A FEASIBILITY ANALYSIS ON THE AIR FORCE EMPLOYMENT OF ESCAPE SUPPLY CHAIN MANAGEMENT PROGRAM

Graduate Research Paper

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Abstract

The United States Air Force (USAF) has committed to modernizing the supply chain management enterprise with an initiative to use Commercial-Off-The-Shelf (COTS) software. The COTS program purchased will directly interface with multiple platforms and allow item managers and depot managers the flexibility to plan and manage their assigned weapon systems. Currently, the demand forecasts are performed by the legacy D200A system. This program operates the whole supply chain for all weapon system parts required for sustainment activities.

The replacement for D200A has been named the Enterprise Supply Chain Analysis, Planning, and Execution or ESCAPE program. The focus of this research is to compare data processing and demand planning from D200A to ESCAPE. The target audience for the study is the USAF supply planners, who will transition the supply chain enterprise from D200A to the ESCAPE program.

The software the USAF selected, ESCAPE, has tremendous capabilities and potential to transform supply chain management and streamline the way forward for aircraft sustainment operations. However, the limitations currently impacting the ESCAPE program are all self-imposed by the USAF. The limitations focus on data, the frequency of data feeds, and the overall integration of the system. The initial phase of ESCAPE looks to be a new face for the supply chain with the same capabilities currently in place with the Requirements Management System (RMS).

To my family

I am grateful for your selfless sacrifice, love, and support through the years of your service to this great country.

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I would like to express my sincere appreciation to my faculty advisor, Lt Col John Dickens, for his enthusiasm and high level of engagement throughout this research effort. The passion and knowledge shared is a testament to his dedication as a professor and officer to his Airman. I would also like to thank my sponsor, Lois Huizar, and Team, from the Air Force Materiel Command, for both the support and latitude provided to me in this endeavor.

Lee R. Russell

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A Feasibility Analysis on the Air Force Employment of ESCAPE Supply Chain Management Program

I. Introduction

The logistical sustainment of the USAF's fleet is a complex and challenging task. On average, the USAF spends $4 billion annually to buy and repair spare parts for its fleets (Mills et al., 2018). One way to reduce these costs is to improve the accuracy of part demand forecasts. The challenge resides in supply chain software that is integrated and able to produce accurate forecasts. Additionally, the software should inform item managers and depot parts managers with what parts are needed to adequately meet aircraft readiness. Meeting demand ensures the right parts are in the correct quantities to satisfy war and peacetime flying requirements. Consequences of not meeting these operational requirements include short-notice cannibalization actions, hasty contract development for spare part solutions, increased transportation requirements through lateral and depot support, and enlarged inventory carrying cost and obsolescence of excess spare parts.

What makes supporting the AF logistics enterprise so challenging is that it encompasses nearly 118 distinct weapon systems that vary from over 60 years to four years in age. For instance, the latest iteration of the B-52 was produced in 1962. Further complicating matters is the life extension of older aircraft, such as the B-52, that has exceeded engineering design service certifications. The new certification for the B-52H airframe is now into the 2040s (Boeing Company, 2018). The suppliers to produce parts for those legacy aircraft are becoming extremely difficult to find. The original parts makers have either gone out of business or are no longer producing parts that require 1960's era technology.

As the logistical challenges continue to stress out the USAF supply chain, the maintainers that work to keep aircraft mission capable are also under pressure to maintain aging and over-employed aircraft. In response, the USAF has chosen an innovative path towards the sustainment of our aircraft fleets with a new system purportedly designed to replace our legacy forecasting system, referred to as the D200A.

The new program is called Enterprise, Supply Chain Analysis, Planning, and Execution program (ESCAPE). The program is a COTS solution programmed by Parametric Technology Corporation (PTC) to transform USAF supply chain management. Similar versions of the supply chain management program are in use by U.S. Coast Guard, U.S. Navy, and three major airlines to manage their sustainment and logistics activities (PTC, 2017). The new ESCAPE program will not only forecast spare aircraft parts but will manage the USAF's supply chain enterprise. The program hierarchy wraps up supply chain management into Service Parts Management (SPM) and further breaks that down into five sub-components: Demand Planning, Inventory Planning, Supply Planning, Exception Planning, and Performance Management (Ruf et al., 2018).

Problem Statement

The USAF needs an updated supply chain management software capable of replacing and subsuming antiquated technology to maintain a competitive advantage against rising near-peer threats.

Research Objectives/Question

This research will focus on the feasibility of the ESCAPE program. The goal of this research is to provide insight into the layout of the program that is programmed to replace the USAF's current supply chain management systems. The study will provide an operational perspective of ESCAPE and review how ESCAPE will theoretically forecast spare parts. The research will attempt to answer the following questions: 1) How will the newly acquired ESCAPE program forecast spare parts? 2) Will the new ESCAPE program perform better than the existing supply chain management system, that is the D200A?

Methodology

This research employed a feasibility analysis and focused on the practicability of ESCAPE as a replacement program to the current legacy system known as the D200A. The study compares the forecasting methods of the legacy D200A system and the ESCAPE program. The study also investigates and compares the data employed by each program to forecast spare aircraft parts.

Assumptions/Limitations

The primary limitation of this research is the current data streams available in ESCAPE to enable a comparative forecasting analysis with the D200A. Also, there is minimal literature related to the ESCAPE program. All ESCAPE information is provided by the software vendor, system manuals, or the AFMC logistics team.

Implications

The ESCAPE program has been purchased by the USAF and is currently being updated to meet an array of USAF specific requirements. The testing of the program is scheduled to start in the summer of FY21. This research will provide a partial inspection of the demand planning capabilities of the ESCAPE program.

Summary

The USAF has purchased updated supply chain management software through a COTS program that is being used by the Coast Guard, Navy, and four major commercial airline companies to manage and forecast aircraft spare parts (PTC, 2017). The integration of the ESCAPE program will not only forecast spare aircraft parts but will manage the USAF's supply chain enterprise.

II. Literature Review

The USAF logistics enterprise is a vital component outlined in the United States' national security objectives. The logistics structure aids in meeting readiness demands for deterrence and operational deployment requirements needed to overwhelm America’s enemies. One direct method of meeting readiness demands is having the correct spare parts on hand to fix aircraft and keep them in the operational fight. Throughout the years, the USAF has pursued various process improvements to reduce inventory costs and adopt industry practices. A few industry practices include outsourcing, global sourcing, single sourcing, and just-in-time deliveries to keep lean inventory levels (Griffin, 2008).

In the 1990s, the USAF initiated the implementation of a Just-In-Time (JIT) logistics strategy. The drastic change in logistics posture was fueled with the ending of the cold war and all military appropriations being significantly reduced for the foreseeable future. The JIT system cut costs by reducing inventory and waste. With time, JIT proved to work well in reducing inventory; however, it created a supply chain that was slow in adapting to changes, which failed to adequately meet operational requirements (Griffin, 2008). The USAF recognized that it needed a smooth operating logistical support structure to enhance its operational effectiveness. In addition to JIT, the USAF recognized the need to centralize its entire logistical enterprise command and control. The reorganization added JIT and many other process improvements throughout the supply chain, which will be discussed in this paper's subsequent sections.

