Cleveland Center ROGER, area of weather at your twelve o'clock 60 miles, let me know if you need to deviate			
01:42:20	WILCO, Jet Blue 174			
01:42:30	Southwest 627 contact Washington Center on 126.72			
01:42:37	Southwest 627			
01:43:00	Hello Cleveland, US Air 187 with you at flight level three-one-zero, light chop			
01:43:10	US Air 187 Cleveland Center ROGER, flight level three-three-zero reported smooth			
01:43:20	We'd like three-three-zero			
01:43:27	US Air 187, standby			
01:44:00	**PROCEED DIRECT TO; YNG;**		01:44:00	
		Listen/Confer/Reply (SOP)		

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
		Replies WILCO/ROGER (CPDLC)		
		Proceeds direct to YNG (LEGS direct to)		
01:44:30	US Air 187, climb and maintain flight level three-three-zero			
01:44:37	Climb to three-three-zero, US Air 187			
01:44:47	US Air 187, slight routing change, let me know when you are ready to copy			
01:45:00	US Air 187, go ahead			
01:45:07	US Air 187 cleared to the Kennedy airport via direct Delancy Kingston niner			
01:45:16	Direct Delancy Kingston nine, US Air 187			
01:46:00	**DESCEND TO FL240; MAINTAIN 280KTS OR; GREATER;**		01:46:00	
		Listen/Confer/Reply (SOP)		
		Replies WILCO (CPDLC)		
		Descends to 24,000 ft (MCP altitude)		
		Maintains 280 kt (speed)		

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:47:00	Center, American 582 back on course to Elwood City			
01:47:10	American 582, proceed direct Youngstown, descend and maintain flight level two-four-zero, do not exceed two-eight-zero knots in the descent			
01:47:22	Direct Youngstown and descend to two-four-zero, two-eighty or less, American 582			
01:48:00	United 8374, contact New York Center on 134.5			
01:48:09	Thirty-four-five, United 8374			
01:48:30	**CONTACT CLEVELAND CENTER 123.75**		01:48:00	Possible step on
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Dials freq 123.75 (radio)		
		“Cleveland Center Delta 751 is with you at FL250” [or “out of (altitude) for FL250”] (voice)		
	“DLA751 Cleveland Center roger”			
01:49:00	Cleveland, American 582 with you descending to two-four-zero			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:49:10	American 582, Cleveland Center, ROGER			
01:49:30	**EXPECT LOWER AT TIME; 0152Z**		01:49:30	
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
01:50:00	**DESCEND TO FL200;**		01:50:00	Possible step-on
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Descends to 20,000 ft (MCP altitude)		
01:51:00	**DESCEND TO 11000 FT; CROSS YNG AT OR; BELOW 14000 FT; CLEVELAND ALTIMETER; 30.12;**		01:51:00	
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Descends to 11000 ft (MCP altitude)		
		Crosses YNG at/below 14000 ft (listen - restriction)		
		Sets altimeter at 30.12 (altimeter)		

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:51:30	American 582 descend to one-one-thousand, cross Youngstown at or below one-four-thousand, Cleveland altimeter three-zero-one-five.			
01:51:45	Down to one-one-thousand, cross Youngstown at or below one-four-thousand, American 582.			
01:52:00	**CLEVELAND HOPKINS; ATIS C;**		01:52:00	
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Dials in ATIS freq on communications radio (radio)		
	"Cleveland ATIS Information Charlie Better than 5000 and 5 temperature 15 Dewpoint 10 wind 240 at 15 altimeter 30.12 Advise on initial contact you have information Charlie"			
01:53:00	**CROSS YNG AT OR; BELOW 14000 FT; CROSS CXR AT AND; MAINTAIN 9000 FT; AT CXR CONTACT; CLEVELAND APPROACH ON; 126.55;**		01:53:00	
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
		Dials altitude 9,000 ft (MCP altitude)		
		Dials freq 126.55 (radio)		
		Crosses YNG at or below 14,000 ft (listen - restriction)		
		Crosses CXR at 9,000 ft (listen – restriction)		
		"Cleveland Approach DLA751 is with you at 9,000" (voice)		
		END SCENARIO		

TEXT ONLY, COUNTERMAND ABSENT

OBSERVER WRITE IN

OBSERVER NAME: _____LOCATION (inside/outside): _____

CREW ID: _____

SESSION (1/2): _____

DATE: _____ LOCAL TIME: _____

Inside: Did Sim Tech remind crew about not talking to ATC? _____

Outside: Is data collection working (red)? _____

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:00:00	"Delta 751 cleared for takeoff"		01:00:00	
		"Delta 751 cleared for takeoff" (voice)		
1 min after TO	"Delta 751 contact departure"			
		"Delta 751" (voice)		
		"Departure Delta 751 out of [altitude] for 5,000" (voice)		
Leaving 400 ft	"Delta 751 roger"			
Leaving 4,000 ft	"Delta 751 cleared direct DEETZ, climb and maintain 15,000"			
		"Direct DEETZ climb to 15,000 Delta 751" (voice)		
		Proceeds direct to DEETZ (LEGS direct to)		
		Climbs to 15,000 (MCP altitude)		
01:03:00	New York Departure, American 582 with you out of 2,000 for 6,000			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:03:07	American 582, radar contact continue heading one-zero-zero			
01:03:14	Heading one-zero-zero, American 582			
01:04:00	American 582 climb and maintain one-five-thousand			
01:04:07	Up to one-five-thousand, American 582			
01:04:30	Jet Blue 281 contact New York Center 134.5			
01:04:37	Jet Blue 281			
01:05:00	United 723 climb and maintain one-five-thousand			
01:05:07	Up to one-five-thousand, United 723			
01:05:30	Southwest 6209 cleared direct Hartford, contact Boston Center 132.5			
01:05:37	Direct Hartford, Southwest 6209			
01:05:45	American 582, cleared direct DEETZ			
01:05:52	Direct DEETZ, American 582			
01:06:00	Departure, Jet Blue 283 with you out of 2,000 for 6,000			
01:06:10	Jet Blue 283 radar contact, climb and maintain one-five-thousand			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:06:17	Climb to one-five-thousand, Jet Blue 283			
01:06:30	United 3215 climb and maintain flight level two-three-zero, contact New York on 127.85			
01:06:40	Flight level two-three-zero contact New York, United 3215			
01:07:00	United 723 climb and maintain flight level two-three-zero, contact Boston Center on 132.5			
01:07:10	Climb to flight level two-three-zero, United 723			
01:07:30	Departure American 2375 with you out of 2,000 for 6,000			
01:07:37	American 2375 radar contact, continue heading one-zero-zero			
01:07:44	Heading one-zero-zero, American 2375			
01:08:00	**PROCEED DIRECT TO; CANDR;**		01:08:00	
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Proceeds direct to CANDR (LEGS direct to)		
01:08:30	Southwest 1204 contact New York Center on 127.85			
01:08:39	Southwest 1204			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:09:00	Departure, Air Tran 284 with you out of 2,000 for 6,000			
01:09:07	Air Tran 284 radar contact, climb and maintain one-five-thousand			
01:09:14	Climb to one-five-thousand, Air Tran 284			
01:10:00	Air Tran 284 cleared direct DEETZ			
01:10:07	Direct DEETZ, Air Tran 284			
01:11:00	**CLIMB TO FL230; CONTACT NEW YORK; CENTER 127.85;**		01:11:00	
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Climbs to 23,000 ft (MCP altitude)		
		Dials freq 127.85 (radio)		
		“New York Center Delta 751 with you out of [altitude] for 230” (voice)		
	“Delta 751 New York Center Roger”			
01:12:00	United 987 contact Cleveland on 132.22			
01:12:10	Thirty-two-twenty-two, United 987			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:12:30	New York Center, American 2314 request higher			
01:12:37	American 2314 expect flight level two-six-zero in five minutes, crossing traffic			
01:12:47	American 2314			
01:13:00	**DUE TO CROSSING; TRAFFIC CROSS CANDR; AT OR ABOVE FL250; CLIMB TO FL260;**		01:13:00	
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Climbs to 26,000 ft (MCP altitude)		
		Crosses CANDR at/above 25,000 ft (listen - restriction)		
01:13:30	New York Center, American 582 with you out of one-eight-zero for flight level two-three-zero			
01:13:38	American 582 New York Center, ROGER, climb and maintain flight level two-six-zero			
01:13:48	Climb to flight level two-six-zero, American 582			
01:15:00	**SQUAWK 5342;**		01:15:00	
		Read Separately/Confer/Reply (SOP)		

