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Information System Availability Status and its impact on Customer Wait Times

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THESIS

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Abstract

Waiting is universally recognized as a form of waste. Between 1 October 2010 and 31 March 2011, the Department of Defense Inspector General identified 193 million dollars in wasteful spending (af.mil, 2014). Waste is identified as a potential problem that drains significant resources and robs taxpayer dollars of their intended purposes (af.mil, 2014). Waiting occurs for various reasons, such as demand exceeding system capacity. Relatively few studies have focused on information system availability status and its potential impact on operations. The Military Personnel Flight relies on Air Force Information Systems, specifically the Defense Enrollment Eligibility and Reporting System (DEERS), to manage the personnel records. When DEERS experiences a failure, then the operational ability of the Military Personnel Flight is affected. This study aims at identifying the impact Air Force information system's availability status has on customer wait times using linear regression.

Acknowledgments

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Joshua A. Cramer

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INFORMATION SYSTEM AVAILABILITY STATUS AND ITS IMPACT ON CUSTOMER WAIT TIMES

I. Introduction

1.1 Motivation/Background

Waiting is an everyday occurrence experienced by anyone consuming products or utilizing a service (Pamies et al., 2016). Common locations most Americans are familiar with waiting are the Department of Motor Vehicles, grocery stores, or the airport. It is estimated that Americans spend roughly 37 billion hours each year waiting in line (Pamies et al., 2016). Time is a finite resource. There are only so many hours in the day to be productive spending wasted time waiting is frustrating and a missed opportunity for something more productive. In the commercial industry, customers have choices of where they choose to shop or receive a service. If a customer enters a queue, they might notice long waiting lines as well as the delay. Customers can also renege or break the queue and take their business elsewhere (DeVries et al., 2018). Customers at a restaurant may balk at long waiting times and take their patronage to another facility. Members of the armed forces do not have this same opportunity to expedite service. Members of the Air Force have a single consolidated location on their military installation that performs certain services depending on the need.

The Military Personnel Flight (MPF) is the centralized location on an Air Force installation that is responsible for managing personnel records for all individuals assigned to the base and retirees in the surrounding service area. The Military Personnel Flight performs several routine activities for customers, including but not limited to assignments, common access card (CAC) issue, retiree identification card issue, dependent identification issue, and retirements. Central to these activities is the information system utilized by the Department of Defense to manage individual information: the Defense Enrollment Eligibility Reporting System (DEERS). DEERS provides the source data for many sub-information systems such as the Real-Time Automated Personnel Identification System (RAPIDS), which is used to schedule and issue military identification cards.

Airmen and Civilian employees assigned to the MPF rely on the different information systems implemented by the Department of Defense to perform their duties. When the information systems are unreliable and fail, customers can feel the effects of waiting for a service to be performed. Often in customer service center locations, the frustration of long wait times is then projected from the customer onto the support staff, even though these employees often have little to no control for the availability of information systems. Customers typically visit MPFs to perform a transaction which can be categorized as a service type. Examples include producing a new ID card or updating dependents in DEERS for benefits. When our information systems are unavailable, the transaction cannot take place as intended. There are impacts that range from minor to extreme if this customer's transaction cannot take place. All Active-Duty military members are issued a Common Access Card with an encryption certificate that authenticates their access to information systems. Military doctors rely on their CAC to authenticate patient records to provide care. Additionally, without access to patient information systems, they cannot access critical health information, degrading the operational ability of that provider.

Cornman (2021) created a simulation model to optimize the number of personnel and ID card terminals to minimize customer wait times. The model was built using data collected from Langley Air Force Base's Military Personnel Flight. Cornman (2021) did not include what, or if any, impact unreliable information systems had on customer wait times. The assumption made was all information systems would operate as they are intended to do so. The simulation model provides a baseline understanding of equipment and manpower requirements needed to perform day-to-day operations. By looking at historical data, information systems have not always been available or reliable. Therefore, the model used to predict optimal levels of manpower and equipment must consider the reliability of the information system. The motivation for this study is to identify through linear regression, whether there is a correlation between information system availability status and customer wait times at the MPF.

1.2 Problem Statement

The Military Personnel Flight is the consolidated location on the military installation for all personnel actions. Customers can either make an appointment or walk-in to the MPF when a transaction must occur. Prior academic manpower studies have examined the appropriate level of equipment and manpower to reduce the wait times customers experience when visiting the MPF. Little attention has been given whether information systems availability status have a significant impact on customer wait times. The purpose of this study is to determine the statistical significance our information systems have on day-to-day operations at the MPF and the impact on customer wait times.

1.3 Research Question

What impact does Air Force information system availability status have on customer waiting times?

II. Literature Review

Chapter Overview

The review of relevant literature exposed a gap in studies aimed at identifying the impact of unreliable information systems on waiting times. There has been limited research into the relationship between information system availability and its effect on customer waiting times.

