# Analysis of Controller-Pilot Voice Communications from Kansas City Air Route Traffic Control Center

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# Notice

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13. ABSTRACT (Maximum 200 words)

The implementation of Controller Pilot Datalink Communications (CPDLC) in domestic en route airspace is a key enabling technology in the Next Generation Air Transportation System. The Federal Aviation Administration plans to implement en route CPDLC in 2019 in Kansas City Air Route Traffic Control Center (ZKC). Here, we examined routine controller-pilot communication in ZKC airspace to provide insights into anticipated benefits of CPDLC implementation and to inform a baseline of communication measures to be used for a post-implementation comparison. While the realized benefits will depend on the level of equipage and actual implementation, these findings highlight some of the anticipated benefits of CPDLC implementation. The analysis showed that frequency changes due to transfer of communications were the largest category of pilot and controller transmissions and the majority of readback errors. The second most common controller instruction was an altitude change. Both of these can be conveyed via CPDLC in the initial en route implementation. Using CPDLC for the most common transmissions will reduce frequency congestion, allowing more time for users to access the frequency and reducing the probability of step-ons and blocked transmissions.

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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)

# Contents



**Table of Figures**



**Table of Tables**

# Acronyms and Abbreviations

| | |
|---|---|
| ATC | Air Traffic Control |
| ATSAP | Air Traffic Safety Action Program |
| CPDLC | Controller Pilot Datalink Communications |
| Data Comm | Data Communications |
| EOR | Electronic Occurrence Reports |
| FAA | Federal Aviation Administration |
| GA | General Aviation |
| MOR | Mandatory Occurrence Reports |
| NAS | National Airspace System |
| NextGen | Next Generation Air Transportation System |
| NORDO | No Radio |
| ZKC | Kansas City Air Route Traffic Control Center |
| PD | Pilot Deviation |

# Preface

This report was prepared by the Aviation Human Factors Division of the Safety Management and Human Factors Technical Center at the U.S. Department of Transportation's John A. Volpe National Transportation Systems Center. It was completed with funding from the Federal Aviation Administration Enterprise Services Directorate (AJM-3), Data Communications Program (AJM-34). We thank Jesse Wijntjes, John Glassley, and Eric Wiggam for their support and Jay Gaumer and Eric Falke (Kansas City Air Route Traffic Control Center) for their time, expertise, and technical assistance.

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

# Executive Summary

The implementation of Controller Pilot Datalink Communications (CPDLC) in domestic en route airspace is a key enabling technology for many capacity and safety enhancements identified in the Next Generation (NextGen) Air Transportation System (NextGen Implementation Plan, 2015). The Federal Aviation Administration (FAA) plans to implement en route CPDLC beginning in 2019 in Kansas City Air Route Traffic Control Center (ZKC).

Past research examined loss of communication events in en route airspace, in general, as well as events specific to ZKC airspace. The present study examined routine communication in ZKC airspace to help project anticipated benefits and to inform a baseline of controller-pilot communication measures to which post-implementation performance can be compared. These data can be used to inform a projection of benefits with assumed equipage levels. By comparing these baseline data to post-implementation data, we can quantify the actual benefits as well as identify collateral benefits and any unanticipated consequences.

Frequency changes due to transfer of communications as pilots transitioned from one sector to another made up the largest category of both pilot and controller transmissions and the majority of readback errors. The second most common controller instruction or clearance was an altitude change. Transfer of communications and altitude clearances accounted for 46% of the controller transmissions; these can be conveyed via CPDLC in the initial implementation. While the realized benefits will depend on the level of equipage and actual implementation, these findings point directly to some of the anticipated benefits of the implementation of CPLDC. Using CPDLC for the most common transmissions will reduce frequency congestion. Reduced frequency congestion allows more time for pilots and controllers to access the frequency and reduces the probability of step-ons and blocked transmissions. In this study, almost two percent of the transmissions were stepped-on or blocked (1.6% were categorized as step-ons, 0.3% were categorized as blocked).

This study also quantified the frequency occupancy time, that is, how often the frequency was in use by either the pilot or the controller. The frequency occupancy time varied from sample to sample of voice transmissions, ranging from 21% to 64%, and averaged 35% of the time. As expected, the busiest times were associated with high-density or complex traffic, weather deviations, and turbulence.

