STRAIGHT FROM THE SOURCE: AN ANALYSIS OF THE INBOUND AIRCRAFT NOTIFICATION PROCESS

Graduate Research Paper

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Abstract

This paper evaluates the current Command and Control (C2) information flow processes at the Air Mobility Command (AMC) airbase level. Specifically, the process for relaying inbound C-17 information to support agencies was examined to assess the timing and quality of the information transmitted. The adequacy of the current process is determined by comparing the average lead time of inbound calls to the time required for support agency preparation and response, and to a limited extent, the accuracy of the information as it is relayed. Subsequently, a future state is proposed that, where applicable, replaces VHF/UHF radio transmissions with Beyond-Line-Of-Sight (BLOS) capabilities such as Aircraft Communications, Addressing, and Reporting System (ACARS) similar to the processes used by commercial airline operations centers. The results indicate that, while the radio transmissions are adequate for most responding support agencies, using BLOS communications in the inbound C-17 notification process can eliminate redundant communications and increase notification lead time. The results also revealed that the Subject Matter Experts (SMEs) are interested in the benefits of BLOS capabilities, like ACARS, for several reasons including better scheduling and utilization of manpower and resources.

"Even minutiae should have a place in our collection for things of a seemingly trifling nature when enjoined with others of a more serious cast may lead to valuable conclusion."

~ George Washington

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First and foremost, I must thank my wife for her patience and understanding throughout this research process. She is a constant source of balance and certainly kept our life on track along this journey. I would also like to thank my advisor, Dr. William Cunningham, for his guidance and flexibility, as well as, all of the ASAM professors and students for everything they taught me throughout this program. Finally, I would like to thank all of the interview participants for their time and inputs. It is my sincere hope that this research will benefit you and those you supervise.

David F. Sustello

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STRAIGHT FROM THE SOURCE: AN ANALYSIS OF THE INBOUND AIRCRAFT NOTIFICATION PROCESS

I. Introduction

General Issue

Every minute of an Airman's time is valuable and every minute wasted on an unnecessary task or using an inefficient method is time that could have been spent elsewhere. Effective communication is a constant struggle throughout any process and military processes are no exception. A constant analysis of the methods used and the tools available for communication is necessary to maximize use of manpower and minimize wasted time. This study looks a very specific process within the United States Air Force, the information flow of support requests from inbound C-17A Globemaster III aircraft, as an example of how a process can be mapped and evaluated to identify areas of wasted time so that a future state utilizing all available communication methods can be visualized and implemented.

Background

Inbound C-17 aircraft transmit information to their destinations including support requirements via Very/Ultra High Frequency (VHF/UHF) radio calls thirty minutes prior to landing or within radio frequency range of the landing base, whichever occurs later. This is a requirement based on two sequential paragraphs in AFI 11-2C-17V3 and has had no recent evaluation for relevancy. The information transmitted is important to preparation of arrival support actions to include appropriate parking assignment and the positioning of personnel and equipment. Technology, such as Aircraft Communications, Addressing, and Reporting System

(ACARS) messaging, is available within the aircraft and command posts to improve the fidelity and timeliness of these relays but is not being used. Ensuring sufficient notification time and accuracy is critical to the efficient use of airbase resources. Air Mobility Command (AMC) plans to upgrade select AMC airframes to perform automatic relay of maintenance information, similar to the commercial industry, as part of an initiative called Conditions-Based Maintenance (CBM+) (Department of Defense, 2018) and to implement a secure messaging system, similar in function to ACARS, called Command and Control Messaging (C2M). However, implementation of these upgrades in the C-17 is still years away. This study is intended to assist in bridging the gap with available technologies until the transition to upgrades like CBM+ and C2M are complete.

Problem Statement

The current process for inbound aircraft notifications has not been evaluated to ensure effective and efficient preparation of support agencies to receive inbound C-17 aircraft. The purpose of this study is to evaluate current inbound C-17 notification processes with the intent of identifying inefficiencies and the possible benefits of applying available beyond-line-of-sight (BLOS) communications technology.

Lead Time Definition

Before proceeding, for the purposes of this research paper, a few terms must be defined. Lead time, in this paper, is defined as the time period from the C-17 arrival radio call to that aircraft's block-in time at the assigned parking spot. Inadequate lead time occurs when support agencies cannot respond to parking spot before aircraft arrival. Inspiration for this term came from Stevenson's *Operations Management*. Stevenson defined lead time as the "time interval between ordering and receiving the order"(Stevenson, 2006).

Research Questions

RESEARCH QUESTION 1: Are inbound C-17 arrival notifications made with sufficient lead time and accuracy to support agency preparation and response actions?

INVESTIGATIVE QUESTION 1a: What are the lead times for arrival notifications at the sample bases and how do they compare to the 30-minute standard?

INVESTIGATIVE QUESTION 1b: How much time do support agencies require to respond to C-17 arrivals?

INVESTIGATIVE QUESTION 1c: Is the information passed sufficient for support agency preparation to service the inbound C-17?

RESEARCH QUESTION 2: Can alternate communication methods reduce process inefficiencies or increase the quality of information passed during this process?

RESEARCH QUESTION 3: Are support agencies interested in using BLOS data communications for C-17 arrival notifications and why?

Methodology

This research used a mixed methods approach. Semi-structured interviews were used to collect the majority of the quantitative and qualitative data. Basic elements of value stream mapping were used to map air base support agency processes and propose changes. Statistics and distribution modeling were used to describe the quantitative data.

Assumptions

Assumption # 1.

Processes are assumed to be conducted as described by base operating instructions and subject matter experts (SMEs).

Assumption # 2.

Each agency in the process is handling one aircraft at a time.

Assumption # 3.

It is in the best interest of operations effectiveness to have support agency personnel and equipment ready to support upon aircraft block-in as opposed to accepting service accomplishment at a later time.

Limitations

Some data, such as lead time, are not currently recorded and/or archived so collecting more over longer than a six-month time period before completion of the research was not possible. Additionally, the researcher will not have the time or funding to personally visit JB LM. Phone interviews and assistants at those bases will be required. If a large enough sample of any process time cannot be collected, average times based on SME inputs were utilized.

Scope

The scope of this research is limited to C-17 arrivals at two AMC airbases, Joint Base McGuire-Dix-Lakehurst (JB MDL) and Joint Base Lewis-McChord (JB LM). JB MDL was chosen because it is a single-squadron base surrounded by relatively flat terrain. JB LM was chosen because it is a multiple-squadron base in mountainous terrain. The qualities of these two bases sufficiently represent the rest of AMC's C-17 bases for the purpose of this research. Response time data, if available, was collected for up to three months from each of the interviewed support agencies. Lead time data was collected over a three-month period and included all missions: real-world, local training and off-station training. The C-5 and C-130 airframes assigned to these bases are not included because they are scheduled for maintenance reporting upgrades in conjunction with AMC/A4's CBM+ initiative. The KC-10 is not included because it is scheduled for decommission by 2025.

II. Literature Review

History of Arrival Messages

Although military aircraft have been making radio calls to destination ground stations since WW2, the exact origin of the 30-minute-out call, as described in current Air Force Instructions (AFI), is not clear. Experts at AMC say the guidance dates back as far as the days of Military Airlift Command 55-series regulations but those archives could not be found (B.M. Mullen, email communication, August 21, 2018). Regardless, it is apparent that line-of-sight radio voice communication was the most economical method for transmitting arrival information when approaching the terminal area of the destination airport.

Per AFI 11-2C-17 Volume 3, all C-17A aircraft are required to transmit an arrival advisory via VHF or UHF radio thirty minutes prior to arrival to the destination Command and Control (C2) agency with the estimated block-in time. This radio transmission traditionally also includes maintenance status, passenger and cargo information, and requests for fuel, parking spot assignment, fleet service, and aircrew transportation. Certain requests such as Customs and Agriculture inspection are transmitted two or three hours prior to landing via voice relay through the 618th Air Operations Center (618 AOC) or satellite link to the destination if directed by flight publications. AFI 11-2C-17V3 also directs that “aircraft system malfunctions that traditionally require extensive trouble shooting” be reported directly or relayed to the destination C2 immediately. Malfunctions that require extensive troubleshooting are not specifically defined for the reporting aircrews and so the malfunction is often not reported until the thirty-minute arrival advisory.

Air Mobility Command Instruction (AMCI) 10-202 Volume 6 states that ACARS will be used "as the primary means of communication for official messages when the aircraft is not within UHF/VHF range". This guidance implies that, within UHF/VHF range, those radios will be primary. The Command Post (CP) Operating Instructions (OI) at both JB MDL and JB LM do not reference the use of ACARS and so no additional definition or guidance is provided for what constitutes an official message. No reason is stated for why UHF/VHF radios should be the primary communication method for any given information relay except for historical precedence.

Joint Publication References

According to Joint Publication (JP) 3-30, *Command and Control of Joint Air Operations*, "Centralized control and decentralized execution requires a robust data communications architecture" and that degraded communications environments should be anticipated. This requires planning to "include considerations for alternate routing, redundant systems, and use of other systems, protocols, and message standards." (JP 3-30, 2014). Additionally, JP 3-30 states that "air mobility missions are integral to the success of joint operations." Mobility Air Force (MAF) aircrews should be adept at using all available communications methods to maximize the utility and efficient of limited air mobility resources.

From a joint communications doctrine perspective, JP 6-0 states that "access to accurate, reliable, and timely information reduces uncertainty and the risk of making poor decisions." Poor decision can have immediate catastrophic consequences but they can also have small, almost imperceptible consequences that aggregate into significant consequences over time in the form of wasted resources, eroded capability and workforce dissatisfaction. JP 6-0 also states that there are two elements to the C2 system. The first is people and the second is the equipment and procedures they use. Ultimately, however, C2 effectiveness "depends on the right person having the right information at the right time to support decision making." (JP 6-0, 2015)

ACARS/AOC

Since 1978, ACARS has been an ever-growing means of BLOS communication between airborne aircraft and ground stations by transmitting information via VHF and HF radio frequencies and satellite links (HQ AMC/A6OC, 2012). Enhancements to the ACARS protocols have allowed these transmissions to be routed through the Internet to various end users. Hundreds of airlines around the world use ACARS for numerous datalink communications across all phases of flight including arrival notifications (also known as gate requests.) These communications ensure airlines have situational awareness concerning numerous aspects of the flight and aircraft including position and weather reports, maintenance status, passenger and cargo information, as well as, departure and arrival information. Currently, C-17s assigned to AMC utilize the ACARS to communicate with various entities within the 618 AOC and Command Posts (CPs) via GDSS2. Within the 618 AOC, the majority of ACARS messages are relayed through the Flight Managers (FM) assigned to a specific mission. FMs and aircrews exchange flight plan information, expected fuel and cargo loads, weather and other pertinent information throughout the flight as necessary. At this time, only the FM assigned to the mission can make themselves the addressee for ACARS message notifications. This means that while other entities in separate locations, such as Command Posts, can search for and retrieve a particular aircraft's ACARS messages, only the addressee will be sent a notification that a new message has been sent and only the addressee, under normal circumstances, can send a message to that aircraft. Multiple addressees can be assigned; however, current 618 AOC policies prevent this due to concerns over clarity of the sender's identity. At this time, only takeoff and landing times are automatically populated into GDSS2 so all other ACARS messages must be relayed from the FM or manually retrieved by searching for a particular aircraft in GDSS2. A graphical depiction of the ACARS network is shown below in Figure 1 (HQ AMC/A6OC, 2012).

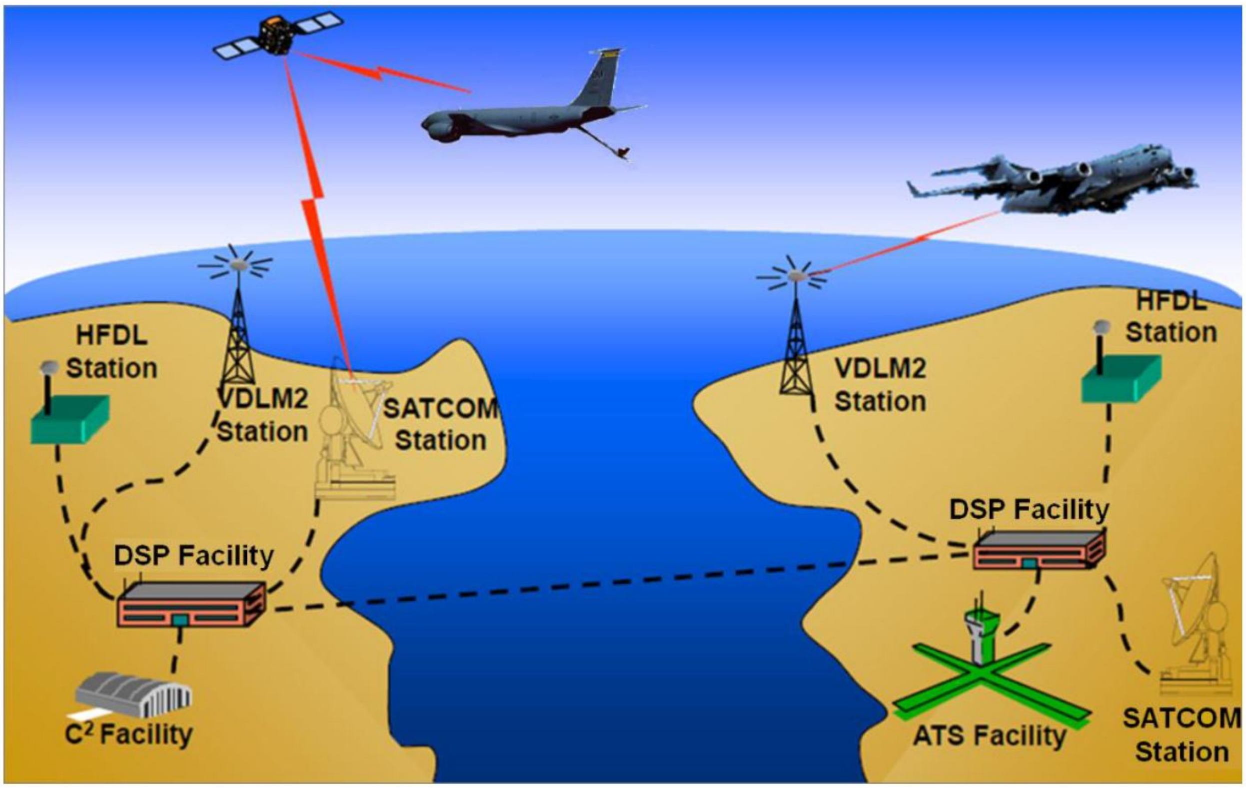


Figure 1: Aircraft Communication, Addressing, and Reporting System (ACARS)

