COMMERCIAL AUGMENTATION AND THE NEED FOR DEMAND FORECASTING

Graduate Research Paper

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FORECASTING

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Abstract

During the wars in Iraq and Afghanistan there were heavy demands placed on the Department of Defense (DOD) transport network. This increase in demand forced a corresponding demand on contract carrier operations that are utilized to supplement the DOD shortfalls. These carriers operate under the Commercial Reserve Airlift Fleet (CRAF) agreement. This agreement offers incentives to contract carriers to participate, while offering increased capacity and flexibility in the DOD transportation network. This augmentation comes at a cost and to avoid paying exorbitant fees, the Air Force must find the right model of demand management to ensure availability while remaining a good steward of tax payer funds.

This study assesses the need for a forecast model for utilizing CRAF resources to augment the demands of channel missions. Due to increasing demands on organic (Air Force owned) aircraft, extensions on the service life of the aircraft, and the shortage of qualified crews, augmentation for airlift grew.

To my family

Acknowledgments

There are several individuals with whom this research would not have been possible. I would like to first thank Dr. Adam Reiman, my AFIT faculty advisor, and Mr. Donald Anderson of AMC/A9, my research sponsor. You gentlemen have been an inspiration through your expertise, feedback, and your desire to share it with me. Finally, I would like to thank the experts at USTRANSCOM and AMC who provided invaluable assistance in gathering information for this project.

D. Keith Callahan

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I. Introduction

> "We're going to build a more lethal force… And at the same time, we'll reform our department's business practices for performance and affordability." (Mattis, 2018.)

Background

Under the current Department of Defense (DOD) logistics construct, Transportation Command (USTRANSCOM) is charged to be the global integrator for mobility operations. In this capacity, USTRANSCOM charges Air Mobility Command (AMC) to manage the chartered air transportation program. AMC must ensure all customer requirements are moved according to customer needs, select the carrier, and must additionally ensure maximum aircraft utilization.

Currently AMC utilizes civilian augmentation resources, also known as Civilian Reserve Air Fleet (CRAF) or the chartered air transportation program, to support airlift operations. This augmentation is meant to aid in the current constrained resource environment. The constraints of crews and tails, requires the use of a robust augmentation initiative to cover shortfalls in the DOD capability.

As the DOD needs augmentation programs to support their missions, civilian industry such as Amazon, are also in need of those same resources. The civilian industry is able to predict demands much further out, while the military struggles to be able to plan for anything beyond 90 days. As each user puts their requirements out for commercial carriers, this creates a high demand low density environment.

Problem Statement

AMC is facing rising demand in commercial augmentation which drives increased cost to the Command. With each need of movement, AMC has the requirement to select a carrier to meet the customer demand. With little ability to forecast customer demand, the ability to maximize the use of wide body equivalent (WBE) aircraft becomes more and more difficult. As AMC and USTRANSCOM must pay the carrier, they can expect some reimbursement through the Transportation Working Capital Fund. Reimbursement is based on aircraft utilization and thus USTRANSCOM will only be reimbursed for the amount of the aircraft used by the customer. This leaves an imbalance of cost versus reimbursement. AMC must pay the remaining amount through the Airlift Readiness Account (ARA.)

Research Objectives

The objective of this study will be to determine proper methodology of implementation and forecasting of augmented cargo and passenger services for channel operations. This study will take a quantitative look at the cargo and passenger movements from 2014 to 2019 through resources such as GDSS and COINS (Commercial Operated Integration System) data sets.

Investigative Question 1: How efficiently are charter aircraft being used?

Investigative Question 2: How accurate is a regression forecast for 2019 using 2014-2018 to train the model?

II. Review of Literature

Chapter Overview

This section will focus on literature that is relevant to the commercial airlift augmentation of the Department of Defense needs in support of the United States National Defense Strategy. The first section will focus on a history of the CRAF program to provide a foundational understanding. Next the air transportation industry, national defense, and economics will be discussed in reference to how they all play a role in making the CRAF program so vital. This will be followed up by a discussion of the basics of forecasting and its impact on business such as the air transportation industry. Finally, a brief view of previous studies related to forecasting for CRAF will be covered.

The literature in this research is extensive, but should not be considered completely exhaustive. The literature reviewed is meant to offer a basic understanding of the CRAF program, its importance to US national defense, and the application of forecasting to help the program remain viable for years to come.

CRAF History

The CRAF program history predates its actual establishment. The beginnings date back to 1941 when the United States entered into World War 2 (WW2) and a Presidential directive seized all commercial aircraft needed to support the war effort. These aircraft flew hundreds of missions in the European theater. Commercial aircraft were also instrumental in the Berlin Airlift operation after the war. With the outbreak of the Korean War in 1950 and the realization the US did not have the airlift assets needed to prosecute this war effectively, President Truman decided to formalize the program between the airline industry and the Department of Defense. In 1952, the program was formalized with a memorandum of understanding written by President Truman and signed by President Eisenhower (Chenoweth, 1990:2.)

The CRAF program is designed in a three-stage structure of activations. Stage 1 is for a regional crisis, stage 2 activation is designed for a major theater war, and stage 3 would be a national mobilization for a world war type scenario. Since its formalized inception, the CRAF program has only been activated twice; once for Operation Desert Shield/Storm and again for Operation Iraqi Freedom. The activation for Operation Desert Shield/Storm was in 1990 and was a stage 2 activation. For Operation Iraqi Freedom, a stage 1 activation was utilized in 2003 (Tirpak, 2015:23.)

Over the years there have been changes to the program through changes to the National Airlift Policy. A significant point of change came in the form of a Government Accountability Office (GAO) report published in 2013. In this report the GAO found that the DOD must balance the use of military and commercial resources to maximize the use of commercial resources participating in the CRAF program to the maximum extent possible (GAO, 2013:35). DOD published a memo stating they were in agreement with the GAO report and put action to those recommendations. This led to a "commercial first" focus in today's use of commercial augmentation in the DOD.

Air Transportation Industry and National Defense

To begin to understand the importance of the CRAF commercial augmentation program to national defense, we must look at direct quotes from US law and Air Mobility Command policy. "...Congress finds the following: (1) The National Airlift Policy states that ''[t]he national defense airlift objective is to ensure that military and civil airlift resources will be able to meet defense mobilization and deployment requirements in support of US defense and foreign policies.'' (2) The National Airlift Policy also emphasizes the need for ‘‘dialogue and cooperation with our national aviation industry,’’ and it states that ‘‘[i]t is of particular importance that the aviation industry be apprised by the Department of Defense of long term requirements for airlift in support of national defense.’’ (3) The National Airlift Policy emphasizes the importance of both military and civil airlift resources and their interdependence in the fulfillment of the national defense airlift objective, and it states that the ‘‘Department of Defense shall establish appropriate levels for peacetime cargo airlift augmentation in order to promote the effectiveness of Civil Reserve Air Fleet and provide training within the military airlift system.’’ (4) Civil Reserve Air Fleet carriers continue to be an important component of the military airlift system in support of United States defense and foreign policies." (NDAA FY2016, 2016:697-698.) "The CRAF program is a vital part of DOD's airlift capability. Up to 93% of all passenger and 40% of all cargo is planned to be moved via CRAF during a major conflict." (AMCI 10-402:31).

Whether you are looking at the national or mobility policy all the way down to the command level, there is a heavy importance put on the relationship between DOD and their commercial partners. This importance dates back to the inception of the CRAF program that was instituted by a Presidential Memorandum of Understanding and up to the most current policies.

Accounting

The commercial augmentation program works on a reimbursement process. This process is completed through the Transportation Working Capital Fund (TWCF) which is a subcomponent of the Air Force Working Capital Fund. A working capital fund is one that provides account funding for business operations that operate on a continuing cycle. These funds receive appropriations from Congress for the initial setup. These funds are designed to be a break-even type of account. The fund charges the customer (i.e. an Army unit needing airlift to Europe) for the services provided (the airlift.) This rate is only meant to cover the cost of the movement and administrative fees of managing the process, nothing more. This means the controlling agency (USTRANSCOM) in the instance of TWCF cannot make a profit. They pay for the airlift with the TWCF funds and the unit will reimburse USTRANSCOM for the cost, plus administrative fees. In turn, USTRANSCOM will reimburse the TWCF account for the cost. (FAS.org, 2018:1.)

To better illustrate this let's take a look at an example. Army Unit A needs to move a vehicle from Georgia to Germany. Unit A will request the airlift through USTRANSCOM and move the equipment to the required APOE (aerial port of embarkation). USTRANSCOM will pass along the request to AMC. The AMC/A3B division is charged with managing the commercial airlift augmentation program. AMC/A3B will select a contract carrier and organize the lift of the Army vehicle. AMC/A3B can utilize this aircraft for more than just the Army vehicle and will try to maximize the cargo space on this aircraft. The maximization of this aircraft is important as USTRANSCOM can only gain reimbursement for the airlift based on the amount of cargo space used. In our example, let's say Army Unit A is only using 10% of the aircraft and thus can only be charged for 10% of the total aircraft cost. Should AMC/A3B fail to maximize the cargo of this aircraft, only 10% of the cost will be reimbursable from Army Unit A.

