Loss of Controller-Pilot Voice Communications in Domestic En Route Airspace

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With the planned implementation of Controller-Pilot Data Link Communications (CPDLC) in en route airspace, information on voice communication performance in this airspace can help to predict specific benefits associated with CPDLC, identify adjustments in equipment or procedures in early implementation, and demonstrate that planned benefits have been achieved. This paper examines existing data on losses of communication between controllers and pilots in the en route environment in anticipation of the implementation of CPDLC. Of particular interest was communication performance with air carrier aircraft, since they are most likely to be equipped with CPDLC for en route ATC communications. One thousand, three hundred and fifteen relevant Mandatory Occurrence Reports (MORs) in domestic airspace at Air Route Traffic Control Centers between March 1, 2014 and October 1, 2014 were examined The times reported for loss of communication ranged from 1 to 235 minutes (Mean = 21 minutes, SD = 19 min, Median = 15 minutes). There were also three losses of standard separation with terrain and seven losses of standard separation between aircraft associated with the controllers' inability to contact an aircraft. Additional refined measures of communication parameters should be examined to further establish baseline performance and assess the benefits of CPDLC.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

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

APPROXIMATE CONVERSIONS FROM SI UNITS

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

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

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Contents

List of Abbreviations

ARTCC	Air Route Traffic Control Center
ASRS	Aviation Safety Reporting System
ATC	Air Traffic Control
CEDAR	Comprehensive Electronic Data Analysis and Reporting
CPDLC	Controller Pilot Data Link Communications
DEN	Domestic Events Network
FAA	Federal Aviation Administration
EOR	Electronic Occurrence Report
GA	General Aviation
MOR	Mandatory Occurrence Report
NAS	National Airspace System
NORDO	No Radio
SD	Standard Deviation

Executive Summary

With the planned implementation of Controller-Pilot Data Link Communications (CPDLC) in en route airspace, research was needed to explore aspects of communication performance. Information on baseline (i.e., voice) communication performance was needed to predict specific benefits associated with CPDLC, to identify needed adjustments in equipment or procedures in early implementation, and to demonstrate that planned benefits have been achieved.

The purpose of this paper was to explore existing data on losses of communication between controllers and pilots in the en route environment in anticipation of the implementation of CPDLC in the domestic en route environment. The analysis was intended to help form a baseline for the number and duration of losses of communication in the voice environment and to further our understanding of the reasons for these losses. Of particular interest was communication performance with air carrier aircraft, since they are most likely to be equipped with Data Comm for en route ATC communications.

There were 1,315 relevant Mandatory Occurrence Reports (MORs) occurring in domestic airspace at Air Route Traffic Control Centers (ARTCCs) between March 1, 2014 and October 1, 2014. The times reported for the loss of communication ranged from 1 minute to 235 minutes. The mean was 21 minutes (SD = 19 min) and the median was 15 minutes. The mean duration for losses of communication involving General Aviation (GA) aircraft was 25 minutes (SD = 22 min), and the mean duration for losses involving commercial aircraft was 16 minutes (SD = 14 min). The median for GA aircraft was 25 minutes and the median for commercial aircraft was 11 minutes. During the same time period, there were also three losses of standard separation with terrain and seven losses of standard separation between aircraft associated with the controllers' inability to contact an aircraft.

It is important to note that these MORs most commonly referred to the time that the individual controller was unable to communicate with the aircraft, and not the total time that the aircraft was not communicating with ATC. In fact, 20% of the reports stated that the aircraft transferred into the center's airspace as NORDO (i.e., No Radio). The implementation of Data Comm in the en route environment is expected to reduce the time required to re-establish communication with an equipped aircraft, and thus reduce the risks associated with pilots not responding on the voice frequency, since it provides an additional and quick means of contacting the aircraft.

The information on communication performance currently collected by the Federal Aviation Administration (FAA) was found to be too coarse to provide an adequate baseline and would not be sufficiently sensitive to show operationally significant improvements in safety. For this reason, more refined measures of a broader set of communication parameters should be used to establish baseline performance and assess Data Comm benefits.

1. Background

With the planned implementation of Controller-Pilot Data Link Communications (CPDLC) in en route airspace, research is needed to explore aspects of communication performance in the National Airspace System (NAS). Information on baseline (i.e., voice) communication performance in the NAS is needed for all phases of implementation. Prior to the implementation of CPDLC, this information can be used to predict specific benefits. In the initial stages of implementation, baseline information can be used to monitor performance and identify any necessary adjustments in equipment or procedures. Finally, such information is needed to assess post-implementation performance in order to demonstrate that planned benefits have been achieved.

