KC-46 WORKFORCE REQUIREMENTS FOR DEPOT MAINTENANCE ACTIVATION

THESIS

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Abstract

The Air Force projects receiving new KC-46 aircraft in 2016 and headquarters is directing organic maintenance. Oklahoma City ALC is the depot projected to provide this support and plans to have aircraft onsite in 2018. However, maintenance requirements are currently unknown. Therefore, this research seeks to identify the requirements necessary to activate operations with a scope in workforce planning.

The KC-46 is a B-767 derivative aircraft and planners are applying a commercial based program, MSG-3, which directs C-check series maintenance. This program is followed by organizations across industry who operate B-767s and the researcher seeks to find out what is involved by observing their practices. The research is case study based and encompasses responses from maintenance experts in eight organizations. Four are third party MROs, three are airline MROs and the remaining organization is the KC-135 maintenance program from Oklahoma City ALC. Organization representatives are interviewed with intent to discover more about their workforce requirements, and responses are analyzed to formulate recommendations for KC-46 maintenance planners. Recommendations identify a per aircraft quantity of personnel required to initiate maintenance, a workforce expansion timeline, required workforce skill groups, a supervisor to technician ratio, a workforce model, and workforce training requirements.

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List of Acronyms

AFI:	Air Force Instruction
AFMC:	Air Force Materiel Command
AFSC:	Air Force Specialty Code
AFSC:	Air Force Sustainment Center
ALC:	Air Logistics Center
ALCARS:	Air Logistics Center Air Frame Rating System
APG	Airframe Powerplant General
A&P:	Airframe & Powerplant
AS:	Aerospace Standard
AVS:	Aviation Safety Organization
CAT I/II/:	Category I, and II
CCAF:	Community College of the Air force
CFR:	Code of Federal Regulation
CLS:	Contract Logistic Service
CoF:	Complex of the Future
CSR:	Case Study Research
DHL:	Dalsey, Hillblom & Lynn
D&SWS:	Develop & Sustain War Fighting
ETOPS:	Extended Twin Engine Operating System
EWIS:	Electrical Wiring Interconnect Systems
FAA:	Federal Aviation Administration
GAO:	Government Accountability Office
GEN FAM:	General Familiarization
HR:	Human Resources
HVM:	High Velocity Maintenance
IBM:	International Business Machine
ICS:	Interim Contract Support
ISO:	International Standard Organization rating
LMP:	Lower Minimum Program
MDD:	Maintenance Data Documentation
MILCON:	Military Construction
MPDD:	Maintenance Program Development Document
MRO:	Maintenance Repair & Overhaul
MSG-1,-2,-3:	Maintenance Steering Group 1, 2, & 3
OC-ALC:	Oklahoma City Air Logistics Center
OEM:	Original Equipment Manufacturer
OJT:	On-the-Job-Training
PDM:	Programmed Depot Maintenance
RCM:	Reliability Centered Maintenance
RFID:	Radio Frequency Identification
RII:	Required Inspection Item
RVSM:	Reduced Vertical Separation Minimum
SACOM:	Sustainment & Acquisition Composite Model

SSQ:	Special Skills Qualification
TATS:	Task Analytical Training System
TO:	Technical Order
Vo-Tech:	Vocational Technical School
WFSP:	Work Force & Succession Planning
WR-ALC:	Warner Robins ALC

KC-46 WORKFORCE REQUIREMENTS FOR DEPOT MAINTENANCE ACTIVATION

I. Introduction

Background

The Air Force contracted with Boeing in 2011 to produce a new generation of Tanker aircraft, the KC-46, which is a commercial derivative of the Boeing 767 (B-767). Besides the addition of the refueling boom, the aircraft deviates from its commercial equivalent in avionics, landing gear, as well as portions of the infrastructure. Following the initial delivery of aircraft, and as part of the purchase agreement, Boeing will provide five 1-year options of initial contract service (ICS) for full service maintenance of the KC-46. ICS is priced at a fixed rate that requires the Air Force to purchase and provide any required normal spare parts (AFLCMC/WKK, 2013). Once the ICS contract is terminated it cannot be reinitiated. The first delivery of aircraft is scheduled for fiscal year 2016. After all ICS options are expended or determination is made that any remaining options not be exercised, the responsibility of maintenance falls upon the Air Force.

United States Code Title 10 paragraph 2466 clarifies the reason for limiting contracted maintenance. This code states, that the Air Force is limited to spending no more than 50 percent of its funds appropriated for depot maintenance in contracted services. Paragraph 2464 defines the purpose “it is essential for the national defense that the Department of Defense maintain a core logistics capability, that is Government-owned and Government-operated (including Government personnel and Government-owned and Government-operated equipment and facilities) to ensure a ready and

controlled source of technical competence and resources necessary to ensure effective and timely response to a mobilization, national defense contingency situations, and other emergency requirements (Simmons II, 2011)." In accordance with this directive and specific to the KC-46 program, Air Force headquarters established a goal to pursue organic depot maintenance (Air Force Materiel Command, 2007). Additionally, the Air Force is financially committed "[it] has procured extensive data rights in order to facilitate organic sustainment and the opportunity to compete maintenance and repair work in the future (Deparment of USAF, 2011)." Therefore organic maintenance is the direction, now how to get there.

Motivation

The Air Force complies with USC title 10 directives through its use of Air Logistics Centers (ALC). These centers are located in Warner Robins, Georgia; Oklahoma City, Oklahoma; and Ogden, Utah. Each location provides specific aircraft depot maintenance support. Warner Robins ALC specializes in avionics, Ogden ALC specializes in landing gear, and Oklahoma City ALC (OC-ALC) specializes in aircraft infrastructure, components, and engines. At some point, each ALC will play a role in providing maintenance support to the KC-46, which will require the ALCs to stand up new processes to provide this support. However, OC-ALC will be the first depot required to activate maintenance operations for the KC-46 following the conclusion of ICS. In fact, a majority, estimated at 95 percent, of the maintenance required for the aircraft will be conducted at OC-ALC (AFLCMC/WKCSI, 2013).

Activating KC-46 maintenance support at OC-ALC creates many challenges. The first of many is that the aircraft is too large to fit in any of the facilities at this location, therefore the KC-46 program management office is establishing plans and a budget to fund a multi-million dollar military construction (MILCON) project to construct a facility to house maintenance operations for the KC-46. In essence, the program is committing itself to organic maintenance through the buildup of infrastructure. However, the problem then becomes how to do the work once the facility is built and the aircraft is onsite for its first non-ICS service. OC-ALC has little experience integrating new aircraft into its work structure. The most recent aircraft brought into the Depot for initial maintenance was the B-2, and this occurred over 20 years ago. A key manager for the KC-46A program, a Product Integrator, attempted to draw lessons learned from this experience to facilitate standing up KC-46 operations at OC-ALC, but found that no documentation was available to show how the new work was initiated at the depot. In interview, he mentioned that he tracked down one of the managers who oversaw the process for the B-2 to find out how it was done. The individual, now retired, clarified that there were regulations that directed step-by-step how to initiate maintenance on new aircraft types for the ALC (AFLCMC/WKCSI, 2013). These regulations are now obsolete and no longer govern the processes at OC-ALC, meaning that very little can be drawn from the last experience the ALC had with integrating new aircraft into its work structure. This increases the difficulty to understand how to prepare the depot for the KC-46. There are many unknowns that need to be studied in order to discover the underlying requirements necessary to activate depot maintenance for this aircraft. One

area in particular is addressed in this document; identifying requirements to establish parameters in developing a workforce to do the maintenance on the KC-46.

Personnel at OC-ALC currently do maintenance for multiple types of aircraft. Here is a list of what they do now and this also includes aircraft that only receive engine or component repair: A-10, B-1, B-2, B-52, C-5, C-17, C-130, C-135, C-141, E-3, F-4, F-5, F-15, F-16, F-22, T-37, and T-38 aircraft (Tinker Public Affairs, 2012). This expansive list of aircraft types suggests that the personnel at Oklahoma City ALC have a wide range of experience and are quite capable of handling the maintenance requirements for many types of aircraft. However, with each aircraft type, unique, airframe specific, characteristics, drive the detailed needs of the development and training of personnel to perform the maintenance. OC-ALC accomplishes this by overseeing the specialization of personnel to perform specific tasks. Instead of maintenance generalists, the depot employs electronic integrated systems technicians, aircraft engine mechanics, aircraft pneudrautic systems mechanics, aircraft repair and reclamation mechanics, surface maintenance mechanics, powered support systems mechanics, aircraft sheet metal mechanics, and many more (US Office of Personnel Management, 2013). This approach of "functional silos or stovepipes, vertical structures built on narrow pieces of a process," breaks up the work into simplified tasks to ensure that the work can be performed by anyone properly trained to do so (Hammer and Champy, 1993:28). However, the KC-46 is a derivative of the B-767 that has over 20 years of operating history throughout aviation industry. OC-ALC does not need to pioneer new processes to support this aircraft but instead has multiple options it can pursue. The ALC can choose to operate as

it has in the past by replicating current internal maintenance processes with this new aircraft or it can justify changes through benchmark of other methods utilized in commercial aviation.

Problem Statement

Maintenance of the KC-46 involves various nuances that the OC-ALC is currently not equipped to handle. This aircraft brings in technology that is new to the ALC. There is time to prepare, but what steps need to be taken in order to be ready? It is known that the KC-46 management office needs to prepare a workforce of maintainers to activate depot maintenance for the aircraft, but the details of how are not clear. One easy assumption to make is that the depot could build its KC-46 maintenance labor pool from other aircraft maintenance lines that may have excess capacity, but such excess does not exist. Another assumption could be made that as new KC-46s are being delivered to the Air Force fleet to replace the KC-135, those supporting the KC-135 can changeover to support the KC-46 as KC-135 requirements diminish, but this also is not a supported assumption. Maintenance is ongoing for all of the other aircraft supported by OC-ALC to include the KC-135. That means that it cannot be assumed that there is sufficient excess capacity to retrain current employees for KC-46 maintenance. Although the Air Force will begin to retire KC-135s from its fleet as KC-46s are brought online, a one-to-one replacement ratio would only deplete less than half of the KC-135 inventory. Four hundred fourteen KC-135s are currently spread throughout the Air Force in Air National Guard units, Air Force Reserve units, and Active duty units and their total, far exceeding the 179 planned KC-46s (Deparment of USAF, 2011). Ultimately, this means that OC-

ALC needs to expand its labor force and retain individuals specific to KC-46 maintenance support. Therefore, the purpose of this research is to determine the requirements necessary to develop a workforce that can initiate depot maintenance for the KC-46.

The next chapter in this text covers practices and procedures that organizations follow to plan for and develop a workforce. The hope is that this research can lead to establishing a framework that the depot can use for further expansion of its workforce to meet future demands of its customer, the Air Force. Developing the framework offers some challenges, the first of which is determining how to transition operations from ICS to organic maintenance. However, that falls outside the scope of this research. The research will focus on what the ALC hopes to accomplish in the early stages of depot activation.

The KC-46 management office recognizes that a transition period is necessary in order to facilitate the activation of organic maintenance operations. One way in which the management office is working to coordinate the transition is by planning to conduct the first C-checks on KC-46s two years after they are delivered to the Air Force beginning in 2016. A C-check involves inspecting multiple aspects of the aircraft to ensure its continued serviceability and addressing any identified maintenance issues. It is also important to point out that there are different levels of C-check inspection. The different levels are labeled C-check 1 through C-check 4. C-check 1 is a basic inspection that will be developed based on input from the maintenance plan document provided by Boeing and the Maintenance Steering Group 3 (MSG-3), a commercial aircraft

maintenance process. This process replaces programmed depot maintenance or how depot maintenance is accomplished for other aircraft at OC-ALC (Air Force Materiel Command, 2007). After C-check 1 is complete, the plan is to bring the aircraft back to the ALC every two years to conduct progressive levels of C-checks. C-check 2 will be a combination of C-check 1 procedures and additional steps, C-check 3 will be a combination of C-checks 1, 2, and additional steps until finally C-check 4 will be an in depth inspection of all aspects of the aircraft.

Other than generally what will take place, there are many unknowns surrounding the first inspection. Therefore, this serves as the first focus area of research to produce a solution to the problem statement mentioned earlier. It is unknown how many personnel will be needed to accomplish the inspection in 2018 and it is unknown what training they will be required to receive once they are integrated into the workforce. These unknowns will be addressed through a series of steps to establish courses of action that can be used to overcome the workforce shortcomings the depot in supporting the KC-46. These actions need to be taken prior to the arrival of the first KC-46 aircraft to the depot in order to ensure a well-established plan is available for the execution phase of training and hiring personnel at the depot who will do the inspection and maintenance.

The second research area focuses on practices associated with integrating a new workforce for a new aircraft type. The goal is create an efficient process that can be expanded in order to meet the increasing maintenance requirements of the KC-46 as it life cycle progresses. Finally, the third research area looks at the secondary effects of workforce expansion as it relates to the management associated with the touch labor of

the KC-46. Overall, the goal is to come up with alternative courses of action that provide sensible measures to meet higher headquarters directives while balancing the effective use of resources with the chosen effect.

Research Questions

Addressing the three research areas listed previously, require clear understanding and a way to gain this understanding is through focused questions. "Designing…research question[s] is probably the most important step to be taken in a research study…" (Yin, 2003:7). Researching a topic generates a myriad of possibilities, and a researcher can easily be distracted by the excess of information available and stray from the purpose. Therefore, research questions act as guidelines to keep the researcher focused on the main objective of his research project. The following questions serve as the research questions for this study:

(RQ1) How many personnel are required to activate C-check operations for the KC-46?

(RQ2) How are KC-46 maintenance technicians employed; task centric, generalist, or a hybrid?

(RQ3) What ongoing training programs are required to support activating KC-46 maintenance?

(RQ4) Is the C-check considered part of the OC-ALC's Core Competencies?

(RQ5) How many management personnel are required to activate depot operations?

(RQ6) What is required to expand operations after depot activation?