AMC has established a standardized data link message set that is intended to reduce the ambiguity when dealing with multiple aircraft, avionics vendors and ground system developers (HQ AMC/A6OC, 2012). Messages are constructed in a format similar to the ARINC 702A-3 used by commercial transport-category aircraft. Each message within the set contains information to be downlinked via ACARS/AOC to the intended ground unit. The In-Range/Ramp Services Report, shown below in Figure 2, is an example of this a message from within the sets that contains most of the information passed via radio by inbound C-17 arrivals(HQ AMC/A6OC, 2012). This message format is part of the software on C-17s that have been upgrade to Block 21 and above (M. W. N. Mansker, email communication, November 26, 2018). Maintenance status and discrepancies can be typed into the free-text section and there is a separate Cargo Report that details cargo load information. Similar message formats are available in C-17s that have not yet been upgraded and any necessary information not included in the pre-formatted messages can be sent via the free text feature. The security of ACARS messages is an issue for AMC because even though the information transmitted is not classified, there are Operations Security (OPSEC) concerns. While radio transmissions containing the same information are currently used, the range of these transmissions is limited to the reception range of the transmission. Conversely, an ACARS message could be theoretically received anywhere that compatible equipment is linked to the Internet. There are encryption methods similar to commercial internet protocol encryption (https) for ACARS messaging (Roy, 2001). However, the cost to modify existing infrastructure to accommodate this encryption may be prohibitive (M. W. N. Mansker, email communication, November 26, 2018). The future of secure messaging lies in the proposed AMC C2 Messaging program. AMC C2 Messaging is complementary to ACARS messaging but can be used to transmit messages on both the classified Secure Internet Protocol Router Network (SIPRNET) and the Non-classified Internet Protocol Network (NIPRNET)(HQ AMC/A6C, 2018). This communication is made possible through a link between the aircraft and ground-based systems like GDSS2 called the AMC Mobility Enterprise

Information Services (MEIS). When this system becomes fully operational, BLOS messaging, similar to ACARS but secure, will be available to AMC assets.

3.17 In-Range/Ramp Services Report

IMI: INR

Message Description: The aircrew initiates this message typically within 30 minutes of landing, providing customs, security, loading equipment needs, etc.

Field Definitions:

IEI	SEQ ID	Field Name	Length (F/V)	Char (A/N/AN)	Max Char	Scale	Units	Range
ID	1	Aircraft Registration Number (ACARS Address with fleet ID)	F	AN	6			
	2	Call Sign	V	AN	7			
	3	Mission Number	F	AN	12			
DC	1	Avionics-Generated Date	F	N	8		DDMMYYYY	
	2	Avionics-Generated GMT	F	N	6		HHMMSS	
MR	1	Message Identification Number	V	N	3			0 - 999
	2	Message Reference Number	V	N	3			0 - 999
NR	1	Customs Required?	V	A	1			"Y" or null
	2	Paramedical Required?	V	A	1			"Y" or null
	3	Security Required?	V	A	1			"Y" or null
	4	Meet And Assist?	V	A	1			"Y" or null
	5	PAX Stand Required?	V	A	1			"Y" or null
	6	K-Loader Required?	V	A	1			"Y" or null
	7	Forklift Required?	V	A	1			"Y" or null
	8	Crew Bus Required?	V	A	1			"Y" or null
	9	Anticipated Landing Fuel	V	N	4	0.1	Klbs	0 - 9999
	10	Number of Seats Released for Next Leg	V	N	3			0 - 999
ET	1	ETA at Destination Day/Time Group	F	N	6		DDHHMM	
FX	1	Free text	V	AN	256			A…Z, 0…9, ".", " ", "(", ")", "-"
FB	1	Fuel On Board	V	N	4	0.1	Klbs	0 - 9999
VR	1	Message Set Version #	V	N	3	0.1		30 - 999
		CRC	F	AN	4			

Example:
INR/ID80221B,RCH221,AJUM75206223/DC11082010,005302/MR23,/NRY,,,,,,,,0270,33/ET111313/FB889/VR30CRCX

Figure 2: In-Range/Ramp Services Report Message Format

Commercial Air Cargo Use of BLOS Messaging

Commercial air cargo companies have been leveraging the capabilities of ACARS for years. Atlas Air Worldwide (AAWW) holding company is one of the world's largest providers of air cargo services through subsidiaries such as Atlas Air, Inc. and Polar Air Cargo Worldwide. AAWW's service and operations, up to but not including combat zones, closely mirrors AMC's strategic mission set. AAWW has seen their aircraft departures almost triple in the last ten years but have not proportionally increased the manning of their TACC-like Global Control Center (GCC). AAWW's Senior Vice President (SVP) of Operations explained that this reduction in proportional manpower demand was achieved by using automated systems that are fed aircraft information from ACARS (K. Sarubbe, personal communication, February 4, 2019). This automation takes the form of a GDSS2-like computer program called Airline Information Management System (AIMS). ACARS feeds information into AIMS such as departure and arrival times, en route position and ground service times. The SVP of Operations estimates that without the current level of information flow and automation, AAWW would have to hire an additional person per shift to collect and input the same data. It is clear that using ACARS saves both time and money for AAWW.

III. Methodology and Data Collection

Chapter Overview

The methodology of this research was broken up into three main areas that correspond directly to the three research questions. Both quantitative and qualitative data were used to assess the first two research questions pertaining to an evaluation of the current and future state of the process. The third research question used qualitative data only. Mixed methods approaches to research can provide a more complete understanding of a problem or question than either individually (Creswell, 2014). Due to the different types of data used and the combination of tangible and intangible aspects of the problem, a mixed methods approach was deemed appropriate. Interviews were the primary mechanism for collecting qualitative and quantitative process information and SME respondent preferences. In many cases the requested quantitative data was not available.

Interview Methodology

Semi-structured interviews were conducted to collect information for two purposes. The first purpose was to produce a process flow map of the inbound C-17 notification process at both sample bases and to solicit quantitative process time data to determine the current process required lead times, as well as the actual notification lead times. The source of the actual notification lead times was a non-interviewee point of contact at each base CP. The second purpose of the interviews was to collect qualitative information from the SME respondents pertaining to their interest in the benefits of receiving BLOS communications from inbound C-17s either directly or indirectly.

Value Stream Mapping and Critical Path Method Approach

The process mapping portion of the research was conducted using basic concepts of the value stream mapping (VSM) and critical path methods (CPM). In commercial industry, value stream mapping is a tool used to visualize the current state of a process including the aspects that are non-value-added or waste, identifying areas for improvement and formulating a plan to create a more efficient process (King & King, 2015). In this research, "non-value-added" or waste areas are parts of the process that adversely affect the timeliness of effective response by support agencies to the arriving aircraft parking spot. Effective response is defined as the properly prepared manpower and equipment required per the arrival notification message.

The concept of the critical path method is used to determine which processes or steps in a process drive the completion time of a process. Typically, this method is used for "defining, analyzing, integrating, and controlling all phases of a project" and has led to considerable savings in both time and cost (Saindon, 1969). The basic premise is identifying which steps in a process drive the overall completion time. In this research, the critical path method is used to determine which support agency requires the most time from inbound notification to arrival at the aircraft parking spot. This critical required time was then compared to the lead time distribution model to determine the adequacy of the current process and the requirements for a proposed future state of the process.

Lead Time Analysis

Lead time analysis consists of mapping a process, collecting data concerning the duration of an item or information in each step of that process, and determining a representative time (mean or average) or range of times spent in each step (Jonsson & Svensson, 2016). The goal is to determine the appropriate start time based on the total time required to produce an item or pass information within a process. In the commercial sector, reducing lead times is critical to responding effectively to consumer desires for mass custom production (Jonsson & Svensson, 2016). In this case, the focus is on reducing the lead time required to produce items faster and meet or exceed consumer expectations. This reduction in lead time required is achieved by identifying the parts of the process that step duration could be reduced. Conversely, in this research, with respect to lead time, there are three goals. The first goal is to determine the probability of a given lead time based on quantitative data and statistical distribution modeling. The second goal is to determine the required support agency notification times so they can be compared to the lead time distribution. The third goal is to identify where in the process participants can reduce the amount of time they are participating in the process so they can spend that saved time conducting other value added activities or to improve quality of life.

Data Collection

In line with the methodology, data collection for this research consisted of three parts: lead time data collection, process flow data collection, and SME preference for an alternate communication method.

Lead time data collection was accomplished providing an Excel spreadsheet tracker to the supervision of each of the two Command Posts. Command Post Controllers tracked inbound C-17 radio call-in times and their respective block-in times including additional information such as mission type, maintenance status and whether or not the aircraft accomplished ground operations training prior to block-in.

Process flow data collection was initiated through semi-structured interviews and followed up with phone calls and emails. These interviews were conducted in person and over the phone with subject matter experts (SMEs) who were either supervisors themselves or chosen by supervisor to represent their function within the process. The interview (Appendix B) consisted of seven questions that aimed at receiving a description of the process flow and timing, communication methods used, and knowledge and receptivity to using alternate means of communicating, specifically ACARS. The semi-structured format enabled the researcher to follow the respondent's train of thought and to explore peripheral areas of interest (Bolderston, 2012). If respondents were not familiar with a term or communication method, the researcher described it and provided context for its use in their functional area. During the interview, the respondents were asked if they were familiar with ACARS and if that communication method or one like it would improve communication in their respective processes. Other digital communication methods such as online chat rooms were discussed, as well, if they were applicable. The respondent's receptiveness to using a new communication method and their reasoning was recorded. While the examples consistently used ACARS as the alternate communication method, the respondent was not persuaded either for or against its potential use in their daily operations. Following the interview, the researcher transcribed hand-recorded answers and notes to a Microsoft Word file. The text from that file was sent to each respondent via email for validation of the content and intent. The transcriptions were modified if the respondent requested any changes.

The majority of the requested process timing data had not been previously recorded and so the researcher followed up with the respondents after a period of time that allowed for the collection of up to three months of data. An exception to this time frame was JB LM APS Freight Dispatch which required more time to collect sufficient data points. The various agencies at each base were not able to collect data using a single uniform format and some agencies were not able to collect data points at all. If the SME could not provide data points, they provided their expert opinion on the range of times for a process step or the process as a whole. If, in the SME's and researcher's opinion, it was impractical to collect the times due to the very small duration (less than one minute) or if the process is the same every time with no significant range, then a SME estimate was used.

IV. Analysis and Results

Chapter Overview

This chapter reviews the analysis of the gathered data and the results of that analysis in three parts. In the first part of the analysis, the lead time data for each base was examined and matched with a distribution model. Then the information process flow is mapped and representative support agency response times are determined by analyzing the interview responses and, if applicable, comparing them to the SME-provided data. Subsequently, the lead time distribution models are compared to the representative response times to determine the probability of insufficient lead time. The second part of the analysis substitutes a specific BLOS communication method, ACARS, into the information process flow to create a future state for the flow and describes its potential efficiencies. Finally, the third part of the analysis discusses the interest the interviewed base support agency SMEs have in using BLOS data communication methods like ACARS.

Lead Time

Samples of lead time data were gathered from representatives at each CP using an Excel spreadsheet tracker to capture inbound C-17 information (see Appendix C). The collected data included: Date, Mission Type (training mission or real-world AMC tasked mission), C-17 radio call time, block-in time, maintenance status, and whether or not aircrew ground operations training was accomplished after landing. Lead time, in minutes, was calculated for each inbound aircraft by subtracting radio call time from the block-in times. Inbound C-17s that performed ground operations training prior to block-in were excluded because these aircraft did not taxi directly to parking and therefore would skew the data to a longer lead time than is truly representative from the sample. Additionally, at JB MDL, there were instances of C-17s not making an inbound at all. These instances constituted 4.3% of the sample and were not included in the distribution because those data points prevented fitting a distribution model to the rest of the data. However, since they may still represent potential insufficient lead times, an adjustment was made to the probability of insufficient lead time described in this section.

Lead time data was analyzed with the intent of answering Investigative Question 1a: What are the lead times for arrival notifications at the sample bases and how do they compare to the 30-minute standard? In Excel, descriptive statistics were used to provide a basic understanding of the data distribution. These are contained in Table 1 below.