USAF Supply Chain Reorganization - Post-Cold War

All the significant positive changes made in the post-cold war can be attributed to the combining of two logistical powerhouses. These essential changes are accredited to the USAF Logistics Command (AFLC) merger with USAF System Command (AFSC) that provides oversight and streamlined maintainability, supportability, and overall life cycle cost management. In 1992, AFLC and AFSC merged into USAF Material Command (AFMC). This merged weapon systems platform research, science, engineering, and acquisition programs with AFLC logistics and management expertise. This merger restructured the Agile Combat Support (ACS) doctrine that defines core competencies for USAF logistics. For the first time in history, program managers possessed cradle-to-grave responsibilities to assigned acquisition programs under the integrated weapon systems management (IWSM) program (Russell, 2007).

Reorganization Did Not Include Updated Systems

While the USAF reorganized and stood up AFMC to centrally manage its supply chain, the programs used to take on the new challenges of enterprise management were unfortunately not upgraded. The current USAF supply chain management program is the RMS D200 suite developed and pieced together, starting in the late 1980s to the present day. Ultimately, the RMS is vital to the planning and projection of Air Logistics Complexes (ALCs) buy and repair requirements (Merkle, 2017). The growing problem with the RMS D200 is the outdated programming language, which constrains important system refinements. Holistically, the D200 is comprised of seven stand-alone programs. Each program executes a unique algorithm that processes data and passes information to the other six programs. The RMS D200 suite resides on the IBM z/OS mainframe platform hosted at the Defense Information Systems Agency's Data Center in Ogden, Utah (Merkle, 2017).

The initial planning or forecasting component of RMS D200 is the Secondary Item Requirements System (SIRS). For each item, the calculations for spare part requirements in SIRS employ historical consumption and program data to forecast a failure rate. More importantly, SIRS provides quarterly expendable, recoverable, and repairable requirements, which are shared with multiple D200 programs and systems (Merkle, 2017).

The Next Chapter in USAF Supply Chain Reorganization

After the reorganization in the 1990s, the USAF logistical supply enterprise's next major milestone occurred in 2008 when the Global Logistics Support Center (GLSC) became fully operational. Since its inception, the GLSC has the responsibility to manage every part of the supply system from strategic sourcing to final disposition. With the addition of the GLSC, the regional supply centers were appropriately dissolved. The support infrastructure shrank from five regional supply centers and consolidated down to two logistics support centers (LSCs), one for Combat Air Forces and the other for Mobility Air Forces. The consolidation of supply centers was directed by the Program Budget Decision (PBD) 720, which mandated significant maintenance workforce reductions to align with congressional spending. The USAF responded to PBD 720 with the consolidation of back shop maintenance activities. This marked a conversion known as the Repair Network Transformation (RNT), which shifted each wing’s 3-level maintenance capabilities for line replaceable units (LRUs) to the new consolidated repair facility (CRF) or depots for the repair of aircraft spare parts (Parrish and Blazer, 2007).

The RNT restrictions placed on maintenance required the USAF to modify the way spare parts are forecasted in D200A. The modification takes into account that all parts removed from the aircraft are categorized as “bad” and will increase the number of parts used in calculating the historical demand (Parrish and Blazer, 2007). The reason for the error in demand history is tied to aircraft parts known as line replaceable units (LRU) associated with any given aircraft. With these restrictions, back shop maintenance specialists no longer possessed the equipment to perform tests on repairable parts to determine serviceability. Consequently, parts are automatically tagged not repairable this station (NRTS) and turned into a supply system for upstream repair, thereby artificially inflating consumption rates that would otherwise be repaired at the base level. Ultimately, the NRTS data feeds directly into the Standard Base Supply System (SBSS) and feeds into the secondary item requirements system (D200A) for a future worldwide requirement and readiness-based leveling computations. The wing’s two-level maintenance restriction is still in place today and continues to impact the forecasting of spare parts. While not the purpose of this research, one could argue that the restriction on base-level maintenance impacts forecasting accuracy and reduces maintenance effectiveness, hinders aircraft availability, and subsequently lowers fleet wide mission capable (MC) rates.

Data for Supply System

This study raises concerns in the accuracy of the data that is fed to the supply systems. Just as important as the parts employed by maintenance are the flying hours that factor in on each forecasted part. The USAF's Flying Hour Program (FHP) is essentially how it funds the organize, train, and equip mission set. The FHP takes into account the hours needed for each wing to attain and maintain combat readiness for aircrews (USAF). In addition to aircrew training, each sortie is an opportunity for maintenance and other support functions to train in specific Air Force Specialty Code (AFSC) requirements and maintain an acceptable proficiency level.

The annual flying hour numbers required to meet both training and operational objectives are calculated at the Major Command (MAJCOM) level. The FHP estimates the number of pilot hours that must be flown to meet training requirements. The projected FHP numbers are fed into the D200 to calculate requisition objectives that is a forecast, for spare parts. These requisition objectives, in conjunction with on-hand inventory and condemnation rates, drive depots and item mangers' logistical decisions and processes to maintain the parts needed to achieve the FHP. Funding issues arise when the actual number of hours flown differs from the number forecasted. The difference can impact operational readiness and increase spending due to the purchasing of spare parts above forecasted demand levels, not buying enough parts, or buying the wrong parts (Mills et al., 2018).

There is a mounting price to be paid as the USAF fleet grows older and requires more logistical support to maintain mission-capable aircraft. The Congressional Budget

Office (CBO) found significant growth in Operation & Sustainment (O&S) costs for nine of the 13 aircraft fleets examined in its 2018 report. As Figure 1 shows, the growth rates in O&S costs per flying hour ranged between 2.7 to 6.8 percent. The CBO used the average age of each MDS, and the actual increased O&S cost for each MDS comparison (CBO, 2018).

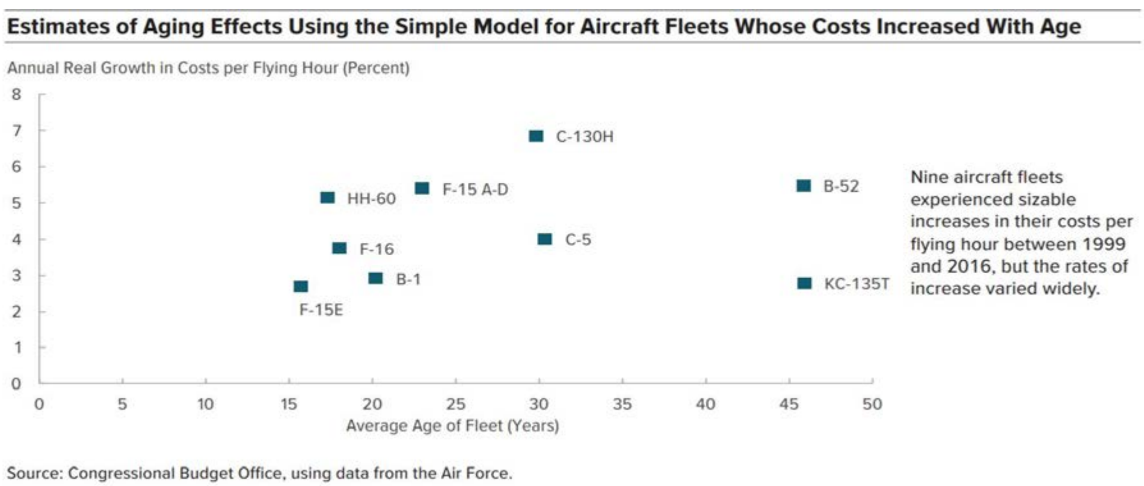

Figure 1 - CBO Increased O&S Cost (Reprinted from Congressional Budget Office Report: Operating Cost of Aging Air Force Aircraft, September 2018: 5)

As aircraft sustainment costs increase and budgets decrease, the ability to forecast spare parts accurately is becoming more vital in meeting readiness requirements. The AFMC is responsible for managing the USAF supply chain readiness requirements through policy and supply chain programs. While the USAF supply chain structure has evolved to meet the changing demands, the software responsible for managing the enterprise has not been upgraded.