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
		Replies WILCO/ROGER (CPDLC)		
		Selects code 5342 (transponder)		
01:15:00	American 2314 fly heading two-three-zero, climb and maintain flight level two-six-zero		01:15:00	
01:15:10	Heading two-three-zero climb to flight level two-six-zero, American 2314			
01:16:00	**CONTACT NEW YORK; CENTER 134.5**		01:16:00	
		Listen/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Dials freq 134.5 (radio)		
		"New York Center Delta 751 with you out of [altitude] for 260"(voice)		
	"Delta 751 New York Center Roger"			
01:16:00	Southwest 4578 contact Cleveland Center on 132.22		01:16:00	
01:16:10	Southwest 4578			
01:16:20	Center United 421			
01:16:25	United 421 go ahead			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:16:30	We'd like to deviate thirty left for weather and get flight level three-two-zero if it's smooth			
01:16:40	United 421 deviation left of course approved. Let me know when you can go back on course, flight level three-two-zero reported smooth			
01:16:55	Deviation approved and call you back on course, United 421			
01:17:00	Center United 751			
01:17:05	United 751 go ahead			
01:17:10	Where was that United, can he give us a ride report?			
01:17:15	About 50 miles west of you. United 421 how's your ride?			
01:17:22	Light to moderate chop, United 421			
01:17:27	United 751 did you copy?			
01:17:33	Affirmative, and we'd like three-two-zero as well			
01:17:40	United 751 Climb and maintain flight level three-two-zero			Similar Call Sign
		Nothing; Does not climb to 32,000 ft (MCP altitude)		
01:17:47	Climb to three-two-zero, United 751			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:18:00	**CLIMB TO FL280;**		01:18:00	
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Climbs to 28,000 ft (MCP altitude)		
01:18:30	United 421 climb and maintain flight level three-two-zero			
01:18:37	Climb to flight level three-two-zero, United 421			
01:18:45	New York Center American 582 with you flight level two-six-zero			
01:18:52	American 582 New York Center ROGER, climb and maintain flight level three-two-zero. Smooth rides at three-two-zero.			
01:19:00	**HAZARDOUS WEATHER; CONVECTIVE SIGMET; 55C VALID UNTIL 0155; FOR ERN OH WRN PA; WRN NY LINE TSTMS; 40 NM WIDE MOVG; NE AT 35KTS; HAIL TO 2 IN PSBL;**		01:19:00	
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:19:05	American 582 climb to flight level two-three-zero, thanks.			
01:19:30	Center, United 421 can go back on course			
01:19:38	United 421 ROGER, cleared direct Pittsburg rest of route unchanged			
01:19:48	Direct Pittsburg, United 421			
01:20:00	**DUE TO CROSSING; TRAFFIC CLIMB TO; REACH FL320 BEFORE; TIME 0130Z;**		01:20:00	
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Climb to 32,000 ft before 0130 (listen - restriction)		
01:20:00	UAL751 Contact Cleveland center on 132.22		01:20:00	Similar Call Sign
		Nothing; Does not contact Cleveland (radio/voice)		
01:20:09	Cleveland on thirty-two-twenty-two, United 751			
01:21:00	New York, US Air 128 with you at flight level two-eight-zero			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:21:07	US Air 128, New York Center ROGER			
01:21:30	Eagle 521 descend and maintain flight level two-three-zero, contact New York approach on 127.85			
01:21:45	Descend to flight level two-three-zero and call approach, EAGLE 521			
01:22:30	New York Center, United 940 with you at flight level two-niner-zero			
01:22:38	United 940 New York Center, ROGER			
01:23:00	New York Center, Delta 761 with you at flight level three-three-zero			
01:23:07	Delta 761 New York Center, ROGER			Similar Call Sign
		Nothing; Does not respond (voice)		
01:24:00	Delta 761 for traffic descend and maintain flight level three-one-zero			Similar Call Sign
		Nothing; Does not respond (voice); Does not descent to 31,000 (MCP altitude)		
01:24:07	Descend to flight level three-one-zero, Delta 761			
01:25:00	**DUE TO WEATHER; CLEARED TO KCLE; AIRPORT VIA DIRECT; BURNI EWC YNG CX2;**		01:25:00	

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Modifies route (LEGS direct to)		
01:26:00	American 582 say your Mach speed			
01:26:07	Mach seven-eight, American 582			
01:26:14	American 582 maintain Mach .78 or less for spacing			
01:26:24	Maintain seven-eight or less, American 582			
01:27:30	US Air 128 descend and maintain flight level two-three-zero			
01:27:37	Descend to flight level two-three-zero, US Air 128			
01:28:00	**MAINTAIN M.78 OR; GREATER FOR SPACING;**		01:28:00	
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Maintains M.78 or greater (PFD)		
01:28:00	US Air 128 contact New York Approach on 127.85		01:28:00	
01:28:07	Twenty-seven-eighty-five, US Air 128			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:29:00	Delta 715 new routing advise when ready to copy			Similar Call Sign
		Nothing; Does not contact ATC (voice)		
01:29:10	Go ahead, Delta 715			
01:29:25	Delta 715 cleared to Atlanta via present position direct ROME, rest of route unchanged			
01:29:35	Direct ROME, rest of route unchanged, Delta 715			
01:30:00	Delta 715 contact Washington Center on 126.72			Similar Call Sign
		Nothing; Does not contact Washington Center (radio/voice)		
01:30:07	Delta 715			
01:30:30	United 421 contact Cleveland Center on 132.22			
01:30:38	Cleveland on 132.22, United 421			
01:31:00	United 940 descend and maintain flight level two-three-zero			
01:31:07	Descend to flight level two-three-zero, United 940			
01:32:00	New York Center Southwest 627 with you at flight level three-one-zero			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:32:07	Southwest 627, New York Center, ROGER			
01:33:00	Southwest 627 turn 30 degrees left for traffic			
01:33:07	Thirty left, Southwest 627			
01:33:30	Southwest 627, traffic two o'clock, ten miles southeast bound an airbus at flight level three-two-zero			
01:33:40	Traffic in sight, Southwest 627			
01:34:00	**CONTACT CLEVELAND; CENTER 132.22;**		01:34:00	
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Dials freq 132.22 (radio)		
		"Delta 751 is with you out of [altitude] for 320" (voice)		
	"Delta 751 Cleveland Center, Roger"			
01:35:30	United 940 contact New York approach on 127.85			
01:35:37	Twenty-seven-eighty-five, United 940			
01:36:00	Southwest 627 cleared direct Rivet			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:36:07	Direct Rivet, Southwest 627			
01:37:00	**CLEARED TO DEVIATE; UP TO 20 MILES SOUTH; OF ROUTE DIRECT EWC; WHEN ABLE;**		01:37:00	
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Deviates south of route (no more than 20 mi) (MCP Heading)		
		Proceeds direct to EWC (LEGS restriction) [may happen later]		
01:37:30	Cleveland Center, American 582 is with you at flight level three-two-zero, Mach seven-eight or less			
01:37:40	American 582 Cleveland Center ROGER area of weather at twelve o'clock, 60 miles, advise if you need to deviate			
01:37:52	Will advise, American 582			
01:38:00	Cleveland Center United 8734 with you at flight level three-seven-zero, smooth			
01:38:07	United 8734 Cleveland Center, ROGER, should be a good ride			
01:38:30	American 237 descend and maintain flight level two-four-zero			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:38:37	Descend to two-four-zero, American 237			
01:39:00	Cleveland American 582			
01:39:07	American 582, go ahead			
01:39:15	Looks like we need to deviate about 30 left for some weather ahead			
01:39:21	American 582, deviation left of course approved, direct Elwood City when able			
01:39:30	Deviate left and direct Elwood City when able, American 582			
01:41:00	American 237, contact Cleveland center on 123.75			
01:41:08	Twenty-three-seventy-five, American 237			
01:42:00	Cleveland Center Jet Blue 174 with you at flight level three-two-zero			
01:42:07	Jet Blue 174, Cleveland Center ROGER, area of weather at your twelve o'clock 60 miles, let me know if you need to deviate			
01:42:20	WILCO, Jet Blue 174			
01:42:30	Southwest 627 contact Washington Center on 126.72			
01:42:37	Southwest 627			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:43:00	Hello Cleveland, US Air 187 with you at flight level three-one-zero, light chop			
01:43:10	US Air 187 Cleveland Center ROGER, flight level three-three-zero reported smooth			
01:43:20	We'd like three-three-zero			
01:43:27	US Air 187, standby			
01:44:00	**PROCEED DIRECT TO; YNG;**		01:44:00	
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Proceeds direct to YNG (LEGS direct to)		
01:44:30	US Air 187, climb and maintain flight level three-three-zero			
01:44:37	Climb to three-three-zero, US Air 187			
01:44:47	US Air 187, slight routing change, let me know when you are ready to copy			
01:45:00	US Air 187, go ahead			
01:45:07	US Air 187 cleared to the Kennedy airport via direct Delancy Kingston niner			

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
01:45:16	Direct Delancy Kingston nine, US Air 187			
01:46:00	**DESCEND TO FL240; MAINTAIN 280KTS OR; GREATER;**		01:46:00	
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO (CPDLC)		
		Descends to 24,000 ft (MCP altitude)		
		Maintains 280 kt (MCP/PFD)		
01:47:00	Center, American 582 back on course to Elwood City			
01:47:10	American 582, proceed direct Youngstown, descend and maintain flight level two-four-zero, do not exceed two-eight-zero knots in the descent			
01:47:22	Direct Youngstown and descend to two-four-zero, two-eighty or less, American 582			
01:48:00	United 8374, contact New York Center on 134.5			
01:48:09	Thirty-four-five, United 8374			
01:48:30	**CONTACT CLEVELAND CENTER 123.75**		01:48:00	

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Dials freq 123.75 (radio)		
		"Cleveland Center Delta 751 is with you at FL250" [or "out of (altitude) for FL250"] (voice)		
	"DLA751 Cleveland Center roger"			
01:49:00	Cleveland, American 582 with you descending to two-four-zero			
01:49:10	American 582, Cleveland Center, ROGER			
01:49:30	**EXPECT LOWER AT TIME; 0152Z**		01:49:30	
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
01:50:00	**DESCEND TO FL200;**		01:509:00	
		Read Separately/Confer/Reply (SOP)		