Research on this relationship is dynamic in the Department of Defense. Unlike much of the prior studies conducted on customer waiting times, this research focuses on identifying the significance of information systems reliability and how the availability of those systems impact customer waiting times not the customer service experience.

There were patterns in the literature that was evident during the literature review. Many studies have been accomplished on waiting times from a customer service level perspective but not from an operational impact perspective. We have highlighted a few of those previous studies of waiting time impacts below and how those studies differ from this one.

Waiting Times

Several studies have examined the relationship between waiting times and customer satisfaction. Prior studies have defined waiting as the time a customer is ready to receive a service, until the time the service commences (Pamies et al., 2016). For example, at a restaurant, the time a customer enters the facility and gives their name to the host/hostess, until the time they are seated would be considered waiting time. Waiting occurs when the demand for a service outpaces the supply (Pamies et al., 2016). This is something managers work aggressively towards reducing since the wait time is often treated as ancillary to the core service experience (McGuire et al., 2010).

Purnell (1995) developed a questionnaire that was sent to hospitals across the United States to explore waiting times by hospital type (public or private). The study analyzed waiting times in the emergency departments at the hospitals. Purnell (1995) analyzed the data for average waiting times between the two different types and whether other variables factored into increased waiting times such as the skill mix at those hospital locations. Predictably, as the demand increased for the emergency department, so did the waiting times (Purnell, 1995). While hospitals have various reasons to explain waiting times, their operations are different from those of the Military Personnel Flight. The emergency department relies on policy to determine a priority system on how to triage patients properly. The Military Personnel Flight does not prioritize their customers but rather makes appointments with the allowance of walk-ins. This study focuses on analyzing secondary data provided by the Military Personnel Flight not capturing survey responses on what causes waiting times.

McGuire et al. (2010) studied waiting times from a customer satisfaction perspective. The finding was that as perceived waiting times increased, satisfaction decreased. Additionally, the study concluded that customers tended to overestimate wait times (McGuire et al., 2010). This overestimation called perceived waiting duration was only one of several psychological factors that waiting times had on customers during their service experience. Psychologists have suggested that waiting is bad because it wastes time, takes control away from customers, creates boredom, leads to feelings of crowding and neglect, and delays gratification (McGuire et al. 2010). Davis & Vollmann (1990) used factor analysis and regression analysis to compare the relationship between waiting times and customer service experience. Factor analysis was used to survey customer satisfaction responses. The responses were then consolidated into a single customer satisfaction index (Davis & Vollmann, 1990). With customer satisfaction defined, their study used regression to analyze the significance between the independent variables from the index and the dependent variable of waiting time. The result was the longer a customer waits, the less satisfied they became with a service. Although both studies highlight the negative psychological impacts waiting times have on customer satisfaction, the purpose of this study is not to measure customer service satisfaction levels but to the statistical significance that information systems can have on waiting times.

Kokkinou & Cranage (2013) studied whether adding self-serving technologies, particularly self-serving kiosks to a service delivery process could lower customer waiting times. Their study used queuing theory and simulation to examine whether the addition of kiosks would facilitate faster check in times and ultimately lead to lower customer waiting times. The results of the study showed no significance between the mean of the current customer check in process and the new process where a representative was replaced by a self-serving kiosk. Kokkinou & Cranage's study is similar in how the Military Personnel Flight enters customers into their queue. There are customer service representatives at the front desk but there is also a self-serving kiosk should customers prefer to sign in on their own. The difference between Kokkinou & Cranage's study and this study is theirs focused on customer waiting times as a performance measure of service levels. The study does not analyze the customer experience aspect of customer waiting times but the linear relationship between information system availability and customer waiting times.

Guiffrida & Messina (2009) took a different approach towards studying customer waiting times. Instead of studying customer waiting times as a performance measurement of service, their study addressed the management and control of customer waiting times from a systems theory perspective (Guiffrida & Messina, 2009). Using general systems theory, the service process is viewed as an overall operation that consists of a series of smaller integrated subunits (Guiffrida & Messina, 2009). The paper's major contributions were developing a model that incorporates the variability in customer waiting time at the individual subunit level of the service process into an overall measure of system-wide customer waiting times. My study is different from theirs in the fact this study focuses singularly on the waiting times customers experience while physically present at the Military Personnel Flight and not the totality of time customers waiting for a service. For example, you hire a contractor to replace your front entry way. Each step in the process may have waiting times. Waiting for the initial sales quote, production of the door, and installation are all subunits of the waiting experience. Guiffrida & Messina's study addressed these waiting time subunits in terms of waiting variability and the associated costs. My study does not focus on the costs aspects of ensuring information system availability but the direct impact that is experienced when those systems are not available for use.

