APPLICABILITY OF SUPPLY CHAIN CONCEPTS FOR MANPOWER MANAGEMENT

GRADUATE RESEARCH PROJECT

Francis E. Rupert, Major, USAF
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Abstract

Manpower levels for Company Grade Logistic Readiness Officer (LRO) positions can show significant variance from year to year based on the needs of the Air Force. This variance often causes problems in future years when the Air Force determines that there are not enough personnel or too many personnel, which results in the voluntary or in-voluntary separation of Airmen. This thesis uses mixed methods to develop a new approach to manpower management based on supply chain models. This approach leverages concepts from Material Requirements Planning (MRP) and the News Vendor model. The resulting model is used to explore the problems with manpower level variation through scenarios derived from historical data. Different policies are examined within the model framework to gain insight into the relationship between yearly decisions and variance in the manpower pipeline. These insights can be used to drive improved decision making, leading to decreased variance in LRO manning from year-to-year and throughout the overall manpower pipeline.

Acknowledgments

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Francis E. Rupert

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I. – Introduction

Background

Each year, the Air Force trains and commissions a new group of Logistic Readiness Officers (LRO's). The exact number of new officers that join the Air Force can vary, sometimes significantly, from year to year. At face value, this variation in numbers seems normal and manageable. The Air Force tracks the number of LRO's as a year group not only at the time they join the Air Force, but also as the year group progresses in time in service. This information is important to understanding the scope of the variation. For example, the number of officers fluctuates, as new officers join the LRO career field later in their career, or officers that originally joined as LRO's decide to separate from the Air Force. The Air Force constantly works to both meet Congressionally mandated end strength numbers as well as posture its manpower to meet future requirements for Field Grade Officers. As part of this force management effort, there are times when the Air Force determines that the number of officers in certain year groups is incorrect. In situations where the Air Force determines there are too many officers, they may introduce force management programs such as voluntary separations or Retention Recommendation Boards, which can be stressful experiences for those Airman and their families.

These force management programs, which result in immediate increases or decreases to LRO manning for Company Grade Officer positions, can also create significant turbulence in the extended manpower pipeline. Excess positions appear as peaks in manpower positions in a given year, whereas shortfalls may appear as valleys.

These peaks may be leveled off through the previously mentioned force management programs which will reduce the manning, while valleys may be addressed by increasing the number of new officers that join the Air Force in future years. An example of this turbulence is shown in Figure 1, which shows the number of new LRO's that joined the Air Force each year between 2007 to 2016.

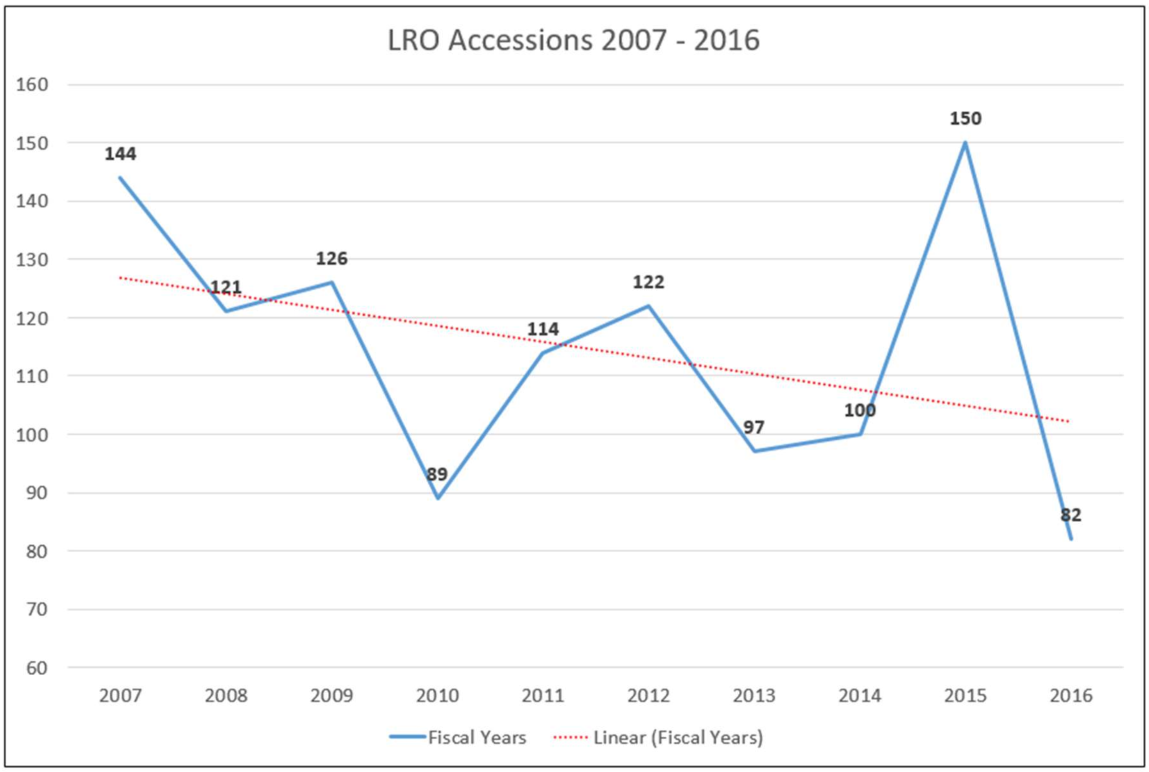

Figure 1: LRO Accessions per year group: 2007 - 2016 (HQ AF/A1, 2017)

The above figure illustrates the volatility from year to year. In general, it seems there is a constant cycle of bringing too many personnel on-board, then determining there are too many personnel and reducing the quantity, only to realize that now there are not enough personnel to meet the demand for Field Grade Officers. To frame this problem in supply chain management terms, this is a bullwhip effect phenomenon. In a supply chain, the bullwhip effect is observed when there are inefficiencies in information flow and ineffective decisions which result in dramatic swings in inventory levels.

Studies involving manpower are always challenging. This is because manpower decisions are nuanced and involve many variables that the Air Force can only influence but not completely control. An example of this is the end strength limit for the Air Force. This limit is set by Congress, annually, through the National Defense Authorization Act (NDAA). It is a limit or cap on the total number of personnel that can be in the Air Force. These limits affect the entire Air Force, and can influence decisions on growth or reduction of personnel. Other examples of variables outside the Air Force's direct control are shifts in the operational focus and mission of the Air Force. One of the best examples of this was the growth that the Air Force experienced during the Cold War era. At its peak in 1986, the Air Force had a budget of $97 Billion and an end strength of over 600,000 personnel. Following the end of the cold war, the mission of the Air Force shifted dramatically, and by 1997 the budget had been reduced to $73 Billion and end strength was reduced to 380,000 ("Evolution of the Department of the Air Force," 2011). This draw-down led to a leaner, operationally realigned Air Force. However, in order to prepare and win a more conventional conflict, or a scenario like the Cold War, the Air Force would likely need to grow significantly and shift operational focuses. The challenge is that Air Force leaders cannot predict every future situation. For this reason, flexibility is important to developing the right weapon systems and personnel to meet emerging requirements.

Due to the dynamic nature through which current manpower requirements are determined, and how future requirements are planned for, there is an opportunity to explore adopting or incorporating supply chain principles to determine what manpower requirements should be and when adjustments to the planned requirements should be made.

Problem Statement

The number of Air Force LRO's that enter Active Duty each year varies from year to year. This high degree of variability results in supply chain inefficiencies that are not identified for several years and require significant effort, in terms of man hours and human capital, to correct. By studying these processes and the variables involved, this research seeks to explore a mechanism to create consistent flows at the initial entry point (entrance to active duty). This mechanism should incorporate knowledge of how decisions at a point in time affect current and future manpower status. Furthermore, this research will investigate whether consistent flow will reduce variance in manning levels from year to year.