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
		Replies WILCO/ROGER (CPDLC)		
		Descends to 20,000 ft (MCP altitude)		
01:51:00	**DESCEND TO 11000 FT; CROSS YNG AT OR; BELOW 14000 FT; CLEVELAND ALTIMETER; 30.12;**		01:51:00	
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Descends to 11000 ft (MCP altitude)		
		Crosses YNG at/below 14000 ft (listen - restriction)		
		Sets altimeter at 30.12 (altimeter)		
01:51:30	American 582 descend to one-one-thousand, cross Youngstown at or below one-four-thousand, Cleveland altimeter three-zero-one-five.			
01:51:45	Down to one-one-thousand, cross Youngstown at or below one-four-thousand, American 582.			
01:52:00	**CLEVELAND HOPKINS; ATIS C;**		01:52:00	

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Dials in ATIS freq on communications radio (radio)		
	"Cleveland ATIS Information Charlie Better than 5000 and 5 temperature 15 Dewpoint 10 wind 240 at 15 altimeter 30.12 Advise on initial contact you have information Charlie"			
01:53:00	**CROSS YNG AT OR; BELOW 14000 FT; CROSS CXR AT AND; MAINTAIN 9000 FT; AT CXR CONTACT; CLEVELAND APPROACH ON; 126.55;**		01:53:00	
		Read Separately/Confer/Reply (SOP)		
		Replies WILCO/ROGER (CPDLC)		
		Dials altitude 9,000 ft (MCP altitude)		
		Dials freq 126.55 (radio)		
		Crosses YNG at or below 14,000 ft (listen - restriction)		
		Crosses CXR at 9,000 ft (listen – restriction)		

Time	Party Line & Live ATC	Pilot Action	☑ / Time	Notes
		"Cleveland Approach DLA751 is with you at 9,000" (voice)		
		END SCENARIO		

Post-Session-1 Checklist

	Action	☑	Notes
In simulator cab…			
	Observer retrieves pilot notes & printouts of CPDLC messages, place in appropriate envelope by condition		
	Observer obtains all experimenter checklists; scan & save on data drive; file hard copy		
In observation room…			
	Observer saves text file of observer data, rename with date, and place in appropriate folder on the desktop		
In briefing room…			
	Participants complete post-session questionnaire		
	Observer backups questionnaire data to USB stick and data directory (or file, if paper)		
	Observer set up instruction sheets (CPDLC SOPs, flight briefing materials) for Session 2 in briefing room		

Post-Session-2 Checklist

	Action	☑	Notes
In simulator cab…			
	Observer retrieves pilot notes & printouts of CPDLC messages, place in appropriate envelope by condition		
	Observer obtains all experimenter checklists; scan & save on data drive; file hard copy		
In observation room…			
	Observer saves text file of observer data, rename with date, and place in appropriate folder on the desktop		
In briefing room…			
	Participants complete post-session questionnaire		
	Crew completes post-experiment questionnaire		
	Observer gives debriefing		
	Observer asks for additional comments: • Is there anything else that you would like us to know about your experience in this experiment? (Remember, we are using you as a Subject Matter Expert evaluating an option to provide Data Comm both visually and via synthetic speech.)		
	When ready, escort pilots out of building		
	Remove “Quiet” signs		

CPDLC/Simulator Support Setup Checklist

Audio Setup	**Check**
ATC mic check (working)	
Run playlist for volume adjust (PL on party line computer)	
Crew Mics in position	
Check audio reference mark on audio mixer (under DVR PC)	
Set mixer levels for crew	
Exit playlist	
Video Setup	
Remove batteries from observers DVR keyboard	
Check camera alignment (Cockpit cam gets bumped entering cockpit)	
Recheck after DRV start of recording/experiment	
Misc	
Recheck printer (on)	
Lights – Observers Room and Sim Room	
Door – shut	
Briefing	
The folks behind you will try to not be a distraction. Alan/Drew/Mike is now an air traffic controller. Please do not treat him like a jumpseater. Please only refer to the folks behind you as jumpseaters if you suspect something is very wrong with the behavior of the simulator. Then considers us jumpseating mechanics.	
After Shutdown	
Printer battery (recharging)	
Video (converted)	
Video (Backed up)	
Data backup	
NMEA	
DataDump	
Message log	

ATC/Trainer Checklist

Training Flight

Route: KBOS PATSS2 PATSS GDM KALB

Depart 4R KBOS

Callsign: DAL751

CPDLC/Simulator Training

Simulator Setup	Check
Gear down; Flaps 5	
Start FSX	
Start SimAvionics—Do not load MFD---start FSCLOCK instead	
Load **Training Scenario**	
Configure **WX** Image	
Start DataCom	
Configure Printer	
Select C:\Datacom Sim Files**training.txt**	
Select C:\Datacom Sim files\MSGLOG.txt	
Set Headset/Speaker Volumes	
Set Cameras	
CDU/Overhead Preflight	
POS Page – Enter airport REF -KBOS	
Perf Page – Cost 75/ Reenter Altitude/confirm weights	
N1 Page – Arm T/O	
Climb page – ensure transition speed entered	
Takeoff Page – Set Flaps 5/select V-speeds/set CG	
Legs Page - Check	
FLT ALT - 23000; LAND – 250; Autobrakes -RTO	
Before T/O Checklist	
Volume checks	
Crew accomplish	
Procedures: PF-Nav;PNF-CPDLC; Crew coordination for text and text+speech	
Advise crew , No VNAV—Level Change, Vertical Speed Only	
Do not enable WX display—80 miles scale on WX image is correct Do not select alternate MFD display, Full power takeoff only	
Simulation Start	
Crew – Ready for Throttle advance	
Datacom - Start	
Cleared for T/O	

CPDLC Training-Accomplished During Flight

CPDLC Training-Accomplished during flight	Covered
1. AfterTakeoff --- Menu Page	
Accessing from NAV pages (MENU/SIM/NEXT PAGE)	
LOGON Page – not relevant to this study	
MSG Log	
SPEECH OFF/ON – Don't press this for this study-we control it.	
Other Items – non functional	
ATC MSG* - LSK 12/Chime- EICAS Message – On all pages	
2. 1:05:00 - Climb to 12000 -- CPDLC MESSAGE PAGE	
Crew Procedures – GOLD, PF, PNF scenario dependent	
Accessed via ATC MSG press or MSG LOG	
Speech on—message read on initial access	
Message header description	
Current Message/Message Status description	
WILCO/ROGER response	
REJECT response	
SPEAK/MUTE –Demo use with live clearance in background	
PRINT	
RETURN	
3. 1:08:00 - Proceed direct GDM – Let message timeout -- MSG LOG PAGE	
Message Timeout screen and EICAS/LSK 12 indications	
List of all received messages	
Latest message first	
Select MSG to make message current message and enable response to open messages	
4. 1:09:00 - Contact Boston on 132.22 –Press Speak before msg access	
5. 1:12:00 - Due to Traffic -- Multi Page Access	
Multi Page Access –Next button/ Back LSK/ must read page 2 Response requirement	
6. 1:14:00 - Cleared to ALB - Practice	
7. 1:16:00 - SQUAWK 5328 – REJECT/UNABLE PAGE	
Select reason for reject	
SEND – to send REJECT to ATC	
8. 1:18:00 - Hazardous Weather – Use of ROGER instead of WILCO	
Show Storm	
9. 1:20:00 - CROSS CAMBRIDGE – Multipage and REJECT practice – Notice WX display	
10. All messages repeated 1 minute apart for practice. (**PAUSE Here**)	
11. Practice start @ **1:22:00** Timeout; Accept; Reject; Print; Message log	
2nd Practice – in 3 messages – 1 Accept/Print/Speech , 2- Reject, 3 –timeout/log	

Simulator Setup	Check
Gear down; Flaps 5; Throttle Idle; Map range 10nm to agree with ND	
Start Hyperterminal/NMEA recording with coded filename	
Configure/check Printer; Move Mouse Pointer to right limit of screen	
Configure WX Image	
Wipe MSGLOG.txt	
Wipe DumpQueue.txt	
Start SimAvionics- Do not load MFD---start FSCLOCK instead	
Start Party Line Player with correct scenario for run	
Load JFKCLE Scenario	
Start DataCom and select speech on/off	
Select C:\Datacom Sim Files\JFKCLE_night.txt	
Select C:\Datacom Sim files\MSGLOG.txt	
Set Headset/Speaker Volumes	
Set Cameras	
CDU/Overhead Preflight	
POS Page – Enter airport REF -KJFK	
Perf Page – Cost 75/ Reenter Altitude/confirm weights/confirm low temps	
N1 Page – Arm T/O	
Climb page – ensure transition speed entered	
Takeoff Page – Set Flaps 5/select V-speeds/set CG	
Legs Page - Check	
FLT ALT – 32000; LAND – 800; Autobrakes -RTO	
Before T/O Checklist	
Crew accomplish	
Procedures: PF-NAV Pages PNF CPDLC Pages –Both Read and Discuss	
Advise crew: No VNAV—Level Change, Vertical Speed Only	
Do not enable WX display—80 miles scale on WX image is correct Do not select alternate MFD display, Full power takeoff only	
Simulation Start	
Observers- Ready – **Roles Briefing**	
Crew- Ready for throttle advance	
Audio/Video recording - Started	
Datacom - Start	
Party line Player - Start	
Cleared for T/O	