Future USAF Supply Chain Management System

To meet USAF logistical demands, a new initiative has begun to modernize the supply chain to provide more effective capabilities to the warfighter. Leading the initiative is the Air Force Sustainment Center's 448th Supply Chain Management Wing. The USAF decided to update the supply chain through a "Software as a Service" (SaaS) solution and leverage a DoD cloud computing strategy rather than a traditional IT acquisition. The SaaS approach successfully deployed by the U.S. Coast Guard and U.S. Navy mitigates risk through the avoidance of significant upfront costs to procure hardware, software, and a system integrator (Windsor, 2017). The new USAF versions of the program were initially scheduled to be operational by FY18. However, due to program setbacks, the new schedule for ESCAPE to be online and replacing part of RMS is FY22 (Ruf et al., 2018).

Figure 2 - ESCAPE Dashboard – Inventory

The overall design of the ESCAPE program is based on the programming structure referred to as Service Parts Management (SPM). It was designed to improve the USAF's supply chain planning capabilities, enabling more effective warfighter combat support, and enhanced supply chain decision making. As mentioned previously, ESCAPE consists of the following five mission areas: demand planning, inventory planning, supply planning, distribution planning, exception management, and performance management (Ruf et al., 2018). The following paragraphs will highlight each mission area's objectives in supply chain enterprise.

The Demand Planning mission area process estimates customer orders and produces a collaborated demand plan for each segment of the supply chain. Demand Planning includes the capability to provide independent (unscheduled) and dependent (scheduled) forecasts, user-selected forecasts, and an automated causal model forecast that incorporates flying hours to predict parts demand (Ruf et al., 2018).

The Inventory Planning mission area (or optimization) is the process of mapping the Demand Plan to location-specific inventory levels, subject to financial constraints. The Inventory Planning capability seeks to achieve specific weapon system availability while simultaneously minimizing inventory investment. Additionally, inventory can be automated or user-controlled through Readiness Based Sparing (RBS) principles. This holds true for parts where RBS cannot be applied, which is minimal to no demand history, through fill rate optimization or other business rules defined by the end-user (Ruf et al., 2018).

The Supply Planning mission area process employs the inventory output to develop a plan on how to allocate the assets to meet warfighter demand. This process seeks to drive repair schedules, purchases, and the (re)distribution of inventory to correlate with historical demands. Integral to supply planning is Distribution Planning.

The Distribution Planning mission area is a crucial element in aligning assets to support immediate weapon system availability requirements, that is Not Mission Capable Supply (NMCS), and proactively manage materiel shortages at operating locations (Ruf et al., 2018).

The Exception Management mission area process hosts a robust error reporting and event management capability, which alerts users to pertinent information where accurate forecasts for unique parts cannot be achieved. This process can also develop autonomous recommendations to reconcile exceptions within discrete planner work queues for Demand Planning, Inventory Planning, and Supply Planning (Ruf et al., 2018). Overall, this process consists of analytics, data stratification, metrics, reporting, and dashboard capabilities to support root-cause and what-if analyses to be performed by the government and the service provider to make best estimates of parts that are difficult to achieve accurate forecasts.

These core mission areas are based on functional supply chain planning activities and closely align with the supply chain actors performing the work across the Air Force Sustainment Center (AFSC). The ESCAPE program will provide centralized supply chain management needed to drive the logistical requirements of the USAF. Demand planning predicts the expected needs of an individual part. While the ESCAPE system performs many functions, this research will focus on the demand planning portion of the program, which is designed to forecast spare aircraft parts.

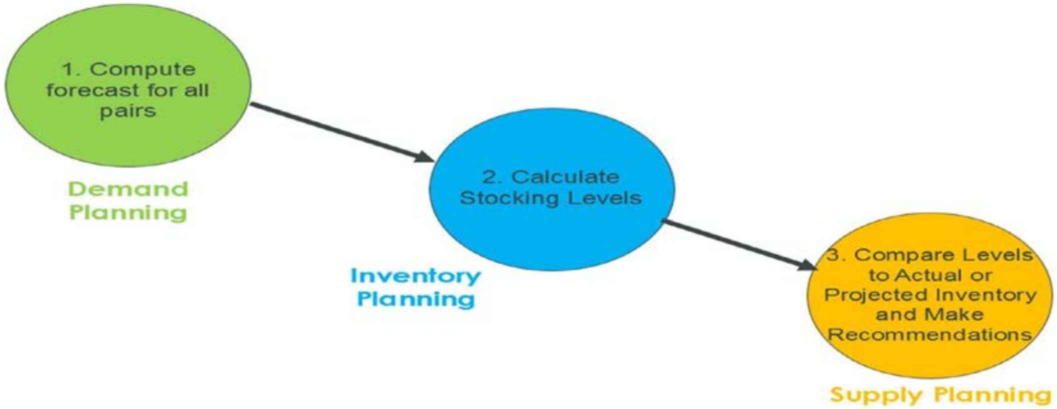

Figure 3 - Simple Overview of ESCAPE SPM (Reprinted from Service Parts Management Solution Description Document, Ruf et al., 2018: 14)

Service Parts Management

The following information details a high-level overview of how the Service Parts Management (SPM) program, that is ESCAPE, will track and flow the parts within the USAF network. Within SPM, the depot retail with three locations, and the base retail (tenant) with 270 locations, will be planned separately under a distinct Department of Defense Account Activity Code (DODAAC) location. Within SPM, each maintenance shop is defined as the organic repair vendor for two-level maintenance actions. Moving from base level there are three supply chain site locations considered as the Source of Supply (SOS) to manage inventory to all base locations. The three SOS site locations are co-located on bases with an air logistics complex that perform USAF depot maintenance, also referred to as the Source of Repair (SOR) (Ruf et al., 2018).

The SPM model tracks inventory from suppliers by further codifying every supplier as internal or external to the supply chain. The SOS internal supplier is defined as the parent location within SPM. All external sources of supply locations are defined as vendors. As for maintenance performed to repair parts, the SPM defines internal/organic or contract repair are both classified as vendor repaired in the system (Ruf et al., 2018).

To effectively manage inventory, SPM follows an interesting methodology. For each SOS, the system follows a series of algorithms to predict the depth and breadth of parts to minimize backorders based upon historical location demand. The ESCAPE program will take each parts NIIN and assign it to a primary SOS. The SOS represents where the National Item Identification Number (NIIN) is managed for wholesale planning purposes, not necessarily where the NIIN is stocked and available for network planning. While the wholesale assets may exist in multiple and various physical locations, the SOS modeled in SPM as a single location with aggregated wholesale inventory amounts assigned to it. This location will be named "WAL09" in SPM (Ruf et al., 2018). Overall, this appears to be an intelligent method for forecasting as it aggregates demand patterns for each part across all locations and develops a single aggregate forecast for the enterprise. However, it does not incorporate other important factors such as fleet size changes and intensity of flying (historical and future).

The overall construct of the SOS network is made up of three echelons; one parent SOS wholesale account level supporting all other depot retail locations, all base retail locations, and Centralized Repair Activities (CRA) for selected items and base combinations. Each CRA location provides intermediate-level maintenance to each item;

it is programmed to repair and subsequently shipped back to base retail when repaired. For the base retail locations that perform intermediate-level maintenance, the SPM algorithm will not pull serviceable parts and ship them to other locations. This is otherwise commonly known as lateral shipments to support unpredicted requirements at sister base retail locations.