To get a better view of this, we must explore the actual cost of chartering an aircraft. For this portion of the research, we will look at a747-400 variant aircraft. For 2018, the average cost of a 747-400 mission for DOD was $416,933.00. (COINS, 2014-2019.) When a reimbursement of only 10% ($41,693) can be charged, the remaining portion must be covered by the Airlift Readiness Account (ARA) that must be paid by AMC. This puts the requirement on AMC to maximize every aircraft to ensure as much cargo can be loaded as possible.

Based on analytical data run by USTRANSCOM CJ3 (Operations) and AMC/A9 the average utilization rate is 51% of commercial augmentation aircraft. (GDSS, 2014-2019.) This indicates an expected cost of $212,635 for every 747-400 contracted to carry DOD cargo. Additionally, when looking at FY20 and FY21, USTRANSCOM projects an ARA shortfall of $332 million and $839 million respectively (USTRANSCOM CJ8, 2019: slide2).

Forecast Basics

A forecast is an attempt to predict or estimate some future volume or demand of a service or product. A forecast can be classified into three categories, short-term, mid-term, and long-term. Short-term forecasts focus on a window of one month to one year, while mid-term focuses on one to five-year periods. Long-term forecasts typically look at windows of five to ten years (Wensveen, 2016:268.)

In addition to the timeframes that forecasts can focus on, there are varying types of forecasts. These types include causal, time series, and judgmental forecasts. Causal method forecasts evaluate a relationship between the dependent (forecasted) variable and any number of independent variables. In a time-series forecasting linear growth model, the dependent variable acts as a function of only one independent variable. The single independent variable will be time. Time series forecasts can also include a seasonal component. The seasonal component is beneficial when the forecast displays a cyclic pattern in the data. The final forecast method to discuss is a judgmental forecast. This type of forecast is based on intuition and subjective analysis. In this type of forecast, a subject matter expert may offer a personal experience based upon judgment that has been developed over years (Wensveen, 2016:270-277.)

Saying there is a need for an accurate forecast when discussing a service such as commercial air transportation seems quite obvious. The airline industry spends millions each year developing forecasts and constantly evaluating customer demands to ensure they can provide service at the time and place of choosing for their customers. Commercial augmentation for DOD cargo and passengers requires forecasts as well, but due to the type of missions and the unpredictability of changing requirements, it can be more difficult.

CRAF Forecast Research

In researching this topic, it has become evident that although some study has been conducted in this area, none has focused on channel missions in a holistic approach. In 2012, DeYoung focused on time series forecasting of cargo being carried into Iraq and Afghanistan (DeYoung, 2012). In 2019, Hemken focused on cargo sustainment for the Pacific theater. Hemken looked at various forecasting models to predict the demand for commercial augmentation of cargo being carried in the Pacific theater. Hemken found that regardless of the model used, the monthly forecast model offered the most accurate prediction (Hemken, 2019.)

Although this research offered great insight into the models that could suggest predictability to a specific region of the world with respect to commercial airlift augmentation, it does not meet the need of analyzing the entirety of the program. This research project is focused on a more holistic approach that sees the forecast for all commercial augmentation, globally, as a necessity for proper management at the DOD level. By looking at the global demand in this research project, it is suggested a more accurate forecast can be made.

One thesis conducted by Captain Taylor J. Leonard (2013) offered a very similar approach of utilizing demand forecasting. The thesis was titled *Operational Planning of Channel Airlift Missions Using Forecasted Demand,* and it looked at several approaches to forecasting demand. Captain Leonard utilized eleven different model approaches to determine the most accurate forecast capability. In the thesis, Captain Leonard forecasted through various methods and included Monte Carlo simulations in his analysis (Leonard, 2013.)

Captain Leonard came to the conclusion that demand forecasting offered opportunity in improvement in the management of channel operations. Additionally, Captain Leonard found that multiple linear regression was a viable methodology to aid in that improvement. Despite the common ideas and findings, there are differences in Captain Leonard's approach and this research. Captain Leonard utilized various models as opposed to focusing on just linear regression. Additionally, Captain Leonard chose to only look at channel missions to one theater of Operation (Afghanistan.) Finally, Captain Leonard looked at Boots on the Ground (BOG) (Leonard, 2013:11) as the independent variable where this research will utilize time as the independent variable. Despite the differences in approach, Captain Leonard's research was found to be a great asset in conducting this research project.

III. Methodology

Chapter Overview

This research will utilize a linear regression technique to analyze data pulled from the Global Decision Support System (GDSS) database to determine a yearly projected demand forecast of commercial augmentation needs. Additionally, the following assumptions and limitations will apply to the research in order to set clear understanding of the financial impacts to DOD for the operation of contract aircraft partnerships.

GDSS Data Collection and Cleaning

Data for this model was pulled from GDSS for the years 2014 through 2019. This data set provides dates, mission id, types of aircraft (mission design series, MDS), owning agency of carrier, mission class, aerial port of debarkation (APOD), aerial port of embarkation (APOE), load data, and numerous other fields. The whole data set of organic and commercial channel sorties from GDSS for those dates consisted of 78,418 lines. This was cut down to 37,701 once all lines were cut that were not designated as channel or exercise by mission class in excel. Once only channel lines were selected by filter, the results were copied over to a clean excel sheet to create a working copy.

The working copy excel sheet was created to limit the size of the file being used while cleaning and collating the data. In the working copy excel, formulas were created to extract the month and year from the GDSS departure date field. Once the month and year were separated, a third field was created (Dep Month_YR) to combine the month and year. This enabled a date field that no longer contained the day. Additionally, a binary field was created to identify the month of departure. For example, a mission that departed on 7 January 2013 would have a Dep Month_YR field containing “1/2013”.

Additionally, the January field would contain a “1” and the remaining months would have a “0” in each field.

Finally, a data field (DA Pair) was created to collect an ICAO (International Civil Aviation Organization) pairing of the departure and arrival ICAO station ids. This field was created by using the concatenate function in excel. By creating the “DA Pair” field a pivot table could be created to determine the “DA Pairs” with the highest number of missions.

COINS Data

COIN data was collected and provided from the Joint Distribution Process and Analysis Center (JDPAC,) a USTRANSCOM agency, for this research. The COINS data allows for load utilization by mission. This data also provides a secondary validation of short tonnage per mission. The short tons are provided in GDSS and thus COINS adds the perspective of the carrier in the number of short tons carried on each mission. Most commercial augmentation missions are purchased for 100 short tons per mission. Effectiveness can be measured against this milestone.

Additionally, COINS data provides cost data per aircraft series. For example, the cost of a 747-400 aircraft mission can be ascertained by each carrier through this data. JDPAC was able to provide COINS data for 2018 and 2019, which offers the most current pricing models for the benefit of this research project.

Linear Regression

The linear regression modeling of this data allows for a historical analysis of the number of commercial augmentation missions utilized (dependent variable) over the time period of 2014 to 2018 (independent variable.) Upon analysis of the historical data of 2014 to 2018, a forecast for 2019 was created. Next the actual demand for 2019 was overlaid against the forecast to evaluate the effectiveness of the forecasting model.

Assumptions

Assumption 1: This model is based off of historical data and any model based on historical data can offer no guarantee of future results.

Assumption 2: All major airline carriers (Delta, American, Southwest, and United) will remain as operating partners in the CRAF program.

Limitations

Limitations 1: The research will only focus on the channel requirements of wide body equivalent cargo requirements.

Limitation 2: Due to the volatility of war-time operations, contingency shipments will be ignored.

IV. Analysis and Results

Chapter Overview

By analyzing the GDSS data for years 2014-2019, this research attempts to determine if linear regression models offer a good forecast for future use of commercial augmentation. As AMC is facing significant cost increases based on under-utilized aircraft, it is imperative to determine a feasible option to forecast demand. The primary analysis tool was the multiple linear regression model.

Data

As mentioned in a previous chapter, two main sets of data were analyzed to develop the results of the linear regression and the analysis of prevalent trends. GDSS data provided the largest component of data with the full data set of all sorties flown in the years 2014 through 2019. COINS data provide actual cost data to compare to the missions identified in the GDSS data. Since contracts are on annual renewal, it was important to only compare years 2018 through 2019 in COINS. This gave the greatest approximation of current contract cost to mirror up to missions. Of note is the difference in how GDSS and COINS report the data. GDSS provides every sortie (leg) of the associated mission, but COINS only identified the originating mission number. The importance of this differentiation will be further explained in the costing factors utilized to develop costing forecast through regression.