Research Objectives/Research Questions & Hypotheses

This research will seek to primarily answer the following question: As the number of LROs entering Active Duty each year varies, is there a supply chain model, such as Material Requirements Planning (MRP), that can be used to create more even manning levels and reduce variance from year to year?

Research Focus

The research will include information on LRO manning levels spanning a 10-year period between 2007 and 2016, and specifically focus on Company Grade Officer (CGO) positions, which are Officers in the grade of O-1 to O-3. The data, provided by Head Quarters Air Force, shows the number of Officers that joined the Air Force in a given year, and then their subsequent manning levels through the following years. From this, we can establish both the gains and losses that occur over a Fiscal Year (FY) for each year group. In turn, we can establish an aggregate total of the number of CGO's across all year groups that are in the manpower pipeline at the start and end of the FY. This information is used to develop supply chain-oriented models of manning level decisions. The study will consider manning levels at the beginning and end of each FY, rather than breaking them down into smaller units, such as weeks, months, or quarters. The reason for this is due to the sources of supply involved. In the context of this study, the sources of supply are the U.S. Air Force Academy (USAFA), Reserve Officer Training Corp (ROTC) and Officer Training School (OTS). Quotas or lot sizes for USAFA and ROTC are determined several years in advance, so it is unlikely that dramatic changes to the lot size would occur with these sources of supply. Quotas for OTS are determined on an annual basis, and typically spread out over the course of several classes. Since the vast majority of LRO's enter Active Duty during the early summer months, this would skew any attempt to look at time in a smaller unit of measurement than yearly.

Methodology Overview

Overall, the methodology of this study will be a mixed methods approach, combining both quantitative and qualitative elements. Qualitatively, it will be driven by seeking a broad explanation or interpretation of the effectiveness behind the process through which manpower requirements for future years are determined and programmed. Quantitative data will be used to examine current trends, and develop models to project forecasts of future requirements. These models and forecasts help answer the question of whether supply chain models decrease variance and reduce the need for force management programs. Throughout the study, a logistics and supply chain perspective will be used to develop a theoretical lens to view the problem.

Assumptions/Limitations

The assumptions and limitations that will be made with this project are significant. The hypothesis, that LRO manning levels can be managed through the application of a supply chain model such as MRP, should be treated as a proof of concept. Currently, LRO and Air Force personnel levels are determined through a process that utilizes a complex and dynamic set of criteria. The process takes into account current, and anticipated future requirements based on operational demands and authorized end strengths. Annually, manpower end-strength quotas for each Service component are included in the NDAA that is passed by Congress. These bills are based with inputs from each Service component, but also take into account broader fiscal policies across the U.S. government. If Congress, and the Service components, feel that there will be additional operational requirements then it is likely that manpower levels will increase from the previous year. For example, participation in an emerging overseas military operation or the launching of a new weapons system during the next FY will require increased manpower. Specifically, the 2019 NDAA authorized the Air Force an end strength of 329,100 personnel ("JOHN S. MCCAIN NDAA FOR FISCAL YEAR 2019," 2019: 100). However, in the 2020 NDAA, the Air Force was authorized an end strength of 332,800 ("NDAA FOR FISCAL YEAR 2020," 2020: 138). Likewise, if there is an anticipated decrease in involvement in named operations, then fiscal appropriations will decrease. This may naturally lead to a decrease in manpower levels. While the results of the NDAA process may directly explain the increases or decreases that occur year-to-year, this project will assume that we can independently establish a manning requirement for officers for each year based on historical data. In reality, the Air Force cannot do this if the decisions exceed Congressionally mandated end strength limits.

One of the ways that end strength quotas are determined in the NDAA is based on the budget that Congress approves. Planning for resources, which affects current and future requirements, is conducted through a process called Future Years Defense Planning (FYDP). The FYDP is a projection of DoD requirements over a 5-year period. One of the main inputs to the FYDP is Manpower, which includes military end strength ("Defense Primer: Future Years Defense Program (FYDP)" 2020: 1). This is relevant to this research as the model will use a 5-year forecast of future requirements, and make the assumption that the Air Force has the ability shape and project future requirements for LRO's.

Managing supply chains using quantitative methods requires a careful consideration of time periods. In particular, the definition of time periods helps frame important supply chain concepts such as manufacturing lead time, and manufacturing cycle time. These times are important to quantifying levels of service. For example, delivering products by the time they are promised with a high level of certainty is an important measure of level of service. Since there is some flexibility with the sources of supply for Air Force Officers and LRO's, it will be assumed that the planned lead time to increase or decrease requirements for the next year is one period. This means that adjustments in manpower can be made ("ordered") the year prior to when they are needed.

Finally, as part of the process of determining an average demand, data on historical retention rates for Company Grade LRO's will be used to develop average rates of retention. These rates are used in the model to determine the number of Officers leaving each year. While retention rate will be computed using averages from historical data, the model dynamics are based on the assumption that there is no fluctuation in retention rates through time. Although this will simplify the analysis, this is simply not true. Retention rates fluctuate year-to-year based on many variables. A good example of this is the current COVID-19 pandemic. As the U.S economy has stagnated, retention rates across the Air Force have sky rocketed, meaning that Airman who would normally leave the Air Force are now choosing to stay. Because of this development, the Air Force initiated a voluntary separation program during 2021 to try to get manning back to a sustainable level.

Implications

The insight gained from this research could potentially affect the way the Air Force LRO Force Development Team and Headquarters Air Force Manpower, Organization and Resources Directorate (AF/A1M) personnel determine and manage LRO end strength requirements planning. Per Air Force Instruction 38-101, AF/A1M is the lead agency for developing policy and overseeing programs related to manpower and end strength management (Department of the Air Force, 2019). Additionally, this research can be used to demonstrate the applicability of the supply chain processes and methodology to problems outside the scope of what is traditionally associated with supply chain management. Lastly, if the application of a supply chain centric process proves effective in managing manpower levels, it could open possibilities for continued research in areas such as how to fill shortfalls in manpower, amongst other critically manned AFSC's.

II. – Literature Review

In Depth/Relevant Background

The issue of Force Management is not a new problem for the Logistics Community. The approaches taken to solve force management issues have a wide-reaching impact on all aspects of the logistics community. This paper is introducing a concept to resolve force management issues through using supply chain management concepts. This section details several sources on the concept of force shaping, applicable supply chain approaches and hypotheses.

"Workforce Reshaping Operations Handbook," Office of Personnel Management, 2013.

This volume is published by the Office of Personnel Management and provides a framework for determining if and when force shaping programs are required. The article does not provide any literature or statistics relevant to the study, but is still important for understanding the conditions in which a Reduction in Force (RIF) could occur. This publication also details specific actions which should be taken to avoid having to use force management programs. It discusses various programs, such as retraining, detailing employees to other agencies, severance of temporary employees, voluntary early retirement, and voluntary reduction of hours. It does not entirely discuss the root cause of RIF actions. Additionally, the guidance in the handbook is mainly targeted for use with civilian personnel. For this reason, it may not be applicable based on the nuances of military personnel management. Regardless, it is relevant to the discussion as it establishes the framework for determining when RIFs are required and the process for conducting them. Air Force guidance would likely fall in line with the process described in this handbook.

"Causes and Effects of Employee Downsizing: A Review and Synthesis," Datta, Guthrie, Basuil, Pandey, 2010.