Table 1: Descriptive Statistics (in minutes) for Lead Time Sample for JB MDL and JB LM

JB MDL Descriptive Statistics		JB LM Descriptive Statistics	
Mean	32.2699	**Mean**	21.1203
Standard Error	0.483868	**Standard Error**	0.603215
Median	32	**Median**	21
Mode	30	**Mode**	18
Standard Deviation	8.225753	**Standard Deviation**	6.956616
Sample Variance	67.66301	**Sample Variance**	48.39451
Kurtosis	0.302597	**Kurtosis**	0.153387
Skewness	0.22345	**Skewness**	0.222939
Range	50	**Range**	38
Minimum	10	**Minimum**	3
Maximum	60	**Maximum**	41
Sum	9326	**Sum**	2809
Count	289	**Count**	133
Confidence Interval (α=0.05)	0.952366	**Confidence Interval (α=0.05)**	1.193219

To determine if the mean lead times are statistically different from the AFI 11-2C-17V3 standard of 30 minutes, a hypothesis test was conducted. A hypothesis test "uses data from a sample to test the validity of two competing statements about a population that are indicated by H_0 and H_a." (Camm et al., 2018). H_0 is the null hypothesis stating the population mean time for inbound C-17 radio calls is the standard 30 minutes. The competing alternative hypothesis, H_a, is that the population mean is not 30 minutes. Following the test, the null hypothesis is either rejected in favor of the alternate hypothesis or fails to be rejected. The hypotheses for the test are shown below in Equation 1.

$$\begin{aligned} \boldsymbol{H_0}&: \mu = \textbf{30 minutes} \\ \boldsymbol{H_a}&: \mu \neq \textbf{30 minutes} \end{aligned} \tag{1}$$

Equation 1: Null and Alternative Hypotheses

To test these hypotheses, a confidence interval approach was used as shown in Equation 2 below. Using the sample mean ($\bar{x}$), the sample standard deviation (s), the sample size (n), the level of significance (α), and a value from the *t*-distribution table. The level of significance is the probability of rejecting the null hypothesis when it is actually true. The level of significance chosen for this test was 0.05 which corresponds with a level of confidence of 95%.

$$\bar{x} \pm t_{\alpha/2} \frac{s}{\sqrt{n}} \tag{2}$$

Equation 2: Confidence Interval Formula

The results of the confidence interval approach are shown in Table 1 above. For the JB MDL lead time sample, the confidence interval is 32.27 ± .95 minutes. 30 minutes does not fall within that interval so we reject the null hypothesis and accept the alternative hypothesis that the mean is not 30 minutes but, in fact more than 30 minutes. For the JB LM lead time sample, the confidence interval is 21.12 ± 1.19 minutes. 30 minutes also does not fall within that interval so we reject the null hypothesis and accept the alternative hypothesis because the mean is significantly less than 30 minutes.

Distribution Modeling

To describe the shape of the distribution of each lead time sample, distribution models were chosen and tested with the assistance of an Excel add-in called XLSTAT. XLSTAT is a statistical tool that can perform many data analysis functions including normality tests and distribution model fitting. Since it was created in 1993, XLSTAT has been used by more than 100,000 people in the academic and commercial sectors in over 200 countries (XLSTAT Website, 2018).

For the JB LM lead time sample, the close proximity of the means to the medians and the low kurtosis and skewness, suggested that a Normal distribution could be good model for comparison to the support agency response times. To further confirm the normality of the distributions, two normality tests were conducted: the Shapiro-Wilk test and a quantile-quantile (Q-Q) plot. These tests were conducted using XLSTAT. The Shapiro-Wilk test uses a test statistic, W, to test the null hypothesis that the data sample came from a normally-distributed population and has been shown to be the most powerful test of normality (Razali & Yap, 2014) The results of the test (Figure 3) show a two-tailed p-value (0.668) that is higher than the level of significance (0.05) indicating that the null hypothesis cannot be rejected. Visually, a plot of a normal PDF versus the sample histogram (Figure 4) suggests that the population is normally distributed. The Q-Q plot is a plot of quantile values from the sample against expected values from a standard normal distribution with the same mean and standard deviation (Thode Jr., 2002). The sample Q-Q plot (Figure 5) is linear indicating that the sample distribution is normal. Based on these results, a Normal distribution model will be used to represent the JB LM lead time distribution.

Shapiro-Wilk test (Lead Time):	
W	0.992
p-value (Two-tailed)	0.668
alpha	0.05
Test interpretation:	
H0: The variable from which the sample was extracted follows a Normal distribution.	
Ha: The variable from which the sample was extracted does not follow a Normal distribution.	
As the computed p-value is greater than the significance level alpha=0.05, one cannot reject the null hypothesis H0.	

Figure 3: XLSTAT Shapiro-Wilk Test Results and Interpretation for JB LM Lead Time

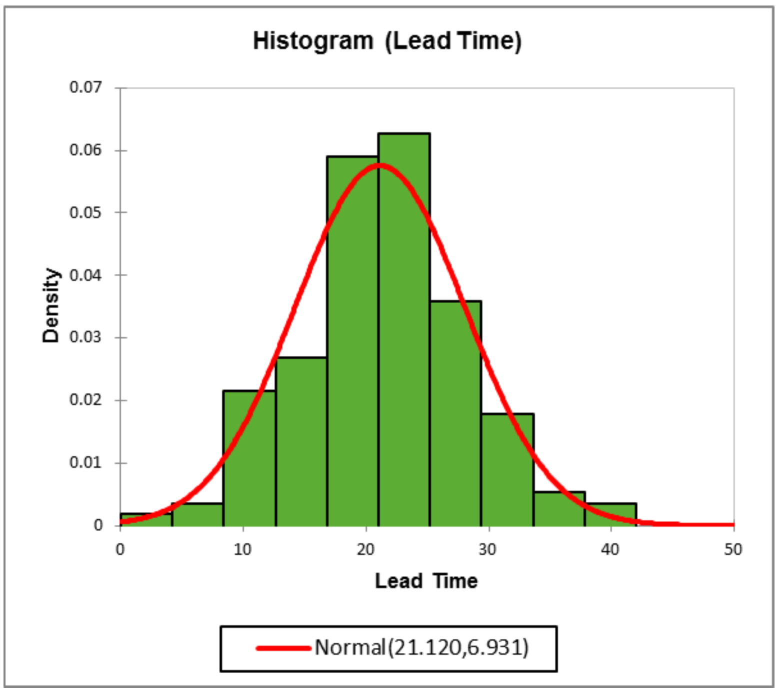


Figure 4: PDF of Normal Distribution vs Histogram of Empirical Data of JB LM Lead Time

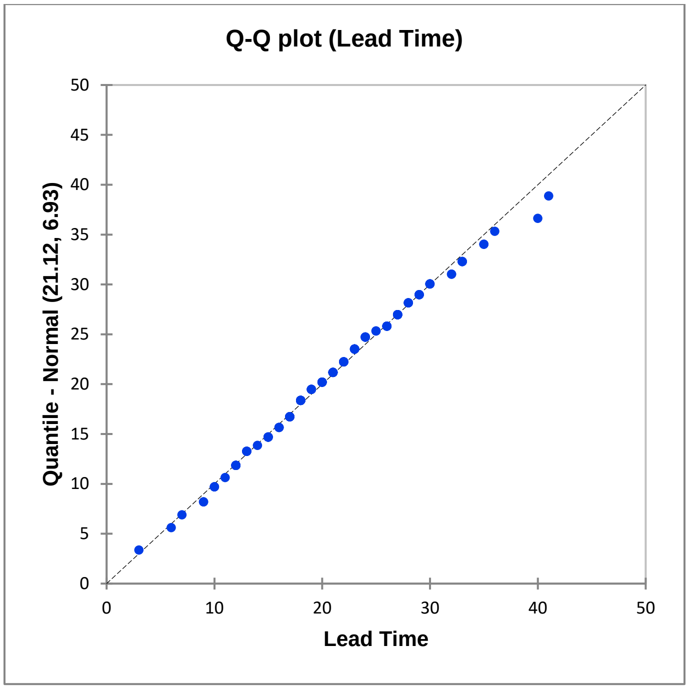


Figure 5: Q-Q Plot of JB LM Lead Time

The JB MDL lead time sample included lead times in excess of sixty minutes up to three hours. These excessive times are not representative of a typical inbound C-17 flight profile either because this is normally outside of radio range for real-world missions or an unanticipated profile change for local and/or real-world missions. For this reason lead times over sixty minutes were excluded from the distribution modeling. As previously mentioned, data from inbound C-17s that did not make a call were removed from the model for subsequent re-addition later in the probability of insufficient lead time. Even with these points removed, the remaining data did not pass the Shapiro-Wilk test for normality because the two-tailed p-value was 0.039 which is lower than the chosen level of significance or 0.05. The distribution fitting function of XLSTAT suggested a Logistic distribution for the model. The Kolmogorov-Smirnov (K-S) test was conducted to determine if the JB MDL sample follows this type of distribution. The K-S test compares the cumulative distributions of empirical data and the hypothetical values from the proposed model to determine the maximum difference (Massey Jr., 1951). The empirical data is the lead time sample and the proposed model is a logistic distribution with a location parameter of (μ) of 32.062 and a scale parameter (s) of 4.641. The result of the K-S test using a level of confidence of 95%, shown below in Figure 6, is that the null hypothesis cannot be rejected and that this sample follows a Logistic distribution. Visually, the probability density function (PDF) of the logistic model matches closely with a histogram of the sample data as shown in Figure 7. Additionally, the cumulative distribution function (CDF) of the logistic model matches closely with the cumulative histogram of the empirical data from the sample as shown in Figure 8. Based on these results, a Logistic distribution model will be used to represent the JB MDL lead time distribution.

Kolmogorov-Smirnov test:	
D	0.059
p-value (Two-tailed)	0.263
alpha	0.05
Test interpretation:	
H0: The sample follows a Logistic distribution	
Ha: The sample does not follow a Logistic distribution	
As the computed p-value is greater than the significance level alpha=0.05, one cannot reject the null hypothesis H0.	

Figure 6: XLSTAT Kolmogorov-Smirnov Test Results and Interpretation for JB MDL Lead Time

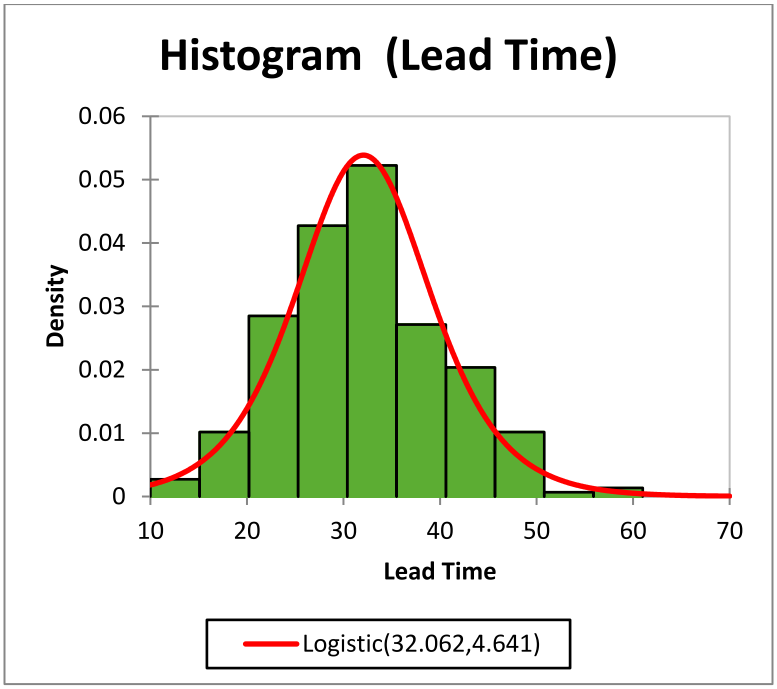


Figure 7: PDF of Logistic Distribution vs Histogram of Empirical Data of JB MDL Lead Time

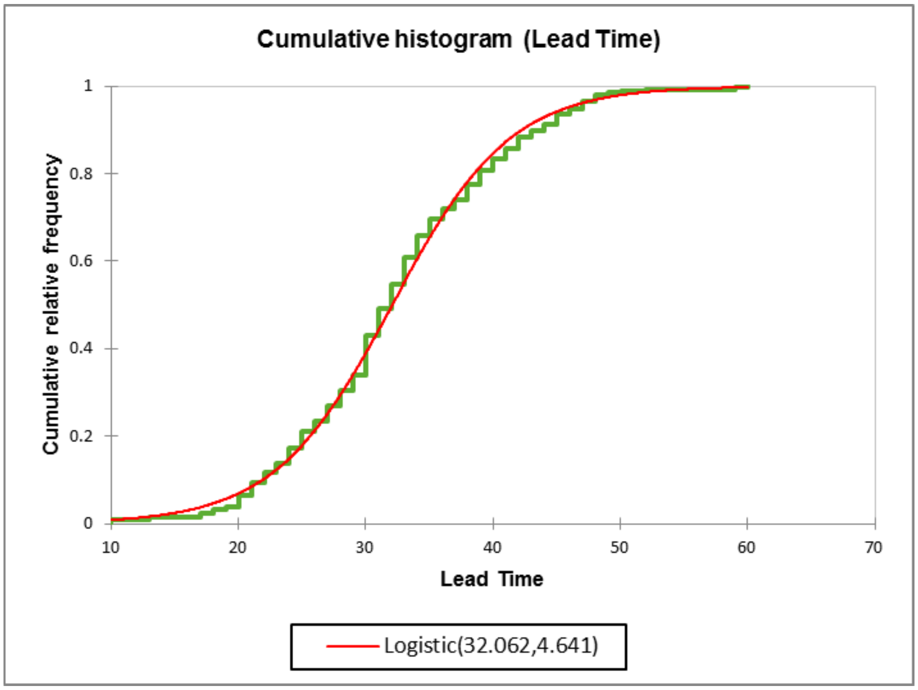


Figure 8: Hypothetical & Empirical CDF of Logistic Distribution of JB MDL Lead Time

Support Agency Response Time Requirements

The goal of collecting and analyzing support agency time data was to answer Investigative Question 1b: How much time do support agencies require to respond to C-17 arrivals? Agencies with corresponding functions at each sample base had similar structure and processes. For this reason, the analysis below is grouped by functional area. Each functional area section will discuss the following: process information flow, type of data collected, characteristics of the data (sample mean, estimated time, range etc.), and any other pertinent information that could affect the time required or preferred by the SME for the process. Only inbound C-17 data was used for the derived times and analysis. Descriptions of each agency are specific to their role in this particular process and are not indicative of all their responsibilities. A time will be designated as the representation of that agency at each base to be compared to that base's lead time distribution. Each designated time will be annotated with "mean" for mean time derived from gathered data or "est" for estimated by the SME.