To assess the actual impacts of en route CPDLC on communication performance, a similar analysis could be repeated about one year after the implementation of initial services. These data on normal communication performance, coupled with an analysis of adverse events (i.e., Mandatory Occurrence Reports on “lost comm” events and Pilot Deviations) and reports submitted to Aviation Safety Reporting System and the Air Traffic Safety Action Program will present a comprehensive assessment of the impact of CPDLC on communication performance that includes anticipated benefits, collateral benefits, and unanticipated consequences, if any.

# Introduction

The implementation of Controller Pilot Datalink Communications (CPDLC) in domestic en route airspace is a key enabling technology for many capacity and safety enhancements identified in the Next Generation (NextGen) Air Transportation System (NextGen Implementation Plan, 2015). The Federal Aviation Administration (FAA) plans to implement en route CPDLC beginning in 2019 in Kansas City Air Route Traffic Control Center (ZKC). (See https://www.faa.gov/nextgen/programs/datacomm/ for a description of planned services).

There are several projected benefits associated with the use of CPDLC in the en route environment that are expected to enhance safety and reduce pilot and controller workload. Factors such as controller or pilot speech-rate and/or accent that can contribute to miscommunications (i.e., communication errors and requests for repeats) in the voice environment cannot impair CPDLC communications. Information communicated via CPDLC is also immune to readback and hearback errors. (This does not mean to imply that CPDLC communications are expected to be error free. For example, the controller can accidentally send an unintended clearance and a pilot can misread a clearance). The anticipated benefits of reduced frequency occupancy time, will not only impact frequency congestion, but also the probability of a stepped-on or blocked communication. Since CPDLC messages can be stored and reviewed on the flight deck, there is a reduced reliance on memory for clearance information. In some implementations, the pilot may be able to load the clearance information on the flight deck with the press of a button or two, reducing the need to manually enter that information on the flight deck.

A key component of the anticipated benefits of en route CPDLC is reduction in the voice communications required for the transfer of communication from sector to sector. Typically, controllers issue a new voice frequency to a pilot prior to handing control off to another controller in a new sector (e.g., “Aircraft 123, contact Kansas City Center on 125.46”). The pilot reads this information back to the controller (i.e., “twenty-five forty-six, Aircraft 123) and then checks-in with the new controller and provides their altitude information (i.e., “Kansas City Center, Aircraft 123, flight level 240”). In turn, controllers acknowledge this check-in (i.e., “Aircraft 123, Kansas City Center, roger”). With CPDLC, controllers can send aircraft an instruction to “contact” or “monitor” the new frequency.

Some of the projected benefits associated with the use of CPDLC in the en route environment—reduced workload and reduced voice channel occupancy time—are partially dependent on the transfer of communication using an instruction to monitor, rather than contact, the new frequency when transferring between sectors within a Center. In this scenario, the pilot would acknowledge this instruction (via CPDLC) and transition into the next sector without a verbal check-in. The capability to use CPDLC to send an instruction to the pilot to contact the controller on a specific frequency should help to decrease the number and duration of losses of communication incidents for equipped aircraft. The purpose of this analysis is to inform a baseline of controller-pilot communication measures to which post-implementation performance can be compared, both to quantify the benefits and to look for unanticipated consequences. The data could also be used to inform a projection of benefits with assumed equipage levels.

# Analysis of Loss of Communication Events

## Domestic En Route Airspace

Past research examined loss of communication events in en route airspace, in general, as well as events specific to ZKC airspace. Cardosi and Lennertz (2017) examined loss of communication events in domestic en route airspace obtained from Mandatory Occurrence Reports (MORs) and a search of the Aviation Safety Reporting System (ASRS). One thousand, three hundred and fifteen relevant MORs were analyzed; the mean loss of communication duration within a sector for General Aviation (GA) aircraft was 25 minutes; for commercial aircraft the mean duration was 16 minutes. These reports most commonly referred to the time that an individual controller was unable to communicate with an aircraft, and not the total time that the aircraft was out of communication with Air Traffic Control (ATC). In fact, 20% of the reports stated that the aircraft transferred into the center's airspace as NORDO (i.e., No Radio).