This article published in the *Journal of Management,* seeks to explore the causes and subsequent effects of employee downsizing. The approach used for the study is an integrative framework, which incorporates elements such as environmental factors, organizational factors, employee downsizing, individual outcomes and organizational outcomes. The article also examines previously published reports on each part of the above framework. The conclusion of the study is that much of the existing research focuses on the immediate individual and organization impacts of employee downsizing, with inadequate research on the market conditions causing organizations to feel the need for downsizing. Overall, this article is particularly relevant to providing background on the impact of force shaping. One interesting quote from the article was the following: "At the organizational level, one possibility is an inverted-U relationship, with low levels of downsizing (under the "right" conditions) having positive effects, whereas higher levels of downsizing might remove "muscle" as well as "fat," leading to diminished or negative returns" (Datta, Guthrie, Basuil, Pandey, 2010). This quote indicates that while there are certainly positives to force shaping, if taken too far, there can be very negative effects.

"Understrength Air Force Officer Career Fields: A Force Management Approach," Galway, Buddin, Thirtle, Ellis, Mele, 2005.

This article from Rand studies understrength officer career fields. While the study does not directly deal with the topic at hand, it does discuss the Air Force's force management approach. This article is relevant because it provides information about how the Air Force establishes force management policies. The core focus of the article is on the Career Field Managers (CFMs) and the role they play. The authors acknowledge the link between CFMs at the operational level and policy makers at the strategic levels. It encourages the use of analytics in the decision-making process. This implies that as recently as 15 years ago, detailed analytics were not being used as part of the force management process for non-rated officer career fields. Overall, this would support the hypothesis that a more systematic approach to force management is needed to provide strategic policy makers with better information to prevent unnecessary fluctuations in personnel levels.

“'Force of the Future': career flexibility, fewer moves,” Tilghman, 2015.

This article from the *Military Times* details proposed changes to the military personnel management system and identified a growing shift in how senior leaders view personnel management. The article identified that a major concern for Senior Leaders has been the perceived cost of personnel. Senior Leaders viewed the cost of training and equipping personnel as unsustainable and eating into the budget for weapon system upgrades. The relevancy of this article is the marked shift in policy that it indicates. In the past, the common belief was that personnel levels were reduced to support the growth of new weapon systems. This article shows that the emphasis is shifting back to personnel development and retention, which in the long term, has an effect on accession rates.

“The Material Requirements Planning System for Aircraft Maintenance and Inventory Control: a note,” Ghobbar, Friend, 2004

The authors of this article interviewed various aircraft maintenance companies about different inventory management procedures and found that while the vast majority were using a re-order point system, there was a small minority using a system called MRP. MRP is a system which can help determine the quantity and timing for ordering new parts to satisfy master schedule requirements. MRP allows you to break a component into subunits and develop a plan for ordering all the parts so they are there when they are needed. Another benefit of MRP is that order sizes are not constant; it is assumed that there will be fluctuations in demand. This is relevant in any situation where demand is not constant. One of the drawbacks with MRP is that it is a fairly complicated program and software to implement. The article suggests that this is a barrier that could be overcome through deliberate training and education for any company interested in using MRP software.

"Quantifying the Bullwhip Effect in a Simple Supply Chain: The Impact of Forecasting, Lead Times, and Information," Chen, Drezner, Ryan, Simchi-Levi, 2000.

This article explores the supply chain phenomenon called the bullwhip effect. It examines whether forecasting demand data and lead times will have any impact on reducing the effect. The article defines the bullwhip effect and lists several of its causes. It develops several models that quantify the impact of the bullwhip effect. The models are used to examine the effect of differing types of demand forecasts. The authors conclude that by centralizing customer demand data and making demand data available at each stage of the supply chain, it was possible to reduce variance. However, they noted that it was not possible to completely eliminate the bullwhip effect from the supply chain.

The bullwhip, for example, can occur when the retailer does not have access to data on the customers mean and variance at that stage. This article is particularly relevant to this research since reducing variance within the supply chain of LRO's is the central goal of this effort.

"A Note on the Economic Order Quantity Model," Tungalag, Erdenebat, Enkhbat, 2017.

This article seeks to recast the classic inventory management technique known as the Economic Ordering Quantity (EOQ) using a calculus of variables. A revised approach is used to create a simple optimal control problem, which is expanded and refined into the EOQ model. This research is related to EOQ lot sizes as well as where and when inventory management decisions must be made. Furthermore, this research expands on the concept that the EOQ allows you to make inventory management decisions at different action times, not just the determined reorder points.

Scope/Refine the Problem

Based on the literature related to this research, it is possible to approach the manpower planning problem through the lenses of supply chain management. Personnel management decisions and manpower levels can be equated to inventory management decisions and units on hand. In these terms, it becomes possible to reframe the manpower planning problem in supply chain management terms. For example: How may we use inventory management concepts to set "lot-sizes" that reduce variance throughout the "supply chain" while meeting long term "demand" for manning that varies over time? How can we determine what the desired "inventory level" should be for CGO positions, or in other words, how many "units" should we try to maintain in the "pipeline" that feeds into and becomes FGO positions? This reframing of the problem leads to several inventory management techniques that could be applied to this scenario, with a goal of reducing variability.

Theoretical Models

The above research identified several inventory management concepts, such as the MRP and EOQ models, that could be applied and tested to see if they would reduce variance in our supply chain. Additionally, there is the concept of lot-for-lot replacement. However, before models are built using each concept, they should be reviewed closer to determine their applicability.

MRP was one of the inventory management concepts identified during the literature review. MRP is used to help manage the two basic dimensions of production control: quantities and timing (Hopp, Spearman, 2008: 115). The goal is to determine what quantities of materials are needed, to include sub-components, to build a final product, while also determining when production should start in order to meet delivery deadlines. The elements that go into MRP are gross requirements, scheduled receipts, projected on-hand inventory and net requirements. With this information, inventory planners can go through the four basis steps of MRP: netting, lot sizing, and the Bill of Materials explosion (ibid: 121). One of the ways that planners put all this information together is in the form of an MRP table. An example is shown below.

Part 500		1	2	3	4	5	6	7	8
Gross requirements		35	35		30		15		
Scheduled receipts									
Adjusted SRs									
Projected on-hand	40	40	5	5	−25	—	—	—	—
Net requirements					25		15		
Planned order receipts					25		15		
Planned order releases		25*	15						

Figure 2: Standard MRP Table (ibid: 126).

One important distinction with MRP is how demand affects these MRP variables. The MRP concept assumes that demand is not constant. Inventory planners are given two ways of addressing demand variability. One solution is lot-for-lot, which we will discuss later in this section. The second option is the Fixed Order Quantity (FOQ). The FOQ is a predetermined quantity that is used whenever an order is placed. While not as accurate as the EOQ, which also seeks to identify order quantities, there is benefit in using the FOQ to manage the cost of production set-ups vs the cost of holding inventory (ibid: 130). There is merit in looking at the MRP concept as a potential solution given the flexibility of demand within the concepts.

The second inventory management concept is the EOQ. Supply chain managers want to figure out the dilemma of how many units should be ordered, when the order should be placed, and how many orders will be required. Fortunately, the EOQ offers a solution. This model identifies the ordering quantity which minimizes and balances the inventory holding costs and the reorder costs (Agarwal, 2014: 2). One of the key variables in the EOQ is demand, and a key assumption is that demand is even, constant and continuous. This is in contrast to MRP, where demand is allowed to vary from period to period. This interpretation of demand is critical to the differences between the EOQ and MRP. Within the context of the manpower problem, it is apparent that there are fluctuations in demand from year-to-year, and because of this, it is not realistic to develop potential solutions or models directly based on the EOQ concept.