Reliability/Availability

Waiting times are one negative impact created by unreliable information systems. Research in reliability and maintainability developed within engineering disciplines as a natural consequence of increasing complexity in system designs and requirements. For the purposes of this research, we define reliability as "the probability that a component or system will perform a required function for a given period of time when used under stated operating conditions"

(Ebeling, 2019: p.5). Further, our definition of maintainability is “the probability a failed system or component will be restored or repaired to a specified condition within a period of time when maintenance is performed in accordance with prescribed procedures” (Ebeling, 2019: p.6). Despite the importance of data management, there are few studies that specifically study data management, reliability, and maintainability.

Previous studies define the availability of information systems and the importance of those systems to operations. Bajgoric & Ibrahimovic (2016) used a modified Bayesian Belief Network Model to predict information system availability. Their study modeled several dimensions of information system availability and the probability of each of those dimensions have on the total availability of the system. They defined availability was expressed as the ratio of the time in which the system was available in relation to the total time. Their model was validated using a Monte-Carlo simulation with experts from the financial sectors of Bosnia and Herzegovina. Their study was more focused on the dimensions of information system availability impact on total system availability. This study does not seek to examine what causes information system availability but rather the linear relationship between customer waiting times and information system availability.

Powerful information systems have been introduced into both civilian and military information systems and the dependability of these systems to perform as designed is a major concern (Knight et al., 2003). Dependability is a system property that is usually states as a set of requirements (Knight et al., 2003). Under the dependability umbrella, there are many facets that have been used to describe dependability. Those include reliability, availability, and survivability each with a term that has a precise meaning. Knight et al. (2003) studied the various definitions for information survivability and found a definition from previous work. Survivability is the ability of a network computing system to provide essential services in the presence of attacks and failures, and recover full services in a timely manner (Knight et. al, 2003). The study performed by Knight et al. (2003) was from a system survivability perspective and not reliability or availability like this study. This study does not focus on information system resilience and recovery time but rather the impact on customer waiting times due to an unavailable resource.

Wang et al. (2018) proposed a quantitative reliability test method for information systems. Their research categorized computer information systems into hardware and software categories and identified the subcomponents for each category. The software reliability model inspected the working condition of each subcomponent. The model described the working condition of each item and was used to estimate the probability that the product will run specified software configuration items during the execution of a task (Wang et al., 2018). The study by Wang et al. (2018) focused on reliability testing an information system and how to determine overall reliability levels of that system. For this study, the focus is not on if an information system is reliable or not. The research question focuses on the operational impact that occurs when information systems fail in the United States Air Force.

III. Methodology

3.1 Overview

The purpose of this chapter begins by explaining the data collection procedures in this study. The chapter then discusses the assumptions and limitations of the data before describing the statistical analysis. The chapter finishes by discussing the uses of the statistical analysis for the study and how they are applicable models.

3.2 Data Collection

The 88th Military Personnel Flight utilizes a subscription-based service called Queue Kiosk to facilitate the day-to-day queuing of customers in the lobby. When a customer arrives to the Military Personnel Flight, they enter the queue in one of two ways. There is a self-service kiosk that allows customers to join the queue without interfacing with a customer service representative or the customer can speak to a representative if they so choose. Upon entering the queue, customers are serviced according to the scheduled appointment first before any walk-in customers are to be serviced.

The secondary data provided from the Military Personnel Flight was pulled directly from the Queue Kiosk website that allows authorized users the ability to generate reports based on specified parameters. The timeframe for this study is 1 January 2022 through 11 July 2022. The report generated had 14, 465 rows of data. Each row on the data set is a representation of a customer seen by the Military Personnel Flight. One important fact is on several occasions multiple individuals are serviced under one appointment time slot. An example would be a family of four all needing updated ID cards. The service member can schedule an appointment time for themselves and under that appointment, the entire family is serviced a new ID card. The data set also includes other key pieces of information such as time of arrival, time services begin, time services are completed, service type, and customer representative that performed the service. The 88th Military Personnel Flight began tracking DEERS system outages 1 January 2022 and provided the list of days that a system wide outage occurred with the data set.

After collecting all the data from the Military Personnel Flight, we tried to identify potential outliers. There were several observations identified as potential outliers. One example was an individual was sitting in the queue for 21,253 minutes. Considering there were only 1,440 minutes in a day, there was an obvious error that the customer did not spend several days sitting in the lobby waiting to be serviced. The data set included qualitative data in the form of technician notes. The Military Personnel Flight is open for customers from 0730-1630 Monday through Friday. For this study, any observation that exceeded 60 minutes was flagged as a possible outlier. Using the qualitative data provided by the technician notes, any observation that could not be justified through their remarks was removed from the data set. An example of this occurrence was a customer displayed a waiting time of 21,253 minutes.

There were 17 different types of services that were recorded within the data set. The Military Personnel Flight is broken up into different specialized sections that handle different types of personnel actions. Due to this consolidation of manpower, the service types recorded in the data set were grouped into 9 different service types.