Inbound C-17 Aircraft

The process begins when a C-17 approaches the airbase for landing. AFI 11-2C-17V3 dictates that the aircrew will contact the base Command Post via VHF/UHF radio transmission at approximately thirty minutes to block-in. The distance the aircraft is from the base, its altitude and airspeed, terrain, and the strength of the transmission can affect the ability of the transmission to be received at the thirty-minute requirement. The information must include estimated block-in time but generally also includes maintenance status and applicable information concerning passenger and cargo details, distinguished visitors (DV) on-board, special cargo requirements, special equipment requests (air carts, life support, etc.) and crew transportation requests. Within thirty minutes to block-in, the aircraft is generally in the approach and landing phase of flight which is a period of increased workload for the pilots. Due to this workload increase, the task of transmitting the information is most often delegated to the loadmaster. All information listed above, with the exception of the passenger/DV/cargo details, is relayed from the pilots in the cockpit via aircraft intercom to the loadmaster in the cargo compartment. Of note, the loadmaster may not be familiar with the relayed maintenance discrepancies.

Command Post (CP)

CP Controllers provide a communication node between inbound aircraft and various base support agencies. In general, the information provided includes estimated time in blocks, maintenance status including any discrepancies, cargo and passenger information, parking assignment requests, fuel and special equipment requests, and aircrew transportation requests. Other than information provided through systems like GDSS2, SMS, and GATES and products like flying schedules and cargo forecast, these support agencies depend on the CP to provide the most current and accurate inbound aircraft information. The CP controller respondents at both JB MDL and JB LM gave similar responses with regards to the process flow and timing. The process begins when the aircraft calls the CP via the VHF/UHF radio. The CP controller at each base copies the information by hand onto a form or blank piece of paper. The MOC at both bases is collocated with the CP so the radio message is often heard simultaneously when received. If not, the message is passed via voice to the MOC controller. The ATOC at JB MDL is collocated as well and the flow is the same as MOC. The ATOC at JB LM is not collocated so the CP controller calls via DSN phone and it takes CP controllers approximately one minute to make that call. At JB MDL, a sample of data from a single controller was collected from the respondent during the time period from September-November 2018 with an average of 1.5 minutes from initiation of the aircraft radio call until the information was fully passed to MOC and/or ATOC. At JB LM, the CP SME provided a similar estimate of 1.5-2 minutes for the same process. The CP controller passes the parking assignment to the aircraft via radio once received from MOC. The CP controller calls two other entities to pass inbound aircraft information: LRS Vehicle Transportation and Aircrew Flight Equipment (AFE). Calls to AFE are infrequent for inbound aircraft and so are omitted from this research. CP controllers contact LRS Vehicle Transportation via DSN Phone and it takes CP controllers approximately one minute to make that call. The designated required response times are shown below in Table 2.

Table 2: CP Process Designated Required Response Times

Base	C-17 to CP	CP to MOC/ATOC	CP to Vehicle Trans
JB MDL	43 seconds (mean)	51 seconds (mean)(for each)	60 seconds (est)
JB LM	30 seconds (est)	30 seconds/60 seconds (est)	60 seconds (est)

Maintenance Operations Center (MOC)

MOC Controllers provide coordination between the CP, maintenance units and POL. They pass information regarding maintenance status, aircraft discrepancies, fuel requests, and any special maintenance equipment requests. Each MOC receives inbound aircraft either directly by listening to the information from the radio call or through voice relay from the CP controller. The information is recorded on paper then relayed to the Production Superintendent (PROSUP) in the AMXS for home station aircraft or Transient Alert (TA) for transient aircraft via LMR or DSN phone. The process takes 15-30 seconds to receive the message from the CP controller and another 15-30 seconds to dissemination to the PROSUP or TA. MOC also calls POL (Fuels Flight) via DSN phone to pass the requested fuel load which takes an average of thirty seconds. MOC may call AFE for life support equipment requests but this is infrequent and not included in this research. Additionally, the PROSUP passes the aircraft parking spot to the MOC during their phone call which is in turn passed via radio to the inbound aircraft through the CP controller. The designated required response times are shown below in Table 3.

Table 3: MOC Process Designated Required Response Times

Base	MOC to Pro Sup	MOC to POL	MOC to TA
JB MDL	30 seconds (est)	30 seconds (est)	30 seconds (est)
JB LM	15 seconds (est)	30 seconds (est)	30 seconds (est)

Air Terminal Operations Center (ATOC)

ATOC controllers provide coordination between the CP and base port functions such as cargo handling (also known as Ramp or Freight), passenger handling, and fleet services. In most cases, the passenger and cargo information passed to the ATOC from the CP will reflect what is contained in GATES. If not, the ATOC controller will update GATES and notify the appropriate agencies. ATOC controllers also call special handling (signature service cargo, U.S. mail, etc.) and Customs and Agriculture (when applicable for aircraft returning from other countries). Signature Service is relatively infrequent and is not included in this research. Aircraft will generally call CP 2-3 hours prior to arrival via aircraft satellite communication equipment to request Customs and Agriculture services so the responding agents have a general estimate of when they need to meet the aircraft. At JB MDL, the ATOC is located in the CP so most inbound aircraft radio calls are heard directly or are relayed by voice from the CP controller. JB MDL ATOC controllers disseminate information to the required agencies via LMR simultaneously. At JB LM, the ATOC is not located in the CP so a phone call is required for every inbound aircraft. JB LM ATOC controllers disseminate information to required agencies via phone. At JB MDL, Fleet Service is integrated into the passenger and cargo handling sections. At JB LM, Fleet Service is a separate entity and requires its own phone call notification.

The JB MDL SME respondent provided data over the period of 8 September to 7 October 2019. The data provided covered the beginning of the radio transmission from the aircraft through to the end of relay from the ATOC controller for the APS agencies. The average time for this relay was two minutes. The average relay time from aircraft radio call through the end of relay to the ATOC controller provided by the CP SME respondent was subtracted from this average to isolate the average time from the ATOC controllers receipt of the message to subsequent transmission. The difference yielded an average of approximately 30 seconds which is used as the representative response time. The designated required response times are shown below in Table 4.

Table 4: ATOC Process Designated Required Response Times

Base	ATOC to Freight Dispatch	ATOC to Passenger Dispatch	ATOC to Fleet Dispatch
JB MDL	30 seconds (mean)	30 seconds (mean)	N/A
JB LM	1 minute (est)	1 minute (est)	1 minute (est)

Aircraft Maintenance Squadron (AMXS)

Aircraft Maintenance Squadrons are responsible to provide recovery aircraft maintenance support actions including marshalling, general mechanics (crew chiefs) and aircraft systems specialists, coordination of fuel aerospace ground equipment, and assignment of a parking spot for home station aircraft. Flight line actions are supervised by the PROSUP and executed by general and special aircraft mechanics through coordination with aircraft Expeditors. PROSUPs use Expeditors to assemble and dispatch maintenance recovery teams for inbound aircraft and transport those teams to the designated parking spot when required. Inbound aircraft information is sent from the MOC to the PROSUP or Expeditor via LMR and then passed via voice to the maintainers who will then go to the Consolidated Tool Kit (CTK) section to pick up any necessary tools. From there, they travel by foot or vehicle to the parking spot. Maintainers pick up general equipment (radios, headsets, recovery kits, etc.) at the beginning of their shift and do not always need to stop at CTK prior to arriving at the parking spot.

The processes at both bases are very similar with the following exceptions. JB MDL has a single active duty C-17 squadron and consequently a single sub-organization called an Aircraft Maintenance Unit (AMU). JB LM has three active duty C-17 squadrons with considerably more aircraft assigned necessitating two AMUs. Each C-17 is assigned to an AMU. This is transparent to the process because the information is disseminated simultaneously via LMR and the process within each AMU is the same. Another difference is the PROSUP's preference of how early the maintainers will show at the parking spot to conduct the conduct the Foreign Object Damage (FOD) and equipment checks. At JB MDL, the PROSUP prefers that the maintainers arrive at the spot at least five minutes prior to estimated block-in time. At JB LM, the PROSUP's preference is two minutes. These spot arrival preferences indicate a desire to have that amount of time to properly perform the required duties and will added to the overall total response time required for each AMXS.

At JB MDL, data was collected from 6 September to 17 October 2018. At JB LM, data was collected from 24 October to 11 December 2018. Both AMXS SMEs were sent a spreadsheet to collect times between steps from MOC notification through maintainer arrival at the aircraft parking spot. An example of this spreadsheet is contained in Appendix B.

In regards to the time required for maintainer notification to arrival at the parking, it is important to note that the timing of AMXS response actions is unique in that, for most circumstances, C-17s must be marshalled into the spot (blocked-in) by a maintainer. Consequently, there was never an instance in the collected data were the aircraft blocked-in to parking before maintenance personnel arrived. The collected data is skewed by this fact as it becomes representative of only how fast a maintainer can get to the spot rather than representative of how much time maintenance needs to adequately prepare and respond to perform all required recovery actions. At JB MDL only, estimated lead times from MOC were collected for each inbound call. At that base, there is a weak-to-moderate positive correlation (0.43) between amount of lead time given to the PROSUP and the amount of time between leaving the squadron or CTK and arriving at the spot. While not conclusive, this correlation indicates to the researcher that the more lead time a maintainer has the more time that maintainer takes to respond. For these reason, this researcher deemed the collected data to be not representative of the time required for this step in the process. A follow-up discussion was conducted with the JB MDL and JB LM AMXS SMEs to determine the expected time between maintainer departure and arrival at the spot. That time is reflected below in Table 5.

Table 5: AMXS Process Designated Required Response Times

Base	PROSUP to Maintainer	Maintainer to Flightline
JB MDL	2.1 minutes (mean)	5 minutes (est)
JB LM	20 seconds (mean)	3 minutes (est)

Transient Alert (TA)

TA is a contractor agency that provides basic services for transient (non-home station) aircraft such as guidance to parking (follow-me service), marshalling, aerospace ground equipment, and deicing. TA monitors GDSS2 and the daily flight schedule with Prior Permission Required (PPR) information for expected inbound C-17 information. When an inbound transient C-17 makes the inbound radio call, that information is relayed through CP/MOC to the TA dispatcher who sends a team out to the designated parking spot. The TAs at both bases have the same process and the SME respondents gave the estimated times listed below. Of note, the TA at JB MDL uses a commercial website (adsbexchange.com) that tracks transponder information of the inbound C-17s for flight following and timelier updates than GDSS2 or the inbound radio call. The designated required response times are shown below in Table 6.

Table 6: TA Process Designated Required Response Times

Base	TA to Parking Spot
JB MDL	5 minute (est)
JB LM	8 minutes (est)

Logistics Readiness Squadron (LRS) Fuels Flight (POL)

At each base, the LRS contains a Fuels Flight, also known as POL, which is responsible for providing aircraft fuel upon request. When an inbound C-17 requests fuel, that request is relayed to the POL dispatcher by the MOC controller via DSN phone. The information passed includes estimated block-in time, aircraft tail number, parking spot and requested fuel amount. The dispatcher selects a driver within the building and passes the required information in person. The driver then exits the building to drive either an R-12 pump truck or R-11 fuel tanker truck for fueling at hydrant and non-hydrant equipped parking spots, respectively. R-11 fuel tanker trucks are typically re-filled upon completion of refueling and a full when the driver receives a request. Data was provided in the form of an Excel spreadsheet export from the Fuel Management Database (FMD) program which is normally used to track fuel operations from request to completion of fueling. The data used for both bases was from the month of September 2018 and included include times of requests, dispatch, and arrival at the parking spot. The designated required response times are shown below in Table 7.

Table 7: POL Process Designated Required Response Times

Base	Request to Driver	Driver to Spot
JB MDL	3.8 minutes (mean)	10.7 minutes (mean)
JB LM	3.7 minutes (mean)	10.2 minutes (mean)

Logistics Readiness Squadron (LRS) Vehicle Operations Section

The LRS Vehicle Operations Section provides aircrew transportation to inbound aircrews using a 15-passenger-style van with or without a towed trailer for professional gear and baggage. Aircrew transportation requests are made by inbound crews during their arrival call and relayed to Vehicle Operations by the CP controller via DSN phone. The information passed includes the required pick-up time, aircraft call sign, parking spot and number of aircrew members requiring transportation. The time data provided by the SME respondent at both bases was from a computer program called the On-Line Vehicle Integrated Management System (OLVIMS). The data provided was from the month of September 2018 and included the transportation request time, dispatch time, time of arrival at the requested parking spot, and time departing that spot. OLVIMS automatically calculated the response times in minutes by subtracting dispatch time from arrival time. In every case, the request time and dispatch times were reported as the same time (to the minute) indicating that the time from request to dispatch is less than one minute. To account for this time between request and dispatch, one consolidated time from request to arrival at the parking spot was chosen as the representative time.

Inputs from interviews with CP and Vehicle Operations SMEs at both bases, indicated that the relay of aircrew transportation requests through CP is inefficient. The inefficiency results from the CP passing the estimated block-in time as the required pick-up. The aircrew members generally conduct post flight duties after block-in and are not ready for transportation when the bus arrives even if they block-in at the estimated time. This results in drivers waiting for extended amounts of time instead being used to perform other transportation duties including picking up subsequent aircrews. The OLVIMS data shows that over half of pick-ups at each base take more than 10 minutes and over 30 minutes in 10% of the cases. During the sample month, the total time drivers spent waiting longer than 10 minutes was 2.6 hours at JB MDL and 21.4 hours at JB LM. The larger time at JB LM is due to the larger sample size 170 versus 38 at JB MDL. The larger sample size is due to more C-17 sorties driven by multiple C-17 squadrons at JB LM.