In many ways, the CPDLC environment will present a paradigm shift for controller-pilot communications. One aspect of this is envisioned to be the requirement for flightcrews to monitor the frequency as they enter a new sector of airspace rather than checking in with Air Traffic Control (ATC). In fact, much of the projected benefits associated with the use of CPDLC in the en route environment—reduced workload (for both controllers and pilots), and reduced voice channel occupancy time (and hence, reduced frequency congestion)—are based on the transfer of communication using an instruction to the pilot to monitor the next assigned frequency (as opposed to "contacting the controller on the frequency"). One concern with this projected shift from "contact" to "monitor" is that it might affect the ability of a controller to contact an aircraft on frequency. Consequently, information was needed to describe the current performance in domestic en route airspace with respect to the frequency and duration of instances in which a controller cannot contact an aircraft. The current analysis was undertaken to address this important issue.

The purpose of this paper is to explore existing data on losses of communication between controllers and pilots in the en route environment in anticipation of the implementation of CPDLC in the domestic en route environment. The analysis was intended to help form a baseline for the number and duration of losses of communication in the voice environment and to further our understanding of the reasons for these losses. Of particular interest is communication performance with air carrier aircraft, since they are most likely to be equipped with CPDLC for en route ATC communications. Information on the causes of such disruptions to communications will add to our understanding of the expected benefits to be achieved with the implementation of CPDLC and can help to inform discussions on the use of "monitor" vs "contact" on transition between sectors within a facility.

2. Reporting Requirements Regarding Loss of Communication

In November 2010, the Federal Aviation Administration (FAA) required that instances in which controllers could not establish or re-establish communications with an aircraft within five minutes be reported to the Domestic Events Network (DEN) (N JO 7210.761). On April 3, 2014 this was revised to include all instances of "loss of radio communication" regardless of duration (FAA Order JO 7210.3Y).

In the context of this analysis, the DEN was contacted as a potential source for information, such as the average time to resolve such losses of communication. Specifically, the DEN was solicited for information on the frequency and duration of losses of communication in the en route environment. Unfortunately, such records are not kept. According to sources inside the DEN, only records that pertain to security-related events are kept and thus the Mandatory Occurrence Reports (MORs) are the best source of information on the frequency and duration of losses of communication.

FAA Order JO 7210.632, Air Traffic Organization Occurrence Reporting, specifies the events to be reported for the collection of safety data. Controllers are to report "Any instance in which communication with an aircraft was not established or not maintained as expected/intended, and results in alternative control actions or additional notifications by ATC, or a flightcrew, or in a landing without a clearance." These MORs are completed within the Comprehensive Electronic Data Analysis and Reporting (CEDAR) database. This database was used for the analysis of losses of communication performance.

3. Method

MORs were searched for events occurring at an Air Route Traffic Control Center (ARTCC) between March 1, 2014 and October 1, 2014 that were classified as involving the factor "Communication not established/maintained as expected/intended". Additionally, ARTCC reports of losses of standard separation during the same period were examined for events involving loss of communication (since incidents that involve a loss of communication that result in a loss of standard separation would only be reported in that section of the database).

4. Results

4.1 Number and Duration of Loss of Communication Events

There were 1,378 MORs identified as involving a communication disruption, 63 of which were excluded as irrelevant (duplicate or blank reports, events occurring in oceanic airspace, etc). The remaining 1,315 events were analyzed to identify useful information. While most of the reports clearly identified the time that the controller was unable to communicate with the aircraft in their sector, 108 contained no information with respect to the duration of the loss of communication. An additional 123 reports did not include specific information and identified the times as only "less than 21 minutes" or "over 20 minutes"; these were excluded from the statistical analysis. (Twenty minutes is the point at which a pilot deviation is considered.) Figure 1 provides the frequency of events by the reported duration of loss of communication. The times reported for the loss of communication ranged from 1 minute to 235 minutes with an average of 21 minutes. Since the standard deviation (SD) for this distribution was quite large (SD = 19 min), the median (50th percentile) was also computed as 15 minutes.

It is important to note that the times recorded in the reports most commonly referred to the time that the controller was unable to communicate with the aircraft and not the total time that the aircraft was not communicating with ATC. In fact, 20% of the reports stated that the aircraft transferred into the center's airspace as NORDO (i.e., No Radio). For example, the following report, "Aircraft X crossing into ZAU approximately 1550Z returned to frequency 1552Z" was associated with an elapsed time of two minutes (and a Quality Assurance time of "less than 21 minutes NORDO"). While the aircraft was out of contact with ATC in that sector for two minutes, clearly the actual time that the aircraft was unreachable was much longer, given that the aircraft transitioned into the sector as NORDO. This is an important qualifier in interpreting the results.