Simulation End	
Simulation- Pause	
DataComm - STOP	
Copy MSGLOG.txt	
Rename copied MSGLOG.txt copy to coded filename	
Save coded filename to data directory and USB stick	
Copy Dumpqueue.txt	
Rename copied Dumpqueue.txt copy to coded filename	
Save coded filename to data directory and USB stick	
Save NMEA data to USB stick and data directory	

Counterbalancing Scheme

Crew	Practice 1	Experiment 1	Practice 2	Experiment 2
1	Text	Text	Text + Speech	Text + Speech Countermand
2	Text	Text Countermand	Text + Speech	Text + Speech
3	Text + Speech	Text + Speech	Text	Text Countermand
4	Text + Speech	Text + Speech Countermand	Text	Text
5	Text	Text	Text + Speech	Text + Speech Countermand
6	Text	Text Countermand	Text + Speech	Text + Speech
7	Text + Speech	Text + Speech	Text	Text Countermand
8	Text + Speech	Text + Speech Countermand	Text	Text
9	Text	Text	Text + Speech	Text + Speech Countermand
10	Text	Text Countermand	Text + Speech	Text + Speech
11	Text + Speech	Text + Speech	Text	Text Countermand
12	Text + Speech	Text + Speech Countermand	Text	Text
13	Text	Text	Text + Speech	Text + Speech Countermand
14	Text	Text Countermand	Text + Speech	Text + Speech
15	Text + Speech	Text + Speech	Text	Text Countermand
16	Text + Speech	Text + Speech Countermand	Text	Text

6.6 Appendix F: Additional statistical information

Wilcoxon Matched-Pairs Signed Rank

The Wilcoxon Matched-Pairs Signed Rank is a non-parametric test which takes into account both the direction (e.g., if ratings were better or worse for text+speech compared to text only) and the magnitude of differences between two matched samples. It is basically the non-parametric equivalent to the paired t-test, and is often used when the data are not normally distributed. In some cases, a sign test was used instead of a Wilcoxon. The difference between the sign test and the Wilcoxon test is that the sign test only takes into account the direction of the difference. For this report, binary response measures (e.g., yes/no questionnaire responses) were examined using sign tests and variables measured by multiple or continuous responses (e.g., Likert scale, response times) were examined using Wilcoxon tests.

Inter-Rater Reliability

Inter-rater reliability between the two gaze-dwell time coders was examined using the Pearson Product-Moment correlation, which was calculated using the Noldus software. The Pearson correlation (r) tests for the degree of relationship between two continuous variables. Noldus calculates r by counting the number of agreements and disagreements within a specified time window (we chose 1 second) and creating a "confusion matrix" which crosses the number of agreements and disagreements for several different agreement "events." Some examples of an "event" include: agreements on concurrent dwell time, disagreements on concurrent dwell time, disagreements where one coder observed concurrent dwell time and the other coder observed PM dwell time, etc. The Noldus software calculates r between the row and column totals in the confusion matrix.

The values of r can range from -1 (a perfect negative relationship, i.e., there were 0 agreements) to +1 (a perfect positive relationship, i.e., there were 0 disagreements). Sixteen separate Pearson correlations were calculated (one for each video file that was coded[18]). The Pearson correlations indicated high inter-rater reliability between the two coders; r ranged from .66 to 1.0, with a median of .97, all $p < .01$. The positive relationship indicates that the coders' data varied in the same direction (i.e., coders' measurement increased or decreased in unison).

[18] Each Data Comm condition was recorded in two parts (i.e., two separate videos) due to computer storage requirements. This resulted in sixteen total videos being used for reliability: 2 parts per Data Comm condition x 2 Data Comm conditions x 4 crews.

6.7 Appendix G: Additional questionnaire data

Appendix G contains additional questionnaire data and analyses that were not included in the main report. The data are reported below by question topic, followed by pilots' open-ended response comments.

Monitoring Pattern

On the post-scenario questionnaires, pilots were asked whether Data Comm affected their monitoring pattern. The number of "yes" and "no" responses is shown in Table 9 by Data Comm condition. As the table shows, most pilots said that Data Comm did affect their monitoring pattern. However, a sign test revealed no significant differences between Data Comm conditions.

Table 9. Pilot responses regarding monitoring pattern.

Response	Text Only	Text+Speech
No	9	10
Yes	23	22

Log Use

Pilots were asked whether they used the log on the CDU to review Data Comm messages. Table 10 shows pilots' responses by Data Comm condition. The table shows that most pilots said they used the log. A sign test found no significant difference between Data Comm conditions.

Table 10. Pilot responses regarding log use.

Response	Text Only	Text+Speech
No	8	9
Yes	24	23

Printer Use

The questionnaires also asked pilots whether they used the printer. As shown in Table 11, most pilots said they used the printer in both conditions. A sign test found no significant difference between Data Comm conditions.

Table 11. Pilot responses regarding printer use.

Response	Text Only	Text+Speech
No	4	3
Yes	28	29

CDU Setup

Pilots were asked how they set up the two CDUs, that is, what CDU pages the PF and PM had open as a default. The reason for asking this question was to examine whether the presence of Data Comm on the CDU affected the way they would typically set up the CDUs. In the pre-experiment briefing, the experimenter recommended what we considered a typical set up: PF on Legs page and PM on Progress page.

Pilots described the CDU setup via free response. Almost all pilots indicated that the PF typically stayed on the Legs page and the PM stayed on the Progress page and the Data Comm page as needed. The detailed comments are provided in the section below titled "Open-ended Response Comments." Pilots were also asked if the CDU setup supported their tasks on the flight deck. Their ratings for this question are provided in Figure 43 by Data Comm condition. As the figure shows, most pilots agreed or strongly agreed that the CDU setup supported their tasks. A Wilcoxon matched-pairs signed-rank test found no significant difference between Data Comm conditions.

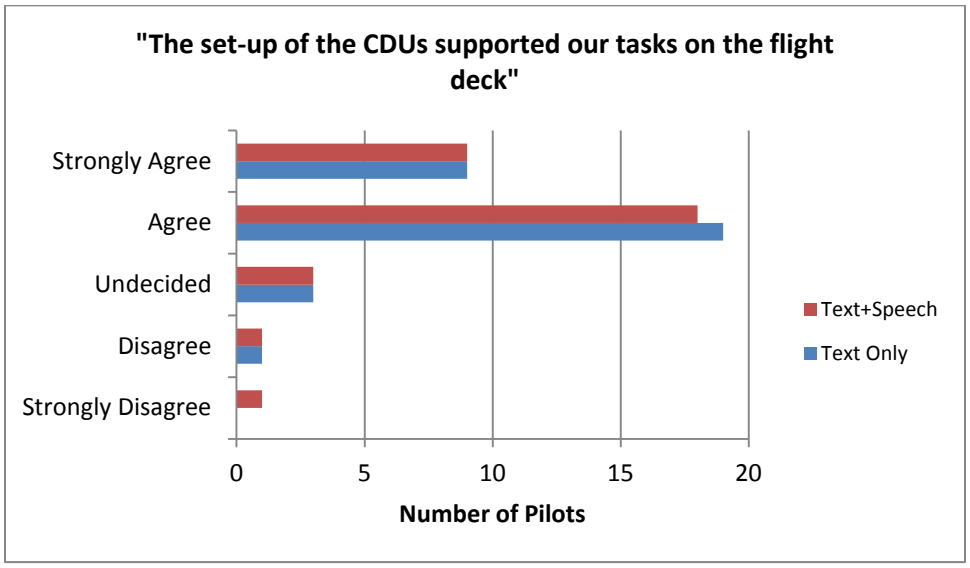

Figure 43. Pilot ratings of CDU setup by Data Comm condition.

Data Comm Message Indications

Pilots were asked to rate their agreement with statements about the effectiveness of the Data Comm indications (Sel Cal tone, "*ATC" on the CDU, ".ATC" on the EICAS). These statements are provided in Table 12 with the number of pilots who provided each rating. As the table shows, most pilots agreed or strongly agreed with the statements, indicating that the Data Comm indications were effective.

Table 12. Pilot ratings of the Data Comm indications.

Question					
I found the AURAL indication of an incoming Data Comm message (ding-dong) to be effective.	0	1	2	13	16
I found the VISUAL indication of an incoming Data Comm message (" *ATC MSG") on the CDU to be effective.	0	2	2	18	10

Use of Text+Speech Data Comm

The post-text+speech questionnaire asked pilots to rate their agreement with several statements about how they used and understood the text+speech Data Comm display. These statements are provided in Table 13 with the number of pilots who provided each rating. Pilot generally agreed that they:

- listened to the speech before responding
- read the text message as well as listened to the synthetic-speech annunciation of the message
- rarely muted the speech
- rarely found the synthetic speech distracting
- rarely confused the synthetic speech with voices on the party line

Pilots generally disagreed that they found the replayed the speech before responding.

Table 13. Pilot ratings of their use of the text+speech display.

Question	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
I typically listened to all of the computer-generated speech before responding	0	0	0	15	17
I typically looked at the written text message at the same time as I listened to the synthetic speech	0	1	5	13	13
I rarely found the computer-generated speech to be distracting	0	0	2	14	15

Question	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
I rarely found the computer-generated speech was confusable with voices heard on the party line	0	1	0	14	17

Computer-generated Speech

Pilots were asked to rate a number of statements about the computer-generated speech itself. These statements and pilots' ratings are provided in Table 14. The table shows that pilots generally agreed that the loudness of the speech was sufficient and that the speech was easy to understand, neither too fast not too slow, and easy to distinguish from a human voice.