The original data set provided over 700,000 lines of GDSS mission data that was paired down to exclude all lines not categorized as channel and mission aircraft. Again, this was paired down to remove organic (military aircraft) from the data set. This left a clean set of channel missions that were flown by commercial augmentation. This list totaled 37,071 total sorties flown in the specified fiscal years.

It is important to notice prevalent trends in the usage of commercial augmentation aircraft. Analysis of the type aircraft used indicate numerous aircraft MDS's were utilized with the B747 being the most prominent. It must be noted there are several variants of the B747, but this research will speak generically about each aircraft as opposed to the specific model (i.e. B747 versus B747-400.) B747 variants flew over 12,000 sorties and the B767 was close behind with over 9,100 sorties.

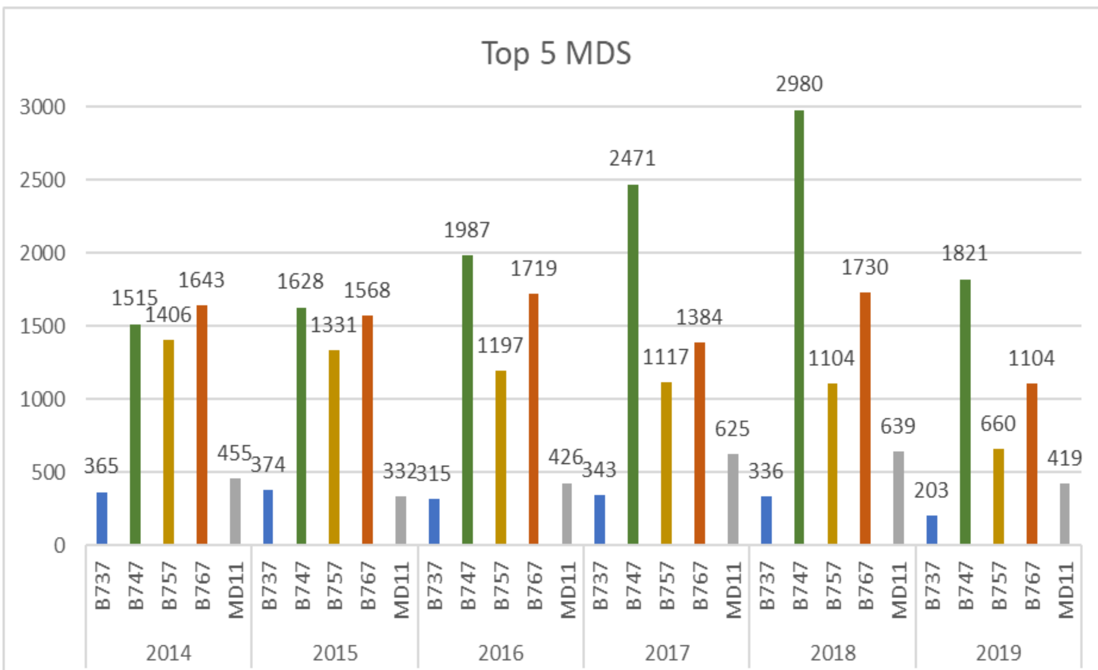

Figure 1 - Top 5 Aircraft by Sorties

Finally, it is of importance to look at the missions flown in reference to locations utilized. Just as in commercial passenger carrier airlines, it is important to have standardized routes to allow for optimization. These routes were broken down by departure and arrival ICAO designations and designated as city pairs. The predominant route was KWRI_ETAR which is McGuire AFB, New Jersey to Ramstein AB, Germany. This route was identified in the data set with over 900 different sorties. In this analysis, three routes were analyzed to give us the greatest variance in routes to ensure the forecast was not impacted by specific regional routings. KWRI_ETAR (McGuire AFB, NJ-Ramstein AB, Germany 3,384 NM), OTBH_OKBK (Al Udeid AB, Qatar-Kuwait City International, Kuwait 303.7 NM), and RJTY_KSEA (Yecheon AB, Korea-Seatle Tacoma International, Washington 4181 NM) were the routes analyzed to give variations in inter-theater and intra-theater missions.

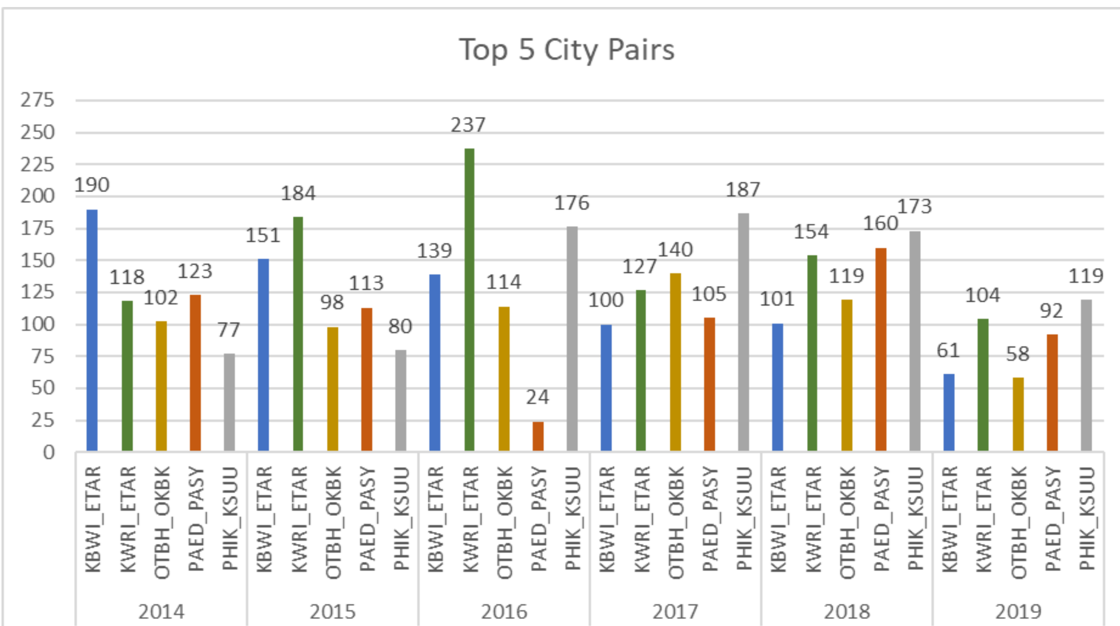

Figure 2 - Top 5 City Pairs by Sorties

Sortie Analysis

Note: 2019 Data only reported through July.

Sortie analysis allows for applying a regression model against the number of sorties in a holistic view by year. This offers the chance to compare the holistic view against the specific routes to determine which would offer a better fit for forecasting sorties for commercial augmentation.

Starting with a heat map (Figure 3) of the sorties in years 2014 through 2018, we can see some level of seasonality. At the beginning of most years, sortie demand is moderate to low and builds to the middle of the year. The build typically peaks out around July and August and begins to slow through the remainder of the year. This follows the typical rotation pattern of movements into and out of the theaters in the Middle East.

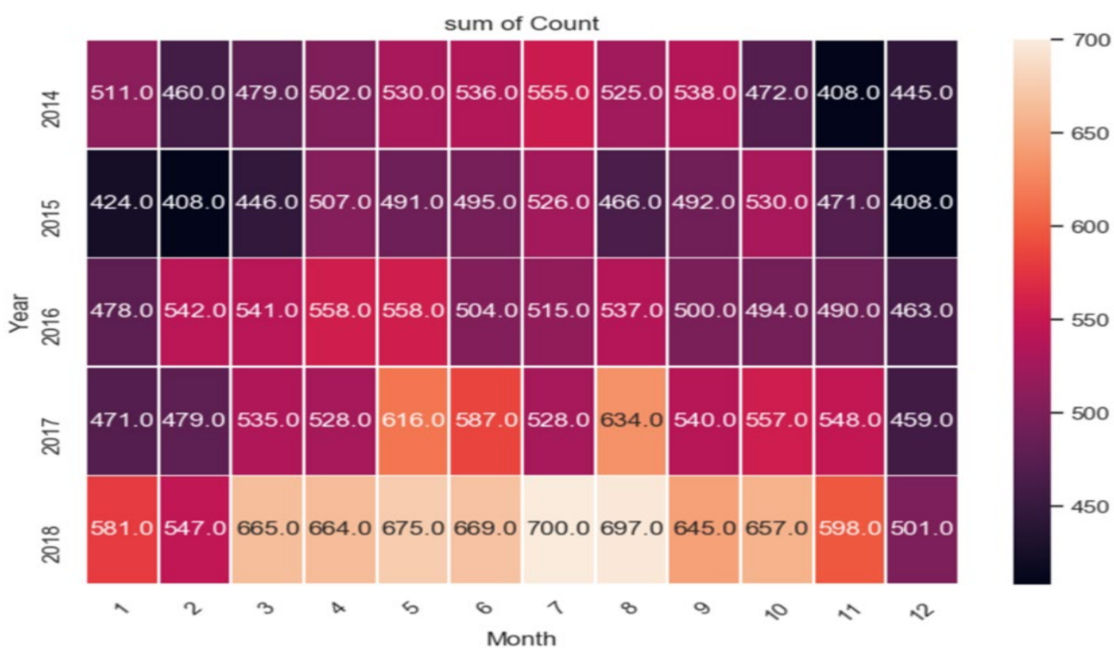

Figure 3 - Monthly Sorties Heat Map

Next is the analysis of sorties in general (Figure 4). This view allows for a regression model to be applied to the sorties flown per year. As mentioned earlier, the determination to utilize sorties over missions can offer greater depth of information. In figure 5, with the regression modeling applied, you can see the closeness of the fit when comparing actual sorties in 2014 through 2018 as compared to forecasted in 2019. The root mean square error is +/- 25.01 sorties when compared against the forecasted amount for this model.