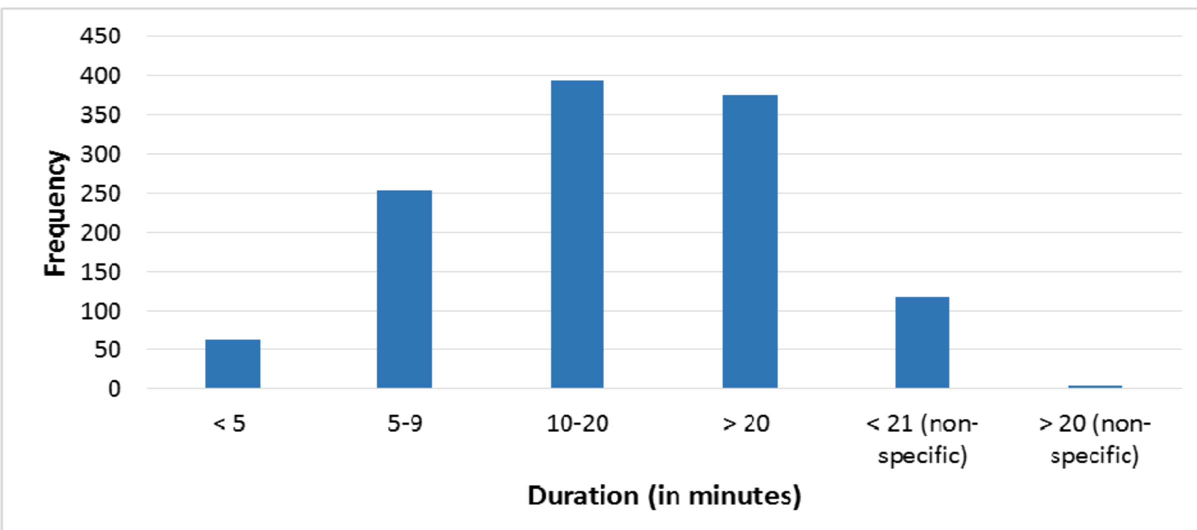

Figure 1. Frequency and Duration of loss of communication events as reported in MORs in Domestic En Route Airspace from March 1, 2014 to October 1, 2014.

4.2 General Aviation vs Commercial Aircraft

Events involving a loss of communication between aircraft and ATC would be expected to be more common and of longer duration with General Aviation (GA) aircraft than with commercial, air carrier flights. Some GA aircraft are quite sophisticated and operate with a crew of two. Nonetheless, in general, air carrier flights would be expected to miss fewer ATC calls than GA flights due to their better equipment (and more frequent maintenance) and a crew of two (compared to typical GA single-pilot operations). Another critical difference is that when contact is lost, controllers are able to contact the company and have dispatch contact the aircraft. As one report stated, "The dispatcher was able to send the request via a data link message to the aircraft. [Air Carrier Aircraft] immediately returned to frequency at 0355Z once the company data link message was sent" (ZLC-M-2014/03/09-0002). Another reason for particular interest in the communication performance with commercial aircraft is that they are more likely than GA aircraft to be equipped with Data Comm capability.

To investigate this aspect of communication performance, the events were classified using the aircraft call signs (whether the aircraft was operating under Part 121, Part 135, Part 91, etc. was not provided in the reports). The 711 reports involving call signs using the registration number of the aircraft (N… for US registration, X…. for Mexican or C… for Canadian) were classified as GA; the 560 call signs that included a company designator were classified as "Commercial". There were 44 reports in the third category of military aircraft.

As expected, the characteristics of the losses of communication with GA aircraft are different from those with commercial aircraft. As can be seen in Figure 2, the durations of the losses are generally longer for GA aircraft (mean = 25 min, SD = 22 min) than for commercial aircraft (mean = 16 min, SD = 14 min). Again, given the high level of variability, the medians also were computed. The median for the GA aircraft was 25 minutes and the median for commercial aircraft was 11 minutes.