Table 14. Pilot ratings of the computer-generated speech.

Question	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
The loudness of the speech relative to party line is sufficient	0	0	3	17	12
The loudness of computer-generated Speech on its own is sufficient	0	1	0	22	9
It is easy for me to understand the computer-generated speech	0	0	1	15	16
The computer generated speech is neither too fast or too slow	0	0	2	21	9
I can easily tell the difference between the computer generated speech and a human voice	0	0	0	13	19

Open-ended Response Comments

Pilots were asked to provide additional comments on several questions. These comments are provided below by questionnaire. The comments are provided in their original form (i.e., as pilots entered them, with no edits).

Pre-Experiment Questionnaire Tables

Table 15. Pilot responses regarding past experience.

Please describe your past and/or current military experience.
• Infantry Platoon Leader, Recon commander • 747-400 Passenger/ Cargo • 9 yrs active duty flying th F-15. 11 years Guard and Reserve flying the F-16. Reserve retired Lt. Colonel • Intelligence Applications Officer KC-135R (3500 Hrs) T-37 IP (1500 Hrs) • A4 and F-18 USMC • Flew as a Naval Flight Officer in the EA-6B and UC-12B. My duites were equivlient Pilot Monitioring. Flew in the right seat of the EA-6B and UC-12B. • C141, C130, AWACs • Naval Aviator-T28,T44,P3,T34 • Navy A6 • A-10 Fighter aircraft • missle officer • !4 years flying F4S Phantoms and F14A Tomcats • 8 years AF T-37, T-38, KC-135, Experimental aircraft

Table 16. Pilot responses regarding experience with Data Comm.

Please describe the environment and aircraft in which you have had experience with Data Comm (e.g. FANS 1/A, ATN).
• 747-400 • JTIDS on the F-15 and PACER TWINS on the F-16. Classified • limited in corporate aviation • B737NG/BBJ - FANS 1/A - CPDLC CL604 - AFIS // CPDLC • Mikitary data link and CPDLC commercial aviation • CPCDLC experience in the B757/767 flying across the North Atlantic and Europe. • BBJ/Private 737 Ops in Pacific. ACARS • B747 NAT, Asia-Alaska, mid asia • CPDLC Flying 767ER, Atlantic • Very little, mostly from computer training • Used CPDLC on 4 ocean crossings during 2013.

Table 17. Pilot responses regarding carrier procedures with Data Comm.

Please explain your carrier's specified procedures for Data Comm.
• Pilot flying and Pilot No flying must confirm messages • Unaware • Oceanic & International Procedures • Integrated within the 777 operating manuel • Yes, the way we login and respond to messages. • PM would read messages, PF confirm them respond. • No all "heads down"- someone is paying attention to flying the airplane • Normal crosscheck procedures.

Table 18. Pilot responses regarding the printing of Data Comm messages.

Please share any comments related to if you typically print Data Comm messages for review.
• During Oceanic Sector • Some were printed immediately, but all were printed at end of flight and included in trip paperwork. • always better to have a hard copy • Only messages on some length or route clearances.

Post Text Only Specific Questionnaire Tables

Table 19. Pilot responses regarding ease of use for the text-only display.

Comments related to how easy it was to use to text display system
• Once we developed a "procedure", using the CPDLC was efficient and easy to use. • To meny CDU functions requiered during high work load periods • N/A[19] • To many button to push to get and see the ATC MSG. Sequence is not obvious. • Interface and steps on message retrival and activation. • Most of the older (45+ years of age approx) do not adapt well to the ACARS system, PDC, etc. Although there are exceptions, this general pilot group in my opinion would shrug off the workload and the learning of the system onto the other pilot in the cockpit. This may create a scenario where two pilots may fly together who do not like to use, nor want to use this system. I have seen this before in regards to ACARS when it was first introduced to an airline company-wide. • This would not be helpful in a very dense, busy area such as New York or Atlanta approach control • Again, i didn't like seeing the previous message when a new message came up. Also, before the FO executes the responses, he needs to verify with the Captain so that both pilots understand the message completely, • Concerned about the prev msg being actively shown in the top left of the display while trying to navigate to the new msg. Think it should NOT be there, Too much room to miss new one, even with the ATC MSG displayed. It should migrate to the MSG LOG once viewd and that menu is

[19] Some pilots indicated N/A rather than leaving the question blank.

Post Text + Speech Specific Questionnaire Tables

Table 20. Pilot suggestions for using the text+speech display.

Suggestions related to using the entire system (that is, the text display and the computer generated speech).
• It might be useful to add some type of warning or reminder of unacknowleged messages still in the que. • N/A • The process of MENU, SIM OPTS, NEXT could be confusing when in a high task load situation. I forget to hit NEXT a few times and forget where the message was. Should make it 3 easy steps. Add ATC message button to menu page instead of pressing next. • Comfort level... in cruise Not sure in climb and descent CDU interface to many steps.. need a specific buttom for replay to a message ATC indicator alert needs to be in the pilots normal line of sight (pilot instruments) pilots can get tunnel vision in stressful situations.. scan reduces. In weather may not hear chime alert • I believe that some of the airline pilot work force (45+ years of age approx.) would find this an unncecessary addition to the pilot workload in the cockpit. However, provided the right training and usage by ATC, this could be a very nice tool to have in the enroute phase of flight as well as any remote area/oceanic activity.

Table 21. Pilot comments regarding the computer-generated speech.

Comments related to computer-generated speech.
• The "voice command" of the ATC MSG was excellent, and I can see improved communications and CRM, especially with pilots and controllers whose first language is not English. • This would be a great improvement for the industry, but only text and voice. • Interface with voice and CDU commands easier to understand • Voice along with data text is in my opinion, a optimal delievery for NextGen • Computer Generated Voice is Def the Way to Go!!!!! • The text messages are adequarte. Having voice generated messages concurrently with VHF voice communications is distracting and confusing. • I like the system and it seems very intuitive the way it is set up. • do not replay message - listened first then read text to support. printed questionable instructions to review. • It is an great improvement over the no voice message system. The amber ATC MSG alert is important to have, in addition to the chime. It is a great system,during lower workloads (cruise), but when it comes to needing immediate actions/requests and during periods of high workload (arrival, approach, it can tend to becomoe more a distraction or can even cause overload. • easier to interpret messages with the addition of voice comm • I don't know how an ATC voice over computer voice would affect the crew's ability to deciffer which instructions to follow first • Nice program - I'll be interested to see where this goes. • I like the voice, I would probably turn it off during day light and have the voice on for red eye flights. I would always have the voice on if either pilot on the flight deck reported being fatigue. • The system seems to be headed in the correct direction. I like it. • The only time the voice became annoying was when we listened to the SIGMET. I would prefer to read only extraneous data

Table 22. Pilot suggestions related to the computer-generated speech.

Suggestions related to the computer-generated speech
• D. The speed of the computer generated speech is probably correct for all pilots, but I would not have minded it being a bit faster. • N/A • Prefer to have text along with speech

Post Text Only and Post Text + Speech Questionnaire Comparison Tables.

Table 23. Pilot comments related to ATC communications workload.

Comments related to the ATC communications workload while flying EN ROUTE	
Post Text Only	**Post Text + Speech**
• my only concern, that at times it is a little difficult to view the received message on the PNF side, in the event he relays the incorrect message, the wrong data will be entered.Multipal ATC computer generated com very distracting - requires both pilots to be heads down • The interface was nice for the enroute portion of the flight. However, in the departure and approach phases caused unnecessary workload in the cockpit. • Prev message should be erased after it is acknowledged or put somewhere where its not the first thing you see when a new message comes up • Didnt like that the prev msg was still displayed on screen while trying to retrieve new msg. Feel it should be relegated to msg log once acknowledged and left msg menu • lots of buttons to push to see message in a busy environment	• N/A

Table 24. Pilot responses to the open-ended scan pattern question.

While EN ROUTE, what did you look at that was "OTHER" (that is, NOT the CDU, NOT the flight instruments, NOT out the window, or NOT at the other display)?	
Post Text Only	**Post Text + Speech**
• Departure SID, Enroute charte, Arrival, IAP ILS 24L • 5 • 25 • overall scan • side window • charts • Systems, charts	• Enroute and approach charts • Charts and approach plates • overall scan • side window • charts • Aircraft systems, charts • Engine Instr • Charts - Printed Weather - Overhead Panel

While EN ROUTE, what did you look at that was "OTHER" (that is, NOT the CDU, NOT the flight instruments, NOT out the window, or NOT at the other display)?	
Post Text Only	**Post Text + Speech**
• engine instruments and fuel • Overhead Panel and Charts • 5 • charts, flight plan • overhead panel - radio panel • center console with printer • Charts, comms, printer, sim setup • charts • Charts, checklist • other guages and instruments, charts, displays. • ovhd pnl/maps/eng inst • fuel, overhead panel, mode control panel • Perifferal controls and overhead • overall situational awareness • ovhd/system displays • I spent about 5 persent of the time reviewing charts • charts •charts & approach plates •paperwork, charts,CPDLC	• VHF Radio • looking at charts • charts, approach plates, overhead panel • over head panel ,, approach charts briefing • Paper charts, etc • charts, route plan weather briefing • Charts, and checklist • fuel, switches, radio control heads • ovhd pnls/maps • looking throughout the cockpit • Overhead panel, perifferal controls and displays. • general cockpit awareness • system panels/displays • looking at charts • charts & app plates • charts, plates • charts, overhead,pedastal

Table 25. Pilot comments related to scan pattern.