The assignment of each type is:

Table 1. List of Functions Performed by Military Personnel Flight

Legend	
1	Assignments
2	CAC Card Issue
3	CAC PIN Reset
4	Civilian Retiree Card
5	DEERS Update
6	Military Retiree or Dependent ID
7	Passport/Visa
8	Retirement
9	Other

3.3 Linear Regression

Linear regression is a method for investigating relationships between two variables that may date back to over 100 years ago (Yan & Su, 2009). The term regression describes the statistical relationship between variables (Yan & Su, 2009). In particular, the simple regression model is the regression method to discuss the relationship between one dependent variable (y) and one independent variable (x) (Yan & Su, 2009). The first mathematical model for linear regression used in this study is expressed as the following:

$$y = a + \beta X_1 + \varepsilon \qquad \text{Equation 1.}$$

y = dependent variable (Waiting Time)

a = intercept

β = coefficient for independent variable

X_1 = independent variable (DEERS Outage)

ε = error term

For this study, the independent variable is when DEERS experiences a failure and is classified as a DEERS Outage using 0 or 1. The dependent variable is customer waiting times in minutes.

Linear regression is a statistical tool that can be useful in making predictions. The common difficulty to the development of reliable forecasts is the determination of sufficient and necessary information to make a good prediction (Bianco et al., 2009). Using a multiple regression model, variables that had high correlation factors to the dependent variable of energy consumption could be forecasted more accurately.

In an effort to find variables that contributed to waiting times at the Military Personnel Flight another linear regression model was ran with an additional independent variable added. The additional independent variable added was a binary variable described as 1 for CAC renewal and 0 all other transaction service types. The second linear regression model can be expressed as:

$$y = a + \beta X_1 + \beta X_2 + \varepsilon \qquad \text{Equation 2.}$$

y = dependent variable (Waiting Time)

a = intercept

β = coefficient for independent variable

X_1 = independent variable (DEERS Outage)

X_2 = independent variable (CAC Renewal or Other)

ε = error term

3.4 Assumptions and Limitations

The wait times calculated from queue kiosk began tracking customer wait times from the moment they entered the queue, either through the kiosk or a representative signed them in until they were seen by a technician. There were several instances where a customer would arrive 45 minutes before their scheduled appointment time and were seen right at the scheduled time. The Military Personnel Flight schedules appointments in 15-minute increments to allow for variation in servicing times depending on the customers' needs. There are just enough DEERS terminals and employees to handle the scheduled appointments and possibly a walk in once that scheduled appointment is completed. By allowing customers to sign into the kiosk and start generating wait times, there was misrepresentation of wait times. During the first analysis of the data provided by the Military Personnel Flight, it was noted that customers were arriving well ahead of their scheduled appointment time. When customers would arrive early and enter the waiting queue, their waiting times were accruing more time than what is truly appropriate. The Military Personnel Flight has a policy to allow customers to sign in 5 minutes early before their scheduled appointment for wait time tracking. Anything before that 5 minute is not calculated in the wait time because the customer arrived well ahead of a scheduled time. This rule did not apply to walk in customers only those with appointments. A formula was built into the model producing an adjusted wait time that allows appointment customers five-minute early arrival time to be calculated into their wait time experience.

The main limitation for this study is utilizing the readily available data on DEERS outages. The 88th Military Personnel Flight at Wright Patterson AFB, OH began recording DEERS outages on a local tracker to highlight the frequency of this system failing to their leadership. Customer complaints were on the rise and the Military Personnel Flight did not have data to back up their claims that DEERS outages were affecting their operations. The Military Personnel Flight only recorded full system failures not anytime there was a degradation in the system’s capability. Due to this limitation, the independent variable for DEERS outages was placed in a binary GO/NO-GO represented by 0 for no failure and 1 for failure. There were instances where certain transaction types could still be performed even though DEERS had experienced issues. An example was a customer could perform a CAC pin reset on a local terminal in the Military Personnel Flight since DEERS was not necessary for that service type.

IV. Results and Analysis

4.1 Chapter Overview

In this chapter we discuss the results from the linear regression model as well as using the Independent t-test against the data set provided by the Military Personnel Flight.

4.2 Descriptive Statistics

Table 2. Descriptive Statistics for Waiting Time

	Mean	Median	Mode	s	s^2	Range	Min	Max	n
Wait Times	24.7	13	1	204.53	41,833.81	21,253	0	21,253	14,665

Table 2 provides the descriptive statistics for the full data set provided by the Military Personnel Flight. The average waiting time before removing outliers and limiting the amount of time customers are allowed to enter the queue is 24.7 minutes.

Table 3. Descriptive Statistics for Adjusted Waiting Time

	Mean	Median	Mode	s	s^2	Range	Min	Max	n
Wait Times	15.91	9	0	21.48	461.58	294	0	294	14,631

Table 3 provides the descriptive statistics for the data set once outliers and customer arrival times were adjusted. By removing errors from the data set and only counting 5 minutes of early arrival towards waiting time, the average wait time was 15.91 minutes. The average waiting time can be used as a benchmark for anticipating how long customers can expect to wait in the lobby at the Military Personnel Flight. The variance to mean ratio was large indicating variability in the data set is very high.