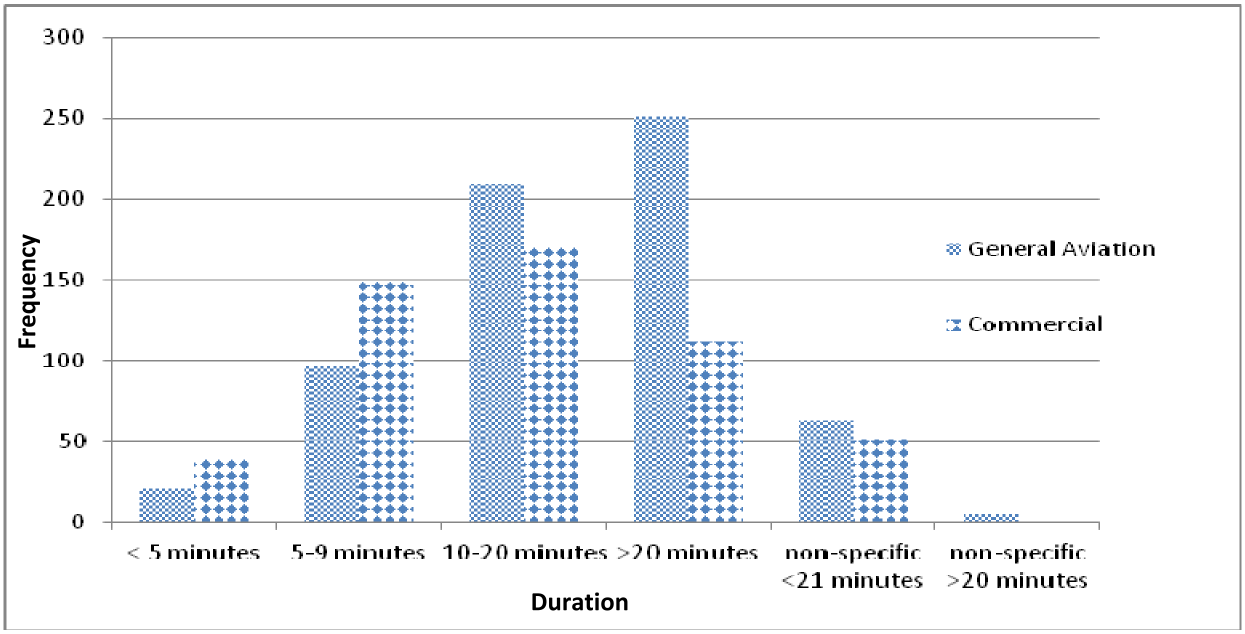

Figure 2. Frequency and Duration of loss of communication events by aircraft type as reported in MORs in Domestic En Route Airspace from March 1, 2014 to October 1, 2014.

5. Causes of Loss of Communications Identified in MORs

In addition to the number and duration of communication disruptions, the reports were examined for insights as to the causes of the disruptions, how they were discovered, and how they were resolved. Unfortunately, this information is not standardized within the reports and is usually not reported. Fewer than 20% of the reports contained information as to the cause, and even fewer contained information on the other issues of interest. Where a cause was identified, the most frequently cited causes were controllers issuing the wrong frequency or never issuing a frequency change (identified in 38% of the reports providing a cause, i.e., 7% of the total reports). The reports detail that the aircraft was issued frequency X instead of the correct frequency Y; but they provide no insights as to why the mistake was made or how such mistakes could be prevented.

Pilot error was identified in 4% of all of the reports. Such errors were associated with frequency changes: dialing the wrong frequency, misunderstanding the frequency, or forgetting to change frequencies. These reports contain even less information about the underlying causes for these errors. Relatively few reports include the results of an interview with the pilot. Pilots report misdialing the frequency (often even after a correct readback), or never hearing the instruction to change frequencies as a source of error for being on the wrong frequency. Pilots who were able to detect their own communication problem, whether due to a being on a wrong frequency or radio problem, noticed that they had not received a clearance or instruction that they were expecting or were cued in by the fact that the frequency was unusually quiet.

While MORs that involve a loss of communication without loss of standard separation are classified as "Communication not established/maintained as expected/intended," those that involve a loss of communication and result in a loss of separation are categorized only as a "validated loss." For this reason, the reports of losses of standards separation that occurred during the same 6-month period as the sampled MORs were analyzed to determine the proportion associated with a loss of communication. This data set included both MORs and Electronic Occurrence Reports (EORs). In this data set of 1,229 reports, there were three losses of standard separation with terrain and seven losses of standard separation between aircraft associated with the controllers' inability to contact an aircraft. One of these losses met the criteria for the more serious "Risk Analysis Event". In this case, the loss of separation between two air carrier aircraft was directly attributed to a stuck mike on the frequency:

> "Aircraft 1 B722 northbound out of FL220 to FL270 had a stuck mike. Aircraft 2 A321 was eastbound at FL250 on a converging course. ATC made several transmissions to attempt to separate the aircraft including broadcasting on other frequencies but aircraft 1 never heard the transmission. Separation was lost however aircraft 2 stated they had aircraft 1 in sight the entire time."
>
> (ZNY-E-2013/10/31-0012)

6. Analysis of Reports Submitted to Aviation Safety Reporting System (ASRS)

In order to gain insights into the causes of controllers being unable to contact pilots on frequency, reports submitted by pilots and controllers to the Aviation Safety Reporting System (ASRS) were consulted. Lost communications was the focus of a 1993 Directline publication. In this analysis of ASRS reports, pilots' inadvertent mis-setting of aircraft radios or audio accounted for over half of all interruptions to communication; aircraft radio problem (or failure) was the next most common (Drew, Scott, & Matchette, 1993). GA aircraft (specifically light single-engine types) were more likely to experience loss of communication through aircraft radio failure than were operators of other aircraft types. Interestingly, a strong effect of pilot experience was observed, specifically there were more lost communications when one or more of the flightcrew was low time on the aircraft type – this was particularly true for general aviation pilots. A blocked frequency was cited in 16% of the reports; in over half of these, a "stuck mike" (in which a microphone, radio transmitter, or audio selector panel failed in the transmit mode) was identified as the cause.