One remedy to loss of communication with air carrier aircraft that is available to controllers is to call the company and have them contact the aircraft and relay the correct frequency to the pilot. With CPDLC, the controller will be able to send an instruction to the aircraft to contact ATC on the correct frequency. This capability 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.

While MORs are useful for helping to quantify how often loss of communication events occur and the duration of these losses, they contain little information as to why communication was lost. While reports submitted to ASRS and Air Traffic Safety Action Program (ATSAP) cannot be used to determine the incidence of such problems, they are a rich source of insight into the underlying causes of adverse events. The Cardosi and Lennertz (2017) study analyzed 136 ASRS reports describing "lost comm" events involving Part 121 (scheduled US air carrier) operations. The majority of reports described instances of pilots being on the wrong frequency. Some causes of pilots being on the wrong frequency were: the controller assigning the wrong frequency, the controller failing to issue a frequency change, or the pilot accepting a frequency intended for another aircraft. The use of CPDLC eliminates the chance of the equipped 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, still exists. Other causes of pilots being on the wrong frequency were: the pilot not hearing the frequency change, mishearing or misdialing the frequency. The use of CPDLC would be expected to reduce these types of errors since pilots should be less likely to miss a frequency change transmitted via CPDLC than via voice. Also, while pilots could misread a frequency, they will be able to refer to the written message on the flight deck to correct it, when needed. This would be expected to take less time than contacting the previous controller to ask for the correct frequency. Additionally, some avionics will arm the frequency conveyed via CPDLC, precluding misdialing (but not a failure to select the correct frequency).

### Kansas City Air Route Traffic Control Center (ZKC)

A previous analysis explored the role of loss of communication in reportable events specifically in ZKC airspace (Cardosi, Lennertz, & Yost, 2017). In that study, two years of MORs, Electronic Occurrence Reports (EORs), and Pilot Deviations (PDs) were examined. Of the 1,761 MOR reports in this analysis, 670 (38%) involved some form of pilot and/or controller error. Of these, nearly 70% were related to loss of communication.

Similar to the findings of Cardosi and Lennertz (2017), losses of communication were longer for GA compared to commercial aircraft (with a mean duration of 28 and 21 minutes, respectively). The most common cause cited for the loss of communication was mechanical issues (24%), followed by the failure of the controller to issue the frequency change (22%) or issuing the wrong frequency (14%). Thirteen percent of the events were attributed to pilot error (e.g., dialing the wrong frequency, misunderstanding the frequency, or forgetting to change frequency). While it is not possible to determine whether these identified causal factors are representative of all lost communication MORs, it is clear that many of the identified factors could be mitigated by the use of CPDLC. In the same study, 43 PDs in Kansas City Air Route Traffic Control Center (ZKC) were also examined: 49% of these reports included a loss of communication event and an additional 40% involved an altitude deviation. Similar to the MOR data, most of these events concerned GA aircraft. For 84% of all PDs, CPDLC was identified as a potential mitigation.

The studies discussed so far examined reportable events associated with miscommunications. The present study analyzed routine communications in ten hours of voice transmissions from ZKC. The results of this analysis will contribute to a baseline of communication performance prior to the implementation of CPDLC. After the implementation of en route CPDLC, a subsequent analysis can be carried out to examine how communication performance has changed, and assess the benefits of CPDLC.

# Method

## Description of Airspace

The ten hours of voice transmissions between pilots and controllers were collected in one-hour increments from June 2016. The transmissions were from both high- and low-altitude sectors and included a representative mix of high- and low-density traffic.

## Coding of Voice Transmissions

All transmissions were coded with a timestamp, speaker (pilot or controller), and aircraft identification. Controller transmissions were coded for purpose: a contact attempt only (e.g., “Airline 123, Center”), a response to a check-in, a response to a pilot request, a clearance, or instruction. Clearances and instructions were coded for whether they included: an altimeter, frequency change, re-route, heading, speed, or altitude (single vs. block, as well as “at pilots discretion”, “immediately” or “expedite”). Any instance in which a controller attempted more than once to contact an aircraft (with or without clearance information) was also coded.

Pilot transmissions were coded for whether it was: an initial check-in, an altitude request, or a request for a repeat of the controller’s transmission. Each pilot acknowledgement of a clearance or instruction was coded for whether it was a full readback, partial readback, or acknowledgement only and for whether it included a full call sign, a partial call sign, or no call sign. Any instance of a blocked or partially-blocked (‘stepped-on’) transmission was coded, as were readback errors. In cases of readback errors, a hearback error was coded if the controller failed to correct the readback error.