Assumptions

Researching requirements for depot maintenance personnel activation requires scope due to the broad objective of preparing OC-ALC for arrival of the KC-46. There is not sufficient time to complete this work if every avenue of research is pursued; therefore, a few assumptions are made.

The first assumption relates to potential hires that OC-ALC will need to pursue in order to fill all of the maintenance personnel positions needed to support the KC-46. In order to avoid the exhaustive process of determining how many people are available, it is assumed that OC-ALC has access to qualified personnel that can be hired to increase its numbers as required.

Next, the Air Force gave the direction that maintenance for the KC-46 is to be organic, so it is assumed that, with the exception of possible minor deviations, the focus is determining how to stand up organic operations as opposed to seeking alternate sources unless absolutely necessary.

Then it is assumed that OC-ALC intends to pursue the means for maintaining FAA certification on the KC-46. This assumption is related to motives of the KC-46 program to participate in a parts pool to preserve its resources and expand access to others.

Finally, it is assumed that the KC-46 program has the ability to modify the contract it made with Boeing concerning ICS to allow for an interruption of service so the ALC can perform the first round of C-checks in 2018. This assumption is made because

ICS will be in effect prior to the KC-46 arriving to the ALC taking over heavy maintenance operations. The ICS contract is established to cover everything including C-check maintenance and if there are interruptions without any prior modifications, the service will cease regardless of whether organic maintenance operations are fully activated or not. The first round of C-checks may serve as a means for the KC-46 program to test its abilities and see what more is needed to fully activate operations. After the first C-checks, the depot may not be ready to end ICS and take over all of maintenance operations. Therefore, a contract modification may enable the continuation of ICS service even though the depot plans to perform C-checks in between.

Limitations

The depot trains and certifies personnel to work on one type of aircraft. Therefore, if personnel desire to work on another aircraft type other than what they were originally trained for, they must retrain and be reclassified to make the change. The cross utilization of maintenance personnel is not practiced at OC-ALC. This implies that a process is necessary to train personnel specific to the KC-46 in order to have a workforce pool necessary to perform maintenance. Further background indicates that mechanics are trained to do work that is task specific, thus limiting them to work on specific portions of the aircraft only.

Although this practice makes sense for a majority employed due to how they were trained, others received their training in vocational schools, and this practice seems trivial. Vocational school training certifies personnel to perform general maintenance on an aircraft. Theoretically, they can do maintenance on aircraft infrastructure (A

certification) and the Powerplant systems (P certification); however, current ALC practices dictate that they are utilized only to do one or the other but not both. In addition, this being a set process, union labor agreements prevent pay incentives to be offered to A&P certified personnel to do more than one job type.

Heavy maintenance for the KC-46 will be new work for the depot. This offers opportunities of change to work processes and procedures as well as new ways to utilize manpower. Within the aircraft maintenance industry, A&P certificated personnel are hired to perform the work and due to their training they are qualified to do more than the typical task centric mechanic does. This provides added flexibility in how their employers use them.

In the past, many of the methods and procedures that OC-ALC practice came into fruition due in part to benchmarking other organizations within the same industry. Now the KC-46 affords opportunity for the ALC to look outward again to benchmark the latest manpower procedures. This research helps identify what the commercial industry is doing and provides alternatives for the KC-46 maintenance program to consider. The use of A&P certificated personnel is merely one example.

However, not everything can change. Once new personnel are hired, regardless of previous experience, training, or certification, they all receive the same orientation, their skills are evaluated, and they are assigned supervisors who oversee their on-the-job training (OJT). Air Force Instructions (AFI) 36- 2232 AFMC supplement 1 and 21-101 Air Force Materiel Command (AFMC) supplement 1 drive the reasoning for this process,

thus limiting how much of the training process can be adapted from commercial aviation industry.

The methodology of this study is to focus on cases related to KC-46 maintenance and utilization of personnel. This method provides opportunity for inference and insight to understand different courses of action. It serves as a way to benchmark ALC practices with those in the commercial industry and ultimately provide a way to facilitate depot personnel activation for the KC-46. However, it is limited by what cases the researcher can find and analyze. Time constraints prevent the extensive gathering of several examples.

Methodology

There are many ways to contrive personnel requirements for performer KC-46 maintenance. Statistical analysis, optimization modeling, or simulation modeling are examples, but there is no KC-46 data available to support these methods. However, the B-767, the airframe utilized to construct the KC-46, has been in operation since the early 80's and has a long history of maintenance records. Thus, the researcher could use this data and with the right assumptions come up with adequate personnel requirements for KC-46 depot maintenance. Yet, on the other hand, the researcher sees the importance of simplifying the process by first identifying what industry managers are doing to fill their personnel requirements to maintain B-767 aircraft. Once KC-46 data is available, more research can be pursued through quantitative research methods for this same subject. Therefore, the method of choice for this research study is to seek expert opinion from those in the field of aircraft maintenance, gather procedural examples from organizations

that maintain the B-767, and explore the methods the Air Force uses to maintain its fleet of aircraft. Then, the next step is to analyze the information with the purpose to make inferences and determine a basis for which the KC-46 program can build its workforce and employ them to support depot activation. Additional research employing quantitative methods should follow later on to make improvements on this model.

Research Contribution

Depot activation requires in-depth research, analysis, and thorough planning to ensure an end result of successful operations. The purpose of this research is to fulfill portions of that research, analysis, and planning process. The hope is to provide KC-46 program decision makers with the requirements to develop a workforce to activate depot operations. The scope encompasses C-check 1, and this serves as a focal point to determine the training, personnel count, and specific skill development required. Furthermore, the research provides alternative options for how to employ personnel in order to adequately manage the utilization of the workforce and minimize the possibility of excess capacity.

Summary

This chapter introduces the reader to the purpose and motivation of this research study. The KC-46 program is unclear on how prepare a workforce to sustain the aircraft at the depots, and this research will serve as a guide to clarify understanding. The Air Force seeks to implement organic operations; therefore, the focus is directed toward what can be done internally at the depots rather than what can be sourced to industry partners. However, this work is limited in scope. Therefore, the focus is on determining the

requirements for activating operations to support the first C-checks projected in 2018 when the KC-46 arrives to Oklahoma City ALC for the first time. Six research questions serve as a guide to come up with a solution and the methodology of choice involves case study research. The following chapter dives into various topics of interest related to answering the research questions and serves as a literature review.

II. Literature Review

Background

The OC-ALC has the responsibility to prepare for the changeover from ICS to activating and providing organic support capabilities. The KC-46 introduces new technology that differs from the other airframes maintained by the depot. Process established in the ALC requires personnel to train and specialize in one specific type of aircraft. The purpose of this research is not to justify whether this practice is wrong or right but instead to clarify what the depot needs to do to develop a workforce to support the KC-46. As was mentioned earlier, the first time the depot will perform any type of maintenance on the aircraft is when it conducts a first round of C-checks on the aircraft.

Workforce Planning

OC-ALC currently does not have a workforce dedicated to KC-46 maintenance, and its planners understand that a workforce will need to be developed in order to support the aircraft. There are multiple ways in which a workforce can be developed to include: current procedures followed by the government (to include how OC-ALC has developed its workforce in the past) and practices found in the aviation maintenance industry. There are also methods applied generally throughout business that may be applicable as well.

A 2007 RAND study looked at workforce planning in AFMC, which included OC-ALC. The study identifies a model that serves as the core for workforce planning and analyzes each step included in the model. The model consists of four steps: 1) determine workforce demand requirements, 2) describe workforce supply, 3) compare demand with supply, and 4) implement solution (Vernez, Robbert, Massey, and Driscoll, 2007). The purpose of the model is to ensure that workforce planners understand the

desired attributes of their workforce, (skill set, capabilities and size) prior to taking any action to solicit positions for hire. The model also allows planners to determine whether the workforce capacity of their organization currently can meet the demand of the new requirements driving the need to do workforce planning.

The first step, determining workforce demand, entails, looking both at current and future requirements. Knowing the organization's requirements in the present and in the future ensures that the appropriate amount of personnel with the right skills are developed or hired now and plans are established for more personnel to be available in the future. The KC-46 program contracted with Boeing to acquire aircraft over a multi-year period, and initially the aircraft will require little maintenance due to the newness of the aircraft. It makes sense for KC-46 maintenance planners to identify fewer requirements in the beginning and then increase the size of the workforce as the demand for maintenance increases.

Understanding future and present workforce requirements is the first step in the overall process, but within this step, there are sub-steps that the planners need to perform in order to resolve the details of their plan. These sub-steps determine quantities of personnel required, the composition of personnel, whether contractors, civilian personnel or active duty personnel are used, and finally what skill sets are needed. After all of this information has been gathered and clarified, the planner can move onto the next step. OC-ALC will be successful in planning its workforce requirements by determining what skills are needed to perform KC-46 maintenance. This seems simple but it requires knowing the aircraft maintenance procedures in detail before skill set requirements can be interpreted and known. Boeing is to provide work specifications that OC-ALC will turn

into work cards and from these work cards "the how" of aircraft maintenance becomes a known. However, determining the number of personnel required will require planners to align OC-ALC's depot work processes and procedures with what the work cards direct.

More than just size of the workforce, there are also implications for knowing what the composition of the workforce will be. Regulations differ for the manner in which contractors, civilian personnel, or active duty personnel are managed. Although the ALC has the option to utilize any of the three types it may not be such a lofty consideration. The depot is mostly made up of government civilian personnel and therefore the opportunities for utilizing active duty or contractor personnel are limited. In 2007, 88 percent of the labor workforce was made up of civilian personnel, 3 percent were active duty and 9 percent were contractors, therefore it seems likely that the workforce will primarily be made up of government civilian employees (Vernez, Robbert, Massey, and Driscoll, 2007).

The next step in the workforce-planning model is focused on determining workforce supply. According to the RAND study, this requires a description of the current workforce (Vernez, Robbert, Massey, and Driscoll, 2007). The workforce planners should consider certain questions: Is there excess capacity within operations that can be transferred to the KC-46 program? Are personnel interested in transferring to the KC-46 program? Are personnel available with the skill sets required to maintain the KC-46? OC-ALC supports an array of different aircraft types, and some individuals in the KC-46 sustainment office are confident that appropriate skill sets are available from within, but of concern will be specialized training required for airframe specific nuances such as the latest technology integrated into the aircraft. Once planners have combed

through the workforce supply currently at the ALC they then may need to look outward to other sources of trained personnel. OC-ALC collaborates with local trade schools who graduate trained and fully qualified aircraft mechanics, but there are limitations. For Instance, the government cannot hire personnel to work in the depot who have police records. Graduating applicants who have felon records are excluded from consideration. How else does OC-ALC find people to fill vacancies? Finally, steps are taken to hire personnel who have no background in aircraft maintenance (AFLCMC/WKCSI, 2013). The ALC has a robust on-the-job-training program that develops untrained personnel into qualified mechanics.

After workforce demand and supply are considered, the next step is to compare the two. The purpose of this exercise is ultimately to come up with the numbers of additional workers of various skill levels needed. Once these numbers are known, then planners can get down to determining whether they are meeting the skill set and composition requirements needed to build the workforce. This step is the one that prepares the recommendations for the decisions makers who then can go out and take action to build the workforce. It is also appropriate at this point in the workforce planning process to consider alternatives to the current plan. In the case of the KC-46, it might be necessary to further research the costs associated with developing an organic workforce and the costs of acquiring a workforce through contract.

Whatever recommendations are offered by the workforce planners to the decision makers, the final steps are to determine the appropriate action to be taken and then implement it. Whether the decision is to hire from within or without, there will be implications for training, organization structure, and supervisory requirements.

Developing a workforce requires more than just acquiring personnel; it involves adapting each individual to the requirements of his or her position within the organization.

A similar study to the RAND 2007 study was done on workforce planning by Pynes, but she focuses more generally on the public sector. Pynes cites five steps from the National Academy of Public Administration to discuss workforce and succession planning (Pynes, 2004). These five steps are much like the four steps mentioned in the RAND study however, they focus on a Human Resource Manager's perspective. Step one includes Human Resources (HR) in strategic plans, step two defines human resource requirements, step three develops the action plan for implementing HR strategies, step four evaluates progress, and step five manages the change in process (Pynes, 2004). Pynes' article is motivated by workforce planning and succession of retiring personnel, which is different than planning for a new workforce. However, similarities can be drawn between the RAND study that focuses on AFMC's workforce and Workforce and Succession Planning (WFSP). Both planning methods gear toward developing the means to meet organizational goals through human resources.

Steps one and two of WFSP gather inputs from planners of organizational goals and timeline requirements to determine what is needed in way of personnel to continue operations (Pynes, 2004). This is the same thing as determining workforce demand. Human resource planners identify a need and come up with a way to fill that need as a continuous process. The planners also look to future and determine ways to ensure the continuation of workforce planning and personnel development. This is applicable to KC-46 workforce planning because there must be a process to identify what is required to conduct maintenance operations. This process is to focus on competency and skill

requirements of personnel required. Once requirements are identified, they serve as a starting point to develop a workforce to sustain operations into the future.

The next step in WFSP, develop action plan for implementing human resource strategies, relates to steps two through four of the government workforce planning process in the 2007 RAND study. The combined steps encompass identifying workforce supply, comparing workforce supply with demand and then coming up with an action plan that implements measures to counter the imbalance between supply and demand. WFSP condenses these steps because it already assumes workforce supply is a known and focuses effort toward, "closing any competency gaps that have been identified" (Pynes, 2004). In the case of workforce planning for the KC-46, WFSP seems applicable. Planners already know that there is no workforce supply to support maintenance operations at this time. A workforce must be created. The purpose of this research study is to aide planners by identifying the labor requirements that need to be filled in order to begin the first organic operations at the depot, (the first C-check).