Since the 1993 Directline ASRS study was not focused on air carrier operations or the en route environment, a more targeted search was conducted on the public ASRS at http://asrs.arc.nasa.gov/search/database.html. For the purposes of this analysis, a search was conducted for reports submitted by pilots or controllers of incidents that occurred between January, 1996 and December, 2015 involving any of the following for Part 121 operations in domestic en route airspace: blocked or congested frequency, stuck or hot mike, wrong or incorrect frequency, lost communications, and NORDO aircraft or aircraft squawking 7600. These searches resulted in 136 relevant reports which were analyzed for insights into the causes of incidents in which the controller was unable to contact an aircraft. Because of the voluntary nature of ASRS reports (and the fact that not all reports that are submitted are entered into the database), they cannot shed light on the frequency with which any type of event happens. However, these reports are a most valuable source of subjective assessments as to the causes of adverse events and the relative proportion of causal factors cited are suggestive of their importance in the eyes of the pilots and controllers who file the reports.

6.1 Wrong frequency

The largest category of reports described instances of pilots being on the wrong frequency. There were 41 reports of this type submitted by pilots and 11 submitted by controllers. All the reports submitted by controllers indicated that they or another controller detected the error; pilots indicated that they had detected the error themselves in 18 of their reports and that they were alerted to the error by controllers in 23 reports.

Five of the 52 reports contained no details as to why the pilot was on the wrong frequency. Of the remaining reports, 11 said that the controller assigned the wrong frequency (3 of these reports were filed by controllers). Another eight reports (including 3 from controllers) said that the controller never issued a frequency change. One of the risk factors identified in the MOR data for giving the pilot the incorrect frequency is when it is transferred to a sector in an adjoining ARTCC that was recently combined or split. According to one controller filing a report in 2014, incorrect frequency assignments across ARTCCs is an all too common occurrence:

"…It is an extreme safety hazard if we don't catch these mistakes because of the icing conditions these 2 sectors face. If aircraft are on the wrong frequency, then we lose them as we are vectoring for final, in a critical phase of flight, often where icing is the most prevalent. And often, this is the only aircraft on the frequency, so there is no way to get the aircraft over to the right frequency until they find their own way. This happens several times daily with ZXX. They consistently put aircraft on the wrong frequency. They have done it to me 4 times in the past week alone, and that's JUST ME!" (ACN 1142933)

Four reports describe instances of pilots accepting a frequency change intended for another aircraft. The use of Data Comm significantly reduces the chances of an aircraft accepting an unintended frequency change, since the message is sent only to that aircraft; however, the possibility that a controller could send a frequency change to the wrong aircraft or send the wrong frequency, will still exist. An additional 16 reports described incidents in which the pilot either didn't hear the frequency change, or misheard or misdialed the frequency. The use of data link would be expected to ameliorate these types of errors. First, pilots should be less likely to miss a frequency change transmitted via Data Comm than via voice. Second, while pilots could misread a frequency, they will be able to refer to the message to correct it, when needed; whereas in the current system, the only recourse is to contact the controller on the previous frequency. However, the only way to determine the extent to which these benefits are realized is to sample communication performance before and after implementation.

6.2 Mechanical problems

Mechanical problems with the radio or frequency issues due to weather accounted for 38 of the 136 reports analyzed. While these reports referenced issues that will not be directly affected with the implementation of CPDLC (that is, the implementation of CPDLC will not change the likelihood of an electrical problem with the radio or the effect of the weather on the voice frequencies), they do point to the advantages of an alternative means of communication.

6.3 Stuck Microphone

Twenty-five reports describe being unable to communicate due to a stuck mike on the frequency. These reports contained some interesting insights into this pervasive problem. Several of these reports point to the difficulty of identifying a stuck mike. In one case, the flightcrew was sure that they were not the cause of the stuck mike (which the controller had broadcast to check for), since they were able to hear the transmission. Actually, the observer microphone was transmitting whenever the pilot's seat was slid back (to accommodate the meal tray); thus, they *were* the source of the stuck mike (ACN 594333). Even after receiving a message from the company that ATC thinks they might have a stuck microphone, the problem can be difficult to identify:

> While transiting through Cleveland Center's airspace, we received an ACARS message from Dispatch stating that ATC thought we had a stuck MIC. The Captain deselected his Push-To-Talk yoke switch from the hot MIC ICS position to get a radio check with ATC. As soon as he did that, ATC reported back loud and clear and that we were the only aircraft they had been unable to check with yet. So, that means we were probably the ones with the hot MIC. There were no other indications of a hot MIC the rest of the flight and we could not duplicate it again no matter how many times the Captain cycled the PTT switch. It is unknown as to how long we had the hot MIC and how much our situation and conversation impacted other ATC communications.
>
> This is the third time that I have been a crew member on an aircraft with a stuck MIC. In all of these situations, we were trying to use the PTT yoke switch to improve crew coordination via ICS hot MIC. However, in all of these situations, we, as the flying crew members have had no indication that our switches were stuck somehow activating both ICS and VHF simultaneously. The PTT yoke switch seems to be well intentioned, but poorly engineered. Accelerating the program to replace the communication panels with the hot MIC selector on the center pedestal would be worthwhile in preventing future incidents such as this one. Also, it would be helpful to have either a light on the VHF radio panel or a visual annunciation on the PFD to show that a transmission is taking place. All of these require money, so in the interim, disabling the PTT hot MIC function might be necessary as well. (ACN: 1120559)

"Stuck mike" events could be significantly reduced or even eliminated with anti-blocking technology or the use of transmitter "time-out" devices that terminate transmission after a reasonable time period. Each of these, however, requires investment by the operators. The implementation of Data Comm should help to alleviate problems associated with a stuck microphone in two ways. First, each Data Comm transmission presents one less opportunity for a stuck mike. More importantly, controllers will be able to broadcast the message “CHECK STUCK MICROPHONE” to all data link equipped aircraft.

6.4 Frequency Congestion

In addition to a stuck microphone on frequency, another impediment to pilot-controller communications is frequency congestion. As the number of communications increases, the number of step-ons increases exponentially (Nadler, DiSario, Mengert, & Sussman, 1990). Stepped-on communications are insidious, as they often necessitate repeated communications, thus further increasing the frequency congestion. Stepped-on communications can also prevent controllers from detecting a readback error. While frequency congestion is clearly a causal factor in clipped and partially-blocked transmissions, these events were outside the scope of the current analysis. However, there were three ASRS reports submitted by pilots describing instances in which the en route frequency was so congested, that they were unable to communicate with ATC, even in an emergency situation. In this case, the circumstances and frequency congestion were both so severe that the pilots squawked 7700 even though the radios were functioning properly.

> …A small cell of weather appeared in front of us… Captain elected to turn right to avoid it while ATC directed us to proceed to XXX and hold. I was not able to get ATC to allow us to deviate left or right. [The] Captain took over the radio and said emphatically that we couldn’t go to XXX. ATC would not acknowledge him, so he squawked 7700 and proceeded to deviate right. As soon as we could, we proceeded to XXX. ATC then acknowledged our 7700 squawk. No traffic conflicts were stated by ATC. The major problem was inability to communicate with ATC at a crucial time due to heavy frequency usage. (ACN 371289)

In a strikingly similar, but separate incident:

> While on vector to intercept arrival, encountered thunderstorm ahead of aircraft. Requested deviation left or right. Radio congestion was very heavy. Controller gave left turn, but by then only a right turn was safe. A right, approximately 90 degree, turn was initiated, but due to very heavy radio congestion was unable to advise controller of [our] right turn. After about two minutes, we were finally able to advise controller of [our] course. They queried us [as to] why we turned in the opposite direction. We were not aware of any traffic alerts or incidents resulting from this. I feel the root cause of this problem was due to extreme radio congestion on XXX frequency and not being able to communicate with them in a timely manner. (ACN 515037)

All of the causes identified in ASRS reports—pilots not hearing the frequency change instruction, mishearing or misdialing the frequency, controllers assigning the wrong frequency or forgetting to issue a frequency change, radio malfunctions, and stuck microphones—involved issues that were also identified in the MORs of incidents in which “Communication not established/maintained as expected/intended” was identified as a factor. While the numbers of MORs that contained reasons for the communications were small, the convergence of the data with ASRS data provides a strong foundation for understanding the causes of such incidents.

7. Expected Benefits of CPDLC Implementation

The implementation of CPDLC in en route airspace is expected to improve communication performance in several ways:

- Messages sent via CPDLC cannot be mistakenly accepted by another aircraft (such as one with a similar call sign).
- The transmission of routine instructions via CPDLC will help to reduce frequency congestion.
- Readback/hearback errors would be expected to decline as the number of readbacks is reduced.
- Altitude busts and other pilot deviations would be expected to decline as pilots are able to load clearances directly into their Flight Management System. Even without this loading capability, the ability to reference the information relayed (such as an altitude or frequency) will provide an advantage over the more transient voice transmission. Additionally, some aircraft will be able to load the frequency directly into the radio, which will preclude pilot errors of misdialing the frequency (but not other errors, such as selecting the wrong radio and having the volume too low).
- The controller will have an additional means to contact an aircraft that is not responding via voice; this should reduce the time required to re-establish communications.
- There is a projected reduction in controller workload associated with the expected use of “monitor” vs “contact” as aircraft traverse sectors within an ARTCC. The effect of the use of “monitor” on pilot workload will depend on whether or not it is accompanied by a requirement to “confirm assigned altitude” and the tasking on the flight deck required to comply.
- Data Comm is expected to reduce the risks associated with pilots not responding on the voice frequency, since it provides an additional and quick means of contacting the aircraft. Notional timelines are presented in the Appendix.