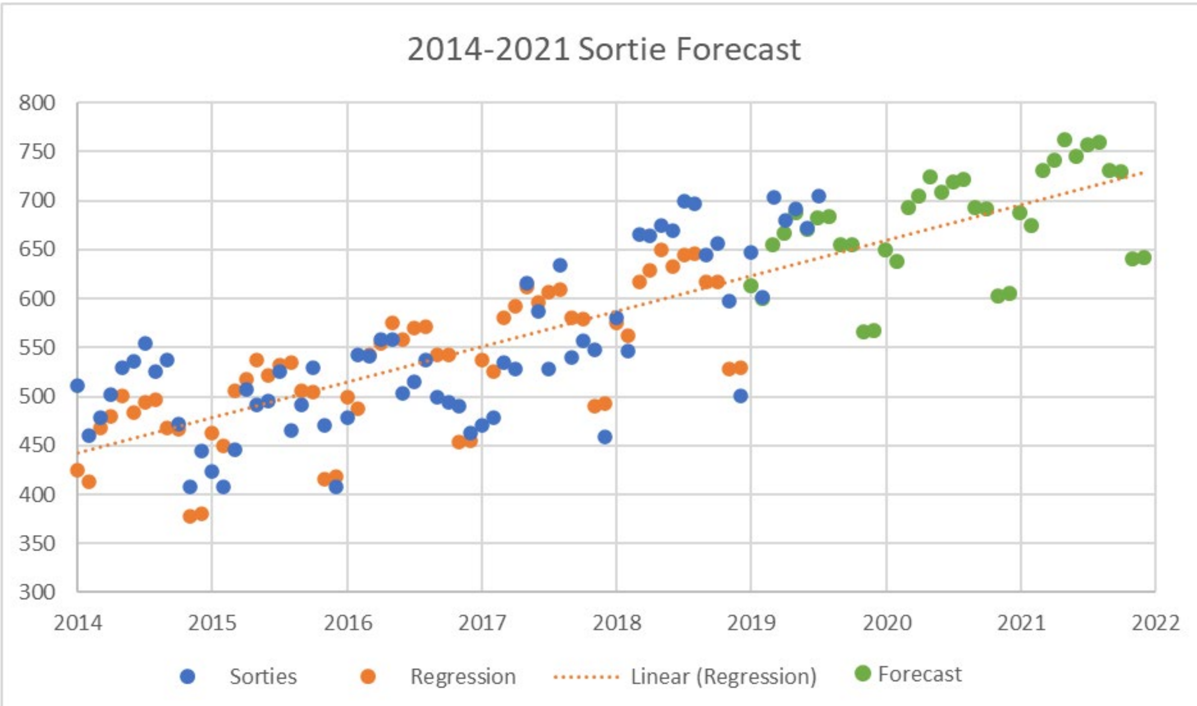

Figure 4 - Sortie Forecasts 2014-2021

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(f_i - a_i)^2}{n}}$$

Where:

f = forecasted value (sorties)

a = actual value (sorties)

Equation 1 - Root Mean Square Error Equation

Regression Statistics					
Multiple R	0.879797609				
R Square	0.774043833				
Adjusted R Square	0.723831352				
Standard Error	43.15848535				
Observations	67				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	12	344562.1004	28713.51	15.41537	2.13525E-13
Residual	54	100583.3623	1862.655		
Total	66	445145.4627			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	
Intercept	-74883.94517	6627.678624	-11.2987	7.62E-16	
Date	37.35362319	3.286030915	11.3674	6.04E-16	
Jan	79.03067633	26.1696026	3.019942	0.003856	
Feb	63.58454106	26.15670517	2.430908	0.018412	
Mar	115.8050725	26.14666944	4.429056	4.66E-05	
Apr	124.1922705	26.1394987	4.751134	1.54E-05	
May	141.5794686	26.13519531	5.417196	1.44E-06	
Jun	121.9666667	26.13376069	4.667016	2.06E-05	
Jul	129.8538647	26.13519531	4.968544	7.16E-06	
Aug	129.0512077	27.31779129	4.724072	1.69E-05	
Sep	97.1384058	27.30818225	3.557117	0.00079	
Oct	93.02560386	27.30131659	3.407367	0.001246	
Nov	50.91280193	27.29719636	1.865129	0.067601	

Table 1 - Sortie Forecast Regression Data

Next, the regression model was applied to sorties related to specific city pair routes (figures 5-7). As mentioned earlier these routes were chosen to show inter-theater and intra-theater movements. Additionally, they were selected for flight direction and theater to ensure there is no regional interference in the data sets.

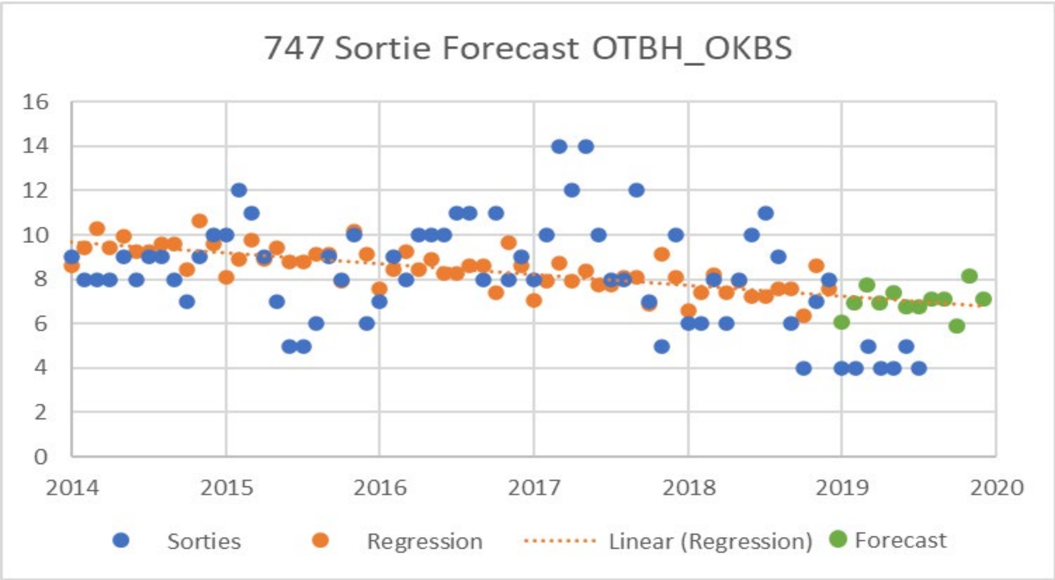

Figure 5 - Sortie Forecast OTBH_OKBK (747)

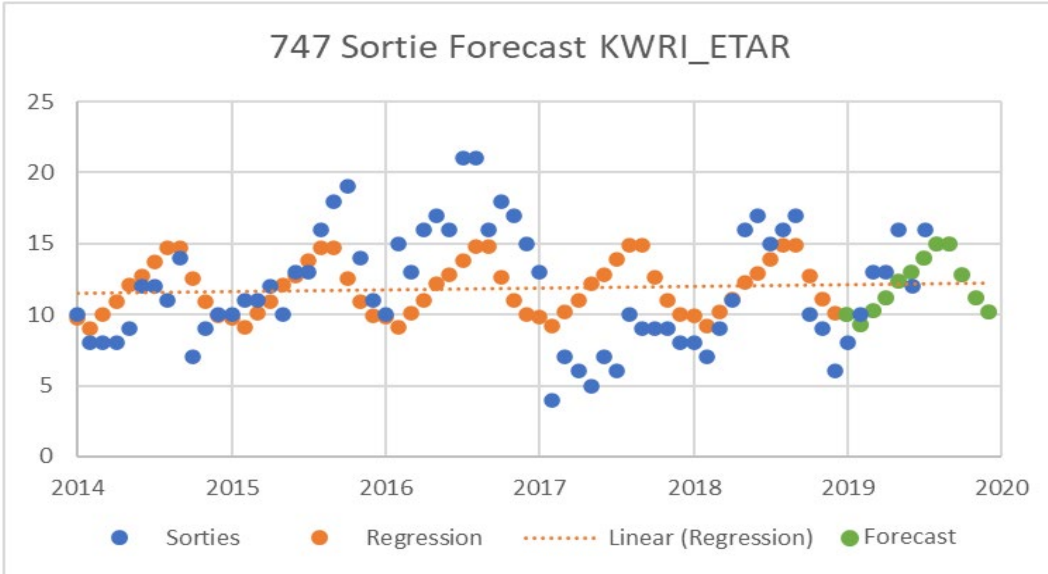

Figure 6 - Sortie Forecast KWRI_ETAR (747)