The final steps of WFSP diverge from how AFMC plans its workforce. WFSP plans for HR to revisit the steps it implemented in order to evaluate progress, and at this time adjustments can be made. If more or less personnel are needed than expected, action is taken etc. WFSP's final step is to ensure flexibility is part of the whole process, and it provides management the ability to look at its workforce to determine how well it is being employed. This step requires the attention of senior leadership. If the leadership identifies a need for a course correction in the manner which human resource capital is being utilized in the organization they set the new direction and serve as the change

agent. As change agent, leadership lays out the plan, identifies any impact, and elaborates on how the change will benefit the organization.

How often does the government look at its workforce to evaluate its effectiveness in meeting demand? It seems as though the fiscal budget motivates some evaluation but perhaps not the right type of analysis. Until the KC-46 is delivered and maintenance procedures specific to the aircraft are established, the program office will only be working with estimates for workforce demand. OC-ALC can benefit from WFSP's final two steps after it has hired a workforce and initiated maintenance operations for the KC-46. The KC-46 serves as reason to facilitate a shift in the way personnel are utilized to perform maintenance. Adding WFSP's last two steps to how workforce planning occurs now can provide time for planners and senior leaders to assess that workforce demand is being met by actions taken to meet it originally. A possible consequence of evaluating workforce planning action implementation is that it might be that the processes governing the way the new workforce is utilized is not adequate. Then senior leaders can come up with new processes and serve as change agents.

Looking within the government's processes to understand workforce planning seems an appropriate place to start. However, to gain a more in-depth perspective of how workforce planning occurs requires alternate perspectives. Brenda Dietrich, a senior research manager of International Business Machines' (IBM) Optimization Center, sums up the processes for the planning of personnel in the business services industry. Although Dietrich's lists of processes refer to general resources, she does clarify that resources includes labor hours by skilled employees, thus relating to workforce planning. The first step is similar to the previous examples in that demand is determined to decide

what personnel are needed. Business services workforce planning starts by forecasting demand for services, and then they forecast the time table of requirements. Afterwards the workforce planner utilizes the forecast to evaluate all of the costs and limitations associated with employing personnel to provide the service. Then like government workforce planning, demand requirements are matched with supply available to ensure that the right actions are taken. Dietrich lists this last step as "Evaluating proposed allocations of resources to known forecasted activities" (Dietrich, 2006).

A comparison is drawn between business services planning and how aircraft maintenance workforce planning occurs. Aircraft maintenance is a service, and like business services, it makes sense to forecast requirements in order to match up the quantity of personnel required to meet demand. Yet, forecasts are typically based on past and present data that make projections into the future demand. Maintenance requirements for the KC-46 can be estimated prior to its arrival, and planners are currently utilizing maintenance data from the KC-135, B-767, and KC-10 to forecast requirements. However, is that enough, will this adequately capture the maintenance workforce requirements to maintain the KC-46? Workforce planning may require additional steps to ensure the right personnel are appropriately developed to begin work on the aircraft.

Another perspective on workforce planning is taken from two organizations, the International Public Management Association for Human Resources and the Office of Personnel Management. The perspective expands further on workforce planning than the other two models already visited by including seven steps in the process. The first step requires the planner to define their organization's strategic direction prior to proceeding

any further. The direction for KC-46 maintenance is clear that operations are to be organic, thus planners understand that it is their responsibility to insource labor to perform the work. However, at a lower level what is the strategic direction of OC-ALC? Their purpose is to provide heavy maintenance support to the Air Force's aircraft fleet. The strategic direction of the workforce planners must be aligned with that function in order to ensure that the right personnel are available to do the work.

After the workforce planner clearly understands the strategic direction, step two requires scanning internal and external environments to the organization. Effective internal scanning typically requires a HR information system that can provide the skill levels and competencies within the workforce. "An employee skills inventory can be a useful component of the workforce inventory" (Cotten, 2007). Additionally, internal scanning allows for consideration of the organization's culture and employee morale. OC-ALC has labor union-member employees and elected union representatives that drive some of the culture within the organization. Some examples of the prevalent culture include promoting from within, position preferential treatment for senior union member employees, and work procedures enforcement. If the ALC desires to change any of its personnel hiring procedures or stray from the way it promotes personnel, it must ensure that union representation accepts the change prior to taking action. It makes sense to involve the labor union in workforce planning process when performing internal scanning.

External scanning allows the organization to step outside of the daily routine to determine resources available external to the organization. The ALC competes for trained personnel with the rest of the industry that performs aircraft maintenance. During

times of financial crisis, the depot may have easy access to highly skilled personnel ready to hire, but during times of prosperity, there may be a labor shortage. An external scan ensures that the organization has a way to sustain the strategic direction in the long term.

Step three requires a model of the current workforce. The model serves as a starting point to know "how the workforce will change during the planning horizon and provides the fundamental understanding of the workforce needed to develop effective gap-closing strategies" (Cotten, 2007). Activating maintenance operations for the KC-46 may require a small set of personnel to start operations and then more personnel as the KC-46 fleet size sustainment requirements grow. Developing a model of the initial workforce can serve as a starting point to facilitate operations while strategic hiring practices are taking place, which fits the next step in the process. However, keep in mind that this model will require expansion as workforce requirements grow.

This workforce planning process provides ideas that step outside the models presented previously, but step four does not differ. It directs an assessment of future workforce needs and then forecasts future workforce supply. This step works off the external and internal scan performed in step two but does not provide anything new that the other models have not already given. Step four is a routine that workforce planners do to decide what they need and also see if what they have fulfills their need. It can serve as time to count heads and see what the organization's workforce position will be in the future as it fulfills labor demand requirements (Cotten, 2007).

The premise of this whole research study is to do exactly what step five indicates, identify gaps, and develop gap-closing strategies. OC-ALC knows the business of aviation maintenance and has a highly trained workforce, but there is a gap between what

they can do and what the KC-46 requires. Step five focuses workforce planners on what their organization lacks in competencies and skill sets or possibly limitations resulting from antiquated work processes. Part of this step includes the ALC properly identifying the skill sets and competencies it needs and whether current work processes are helping or hindering the organization. Identifying the skill sets and competencies is not such an issue, but there may be some limitations caused by the way A&P certified technicians are being utilized. A&P certified mechanics are trained to perform maintenance on any aspect of the aircraft; however the ALC's work processes confines them to working on only one portion of the aircraft, either airframe or Powerplant but not both. The topic has been visited in the past, and an old agreement between the labor union and the ALC was reviewed that indicated that personnel were not intrinsically incentivized to multi-skill and if they were supervisors did not know how to utilize them, but the study led to no changes in the manning policy (Dunn, Barone, and Peterson, 2003). The KC-46 program offers a new opportunity to revisit the issue of fully utilizing A&P certified personnel.

The last two stages in the process focus on similar steps as the WFSP model. Step six takes the recommendations from step five and implements the strategy. Then step seven calls for evaluation of the whole process to determine its effectiveness. Management can use the analysis to determine the status of how well the gap closing strategies are taking effect. The Air Force is planning on buying 179 new KC-46s over an extended period of many years, meaning that if workforce planning results are not found to be satisfactory, course corrections can be made by some means of strategy revision. Step seven also suggests a couple questions to consider including "Are the strategies being implemented as intended?" Second, agencies must monitor impact by

asking, “What results, intended or unintended, have been achieved as a result of the strategies?” (Cotten, 2007).

Workforce planning using the seven step model provides a more comprehensive approach than the other two models for solving the KC-46’s dilemma of knowing how to activate its maintenance program in the depot. This approach advances workforce planners more toward seeking out the best method of developing its workforce rather than conforming to the normal routine of how planners have met demand in the past. The seven step method is an adequate model for the depot to follow in order to adapt more effective methods of workforce planning. It pushes planners to learn from other organizations who may lead the way in innovation.

OC-ALC has multiple ways that it can build its workforce once requirements are understood. As was mentioned earlier, they can partner with local trade schools that provide fully trained and certified aircraft mechanics upon their graduation, they can hire from within by soliciting job openings within their own organization, and, finally, they can open up jobs to almost anyone willing to work because of their on-the- job training (OJT) program. However, once personnel are hired the issue then becomes adapting each individuals’ skill level to that which is required to conduct KC-46 maintenance. One individual may be able to do anything required to maintain a KC-135, a B-52, an E-3, or other airframe, but that does not necessarily mean that he or she is immediately capable of doing what is required to work on the KC-46. Just like the individual that has no training at all, specific OJT is required to train each maintainer on the specifics of a KC-46.

Workforce Sizing

An imbalance between demand for a workforce and supply available appears to be the main driver for determining labor force size, however there is more to consider. Portions of another RAND study conducted on AFMC in 2006 focused on workforce sizing. It provides the reader with two insightful questions and limitations: What is the right size of the labor force and at what rate should it grow? Aggregate manpower constraints are often set at Air Force, Department of Defense, and even congressional levels, thereby limiting manpower flexibility (Gates, Eibner, and Keating, 2006). Rather than relying upon workforce planners to come up with the allocation, AFMC employs a modeling system to determine the quantity of personnel required. AFMC uses the Sustainment and Acquisition Composite Model (SACOM) in order to make estimates of the size required for its workforce in product and logistics centers (Gates, Eibner, and Keating, 2006). SACOM takes the work to be performed and correlates it with the workload factors using regression and provides scores to help decision makers determine the right quantity of personnel. A few of the workload factors include the volatility of user requirements, the involvement of contractors, the amount of interaction with other government agencies, and the amount of management and technical oversight required (Gates, Eibner, and Keating, 2006).

The 2006 RAND study also includes additional background behind how AFMC approaches workforce sizing when considering alternate sourcing options. The process is called a most efficient organization approach (Gates, Eibner, and Keating, 2006). It is basically a sourcing study to determine the financial impact to the government if outsourcing is desired. A thorough analysis allows decision makers to explore an

additional option of including contractors in the mix of the labor force. The KC-46 can use this type of analysis to improve its use of labor resources. OC-ALC has no experience maintaining a KC-46 or B-767, therefore what must it do to overcome this challenge. There is the option to send technicians offsite to receive training and, depending upon the individual, learn everything they need to know about the aircraft. However, aircraft are complex and require years of experience to maintain. Organization H, an organization that provides air freight transportation, overcomes this challenge by mixing seasoned technicians with new less experienced technicians in their maintenance facilities to ensure that knowledge transfer occurs and, more importantly, that the work is done properly (Org. H Representative, 2013). They also include contractors in their labor pool when needed to develop new skills. OC-ALC has personnel highly seasoned in KC-135 maintenance, B-52 maintenance, E-3 Maintenance, and various other types of aircraft, but they are not experienced in KC-46 maintenance. This provides an opportune time to consider including contracted personnel in the maintenance labor force. OC-ALC is already planning to include contractors in its workforce like what Organization H does with its aircraft maintenance program but in the KC-46 systems software maintenance program. The potential benefit is that the work will be done right and knowledge transfer will occur. In fact, the next section covers what knowledge transfer is required and how it occurs.

Maintenance Training Requirements

The specifics for KC-46 maintenance, even C-check inspections, are currently not known. The specifics will be spelled out once Boeing fulfills it requirement to deliver work specifications so that work cards can be developed that indicate the steps for doing

maintenance on the aircraft. However, the dilemma of identifying the difference between what the ALC's personnel is capable of and what the KC-46 will require still exists. This is key because part of the ALC's process of activating new work is relying on senior ranking, highly experienced technicians to learn the differences, and then train others. The ALC ensures these senior technicians are trained by a reputable source, be it the original equipment manufacturer (OEM) or by some other means, and then they become a cadre of trainers to help others perform the work. The typical method in which they share their knowledge is through OJT. OJT is a training technique in which trainees receive guidance from a trainer on how to complete work tasks at the same time the work is being done (Walter, 2000).

OC-ALC is not unique in its method of utilizing OJT to bridge the gap between workforce and capability, and there are negative aspects to the process. Literature on OJT suggests that, "most maintenance rely on a degenerating buddy system" (Walter, 2000). Ninety percent of the skills needed to maintain aircraft are taught to a mechanic by an experienced technician in an unstructured format who may or may not be interested in passing on his or her knowledge. The article continues to point out more of negative aspects of OJT. "Aviation maintenance technicians sometimes go through their job motions more or less by rote, without a real feel for what they are doing" (Walter, 2000). More issues with aviation maintenance training are described, but the author offers an alternative. She develops a model that adds structure to an OJT program and calls it a task analytical training system (TATS). When this program is applied, the training plan is developed by a team of technicians, who serve as both aircraft technicians and trainers of new personnel. Then the training is broken into modules and tailored to the scope of

specific jobs. TATS is in practice at the Boeing Company and at least four major Airline companies: US Airways, United, Northwest Airlines, and Trans World Airlines (Pynes, 2004).

Prior to any aircraft mechanics doing C-checks on the KC-46, they will need to be trained and certified to do the work. Boeing is contracted to provide guidance on what work is to be done, but the ALC will still need to come up with a way to adapt its personnel to new work specific to the KC-46. TATS offers a way for them to achieve this through its 8-step process laid out to help training managers to determine what needs to be trained and how the training will be accomplished. The following model lays out the eight steps for implementing TATS:

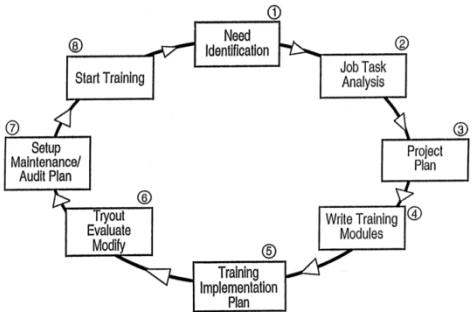

Figure 2.1. The Eight-Step Process (Walter, 2000)

TATS serves as a means for aviation maintenance to standardize training and improve its effectiveness in training fully qualified personnel. This method is applicable in any situation in which little or no structure is exhibited in OJT. It also may be a good fit for an organization that has to fill various positions due to job turnover or when new work is brought to an aircraft maintenance facility due to new requirements. Either way, the program author indicates higher output of productivity will be achieved using the TATS method.

The KC-46 is a new aircraft to the Air Force, but it is not new to commercial aviation. The platform aircraft from which the KC-46 is built has been around since 1982. The KC-46's commercial derivative characteristics make it prime for the ALC to look outside its own organization to determine what personnel need to know in order to be able to maintain this aircraft. TATS is one method that might work, but there are others.