The SOR and the SOS networks are responsible for managing all the aircraft parts inventory within the USAF supply chain enterprise. The cycle of inventory flow from the vendor to the warfighter is depicted in Figure 4.

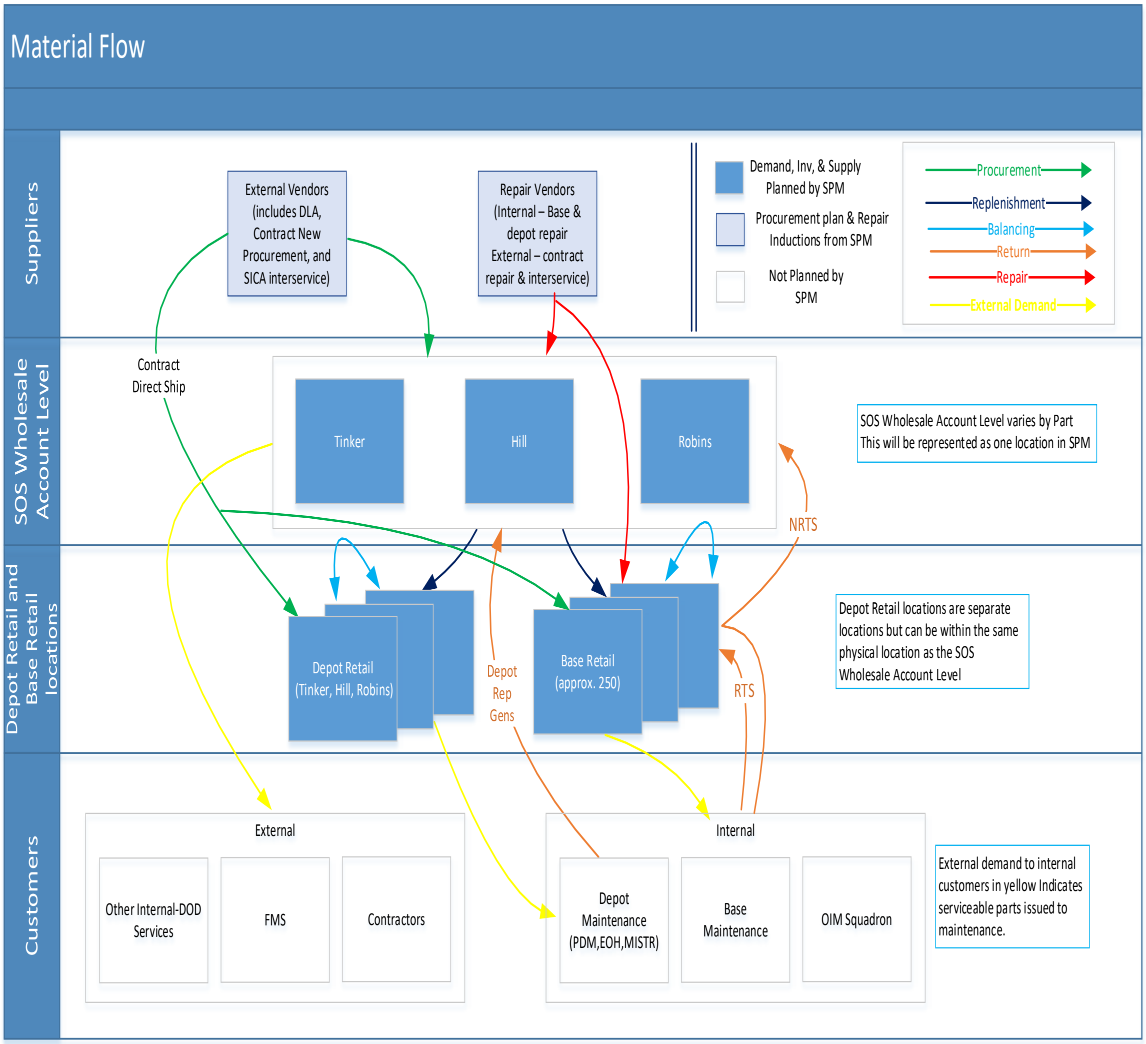

Figure 4 - Base/Depot Part Flow (Reprinted from Service Parts Management Solution Description Document, Ruf et al., 2018: 17)

Defense Logistics Agency (DLA) Controls Part Identification Process

The identification number assigned to a part is essential in managing the millions of parts in the supply system. The US Defense Logistics Agency (DLA) owns the part identification process and is responsible for giving each piece of inventory a unique part identification number. The following National Stock Number (NSN) structure identifies and catalogs approximately 14 million active and inactive items. As discussed previously, the SPM will use the NIIN of the NSN for specific part identification and inventory planning to forecast future requirements accurately. The NSN communicates essential information and links parts to supply groups and weapons systems. The breakdown of NSN is depicted in Figure 5.

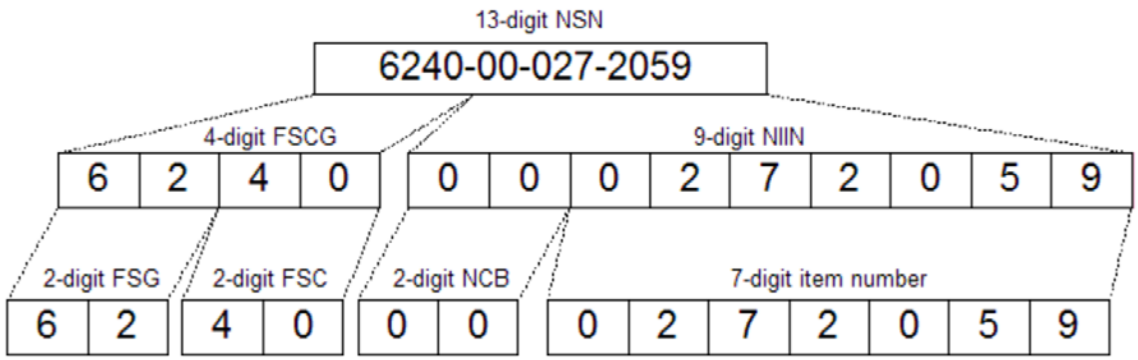

Figure 5 - National Stock Number Breakdown (Reprinted from Service Parts Management Solution Description Document, Ruf, Wright, & Halligan, 2018: 21)

Several components encompass the National Stock Number (NSN) system. The NSN is the official label applied to an item of supply procured, stocked, stored, issued, and used throughout the federal supply system. It is a concatenation of the Federal Supply Class Group and the National Item Identification Number. The Federal Supply Class Group (FSCG), which is the first four digits in the NSN designator, identifies the commodity group and class within the group. Each FSCG covers a relatively large and mixed area of commodities (Ruf et al., 2018). The National Item Identification Number (NIIN) is a nine-digit code that identifies each item of supply. The first two digits identify the North American Treaty Organization (NATO) Country Code (NCB), which represents the country that entered the item into the supply system. The remaining seven digits are sequentially assigned to identify each item in the Federal Catalog System (Ruf et al., 2018).

While the SPM uses NIIN, the D200A is programmed to use the full NSN. The NSN is how parts are ordered and tracked in the supply system. The D200A segment uses a system-sparred part forecast, and ESCAPE will operate on an item-sparred forecast or a system-sparred part forecast. The difference in the two forecasting methods is the item-sparred forecast strictly looks at each item without regard to a weapon system. The system-sparred part forecast looks at the entire weapon system as it forecasts parts strictly for a specific aircraft to meet a standard of mission-capable performance as determined by the user (Ruf et al., 2018).