Use of CPDLC for transfer of communication alone would also be expected to noticeably reduce the number of readback/hearback errors; in a study of readback/hearback errors in the en route environment, 41% of all readback errors were associated with radio frequencies (Cardosi, 1993). Data Comm is also expected to reduce controller workload, in part, with the instruction to “monitor” rather than “contact” the next sector when operationally practical within an ARTCC. This will also reduce voice channel occupancy time and hence, reduce frequency congestion.

The initial implementation of data link in the en route environment began in Miami ARTCC in 2002. While this was a very limited implementation, in terms of services, the operational experience was well received by pilots and controllers (Gonda et al., 2004). From October 7, 2002 to August 31, 2004, “Contact [frequency]” instructions accounted for 28% of the uplink messages sent, whereas the use of the “Monitor [frequency]/Confirm Assigned Level” message accounted for 41% of the uplink messages sent. The report on the initial operational experience did not report any problems with this use of “Monitor” (Gonda et al., 2004).

In the data analyzed, not a single event involved a pilot being instructed to “monitor” (as opposed to “contact”) a given frequency. The prevalence of the use of “monitor” in the NAS is unknown, but is presumed to be quite small. While the current data analysis cannot shed much light on this issue, the use of “monitor” over “contact” to effect a “silent check-in” has been used in other countries, most notably in New Zealand: “When doing a CPDLC transfer, we use “monitor” for Brisbane, Melbourne and Nadi while we use “contact” for Tahiti and Oakland. We have not had any issues with the ‘silent check-in’ in over last 13 years” (Paul Radford, personal communication, 2014).

8. Next Steps

The expected benefits of Data Comm implementation have been outlined here and continue to be refined. Whether or not these benefits are realized will need to be assessed with careful comparisons of aspects of post-implementation communication performance to established baselines. Post-implementation performance monitoring is also critical to ensure that any negative effects of implementation are identified and mitigated.

The information on communication performance currently collected by the FAA is too coarse to provide an adequate baseline and would not be sufficiently sensitive to show operationally significant improvements in safety. For this reason, more refined measures of a broader set of communication parameters should be used to establish baseline performance. The same measures would then be used after Data Comm implementation to assess Data Comm benefits. Candidate measures include:

- Time to contact an aircraft
    - in routine transfer of communications,
    - coordinated into airspace as NORDO,
    - transferred with a “monitor” compared to a “contact” instructions,
- Number of readback and hearback errors (by type of transmission),
- Number of altitude busts and other pilot deviations,
- Number of aircraft issued the wrong frequency on transfer of communication.