In 2008, a study was conducted in Australia that provides perspective on another approach. It considers combining formal and informal learning to develop workforce skill. The report also includes one more category: non-formal learning. One of the report's findings agrees with the other research thus far that OJT is a common practice, succeeding to "…blend learning acquired in non-formal with on-the-job practice and experience." However, it does offer another strategy, "…action learning approaches..." This approach "provide[s] opportunities for workers to get together to share information and develop suitable action plans for quality improvement initiatives, business innovation, and self-help for users of newly introduced or critical technologies and products" (Misko, 2008). This training strategy suggests that management can lean on its workers to think through some of their own issues. Then once an issue is resolved, the workers can pass the solution on to the others, an active approach to both problem solving and training.

Lessons learned from the available literature on workforce training are that whatever the training strategy must be it has to be consistent and quality training depends heavily upon the interactions between the trainer and trainee. OJT of the past appears to be designed for simplistic learning; teach the trainee all they need to know to complete a

specific task, and then watch him or her to make sure he or she does it right. The simplicity makes it easy for personnel to master the tasks and quality can be easily controlled, but it may not be an effective way. Breaking up training to specific focus areas limits maintainers to looking at only small portions of the aircraft. This method has its advantages, but it also takes the maintainers eyes off of the big picture of making sure the whole aircraft system is operational when complete. The KC-46 program needs a training plan that focuses personnel on the whole system and allows their growth as problems solvers.

Initially KC-46 maintainers at the depot will have assistance from Boeing to learn how to conduct maintenance operations, but it will be up to them to come up with the long-term plan. When the plane is new there most likely will be few issues to be worked out, and dividing the aircraft up according for task specific training should not be an issue. As the aircraft ages the likelihood of problems arising will increase. Using a training plan that focuses personnel on the whole system may be difficult to employ, but it should provide a superior method in the long run. The next section speaks specifics to how a workforce would be shaped.

Multi-skilling

OC-ALC trains its personnel much like maintenance airmen are trained for active duty operations. Each individual trains to the requirements of a specific Air Force Specialty Code (AFSC). Also, "Air Force depot maintenance personnel are currently (and have been for quite some time) […] categorized in very narrow occupational specialties, resulting in the approximately 23,000 personnel to be spread over 171 different occupational specialties" (Levien, 2010). Within a particular AFSC, airmen or

civilian personnel are confined to specific tasks due to their specific training. This practice makes sense for personnel who change locations frequently. Airmen on active duty are required to move around much through their Air Force career in order to ensure that they have high exposure to multiple airframes to provide them with breadth in experience. This practice makes it necessary to maintain rigidity of specific AFSC training to ensure airmen become experts in their field. However, personnel at the depot do not move around, in fact they may stay their whole careers in one location working on one type of aircraft. Whether depot personnel should develop more breadth in their skill sets and become a multi-skilled workforce has been debated and efforts have been made to push the depot in this direction, but there continues to be resistance.

The KC-46 program offers many reasons multi-skilling should continue to be revisited for depot operations. The first reason is that the program office desires to collaborate with other B-767 operators in aviation industry to form a parts-pool. In order to maintain full partnership in an open parts pool, repairs made at the depot must be signed off by an FAA credentialed maintainer. Typically, the maintainers that are credentialed by the FAA hold A&P certifications. These certifications authorize the holder to perform maintenance on any portion of the aircraft. However, in the traditional setting at the depot these personnel would be assigned a specific AFSC that limits their tasks to only specific portions of the aircraft. In this case, an A&P certified mechanic is overqualified and underutilized. Establishing a multi-skilling model for the KC-46 allows for improved utilization of A&P certified mechanics.

The second reason is derived from a study conducted by the Center for Construction Industry Studies, who surveyed several construction companies to

determine how multi-skilling would benefit their organizations. "The surveyed companies consider a multi-skilled workforce to be more productive because idle and transition time is reduced" (Haas, Borcherding, Glover, Tucker, Rodriguez, and Gomar, 1999). The article also mentioned, "multi-skilling makes workers more valuable and gives them more possibilities to advance and develop a career path" (Haas, Borcherding, Glover, Tucker, Rodriguez, and Gomar, 1999). In essence multi-skilling is better for the organization and better for the employee.

The depot has an opportunity to use multi-skilling to close the gap between how maintenance operations are conducted in commercial aviation and their current practices. The KC-46 is a new aircraft to the Air Force but not to commercial aviation; therefore, workforce planners should be looking to other organizations that already have experience maintaining it. The depot does have a few personnel mixed among its numbers who are A&P certified, it can use its partnership with the local trade schools to hire more or encourage potential applicants transitioning from active duty to accomplish their Community College of the Air Force (CCAF) diploma for A&P certification prior to leaving active service. The CCAF program takes into account a maintainer's experience on active duty: the individual must complete 30 months of practical aircraft maintenance then complete the FAA exams to receive the A&P certification (Air University, 2012). The KC-46 program has the potential to improve workforce utilization through multi-skilling and employing A&P certified personnel is one way to make it possible. The next section of this text covers the history and possible future of multi-skilling for OC-ALC.

ALC Personnel Practices with Multi-skilling & Multi-trade

A diverse spread of skills and background is found within the workforce of the Air Force ALCs, and within this lies the challenge of how to effectively employ them. From an outsider's perspective, an aircraft mechanic is an aircraft mechanic, meaning that if an individual holds the right credentials or certifications, he or she is capable of working on any aircraft and any portion of it. In the case of commercial aviation, this is not too far from the truth. A common practice for many airline maintenance organizations is to hire certified A&P aircraft mechanics to maintain their fleets of aircraft.

However, as was pointed already, the Air Force, to include the ALCs, perceives the situation differently. When the Air Force sees an aircraft mechanic it sees an electronic integrated systems technician, an aircraft engine mechanic, an aircraft pneudraulic systems mechanic, an aircraft repair and reclamation mechanic, a surface maintenance mechanic, a powered support systems mechanic, or an aircraft sheet metal mechanic (US Office of Personnel Managment, 2013). Though this list is long it is not exhaustive; there are many more specialties involved in Air Force maintenance operations. In this framework, aircraft mechanics conform to specific tasks, and only the skills and abilities required to fulfill those tasks are developed.

Reengineering the Corporation, a text based on overhauling an organization's way of doing business, calls the ALCs' type of personnel structure "functional silos or stovepipes, vertical structures built on narrow pieces of a process" (Hammer and Champy, 1993:28). Perhaps the reason is rooted in that aircraft are complicated pieces of machinery and require skilled and experienced experts to maintain them. Regardless of

the reason, the ALCs have structure in place that simplifies the scope of a task to facilitate personnel training and the monitoring of quality assurance.

Reengineering the Corporations suggests different reasoning for the structure at the ALCs. The authors of the text point to a model developed by Adam Smith in the late 1700s and later perfected by Henry Ford with his work on the moving assembly line. What they each built into their companies was based on this, "the larger the organization, the more specialized is the worker and the more separate steps into which the work is fragmented" (Hammer and Champy, 1993:12). This idea worked for quite some time and made each of the organizations these men controlled successful but, "three forces…customers, competition and change," brought about a shift in how labor is managed (Hammer and Champy, 1993:17).

The model Smith developed and Ford applied is prevalent in the structure of active duty personnel who provide O-level (non-depot) aircraft maintenance. Trainers are enabled to teach recent basic training graduates, who may only hold high school diplomas, the basics of aircraft maintenance, and how to perform specific tasks. AFSC task centric methods are sensible for Airmen on active duty, because they are subjected to the rigor of multiple relocations through much of their Air Force careers in order to ensure high exposure to multiple airframes, providing them with in-depth experience. Maintaining rigidity in their specific AFSC training ensures that they become experts in their field. However, personnel at the depot do not move around. In fact, they may spend their entire careers in one location working on one type of aircraft. Whether depot personnel can develop more breadth in their skill sets in order to become a workforce

with more diversity in task output has been debated in the past, and efforts have been made to push the depot in that direction.

In 1993 the ALCARS was created to facilitate an agreement between labor union representatives and government management at OC-ALC. The intention was for the idea to disseminate to the other ALCs. The main purpose behind ALCARS was to match initiatives undertaken in commercial aviation to "[train maintainers in] additional skills and trades to enable [them] to perform a wider variety of functions" (Federal Service Impasse Panel, 1997). The term they used to refer to this practice is multiskilling and it "…is defined as a position that combines two or more journeymen, full performance or higher level occupation skills within the same pay plan..." (Federal Service Impasse Panel, 1997). Multi-skilling applied in ALCARS was the answer to streamline processes and save money in workforce efficiencies. The Air Force stated, "…that multi-skilling would produce significant savings; its contention is that ALCARS has [already] saved an excess of $4.4 million per year…" (Federal Service Impasse Panel, 1997). In 1997, the future of Air Force multi-skilling appeared to be solidified in a memorandum of agreement created between the labor union governing the depot workforce and the Air Force that agreed on the terms for implementing procedures to adapt the workforce to multi-skilling practices. However, ALCARS ultimately failed. In 2003, depot-reengineering researchers discovered that multi-skilling was not working for a few reasons. "…Depot maintenance employees [were] not incentivized to become multi-skilled and supervisors [were] not well versed in how to fully employ multi-skilled technicians" (Dunn, Barone, and Peterson, 2003). The idea made sense but the approach to implement the change was not correct.

The issue why multi-skilling is not working at the depot is not so much a problem of realizing the benefits that can be gained but rather something more. It may be that organizations, especially large and old ones, develop a certain way of conducting business. This way of conducting business then can become a driver for the culture of the organization. The depots have a history of employing their personnel in one way, and multi-skilling, though an accepted business practice, takes the depots in a different direction, and change is difficult to implement. The concept has been brought up repeatedly, and it almost caught on through the application of ALCARS and a memorandum of agreement to solidify the use of multi-skilling, but no permanent changes are in place.

The most recent formal discussion concerning this topic occurred in 2004. A demonstration project was established within the Naval Aviation Depots to test whether these facilities could be granted the flexibility to promote workers up one grade who are certified at the journeyman level and are able to perform multiple trades. The goal of the demonstration was to show how multi-skilling could lead to process improvement and ultimately a decrease of costs, improvement of work scheduling and quality of work. A restriction was placed on how many personnel could participate in the study of no more than 15 percent of the wage grade journeymen. In addition to a restriction on personnel participation, there also was an expectation set for the personnel participating in the program. "A certified multi-trade worker who receives a pay grade promotion under the demonstration project must use each new skill during at least 25 percent of the worker's work year" (House of Representatives, 2003). The matter was brought before the House of Representatives again in 2007, and the demonstration was expanded beyond the Navy

to include the Army and Air Force. However new guidance limited the application of the demonstration to one Army depot, on Navy fleet readiness center, and one Air Force ALC (House of Representatives , 2007). Another provision was made for the multi-trade demonstration project in 2013. This provisions would expand the authorization of increasing the pay grade by one of an employee who demonstrates proficiency in more than one field to all civilian workers in any of the branches of the military (House of Representatives, 2012). The provision was not clear whether or not the 15 percent restriction imposed on the quantity of personnel involved in the demonstration would be lifted or not.

In the past the application of multi-skilled and or multi-trade concepts to the ALCs was inhibited by two things, knowing how to manage and utilize multi-skilled or multi-trade personnel and the providence of incentives to encourage personnel to expand their skill sets. Currently the ALCs provide opportunities for personnel to gain depth and experience in various skill sets, but the concepts of multi-skilling are not formally practiced in the sense that personnel are paid more for being qualified in more than one field. However, the provisions being discussed as part of the demonstration project provide the possibility of formalizing the process and paying personnel a one level wage increase for their expanded skill sets. That only leaves the issue of knowing how to manage personnel with these abilities. More will be discussed about how multi-skilled personnel are managed in the next chapter.

The primary motive for the Air Force to apply a multi-skilling, multi-trade concept to personnel practices, is the potential for reduced cost, since, current fiscal constraints are driving organizations across the entire Department of Defense to perform

the same missions with less resources. Although cost seems reason enough, there are other underlying motives. Looking to the commercial sector, merely benchmarking their practices can lead to identifying value added concept applications. However, commercial aviation abides by a different rule set that regulates their maintenance practices. The FAA establishes and enforces these regulations and ultimately these regulations, lead to the reasons why it is common for an individual to hold an A&P certificate to work in the aviation maintenance industry. Holding these certificates is an indicator that the individual is qualified in more than one field and has the capability to sign for his or her own work. The KC-46 program is seeking to apply FAA standards to its maintenance processes to support the new tanker and A&P certificated personnel can help facilitate this. The next section goes into more detail about applying FAA standards, and it also covers what the KC-46 program is hoping to do.

Meet the Intent

The Federal Aviation Administration's (FAA) mission is "to provide the safest, most efficient aerospace system in the world. [They] continually strive to improve the safety and efficiency of flight in this country" (US Department of Transportation, 2013). The safe operation of aircraft requires the strict adherence to FAA driven maintenance standards. The FAA, therefore, enforces safe practices within the aviation industry through its Aviation Safety organization (AVS).

> [This] organization is responsible for the certification, production approval, and continued airworthiness of aircraft; and certification of pilots, mechanics, and others in safety-related positions. [It] is also responsible for:

a. Certification of all operational and maintenance enterprises in domestic civil aviation

b. Certification and safety oversight of approximately 7,300 U.S. commercial airlines and air operators

c. Civil flight operations

d. Developing regulations (US Department of Transportation, 2013)

Therefore, the FAA oversees almost all aviation related activities, but the first bullet clarifies its limiting scope, domestic civil aviation. So focusing on this topic could seem trivial, because Air Force aviation does not fall subject to FAA jurisdiction, specifically aircraft maintenance operations, but adhering to these guidelines opens up opportunities to the Air Force.