SPM Requirements

In contrast to the D200A, the ESCAPE program employs the NIIN and focuses on a per item-sparred forecast. In the SPM demand planning mission area, every historical consumption transaction is captured by a specific part number. The transaction occurs only when a maintenance representative requests an NSN from supply. The SPM algorithm will subsequently search for the part to determine its stock status. Per the ESCAPE operating manual, demand is imported into the SPM data warehouse daily via an interface and is summarized by months for planning purposes (Ruf et al., 2018).

There are many interesting requirements from ESCAPE's development agreement with the USAF. For example, USAF planners requested visibility on the last fifteen years of demand data for each NSN. However, according to the ESCAPE manual, it requires two years of demand data for planners to build an initial part forecast. In contrast, the ESCAPE manual highlights that planners will have the option to choose four or eight quarters of demand history for ESCAPE to calculate part usage rates for causal forecasts. These multiple sources provide conflicting guidance and obscure the capabilities of the ESCAPE system (Ruf et al., 2018).

More troubling, the timeframes that planners can use to build forecasts are user-defined and in accordance with user preference. To compensate for this weakness, the ESCAPE team is manually grouping parts into historical demand timeframes. Item managers will have this available to create initial and subsequent forecasts. The ESCAPE manual refers to this as the forecasting horizon, which covers short and long-term planning. (Ruf et al., 2018). More specifically, the short-term is up to three years per part forecast. Alternatively, the long-term is a six to nine-year forecast. The ESCAPE program does incorporate a “what-if” scenario for decision-makers to account for potential demand changes. However, this can only be accomplished in the analysis portion of the program. Planners will have to use lessons learned from the “what-if” analysis and incorporate those desired changes into the actual demand planning forecast model (Ruf et al., 2018). More clearly, this portion is not automated and will likely require significant time investments by the planners, given they have a solid understanding of this aspect of the program.

Planning and Reliability

The dependability of the USAF supply chain is always a concern for operational commanders. The success of operational missions depends on how reliable the supply chain enterprise meets the warfighter demands. More specifically, how accurately will the SPM forecast each part to fail and have the correct replacement available in the supply chain. In the study performed by Sandborn and Myers, the authors argued that reliability is probably the most important hallmark of any system. It does not matter if referring to the supply system or an aircraft system (Sandborn and Myers, 2008).

If reliability is low, then all values calculated contain a high percentage error making it challenging to forecast future part estimates accurately. The reliability of the supply chain is based on life cycle management and tied to sparring parts, maintainability, and system availability. The maintainability piece is how quickly an item is replaced or repaired and restored to operational status after failing (Sandborn and Myers, 2008).

SPM Demand History

The SPM stores 60 months of demand history to forecast spare parts. In the demand planning section, users may view specific demand details, total demand history by month, and annual totals for each of the past five years on the SPM demand screens. Demand history greater than 60 months will not be available via SPM screens or SPM reporting. However, a business object report used to view demand history is archived for up to 15 years. To capture seasonality, the ESCAPE program requires at least 24 months of demand history in forecast calculations (Ruf et al., 2018).

Methods of SPM Forecasting

The ESCAPE program provides planners the ability to select from multiple forecasting methods. The main methods and areas available are statistical forecasting, causal forecasting, scheduled event maintenance forecasting, and replacement rate forecasting. The statistical forecasting employs historical information to calculate a statistical forecast. Causal forecasting uses forward-looking known factors applied to the product population to predict part needs based on failure rates. Scheduled Event Maintenance Forecasting deploys known future events to determine the parts that will be needed to support the events. For example, inspection time frames for engine overhauls and regular aircraft checks will be updated in SPM to ensure parts are available to support maintenance tasks. The last method is Replacement Rate Forecasting, where components forecasts are derived from LRU forecasts by using a tracked replacement rate (Ruf et al., 2018).

SPM Causal Forecasting

The ESCAPE program is designed to heavily rely on causal methods when forecasting spare parts. The actual ESCAPE causal forecast calculation is depicted in Figure 6. Similar to the D200A forecasting method, the USAF is determined to use flying hours and demand for an item to forecast each aircraft part. The basic mindset is that higher-flying hours will increase part demand, and the opposite is true for lower flying hours. Since the USAF employs flying hours by weapons system to train pilots, and the training requirement varies each year, it is important to capture the flying hour requirement into the forecasting methodology. The causal forecasting method will capture both demand and flying hours for each part.

This study has highlighted a concern with ESCAPE and not with the program itself. One of the first major concerns revolves around the data that the USAF has chosen to input into ESCAPE. The ESCAPE program will not receive real-time FH data feeds that would capture demand changes one to three months quicker and provide a more accurate forecast. While SPM can use multiple casual variables in a single forecast calculation the USAF is limited to only selecting one due to data limitations. Overall, this limitation overly constrains the employment of ESCAPE.

Additional concerns with ESCAPE forecasting stem from the frequency of data files being pushed to the system. Currently, the data pushed for employment range from quarterly to monthly with no real-time data updates. For example, if sorties and FHs were pushed daily to ESCAPE, then causal forecasts using sortie data could be compared to forecasts using FH data. Unfortunately, no plans have been made to provide ESCAPE with real-time FHs data or any sortie data. This is yet another instance where the USAF has limited the new capability to only being able to select one causal variable due to self-imposed data limitations. (Ruf et al., 2018).

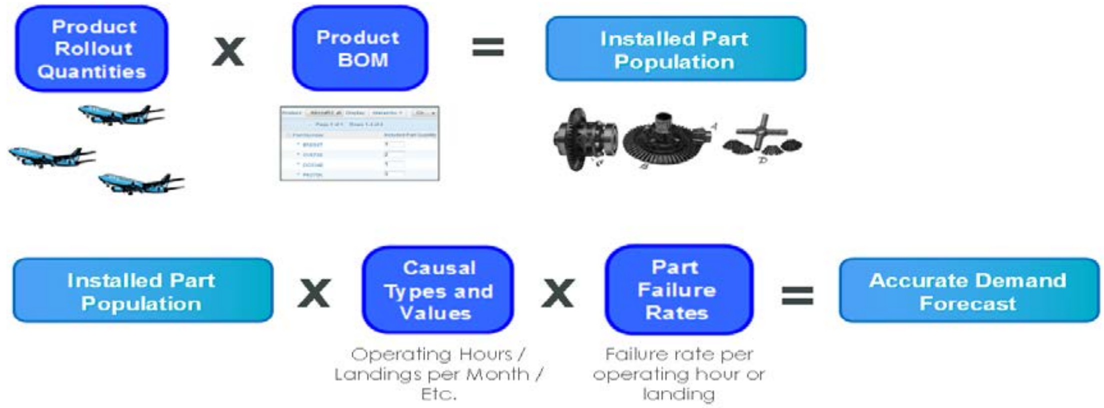

Figure 6 - ESCAPE Causal Forecast Calculation (Reprinted from Service Parts Management Solution Description Document, Ruf et al., 2018: 58)

Initial SPM Feasibility Study

The Air Force Sustainment Center (AFSC) did not conduct a feasibility study before the purchase of ESCAPE as it was not required prior to program procurement. The USAF supply chain enterprise falls under a logistics Defense Business System. Under the National Defense Authorization Act (NDAA), 10 U.S.C. 2222 "Defense Business System Modernizations," are subject to different rules compared to purchasing equipment or taking on new projects/programs. While within the confines of the NDAA, the decision to purchase ESCAPE prior to proof of concept may have been better served through a series of tests to illustrate the efficacy of the system.