The third inventory management concept is the lot-for-lot replacement technique. Lot-for-lot is a fairly straight forward concept which proposes that you simply produce what you need, or what your requirement is, in each period that a decision is possible. There is no looking forward in time to make decisions based on longer term criteria. Lot-for-lot aligns with the Just-in-Time theory, and when used should result in no excess inventory at the end of the inventory period and a fairly smooth production schedule ((Hopp, Spearman, 2008: 129). While there are merits to lot-for-lot, there are also downsides. One particular downside is that it removes flexibility in supply chain decisions. Increasing your inventory is inconsistent with lot-for-lot policies if your demand is also not increasing. In looking at this from a manpower perspective, there may be times where inventory needs to increase. In this case the number entering the pipeline would increase. In succeeding periods, there would be an increase in the number of losses, or separations, as there is an inherent relationship between these two variables. Likewise, if the scenario involved separations, or demand, slowing down then it would be unwise to decrease the quantity entering the pipeline as we know that the separation rates will increase again. Lastly, lot-for-lot policies would not give us flexibility to make adjustments to address ineffective decisions. One such scenario is increasing the flow into the pipeline and thus increasing inventory levels to address shortfalls due to bad decisions from the past. Another scenario could be that separation rates skyrocket and we need to increase the introduction of new inventory. Making adjustments to the scheduled receipts would not be feasible under a lot-for-lot inventory management approach if the adjustments did not match the losses or gross requirements.

Hypotheses

Given the relevant literature, and the identification of several inventory management techniques, we can revise our hypotheses from "As the number of LROs entering Active Duty each year varies, is there a supply chain model, such as the MRP, that can be used to create more even manning levels and reduce variance from year to year?" to "Use of an expanded MRP netting process will result in reduced variance long term when compared to available historical data."

III. – Methodology

This chapter will look at the data used for this research and explore the methodology used to build the relationship between LRO manpower and the MRP process. Furthermore, this chapter will also explain and provide details on the model that will be built to test the hypothesis. The model will incorporate manpower data provided over a 10-year period, while also projecting future requirements for new personnel.

The numbers used to build the forecast of future requirements is based on relationship of data within the model.

Manpower Data Sources

In order to understand the history of LRO manpower decisions, information is needed on the number of personnel entering and leaving the career field. To satisfy this requirement, Head Quarters Air Force A1, Manpower, Personnel and Services, replied to a research request and provided two sets of data. The first set of data was a snapshot of "21R-LRO Career Field Health". This included information on sustainment requirements, stress metrics, accession targets and retention data (2017). The second set of data was labeled as "21R Grad Student Question." This set of data provided detailed data in the following categories: Beginning of FY Inventory, Gains during FY, Losses during FY, Retention percent and Still in Inventory at end of FY. This data was initially provided in 2017. An updated version of the 21R-LRO Career Field Health slide was provided by HQ Air Force A4LR, 21R Force Development. This slide contained similar information, but also included data from FY18 to FY20 (Career Field Health, 2020).

Data Analysis

The two 21R-LRO Career Field Health slides did not provide detailed data on a year-to-year basis, but were effective at conveying the overall health of the career field and illustrating the potential impact that bad decisions can have over multiple years. As figure 3 shows, in 2015 the Air Force gained a significant number of LRO's onto Active Duty, well above what the sustainment target was. In the following year, 2016, the number of new LRO's dropped dramatically, well below the sustainment target. As a result, the 2016-year group would likely be below the 21R sustainment target for the next 9 years.

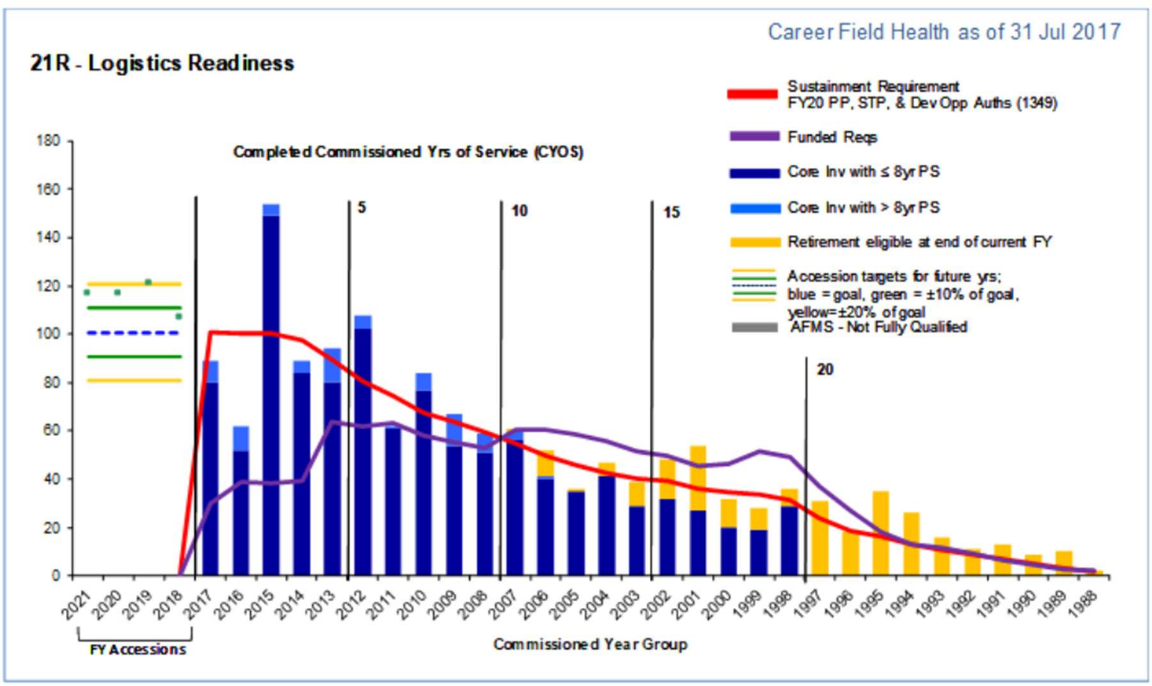

Figure 3: 2017 21R-LRO Career Field Health Data (HQ Air Force A1, 2017)

The second set of data provided a much more detailed analysis of LRO gains, losses and sustainment over an extended period of time. This data is relevant for several reasons. Firstly, the information is detailed enough to allow us to build correlations with the data elements which comprise the MRP model. We will discuss these correlations in more detail later as we develop the model. Secondly, the data not only shows gains, losses and sustainment trends, but enables the ability to track a group of units from the point they enter the pipeline, to the point they leave the pipeline, roughly 10 years later. The data is detailed enough that gains or losses that occur for the group of units over each year can be tracked. All groups together make up the total number of CGO's in the pipeline. This is important because it illustrates the impact of bad decisions. For instance, when the target is missed by a large number, the impact will be seen not only immediately, but for all the years that the units are in the pipeline. The figures below show several of the data elements, and illustrates both the entry point for units into the pipeline, the period of time that units will stay in the pipeline and how you can track the growth or decrease of units throughout their entire time in the pipeline. Again, this is just a single year group, so decisions made prior to the point of entry will impact future decisions for the entire time that those units are in the pipeline.

Gains during FY (includes accessions, crossflow in, IST in)										
cyos_efy	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
0		104								
1			7							
2				3						
3					2					
4						3				
5							1			
6								0		
7									0	
8										0

Beginning of FY inventory										
cyos_efy	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
0			105							
1				111						
2					109					
3						106				
4							96			
5								88		
6									73	
7										67
8										

Losses during FY (includes separations, FM actions, promotion to Maj, and crossflow out)										
CYOS	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
0			1							
1				5						
2					5					
3						13				
4							9			
5								15		
6									6	
7										5
8										

Figure 4: Pipeline Illustration

Data Comparison

The data provided through HQ Air Force A1 provided data in the following categories: Gains during FY, Beginning of FY Inventory, Losses during FY, Still in Inventory at end of FY, and Retention Percent. Moving forward, the following data interpretations can be applied to category:

- Gains during FY: Number of Units Entering the pipeline.

- Beginning of FY Inventory: Number of Units in the inventory at the start of the FY. Each FY starts on 1 Oct and ends on 30 Sep in the following year. For example, FY21 goes from 1 Oct 20 to 30 Sep 21.
- Losses during FY: Number of units that are leaving the pipeline during the FY.
- Still in Inventory at end of the FY: Difference between the number of units in the pipeline at the start of the FY versus the number of units that left the pipeline during the FY.