The Air Force has a history of purchasing mainly military specific airframes designed to carry out its mission, which is the case for all fighter aircraft, bombers aircraft, and most transport aircraft. However, it also has the occasion to purchase commercial derivative aircraft. These are aircraft originally designed for commercial aviation but with modifications that change the aircraft to fit the needs of the Air Force. Examples include the E-3 and KC-135, based on the B-707, and the KC-10, based on the DC-10. The Decision to purchase a commercial derivative aircraft is based on the commercial airframe's proven record and, even more importantly, the assurance of an adequate supply of parts due, in part, to additional demand created by other entities operating the aircraft. As long as the airframe is being flown by organizations other than the Air Force, there should be sufficient demand to ensure parts availability.

The KC-46 is a B-767 derivative aircraft, which is common amongst commercial carriers. Therefore, the Air Force has the opportunity "to leverage the efficiencies the

commercial air carriers use daily to reduce the costs of operations and maintenance" (Langen, 2013). One efficiency KC-46 decision makers are discussing is the possibility of creating a partnership with commercial carriers for the pooling of parts, a practice common among commercial carriers to expand access to aircraft parts throughout the world. The way parts pools work is that organizations who operate the same airframe allow parts pool members access to their parts inventory with the guarantee that they replace a part taken out with a repaired part and that they also reciprocate the practice. It is a give and take relationship sustained by the mutual understanding that all parts flowing in and out of the pool are FAA certified. The benefit of a parts pool is that operators have access to parts in many more locations in the world, and thereby decreasing the time required to obtain parts, especially when far from home station. However, although this initiative is being considered by KC-46 decision makers, there is a disconnect between commercial carriers and the Air Force regarding FAA jurisdiction. The Air Force is not subordinate to FAA regulation so it does not follow the same rules as commercial carriers. Unless a mutually agreed upon method is developed for the Air Force to abide by the same rules, there is no way for the Air Force to apply any initiatives that involve commercial carriers.

The way that the Air Force, specifically OC-ALC, can abide by the same rules as commercial carriers is that it "meets the intent." "Meets the intent" means that the Air Force regulations and processes meet the applicable 14 Code of Federal Regulation (CFR) Part 121 Air Certification regulation. Further, it means that the Air Force is able to perform aircraft operations and aircraft maintenance in a manner consistent with maintaining safety standards and managing hazard-related risks, as other FAA

certificated commercial air carriers. Also, there is a possibility that the maintenance performed by the Air Force could be recognized by MRO facilities and air carriers (Langen, 2013). Finally, "meets the intent" means that an "analysis of [Air Force] overhaul facilities (e.g., depots), compared to FAA certificated repair station criteria (i.e., in accordance with FAR Part 145)," is necessary (Langen, 2013).

14 CFR Part 121 Air Carrier Certification is an application process that requires an air carrier to demonstrate that it is "able to design, document, implement, and audit safety critical processes that do two things: (1) comply with regulations and safety standards, [and] manage hazard-related risks in your operating environment" (US Department of Transportation, 2013). Once an air carrier is 14 CFR Part 121 certified, the FAA periodically reviews their processes to ensure that they are abiding by the standards. However, due to the jurisdiction limitations, a different approach is planned for certifying that the Air Force and ultimately OC-ALC "meets the intent" of the regulation.

The first step in the process to determine if the Air Force "meets the intent" is that a matrix is constructed to compare applicable Air Force regulations to FAA Part 121 regulations. During this stage, comparison is also made of Air Force depot facilities with FAA certificated repair station criteria. The matrix will include operational and maintenance regulations as governed by Part 121 regulation. After the matrix has captured all of the regulation comparison, it is sent to the FAA's Flight Standard National Field Office (AFS-900). This organization is responsible for "oversight of the certification and surveillance of airmen, air operators, and air agencies engaged in air transportation under 14 CFR Part 121" (US Department of Transportation, 2013). Once

they have reviewed the matrix they will open up a dialogue between the FAA and Air Force to discuss their findings and possible modifications to Air Force regulations in order to match FAA regulation to "meets the intent." Then the Air Force makes any necessary adjustments to its practices, updates the matrix, and submits to the FAA for final approval. If approval is granted the FAA issues a "Meets the Intent," letter to the Air Force and this letter serves as proof that the Air Force is following the same regulations as commercial operators and thus permits them to work together (Langen, 2013).

The hope is that the letter makes it possible for an Air Force FAA certified designated engineering representative to sign for parts repairs that may be acceptable to commercial carriers of the same airframe type. Then the Air Force at least meets the requirements necessary to participate in an open parts pool with commercial carriers if it decides to implement this option. Though this is merely one example of what "meets the intent" can achieve for the Air Force, additional possibilities may arise as the Air Force seeks to adopt many of the innovative practices that commercial aviation is developing.

Innovation seems to be at the forefront of Air Force leadership's plans for the ALCs involvement with the KC-46. The current austere fiscal reality is an obvious force driving improvements in operations and maintenance practices. Maintaining aircraft is expensive but necessary in order to sustain operations so an option to do less maintenance may not be sensible, but there may be other ways to accomplish the same mission at lower cost. Throughout this chapter, examples are given how the ALCs are striving to seek out innovation and make process improvements. However, process improvement is ongoing, never ceasing in the pursuit of doing things better, faster, and cheaper, while

sustaining or improving upon quality. The next section discusses ways in which the ALCs are working to improve aircraft maintenance through the application of new programs.

Progressive Steps: PDM, HVM & MSG-3

The maintenance of aircraft is complicated, expensive, and requires detailed planning to be successful. The purchase price of a new aircraft is merely a small fraction of the overall cost to operate and maintain the aircraft throughout its life. The Air Force develops and implements aircraft maintenance concepts, and these concepts have evolved over time. Three of the main concepts implemented at the ALCs are programmed depot maintenance (PDM), High Velocity Maintenance (HVM), and Maintenance Steering Group-3 (MSG-3). This section discusses each concept and the evolution of one concept to the other over the years.

PDM is "the inspection and correction of defects that require skills, equipment or facilities not normally possessed by operating locations" (HQ AFMC/A4F, 2011). The PDM concept is made-up of multiple sources; one is a result of applying data derived from Reliability Centered Maintenance (RCM). According to AFMCI 21-103, "RCM is a maintenance concept that has the objective of achieving the inherent, or designed-in, reliability of a system." (HQ AFMC/A4F, 2011) RCM originated in the private sector as a result of the collaboration of representatives from both the FAA and commercial airlines in 1960, "to investigate the capabilities of preventive maintenance" (Rose, 2002). Although RCM serves as key source for PDM it is also derived from the Maintenance Data Documentation (MDD) systems, the Maintenance Program Development Document

(MPDD), and other requirements directed by reliability and maintenance data sources (HQ AFMC/A4F, 2011).

PDM involves heavy aircraft maintenance accomplished at the ALCs according to a specific timeline. "The PDM interval is measured from the output date of the last PDM to the input date of the next due PDM" (HQ AFMC/A4F, 2011). In other words, heavy maintenance occurs at the end of a designated time-period in its maintenance PDM cycle. Cycle times specific to different airframes are indicated in the Air Force Technical Order (TO) 00-25-4 on table 1-2. In the case of the KC-135, when the aircraft hits its 60^{th} month it is time for the aircraft to undergo programmed depot maintenance at OC-ALC. The interval length is determined as a basis of "conditional analysis of a representative sample of aircraft" (HQ AFMC/A4F, 2011). However, the program does allow some leeway for operating units to request extensions to the interval cycle period before it returns for depot maintenance.

The PDM program provides definition and clarity for aircraft operators and maintainers to know when the aircraft requires heavy maintenance. However, the extended time between heavy maintenance requires the aircraft to be unavailable for several days, or even months. "A typical PDM visit may require between 2,000 and 50,000 labor hours (depending on the fleet) and substantial material. The total labor required to complete PDM is expected to increase as a function of the age of the fleet" (Loredo, Pyles, and Snyder, 2007). The 2,000 to 50,000 labor hours may appear typical, but consider the amount of hours available at the ALCs for touch labor.

In a typical eight-hour shift, maintenance technicians do not spend the whole time doing maintenance. They have other requirements that take their time at work. Ancillary

training, authorized down time for fitness, training classes, and more, all take time. Additionally, personnel take both regular and sick leave, go TDY, and experience down days for holidays. This time, doing other than maintenance activities, is tracked and is used to calculate yield. Yield is available output of personnel when all of these things are considered, including these contributors and one additional factor, efficiency. In an eight-hour shift, 35 percent of the time is attributable to an indirect labor factor, or the time accounted for all of the different types of official off-the-clock time, leaving roughly 5 hours of productive time in a full shift (AFSC/LGPM, 2013). The ALCs are also not 24-hour facilities that extend operations seven days per week like most commercial MRO facilities. Ultimately, this causes aircraft to remain longer at the ALCs and thus has motivated improvements to the process to release the aircraft back to the customer faster. One of the improvements in practice is HVM.

The HVM concept is the result of a process improvement event conducted in 2007. A steering group and a team of maintenance and maintenance support experts met to develop the concept and their first step was to map out all of the processes tied to depot maintenance. With the steps clarified, they were able to identify attributes and characteristics of Air Force depot maintenance for benchmarking with the commercial industry. Through the benchmarks, they were able to make comparisons between the rate of production in commercial industry and that within the depots. Further study also led the team to identify that there was too much variability in maintenance requirements so they saw a need to decrease the cycle times driven by PDM. It was suggested that the work packages generated by PDM could be divided into four smaller sub packages. This would require the aircraft to come in more often, but each visit would be much shorter

and those maintaining the aircraft would have a firmer grasp of the overall airframe health rather than what would be seen following a normal PDM program cycle. The way they do this is through "…a single maintenance concept that integrates field isochronal inspections into the depot level requirement and allows a better understanding of equipment condition" (High Veloctiy Maintenance Team, USAF, 2010). Another benefit to HVM is that it allows technicians to defer portions of the maintenance to the next cycle, and this facilitates a more accurate picture of what to expect the next time the aircraft is in for maintenance (High Veloctiy Maintenance Team, USAF, 2010).

The HVM concept shifts the Air Force's depot practices to resemble more of what is standard in commercial aviation industry. The technicians see the aircraft more often and thus have the capability to do more to keep the aircraft readiness level at an acceptable level. Ultimately, "benchmarking of commercial practices revealed that the civilian aviation community routinely obtains daily maintenance man-hour burn rates, [maintenance production hours], 4-10 times higher than the Air Force resulting in much less time their aircraft spend undergoing maintenance. If the USAF can develop a process to accomplish aircraft maintenance at rates comparable to civilian aviation then an improvement in aircraft availability of at least 14 percent is possible along with greater efficiencies and a potential to reduce costs" (High Veloctiy Maintenance Team, USAF, 2010). The C-130 was chosen as the pilot airframe for the concept and its implementation is currently in effect at Warner Robins ALC (WR-ALC). In 2010 they had "develop and sustain war-fighting systems" (D&SWS) targets set at a 20 percent improvement in aircraft availability and a 10 percent decrease in funding requirements for fiscal year 2011 (High Veloctiy Maintenance Team, USAF, 2010).

HVM allows Air Force maintenance operations to closer resemble what is practiced by commercial aviation organizations. The more the Air Force benchmarks with industry the more it will gain, especially for the acquisition of aircraft derived from commercial platforms. The final progressive step therefore becomes integrating maintenance programs that industry applies now. Those programs focus on MSG-3.

MSG-3 is a "structured means for developing optimal scheduled maintenance tasks and intervals with three targeted goals: [1)] recognize inherent reliability of aircraft systems [, 2)] avoid unnecessary tasks [, and 3)] achieve increased efficiency" (Crowley, 2013). This program has developed and evolved over several years. In its initial stage, it was derived from Aeronautical Bulletin 7E of May 15, 1930. Then in 1968 a task group, MSG-1, came together with the purpose to develop maintenance requirements decision and analysis logic. These requirements would drive scheduled maintenance and inspection programs. Later in 1970 with the addition of revisions to what MSG-1 created, MSG-2 met to establish minimums for scheduled maintenance and inspection recommendations for aircraft and engines and the Air Transportation Association of America (ATA) was recognized as the industry chair for the program. Finally, in 1980 MSG-3 formed the third task group to revise the previous editions of maintenance and inspection minimum recommendations. At this point, the FAA and ATA combined their efforts and came up with tasking and interval requirements for maintenance. In the coming years, further revisions were made leading up to what is now being applied (Federal Aviation Administration, 2012). The program currently works to ensure regulatory compliance and the continued airworthiness of the aircraft. It takes into account the reliability and consequence of failure at a system level for four different

categories. The categories are lightning and high intensity radiated fields (HIRF), zonal (e.g., a zonal inspection program), systems and structures (Crowley, 2013).

MSG-3 guides maintenance practices throughout commercial aviation and is the direction the Air Force is taking with the KC-46. Commercial carriers utilize inputs from MSG-3, maintenance-planning development document from the OEM, and a few other sources to customize the way in which they will maintain their fleet's health. This is the industry standard. B-767 guidelines created by MSG-3, formed in 1980 as well as other documents serve as the point of reference for customizing a maintenance program for the KC-46. The other documents involved are the Maintenance Management Plan (CDRL B043) and Technical Manual Contract Requirements (CDRL B037) (Crowley, 2013).

As the aviation industry continues to evolve the concepts applied to aircraft maintenance, continual changes and updates will occur within the ALCs. RCM came from commercial aviation and the Air Force has integrated it into its practices, HVM involved adapting PDM to commercial maintenance practices to accelerate maintenance; and finally implementing MSG-3 concepts sets the precedence of fully incorporating commercial practices. The next section of this chapter dives into proposed steps toward the way ahead for the future state of the ALCs. Although the sourcing document is in its draft stage and is not due for publication until after the publication of this document, it provides a general idea of the direction that the Air Force Sustainment Center (AFSC) leadership desires to take.

Complex of the Future

Complex of the Future (CoF) is a document created by the commander of the AFSC, and in it, he outlines a roadmap for achieving several specific attributes or goals

that will lead his organization to success. This research relates specifically to attributes 4 and 5, which outline steps to create a more efficient depot and more effective workforce. Each attribute is covered separately with the purpose of outlining motives for focusing on the attribute and what the hope is to achieve.