Comments related to scan percentages.	
Post Text Only	**Post Text + Speech**
• Only looked out the window during takeoff and enroute for wx avoidance • Charts, Approach Plates , printed messges. Most of my time I spent confirming messages and confirming inputs of the FCP. I was really trying not to lose situational awareness and staying ahead of the airplane. • N/A • Because I was more comfortable with the sim and the scenario, I did not look at the CDU anywhere the amount of time I did during the first scenario. • MCDU is good in flow, the amber message alert on the iinstrument display is important however, as ATC communication can distract you from listening for or missing the chime.	• Text with voice was a big improvement from just text clearences. It was familiar to me almost like ATC voice intructions. I felt more comfortable and had more time to achieve situational awareness. • Visual and oral better • Dialogue with FO more, this leg, talking about life, finances, other business interests • Computer Generated Voice is much Better for Avoidiung Both Pilots Heads Down Situation!!!! • Difficult to estimate the percentages. • Spent to much time looking at the CDU in anticipation of the next CPDLC message from Center. Would not normally spend that much time focused on CDU panel which made me

Comments related to scan percentages.	
Post Text Only	**Post Text + Speech**
During cruise and climb, the message system works fine, but during deschent in preparation for approach and arrival, it becomes a little distracting and intruding on other procedures in this busier phase of flight. It takes a little longer than a straight ATC voice instruction, which is also less disturbing during busy times. • Enroute function of the CPDLC interface was good. I enjoyed using it. • There were 2 ATC instructions that were not clear. The first was the the CDU msg to contact ATC. I WILCO the msg but didn't realize I had to also contact ATC on frequency to check in. In the descent there was a ATC instruction to Ignore the next CDU msg. When the msg. was received there was some communications confusion as to whether to Ignore or reject the msg • I think that if it weren't for so many key strokes, I would be able to look out of the window more. I found myself having to concentrate a lot on the sequence of the key strokes and finding the actual messages that were sent previously. Once I got the order of operation down with the CDU it became easier. There was one particular time when we received a message late and it really affected our decision making as to how we would manuever the airplane. • I prefer the voice/text method over the text only method.	miss other things. • I believe in the sim session we were more focused on the instrument panel for the ATC alert and CDU in anticipation of an event .. I believe in actual routine flight on the line, this would be reduced. • The combination with voice, allows for a little less time, looking at the MCDU. It still does not seem as practical as just voice communication with ATC , except for the fact when you are busy and/or distracted, you do not have the ask teh controller to repeat the clearance, and does reduce confusion/misinterpretation of a clearance: since you can look at it on the MCDU. It does not affect how I scan and monitor the cockpit. It can be a nice additon to the safety, but at the same time during busy arrivals, it can add to distractions • easier for the non-flying pilot with voice/data • In this session the text and speech prompts from ATC were more realistic. With this method the Flying pilot can start making airplane imputs in advance while the none flying pilot could both hear and retrieve the messages • instruments included wx radar picture • I'd much rather have this system with the speech portion ON. • Seems to be a pretty user friendly and reliable system. Messages tend to back-up any missed ATC comms.

Table 26. Pilot comments regarding Data Comm and scan pattern.

Comments on how Data Comm affected the pilots' monitoring patterns.	
Post Text Only	**Post Text + Speech**
• I had to change from Legs/Prog page to answer ATC prompts, then return. • it gave us another thing to monitor, but that was not a bad thing. I did lighted the workload and make communications smother, I know from experience the	• I spent more time "in the box" to perform the necessary keystrokes to retrieve and acknowledge the CPLDC messages and review it with the PF/Captain • it was a new experience. Selcal chim was probably more of a priority than it would

Comments on how Data Comm affected the pilots' monitoring patterns.	
Post Text Only	**Post Text + Speech**
difficulty of understanding forign country ATC, this will greatly eliminate the current frequent communication errors. HUGE PLUS FACTOR! • It slows down my cross check and confirmation • ATC notification -chime very distracting • it seems to draw your attention to the CDU. And to me, it's a new event in the flight deck, so my guess is that I devoted more to it than I probably would once I get used to it. • altered scan to include engine instruments to monitor for atc msg display • normally would not look across cockpit at other cdu unless an acars message was recieved, which is rare • Have to include in crosschecking and scanning along with other PF duteis • Had to fight the tendency to look down for every single message, which would have distracted from monitoring the aircraft. • Although more Heads Down! Made me pay more attention to FlightDeck Duties and Less Time on Non Essential Duties • checking for messages on cdu, and being sure they were ackowledged • Somewhat. In the descent there was so many ATC MSGS, my head was down looking at the CDU a lot more than I would have liked. I was relying on the PF to fly the airplane while I worked my way through so many buttons to get the ATC MSG and acknowledge the ATC instruction. • in Descent • In the descent and approach phase caused undue workload in screen changes, etc. while attempting to brief and load the approaches into the FMC. • interupted other cockpit duties • only temorarily while reading messages. • had to read more carefully without the voice. all info derived from text, rather than as a backup to voice • I spent more time looking at the cpdl than	normallmy become. • adjusted instrument scan to monitot engin instrument panel, checking to assure atc msg was not displayed • looked cross cockpit at #2 cdu • Postive requirment to cease whatever non-flying activities I was doing and devote attention to data comm • Much easier as the PF to comply with instructions via voice, rather than distracting my attention away from flying the airplane by reading an instruction. Response time to clearance was much more immediate. • Allows for monitoring more than with conventional communication! Always looking at either CDU, ND, MFD, PFD • Requires the CDU page to be monitored cross cockpit. It adds an additional layer of cockpit coordination over purly voice responses to ATC. • I made a flow to always check the messages to see if any were open, and was subconsciously concerned about missing messages, similar to being concerned about missing radio calls. • After we missed an CPDLC message from Center spent a lot time focused on the engine instrument panel in anticipation of next CPDLC. Scan instrument panel more often - anticipating an alert • used data comm as guide to enter info into efis, radios, baro before replying rather than writting info on note pad and doing the same. Otherwise monitoring pattern normal. • required for backup of PM and own understanding of clrnc • I spent more time looking at it than normally • Somewhat more focused due to the emphasis given the CPDLC study. • It changes my scan of the systems and the window. • I was able to minitor better with voice on • Look at fms to confirm instructions • read message before responding to clearance. Could reread mesage to confirm clearance

Comments on how Data Comm affected the pilots' monitoring patterns.	
Post Text Only	**Post Text + Speech**
normal • It made me have to change my scan and incorporate it into my cockpit flow because I spent more time "head down". • it is to easy to get fixated on the data comm • Looked at FMC more • looking at screen somewhat more for messages..	• watched more for incoming messages and was very cautious in acknowledging..

Table 27. Pilot responses regarding use of the message log.

Please specify how you used the Log on the CDU to review messages.	
Post Text Only	**Post Text + Speech**
• Looking back, it would be a good idea to implement a procedure/SOP to print msg as received to have as a review of the flight • No i felt more comfortable printing the latest clearences • making sure all msgs were wilcoed • Checked occasionally to confirm that I had not missed a message. • Altimeter setting KCLE • review the altimerter setting we had forgotten • MENU - (& SIM - ATC MSG Line Select Keys) • To clarify and verify clearances / ATC inrstructions. • Mainly to ensure that messages were complied with. • All the time to confirm that I had acknowledged all messages. • just once, to recover an open instruction • When I had any doubt that there were unread messages I used this function to review (time permitting). • clearances in question • I ocassionally the msg log line select key • refer to previous msg • To make sure all of the messages were aknowledged • verification each time I acknowledged a message. • Just for informational purposes	• I used the LOG periodically to review that I had received and complied with all the messages in the order they were received. I also printed them out as I received them to have a paper copy of the log. • closed out open message • Read back • returned to log screen when we discovered we had not yet replied to a timed out message • to make certain that there no unacknowledged msgs • After top of clinb, at top of descent, and after every few messages to confirm I haven't missed one. Also if I think I might have missed one. • Cannot recall • confirm message • MENU (& Sim plus ATC MSG) • To review and print lengthy clearances e.g. reroutes. It was nice to have a paper copy of the changes. • Actually, I checked the log after most mesages to be sure I didn't miss any messages. • All the time to check status of messages. • The log was useful when unsure of whether or not a clearance had been read or acknowledged. • verification of longer or more comlex messages

Please specify how you used the Log on the CDU to review messages.	
Post Text Only	**Post Text + Speech**
• Their was a few times that we didnt wilco a MSG. • To make sure I didn't have any open messages. Double check my tasking. • Made sure we got all messageshiwas allert review	• After missing a WILCO I used the Flight log prompt as a way to make sure I answered all ATC requests •waited untill action complete before "wilco" response. checking open messages was good as a reminder complete action. • review/confirmation • often • Frequently checked the acknowledged or willco log on previous messages. • To mske sure that I didn't miss any messages. • Once again we forgot to Wilco a MSG and the log helped to find in • To double check that we didn't miss anything and to review a few messages

Table 28. Pilot responses regarding use of the printer.