Courtesy communications between pilots and controllers, such “thank you”, “good day”, or “see ya”, were not coded as such to be counted, but were included in the analysis of frequency occupancy time (described below).

## Frequency Occupancy Time

An analysis was conducted to code the total frequency occupancy time, that is, the proportion of time that the frequency was in use, by either the pilot or controller. Each hour-long file was filtered using “Goldwave” to remove all periods of silence longer than .01 seconds. This resulted in a file of continuous voice transmissions from which the frequency occupancy time was calculated by dividing the duration of the filtered file by the 60 minute total file duration.

# Results

## Characterization of Routine Voice Communications

There were 3,816 total transmissions in the ten hours of voice communications; 52% of these were pilot transmissions, and 48% were controller transmissions. Controllers issued a total of 1,169 clearances and instructions (note, that a single transmission could include more than one clearance or instruction, e.g., an altitude and a frequency change). As shown in Figure 1, the most common controller instruction was a frequency change. In fact, issuing frequency changes comprised 50% of all controller clearances/instructions and 32% of all controller transmissions. An additional 29% of controller transmissions were responses to pilot check-ins. The entirety of transfers of communication (frequency changes and responses to check-ins) comprised 61% of all controller transmissions.

The second most common clearance or instruction in a controller transmission was an altitude clearance. Of these, six percent were “at pilot’s discretion” clearances, another six percent were accompanied by the instruction to “expedite” the climb or descent and less than one percent were accompanied by the instruction to climb or descend “immediately”.

Only about ten percent of controller transmissions were responses to pilot requests or inquiries. It is interesting to note that 5.5% of the controller transmissions conveying clearances or instructions needed to be repeated due to a lack of a pilot's immediate response; in 72% of these cases, it was the attempt to transmit a frequency change that required the controller to repeat the attempt to contact the pilot.

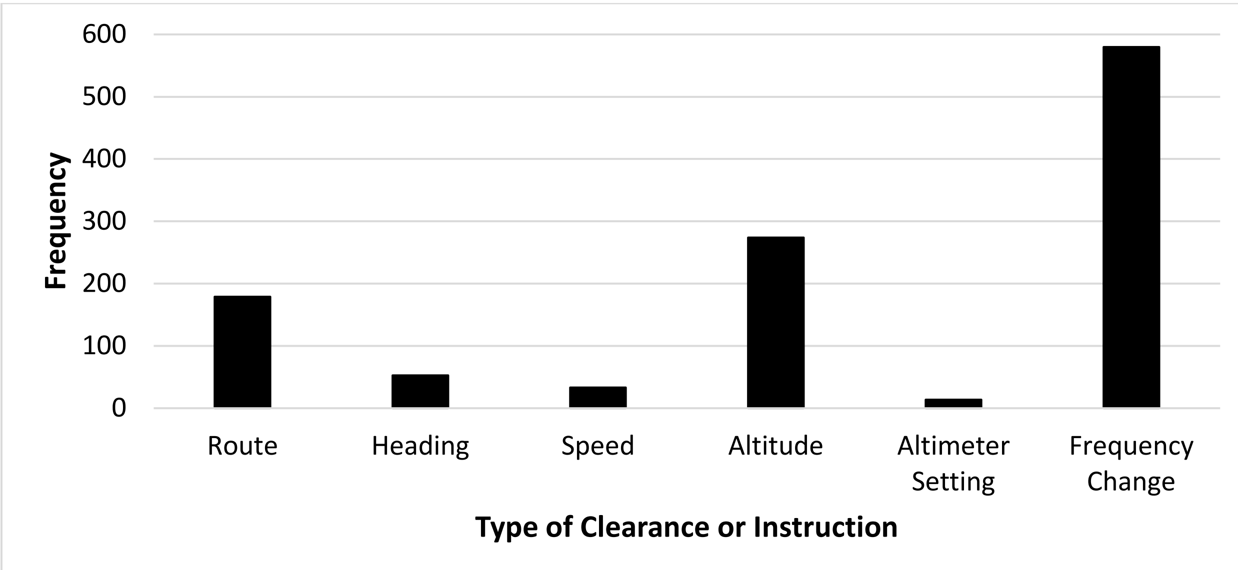


**Figure 1.** Frequency of clearances by type of information.

As with controller transmissions, a substantial portion (28%) of pilot transmissions were initial check-ins. Most of time (93%), pilots provided their altitude information when checking in. Fewer than three percent of the check-ins included a request with their check-in (e.g., for an altitude, for ride information, for a heading or route). An additional 9% of pilot transmissions were a request not occurring with a check-in. As can be seen in Figure 2, the most common requests were for a change in altitude (28%), followed by ride or weather information (25%), and route requests (22%).