Attribute 4, Efficient Depot, focuses on the improvement of operations at the depots in order to sustain safe practices while consistently turning out high quality outputs. The draft CoF document identifies several shortfalls and limitations that motivate the focus on depot efficiency. There are issues in the ALCs with work task scheduling; much of the work processes rely on manual procedures; coordination of personnel and resources is cumbersome; there is limited flexibility due to reliance on current facilities and expensive equipment; the rate for certifying new maintenance and repair processes is too slow; and there are unsatisfactory limitations on inspection processes (Air Force Sustainment Center, 2013:56). Though this list is not exhaustive, it shows that there is much to do to make the depots more efficient.

Achieving desired results starts with finding and eliminating duplicated efforts and then working toward a just-in-time concept for the allocation of resources to complete the work. The rest of the desired outcomes involve eliminating waste by reducing wait time, reducing the need to rework tasks, setting up automated processes where sensible, and establishing a work infrastructure that facilitates multiple types of weapon system platforms. In some ways, the three ALCs that fall under AFSC conduct operations differently. There are some differences due to the unique types of work they perform and weapon systems they support, but within similar types of work, proven best practices from within the AFSC or aviation maintenance industry are made the standard

for all three (Air Force Sustainment Center, 2013:56-57). Then standard measurements will apply to ensure that the ALCs are tracking the metrics that can show how changes are affecting cost reduction, quality improvement, and safety.

Attribute 5 focuses on improving the effectiveness of the workforce. This attribute encompasses a long-term strategic plan that involves research to ensure the progressive development of the workforce. According to the draft CoF roadmap, "the workforce must be proficient and competent in all maintenance tasks with an added focus on supportability awareness, schedule discipline and task completion documentation" (Air Force Sustainment Center, 2013:68). The ways AFSC hopes to accomplish this attribute starts with the consolidation of skill types under one category, similar to an A&P certification process that could facilitate the flexibility of a multi-skilled workforce. The next area seeks to reduce the size of a task card so that it limits the scope of the work to an 8-hour shift rather than splitting the requirements of one task card between two or more shifts. Another area focuses on developing training that meets the needs of the individual rather than the collective whole in order to ensure an individual's proficiency and competency at the right time. Finally, measures are taken to improve task planning in order to eliminate waste associated with the process; non-value-added steps are identified and removed.

The draft CoF outlines several reasons why workforce effectiveness requires attention. AFSC realizes that work cards take longer than one 8-hour shift to accomplish and thus the work must be handed over to the oncoming shift. This practice ties up additional man-hours to ensure that shift replacements understand what tasks are complete on the work card and what remains. Next, there are inconsistencies amongst

planners and those who schedule tool sets across the ALCs. Tied with that, there are problems with the sequencing of events to fix constraint issues caused by bottlenecks in the work processes. Then there is inherent variability within the competency and or proficiency of the employees. Additionally, the ALCs practice of shredding out skill sets to individual workers complicates the scheduling of personnel to cover all of the maintenance requirements within any given shift. Also, waste is found throughout the maintenance process including unnecessary movement, labor and management relationship issues, excess rework, and how the workforce is balanced between direct and indirect labor (Air Force Sustainment Center, 2013:68).

Summary

The purpose of this research is to identify requirements for preparing personnel to activate maintenance operations for the KC-46. Workforce planning serves as a means to identify what is needed. Then workforce sizing gives a number to quantify how many personnel are required to initiate the first C-checks. The first two categories are more focused on big picture planning whereas the remaining categories provide the reader with incremental steps on what details need to go into the overall plan. Maintenance training strategy is a way in which the gap between general aviation mechanics and KC-46 maintainers is bridged. This strategy provides a way in which this is done. Multi-skilling is an extension of training strategy, in that it serves as a possible way to improve the training and use of personnel. Finally, the chapter concludes by providing background of OC-ALC maintenance practices and a small glimpse of leadership's guidance for the way ahead. Overall, the literature for all categories, thus far, has provided insight and

limitations to what has been done so far. Close analysis will lead to new insights that can help the KC-46 program successfully activate its maintenance operations.

III. Methodology

Overview

The literature review in chapter two outlined several areas applicable to activating a new workforce. It specified what type of planning is involved and provided details behind the steps that enable the workforce to fulfill its responsibilities. These topics are broad in scope, but they are applicable to the process of determining the personnel requirements for activating KC-46 depot maintenance. However, as was mentioned in chapter one, the focus of this work is to come up with a way to determine those requirements. Therefore, it requires a specific approach that outlines a step-by-step methodology that delivers valid results. Valid results lead to a solid course of action that KC-46 program decision makers can implement prior to the arrival of the first KC-46 to the depot for its initial C-check maintenance.

Method Choice & Definition

An applicable approach to developing the methodology is case study research (CSR). CSR is defined as "inquiry focusing on describing, understanding, predicting and or controlling the [process, culture or organization]" (Woodside and Wilson, 2003). This method is a, "preferred strategy when "how" or "why" questions are being posed, when the investigator has little control over events, and when the focus is on a contemporary phenomenon within some real-life context" (Yin, 2003:1). Developing a workforce to conduct KC-46 C-checks requires determining the answers to many "how" and "why" questions. A few general questions driving the reason for the research: how many personnel are needed, how personnel are integrated into their workplace, and how are personnel prepared to meet maintenance requirements, among others. CSR focuses a

researcher on gaining an in depth understanding of the issues to resolve by exploring processes related to the topic. In the case of developing a workforce to maintain the KC-46, possible application may involve analyzing approaches of how other organizations develop their labor pool to support aircraft that are similar to the KC-46, B-767s.

Another definition suggests, "the case study…exists to systematize evidence so as to suggest hypotheses for testing, and pending that, to provide a basis of fact and insight for possible application to decision making" (Schramm, 1971:2). CSR is different from a more quantitative research method in that it focuses less on number calculations and statistics, but instead follows a qualitative approach to gather and process data useful for conclusion inference. If adequate steps are taken to apply CSR methodology, the outcome can provide KC-46 program decision makers with the information they need to make the right choices when working through the process to activate maintenance for the KC-46 prior to its arrival to the OC-ALC.

Process

The principle objective of CSR is deep understanding and it suggests that steps are taken for sense making. "Sense making is [working with informants to determine] how the [process, culture or organization] [focus] on what they perceive; [frame] what they perceive; and [interpret] what they have done including how they go about solving problems and the results of their enactments – including the nuances, contingencies, in automatic and controlled thinking processes" (Woodside and Wilson, 2003). Sense making of the personnel requirements for the KC-46 can start with internal operations at OC-ALC. The ALC maintains the KC-135, an aircraft that supports the same primary mission as that which the KC-46 will support – aerial refueling. It may have similar

systems driving some of the same maintenance requirements. CSR's sense making involves working with informants to gain insight and then that insight can be used to make inference. This inference leads to progress in determining a solution to the problem being addressed. In order to make this progress, a deep understanding of personnel maintaining aircraft similar to the KC-46 must be captured. Therefore, a natural first step in developing methodology is gathering information that encompasses the means and methods used by managers to develop their workforce to maintain other similar aircraft. Information gathering can start with internal personnel processes at OC-ALC. The KC-135 can serve as the first example because of other possible examples, it is the only one that has processes in place to support a refueling capability, something also needed for KC-46 maintenance. Then, research can expand to other personnel maintenance processes within the Air Force or outward to non-government commercialized organizations.

When the process to gain deep understanding is applied it involves steps of triangulation: "direct observation by the researcher within the environments of the case; [probe] by asking case participants for explanations and interpretations of, as explained by Van Maanen 1979, "operational data;" and analyses of written documents and natural sites occurring in case environments" (Woodside and Wilson, 2003). This approach requires interviewing subject matter experts who can provide valid details surrounding the area of research, and their input serves as a basis for understanding their maintenance personnel processes. Then to confirm the information gained during the interview it becomes necessary to gather and analyze documentation that formalizes the way that

their processes are applied in their organizations. The following two bullets further define CSR and provide scope to the process:

1. *A case study is an empirical inquiry that Investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident*

2. *The case study inquiry copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result relies on multiple sources of evidence, with data needing to converge in a triangulation fashion, and as another result benefits from the prior development of theoretical propositions to guide data collection and analysis (Yin, 2003:13-14).*

The first bullet explains that the process of case study research is to seek for understanding of a current situation as it relates other similar situations. Then the hope is to find direction that leads the researcher to resolving the issues he is attempting to resolve. Researching workforce development for KC-46 maintenance requires the selection of cases that can serve as examples of processes and procedures used to create a workforce with similar purpose. The second bullet guides the researcher to identify points of reference to serve as evidence for making a compelling case that justify implementation. The overall goal of going through the effort of implementing CSR methodology is to come up with valid solution alternatives that the KC-46 program office can work from to activate depot maintenance personnel. The process also helps serve as justification for selecting one way over the others.

Justification

The following rationale will detail what makes CSR a valid approach for coming up with the details to activate a workforce for the KC-46. Developing a workforce is a managerial process common to any organization that employs personnel. The literature

review in chapter two outlined a few ways that organizations develop their workforces. They identify a labor shortage and then they work to fill it. "Case study method allows investigators to retain the holistic and meaningful characteristics of real life events – such as …managerial processes" (Yin, 2003:2). "It [also] has revolutionized the study of decision-making in fields like business administration" (Schramm, 1971:1). This method seeks to answer questions about business processes that the KC-46 program office currently needs to understand. The KC-46 is new to the Air Force, and many of the "how" and "why" questions to be answered will provide decision makers with clear objectives to know what needs to be accomplished to have a workforce ready to conduct the first round of KC-46 C-checks.

CSR methodology has been used in other areas to provide Air Force decision makers with relevant guidance. An Air Force Institute of Technology thesis was completed in the early '90s to explore commercial air cargo operation practices in the commercial industry for comparison to those found in the Air Force. The hope was to glean insight on other ways of doing business in order to identify best practices that either the Air Force exhibited in its air cargo operations or what it could integrate into its processes from other organizations to improve its efficiencies. Multiple organizations were observed and analyzed; United Parcel Service, Federal Express, Emery Air Freight, Airborne Freight, Dalsey Hillblom and Lynn (DHL) Airways, Burlington Air Express, and the 436th Aerial Port Squadron at Dover AFB represented the Air Force. The authors interviewed representatives from each organization, conducted onsite observations, and made comparisons based on their procedures of handling cargo. After conducting the CSR the authors came up with four areas that the Air force could replicate

in its operations from the commercial sector; “cargo-handling equipment, in transit visibility, operations interface, and safety” (Abalateo and Lee, 1993:67-68). Specifically, the authors identified the need for the Air Force to develop the capability to integrate commercialized containers into its 463L pallet system; they confirmed a need of the Air Force to continue developing its radio frequency identification system (RFID) to promote in transit visibility; and the authors also identified a couple of measures the Air Force could apply to promote safety in the workplace through use of painted walkways and lifting support belts (Abalateo and Lee, 1993:70-71).

Abalateo and Lee’s work did not lead to any new discoveries. However, they did establish an objective process that generated valid and viable alternatives that decision makers could use to improve the effectiveness of Air Force air cargo operations. The Air Force utilizes RFID tags to track cargo for in transit visibility, it has painted walkways in the work areas and it has developed the capability to integrate commercialized containers into its 463L pallet system. Parallels can be drawn between what was accomplished by benchmarking Air Force air cargo operations with those in the commercial industry and the intended result of this research. CSR methodology serves as a process to objectify the observation and comparison of maintenance work force development of the OC-ALC to support the KC-46 and that found in commercial aviation supporting the B-767. The desired result is to provide decision makers with both the requirements necessary to initiate C-check operations and a proven way to do it. This requires a designed experiment that provides the researcher with valid conclusions. The next section covers the steps leading up to data collection.

Research Design

The process to gather data effectively requires additional research prior to actively seeking inputs required to conduct this research. Fortunately, methodology for establishing CSR suggests a way to accomplish this. It suggests the use of a pilot case study prior to gathering primary data. This "help[s]…refine …data collection plans with respect to both the content of the data and the procedures to be followed" (Yin, 2003:79). Conducting a pilot case study also will help to develop the correct approach for designing the process to capture the data needed to infer answers to the research questions. More needs to be understood about how aircraft maintenance operations are conducted prior to offering any comparison between the different organizations that provide that maintenance. The Air Force employs aircraft mechanics to fulfill functions that differ from those of organizations found in the commercial sector, thus motivating the reason to discover why. The Air Force hires and trains maintenance technicians to perform specific tasks whereas commercial industry maintenance technicians are hired to perform work that is more generalized in nature. Exploring these differences will help provide a way to pinpoint the spread between the benchmarked practices in industry and the Air Force practices which is considered suboptimal; a basis for selecting one option over another (options being courses of action that detail how to meet requirements to conduct the first round of KC-46 C-checks).

"Benchmarking can be defined as the pursuit by organizations of enhanced performance by learning from the successful practices of others. Benchmarking is a continuous activity; key internal processes are adjusted, performance is monitored, new comparisons are made with the current best performers and further changes are explored" (Francis, Hinton, Holloway, and Humphreys, 1999).

Then CSR suggests, “Each case study and unit of analysis either should be similar to those previously studied by others or should innovate in clear, operationally defined ways” (Yin, 2003:26). The goal of this research pilot study is to gain more background and understanding of how OC-ALC conducts maintenance operations in comparison to the maintenance operations of one commercial organization.