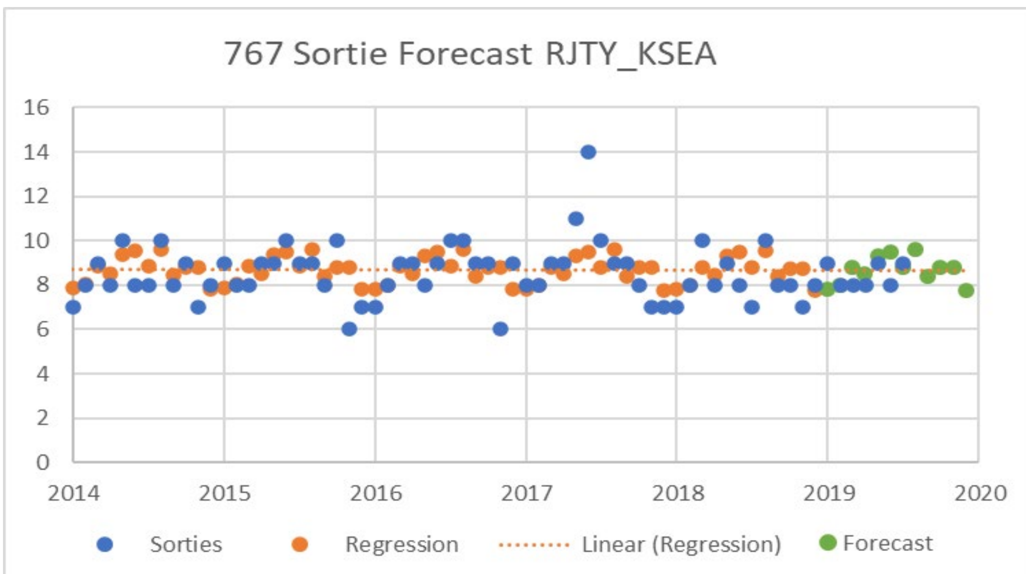

Figure 7- RJTY_KSEA Sortie Forecast (767)

This sortie forecast by specific city pairs provides a unique perspective. As can be seen, not all city pair routes follow a similar pattern. For example, the KWRI_ETAR city pair (Figure 6) follows a very cyclical, seasonal forecast. In contrast, the other two city pair routes indicate either a descending (Figure 5) or flat trend (Figure 7). Additionally, it is easy to see when changes such as declines happen as can be seen in Figure 5 in 2016. Each graph indicates the uniqueness of each route's demand. (See Appendix A for city pairs sortie forecast regression data.)

Cost Analysis

As mentioned earlier there is a difference in the reporting styles of GDSS and COINS. Due to this difference, the data was merged based on mission number. It was determined it would be best to analyze the data set through the lens of sorties. Again, this was not only due to the differences between the two systems, but analyzing sorties can provide a better picture of utilization on each leg as opposed to looking at the efficiency of the mission in whole. This brought up a new problem in trying to match the cost data of COINS to the sorties. Again, COINS recorded all cost against the first leg of the mission, ignoring the individual cost of each sortie. To assess total cost and address the missing cost data, an approximation was created to develop the average cost per sortie in COINS. By taking the mission and counting the number of sorties (done with a text field in COINS) and dividing that sortie count into the total mission cost, an approximate sortie cost was developed.

Once the approximation was complete, the regression model was used to determine the forecasted cost based on forecasted sorties. An overall sortie costing forecast was generated out to the year 2021 (Figure 8). For each city pair a costing analysis regression was created for the years 2014-2018 with a forecast of 2019.

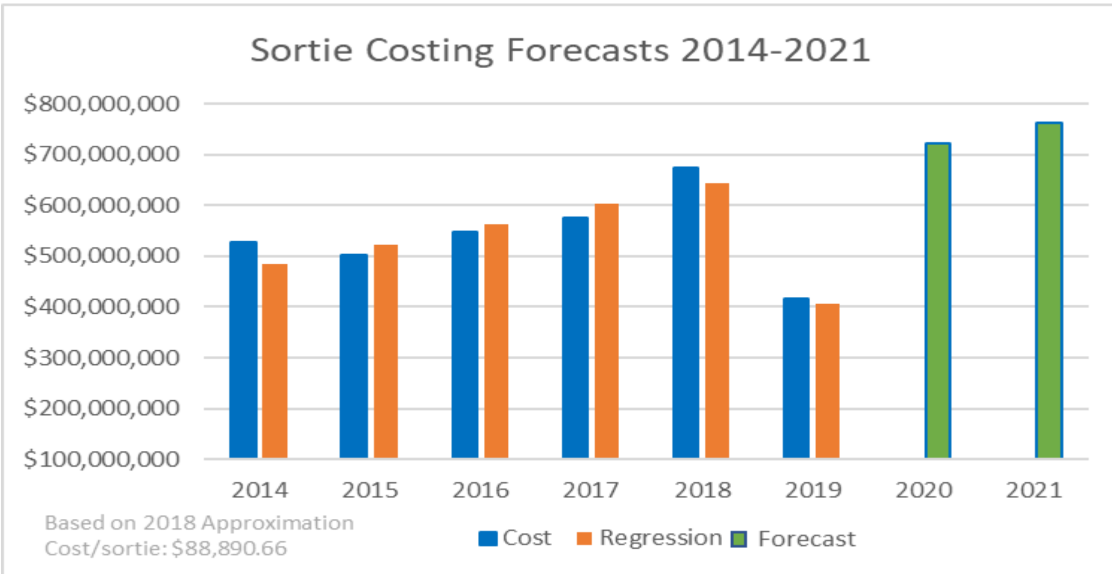

Figure 8 - Sortie Costing Forecast 2014-2021

In viewing Figures 9-11 below, you can see the regression forecasts are sometimes moderately accurate and other times appear to be near exact. In years 2017 – 2018 you can see very distinct patterns of the approximated cost and the forecast being in line with each other. In the years that the regression does not have a near-exact match, you can see the forecasts are still very close.

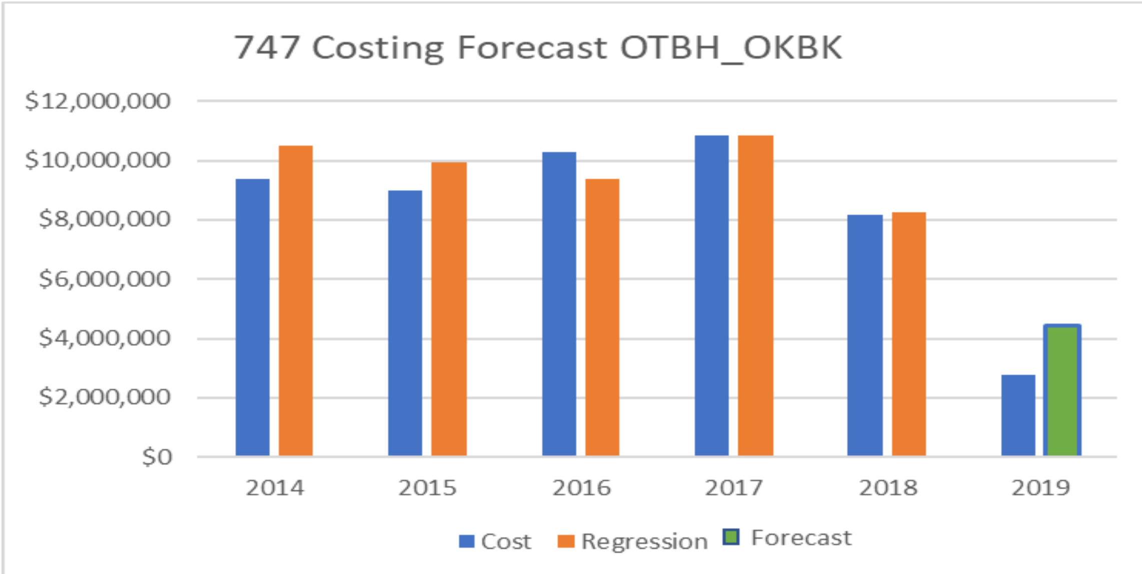

Figure 9 - Costing Forecast OTBH_OKBK (747)