Please specify how you used the printer during flight.	
Post Text Only	**Post Text + Speech**
• I used it often when the cockpit workload increased, The printed hardcopy felt like a safe back up and a reference. • Message Review • ATIS • printed clearances involving crossing restrictions and or altitudes. messages of 2 pages • long clearances and clearances that would continue to be valid for longer periods of time • To print complex route instructions. • Re-route to CLE • confirm the reroute • WX >> and ATIS and Complicated (Long) CLNCs • To print messages / clearances and weather SIGMETS. • For more complicated clearances. • To have a hard copy of a clearance or instruction. • we used it for all ATC clearances and other pertinent info • Used the printer to collect a paper copy of clearances and weather. • more important/complex messages were printed • I used a printing a log of pertinant clearances • print clearances other than altitude changes. • backup clrnce with hard copy • For a complex clearance • Messages of more than one page were printed. • As an aid and reminder • Printed new routing clearances. • to print long messages • We printed off almost every MSG • Used to print multi-page messages. Logging certain clearances. • Print routes or weather.	• I used the printer to create a running log of ATC communications and responses. • ATIS - Read back Clearence • the Polot monitoring printed the ATIS information. • for clearances with multiple crossing restrictions or instructions • to print out a route change with more than two data points • For more complex clearances. i.e. more than 1 or 2 bits of data. • Re-route to KCLE • get reroute verified • Printing weather and complicated CLNCs • To print hard copy messages for review. • On clearances with several items (altitudes, freq, etc) which were difficult to remember, I printed out the messages. • To have a hard copy of certain messages. • most ATC clearances and other pertinent information was printed • Printed off more complicated clearances. • to print more pertinent messages • I printed important clearances that related to route changes, altitude and speed changes. • print clearances, wx. • hard copy of clrnce • Good for a complex clearance • Pages greater than 1 were normally printed out. • As a backup • print route chngs • I used it as back up and to confirm that I had covered myself on an instruction. • we printed off everything and I the CA re-read it • For multiple page messages and to back up some clearances.

Table 29. Pilot responses regarding the set-up of the CDUs.

Please describe how you set up the two Control Display Units (CDUs) on the flight deck.	
Post Text Only	**Post Text + Speech**
• Left CDU - Legs page - Captain entered course/altitude/route info and PM (me) confirmed his entries. Right CDU - Prog page - when msg rec'd, I answered "wilco" or "unable" after confirming with Captain (PF). • as PF at takeoff I had it set to takeoff, then switched legs. • Standard....adjusted range often • Legs- Progess page • PF on Legs, PM on the ATc message page. • one on legs page one on prog page or message display page • capt - legs, F/O progress • PF in legs, PM in progress. • PF legs, progess PM • numerous different screens • PF=LEGS PM=Progress or CPDLC • PF - LEGS PM - Progress • PM on Prog; PF Legs page. • PF on legs display, PM on progress page, except for viewing messages. • Leave that up to company specific policies. • Takeoff display on Takeoff Climb/Crise/ Descent Legs Progress • Legs/ on PF and we kept PM on ATC meswages • Enroute the captain (PF) had the legs page up and I (PNF) displayed prog when not using CPDLC. • pf for route/path information pnf mostly message monitoring • The Flying Pilot was on the legs page and I was on the progress page until I received an ATC msg. • PF-legs PM-prog, atc messages • PF-mostly legs page PM-CPDLC/ ACARs • Pilot flying: Legs page. Pilot monitoring: Progress page • Capt. Legs page, F/O progress page. • PF - Legs PM - Progress page You can always look at whatever you want, but just go back to the legs/progress • PF - Legs PM - Prog	• The PF CDU was on the LEGS page, and the PF entered the COURSE/ALTITUDE entries while I confirmed his entry. The CDU on the PM side was set to the PROG or PERF pages. When an ATC MSG was received, I read the message, let it "speak", and printed it for record. • PF on legs, PNF on progress and CPDLC • Standard • legs page -PF • Pilot flying mostly used the legs page.Used route page for the revised routing clearance. We tried the Vref page and found it wasn't funtional. The PM used the pages used for sel call recall. • pf used legs page and pm used several different pages while enroute • captain on legs page, F/O on Progress • PF on legs, PM on progress. • PF legs, and various phases of flight, climb cruise, etc. and PM on Progress • legs page • PF=LEGS PM=PROGRESS • PF - LEGS PNF - Progress • PM was on the Prog page, PF was on the FMC Legs, Fix and Rte page. • Normal AA procedures: For Takeoff, PF monitors takeoff page, and PM monitors legs page. No specific procedure during cruise, although most pilots monitor the VNAV. On approach PM monitors Progress page 4 (to ensure RNP is satisfied). During this session PF stayed on legs, PM (myself) stayed on Progress (per experimenters suggestion)except when looking at datalink messages. I always tried to return to the progress page. • Certain comes have specific policies what page the PM and PF should be on at certain phases of flight. Your recommendations at find but I would leave it to company specific. • As the flying pilot Takeoff page for takeoff performance page on level off Legs page in climb - cruise - descent

Please describe how you set up the two Control Display Units (CDUs) on the flight deck.	
Post Text Only	**Post Text + Speech**
• flying pilot - legs non flying pilot - progress • PF on legs, PM on everything else • Legs & Prog pages mostly. • CPT legs FO progress and get messages • PF legs PM progress, CPDLC • Capt. on legs page and I was on progress and cpdlc	• PF: on Legs, PM on ACARS /ATC messages • PF on legs and PNF on prog page or CPDLC screen depending on need. • pf normal usage for phase of flight pm normal usage, with interuptions for messages • Initially, flying pilot on the FIX page and none flying pilot on the progress page. Then witht the ATC voice interaction, I had the CDU page so that I can just select the SPEAK line select button • PF-legs PM-progress, atc messages • PM on CPDLC/ACARS PF on legs page primarily • Pilot flying on legs page, pilot monitoring on progress page • Typically legs page on 1 and progress or CPDLC page on2. • PF - legs PM- progress • PF - Legs PM - Progress • pilot flying - legs page pilot monitoring - progress page • CA on LEGS FO on PROG • Legs Page and Prog Page. • Captain on legs FO on progress and retrieving messages • PF legs PM progress or CPDLC • Capt on legs and I was on progress or cplc...

Table 30. Pilot comments regarding how the set-up of the CDUs supported flight deck tasks.

Comments related to the set-up of CDUs supported our tasks on the flight deck.	
Post Text Only	**Post Text + Speech**
• Multipal inputs required • N/A • Not normally have the PM on progress, would have liked flexibility to keep on legs page especially during route and altitude clearances to better verify the changes	• it takes too many key strokes/button pushes to get to ATC messages. • N/A • Having the PM on the Prog page was necessary due to the number of comm messages recieved. • Still think the PM should be on LEGS more ... during cruise especially • Still to many key strokes, You need to get to the message faster under stress. Two keystrokes would be nice than one more to Wilco

Post Experiment Questionnaire

Table 31. Pilot comments related to the helpfulness of the text display.

Comments related to the helpfulness of the text display.
• Text only and both pilots reading message I believe is unsafe. Both pilots have head down trying to read will distract attention too long. • N/A • The text displays are easy to understand providing clear instructions from ATC. • helps eliminate any confusion in controller verbal communication. • I agree with one caveat: the text and CPDLC is work overload and a hinderance when in the approach and landing phase. • interupts normal cockpit duties/flows. however makes comm more secure. • However, it would be easy to miss very important ATC message in a high work load environment • Saves writting down all clearances. In extremely busy enviroment text would be a benefit if we did not receive voice call at same time.

Table 32. Pilot comments related to the helpfulness of the text+speech display.

Comments related to the helpfulness of the computer-generate speech in addition to the text display.
• Excellent improvement • N/A • The computer-generated voice prompts add distractions in the cockpit when competing with ATC VHF comm. More unnecessary noise. • I feel text is more important. • During the first scenario, I thought the computer-generated speech was very helpful. During the second scenario, when I was more comfortable with the sim and scenario and I did not have the computer-generated speech was not missed. • System works a lot better with speech added, it reduces the risk of misreading and increases the process time of the message to the brain, • When the PF is doing something else, he/she can still hear the information that the PNF is receiving/reading. • eases workload during busy times. • At present, it is still a noval situation. I do not know if I would appreciate it after repeated use. • The voice generated speech is very helpful • Voice communications allow the flying pilot to initiate a clearance before looking at the CPDLC with the monitoring pilot for final verification. • I like that you can turn the voice off. • Prefer this method.

Table 33. Pilot comments related to a preference of only the text display.

Comments related to the preference of only the text display.
• I would advance that it would be nice to make it optional to the crew. • N/A • Text only is adequate as long as there is VHF voice back up if needed. • In retrospect I would agree. My recommendation would have it as an option which the crew could turn on or off at their discretion. • The speech is a good addition. • see above

Comments related to the preference of only the text display.
• I agree with this during the day, but durning night flights it can help. Both pilots and ATC can get fatigue at night and I can see this helping.. • I think as a pilot I am conditioned to hear an atc clearance. So I think it is helpfull to have the computer generated voice.

Table 34. Pilot comments related to a preference for the computer-generated speech.

Comments related to the preference of only the computer generated speech
• N/A • The speech needs to be backed up with a text. Unlike when talking to controllers live, there is no "cadence" or verbal rhythm to the clearances or information that is being read by the computer. • Voice only would be characterized as a traditional ATC voice clearance • I want to be able to read the message regardless of whether speech is available; and to be able to print if necessary. • Both seem best to me.