The AFSC was required to submit an ESCAPE problem statement document outlining the current system limitations with defined problem sets and proposed fixes through ESCAPE (AFMC, 2014). The problem statement document went through a formal review and approval process before purchasing the ESCAPE program. Part of purchasing the SPM software was a technical review of software capabilities and functionalities during source selection. According to AFSC's, ESCAPE functional manager, there were multiple COTS software proposals received and evaluated (Farmer, 2020). The parent company of ESCAPE, PTC's SPM software most closely aligned to USAF needs. Unfortunately, this study was unable to analyze the final Proposal Analysis Report. The details of the report would provide insight into analysis performed on each proposed software source against defined requirements. The Proposal Analysis Report is considered "source selection sensitive" per AFSC and not releasable.

Summary

The USAF has experienced several periods when demand for aircraft parts and available parts have not aligned, severely impacting operational readiness. In response, the USAF selected ESCAPE to meet the dynamic challenges with aircraft sustainment and part allocation. The following chapter reviews the methodology used in the D200A system and the ESCAPE program.

III. Methodology

This research intends to compare the legacy D200A system with the newly obtained USAF ESCAPE program. The information used to compare both programs come directly from each program's instructional manuals (Ruf et al., 2018). In addition, this research will summarize information provided by AFMC technical experts for both the D200A and ESCAPE. The findings presented are for the sole purpose to inform and potentially identify risks for management to address before the scheduled implementation date. Due to data limitations and overall system maturity, this feasibility study does not investigate the full operational capabilities of ESCAPE; rather, only the parts demand segment of the program.

Feasibility Development

The feasibility study was challenging to conduct based on limited available information. The study focused on the AFSC problem of RMS being an antiquated legacy system that no longer allows integrated operation throughout the USAF supply enterprise. As previously discussed, the ESCAPE program was identified and purchased by the USAF to replace RMS. There are many capabilities described in the ESCAPE manual; however, not all features will be available until data becomes unclassified, and ESCAPE replaces RMS. The first piece of ESCAPE to be integrated is the demand planning mission area that will replace the D200A segment of RMS.

The study focused on three areas that each program requires to perform supply chain management functions. The first area is the data being supplied to both programs to calculate and provide part forecasts. The other area of study was taken from an overview perspective on the integration of ESCAPE into legacy systems.

The intent of conducting a feasibility analysis was to compare the forecasting methods of each program accurately. However, the challenges encountered during the study have made this a difficult task. Critical parts of information and updated ESCAPE program manuals were not available during the timeframe of the study. While there were limitations defined for the study, the overall function of ESCAPE and draft manuals were made available. The manuals provided the opportunity to introduce the rest of the USAF to the future of supply chain management.

Forecasting Methods

The D200A and ESCAPE's quantitative methods for forecasting the continuation of a set are simple. The only difficulty in forecasting spare parts for aircraft is that the data do not guarantee distinct or identifiable patterns. The quantitative methods for both D200A and ESCAPE programs are grouped into two categories, time-series, and causal methods.

The time-series method that this feasibility study used as a baseline was naïve forecasting and is considered a basic method of forecasting. It assumes historical demand will resemble future demand. The causal methods focus on forecasting by defining relationships between independent variables and dependent (or influencing) variables that predict aircraft part demands (Chase, 2009).

The ESCAPE method will use simple linear regression and only assign one causal type variable per part due to data or program limitations. The simple linear regression forecast will use historical demand and the relationship with flying hours to each aircraft part. More clearly, this means the ESCAPE program will establish a causal relationship with demand (dependent variable) and the flying hours (independent variable) associated with each part.

As with most methods used to forecast parts, there are disadvantages associated with each of them. For time-series forecasting, the major disadvantage is that it requires a large amount of data over an extended timeframe. Data is not a problem as the USAF has years of consumption data; however, with all the data available, the forecasting method does not capture or adapt to changes in a manner that makes it highly effective in forecasting parts.

The major disadvantage with the causal method to forecast accurately depends on a consistent relationship between independent and dependent variables. Consequently, the inconsistent relationship between variables makes this method difficult to get highly accurate forecasts (Chase, 2009). One of the main reasons is that maintaining and sustaining mission-capable aircraft is dynamic. On average a units FHs do not drastically change from year to year; however, how the FHs are used will impact demand. For example, the operating environment, climate, aircraft configurations, and overall operations tempo will impact each weapon systems demand in different ways.

Summary

The methodology focus is to answer the research questions and provide insight into the ESCAPE program. However, due to inadequate and often contradictory information from the available draft resources, it has limited this study. The analysis of the ESCAPE program is pieced together to provided valuable information and feedback for future users and follow on studies that seek to test the efficacy of the ESCAPE program.

IV. Analysis and Results

This study identified some critical differences in how each program forecasts spare parts. These key differences will be discussed, along with two areas of concern that should be considered prior to ESCAPE system wide employment. First, some data limitations are due to the classification of data and ESCAPE not being a secure program. Second, the entire premise that ESCAPE is replacing RMS and will function as a supply chain management enterprise was not fully supported by this study.

Forecasting Methods

It is essential to mention again that the comparison of forecasting methods proved to be extremely difficult. The D200A system has been in service for decades and is thoroughly understood by AFMC. On the other hand, the ESCAPE program is still in the development phase getting ready for its test phase. The study found inconsistencies when comparing the ESCAPE operating manual and discussing the system with the USAF ESCAPE program team.

The highlighted key difference between how each of the program forecasts are based on item and weapon system. The D200A program forecasts based on the weapon system and ESCAPE program forecasts based on each part (Ruf et al., 2018). Currently, USAF planners forecast and manage based on the weapon system; this is also known as a system-wide forecasting approach. Alternatively, the item forecast is a new way for the USAF to forecast and manage parts.

The study was unable to conclude that one forecasting method is higher performing than the other in forecasting spare parts. However, it does recognize that changing from a system-wide methodology to an item-based forecast will have an impact on the supply chain enterprise. Unfortunately, without system test data to perform an intelligent comparison, there was no way to conclude whether it will have a positive or negative impact for the study. In the next few sections, the analysis will explore the systems and different approaches to forecasting spare parts.

SPM Data Feed

ESCAPE will receive data feeds in a similar way the D200A receives data. The data flows from multiple sources within the enterprise and under varying frequencies. The non-standard information flow is a constraint-based on current requirements. Many of the data sources are programmed to create files and share with other systems quarterly. The requirements are based on cost savings measure as segments of RMS are only funded to run quarterly data file updates. The second factor is the cost and timeline to implement a data push or feed file. Per AFSC, the average cost to create an interface that is a copy of an existing quarterly file is sixty-thousand dollars and must be requested 12-18 months in advance. Many source systems operate under small sustainment budgets and cannot support the request and demand required to adequately feed data to ESCAPE (Farmer, 2020).

In Table 1, the frequency of how often data files are being pushed to D200A and ESCAPE is depicted in the Incoming Data Frequency column. The table is from AFMC and what they are currently tracking for data updates to the system. Under the ESCAPE header, the only line that has information is the first line labeled D200A and it currently receives data quarterly. This limitation has been recognized by the ESCAPE and programming team. Per the ESCAPE functional manager, the ESCAPE program office has been providing funding to ensure D200A part data is provided every month (Farmer, 2020). Pushing data feeds up to monthly could reduce the error as the program will correct variations twelve times a year versus only three times a year. A seventy percent increase in information flow and updating data to forecast parts will most likely reduce modeling error. Ideally, the system would be designed to use real-time data and update the supply chain more frequently to allow the enterprise to adjust for rapid demand changes. According to the ESCAPE functional team, this is not an option as the costs to upgrade data files from each system daily or even monthly would drive the cost of ESCAPE much higher (Farmer, 2020).