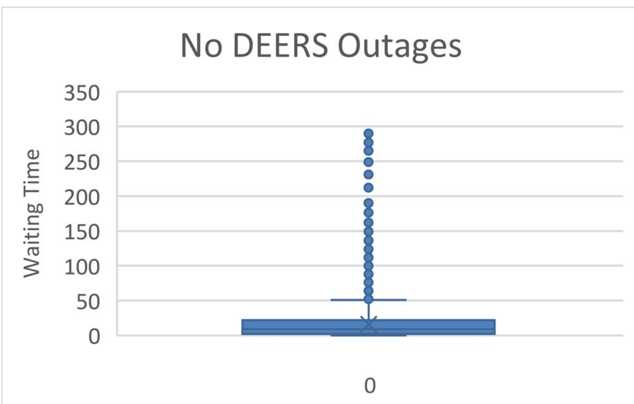

Figure 1. Box Plot Kiosk Data

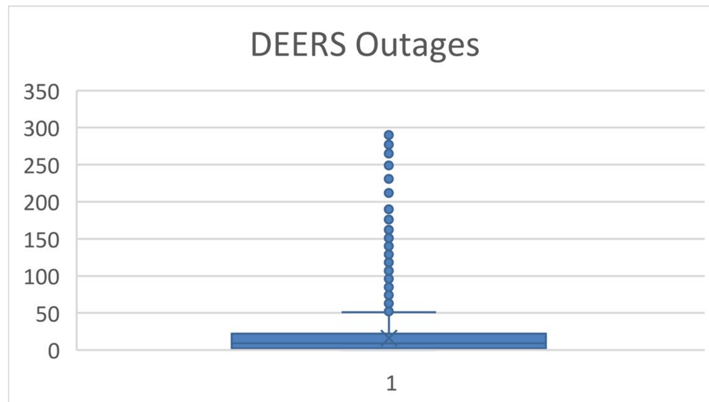

Figure 2. Box Plot Adj Wait Times

Figure 1 and 2 represent the two populations no DEERS outages and DEERS outages in box plot visual representation. Both box plots visually depict the majority of observations occurring within the interquartile range with long upper tails indicating the existence of extreme values for waiting time.

4.3 Service Type Count

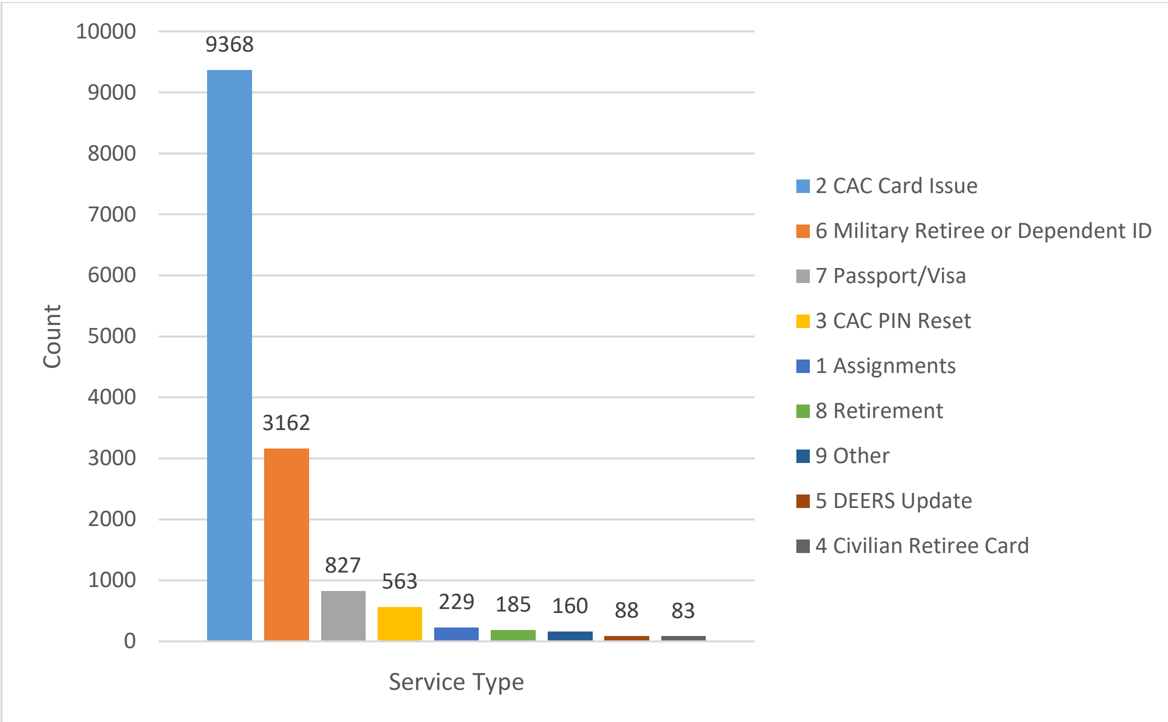

Figure 3. Service Type Count

Figure 3 provides a visual breakdown of the different types of services provide by the Military Personnel Flight in the data set. The two largest service types performed deal with common access card disbursement actions and require sponsors presence at the time of service.