SMEs from both bases prefer that the transportation requests be made directly from the aircrew via cell phone when the aircrew is 10 minutes from being ready for pick-up. Relay through CP is not necessary except as a backup when the cell phone communication fails. The designated required response times are shown below in Table 8.

Table 8: Vehicle Operations Process Designated Required Response Times

Base	Dispatch to Spot
JB MDL	7.1 minutes (mean)
JB LM	6.9 minutes (mean)

Aerial Port Squadron (APS) Cargo Handling Flight

The Cargo Handling Flight provides cargo handling services to inbound C-17s including use of Material Handling Equipment (MHE) such as 25K Halvorsen Loaders and 10K All-Terrain forklifts for loading and unloading aircraft. This flight is commonly known as “Ramp” at JB MDL and “Freight” at JB LM. At JB MDL, the cargo handling section also provides certain fleet services including lavatory service and removal of trash. On a C-17 missions returning from outside the United States, fleet service is required upon block-in to work in conjunction with Customs and Border Protection prior to trash removal. At JB LM, fleet services are consolidated in a separate section. All fleet services at both bases are discussed further in the “Fleet Service” section below.

The ATOC controller notifies the Cargo Handling Dispatcher of inbound C-17s via LMR who in turn notifies a Load Team Chief (LTC). The information passed include estimated block-in time, tail number, parking spot, cargo information, and any required special equipment or vehicles. The LTC assembles a load team of 3-4 members and conducts a load team brief including load and safety information. After the brief, the team inspects the required MHE and drives to the parking spot. At JB MDL, the SME respondent provided estimates for time data. The JB LM respondent provided an Excel spreadsheet containing a sample of times from ATOC notification to the load team leaving the office and from leaving the office to arriving at the parking spot with the required MHE and briefings complete. The designated required response times are shown below in Table 9.

Table 9: Cargo Handling Process Designated Required Response Times

<table>
<tr><th><u>Base</u></th><th><u>Dispatch to LTC</u></th><th colspan="2"><u>Load Team to Parking Spot</u></th></tr>
<tr><td>JB MDL</td><td>1 minutes (est)</td><td colspan="2">16 minutes (est)</td></tr>
<tr><td></td><td><u>Dispatch to LTC</u></td><td><u>LTC to Load Team</u></td><td><u>Load Team to Parking Spot</u></td></tr>
<tr><td>JB LM</td><td>1 minute (est)</td><td>10 minutes (est)</td><td>10 minutes (est)</td></tr>
</table>

Aerial Port Squadron (APS) Passenger Terminal

The Passenger Terminal provides transportation of passengers, including Distinguished Visitors (DVs) and their baggage from arriving aircraft to the Passenger Terminal located on the flight line. Passengers are typically transported via 15-passenger-style vans or 44-passenger buses and the baggage via 10K All-Terrain forklifts. At JB MDL, this flight also coordinates "clean" fleet services including replacement of used comfort items such as pillows and blankets, expendables such as hand soap and paper towels, water igloos, and cleaning of the galley area. At JB LM, fleet services are consolidated in a separate section. All fleet services at both bases are discussed further in the "Fleet Service" section below.

The ATOC controller notifies the Passenger Service Dispatcher of inbound C-17s via LMR. At JB MDL, the dispatcher tasks drivers of buses and/or MHE in person. The drivers then walk outside to their vehicle and drive to parking spot. The process is the same at JB LM except that the information flows from the dispatcher to a Shift Supervisor who in turn chooses and passes that information to drivers who respond to the request. All of this communication is conducted in person. For the purpose of this research, the dispatcher and the Shift Supervisor are considered one entity called “Passenger Dispatch” and the time the information resides with each will be combined below. In lieu of data, the JB LM SME provided estimates of the required times.

The JB MDL SME respondent provided an Excel spreadsheet with time data from dispatcher notification to driver notification and from driver notification to the aircraft parking spot over a three month period from October through December 2018. The mean of the dispatcher notification to driver notification appeared high at 13 minutes. To verify this suspicion, the JB MDL SME respondent was questioned and the response was that dispatchers will sometimes notify a driver immediately after ATOC passes the information and other times they will pass the information when the aircraft has landed. Since the provided data for that transition does not represent how long the dispatcher truly needs to pass the information, the JB MDL SME respondent-provided estimate of the required time is used. Additionally, one sample time from the assignment of the driver to arrival at parking spot was excessive at 36 minutes. This time was removed because it was only a replacement of a water cooler that was not required to be accomplished upon aircraft arrival. The JB MDL SME respondent confirmed this via a follow-up email.

The JB LM SME respondent also provided an Excel spreadsheet with time data over from dispatcher notification to driver notification and from driver notification to the aircraft parking spot over a three month period from November 2018 through January 2019. The time data from Dispatch to Driver Assigned had a large range (2-85 minutes) and standard deviation of 24 minutes. This indicates that the average time derived from the provided data (16 minutes) may not be representative of the time required. In this case, the estimate provided by the JB LM SME respondent (4 minutes) was used at the representative time. The time data from Driver Assigned to Parking Spot yielded an average of 5.1 minutes and a much smaller standard deviation (2.5 minutes). The JB LM SME respondent initially provided an estimate of 10 minutes for this timeframe and, in a follow-up email, he confirmed his estimate over the data-derived average of 5.1 minutes. His rationale was that the data may have been skewed because they did not include all preparations actions taken before departing the passenger terminal for the parking spot. The designated required response times are shown below in Table 10.

Table 10: Passenger Terminal Process Designated Required Response Times

Base	Dispatch to Driver Assigned	Driver Assigned to Parking Spot
JB MDL	3 minutes (est)	11.8 minutes (mean)
JB LM	4 minutes (est)	10 minutes (est)

Aerial Port Squadron (APS) Fleet Service

Fleet services are generally broken down into two areas: “Clean” and “Dirty”. Clean fleet services include replacement of used comfort items such as pillows and blankets, expendables such as hand soap and paper towels, water igloos, and cleaning of the galley area. Dirty fleet service includes lavatory service and removal of trash.

At JB MDL, clean fleet services are integrated into the Passenger Terminal and dirty fleet service are integrated into the Cargo Handling Flight. According to the SME respondents in those areas, the response time for fleet is the same as the function it is integrated with. At JB LM, all fleet services are consolidated into a single section. ATOC notifies the Fleet dispatcher of inbound C-17s via DSN phone. The dispatcher then notifies the appropriate fleet team(s) who walks outside to their vehicles and drive to the parking spot. The response times in Table 11 below are estimates provided by the SME respondent.

Table 11: Fleet Service Process Designated Required Response Times

Base	Dispatcher to Driver	Driver to Spot
JB MDL	Included in cargo-handling and passenger response times in Tables 9 and 10	
JB LM	1 minute (est)	6.5 minutes (est)

C2 Information Flow Charts

Each step of the information flow and associated communication methods and times are detailed in Charts 1 and 2 below. Within each information flow chart, boxes represent a person who receives and/or transmits information. The arrows represent transitions in the form of transmission of information between persons or the physical transition of a person to another area. Bi-directional arrows indicate that information flows in both directions regularly. For example, each time the MOC controller notifies the PROSUPER of an inbound C-17, the PROSUPER informs the MOC controller of the assigned parking spot. The MOC controller will then relay information to the CP controller who relays it to the inbound C-17. Each arrow contains a notation for the method of transmission (voice, radio, etc.) and the time that transition takes to complete. The oval shapes at the top and bottom of the chart represent the origin of the information from the inbound C-17 and the end goal of arriving at the inbound C-17 parking spot ready to provide the required services. In some cases, SME respondents provided a time that covers two transitions. These cases are denoted with an asterisk.

As discussed in the Methods section, the critical paths in a process is the one that takes the longest time and, therefore, control the amount of time an entire process takes. For the purpose of this research the critical path is the support agency that needs the most lead time to respond to inbound C-17s. At both bases, the critical path is the cargo handling flight also known as Ramp at JB MDL and Freight at JB LM. All required response times, from longest to shortest, are shown in Figures 9 and 10 below.