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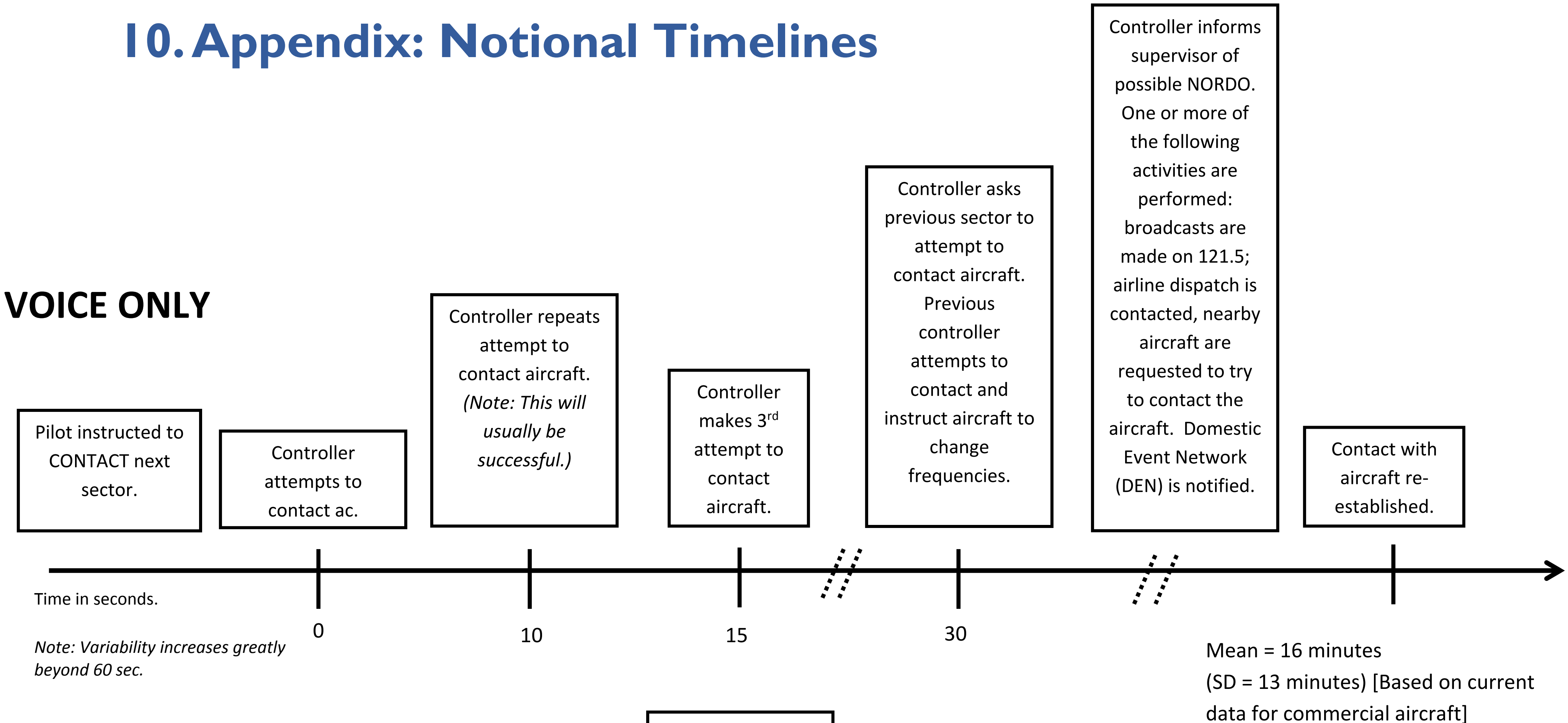
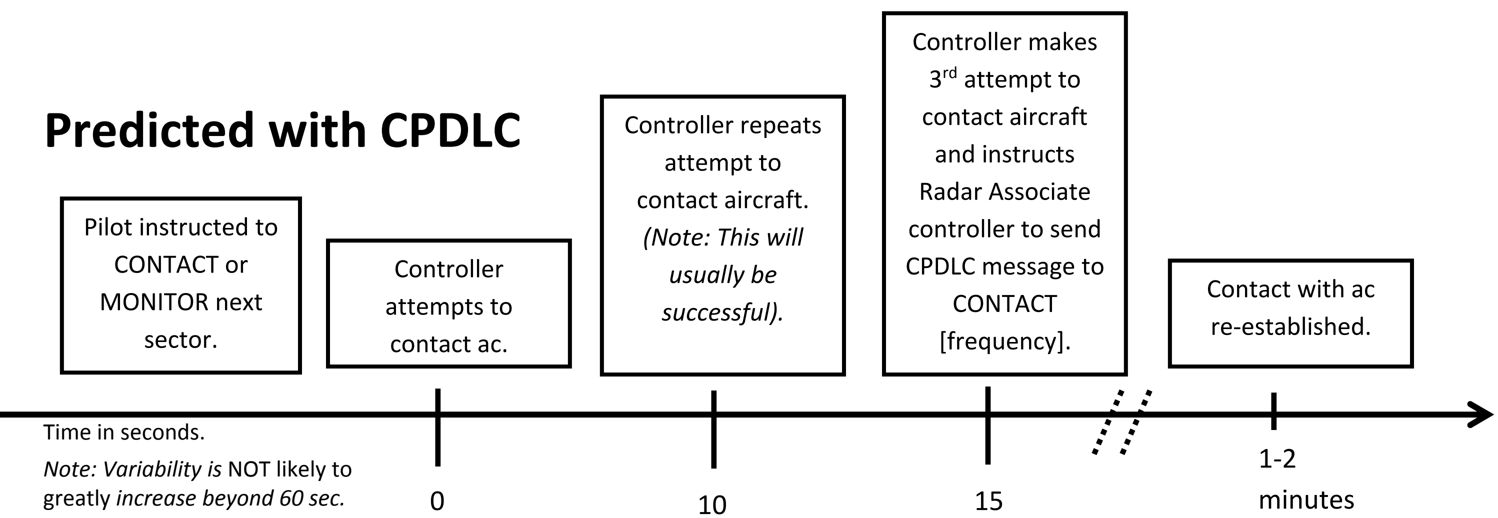
10. Appendix: Notional Timelines





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