Table 35. Pilot comments related to a preference for the text+speech display.

Comments related to the preference of communicating with the ATC using both the text display and the computer-generated speech.
• A live controller allows the crew to udilze commands to other aircraft to give you a situational awairness of what other aircraft are doing around you. • N/A • I believe you can communicate primarily by text but a controller as a back-up for clarification is a must. • direct communication with a controller allows for faster decision making when questions about clearance/instruction. It feels like it is a little quicker and/or more effective to just respondi to a voice call and respond. • I prefer the controllers voice and intonations. Sometimes there is no substitute for subtle voice cues. • it depends on the particular airspace/workload. high volume areas would be too distracting. • Real time voice is best as long as frequency congestion is not a factor. I can see text delivery as a convience on long cross ocean routes outside of VHF range. • Only during low workload times. NOT on appraoch control etc. • Generally agree, but approach environment would not work well with text only. Center frequency handoff would be greatly prefered by text. • Accents can be very challenging, this can help. I'm from the south, its hard to understand what they are saying. • Think I prefer ATC as well. • Too many buttons to push to get message in busy airspace

Table 36. Pilot comments related to the preference for the text-only display.

Comments related to the preference of communicating with the ATC using only the text display and not the computer generated speech.
• N/A • During cruise and low workload periods, it works great and is very pleasant and effective., but during other times, it may not be as effective and efficient.

Comments related to the preference of communicating with the ATC using only the text display and not the computer generated speech.
• If there is to be some form of CPDLC in daily operations then both spoken and written clearances would be helpful. Why only have one form of communication when you can have both. I believe it reduces the chances that only one pilot would receive the information and therefore reduces the chances of mistakes while reading/deciphering clearances (i.e. dyslexic reading by pilots) • Old habits are hard to change.

Table 37. Pilot comments regarding the feasibility of the recommended SOP for text+speech.

Comments related to the operational feasibility of both crew members hearing and understanding the message at the same time with computer-generated speech and a text display.
• N/A • not sure what volume would be in weather.. does it self adjust to ambient noise.

Table 38. Pilot comments regarding the operational acceptability of the recommended SOP for text+speech.

Comments related to the operational acceptability of only one crewmember reading the text message after both crewmembers listen to the computer-speech message before taking action with computer-generated speech AND a text display.
• I think both crew members should have to read, understand, and agree upon the clearance prior to action. • both need to confirm what was heard is correct • N/A • Both crewmembers will need to read the message. The message could be printed and passed between both crewmembers to read. • It would be good practice to have both crewmembers visually confirm the message is correct and current. • unless it is a longer, more comlex message. • both should read and listen • Both should verify any changes to the AC

Table 39. Pilot comments regarding the operationally necessity of the recommended SOP for text only.

Comments related to the operational necessity for both crewmembers to silently and individually read the Data Comm message and reach consensus to avoid misinterpretation with a text display ONLY.
• I would rather each read or one read to the other and then both confirm the message • N/A • Both crewmembers should read the message, acknowledge reading to each other and be in agreement before acknowledging with ATC. • One crewmember may read aloud. If he reads the information wrong, then he may lead the other crewmember to believe a clearance was issued that ATC may not have given.

Table 40. Pilots comments regarding use of the recommended SOP for text only.

Descriptions of why pilots did NOT always use the GOLD procedure (silent & individual read, confer, then respond).
• I am new to the system, and did not remember to always use the proceduere. However, I see the great value of this system. • I always want to confirm for myself unless I heas the speech. • Initial response is fine, but not always use GOLD. Too much time to read. • Used to verballizing everything that concerns the safety and legality of the flight • Usually both read the message out loud. • I verbalize a lot of SOP's at USAirways so the conflict becomes remaining silent and not verbalizing msg's, and fighting the tendency to vocalize this processes • I would rather both pilots read and discuss the message not silently • 90% of time (Sometimes I talk to myself out loud reading the MSG • subconsciously it was difficult to not read aloud.. because this is how i comprehend • distractions, while in briefing or executing other required actioins (altitude/course change etc.) • flying pilot performing other duties • I did very little Oceanic crossings • Sometimes I wanted to confirm what the other pilot is thinking and wanting. • Sometimes one of the crew members would read the text outloud • Needed to practice not jumping ahead of the other pilot and stating what I read. • Thought it was better to work as a team to determine the intent of the message. I think as the system becomes more ingrained with experience the GOLD procedure might be more common, but until then I think CRM is better served doing together as much as feasible • It was difficult to make myself do that everytime when it was so easy to just read it and then do it. • Its more natural to read it outloud. • in the execution mode trying to get tasks done, i'd say and do. • inadvertantly reading aloud a clearance..

Table 41. Pilots comments regarding intracrew communication for text-only messages.

Comments related to the method of communication with the other flightcrew members about the Data Comm message if the GOLD Procedure was NOT always used.
• I read the message aloud to him, then confirmed that he understood the message. • self read. • Point and repeat • verbally • Out loud. • Thumbs up, and wilco verbal. • we both read and discussed it • Sometimes I read to myself Outloud however the Pilot Flying still verified prior to Accepting CLNC • Tried to always communicate verbally and get acknowledgement from other crewmember. I think this is important with or without a datalink system. • We tried hard to use the GOLD procedure but when we did and did not we confirmed the clearance out load between both crewmembers. • both read out loud.. individually..then discussed • usually with a replay. • We received very little other than cell call from ATC • Confirm? Just ask what he wants or understands.

Comments related to the method of communication with the other flightcrew members about the Data Comm message if the GOLD Procedure was NOT always used.
• Checked and rechecked • Verbally stating what I read before the other pilot made their own interpretation of the text. • Verbally. Reading/Verifying together • i let them read it. But it was much easier to do the GOLD procedure with the Speech than without. • communicated actions after/as reading the message • reading the message aloud.

Table 42. Pilot comments regarding the aural indication for a new message.

Comments related to finding the AURAL indication of an incoming Data Comm message (ding-dong) to be effective.
• Sounds to much like a selcal • N/A • Very effective. I listen for that aural indication. • needs to come through head set - also,,, • common sound used for other notification • It took a few times to recognize what the new noise was. • it could be louder, for night flights

Table 43. Pilot comments regarding the visual indication for a new message on the EICAS.

Comments related to the effectiveness of the VISUAL indication of an incoming Data Comm Message ("ATC MSG") on the EICAS display.
• It was helpful, but it was out of my normal scan. If it was placed in the ND display might be helpful. • Needs to be placed in the pilots primary scan.. flt instruments

Table 44. Pilot comments regarding the visual indication for a new message on the CDU.

Comments related to the effectiveness of the VISUAL indication of an incoming Data Comm message (" *ATC MSG* ") on the CDU.
• Great expereince and great staff for all of this!! • N/A • The prompt on the upper display and aural prompt are adequate. • I believe there needs be less steps to actually to a message. instead of MENU, SIM OPT, then NEXT PAGE maybe NEXT, SIM OPT, ATC MSG... • Needs to be placed in the pilots primary scan.. flt instruments

Table 45. Pilots' final comments.

Final comments
• I appreciate the effort and the thoroughness that went into this training. I feel I am better prepared to fly in this "system" with the training I did today. • I think it's excelent. • Both voice and visual commands are benificial nin reducing ruduce loads • One suggestion...if able, possibly have the incoming atc msg display on the artificial horizion, or nav display, as well as the engine instruments. For me personally, i usually do not include the engine instruments in my continul scan. Thank you • The logical next step is to data link instructions directly to the CDU, and require pilots to confirm

Final comments
and execute them. • Look forward to participating again with this!! • I would rather not read the message silently and both discuss it before taking action even if it means reading together. • Would be nice if ATC MSG Ding Dong Chime to Chime again after a preset period if no reponse. Or as another option - ATC MSG can start to Flash if no Reponse after a preset period of time • Excellent experiment! • I think the text only message is a great system, and will help eliminate any confusion concerning clearances, and reduce pilot/controller workload. This workload often is increased as a result of incorrectly read back clearances. • Everyone was was fantantic and this could be a great tool but only with a live controller as a back-up. This was a great experience.. • I believe this program would be effective in cruise. I have concerns during the busy times in flight - climb and descent Concerns over ambiemt noise conditions... distractions.. in weather .. alerts need to come through head sets also. • Great system, but can be less effective and distracting during high workload peroids in flight. • The incoming message aural tone mixed with a visual cue is something that we pilots of modern aircraft are quite used to. A sound of some sort alerts us to a non-normal condition or something that needs attention sooner, rather than later. The visual cue confirms that we have a message and directs us to the appropriate area. If we forget or miss a message, then a continuing cue is critical in order to process the information and keep us from moving on. Assuming that both the aural and visual cues are implemented, then most pilots will have no problem with adjusting to this new program. • good system, but not for busy terminal areas. • Great for use in a non high density airspace • As i mentioned, a live controller would be needed in a very busy environment • Wonderful staff, thank you for allowing me to participate. • Nice systems - good luck with the program • I think that having the old msg still showing in the top left of the display is going to lead to missed messages. Once a message is acknowledged then it should migrate to the LOG page and ONLY the new message should be showing. Also found having to hit BACK instead of Prev Page to return to page one of a message to be counter intuitive. Most of ACARS uses Prev Page not BACK to move among multi-page msgs. Tripped alot on that one • This is going to be a useful tool when it is implemented. Gives flight-deck crews addl backup during flight. Thanks for letting me participate.