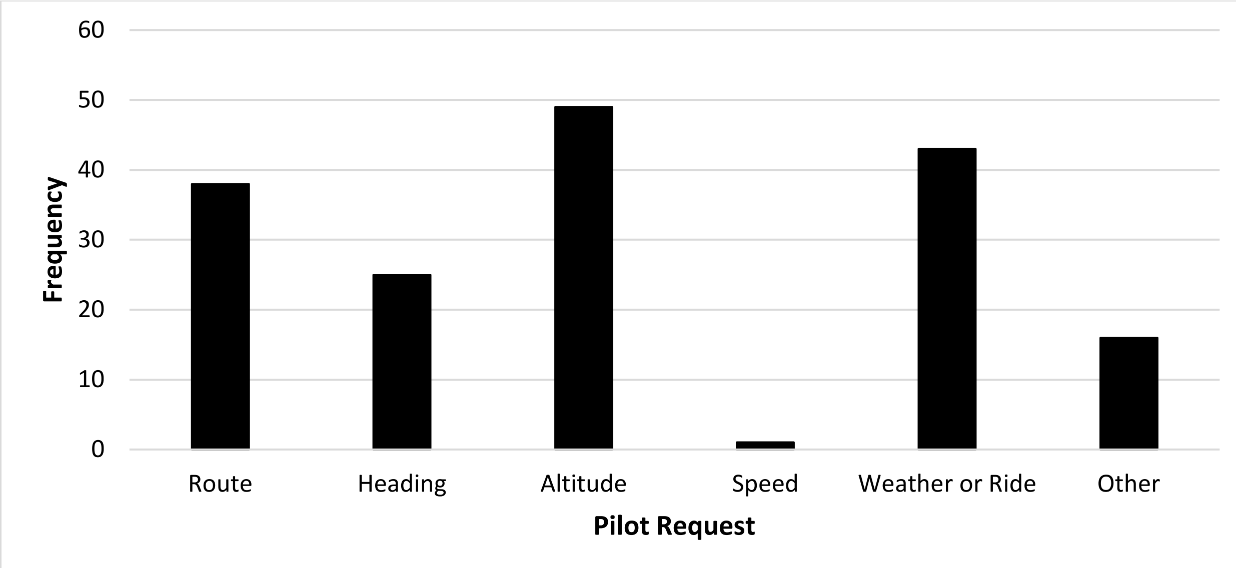


**Figure 2.** Frequency of pilot requests by type.

About 50% of pilot transmissions were acknowledgments of controller transmissions. As shown in Figure 3, most (74%) of the time, pilots provided a full readback of the controller's clearance or instruction with their full call sign. This is strikingly similar to the 71% of ATC clearances responded to with a full readback found in a previous study of en route communications (Cardosi, 1993).