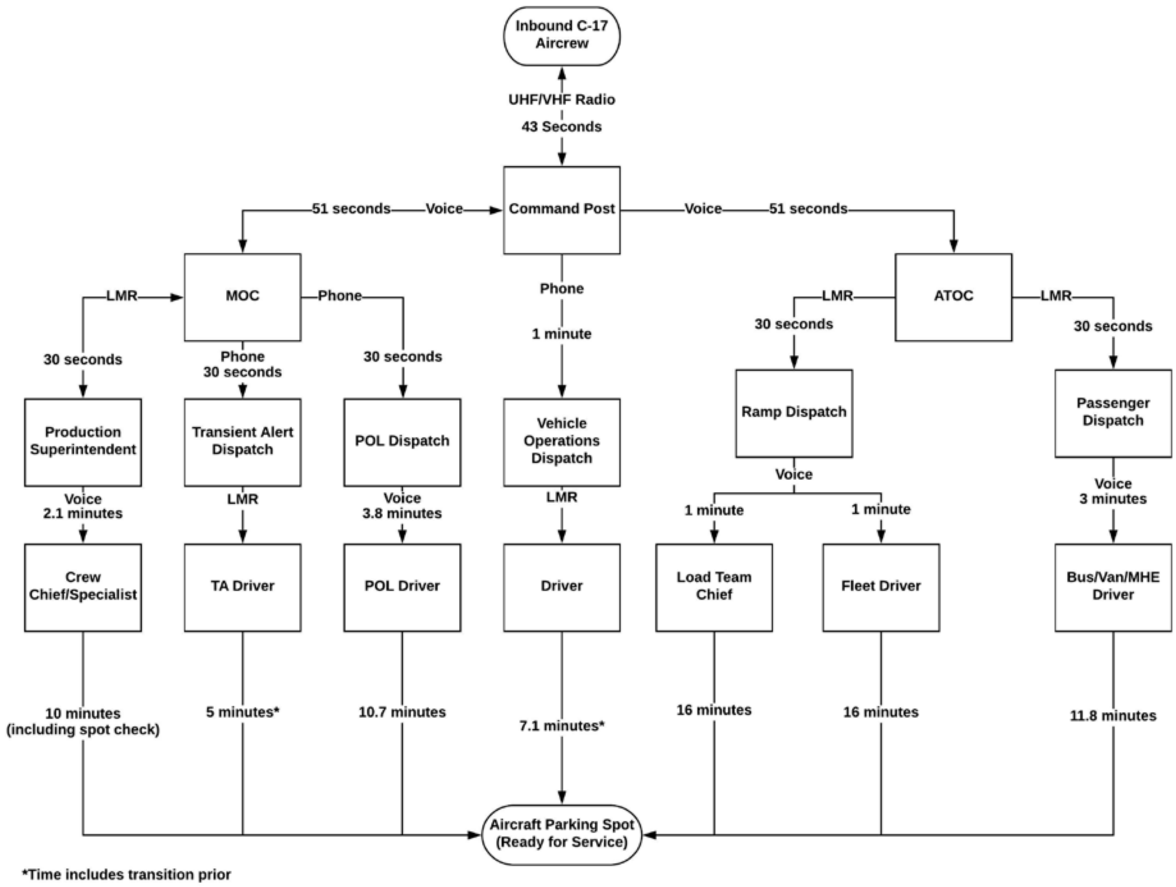


Chart 1: JB MDL Information Flow

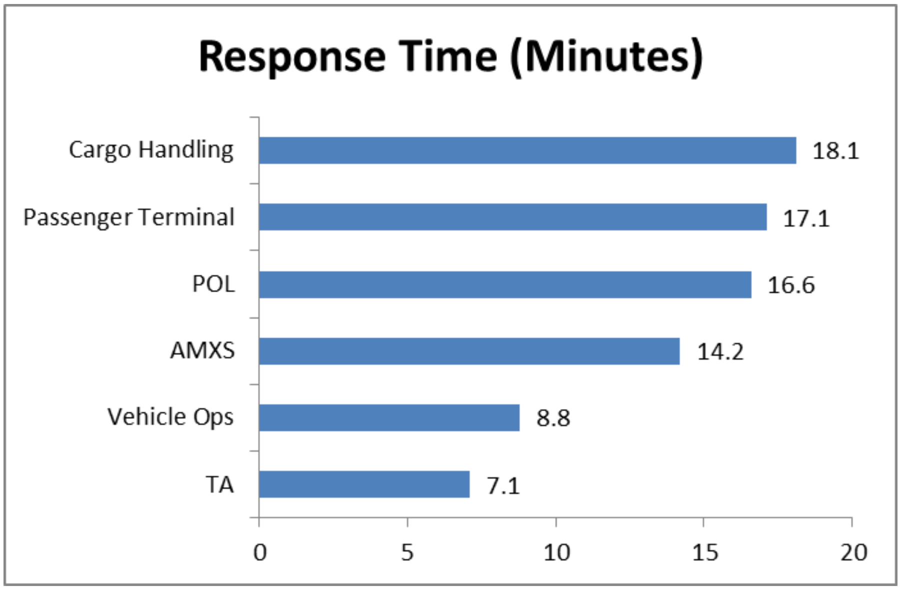


Figure 9: JB MDL Support Agency Response Times

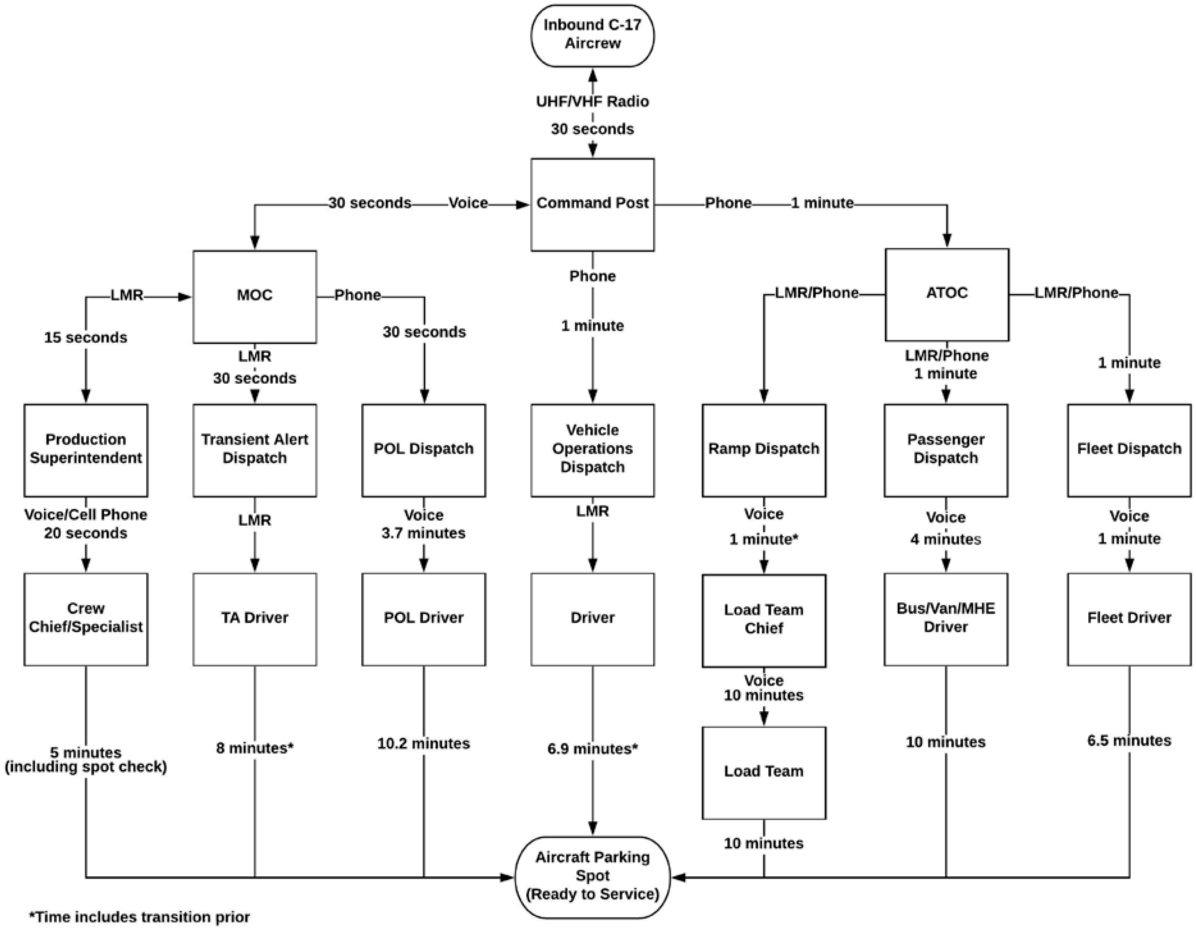


Chart 2: JB LM Information Flow

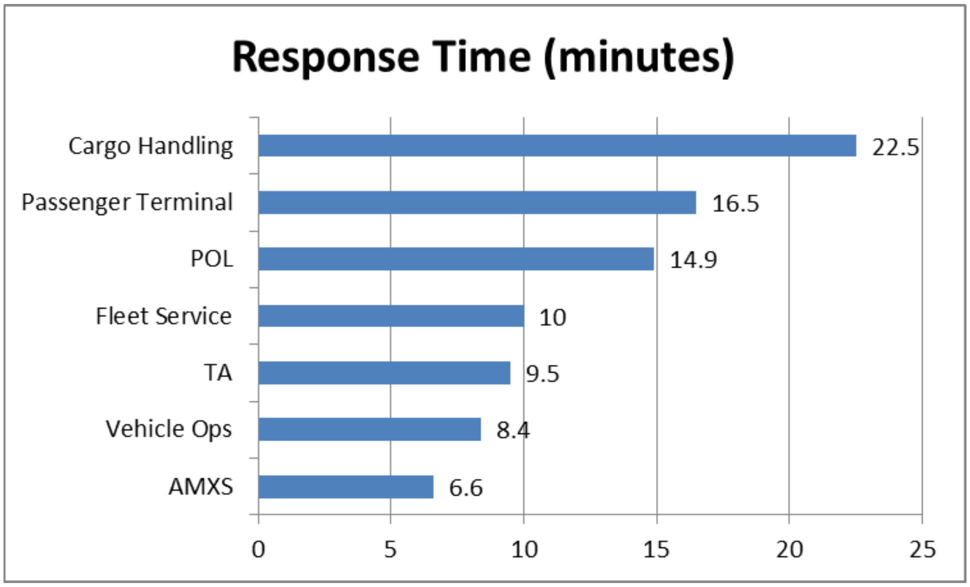


Figure 10: JB LM Support Agency Response Times

Comparison of the Lead Times and Response Times

To answer the time portion of Research Question 1, the representative response times for each base were compared to that base's lead time distribution model. For JB LM, using the mean ($\bar{x}$) and standard deviation (s) of the normal distribution model, a response time (x_i) can be converted into a standardized value, z, using Equation 3 below, that corresponds to a probability of on a standard normal distribution table (Camm et al., 2018). An example of the standard normal distribution table is included in Appendix D. This probability represents the chance that an inbound C-17 notification lead time will be less than the given response time. In other words, this is the probability that the lead time will be insufficient for the adequate preparation of the support agency.

$$z = \frac{x_i - \overline{x}}{s} \tag{3}$$

Equation 3: Standard Z-Score Formula

The sample from JB MDL contained data on C-17s that did not make an inbound notification at all. In these cases, CP is notified of the arrival once the C-17 has landed and calls to obtain a parking spot assignment. Consequently, these data points, which comprised 4.3% of the data, equate to a lead time of 10.5 minutes which is the average taxi time (from landing to block-in) of the sampled inbound C-17 flights. Flights where no inbound notification was made were excluded from the distribution modeling portion but are still included using the addition law of probability shown in Equation 4 below.

$$P(A \cup B) = P(A) + P(B) - P(A \cap B) \tag{4}$$

Equation 4: Addition Law of Probability

This law states that the probability of Event A *or* Event B (union) occurring is the sum of the probabilities of Event A and Event B minus the probability of Event A *and* Event B (intersection) occurring (Camm et al., 2018). The probability space is comprised of all inbound C-17 flights to JB MDL. Event A represents a C-17 that makes a notification with less time that required for a support agency to adequately prepare and respond given that an inbound notification has be made. Event B represents a C-17 that does not make a notification. The probability of Event B is 4.3% based on the sample. The probability of the intersection of Events

A and B, $P(A \cap B)$, is zero because these events are mutually exclusive. The aircraft either made a notification or not.

The probability of Event A is calculated using both conditional probability and the cumulative distribution function (CDF) of logistic distribution model (μ=32.062, s=4.641). First, the probability of a notification occurring in less than a given time, x_i, is calculated using Equation 5 below.

$$\boldsymbol{F(x; \mu, s) = \frac{1}{1 + e^{-\frac{x_i - \mu}{s}}}} \tag{5}$$

Equation 5: Logistic Distribution CDF Formula

Since this distribution model represents only the 95.7% of C-17s that made an inbound notification, it is necessary to use the conditional probability formula in Equation 6 below. Event C is the probability that a notification is made within a specified time as determined by the logistic function CDF. Event D is the probability that a notification was made in the first place or 95.7%. Event A is the probability that Events C and D both happen (intersection). $P(C|D)$ represents the probability of Event C given the Event D has occurred. Since Event C is a subset of Event D, Event A becomes the probability that Event C will happen in the entire probability space and not just within the space of Event D.

$$\boldsymbol{P(A) = P(C \cap D) = P(C|D)P(D)} \tag{6}$$

Equation 6: Conditional Probability Formula

For example, the JB MDL Fuels Flight (POL) has a response time, x_i, of 16.6 minutes. Using Equation 5, the probability of an inadequate response time given that a notification was made, $P(C|D)$, is 3.5%. Using Equation 6, the probability of inadequate response time is converted from the context of the Event D probability space (95.7%) to the probability in the absolute probability space yielding $P(A)$= $P(C \cap D)$= 3.3%. Finally, using Equation 4, the probability of no notification, $P(B)$, is combined with $P(A)$ to yield a 7.6% chance of a lead time that is less the specified response time.

Table 12 below contains each agency's required response time and corresponding probability that an inbound notification lead time will be insufficient. JB MDL TA and Vehicle Ops have a zero probability of insufficient lead time due to the average taxi time of 10.5 minutes exceeding their required response times. At JB MDL, the highest probability of insufficient lead time is 8.8%. At JB LM, due mainly to the lower mean lead time, the highest probability of insufficient lead time is 57.9%.

Table 12: Percentage of Insufficient Lead Time

	JB MDL		JB LM	
Response Function	Response Time (minutes)	% of Insufficient Lead time	Response Time (minutes)	% of Insufficient Lead time
AMXS	14.2	6.4%	6.6	1.8%
TA	7.1	0%	9.5	4.7%
Vehicle Ops	8.8	0%	8.4	3.4%
POL	16.6	7.6%	14.9	18.7%
Cargo Handling	18.1	8.8%	22.5	57.9%
Passenger Terminal	17.1	7.9%	16.5	25.4%
Fleet Service	Combined with Cargo Handling	N/A	10	5.6%

Quality of Information Flow

Responses from the SME interviews were the main source of data to answer Investigative Question 1c: Is the information passed sufficient for support agency preparation to service the inbound C-17? For the purposes of this research, the sufficiency of the information passed is broken into two main areas: detail and accuracy. Sufficient detail is defined as the amount of information required to adequately prepare to service an inbound C-17. Sufficient accuracy is the defined as the information being correct enough to adequately prepare to service an inbound C-17.

Concerning the level of information detail, 9 of the 19 SME respondents stated that they would like more information from the inbound C-17 than their organization currently receives. The main themes of the desired information were more details maintenance statuses and the number and types of passengers.

As for the accuracy of the information passed, only one function, the AMXS, provided quantifiable data displaying an indicator of deficiency. The spreadsheet tracker provided by the AMXS SME respondents at both bases contained the maintenance status passed to their offices by MOC and the maintenance status reported by the maintainers that met the aircraft on arrival. Approximately 25% of the maintenance statuses passed by MOC (as reported by the inbound aircraft) were different than the maintainers encountered on arrival. The collected data was insufficient to determine the source of each error, but the potential causes are inaccurate aircrew reporting of the status, changes to the between the notification radio call and block-in or an error introduced by the various relaying agencies within the information flow process.

Substitution of BLOS Communications

To answer Research Question 2, a basic value stream mapping approach was used to eliminate some unnecessary process steps. A BLOS communication method, ACARS messaging, was substituted for UHF/VHF radio air-to-air communications and LMR/DSN phone ground-to-ground communications where the receiving agency uses GDSS2 on each air base's inbound C-17 notification process. One exception is the Vehicle Operations Section, where relay through CP is replaced with cell phone use directly from the aircrew to the vehicle dispatcher DSN phone. The proposed future state of each base's process using BLOS communication methods is shown below in Charts 3 and 4.