Table 1 - D200A & ESCAPE Data Frequency

Source	SPM Export View	Internal ETL View	Incoming Data Frequency
D200A			
D002A/Q310	vD002A_SPLY_PT_DTL_CUST		Daily
D002A/Q310	vD002A_SPRAM_DTL_CUST		Daily
D002A	vSPM_SRRB_INP_FIL		Monthly
D200A		vD200A_AA_MDL_RCOVR_INDENTURE	Quarterly
D200A		vD200A_AA_MDL_SUBGRP_MSTR_MDS	Quarterly
ESCAPE			
D200A		vD200A_SUBGRP_MSTR_NHA_MDS	Quarterly
ESCAPE	vSPM_BOM		N/A
ESCAPE	vSPM_CFFailureRate		N/A
ESCAPE	vSPM_LOC_LED_TM		N/A
ESCAPE	vSPM_PRT_MSTR		N/A
ESCAPE	vSPM_VNDR_LOC_PRT		N/A
ESCAPE	vSPM_VNDR_LOC_SKU_LED_DUAL		N/A
D200A Input Sources			
D035T		Weight, dimension, cubic size	Quarterly
D035C		repair cycle times and base order & ship	Quarterly
D035E		ASL, demand levels, CE depot floor	Quarterly
W001		FMS reqts and retention levels	Quarterly
D087H		Warime rates and adjustments, prepositioned reqts qtys	Quarterly

The data frequency is a considerable limitation to ESCAPE, and the planners responsible for forecasting spare parts accurately. However, the ESCAPE functional team is optimistic that when the legacy system is replaced, the frequency of data feeds should no longer be constraint as one system will receive all the data and inform the entire supply chain.

Part Identification Number

The D200A uses NSN's and ESCAPE was designed to use NIIN with DoDAAC (operating location) to forecast parts. As explained in the first chapter, the NSN contains the NIIN. The difference is the first four numbers of the NSN. The first four numbers from a supply and aircraft perspective tie parts to associated supply class and aircraft systems. More clearly, the NIIN does not associate aircraft parts with aircraft systems.

The D200A aggregates the DoDAAC level information before sending it out to the enterprise for planning purposes. Originally ESCAPE was programmed to plan at the NIIN/DoDAAC level since its DNA is from the commercial origins, which plans at the item-location pair. However, the USAF insists that ESCAPE employ flying hour data and this change is currently being performed by the programming team (Ruf et al., 2018).

The ESCAPE program will aggregate demand streams and produce forecasts at the enterprise level by item-location pairs and a single retail location. Once a part is forecasted, it will then be distributed throughout the enterprise based on historical demand by location. The item-location pair has the advantage of using location-specific data to make the best plan for that site; however, this works when the demand signal for the part is strong to avoid the problems associated with high variability due to low or volatile demand. To compensate, ESCAPE does have non-parametric approaches; however, the manual simply refers to it as a “Best Fit” forecasting technique (Ruf et al., 2018).

Perhaps an advantage of using the NIIN/location methodology in ESCAPE is its successful employment within the civilian airline industry. This may present a rare opportunity that the USAF can learn from and potentially adopt best civilian practices. In discussing with the ESCAPE functional manager, the program will look at the weapon system level only to build an initial forecast in the demand planning module of SPM (Farmer, 2020). The forecast is based on a parts level representing the NIIN/location supplied to the program's inventory planning process (optimization). Only from the analysis or "test" part of the software can item managers look at parts from a whole weapons system perspective (Farmer, 2020). While it is possible that ESCAPE will perform better than D200A, there is also inherent risk due to the complexity and operations structure of the USAF that ESCAPE program will miss the mark on demand.

D200A Programed Flying Hours

Methodologically speaker, both the D200A and ESCAPE employ FH as an independent variable within the causal forecast process. The importance of FHs in the USAF is how training and budgets are developed and funded. Tracking FH's provides real-time fleet data that will impact overall supply chain forecasting and parts funding.

The D200A computes the historical failure rate per 100 flying hours to forecast up to six years out. The program uses the forecast to compute the projected failures by taking the projected flying hours and multiplying it by a ratio of historical failures divided by historical actual flying hours. The forecasted demand for the next two to six years then depends on the forecasting method selected. The most common demand forecast is based on the parts moving average. A second option is simple exponential smoothing, which gets used for a few select parts (AFMC, 2014).

Demand planning takes into account how many spares are required in the pipeline (transportation time, repair time, and procurement time) to ensure availability when there is a failure. The bottom line is those flying hours are vital to forecast failures (demands). The next challenge is to then figure out the required spares needed to meet part availability in supply. It is crucial to keep in mind that flying hours are just one variable to use in causal forecasting of demand; D200 also uses PDMs, engine overhauls, next higher assembly repair (for SRU forecasting), and end-item inventory (AFMC, 2014).

The D200A program incorporates flying hours in its time series calculations. While there are other ways to approach forecasting, for example, employing sorties could be a more accurate alternative. Regardless, the USAF has decided to use flying hours in the ESCAPE program.

SPM Feed Calculated FHs

The ESCAPE program is based on the commercial aviation world and designed to use FHs to perform necessary causal forecasting per item demand. However, after design requirements and program algorithms were written, FHs are currently classified and cannot be fed to ESCAPE for forecasting. Per the ESCAPE functional manager, planned FH’s and inventories by location are classified. Until the classified data is released to ESCAPE, the locations most recent data is used. Future flying hours are used at an aggregate level, while historical flying hours, number of aircraft, BOM, and NIIN usage will be used in causal forecasts (Farmer, 2020). In comparison, D200A is using similar flying hour data due to the same classification issues.

The flying hours calculated for ESCAPE's forecasting will use historical flying hours with historical demand and projected flying hours for future demand forecasts. The total number of forecasted flying hours per MDS is allowed to be sent to ESCAPE; however, any real-time data or further breakdown of flying hours is not provided. Currently, the ESCAPE team is developing "global future flying hours," calculated by using a ratio based on historical demand. Using a historical flying hour statistical forecast, as well as the global flying hours causal forecast, and constructing an algorithm to blend the two of them in one forecast (Farmer, 2020). More clearly, the design team’s intent is to employ a time-series forecast and a causal forecast to create an average best fit forecast for each part by analyzing both programs with flying hour data. Until the efficacy of this approach can be measured against the D200A, this study finds both programs to be at a disadvantage in forecasting and managing spare parts.

The study is also limited by proprietary information. More clearly, this study could not investigate equations and algorithms that are programmed into both the D200A and ESCAPE systems. This limitation subsequently leaves methodological forecasting questions unanswered. However, this study has identified major limiting factors with data and how often it is processed through systems. The significant limitations of both programs is the frequency and data being used to calculate and manage parts. The outcome is that the USAF supply chain is getting an updated user interface that has similar limitations in its capability of forecasting parts.

ESCAPE Integration

The projected future is to have ESCAPE manage the supply chain enterprise and subsume the D200 suite. However, as of right now, there are legacy systems outside the current scope of initiatives in work that will prevent ESCAPE from achieving that objective. When ESCAPE becomes operational, the RMS system will still be performing six segments that will feed or receive data from ESCAPE. A quick recap of the RMS D200 suite is made up of several segments: D200E (catalog), D200F (BOM). D200A (Plan), and D200N (Stratification). Initially, ESCAPE will only replace the D200A segment. If only one segment is being replaced by a system that was purchased to replace the entire D200 suite, then further challenges should be anticipated.