Using these interpretations, we can examine the terminology used in the MRP table and make comparisons between the MRP definitions and definitions of our variables. A traditional MRP table uses standard supply chain definitions and logic. The MRP table used to test the hypothesis is based on similar logic, but modifies the definitions to fit the unique scenario involving manpower pipelines. Below are some of the standard definitions that make up the MRP Table and their application in the models used for this research.

Table 1: MRP Definition Comparison

Term	Standard Definition	Modified Definition
Gross Requirement	Demand for the period	Quantity scheduled to leave the pipeline or "Losses"
Scheduled Receipt	Quantity scheduled to complete in the period	Quantity scheduled to enter the pipeline or "Gains"
On-hand Inventory	Projected on-hand inventory at the end of the period	Projected on-hand inventory for all phases of the pipeline
Inventory Target	This term is not typically used	Projected inventory variation between on-hand inventory and safety stock level
Net requirement	Demand beyond what the on-hand inventory and scheduled receipts can cover	Demand beyond what the on-hand inventory and scheduled receipts can cover

Model Construction

With a common understanding of the similarities and differences between the data that goes into the traditional MRP table, and the data available for this research, it is possible to build off the comparisons and develop the relationships and steps that will go into the model. Using the data available, we developed a series of steps or rules that will be followed as we develop our MRP table, as referenced in Figure 2.

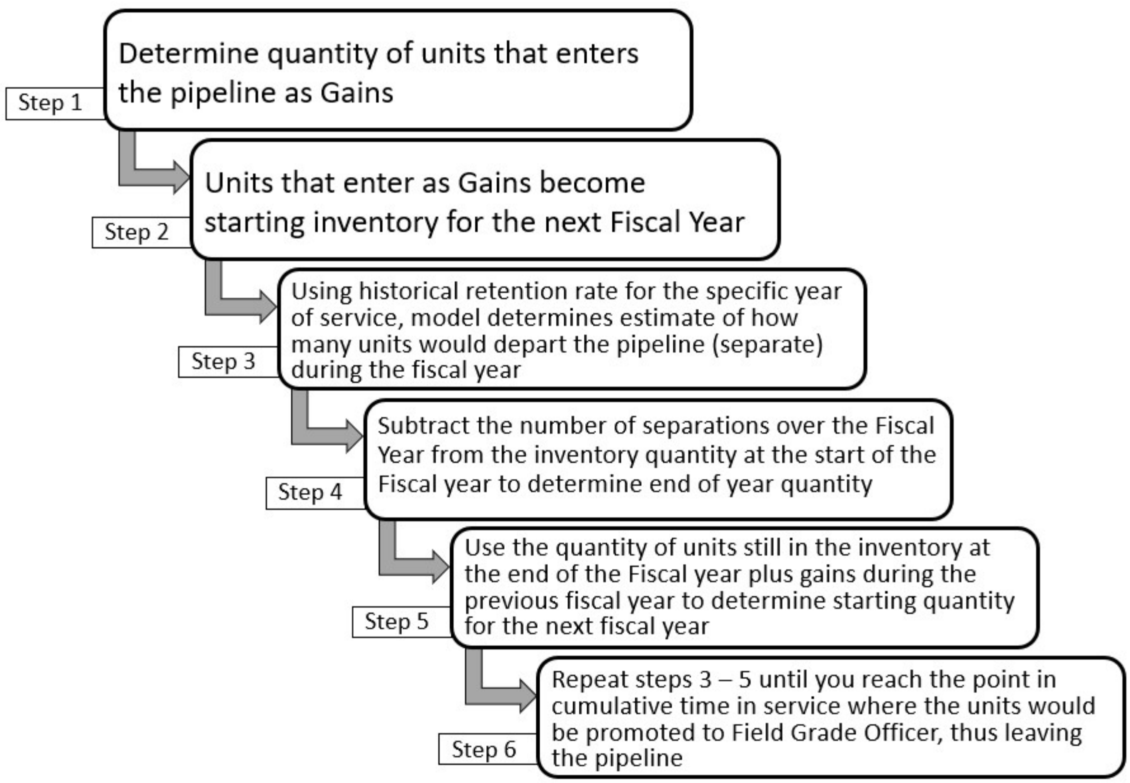

Figure 5: MRP Steps

One of the data elements that will go into our MRP table is the number of anticipated losses each year as a group of units moves through the pipeline. The initial data provided by HQ Air Force A1 showed data on losses between 2007-2016 and retention percentages for each year. In order for our model to test our hypothesis, we needed to forecast how future gains will move through the pipeline and how inventory management decisions play out differently in each model. To do this, we needed to use a standard data set for retention rates to estimate future losses. Using information provided for data over 2007 – 2016, we established an average retention rate for each year in the pipeline. This information would be applied against the inventory quantity at the start of the FY to determine the estimated losses for that FY. The below table shows the average retention rate for each year in the pipeline.

Table 2: Average Retention Rates

Years in Service	Retention Rate
0	99%
1	98%
2	95%
3	89%
4	87%
5	86%
6	87%
7	91%
8	83%
9	99%

Another aspect of the model is the scope of the model. Instead of focusing on one specific year group, the model will look at the requirements for CGO positions across all year groups. To do this, the model will have to establish a baseline requirement for the total number of positions. One way this can be accomplished is through the use of another model called the News Vendor problem. The News Vendor problem is traditionally associated with products that are seasonal, such as Christmas lights, and helps the manufacturer determine how many units to produce when demand is unpredictable. Once the quantity of CGO positions that we should seek to fill is determined through the News Vendor problem, it will become our inventory target in the MRP table.

Another difference in the traditional MRP table and how we will build our model is the structure of the table. A traditional MRP table typically looks at periods, and what the overall gross requirements and scheduled receipts for that period are. As stated above, in our modified table decisions made in the first period may affect the status of variables and thus the decisions in future periods. This is not standard in an MRP table, as decisions in a specific period do not affect the decisions or requirements in other periods. Additionally, the table developed for this model will provide information on the first period, which is the period in actual execution, then treat the following five periods as a planning forecast. This is consistent with the FYDP process as explained in the Assumptions/Limitation chapter of the Introduction.

Model Examples

As referenced above, we will use a traditional MRP table that is modified to meet the definitions and interpretations applied to our data as explained in Table 1. An example of this modified MRP table is shown below.

Assumption: Overall Inventory can and should be maintained XXX CGO Positions						
Part A	18 (2024)	(19) 2025	(20) 2026	(21) 2027	(22) 2028	(23) 2029
Gross Requirements (Losses over FY)						
Scheduled Receipts (Gains during FY)						
Adjusted SR's						
Actual Projected On-hand:						
Inventory Target (Level:)						
Net Requirements						
Planned Order Receipts						
Planned orders releases						
	Actual	5 Year Planning Forecast				

Figure 6: Modified MRP Table

Model Details

Before using the manpower table to fill out the MRP table, it is necessary to establish the inventory target level using the News Vendor problem. Per "Factory Physics," (Hopp, Spearman, 2008: 67) the variables below are used to develop the News Vendor targets.

- X = demand (in units), a random variable
- μ = mean demand (in units)
- σ = standard deviation of demand (in units)
- Co = cost (in dollars) per unit of overage (i.e., stock leftover after demand is realized)
- Cs = cost (in dollars) per unit of shortage
- Q = production or order quantity (in units); this is the decision variable (Hopp, Spearman, 2008: 67)

Within the context of this scenario, we can further define the variables as:

- μ is based on the total inventory quantity each year 2007 - 2016. Therefore μ = 978.
- σ = 108.95.
- Co is based on the total salary incurred over the course of a 20-year military career. Thus, Co = $1,751,590.8.
- Cs is based the unit shortage cost. This is determined by subtracting the total salary from the cost to make, which is based on average tuition costs over a 4-year Bachelor's degree and equals $87,944 (Powell, Kerr, 2020). Thus, Cs = $1,751,590.8 - $87,944 which equals $1,663,646.8.