Following the pilot study, the researcher is ready to move to the next step, designing the method for gathering primary data for the research project. “[It] is the logic that links data to be collected (and the conclusions to be drawn) to the initial questions of the study” (Yin, 2003:19). Case study research design involves reference to a single case or multiple cases. However, it is crucial to determine up front which approach should be taken. “A primary distinction in designing case studies is between single and multiple case designs. This means the need for a decision, prior to any data collection, on whether a single case study or multiple cases are going to be used to address the research questions” (Yin, 2003:39). A single case study approach is appropriate “when the case represents an extreme case, or unique case,” and “critical case in testing a well-formulated theory” (Yin, 2003:40). Though the KC-46 is unique, something new, and different to the Air Force, the fundamentals to maintain it are not. As mentioned, the KC-46 is merely a derivative of the B-767, an aircraft commonly found in commercial aviation. Multiple points of reference are available for drawing conclusions on how requirements are to be met to activate personnel to conduct C-checks on the KC-46 at OC-ALC. “Analytic conclusions independently arising from two cases [or more], as with experiments will be more powerful than those coming from a single case (or single experiment) alone” (Yin, 2003:53). Multiple case design is the choice to capture data

from a myriad of reference points. The figure below, figure 3.1., outlines an approach to apply multiple case designs. According to Herriot and Firestone (1983), this design often provides more compelling evidence, "and the study is therefore regarded as being more robust" (Yin, 2003:46).

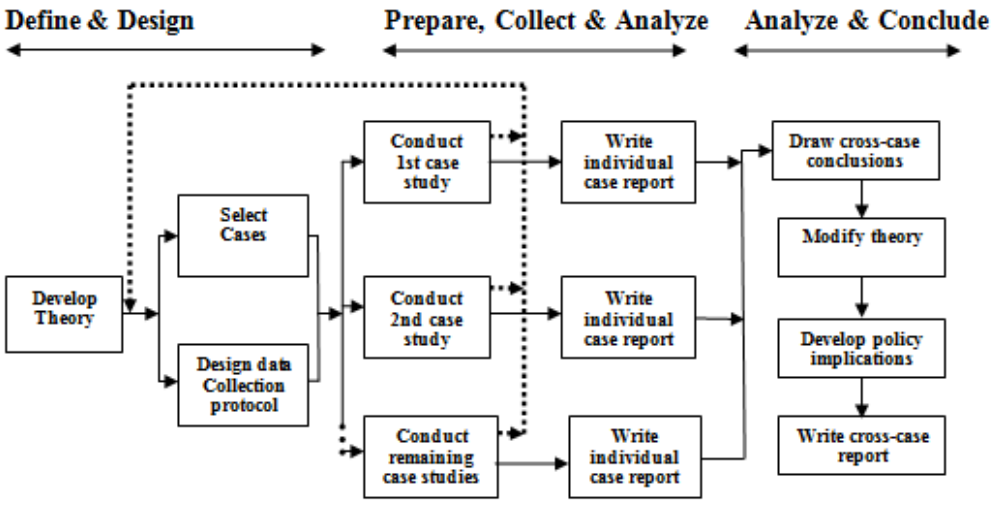

Figure 3.1. Case Study Method (Yin, 2003:50)

The first step in developing a multiple case design requires the development of theory, what the researcher believes the answers may be to his research questions prior to applying CSR method. The following section elaborates on the intended theory that is tested using this methodology.

"Theory development prior to collection of any case study data is an essential step in doing case studies" (Yin, 2003:28). This requires the researcher to objectify his position in the matter or in other words make a claim of what he thinks the solution to the problem is prior to solving it. The next step then is to prove that the position taken by the researcher is valid. Once the claim is proven valid then it can serve as a course of action, an alternative that KC-46 program managers can choose to implement. "The use of

theory, in doing case studies, is not only an immense aid in defining the appropriate research design and data collection but also becomes the main vehicle for generalizing the results of the case study" (Yin, 2003:29).

OC-ALC has a history of altering procedures and changing processes to improve the way work is done. In some cases, they make changes to their internal processes to copy practices found in commercial aviation. One example is ALCARS or Air Logistics Center Air Frame Rating System and which created to facilitate an agreement between labor union representatives and government management at OC-ALC. The main purpose behind ALCARS was to match initiatives undertaken in commercial aviation to "[train maintainers in] additional skills and trades to enable [them] to perform a wider variety of functions" (Federal Service Impasse Panel, 1997). The KC-46 is new to the Air Force but the airframe it was built on is not new to commercial aviation. Therefore, similar to how OC-ALC instituted an idea from commercial industry to modernize its work processes it also can replicate commercial practices to support the KC-46 with C-check maintenance. OC-ALC can potentially improve the way its personnel are employed by following similar practices that are applied in commercial aviation maintenance facilities, including training practices. With the theory clarified, the next step involves selecting cases.

Selecting cases is more complicated than determining whether or not to use single or multiple cases. The first reason is that, while there are several options available, what is considered an option is not clear. In commercial aviation maintenance terms, OC-ALC is considered a Maintenance, Repair, and Overhaul facility (MRO), so an individual case may include the personnel activities, procedures, and characteristics that a MRO follows

to complete C-checks on the B-767. Not all MROs conduct C-checks, not all are located in the United States and not all MROs maintain the B-767 therefore some limitations are placed on which ones are selected for evaluation. MRO cases are selected primarily on whether or not they perform C-checks on the B-767 and whether or not they are located in the U.S. Extending research outside the U.S. is beyond the resources and time available to conduct this research.

General limitations help to pinpoint the MROs applicable to this research, but they do not help to define which ones to select for study and possible benchmark of their application of maintenance personnel to the C-check process. An MRO's experience and reputation help justify selecting one over the other and ultimately guides the benchmarking of methods observed. Although each MRO is subject to the same FAA guidelines and the service they provide fulfills the same purposes, they all have their own unique way of accomplishing the work. The hope is to first learn about these different means and methods to accomplish C-checks and then determine which practice or practices offer meaningful improvements to the OC-ALC's personnel practices. It may not be one particular case that offers all of the solutions. A couple of different strategies in the research design will be used to determine which cases to select and what characteristics of the individual cases need to be compared once they are selected. Many more MRO options remain after applying the qualification filters discussed, so it is reasonable to assume that at minimum four cases are to be considered, OC-ALC (using KC-135 practices) and at least three commercial MROs.

The logic for studying the minimum of three commercial MROs is based on linear regression that seeks to identify trends by identifying high, low and midpoints in the data

and where a majority of the data points lie. Therefore, data gathered from at least three commercial MROs can help to pinpoint what industry standard practices presently are to conduct C-check maintenance and contribute to goal of determining where the KC-46 program needs to be once maintenance operations begin. Practices standard to the KC-135 program serve as a fixed location or starting point, what is already known to the Air Force, and the other points of reference, commercial MRO cases, serve as a possible roadmaps to improvement.

Commercial MROs are selected based on the following criteria: industry rating, years of experience maintaining aircraft, organizational size, and number of clientele. CSR methodology states that, "each case must be carefully selected so that it either (a) predicts similar results (a literal replication) or (b) predicts contrasting results but for predictable reasons (a theoretical replications)" (Yin, 2003:47). These criteria are selected because they provide further justification for selecting one MRO over another, and they support the validity of their practices. Maintaining a reputation of being top in the industry suggests that perhaps the organization's practices are a more efficient or effective method as compared to others.

There are multiple aviation MROs from which to gather data in support of the selection criteria. There is no single source that details which MROs are considered the best, therefore multiple sources are used to pinpoint which ones to study and benchmark. Aviation Week Magazine compiles a top ten list of commercial MROs in the world and publishes it in June each year. They base their ranking on a "biennial airframe MRO survey" and it collects data on "their capabilities, footprint, labor hours, and revenue" (Tegtmeier, 2013). Next, various organizations such as the Federal Aviation

Administration, Aircraft Technology Engineering and Maintenance Award program and, OneAero MRO Top Shop Award program seek to recognize achievements in organizational practices (Federal Aviation Administration, 2013; Aircraft Technology Engineering and Maintenance Awards, 2013; OneAero-MRO, 2013). These awards further contribute to defining an MRO's ranking in industry. Then, there are also various professional certifications that MROs can earn to set themselves apart from the rest such as International Standard for Organization (ISO 9001) rating, and Aerospace Standards (AS 9100) rating (International Organization for Standardization; G-14 Americas Aerospace Quality Standards Committee, 2009). These certifications identify that these organizations conduct lean managerial and operational processes in their work practices. Finally, the MROs advertise their business through websites, and on these websites, they provide information detailing their competitiveness in the market. Average years of maintenance technician experience, years in the industry, size of the organization type, and quantity of clientele can all be found on these websites. After the information is gathered, a matrix is constructed for MRO comparison and the ultimate decision, of which are to be considered as part of this research study. No reference is made to the matrix in order to provide anonymity for the organizations participating in this research.

Process to Gather Data

After all of the cases are selected, data collection protocol is designed, and this provides guidance for the researcher to approach each case with the method to obtain the data either to support or to refute his theory. Denzin (1978) uses a form of triangulation to derive data in his case study research and the following steps apply:

(a) Direct observation by the researcher within the environment of the case;

> *(b) Van Maanen (1979) suggests probing by asking case participants for explanations and interpretations of "operational data;" and*
> *(c) Analyses of written documents and natural sites occurring in case environments* (Woodside and Wilson, 2003:498)

These same steps are applicable to gathering data for analysis of the procedures followed by organizations in commercial aviation that perform B-767 C-checks. Denzin's triangulation is applied by first conducting personal interviews with subject matter experts representing the selected organizations for this research. In order to conduct an interview that provides meaningful results the questions need to be carefully drafted. "Designing the research questions is probably the most important step to be taken in a research study…" (Yin, 2003:7). The following list of questions will guide the discussion with the representatives from each organization, and the same questions will be asked of each one to maintain control of the data received.

(1) How many years of experience performing B-767 C-checks?

(2) How many B-767s are supported per year?

(3) How many personnel per aircraft are required to perform the C-checks?

(4) What is the ratio of technicians to supervisors?

(5) How long does it take to perform the C-check?

(6) What training programs are required to maintain the proficiency of your technicians?

(7) What is the average experience level of your technicians when first hired?

(8) What certification requirements if any are required for technicians to be hired?

(9) What methods or procedures are followed to divide work amongst the technicians to perform the C-check?

(10) What is the ratio of Airframe and Powerplant Certified mechanic technicians to Non Certified mechanic technicians?

(11) What are the types of costs (direct and indirect) associated with costing the C-check activity?

(12) Are your maintenance technicians multi-skilled? If yes, for how long and what affect has it had on your work efficiencies?

Question responses will be recorded as dictated, and the details of the responses will be consolidated for comparison to the responses from the other MRO cases.

In addition to the personal interviews, the researcher makes personal observations of the personnel processes and procedures he sees at the MRO locations. This is facilitated through a site visit. Observation data coupled with personal interview responses allows the researcher to validate what he sees and hears. It also helps the researcher gain deep understanding as to what is required in CSR to accurately interpret the data and infer its meaning.

Finally, the process is confirmed through a third point of reference, the reason for the term triangulation. That point of reference is a review and analysis of the documentation. This involves gaining access to and gathering the documents that outline the business practices of each MRO. This portion of the research, however, does have its limitation. Some of the information may be proprietary or could be restricted to only the personnel working for the organization. The researcher may have to rely upon whatever sources that are either publicly available or the MRO case organization is willing to offer. The next section elaborates on the approach of the researcher to analyze the data gathered.

Analysis Plan

The first step in the data analysis process is to identify the data available, then build a framework to lay a foundation for comparison. The framework provides the means for finding similarities and differences within the data. When similarities are found, depending on the frequency of observations, the researcher can decide whether or not what he sees in the data is considered a common practice in aviation maintenance industry or the observed practice is unique to the organization in which it is found. Therefore, making general comparisons can help focus the researcher to common practices and practices unique to the industry.

Interviews will be conducted over a two-month period and the researcher may find that responses vary or that responses may follow a common theme. In order to discuss the variation and or similarity in responses, each question will be listed with an abbreviated response from each interviewee. It is expected that responses will be lengthy so they will be abbreviated to condense the meaning of the message conveyed during the interview process. Verbatim responses will not be included, as the volume of text would distract from the comparative analysis. At the end of each question's response section the researcher will identify similarities and contrasts among the commercial organizations and between the commercial organizations and OC-ALC. Finally, inferences will be made, which ultimately contribute to the findings and recommendations portion of this research project and will be covered in chapter 5.

Anonymity

When human subjects are used in research, there are additional steps that must be taken to ensure their protection. This research involves the participation of

representatives from commercial organizations who provide interview responses. Therefore, in order to protect their identity and that of the organization they represent their names and the names of the organizations they represent are withheld. However, in order to maintain a basis for comparison amongst and between organizations there must be a means for distinguishing their inputs. This is done by using letter signifiers that replace the organizations' names (e.g., A, B, C and etc.). The letter signifiers are randomly chosen with the intent to provide representatives with a non-attribution setting in which they can share expert opinion about maintenance practices in their organizations.

Summary

Case study research involves selecting a topic of interest and then identifying areas of study related to the topic that can serve as a source for gaining a deep understanding. Gaining this understanding requires a procedure or method designed to capture data that validates and justifies insights gained from studying the topic. Additionally, the researcher must develop a theory or idea of what he thinks he will discover through the process of applying case study research. The theory channels and scopes the researcher's efforts to gain insight and ultimately make inference on what is found. Case study research is the chosen methodology to gain deep understanding of the way to apply personnel to KC-46 C-check maintenance. At least four cases are to be selected for study. The data is to be collected through personal interviews, personal observations, and in-depth study of organizational procedural documents. The intended result is that the data gleaned from the individual cases provides comparative study and allows the researcher to benchmark these practices with those found at the OC-ALC. The

results can provide a source for determining a way ahead, a course of action that KC-46 decision makers can implement to activate maintenance activities at the depot. Chapter 4 details initial findings after the CSR design is implemented.

IV. Analysis & Results

Background

Chapter 3 outlines all of the steps taken to gather data applicable to this research study. The researcher conducted interviews, made personal observations, and reviewed organizational documents. Upon completing the information-gathering portion of this research, the researcher progressed to data analysis. The purpose of the analysis is to make sense of what was gathered. Part of research is to develop a process that adds logic to the data analysis and facilitates duplication for the reader if he or she desires to replicate the research outcome. "Data analysis consists of examining, categorizing, tabulating, testing or otherwise recombining both quantitative and qualitative evidence" (Yin, 2003:109).