4.4 Independent T-Test Results

The independent t-test is an inferential statistical test that determines whether there is a statistically significant difference between the means in two unrelated groups. For this study's independent t-test, the data was divided into two groups of subjects. The first group is those serviced without experiencing a DEERS outage. That group is represented with a 0. The second group was subjected to a DEERS outage and represented by a 1.

The resulted p-value was significantly smaller than our test alpha of .01, indicating the results were significant. Therefore, we rejected the null hypothesis that the means between the two groups were equal. We accepted the alternate hypothesis that the groups had different average wait times and that it was statistically significant.

4.5 Linear Regression Results

Both linear regression models were performed using R studio and Excel. The original linear regression model was ran with DEERS outages as the independent variable and Waiting Times as the dependent variable. The R-squared value for the orginanl regression model was 4.3%. The 4.3% R-squared value was from the independent variable DEERS outages described in binary form. The analysis of variance (ANOVA) p-value was 3.92E-141 which is significantly smaller than the test alpha .01. Therefore we rejected the null hypothesis for the ANOVA test that the means of the two groups were equal.

The original linear regression model's p-value for DEERS Outages was 3.9E-141 making the results significant. From these results, we failed to reject the null hypothesis that DEERS outages affected customer wait times at the Military Personnel Flight. From the linear regression model, the formula for waiting times was expressed as:

$$\text{Waiting Time} = 14.65 + 16.89X_1 \qquad \text{Equation 1}$$

The independent variable DEERS Outages was expressed as binary 0 or 1. The DEERS Outage coefficient multiplied by 0 or 1 represented the mean for the two populations from the data set. Those that were serviced during a DEERS Outage and those that were service with no DEERS Outage. For formula interpretation, the intercept 14.65 is the average waiting time for the group with no DEERS outages from the data set. The coefficient for the independent variable DEERS outages was 16.89. The independent variable was a binary variable represented by 0 or 1. When there were no DEERS outages, the coefficient was multiplied by 0 resulting in the average. When there were DEERS outages, the coefficient was multiplied by 1 resulting in an additional waiting time of 16.89 minutes.

In an effort to identify other possible variables that impacted waiting times at the Military Personnel Flight, a second regression model was performed adding the independent variable CAC renewals. The added independent variable was a binary variable where 1 represented CAC renewal services and 0 represented all other service types. The R-squared from the second regression model was also 4.3% due to the binary representation of both independent variables. The analysis of variance (ANOVA) p-value was less than .001 which was also significantly smaller than the test alpha .01. Therefore, we also rejected the null hypothesis for the ANOVA test that the means of the two groups were equal.

The second regression model's p-values for the independent variables were 3.9E-141 for DEERS outages and 0.06 for CAC renewal. The p-value for DEERS outages again was significant at the test alpha of .01. The CAC renewal p-value however was not significant at .01. The significance level was between .05 and .10 indicating a marginal level of significance. The intercept for the second regression model was 15.09 and the coefficients for the two independent variables were 16.88 DEERS outages and -0.0679 for CAC renewal. The mathematical model can be represented as follows:

$$\text{Waiting Time} = 15.09 + 16.88X_1 - 0.0679X_2 \qquad \text{Equation 2}$$

There are multiple calculations of waiting time depending on the condition. If customers experienced a DEERS outage then a 1 is multiplied by the coefficient 16.88 otherwise if no outage occurred it would be 0. The second variable CAC renewal is dependent on transaction type. If the transaction was a CAC renewal then we multiplied the coefficient -0.0679 by a 1, otherwise all other transaction types were multiplied by 0. The negative coefficient for CAC renewal indicated CAC renewal customers waited less than all other transaction types. The Military Personnel Flight has dedicated terminals for CAC renewals. It is possible these services are processed faster than other service types which led to the lower waiting time.

4.6 Discussion

The previous thesis study built a simulation model that would identify the optimal level of DEERS terminals and personnel to make operations as efficient as possible at the Military Personnel Flight. That model however was built in with the assumption that information systems are 100% reliable and operate as designed all the time. From the data set collected by the 88th Military Personnel Flight, it is obvious that assumption is not accurate. This study utilized linear regression and an independent t-test to determine whether DEERS reliability was statistically significant and what the impacts were on customer waiting times. Chapter 5 discuss suggestions for future research ideas that could help identify the variables that impact waiting times the most significantly.