In order to solve for Q*, it is necessary to determine the value of *z*. This can be done by first computing the *ratio* as follows:

$$ratio = Cs/(Co + Cs)$$

For the cost values above

$$ratio = \frac{1{,}663{,}646.8}{1{,}751{,}590.8 + 1{,}663{,}646.8}$$

$$= \frac{1{,}663{,}646.8}{3{,}415{,}237.6}$$

$$= 0.487$$

Looking up the corresponding ratio value (0.487) in the standard normal table (Hopp, Spearman, 2008: 69) leads to: z = -0.03 (ibid: 695).

Given that z = -0.03, Q* can be obtained by using the following equation:

$$Q^* = \mu + z\,\sigma$$

This becomes Q* = 978 + (-0.03)(108.95). When solved, it is determined that Q* = 974, meaning 974 is the optimal quantity of units that should be maintained in our manpower pipeline. Using this quantity as our inventory target, this information can be added to the MRP table and help inform future decisions regarding increases or decreases items entering the pipeline in order to meet the optimal inventory level.

Using this information and the first sets of data, we develop the MRP table below and explanation of how it is completed.

Assumption: Overall Inventory can and should be maintained 974 CGO Positions						
Part A	11 (2017)	12 (2018)	13 (2019)	14 (2020)	15 (2021)	16 (2022)
Gross Requirements (Losses over FY)	79	135	119	120	119	125
Scheduled Receipts (Gains during FY)	144	116	92	132	107	123
Adjusted SR's						
Actual Projected On-hand: 870	935	916	947	986	974	972
Inventory Target (Inv Level: 974)	-39	-58	-27	12	-	-2
Net Requirements		58	27			2
Planned Order Receipts		58	27			2
Planned orders releases	85				2	
	Actual	5 Year Planning Forecast				

Figure 7: Completed MRP Table

The table above starts with an on-hand inventory of 870 units. The gross requirement for period 11 is 79 units, meaning 79 units will leave the pipeline during this period. The total on-hand inventory would drop to 791 units. However, we also have a scheduled receipt of 144 units, meaning 144 units are entering the pipeline during period 11. As a result, our on-hand inventory at the end of period 11 is 935 units. Because our target level is 974 units, we are short by 39 units. This is an additional demand in the subsequent period and must be incorporated if we will meet our target requirement. Note that this short fall will not be addressed in period 11, as this period is in execution. Instead, the requirement will roll over to period 12. This is because we have little ability to add additional personnel during the year they enter the pipeline. We can, however, make those adjustments during FY's identified as planning years. As net requirements develop, as shown in the above table, they are incorporated into the pipeline as additional planned order receipts for that FY.

Alternate Scenarios

The MRP table shown in Figure 7 represents the baseline model. To compare the effectiveness of this model, we will also develop a model which has a FOQ of 115 for all units entering the pipeline. 115 is used since this was the average number of units that entered the pipeline across 2007 - 2016. As future decisions are made, the starting basis for each planning year will be 115, which will then be increased or decreased as required by the net requirements.

Assumptions/Limitations

The primary assumption in this model is the cost variable used in the News Vendor problem. Information on ROTC scholarships was not readily available, so an average cost of tuition for Colleges across the US was used instead. Some ROTC scholarships would not cover this amount, while others would. This also does not take into account the cost of OTS and the US Air Force Academy. These cost figures were not used as the preponderance of LRO's who are commissioned through ROTC.

IV. Analysis

Using the information available, and the modified MRP table, we developed current and future forecasts of requirements for 2017 - 2024. Each table shows the year of execution and five planning years. The results are shown below in sequential order.

Assumption: Overall Inventory can and should be maintained 974 CGO Positions						
Part A	11 (2017)	12 (2018)	13 (2019)	14 (2020)	15 (2021)	16 (2022)
Gross Requirements (Losses over FY)	79	135	119	120	119	125
Scheduled Receipts (Gains during FY)	144	116	92	132	107	123
Adjusted SR's						
Actual Projected On-hand: 870	935	916	947	986	974	972
Inventory Target (Inv Level: 974)	-39	-58	-27	12	-	-2
Net Requirements		58	27			2
Planned Order Receipts		58	27			2
Planned orders releases	85				2	
	Actual	5 Year Planning Forecast				

Assumption: Overall Inventory can and should be maintained 974 CGO Positions						
Part A	12 (2018)	13 (2019)	14 (2020)	15 (2021)	16 (2022)	17 (2023)
Gross Requirements (Losses over FY)	134	116	116	116	121	124
Scheduled Receipts (Gains during FY)	116	92	132	110	119	121
Adjusted SR's						
Actual Projected On-hand: 926	908	884	990	974	972	971
Inventory Target (Inv Level: 974)	-66	-90	16	-	-2	-3
Net Requirements		90			2	3
Planned Order Receipts		90			2	3
Planned orders releases	90			5		
	Actual	5 Year Planning Forecast				

Assumption: Overall Inventory can and should be maintained 974 CGO Positions

Part A	13 (2019)	14 (2020)	15 (2021)	16 (2022)	17 (2023)	18 (2024)
Gross Requirements (Losses over FY)	115	112	112	118	120	124
Scheduled Receipts (Gains during FY)	92	132	116	119	115	126
Adjusted SR's						
Actual Projected On-hand: 901	878	898	978	979	974	976
Inventory Target (Inv Level: 974)	-96	-76	4	5	0	2
Net Requirements		76				
Planned Order Receipts		76				
Planned orders releases	76					
	Actual	5 Year Planning Forecast				

Assumption: Overall Inventory can and should be maintained 974 CGO Positions

Part A	14 (2020)	15 (2021)	16 (2022)	17 (2023)	18 (2024)	(19) 2025
Gross Requirements (Losses over FY)	112	111	118	116	118	114
Scheduled Receipts (Gains during FY)	132	116	123	116	121	107
Adjusted SR's						
Actual Projected On-hand: 873	893	898	979	979	982	975
Inventory Target (Inv Level: 974)	-81	-76	5	5	8	1
Net Requirements		76				
Planned Order Receipts		76				
Planned orders releases	76					
	Actual	5 Year Planning Forecast				

Assumption: Overall Inventory can and should be maintained 974 CGO Positions

Part A	15 (2021)	16 (2022)	17 (2023)	18 (2024)	(19) 2025	(20) 2026
Gross Requirements (Losses over FY)	110	116	114	114	109	142
Scheduled Receipts (Gains during FY)	116	123	121	119	103	127
Adjusted SR's						
Actual Projected On-hand: 884	890	897	981	986	980	965
Inventory Target (Inv Level: 974)	-84	-77	7	12	6	-9
Net Requirements		77				9
Planned Order Receipts		77				9
Planned orders releases	77				9	
	Actual	5 Year Planning Forecast				

Assumption: Overall Inventory can and should be maintained 974 CGO Positions						
Part A	16 (2022)	17 (2023)	18 (2024)	(19) 2025	(20) 2026	(21) 2027
Gross Requirements (Losses over FY)	116	114	113	105	137	108
Scheduled Receipts (Gains during FY)	123	121	126	102	127	127
Adjusted SR's						
Actual Projected On-hand: 884	881	898	987	984	974	993
Inventory Target (Inv Level: 974)	-83	-76	13	10	-	19
Net Requirements		76				
Planned Order Receipts		76				
Planned orders releases	76					
	Actual	5 Year Planning Forecast				