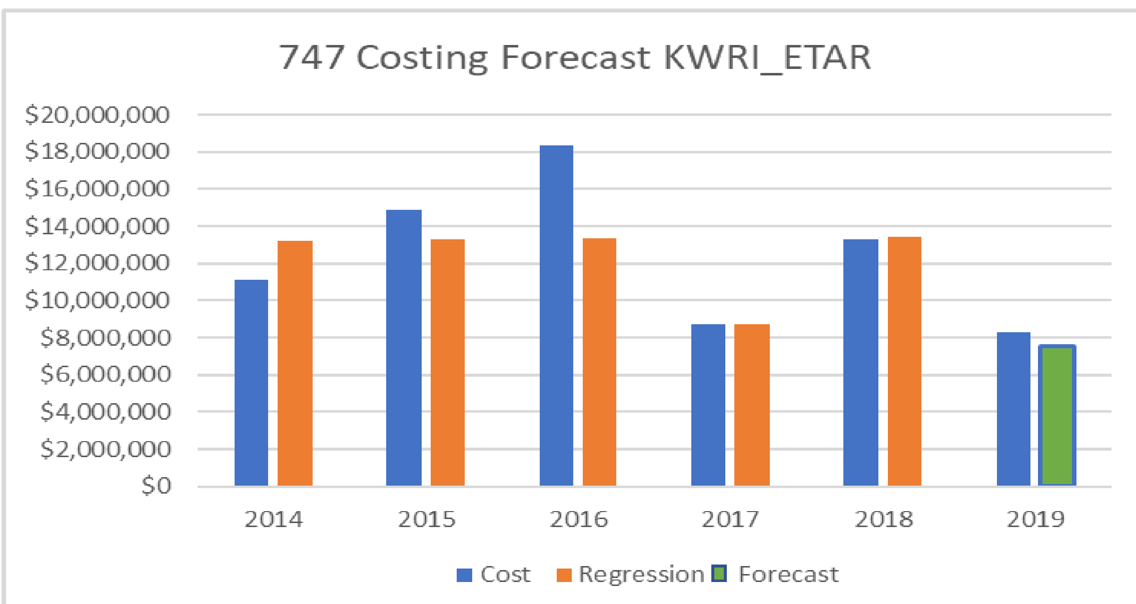

Figure 10 - Costing Forecast KWRI_ETAR (747)

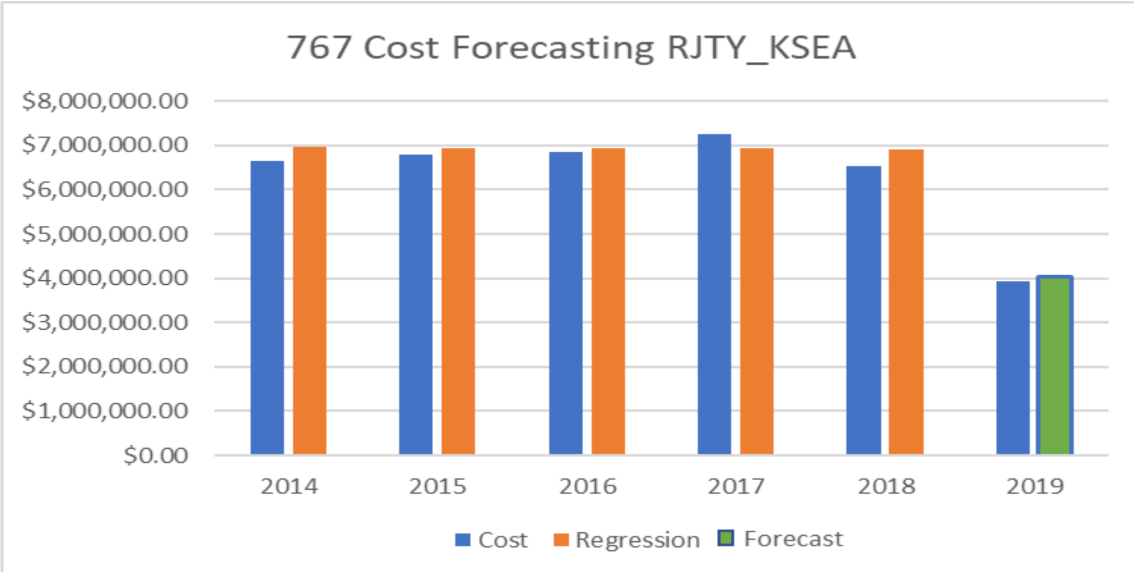

Figure 11 - Costing Forecast RJTY_KSEA (767)

Based on the analysis of these three city pair routes, it is clear that linear regression can offer a good fit when looking at the variable of approximated cost. To continue to analyze the goodness of the fit, the same regression model will be applied to cost and tonnage (short tons).

Tonnage Analysis

Analysis of short tons offers a third variable to measure the accuracy of forecast created by multiple linear regression. Figure 12 offers a view of short tons moved across years 2014-2019. In comparison to the sortie analysis (Figure 4), it is easy to see the closeness of the prediction capability of the regression model between these two variables.

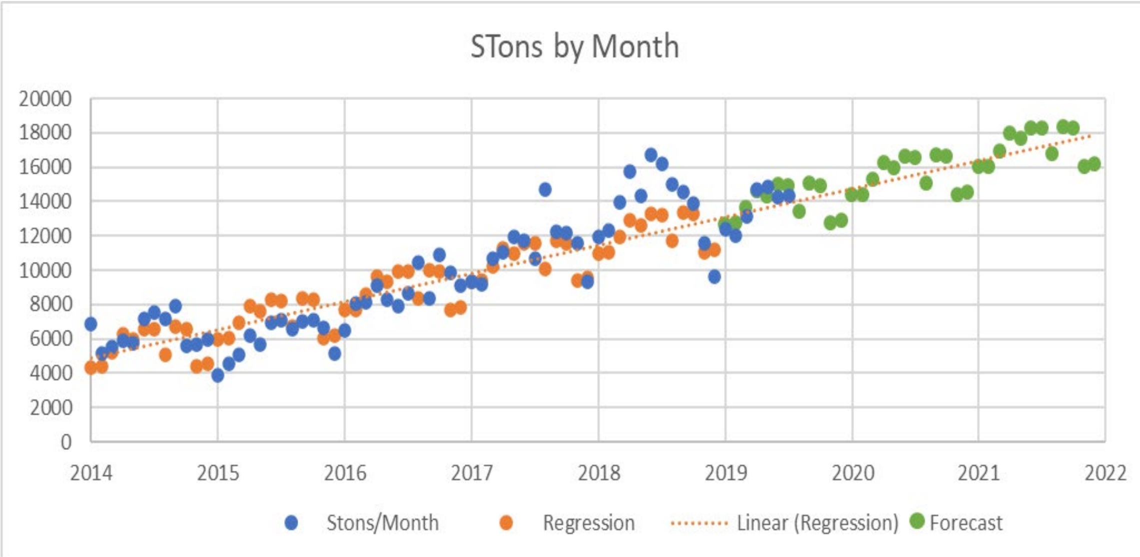

Figure 12 - Short Ton Forecast

Utilization Analysis

The final, and potentially one of the most important variables, was utilization of aircraft. This analysis was not created utilizing a regression model. This variable was evaluated based solely on past performance. By averaging together utilization rates per month by year, a visual representation was created to display the significantly low levels of utilization of commercial augmentation aircraft. Utilization has a direct impact on the numbers of sorties needed to accomplish a specific mission.

Passenger

AC Type	MDS	AMC PAX	MPM	WBE
B-747-400	B747	355	0.761	1.071
B-747-400	B747	355	0.761	1.071
B-757-200	B757	126	0.252	0.355
B-767-300ER	B767	249	0.537	0.756
B-767-300ER	B767	249	0.537	0.756
B-767-300ER	B767	249	0.537	0.756
B-767-300ER	B767	249	0.537	0.756
B-767-300ER	B767	226	0.448	0.631
B-767-300ER	B767	226	0.448	0.631
B-767-300ER	B767	226	0.448	0.631
B-767-300ER	B767	226	0.448	0.631
B-767-300ER	B767	226	0.448	0.631
B-767-300ER	B767	226	0.448	0.631
B-767-300ER	B767	226	0.448	0.631
B-767-300ER	B767	226	0.448	0.631
B-767-300ER	B767	226	0.448	0.631
B-767-300ER	B767	226	0.448	0.631
B-767-300ER	B767	226	0.448	0.631
B-767-300ER	B767	226	0.448	0.631
B-767-300ER	B767	226	0.448	0.631

Table 3 - AMC Passenger Planning Factors (Sample)