Investigative Questions Answered

The ESCAPE program is devised with multiple forecasting methods designed to allow item mangers and planners more options to forecast each part more accurately. What remains to be evaluated is how accurately ESCAPE will forecast spare parts. The conclusion of the study does not find that ESCAPE will improve and eliminate current challenges with the outdated legacy system. The ESCAPE program was purchased to fix the integration issues currently limiting the RMS suite. While this remains the goal of ESCAPE, the current problem in fielding ESCAPE is integrating it into the legacy system. At a minimum, the limitations facing ESCAPE seem to be commensurate with the same limitations of the current system.

Summary

The feasibility analysis highlights areas of concern within ESCAPE due to data constraints and overall system integration. What the study does reveal is regardless of the additional capabilities, the data used to analyze and calculate spare part forecasts is limited by the timeliness of data feeds and the actual data that is fed into SPM. Currently, the ESCAPE program is under development, and no formal testing has been conducted to give a comparative analysis on the accuracy of the forecast models. Doing so may confirm that if all ESCAPE capabilities were brought online and data issues were resolved, it would be a far superior program to manage the USAF's supply chain enterprise.

V. Conclusions and Recommendations

The USAF supply chain system has become outdated with the speed of technology and the continual demand to plan more effectively and efficiently to support the aging aircraft fleet. This chapter will discuss the conclusions of the feasibility study, implications to the USAF, and areas of future research.

Research Conclusions

The new USAF ESCAPE program is scheduled to be fielded in FY21 and be partially operational by FY22 (Farmer, 2020). The USAF supply chain management is configured with a multitude of twenty-year-old legacy systems responsible for enterprise-wide core planning functions. In working to overcoming legacy IT shortfalls, the solutions are nested in adding processes and increasing contractor manpower. These solutions are accompanied with a negative effect, resulting in slower system response times and increased sustainment costs (Ruf et al., 2018).

This feasibility analysis concludes that the overall functionality of ESCAPE is capable of managing the USAF supply chain enterprise. The problem is that the USAF will not be using ESCAPE as an enterprise solution for supply chain management for the foreseeable future. Many of the legacy systems will continue online for years to support the enterprise, along with ESCAPE. If ESCAPE is not fully subsuming the entire RMS, then the USAF has increased the complexity of its supply chain management enterprise. This will also likely be accompanied with increasing the costs to operate and manage the combined and more complex RMS and ESCAPE program cohabitation.

Implications of Findings

One of the purposes of this study is to inform end-users of the comparison between ESCAPE and our current system (D200A) and the USAF supply chain management enterprise's future. The changes in how ESCAPE performs calculations and the data used are significant for item managers and depot managers to understand when forecasting parts. The ESCAPE manual reviewed for this study is an excellent overview of what the program could do and does not necessarily reflect what the program will be capable of providing when initially fielded. This and other disconnects could provide other unanticipated challenges for the sustainment and supply chain management enterprise.

Recommendations for Future Research

This study recommends future research to evaluate and analyze ESCAPE forecasting results in comparison to the D200A. If accomplished, the results of the forecasting methods will provide planners a much-needed efficacy test of ESCAPE's capabilities and associate performance.

Additional future research areas that will build off this initial feasibility study are analyzing the Final Proposal Analysis Report once available from AFMC. Additionally, the training program can be evaluated and critiqued as this is going to be the key to effectively managing the supply chain successfully.

Summary

The USAF-selected the ESCAPE software, which has tremendous capabilities and potential to transform supply chain management. In addition, it shows some promise towards streamlining supply chain management processes and presents a positive way forward for aircraft sustainment activities. However, the limitations currently impacting the ESCAPE program are all self-imposed by the USAF. The limitations focus on data feed frequency, item-location based forecasting, and the overall integration of the system. While these limitations may be overcome, future testing of its forecasting capabilities are needed to provide confidence in its unique approach to aircraft spares demand management.

HOW THE AIR FORCE PLANS TO ESCAPE SUPPLY CHAIN MANAGEMENT

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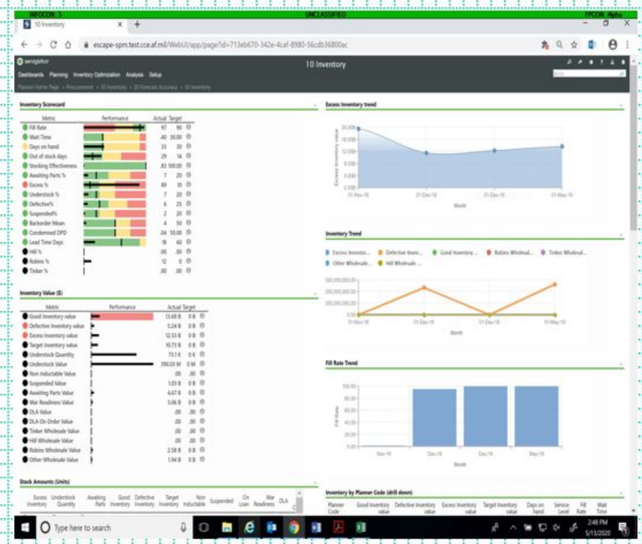
Abstract

The Air Force has committed to modernizing the supply chain management enterprise with an initiative to use Commercial-Off-The-Shelf (COTS) software. The COTS program purchased will directly interface with multiple platforms and allow item managers and depot managers the flexibility to plan and manage their assigned weapon systems. Currently, the demand forecasts are performed by the D200A system. This program operates the whole supply chain for all weapon system parts required for sustainment.

The software the AF selected, ESCAPE by PTC Inc., has tremendous capabilities and potential to transform supply chain management and streamlining the way forward for aircraft sustainment. However, the limitations currently impacting the ESCAPE program are all self-imposed by the AF. The limitations focus around data, the frequency of data feeds, and the overall integration of the system. The initial phase of ESCAPE looks to be a new face for supply chain management with similar forecasting methods as RMS system.



EXAMPLE OF ESCAPE DASHBOARD – INVENTORY TAB

Significance

This research addresses the feasibility of the newly acquired ESCAPE program. As we have studied, logistical supply chains can make or break an operational campaigns success. Today the AFMC is responsible for the AF supply chain management enterprise. In order to meet the warfighters demands and maintain mission capable aircraft, the supply program needs to accurately forecast parts and ensure the required parts are available.

Methodology

This research focused on the feasibility of ESCAPE as a replacement program to the current legacy system, D200A. The study compares forecasting methods of the legacy D200A system and the ESCAPE program.

Collaboration

AIR FORCE MATERIAL COMMAND

AFSC/LGP

Research Objective

This research will focus on the feasibility of the ESCAPE program. Bringing insight into the layout of the program that will replace the AF's current supply chain management systems. The study will provide operational scope of ESCAPE and review how ESCAPE will theoretically forecast spare parts. In order to meet this objective, the research will attempt to answer the following questions: 1) How will newly acquired ESCAPE program forecast spare parts? 2) Will the new program perform better than the existing supply chain management system?

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14. ABSTRACT
The United States Air Force (USAF) has committed to modernizing the supply chain management enterprise with an initiative to use Commercial-Off-The-Shelf (COTS) software. The COTS program purchased will directly interface with multiple platforms and allow item managers and depot managers the flexibility to plan and manage their assigned weapon systems. Currently, the demand forecasts are performed by the legacy D200A system. The replacement for D200A has been named the Enterprise Supply Chain Analysis, Planning, and Execution or ESCAPE program.

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