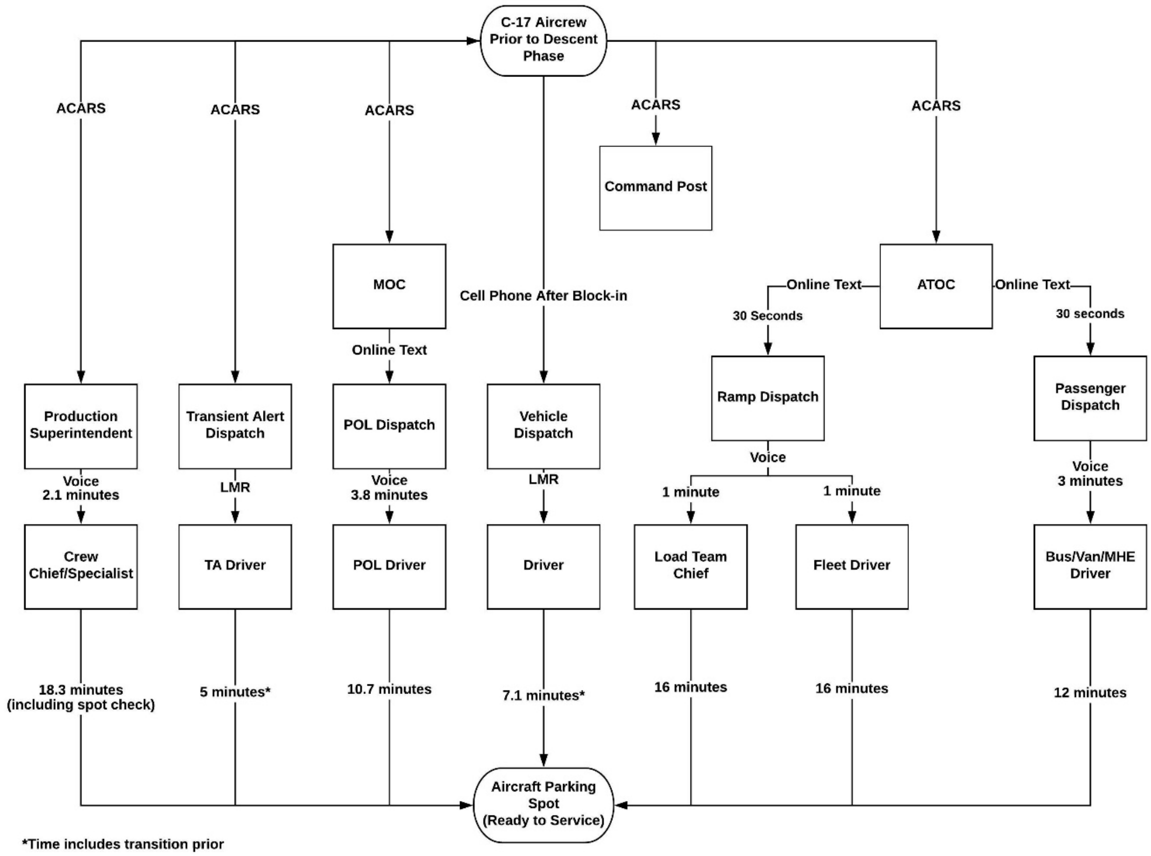


Chart 3: JB MDL Proposed Future State Information Flow

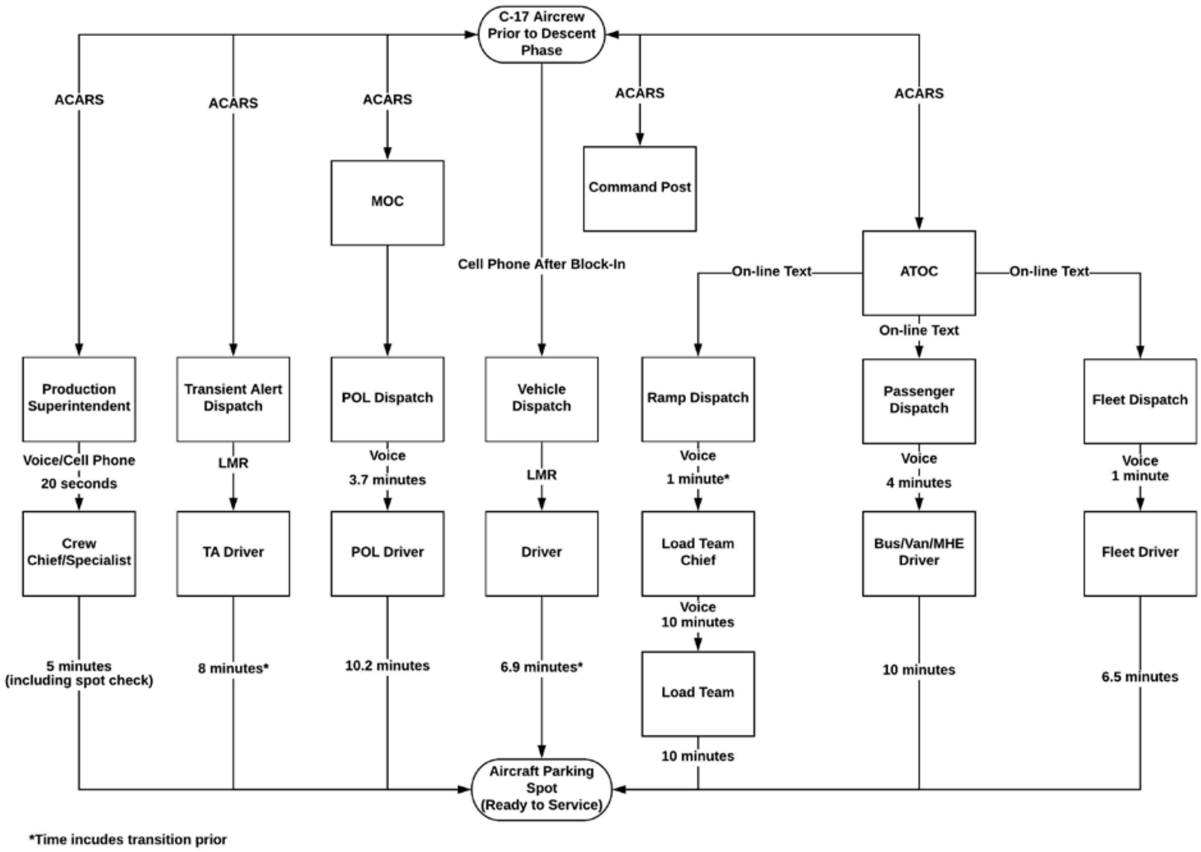


Chart 4: JB LM Proposed Future State Information Flow

The time saved is quantified by adding up the process times eliminated by using ACARS messaging and cell phones. For example, at JB MDL, if the inbound C-17 sends an ACARS message directly to CP, MOC, ATOC and the PROSUPER, the CP controllers save an average of 43 seconds by not having to receive the radio call from the inbound aircraft, 51 seconds by not having to relay to the MOC/ATOC controllers and one minute by not having to call Vehicle Dispatch because the aircrew will contact them directly via cellphone after landing. The result is a total of 154 seconds (2.57 minutes) saved for the CP controller for other duties or quality of life. The number of actions saved is quantified by adding up the actions eliminated by using

ACARS messaging and cell phones. For example, at JB MDL, if the inbound C-17 sends an ACARS message directly to CP, MOC, ATOC and the PROSUPER, the CP controllers required actions are reduced from three (C-17 to CP, CP to MOC/ATOC, CP to Vehicle Dispatch) to just one for checking the contents of the message. The result is two non-value-added actions eliminated.

Tables 13 and 14 below showed the time saved per process cycle and per month. The monthly total is derived from the monthly average C-17s sorties based on one year of data from each base. The monthly average is not based on the sample average. Additionally, ATOC controllers will only see savings if the cargo-handling, passenger terminal and fleet dispatchers have access to GDSS2 or another program to receive ACARS messages which they currently do not.

Table 13: Time and actions saved by substituting BLOS communication methods at JB MDL

	Per Inbound Notification		Per Month (based on average 84 inbound C-17s)	
	Time Saved	Actions Eliminated	Time Saved	Actions Eliminated
CP	2.57 minutes	2	3.6 hours	168
MOC	30 seconds	1	42 minutes	84
ATOC (if dispatches use GDSS2)	30 seconds	1	42 minutes	84

Table 14: Time and actions saved by substituting BLOS communication methods at JB LM

	Per Inbound Notification		Per Month (based on average 146 inbound C-17s)	
	Time Saved	Actions Eliminated	Time Saved	Actions Eliminated
CP	2 minutes	2	4.8 hours	292
MOC	15 seconds	1	36.5 minutes	146
ATOC (if dispatches use GDSS2)	1 minute	1	2.4 hours	146

In addition to time and actions saved, adding BLOS communications also shortens the response time for each agency. Reducing the response time reduces the required lead time. However, since the BLOS communication method provides significantly longer lead time for notifications, the associated benefit of shortening of the response times becomes irrelevant.

BLOS Communication Implementation

The estimated time for training on the use of ACARS messaging in GDSS2 is approximately 30 minutes per trainee which is 0.5 man-hours invested for the trainer and trainer each. The time for the GDSS2 Unit Program Account Manager (UPAM) to adjust the permissions for use is approximate 15 minutes. The total man-hours required to implement the use of ACARS in this process are 1.25 hours per trainee. Considering the time saved from Tables 13 and 14 above, ACARS messaging implementation pays for itself in man-hours in less than one month.

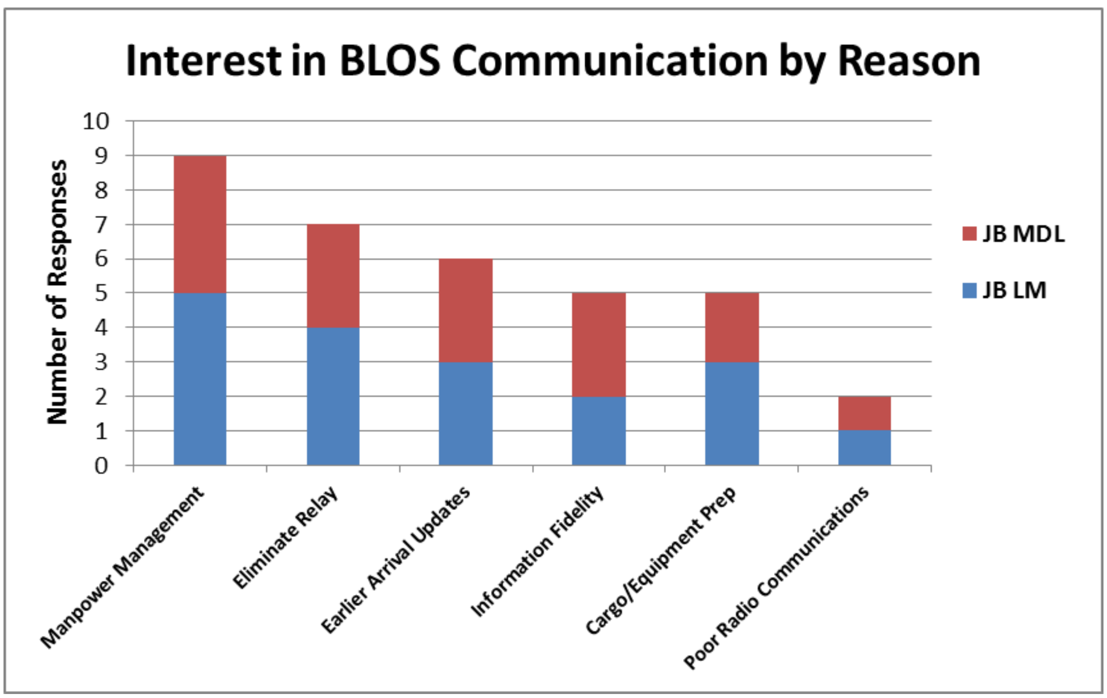
User Preference for BLOS Communication Methods

To answer Research Question 3, SME responses to interview questions were used. During each interview, support agency SME respondents were asked if they were familiar with ACARS. If not, this researcher explained the system and its capabilities and provided examples of its applicability to their process. Once familiarity with ACARS was established, the respondent was asked if they would be interested in using a capability like ACARS messaging. If the respondent was not able to use ACARS messaging because their section does not use GDSS2, they were asked how they would change the process, if at all. If their response indicated interest in the use of BLOS communications by other agencies in the process then the respondent was considered interested. For example, the POL SME respondent's response of wanting more timely updates concerning inbound aircraft from MOC to better coordinate manpower was considered interest because MOC could provide that if using BLOS communication with inbound aircraft.

All of the SME respondents expressed interest in using a BLOS communication capability. Specifically, 18 of the 19 SME respondents from both bases indicated that they were interested in the benefits of using ACARS messaging. The one respondent that was not interested stated that he uses a publically available website that tracks aircraft transponder signals (adsbexchange.com) for updates to arrival times. Since transponder signals are still a BLOS communication capability, this TA respondent is counted as interested. Additionally, the TA respondent stayed that if the public website were taken offline, he would use the GDSS2 C2 messaging function for aircraft arrival updates.

Chart 5 below contains a count of respondents broken down by the reasons they are interested in using BLOS communication methods. There were six main reasons for interest in using BLOS communications methods: opportunity for more deliberate manpower management, elimination of unnecessary information relay, more accurate and detailed information (fidelity), increased arrival notification lead times, opportunity for more deliberate cargo and equipment preparation, and to avoid poor quality radio communications that can lead to relay errors and the need for multiple radio calls. If the respondent gave more than one reason for their interest, that respondent was counted in each of the corresponding reason categories. For example, the PROSUPER's interest in earlier arrival updates and more information fidelity is counted twice, one in each of those categories.

Table 15: Responses by Base for Interest in BLOS Communications



V. Conclusions and Recommendations

Chapter Overview

This research demonstrated that there are efficiencies to be gained by substituting BLOS communications into airbase C2 processes. Additionally, it showed that Airmen within these processes want to use these capabilities. The next section will discuss the interpretation of the research results and recommendations to change guidance and processes to leverage existing communications technology.

Effectiveness of Current Information Flow Process

Research Question 1: Are inbound C-17 arrival notifications made with sufficient lead time and accuracy to support agency preparation and response actions?

Based on the samples taken at each based, up to 8.8% and 57.9% of the lead times for notifications at JB LM and JB MDL, respectively, do not give at least one support agency the time required to adequately prepare for support upon aircraft arrival. At both bases, the highest probability of insufficient lead time is for the cargo handling flight. This can be attributed the SME respondents' estimates of required time to complete load team briefs and MHE inspections prior to departing for the aircraft parking spot. At JB MDL, overall, it is expected that approximately one in every twenty C-17 arrivals will have insufficient notification lead time for most of its support agencies. This estimate excludes TA and Vehicle Ops who are not expected to experience any insufficient notification lead times due to having response time lower that the average C-17 taxi time. Excluding the Cargo Handling Flight, JB LM is expected to have insufficient notification lead time in approximately one in every ten C-17 arrivals. Additionally, support agencies both bases reported various types and degrees of discrepancies in the accuracy of the information passed with nearly half of the agencies requesting that additional information be passed in the initial radio call or relay.

Overall, these results indicate that notifications are not always made with sufficient lead time and accuracy to support preparation and response actions. However, the probabilities discussed above are subject to the judgment of AMC and air base leadership with regards to the acceptable level of insufficient notifications. The decision rests with commanders, in conjunction with their support agency SMEs, as to whether the chance of insufficient lead time warrants adjustment to current processes.

Effectiveness of Proposed Information Flow Process

Research Question 2: How can alternate communication methods reduce process inefficiencies or increase the quality of information passed during this process?

As shown by the hypothetical substitution of BLOS data communication methods into the inbound C-17 notification process, certain process steps, mainly related to oral information relay, can be eliminated while preserving the quality of the information generated by the inbound aircrew. Virtually all relay error is eliminated while increasing the amount of information that can be effectively communicated. At JB MDL, a total of 5 hours of work and 336 unnecessary actions per month can be eliminated. Similarly, at JB LM, a total of 7.8 hours of work and 584 unnecessary actions per month can be replaced with other mission essential tasks.

The cost of implementing this change is low given the existing infrastructure and adequate bandwidth available (M. W. N. Mansker, email communication, November 26, 2018).

The cost of changing the current process is also very low with minor modifications to air base-level operating instructions and a training program that pays for itself in man-hours within one month.

Interest in Using BLOS Data Communications

Research Question 3: Are support agencies interested in using BLOS data communications for C-17 arrival notifications and why?