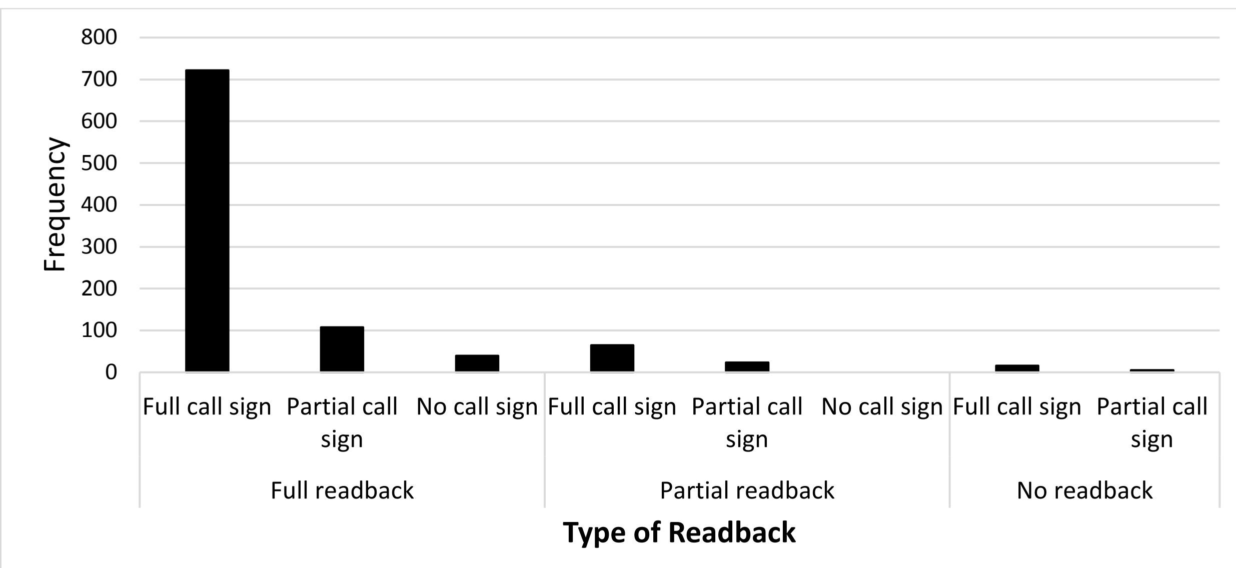


**Figure 3.** Frequency of readback type by call sign usage.

## Communication Errors and Requests for Repeats

The miscommunication rate, as defined by communication errors and requests for repeats was also examined and compared with previous results. In this study, there were nine readback errors (in which the pilot read back a critical part of the clearance or instruction that was different than what the controller said). All but one of these readback errors involved pilots reading back an incorrect radio frequency; the other involved an altitude clearance. Of these nine errors, only two (22%) were not corrected by the controller (i.e., a hearback error). This readback error rate of less than one percent (.77%) of controller instructions and clearances is practically identical to that of the previous study of en route communication (.76% in Cardosi, 1993). The hearback error rate of 22% is also very similar (11%), given the small numbers of errors. These remarkably low readback and hearback error rates are a tribute to pilot and controller professionalism. There were 28 pilot requests for the controller to repeat information; this represents 2.4% of all controller instructions and clearances (slightly higher than the 1.4% found in Cardosi, 1993).

## Stepped-On and Blocked Transmissions

Almost two percent of the transmissions were stepped-on or blocked (1.6% were categorized as step-ons, 0.3% were categorized as blocked). A transmission was identified as either partially or completely blocked by a simultaneous transmission if it was heard on the tape, pointed out by the controller as such, or was indicated by an audible screech.

## Frequency Occupancy Time

Frequency occupancy time that is, how often the frequency was in use by either the pilot or the controller, was calculated. As shown in Table 1, the frequency occupancy time varied from sample to sample of voice transmissions; this is as expected since a range representative traffic loads was requested. Occupancy time ranged from 21% to 64% and averaged 35% of the time.

As expected, the busiest times were associated with high-density or complex traffic, weather deviations, and turbulence. Operationally, this means that the frequency is the least accessible at the same times that pilots are most likely to need to make requests (e.g., to request re-routes around weather or a less turbulent altitude).

**Table 1.** Frequency occupancy time by one-hour samples.

| Sample | Frequency Occupancy | Percent Frequency Occupancy |
|---|---|---|
| 1 | 0:18:26 | 31% |
| 2 | 0:15:59 | 27% |
| 3 | 0:23:27 | 39% |
| 4 | 0:23:13 | 39% |
| 5 | 0:16:43 | 28% |

| Sample | Frequency Occupancy | Percent Frequency Occupancy |
|---|---|---|
| 6 | 0:38:08 | 64% |
| 7 | 0:27:18 | 46% |
| 8 | 0:22:44 | 38% |
| 9 | 0:12:56 | 22% |
| 10 | 0:12:32 | 21% |

Another interesting aspect of frequency occupancy examined was the total time required for frequency changes. Under normal circumstances, no pilot would intentionally key the microphone to speak to a controller or check-in knowing that the controller was waiting for another aircraft to respond. Nor would a controller usually initiate a transmission to another aircraft before giving the first aircraft a chance to respond. This means that the time between the end of the controller's transmission and the beginning of the pilot's response is time in which the frequency, while not occupied *per se*, is not optimally available. As measured from the beginning of the controller's transmission to the beginning of the pilot's response to the controller's transmission (across all ten hours of transmissions), this measure of frequency change occupancy time totaled one hour and ten minutes. This was not intended to assess the time required by the pilot or controller to perform these tasks, but rather an additional indicator of frequency availability.