Assumption: Overall Inventory can and should be maintained 974 CGO Positions						
Part A	17 (2023)	18 (2024)	(19) 2025	(20) 2026	(21) 2027	(22) 2028
Gross Requirements (Losses over FY)	114	113	103	134	103	133
Scheduled Receipts (Gains during FY)	121	126	115	122	127	109
Adjusted SR's						
Actual Projected On-hand: 888	895	908	986	974	998	974
Inventory Target (Inv Level: 974)	-79	-66	12	-	24	-
Net Requirements		66				
Planned Order Receipts		66				
Planned orders releases	66					
	Actual	5 Year Planning Forecast				

Assumption: Overall Inventory can and should be maintained 974 CGO Positions						
Part A	18 (2024)	(19) 2025	(20) 2026	(21) 2027	(22) 2028	(23) 2029
Gross Requirements (Losses over FY)	112	103	133	100	129	125
Scheduled Receipts (Gains during FY)	126	115	127	127	108	125
Adjusted SR's						
Actual Projected On-hand: 891	905	917	968	995	974	974
Inventory Target (Inv Level: 974)	-69	-57	-6	21	-	-
Net Requirements		57	6			
Planned Order Receipts		57	6			
Planned orders releases	63					
	Actual	5 Year Planning Forecast				

Figure 8: MRP Table Baseline Model Results.

Using the same information that populated the baseline MRP model, an alternate MRP model was also tested. This model used a FOQ of 115 units. The results of this table are listed below.

Assumption: Overall Inventory can and should be maintained 974 CGO Positions						
Part A	11 (2017)	12 (2018)	13 (2019)	14 (2020)	15 (2021)	16 (2022)
Gross Requirements (Losses over FY)	79	135	119	120	128	127
Scheduled Receipts (Gains during FY)	132	132	132	119	120	118
Adjusted SR's						
Actual Projected On-hand: 870	923	920	987	986	988	979
Inventory Target (Inv Level: 974)	-51	-54	13	12	14	5
Net Requirements		54				
Planned Order Receipts		54				
Planned orders releases	54					
	Actual	5 Year Planning Forecast				

Assumption: Overall Inventory can and should be maintained 974 CGO Positions						
Part A	12 (2018)	13 (2019)	14 (2020)	15 (2021)	16 (2022)	17 (2023)
Gross Requirements (Losses over FY)	134	117	116	117	122	125
Scheduled Receipts (Gains during FY)	132	132	132	116	117	124
Adjusted SR's						
Actual Projected On-hand: 926	924	939	990	989	984	981
Inventory Target (Inv Level: 974)	-50	-35	16	15	10	7
Net Requirements		35				
Planned Order Receipts		35				
Planned orders releases	35					
	Actual	5 Year Planning Forecast				

Assumption: Overall Inventory can and should be maintained 974 CGO Positions						
Part A	13 (2019)	14 (2020)	15 (2021)	16 (2022)	17 (2023)	18 (2024)
Gross Requirements (Losses over FY)	115	113	113	121	121	126
Scheduled Receipts (Gains during FY)	132	132	132	113	121	121
Adjusted SR's						
Actual Projected On-hand: 901	918	937	993	985	985	980
Inventory Target (Inv Level: 974)	-56	-37	19	11	11	6
Net Requirements		37				
Planned Order Receipts		37				
Planned orders releases	37					
	Actual	5 Year Planning Forecast				

Assumption: Overall Inventory can and should be maintained 974 CGO Positions						
Part A	14 (2020)	15 (2021)	16 (2022)	17 (2023)	18 (2024)	(19) 2025
Gross Requirements (Losses over FY)	112	111	118	116	119	114
Scheduled Receipts (Gains during FY)	132	132	132	118	116	1198
Adjusted SR's						
Actual Projected On-hand: 873	893	914	988	990	987	992
Inventory Target (Inv Level: 974)	-81	-60	14	16	13	18
Net Requirements		60				
Planned Order Receipts		60				
Planned orders releases	60					
	Actual	5 Year Planning Forecast				

Assumption: Overall Inventory can and should be maintained 974 CGO Positions						
Part A	15 (2021)	16 (2022)	17 (2023)	18 (2024)	(19) 2025	(20) 2026
Gross Requirements (Losses over FY)	110	117	114	115	109	143
Scheduled Receipts (Gains during FY)	132	132	132	114	115	120
Adjusted SR's						
Actual Projected On-hand: 894	906	921	992	991	997	974
Inventory Target (Inv Level: 974)	-68	-53	18	17	23	-
Net Requirements		53				
Planned Order Receipts		53				
Planned orders releases	53					
	Actual	5 Year Planning Forecast				

Assumption: Overall Inventory can and should be maintained 974 CGO Positions						
Part A	16 (2022)	17 (2023)	18 (2024)	(19) 2025	(20) 2026	(21) 2027
Gross Requirements (Losses over FY)	117	114	114	108	139	108
Scheduled Receipts (Gains during FY)	132	132	132	114	115	132
Adjusted SR's						
Actual Projected On-hand: 900	915	933	992	998	974	998
Inventory Target (Inv Level: 974)	-59	-41	18	24	-	24
Net Requirements		41				
Planned Order Receipts		41				
Planned orders releases	41					
	Actual	5 Year Planning Forecast				

Assumption: Overall Inventory can and should be maintained 974 CGO Positions						
Part A	17 (2023)	18 (2024)	(19) 2025	(20) 2026	(21) 2027	(22) 2028
Gross Requirements (Losses over FY)	114	113	106	137	104	134
Scheduled Receipts (Gains during FY)	132	132	132	112	132	106
Adjusted SR's						
Actual Projected On-hand: 912	930	948	1000	974	1002	974
Inventory Target (Inv Level: 974)	-44	-26	26	-	28	-
Net Requirements		26				
Planned Order Receipts		26				
Planned orders releases	26					
	Actual	5 Year Planning Forecast				

Assumption: Overall Inventory can and should be maintained 974 CGO Positions						
Part A	18 (2024)	(19) 2025	(20) 2026	(21) 2027	(22) 2028	(23) 2029
Gross Requirements (Losses over FY)	113	106	137	104	131	124
Scheduled Receipts (Gains during FY)	132	132	132	132	104	131
Adjusted SR's						
Actual Projected On-hand: 927	946	972	969	1003	974	982
Inventory Target (Inv Level: 974)	-28	-2	-5	28	1	8
Net Requirements		2	5			
Planned Order Receipts		2	5			
Planned orders releases	7					
	Actual	5 Year Planning Forecast				

Figure 9: MRP Tables with Fixed Order Quantity

Each of the above models yielded the same goal (maintain the pipeline at 974 positions) but achieved it slightly differently. One way to determine the effectiveness of each model is to look at the variability in each model. This will help us determine which approach was more effective and whether they met the goal expressed through the hypothesis. The below table shows the adjustments from the MRP tables for each year group, the average quantity that would have joined based on the supply decisions, and the standard deviation of the model. Standard deviation is an effective metric as it measures the variation with each each model.

Table 3: Standard Deviation Rates

	Execution Yr	Planning Yr 1	Planning Yr 2	Planning Yr 3	Planning Yr 4	Planning Yr 5	Average	Std Deviation
2017 Baseline	144	174	119	132	107	125	134	21.36
2017 FOQ	132	186	132	119	120	118	135	23.76
2018 Baseline	116	182	132	100	121	124	129	25.55
2018 FOQ	132	167	132	116	117	122	131	17.32
2019 Baseline	92	208	116	119	115	126	129	36.70
2019 FOQ	132	169	132	113	121	121	131	18.12
2020 Baseline	132	192	123	116	121	107	132	27.94
2020 FOQ	132	192	132	118	116	119	135	26.37
2021 Baseline	116	200	121	119	103	136	133	31.69
2021 FOQ	132	185	132	114	115	120	133	24.36
2022 Baseline	123	197	126	102	127	127	134	29.65
2022 FOQ	132	173	132	114	115	132	133	19.53
2023 Baseline	121	192	115	122	127	109	131	27.86
2023 FOQ	132	159	132	112	132	106	129	17.05
2024 Baseline	126	172	127	127	108	125	131	19.59
2024 FOQ	132	134	137	132	104	131	128	11.06

Average Standard Deviation	
Baseline	27.54
FOQ	19.70

Based on the above information, the FOQ model was more effective at decreasing variation between different years as compared to the Baseline model. The FOQ model was more effective at reducing variation. The standard deviation for the FOQ model was smaller by 7.84 (28%).