Based on the results of the interview question analysis, it is clear that each SME interviewed was interested in the potential benefits of using BLOS communications methods such as ACARS messaging. The most prevalent reason among the C2 nodes (CP, MOC, ATOC) was to eliminate unnecessary relay of information. Among agencies at the squadron level, the most prevalent reason was for more lead time and information on inbound C-17s to better manage manpower. It is important to note that while ACARS was used as an example, it is not the only BLOS capability that the SME respondents were interested in. Other aircraft equipment, such as transponders, can provide a flight following capability that can provide near-real-time aircraft position updates that would allow for better management of response preparation actions if authorized to be used for that purpose.

Recommendations for Action

Based on the results, AMC should adopt ACARS as the primary communication method for inbound C-17 notifications and the guidance should be changed to send the inbound notification message prior to descent for real-world and off-station training missions and NLT 30 minutes for local training missions. This will increase lead time of inbound notifications by consistently transmitting the message earlier in the flight profile and it will reduce errors during information relay through multiple agencies by transmitting directly each airbase C2 node. The primary documents to be changed are AFI 11-2C-17V3 and CP Operating Instructions, as well as, business rules within each affect support agency. Aircrews can be directly made aware of the change in primary communication via a Flight Crew Information File (FCIF) from the AMC level.

Additionally, AMC base support agencies should use online communicators such as TransVerse and Skype for Business to relay information to non-GDSS2 users for the following reasons:

1. To reduce information relay errors
2. To reduce the amount of time to relay information
3. Create an asynchronous communication process that does not require the receiver to be present at the workstation to receive the transmission
4. Provide a more efficient means of archiving information

Implementing this change requires minimum man-hours for re-writing support agency level business rules and processes. This change will also require minimal training in and access to the aforementioned software applications.

Finally, airbase-level procedures should be modified to make aircrew cell phones as the primary communication method directly to Vehicle Operations to reduce service time to inbound transportation through more accurate pick-up time estimates and to reduce workload on CP Controllers by eliminating a redundant step. This change requires minimal man-hours for procedure re-write and could be combined with other process-related changes in the aforementioned FCIF but could save as much as 2.6 and 21.6 hours per month at JB MDL and JB LM, respectively. To address OPSEC concerns with personal cell phone use, procedures including brevity codes could be developed. However, considering the short time frame from call to pick up (less than 10 minutes), OPSEC may not be a concern.

Recommendations for Future Research

This research was narrowly scoped but the methodology, analysis, and results could be applied to any AMC airframes and C2 operations that do not yet use BLOS communications methods such as ACARS. Any airframe that has BLOS capabilities stands to benefit from a similar analysis. Elements of the Global Air Mobility Support System (GAMSS), including Contingency Response Forces (CRFs), should consider the findings of this research as well. The operations CRFs participate in are often complex and volatile making any increase in inbound aircraft notification time and accuracy potentially valuable. Implementing ACARS as a primary method of communications in a contingency environment presents information security concerns but none that could not be addressed by using the brevity/code word system that is currently employed with radio transmissions.

Summary

An Airmen’s time is the U.S. Air Force’s most valuable resource. Communications technology enhances each Airman’s situational awareness and productivity. Every effort should be made to ensure these technologies are available and that the appropriate procedures are set in place to maximize their usefulness. This research has shown that using all of the communication technology available can save time and energy that could be used more effectively elsewhere. With relatively small changes to existing publications and a minimal manpower investment for new process training, AMC could better leverage its air base assets and ensure each minute of their Airmen's time is put to good use.

Appendix A

Quad Chart

Straight from the Source: An Analysis of the Inbound Aircraft Notification Process

AIR FORCE INSTITUTE OF TECHNOLOGY

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Abstract

This research evaluates the current C2 information flow processes at the AMC Air Base level. Specifically, the process for relaying inbound C-17 information to support agencies was examined to assess the timing and quality of the information transmitted. Adequacy of the current process will be determined by comparing the average lead time of inbound calls to the time required for support agency preparation and response, and to a limited extent, the accuracy of the information as it is relayed. Subsequently, a future state was proposed that, where applicable, replaces VHF/UHF radio transmissions with Beyond Line-Of-Sight (BLOS) capabilities such as Aircraft Communications, Addressing, and Reporting System (ACARS) similar to the processes used by commercial airline operations centers. The results indicate that, while the radio transmissions are adequate for most responding support agencies, using BLOS communications in the inbound C-17 notification process can eliminate redundant communications and increase notification lead time. The results also revealed that the Subject Matter Experts (SMEs) are interested in the benefits of BLOS capabilities, like ACARS, for several reasons including better scheduling and utilization of manpower and resources.

Research Questions

1. Are inbound C-17 arrival notifications made with sufficient lead time and accuracy to support agency preparation and response actions?

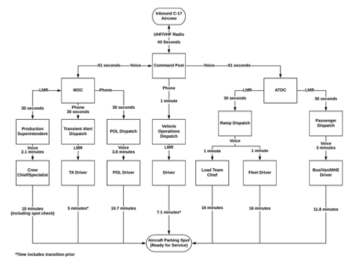
1a. What are the lead times for arrival notifications at the sample bases and how do they compare to the 30-minute standard?

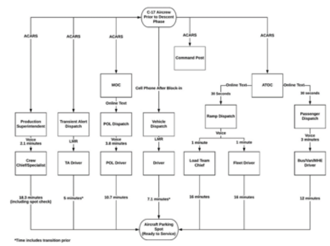
1b. How much time do support agencies require to respond to C-17 arrivals?

1c. Is the information passed sufficient for support agency preparation to service the inbound C-17?

2. Can alternate communication methods reduce process inefficiencies or increase the quality of information passed during this process?

3. Are support agencies interested in using beyond-line-of-sight (BLOS) data communications for C-17 arrival notifications and why?





	JB MDL		JB LM	
Response Function	Response Time (minutes)	% of Insufficient Lead time	Response Time (minutes)	% of Insufficient Lead time
AMXS	14.2	6.4%	6.6	1.8%
TA	7.1	0%	9.5	4.7%
Vehicle Ops	8.8	0%	8.4	3.4%
POL	16.6	7.6%	14.9	18.7%
Cargo Handling	18.1	8.8%	22.5	57.9%
Passenger Terminal	17.1	7.9%	16.5	25.4%
Fleet Service	Combined with Cargo Handling	N/A	10	5.6%

	Per Inbound Notification		Per Month (based on average 84 inbound C-17s)	
	Time Saved	Actions Eliminated	Time Saved	Actions Eliminated
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MOC	30 seconds	1	42 minutes	84
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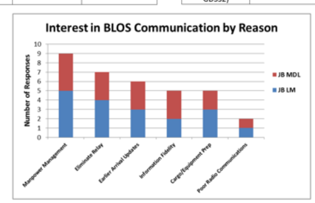

Methodology and Analysis

1. Semi-structured interviews were used to collect process information and SME preferences from alternate communication methods. Process time data was solicited during the interview and collected during follow-up communication.
2. Lead time information was collected from each base Command Post. Each base's data was organized and analysed using an Excel add-on called XLStat. Using the model-fitting function of XLStat, a distribution model was assigned to each base's lead time data set that was used to determine the probability of an inbound C-17 radio call occurring within a specified period of time.
3. Information flowcharts were created using the interview data and time data from follow-up communications. Each transition between entities was assigned a representative time based on a combination of the time data and SME preferences. The flowcharts were compared to the distribution models to determine the probability of inadequate lead time.
4. A BLOS communication method, ACARS, was substituted in the flowcharts to determine the amount of time and actions saved by the substitution.
5. SME interest in using BLOS communication methods was analyzed and grouped into reasons for their interest.

Recommendations

1. Institute ACARS as the primary communication method for transmitting inbound notification methods prior to descent or 30 minutes whichever occurs first.
2. Substitute online communicators, such as Transverse and Skype for Business, into processes in the place of legacy equipment such as phones and radios.
3. Initiate aircrew transportation requests directly to Vehicle Operations via cell phone.

Appendix B

Interview Questions

1. What is your role in coordinating/providing service to inbound C-17As?
2. What are the steps from notification to arriving at the aircraft?
3. What systems do you use to receive/send inbound aircraft information?
4. How long does each step take, conservatively (worst case) and on average?
5. What information is passed and do you think it is enough? If not, what information would you like to see passed?
6. Are you familiar with ACARS/GDSS2? Would you be interested in using it to communicate requirements?
7. What would you change about this process?

Appendix C

Excel Lead Time Tracker Example

Date	Mission Type	Ground Ops?	Call In Time	Block In Time	Lead Time	A-Status and Notes (If applicable/desired)				

Excel AMXS Time Tracker Example

AMXS Process Time and Information Tracker

		Times					Information	
Date	Tail Number	MOC Call to Pro Sup	Pro Sup Pass to Expeditor	Expeditor Pass to CC/Spec	CC/Spec to CTK	CC/Spec to Parking Spot	A-Status Passed by MOC	A-Status from Aircrew at Debrief
4-Sep-18	10-0213	1200	1202	1205	1210	1215	A-1	A-3 for GEN 3 Oil on WAP

Appendix D

Standard Normal Distribution (Z-Score) Table

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
–3.4	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0002
–3.3	.0005	.0005	.0005	.0004	.0004	.0004	.0004	.0004	.0004	.0003
–3.2	.0007	.0007	.0006	.0006	.0006	.0006	.0006	.0005	.0005	.0005
–3.1	.0010	.0009	.0009	.0009	.0008	.0008	.0008	.0008	.0007	.0007
–3.0	.0013	.0013	.0013	.0012	.0012	.0011	.0011	.0011	.0010	.0010
–2.9	.0019	.0018	.0018	.0017	.0016	.0016	.0015	.0015	.0014	.0014
–2.8	.0026	.0025	.0024	.0023	.0023	.0022	.0021	.0021	.0020	.0019
–2.7	.0035	.0034	.0033	.0032	.0031	.0030	.0029	.0028	.0027	.0026
–2.6	.0047	.0045	.0044	.0043	.0041	.0040	.0039	.0038	.0037	.0036
–2.5	.0062	.0060	.0059	.0057	.0055	.0054	.0052	.0051	.0049	.0048
–2.4	.0082	.0080	.0078	.0075	.0073	.0071	.0069	.0068	.0066	.0064
–2.3	.0107	.0104	.0102	.0099	.0096	.0094	.0091	.0089	.0087	.0084
–2.2	.0139	.0136	.0132	.0129	.0125	.0122	.0119	.0116	.0113	.0110
–2.1	.0179	.0174	.0170	.0166	.0162	.0158	.0154	.0150	.0146	.0143
–2.0	.0228	.0222	.0217	.0212	.0207	.0202	.0197	.0192	.0188	.0183
–1.9	.0287	.0281	.0274	.0268	.0262	.0256	.0250	.0244	.0239	.0233
–1.8	.0359	.0351	.0344	.0336	.0329	.0322	.0314	.0307	.0301	.0294
–1.7	.0446	.0436	.0427	.0418	.0409	.0401	.0392	.0384	.0375	.0367
–1.6	.0548	.0537	.0526	.0516	.0505	.0495	.0485	.0475	.0465	.0455
–1.5	.0668	.0655	.0643	.0630	.0618	.0606	.0594	.0582	.0571	.0559
–1.4	.0808	.0793	.0778	.0764	.0749	.0735	.0721	.0708	.0694	.0681
–1.3	.0968	.0951	.0934	.0918	.0901	.0885	.0869	.0853	.0838	.0823
–1.2	.1151	.1131	.1112	.1093	.1075	.1056	.1038	.1020	.1003	.0985
–1.1	.1357	.1335	.1314	.1292	.1271	.1251	.1230	.1210	.1190	.1170
–1.0	.1587	.1562	.1539	.1515	.1492	.1469	.1446	.1423	.1401	.1379
–0.9	.1841	.1814	.1788	.1762	.1736	.1711	.1685	.1660	.1635	.1611
–0.8	.2119	.2090	.2061	.2033	.2005	.1977	.1949	.1922	.1894	.1867
–0.7	.2420	.2389	.2358	.2327	.2296	.2266	.2236	.2206	.2177	.2148
–0.6	.2743	.2709	.2676	.2643	.2611	.2578	.2546	.2514	.2483	.2451
–0.5	.3085	.3050	.3015	.2981	.2946	.2912	.2877	.2843	.2810	.2776
–0.4	.3446	.3409	.3372	.3336	.3300	.3264	.3228	.3192	.3156	.3121
–0.3	.3821	.3783	.3745	.3707	.3669	.3632	.3594	.3557	.3520	.3483
–0.2	.4207	.4168	.4129	.4090	.4052	.4013	.3974	.3936	.3897	.3859
–0.1	.4602	.4562	.4522	.4483	.4443	.4404	.4364	.4325	.4286	.4247
–0.0	.5000	.4960	.4920	.4880	.4840	.4801	.4761	.4721	.4681	.4641

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14. ABSTRACT
This paper evaluates the current C2 information flow processes at the Air Base level. Specifically, the process for relaying inbound C-17 information to support agencies was examined to assess the timing and quality of the information transmitted. Adequacy of the current process will be determined by comparing the average lead time of inbound calls to the time required for support agency preparation and response, and to a limited extent, the accuracy of the information as it is relayed. Subsequently, a future state was proposed that, where applicable, replaces VHF/UHF radio transmissions with Beyond Line-Of-Sight (BLOS) capabilities such as Aircraft Communications, Addressing, and Reporting System (ACARS) similar to the processes used by commercial airline operations centers. The results indicate that, while the radio transmissions are adequate for most responding support agencies, using BLOS communications in the inbound C-17 notification process can eliminate redundant communications and increase notification lead time. The results also revealed that the Subject Matter Experts (SMEs) are interested in the benefits of BLOS capabilities, like ACARS, for several reasons including better scheduling and utilization of manpower and resources.

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