Cargo

AC Type	MDS	Max ACL in Short Tons	Wartime Payload in Short Tons (75% Max ACL)	MTM	WBE	Main Deck Pallets
B-747-400F	B747	124	107.88	0.234	1.373	34
B-747-400F	B747	124	107.88	0.234	1.373	34
MD-11-11F	MD11	104.738	91.122	0.192	1.126	34
MD-11-11F	MD11	104.738	91.122	0.192	1.126	34
MD-11-11F	MD11	104.738	91.122	0.192	1.126	34
MD-11-11F	MD11	104.738	91.122	0.192	1.126	34
MD-11-11F	MD11	104.738	91.122	0.192	1.126	34
MD-11-11F	MD11	104.738	91.122	0.192	1.126	34
MD-11-11F	MD11	104.738	91.122	0.192	1.126	34
MD-11-11F	MD11	104.738	91.122	0.192	1.126	34
MD-11-11F	MD11	104.738	91.122	0.192	1.126	34
MD-11-11F	MD11	104.738	91.122	0.192	1.126	34
MD-11-11F	MD11	104.738	91.122	0.192	1.126	34
B-767-200	B767	41.395	36.014	0.072	0.422	21
B-767-300F	B767	60.868	52.955	0.107	0.628	26
B-767-300F	B767	60.868	52.955	0.107	0.628	26
B-767-300	B767	59.815	52.039	0.106	0.622	26
B-767-200	B767	41.395	36.014	0.072	0.422	21
B-767-200	B767	41.395	36.014	0.072	0.422	21
MD-11	MD11	101.956	88.702	0.189	1.109	32

Table 2 - AMC Cargo Planning Factors (Sample)

Utilization rates were calculated based on Tables 2 and 3 provided by AMC/A3B. These tables are utilized to determine the best asset selection for the mission. By applying these planning factors, the utilization rate of each sortie could be determined. It is of note to mention that any GDSS lines with no cargo or passenger data entered were removed from the calculations. Additionally, as these tables contained carrier and tail numbers, only an excerpt of each chart is provided. Finally, an average planning factor was created based on the MDS as opposed to variant type.

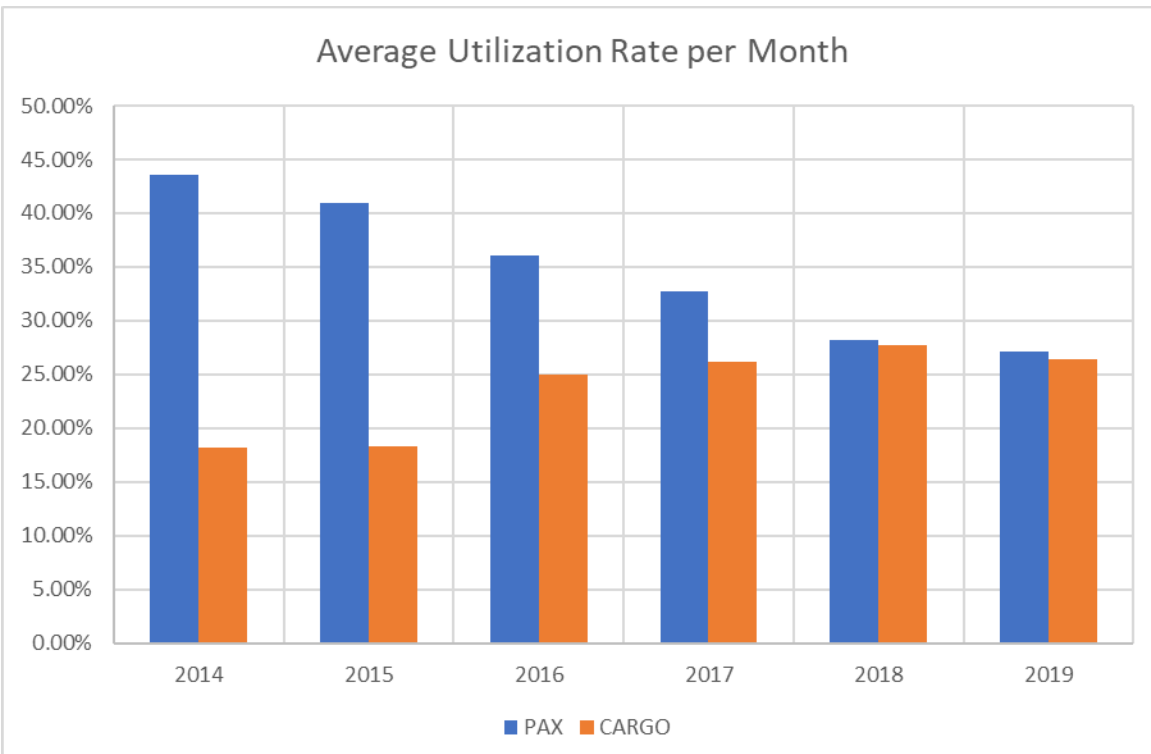

Figure 13 - Pax and Cargo Utilization Rates

One could conclude it is self-evident that utilization rates of aircraft have a direct impact in the ability to forecast demand. If aircraft are historically under-utilized, this will only continue false demand in the system. Is it truly false demand or is it based on the priority of the cargo and the nature of theater movement that creates this under-utilization?

V. **Conclusions and Recommendations**

Chapter Overview

This chapter will provide the final conclusions reached after exhaustive analysis of GDSS and COINS data from 2014 through 2019. By analyzing numerous variables such as costing factors, sorties, tonnage, and utilization this research was able to provide a determination on the use of regression modeling in determining future demand. These factors offered the basis for answering the primary research objective.

Conclusions

The objective of this research project was to determine a methodology to forecast demand for commercial augmentation aircraft. The program of commercial augmentation offers the DOD a viable method to meet day-to-day movements while maintaining the readiness of organic forces and aircraft. Having access to these additional commercial assets requires a great deal of management and optimization to ensure the best use of aircraft, crews, and taxpayer's money. Additionally, there is a significant cost associated with this program that must be paid by AMC.

The sortie and short ton forecast indicate an upward trend in demand current date to 2021. With the downsizing of theaters and locations in those theaters it could be presumed the opposite would be true, but the use of commercial augmentation is expected to grow. The DOD has placed on emphasis on commercial first to aid in limiting the use of organic aircraft in order to offer relief to older airframes and offer more opportunity for crew training. In addition to the impact of theater changes, the COVID-19 pandemic will have a significant impact on the demand for commercial augmentation. As movement was halted by the DOD, this has decreased the demand on contract aircraft. The length of time associated with COVID-19 counter measures can have a significant impact on demand for commercial augmentation.

Two primary investigative questions were posed in the beginning of this project. The first being, is commercial augmentation being utilized efficiently? By analyzing the utilization rates of sorties, it was determined that most contract aircraft are being used at 45% or less. (Caveat: This data analysis was conducted by each channel sortie when compared to planning factors in Table 2 and 3. Additionally, channel cargo density will not often allow a planner to reach maximum utilization compared to planning factors.) When compared to other charter industries, this would fall well below industry standards. The utilization rate is extremely important for contract aircraft as unused space can inflate demand. Passenger and cargo not moved will mean there must be another mission generated and thus more aircraft and crews are needed. Additionally, the importance to AMC is a financial concern. AMC has projected a potential ARA bill of over $800 million for commercially contracted aircraft services by 2021.

The second investigative question is how accurate is forecast demand for 2019 when utilizing data from 2014 through 2018 to train the model? This research applied a multiple linear regression against several variables in order to determine accuracy of the demand forecast. First, sortie costing factors were analyzed against actual performance. Second, sorties were analyzed in a two-pronged approach. First, was the analysis of sorties in a holistic approach or all sorties regardless of MDS and travel locations. The second approach was to compare various city pairs along with specific aircraft to build a forecast model. Both models offer what could be determined a "good fit" when evaluating R2, however analyzing the city pairs and aircraft mixture can offer greater detail in forecasting. The third variable was tonnage. In this analysis, the forecast was built on the total number of short-tons shipped in a month. Finally, utilization was analyzed to draw attention to the importance of utilization and the impact it has on future demand.

Recommendations

As AMC is the day-to-day manager of the commercial augmentation program, it is recommended they adopt a linear regression model to predict future demand. By utilizing the multiple linear regression model and analyzing five-year buckets of data, AMC can provide a moderately accurate forecast that can be utilized for the "fixed-buy program." Providing a more accurate forecast to USTRANSCOM, AMC can limit their exposure to ARA cost.

Additionally, AMC should be given full control of cancelling commercial augmentation sorties within the prescribed contract limits. Under current USTRANSCOM CJ3 direction, the AMC Commercial Barrell team must get approval from CJ3 before cancelling any commercial augmentation services. This policy has led to a continued process of reduced utilization of aircraft thus continuing to over-inflate demands for contract services and increasing ARA cost to AMC.

Future Research

The utilization rates of sorties analyzed in this research project report are historically low. Based on this analysis, it would be imperative to run the forecasted short tons through a load optimizer to be compared to annual sortie forecast. This will aid in eliminating the concerns of over-inflated forecasts. Additionally, this approach could be applied to city pairs to aid in forecasting optimized loads between predominant use routes.