The maximum time it took for a pilot to reply to frequency change was 8 minutes and 20 seconds, and the minimum amount of time was two seconds. The average was eight seconds. In 46 instances (8% of all the frequency changes), the pilot did not immediately respond to the controller, requiring the controller to try again. In seven instances, the pilot had not responded by the end of the one-hour sample (i.e., a potential NORDO situation).

In the receiving sector, the average time from the beginning of the pilot's check in to the beginning of the controller's response was seven seconds. In 38 instances (6.8%), the controller did not immediately acknowledge the pilot's check-in and the pilot tried again. In seven instances, the controller did not acknowledge the check-in before the audio file ended. Across all ten hours of transmissions, check-ins comprised about 51 minutes of the total frequency time. Adding these 51 minutes to the hour and 10 minutes measured for the transfer estimates, the total elapsed time associated with a frequency change and a pilot check-in is about two hours, or 20% of the ten hours of analysis. Note that while this operational estimate of the time that the frequency was unavailable due to check-ins includes the lag time between initial message and the response, it does not include the duration of the pilot's response to the instruction to change frequencies or the duration of the controller's acknowledgement to the pilot's check-in.

# Discussion and Next Steps

This study of routine pilot-controller voice communications was conducted to baseline key aspects of controller-pilot voice communications in order to help project expected benefits of CPDLC and support a pre- and post- implementation comparison. The results of this analysis of routine communications from ZKC were consistent with previous results of en route controller-pilot voice communications in terms pilot readback behavior, pilot's use of call sign in readbacks, readback error rates, and hearback error rates. In this, as in previous studies of controller and pilot voice communications, frequency changes made up the largest category of transmissions and the majority of readback errors. This points directly to the benefits of using CPDLC for frequency changes. When a frequency is nearly saturated, it can result in controllers increasing their speech rate. While intending to get more information out quickly, it also reduces the signal-to-noise ratio of the controllers' speech, increasing the chances of communication errors. Busy frequencies also signal a reduced opportunity for, or discouragement of, pilot readbacks (which is a vital part of the communication safety net). Reduced frequency congestion not only allows more time for pilots and controllers to access the frequency, but also is associated with a reduced probability of step-ons and blocked transmissions.

Transfer of communications and altitude clearances accounted for 46% of the controller transmissions and these can be conveyed via CPDLC in the initial implementation. The benefits realized will depend on the level of equipage and actual implementation. Concerns have been raised regarding one of the cornerstones of the benefits of en route CPDLC. The capability to send a "monitor" message to the flight deck when transitioning between sectors within a Center alleviates the need for the flightcrews to check in via voice; with CPDLC, the pilot can acknowledge the "monitor" instruction and silently transfer into the new sector. Some fear that this may result in a higher incidence of "lost comm" incidents, despite the capability for the controller to send a "contact [frequency]" instruction. It is also the case that, depending on the implementation (e.g., whether or not the pilot is required to confirm their assigned altitude after acknowledging the instruction to monitor the frequency), the CPDLC check-in may increase pilot workload over the voice check-in. If so, pilots would be less likely to use CPDLC for this function. It is worth noting that this "silent check-in" procedure without an altitude confirmation has been in use successfully in portions of New Zealand, Australian, and Canadian airspace for many years.

To assess the actual impacts of en route CPDLC on communication performance, it is intended that a similar analysis will be repeated, about one-year after the implementation of initial services (e.g., around 2020). These data on normal communication performance, coupled with an analysis of adverse events (i.e., MORs on "lost comm" events and PDs) and reports submitted to ASRS and ATSAP will present a comprehensive quantitative assessment of the impact of CPDLC on communication performance that includes not only the expected benefits, but also collateral benefits and unanticipated consequences, if any.

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