V. Conclusions and Recommendations

5.1 Chapter Overview

The purpose of this chapter is to summarize the results from this study and provide recommendations for future research to continue the analysis of the Military Personnel Flight and the factors that impede their ability to operate as effectively as possible.

5.2 Conclusion

The purpose of this study was to analyze the impact of Air Force information systems on the customer wait times at the Military Personnel Flight. The Air Force uses dozens of information systems throughout the many different Air Force Specialties. For this study, the information system of concern was the Defense Enrollment Eligibility and Reporting System (DEERS) and what the impact on customer wait times were in the case of a failure. For this research, we defined a failure as the system either working normally as designed or was inaccessible to the end user. The data set collected by the 88th Military Personnel Flight, included 14,665 observations or transactions that occurred between 1 January 2022 and 11 July 2022.

Using linear regression, we were able to prove that DEERS outages have a significant impact on the customer waiting times at the Military Personnel Flight. The p-value for DEERS outages was significant at $\propto = 0.01$. Often the Military Personnel Flight has been criticized for lengthy waiting times and challenges from customers to make an appointment. The literature review of this study failed to find a study that focused on finding the impact of information system availability status on daily operations. The simple method of linear regression was able to identify significance in waiting times at the Military Personnel Flight, which affected customer service. In the civilian industry, poor customer service leads to loss of revenue and ultimately loss of customer loyalty.

The result of an independent t-test further concluded that the average waiting time was affected by DEERS outages. For this study, there were two separate groups in the data. The first group was identified with a zero and were not subjected to a DEERS outage. The second group was identified with a one and was subjected to a DEERS outage. The group that was serviced on days with a DEERS outage waited on average 17 minutes longer than the group that did not have any failures. The p-value for our t-test was lower than our significance level of .01 confirming that the means of the two groups were from different populations.

5.3 Limitations

The main limitation for this study is utilizing the readily available data on DEERS outages. The 88th Military Personnel Flight at Wright Patterson AFB, OH began recording DEERS outages on a local tracker to highlight the frequency of this system failing to their leadership. Customer complaints were on the rise and the Military Personnel Flight did not have data to back up their claims that DEERS outages were affecting their operations. The Military Personnel Flight only recorded full system failures not anytime there was a degradation in the system's capability. Due to this limitation, the independent variable for DEERS outages was placed in a binary GO/NO-GO represented by 0 for no failure and 1 for failure.

5.4 Recommendations for Future Research

To fully quantify how failures affect wait times, more data can be collected from the information system owner that includes any type of degrade in the system. This study focused on failures as a go/no-go status. There are times when DEERS is degraded, and certain services can still be performed. A multiple regression model can be built with different independent variables against the dependent variable of waiting time to see the impacts degradations have on wait times. Once the additional variables have been identified as having the most significant impact on wait times, an enhanced simulation model that includes the failure rates of those variables can help identify optimal levels of personnel and DEERS terminals for optimal efficiency.

5.5 Summary

This study provided valuable insight to the 88th Military Personnel Flight and the impact that DEERS outages have on customer wait times. No prior study has been performed that identified the statistical significance of information system failures and what the impacts are on customer wait times. The Military Personnel Flight is the consolidated location on military installations with the responsibility of updating personnel records, performing personnel actions, and issuing identification cards. Waiting times are more than just a personal inconvenience. As stated previously in this study, all military and DOD civilians working on the installation use the Common Access Card to access other information systems for their duties. When a doctor's ID card fails and needs a replacement, the Military Personnel Flight relies on DEERS to issue that card. If that system fails, the doctor is unable to provide adequate care for their patients. The techniques used in this study identified negative impacts from unreliable information systems using simple yet effective statistical methods.

Bibliography

Antonides, G., Verhoef, P. C., & van Aalst, M. (2002). Consumer Perception and Evaluation of Waiting Time: A Field Experiment. *Journal of Consumer Psychology*, *12*(3), 193–202.

Ayodeji, Y., Rjoub, H., & Özgit, H. (2022). Achieving sustainable customer loyalty in airports: The role of waiting time satisfaction and self-service technologies. *Technology in Society*. https://doi-org.afit.idm.oclc.org/10.1016/j.techsoc.2022.102106

Baker, J., & Cameron, M. (1996). The effects of the service environment on affect and consumer perception of waiting time: An integrative review and research propositions. *Journal of the Academy of Marketing Science: Official Publication of the Academy of Marketing Science*, *24*(4), 338–349. https://doi-org.afit.idm.oclc.org/10.1177/0092070396244005

Bajgoric, N. & Ibrahimovic, S. (2016). Modeling Information System Availability by Using Bayesian Belief Network Approach. *Interdisciplinary Description of Complex Systems*, *14*(2), 125–138. https://doi-org.afit.idm.oclc.org/10.7906/indecs.14.2.2