Following the idea of utilization, future research could focus on the root causes of the under-utilization of contract aircraft. As mentioned earlier, under-utilized aircraft have a direct financial impact to AMC. As the day-to-day controller, understanding the causes can ensure proper management, but also maximize the cost reductions in ARA. Utilization of contract services offers numerous opportunities and avenues of research that can only increase the forecasting capabilities applied through regression forecasting.

Appendix A

Regression Statistics					
Multiple R	0.400785596				
R Square	0.160629094				
Adjusted R Square	-0.025897774				
Standard Error	2.438277244				
Observations	67				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	12	61.43703223	5.119752686	0.861157942	0.589578304
Residual	54	321.0405797	5.945195921		
Total	66	382.4776119			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	
Intercept	1037.519807	374.4366338	2.770882209	0.007651297	
Date	-0.510144928	0.185647257	-2.747926023	0.008135988	
Jan	-1.479227053	1.478475113	-1.000508591	0.321526833	
Feb	-0.603381643	1.477746462	-0.40831202	0.684659225	
Mar	0.272463768	1.477179484	0.184448654	0.854352459	
Apr	-0.518357488	1.476774366	-0.351006558	0.726949193	
May	0.024154589	1.476531243	0.01635901	0.987008274	
Jun	-0.6	1.476450192	-0.406380116	0.686069399	
Jul	-0.557487923	1.476531243	-0.377565951	0.707233025	
Aug	-0.170048309	1.54334306	-0.110181795	0.912673672	
Sep	-0.127536232	1.542800189	-0.082665424	0.934423246	
Oct	-1.285024155	1.542412308	-0.833126232	0.408443416	
Nov	-0.842512077	1.542179532	-0.546312579	0.587101318	

OTBH_OKBK Regression Data

Regression Statistics					
Multiple R	0.460759989				
R Square	0.212299767				
Adjusted R Square	0.037255271				
Standard Error	3.945529551				
Observations	67				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	12	226.5650443	18.88042036	1.212833149	0.298652442
Residual	54	840.6289855	15.56720344		
Total	66	1067.19403			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	
Intercept	-83.53816425	605.8994344	-0.137874636	0.890852332	
Date	0.046376812	0.300407486	0.15437968	0.877885926	
Jan	-0.147342995	2.39241344	-0.061587597	0.951118642	
Feb	-0.817874396	2.391234363	-0.342030212	0.733655764	
Mar	0.17826087	2.3903169	0.07457625	0.940827456	
Apr	1.007729469	2.389661354	0.421703881	0.674915248	
May	2.170531401	2.389267941	0.908450394	0.367676979	
Jun	2.833333333	2.389136788	1.185923446	0.240844623	
Jul	3.829468599	2.389267941	1.60277905	0.114817437	
Aug	4.815458937	2.497380339	1.928204071	0.059094655	
Sep	4.811594203	2.496501886	1.927334496	0.059205409	
Oct	2.607729469	2.49587423	1.044816056	0.300762675	
Nov	1.603864734	2.49549756	0.642703387	0.523136219	

KWRI_ETAR Regression Data

Regression Statistics					
Multiple R	0.651271407				
R Square	0.424154446				
Adjusted R Square	0.296188768				
Standard Error	1.036349554				
Observations	67				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	12	42.71931646	3.559943038	3.314595372	0.001207847
Residual	54	57.99710145	1.074020397		
Total	66	100.7164179			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	
Intercept	37.03067633	159.1481195	0.232680577	0.81688912	
Date	-0.014492754	0.078906306	-0.18367041	0.854959972	
Jan	0.027294686	0.628401478	0.043435108	0.965514908	
Feb	0.195169082	0.628091776	0.310733382	0.757199594	
Mar	1.029710145	0.627850792	1.640055501	0.106806848	
Apr	0.697584541	0.627678603	1.111372185	0.271332027	
May	1.532125604	0.627575268	2.441341594	0.017940571	
Jun	1.7	0.627540819	2.708987128	0.009023162	
Jul	1.034541063	0.627575268	1.648473285	0.105062375	
Aug	1.795169082	0.65597253	2.736652834	0.008384209	
Sep	0.596376812	0.655741791	0.90946897	0.367144165	
Oct	0.997584541	0.655576928	1.521689519	0.133921598	
Nov	-1.201207729	0.655477991	-1.832567602	0.072382891	

RJTY_KSEA Regression Data

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COMMERCIAL AUGMENTATION

AND THE NEED FOR DEMAND FORECASTING

Abstract

During the wars in Iraq and Afghanistan there were heavy demands placed on the Department of Defense (DOD) transport network. This increase in demand forced a corresponding demand on contract carrier operations that are utilized to supplement the DOD shortfalls. These carriers operate under the Commercial Reserve Airlift Fleet (CRAF) agreement. This agreement offers incentives to contract carriers to participate, while offering increased capacity and flexibility in the DOD transportation network. This augmentation comes at a cost and to avoid paying exorbitant fees, the Air Force must find the right model of demand management to ensure availability while remaining a good steward of tax payer funds.

This study assesses the need for a forecast model for utilizing CRAF resources to augment the demands of channel and exercise missions. Due to increasing demands on organic (Air Force owned) aircraft, extensions on the service life of the aircraft, and the shortage of qualified crews, augmentation for airlift grew.

Collaboration

US TRANSCOM CJ8

AMC/A9

AMC/A3B

AIR FORCE INSTITUTE of TECHNOLOGY

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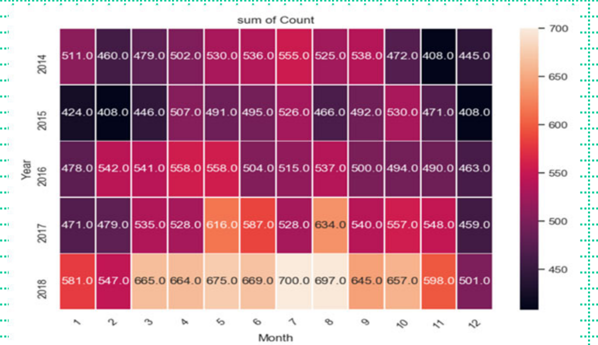
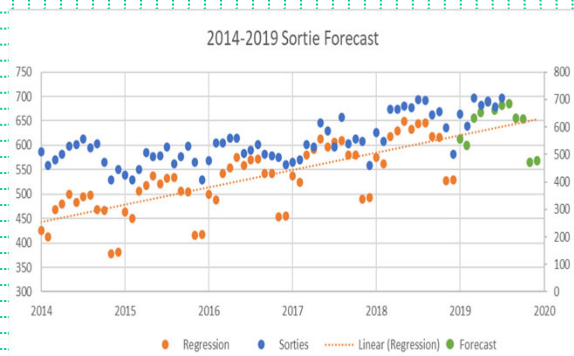
Air Force Institute of Technology



Historical



Forecast

Significance

This research addresses the critical need of CRAF/commercial augmentation aircraft to support the DOD's need for lift support. US TRANSCOM is the purchasing agent for CRAF/commercial augmentation services, it is imperative they can forecast the demand for the "fixed buy" portion of the program. AMC is the day-to-day manager of the program and have a significant financial stake in the game through the Airlift Readiness Account (ARA). In order to support both agency objectives, an accurate forecast capability is needed.

Methodology

A systematic literature review (SLR) was conducted to answer the investigative questions of this research. A systematic literature begins with identifying an exhaustive list of pertinent literature based upon certain inclusion criteria while also creating exclusion criteria to minimize the amount of irrelevant material gathered. The included material is examined to identify relevant themes as they pertain to the research questions.

This research will utilize a multiple linear regression technique to analyze data pulled from the Global Decision Support System (GDSS) database to determine a yearly projected demand forecast of commercial augmentation needs. Additionally, Commercial Operated Integration System Database (COINS) data is provided for load utilization by mission, costing factors, and provides a secondary validation of short tonnage per mission.

Research Objective

The objective of this study will be to determine proper methodology of implementation and forecasting of augmented cargo and passenger services for channel and exercise operations. This study will take a quantitative look at the cargo and passenger movements from 2014 to 2019 through resources such as GDSS and Commercial Operated Integration System Database (COINS) data sets.

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14. ABSTRACT
During the wars in Iraq and Afghanistan there were heavy demands placed on the Department of Defense (DOD) transport network. This increase in demand forced a corresponding demand on contract carrier operations that are utilized to supplement the DOD shortfalls. These carriers operate under the Commercial Reserve Airlift Fleet (CRAF) agreement. This agreement offers incentives to contract carriers to participate, while offering increased capacity and flexibility in the DOD transportation network. This augmentation comes at a cost and to avoid paying exorbitant fees, the Air Force must find the right model of demand management to ensure availability while remaining a good steward of tax payer funds.

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