V. Discussion

Summary of Results

There are several observations that can be inferred from the results of the MRP tables for the two models. Each model provided eight sets of data, and each data set showed gains and losses across 6 years. The aggregate view in Table 3 is useful for comparisons between the models. First, we will examine the average number of units that were gained after adjustments were made to the supply chain. The average for all Baseline models is 131.48, or 132, units gained. The average for all FOQ models is 131.85, or 132, units gained. This difference of less than 1 unit is not significant. It is notable that the FOQ model had a very slightly higher average quantity. This could be explained through the observation that while the Baseline model had larger initial numbers of gains, gains through the middle and backend of the planning cycle were typically smaller. Conversely, as the FOQ model deliberately adjusted all scheduled receipts to a quantity of 115, scheduled receipts in the middle and backend of the planning cycle would be higher than normal.

While the averages for both models were essentially equal, it should be noted that neither model was very effective at reducing the bullwhip effect. Both models had significant issues with large quantities of new units entering the pipeline, especially in the early years. Eventually the pipeline did begin to even out. This is shown through the decreasing levels of variance in the later years. Based on the downward trend observed in Figure 1, it was necessary to add large quantities of new units to address previous deficiencies in the pipeline. As shown in Figure 1, accession levels were on a general downward trend. It is impractical to immediately reach the inventory objective with an existing pipeline that has deficiencies due to earlier decisions. As the bullwhip effect continues to impact the pipeline, it is likely that future year groups will still be impacted by Force Shaping actions.

The third observation relates to variance. The resulting data demonstrated how the models performed when compared to each other, but it is necessary to compare them to the source data as well. Using information on gains between 2007 – 2016, variation in the source data is 21.41. This provides us with a benchmark to compare to the performance of the baseline model and the FOQ model. Comparatively, the FOQ did perform better as the standard deviation was 19.7. This illustrates that the dispersion of the gains was more consistent, 8% lower than the historical results, which is an improvement compared to the current process

Significance

The significance of this research is threefold. Firstly, it validates the concept that supply chain management concepts can be applied in scenarios or problems that are not traditionally viewed as supply chain centric. This research shows that concepts such as the New Vendor problem and the MRP process can be adapted and applied. The users of such models would be personnel responsible for managing and overseeing current manpower levels and forecasting future requirements. Successful application would likely require significant training on the design and function of the supply chain models. It is possible that other supply chain models are also applicable in different scenarios, such as ones with more consistent demand.

Secondly, this research is significant as it shows that it is possible to reduce the variance in our current manpower pipelines. The process currently being used does exhibit more variance than an MRP based approach. This implies that, at minimum, it is possible to improve the current process which would reduce variance. Reduced variance may reduce future Force shaping actions. This could also lead to fewer vacancies at the unit level, and potentially more fulfillment of FGO billets that are routinely left vacant.

Lastly, the results of the model demonstrate that planning incorporating a larger time frame is necessary to truly understand the impacts of current decisions. The current process, as executed under the FYDP program only incorporates a short group of future years. As established through this research, units will stay in the manpower pipeline for a period longer than used by the FYDP. Because of this, the impact of past decisions can impact future decisions without necessarily being visible during the FYDP process. A way to mitigate this would be to use a model similar to the one developed for this research that incorporates a larger scope of the manpower pipeline. This would address the information deficiencies and enable planners to make informed, deliberate, decisions.

What we learned/limitations of model

Perhaps the most important lesson learned from this model is that it did not eliminate the bullwhip effect in the supply chain. This is important as one of the impacts of the bullwhip effect was the peaks and valleys in the manpower pipeline which became a catalyst for the 2014 Force Shaping boards. While the FOQ was successful in reducing variance, it could be argued that it ultimately did not achieve the goal of this research as it did not fully eliminate the bullwhip effect. Further research on this topic and application of other models or further refinement of the approach may prove more effective at reducing the variance and bullwhip effect.

The applicability of this research is relatively limited. The way that Congress authorizes end strength figures means there is a hard cap on growth for the Service components. While Figure 1 showed a general downward trend, both models developed to test the hypothesis would have resulted in significant growth in the number of CGO's. Personnel weighing manpower decisions would have to examine the merits of this process and determine if it is sustainable and supportable by the Air Force in an increasingly resource constrained environment. Advocates and manpower managers would need to make persuasive arguments about the positive effects to convince Senior Leaders to reallocate quotas to the LRO community. This would be largely dependent on variables that individual career fields have little control over. For example, is the Air Force growing, or shrinking? If the Air Force is shrinking, then there is little opportunity or need to increase manning or sustain current levels; we will need to decrease our foot print along with the other career fields. There is also the question of broad applicability. Is this approach sustainable if more than just the LRO career field were to adopt an MRP like process to managing manpower? The answer is likely no, this approach is not sustainable. Again, the average number of LROs joining the career field between 2007 to 2016 was 115. In the models, this number increased to 132. The only scenario where an MRP like approach could work is if the inventory target level was much lower.

Recommendations for Future Research

The prominence of unknown factors and outside variables leaves a multitude of potential research options moving forward. Some examples include:

- As the lead Air Force agency for manpower and end strength management, future research should explore the policies and methodologies used by AF/A1M.

Research could seek more information on how AF/A1M policies and programs affect decisions on manpower end strength management. Research could also explore how AF/A1M policies and methodologies relate to concepts of supply chain management.

- Research and refinement of the MRP models developed in support of this research. For example, can inventory targets and lot sizing rules be developed that more closely fit Air Force manpower needs?
- Continued development of the MRP model used for this research. Future research could seek to explore impacts of the model over a longer period of time, such as 10 to 20 years in the future. Research would seek to identify trends with variability over the longer time period. Research questions could examine whether variability stays at the levels exhibited when the models ended in this research, or continue on a downward trend.
- Exploration of other inventory management models that address uncertain demand.
- Exploration of other approaches that are focused on management of specific year groups.
- Research on retention rates and influences behind decisions for separation.
- Applicability to other manpower pipelines, such as Air Force Reserves or Air National Guard.
- Potential application for management of manpower for Enlisted career fields.

Conclusion

The Air Force manpower process is intricate and dynamic, but there is opportunity to reform our processes for managing manpower and future accessions. The goal of this research was to explore the variations in the accession quantities, which appear as peaks and valleys. These peaks and valley exhibit the bullwhip effect, which is a supply chain phenomenon. As this research shows, it is possible to also use inventory management techniques to address these problems. The efficacy of these solutions as they currently stand is not significant, and there are significant barriers that would need to be overcome before they can be successfully implemented. However, these solutions present an opportunity for future leaders to consider as ways to improve the quality of life for Airman and enhance mission sustainment, which should be at the top of every leader's priority list.

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14. ABSTRACT

Manpower levels for Company Grade Logistic Readiness Officer (LRO) positions can show significant variance from year to year based on the needs of the Air Force. This variance often causes problems in future years when the Air Force determines that there are not enough personnel or too many personnel, which results in the voluntary or in-voluntary separation of Airmen. This thesis uses mixed methods to develop a new approach to manpower management based on supply chain models. This approach leverages concepts from Material Requirements Planning (MRP) and the News Vendor model. The resulting model is used to explore the problems with manpower level variation through scenarios derive

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