Bianco, V., Manca, O., & Nardini, S. (2009). Electricity consumption forecasting in Italy using linear regression models. *Energy*, *34*(9), 1413–1421. https://doi-org.afit.idm.oclc.org/10.1016/j.energy.2009.06.034

Bruton, A., Conway, J. H., & Holgate, S. T. (2000). Reliability: What is it, and how is it measured? *Physiotherapy*, *86*(2), 94–99. https://doi-org.afit.idm.oclc.org/10.1016/S0031-9406(05)61211-4

Davis, M. M., & Vollmann, T. E. (1990). A Framework for Relating Waiting Time and Customer Satisfaction in a Service Operation. *Journal of Services Marketing*, *4*(1), 61–69. https://doi-org.afit.idm.oclc.org/10.1108/EUM0000000002506

De Vries, J., Roy, D., & De Koster, R. (2018). Worth the wait? How restaurant waiting time influences customer behavior and revenue. *Journal of Operations Management*, *63*, 59–78. https://doi-org.afit.idm.oclc.org/10.1016/j.jom.2018.05.001

Ebeling, Charles. 2019. P.5-6. *An Introduction to Reliability and Maintainability Engineering*. Third. Long Grove, Il: Waveland Press, Inc.

Guiffrida, A. L., & Messina, M. J. (2009). A Cost-Based Model for Improving Customer Waiting Times. *2009 42nd Hawaii International Conference on System Sciences, System Sciences, 2009. HICSS '09. 42nd Hawaii International Conference On*, 1–7. https://doi-org.afit.idm.oclc.org/10.1109/HICSS.2009.8

Ibrahimovic, S., & Franke, U. (2017). A probabilistic approach to IT risk management in the Basel regulatory framework : A case study. *Journal of Financial Regulation and Compliance*, *25*(2), 176–195. https://doi-org.afit.idm.oclc.org/10.1108/JFRC-06-2016-0050

Inspector general guide to fraud, waste, or abuse awareness - AF. (n.d.). Retrieved February 13, 2023, from https://www.af.mil/Portals/1/documents/ig/FWA_Guide_Final.pdf

Knight, J. C., Strunk, E. A., & Sullivan, K. J. (2003). Towards a rigorous definition of information system survivability. *Proceedings DARPA Information Survivability Conference and Exposition, DARPA Information Survivability Conference and Exposition, 2003. Proceedings, DARPA Information Survivability*, *1*, 78. https://doi-org.afit.idm.oclc.org/10.1109/DISCEX.2003.1194874

Kokkinou, A., & Cranage, D. A. (2013). Using self-service technology to reduce customer waiting times. *International Journal of Hospitality Management*, *33*, 435–445. https://doi-org.afit.idm.oclc.org/10.1016/j.ijhm.2012.11.003

Independent T-test for two samples. Independent T-Test - An introduction to when to use this test and what are the variables required | Laerd Statistics. (n.d.). Retrieved December 27, 2022, from https://statistics.laerd.com/statistical-guides/independent-t-test-statistical-guide.php#:~:text=The%20independent%20t%2Dtest%2C%20also,means%20in%20two%20unrelated%20groups.

McGuire, K. A., Kimes, S. E., Lynn, M., Pullman, M. E., & Lloyd, R. C. (2010). A framework for evaluating the customer wait experience. *Journal of Service Management*, *21*(3), 269–290. https://doi-org.afit.idm.oclc.org/10.1108/09564231011050760

Pàmies, M. del M., Ryan, G., & Valverde, M. (2016). What is going on when nothing is going on? Exploring the role of the consumer in shaping waiting situations. *International Journal of Consumer Studies*, *40*(2), 211–219. https://doi-org.afit.idm.oclc.org/10.1111/ijcs.12244

Paul, R. J. (2009). What an Information System is, and why is it important to know this. *Proceedings of the ITI 2009 31st International Conference on Information Technology Interfaces, Information Technology Interfaces, 2009. ITI '09. Proceedings of the ITI 2009 31st International Conference On*, 27–32. https://doi-org.afit.idm.oclc.org/10.1109/ITI.2009.5196049

Purnell, L. (1995). Reducing Waiting Time in Emergency Department Triage. *Nursing Management*, *26*(9), 64Q–64V.

Qiang Wang, Jingwei Shang, Liewen Lu, & Ping Chen. (2018). Information System Reliability Quantitative Assessment Method and Engineering Application. *2018 IEEE International Conference on Software Quality, Reliability and Security Companion (QRS-C)*.

Xin Yan, & Xiaogang Su. (2009). *Linear Regression Analysis: Theory And Computing*. World Scientific.

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14. ABSTRACT

The Military Personnel Flight relies on Air Force Information Systems, specifically the Defense Enrollment Eligibility and Reporting System (DEERS), to manage the personnel records. When DEERS experiences a failure, then the operational ability of the Military Personnel Flight is affected. This study aims at identifying the impact Air Force information system's availability status has on customer wait times using linear regression.

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