In chapter 1 the researcher identifies research questions that motivate the steps taken for gathering data. The researcher then expands the research questions and creates 12 questions used to interview experts from MROs in the field of aviation maintenance. Chapter 3 explains the logic behind how these experts are chosen. The analysis of their responses in this chapter helps determine responses to the questions initially posed by the researcher. Eight organizations participated in the research study. Four are third party commercial MRO organizations that provide contract service, three are commercial airliners that provide their own MRO service, and the last organization is the portion of OC-ALC that provides depot maintenance service for the KC-135. Table 4.1., Organization Characteristics, provides a letter identifier for each organization and some of their characteristics. The next section establishes a basis for comparison.

Table 4.1. Organization Characteristics

Organization	Size (personnel)	Average B-767 Tech Experience (years)	Number of Clientele
A	260	10	13 airline and cargo transport organizations
B	1300	23	Not provided
C	1000 to 1200	13	3 core customers and all of the major air carriers
D	400 regular & up to 1000 temporary	Not provided	6 airline and cargo transport organizations
E	438	Not provided	Not provided
F	Not provided	20	Only internal to the organization maintenance provided
G	1350	26	Not Provided
OC-ALC	1340 (KC-135)	Not Provided	Not applicable

Comparison Baselines & Assumptions

All of the participating organizations with the exception of two, base their responses on the same wide-body airframe or B-767 aircraft. This aircraft type is the focus of the interview because it is the aircraft from which the KC-46 is derived. Organization E manager representative references his experience with B-757, and B-737 aircraft. He mentioned that they operate B-767 aircraft, but C-check maintenance is outsourced. OC-ALC refers to the KC-135, a B-707 derivative aircraft. Although the requirements will differ somewhat between the B-767 and these other two types, they are similar enough that a basis for comparison remains consistent. Analysis of the KC-135 allows the research to capture personnel requirements necessary to support maintenance of the aerial refueling equipment and bladders. None of the other aircraft referenced in the study have these characteristics.

A main attribute that all of the interviewee organizations hold in common, with the exception of OC-ALC, is that they follow MSG-3 maintenance concepts that drive routine C-check support for the aircraft. OC-ALC follows a 60-month PDM cycle to maintain the KC-135. PDM is a largely different way of doing maintenance than the MSG-3 method applied by other organizations involved in this study. Heavy maintenance performed on the KC-10 follows the MSG-3 concept and would seem to be a more applicable airframe for this study but, due to current ongoing efforts to extend the contracted logistic service contract, the researcher is inhibited from gaining access to any information for this particular aircraft. The researcher acknowledges that limitations exist for making comparisons between KC-135 maintenance concepts and personnel requirements and those associated with wide body airframe commercial aviation maintenance. However, a comparison and contrast discussion provides insights for what OC-ALC can do now and what it will need to develop in order to handle KC-46 C-check maintenance requirements.

Interview Question Comparison & Discussion

(1) How many years of experience performing B-767 C-checks?

Table 4.2. Responses to Question 1

Organization	Years of Experience
A	9 years
B	23 years
C	11 years
D	10 years
E	Not Provided
F	20 years
G	1 to 26 years
OC-ALC	N/A

Organization A –

Organization A specializes in B-767 maintenance and has been performing C-check maintenance on this type of aircraft since 2005 (e.g., nine years of experience) (Org. A Representative, 2013).

Organization B –

Managers from organization B indicate that their technicians have 23 years of experience performing B-767 C-check maintenance (Org. 1B Representative and Org. 2B Representative, 2013).

Organization C –

Organization C manager representative explains that his technicians have been performing C-check maintenance on B-767 aircraft since the year 2002 (e.g., 11 years of experience). However, he also mentions that they do not work on them continuously like other lines, but they do fill in work every year (Org. C Representative, 2013).

Organization D –

Organization D technicians have 10 years of experience performing B-767 C-check maintenance (Org. D Representative, 2013).

Organization E –

The manager from organization E explains that his organization has very few years of experience performing B-767 C-check maintenance. His organization made a decision to outsource B-767 C-check maintenance approximately 10 years ago to a third party MRO maintenance organization. Organization E's manager primarily focuses his technician on C-check maintenance for B-757 and B-737 aircraft (Org. E Representative, 2013).

Organization F –

According to Organization F's manager representative, the maintenance technicians have 20 years of B-767 C-check maintenance experience (Org. F Representative, 2013).

Organization G –

The organization, as a whole, has 26 years of experience performing C-check maintenance on the B-767, but for the facility that the interviewed manager represents, there is less experience. He explains that C-check maintenance for the B-767 aircraft was performed previously at the facility 21 years ago before being sourced elsewhere. However, a more recent decision was made to return maintenance operations to its previous status and workforce numbers increased to meet the returning requirement. Due to the change, approximately 90 percent of their workforce has one year or less in B-767 C-check maintenance experience (Org. G Representative, 2013).

OC-ALC –

This question is not posed to managers overseeing KC-135 maintenance. They follow a completely different maintenance program than the C-check process that guides maintenance for the B-767. However, they do have many years of experience performing heavy depot maintenance on the KC-135 at the OC-ALC (OC ALC Representative Panel, 2013). The current PDM process dates back to the early '70's and prior to that technician were following an "Inspect and Repair as Needed" program (AFLCMC/WKCSI, 2013).

Discussion

This question is asked to each organization in order to understand how well they grasp the concept of C-check maintenance for the B-767. It appears that most have sufficient years of experience to provide validity to how they operate. This comparison provides a general understanding of how robust each organization's method is to assign personnel to the maintenance work (refer to Table 4.2.)

(2) How many B-767s are supported per year?

Table 4.3. Responses to Question 2

Organization	Quantity Per Year
A	54 to 113 aircraft
B	30 to 60 aircraft
C	0 to 5 aircraft
D	3 to 4 aircraft
E	Not Provided
F	Not Provided
G	129 aircraft
OC-ALC	90 KC-135 aircraft

Organization A –

The manager representative from Organization A provides historical data for 2012 and 2013 that accounts for C-check maintenance visits, modifications visits and, as he refers to it, "drop-in-visits." In 2012, the organization supported 54 B-767 maintenance visits, and in 2013 (by October), the organization already supported 113 visits with potentially more to come in the remaining two months of the year. An average annual quantity of B-767 aircraft supported is not provided but the manager indicates that his organization is seeing a positive increase in the volume of work (Org. A Representative, 2013).

Organization B –

Organization B's manager representative provides an average quantity of between 30 to 60 B-767 aircraft per year for heavy maintenance (Org. 1B Representative and Org. 2B Representative, 2013).

Organization C –

The manager representative from Organization C explains that B-767 aircraft maintenance is not their primary work. They focus more on other aircraft types so the average quantity per year varies from no aircraft at all to as many as five. However, the norm is to see at least one B-767 aircraft per year (Org. C Representative, 2013).

Organization D –

Organization D projects that they will see an increase in the quantity of B-767s they support, but for now they average about three to four per year, and that quantity can vary (Org. D Representative, 2013).

Organization E –

Organization E's manager representative oversees primarily narrow body aircraft maintenance or maintenance for aircraft types that are smaller than B-767 aircraft. Although Organization D outsources C-check maintenance for their B-767 aircraft, they perform other maintenance functions, but Organization E's manager representative was unable to provide the specifics on how many B-767s are supported because it falls outside of his area of responsibility. He also did not provide the quantity of narrow body aircraft that his organization supports (Org. E Representative, 2013).

Organization F –

The manager representative from organization F indicates that his organization owns and operates 10 to 15 B-767 aircraft and they perform all of the maintenance on these aircraft. The quantity of specific aircraft maintenance visits is not provided (Org. F Representative, 2013).

Organization G –

The managers overseeing B-767 maintenance for Organization G provide a maintenance work projection for the next 12 months and it includes all 72 B-767 aircraft that the organization owns and operates. They plan on 129 aircraft visits and of that, 43visits are specifically for C-check maintenance. The remaining visits will be for aircraft modification (Org. G Representative, 2013).

OC-ALC –

OC-ALC is set up to support 75 routine PDM lines per year, which equates to 75 KC-135 visits and then typically 15 additional visits are factored into planning to cover any unscheduled work (OC ALC Representative Panel, 2013).

Discussion

Approximately half of the organizations interviewed support aircraft from their own fleets. These are the commercial airline organizations, whereas the other half is comprised of organizations that provide third party MRO maintenance service. They support the commercial carriers and any other organization that requires aircraft heavy maintenance. This is why some of the aircraft quantities listed ranges rather than single values. The third party MRO maintenance providers' volume of work can fluctuate greatly. Although the responses to this question do not serve as a means to distinguish

which organization is better at B-767 maintenance than the others are, these quantities provides further evidence of how robust their maintenance organization is in terms of accomplishing B-767 maintenance. Organizations A, B and G provide an amount of support to B-767s (in terms of quantities of aircraft serviced) comparable to the number of KC-135 aircraft that OC-ALC is able to handle. The other organizations state that they focus more on other aircraft types but do B-767 maintenance when requested.

(3) How many personnel per aircraft are required to perform the C-checks?

Table 4.4. Responses to Question 3

Organization	Quantity of Personnel
A	70 personnel
B	40 to 200 personnel
C	40 to 100 personnel
D	20 to 60 personnel
E	140 personnel
F	$\geq$ 60 personnel
G	106 personnel
OC-ALC	58 personnel

Organization A –

There are 60 A&P and structure type maintenance technicians dedicated to each aircraft and then an average of 10 support staff. Support staff includes painters, composite shop workers, welders, fuels technicians, avionics, and panel removers. These 70 personnel are allocated across three shifts that perform maintenance 24 hours per day, 7 days per week. One shift concentrates on landing gear, wings, and the upper cargo system; the next shift is assigned to the engines, four lower cargo areas and aft accessories; and the third shift focuses on aft lower cargo and the tail. Personnel work the same shift and are dedicated to a single aircraft until its completion. This allows them to complete 400 man-hours of work per day throughout the duration of the C-check (Org. A Representative, 2013).

Organization B –

The manager representative for Organization B specifies that his organization assigns 40 technicians to perform light C-check maintenance and as many as 200 to perform heavy C-check maintenance. He also mentions that the manpower allocation is cyclical based on the phase of the check (Org. 1B Representative and Org. 2B Representative, 2013).

Organization C –

The manager representative indicates that 40 to 60 personnel are assigned to perform light C-checks for Organization C and 100 are assigned to perform heavy C-check maintenance. He shares these numbers with the caveat that his organization depends on knowing the type of check line before specifying how many personnel are required (Org. C Representative, 2013).

Organization D –

The manager representative for Organization D explains that his organization assigns 20 to 30 personnel per aircraft to complete C-check maintenance, and they plan on the work taking no more than two weeks. However, he elaborates that the amount and time dedicated to one aircraft depends on how long customers can leave their aircraft in maintenance. Their baseline for 20 to 30 technicians is flexible based on what the customer requires. In the case of a heavy check, they double the number of personnel assigned to the aircraft from 20 to 30 up to a range of 40 to 60. Most of the aircraft that Organization D supports are air-freight configured. This means that they do not have to dedicate as many technicians to interior work as some of the other organizations that

primarily perform maintenance on passenger B-767 aircraft (Org. D Representative, 2013).

Organization E –

The manager representative for organization E explains that the quantity of personnel required to perform the C-check maintenance is dependent upon how many man-hours his organization is planning on producing in one day. Speaking to his historical data for narrow body lines, he set his base at 500 to 600 man-hours per day performing work 24 hours per day, 7 days per week. Combining all of these parameters equates to 140 technicians assigned to one aircraft to perform the C-check maintenance. He also specified that for a wide body aircraft they factor 800 hours per day to calculate the number of personnel required but did not indicate what the actual calculated quantity is. The increase in workable hours is facilitated because the increase in size of the aircraft proportionally allows for an increase in space available for the technicians to work and thus more can be done in a day (Org. E Representative, 2013).

Organization F –

The manager representative for Organization F indicates that his organization dedicates at least 60 personnel to C-check maintenance for the B-767 aircraft (Org. F Representative, 2013).

Organization G –

Organization G assigns 106 technicians to one aircraft to perform C-check maintenance. The breakdown is 64 of the personnel are general mechanics, 20 are avionics specific mechanics, and the remaining 21 are assigned to work inside the aircraft cabin. Interior work requires less skilled labor, so those technicians are not paid a

premium wage for holding A&P licenses. The work involves inspecting and making repairs to the seats, sidewalls, and door liners (Org. G Representative, 2013).

OC-ALC –

A modified question is posed to managers representing the KC-135 maintenance organization. The question is, "How many personnel are required to perform depot maintenance on a KC-135 prior to the current structure maintenance concept?" The question is modified because the type of maintenance performed on the KC-135 is more of an overhaul in nature than an inspection program like the C-check for the B-767 aircraft. The current maintenance process for the KC-135 has been going on so long that data for the process prior to overhaul maintenance is not available. Therefore, the response given covers only the current maintenance process. There are 1,340 direct labor personnel dedicated to support 55 KC-135s in the current Fiscal Year, 2014. When the aircraft are onsite roughly 55 technicians directly involved in touch labor and 3 additional support personnel are assigned to perform the maintenance (OC ALC Representatives 1 and 2, 2013).

Discussion

The quantity of personnel dedicated to one B-767 C-check depends on a few planning factors: how long the aircraft is scheduled for maintenance, how assignments are organized for the technicians to perform the work, how many labor hours the maintenance facility intends to produce per day, and the level of C-check. For a lighter C-check, the maintenance facility can plan to dedicate between 20 and 70 personnel to one aircraft. For a heavier C-check the personnel count varies even greater: the facility can plan for between 60 and 200 personnel (refer to Table 4.4.). It must be noted that

more validity should be added to the organizations that focus primarily on performing maintenance for air-freight configured B-767 aircraft. They require fewer personnel to perform maintenance within the aircraft as will be required for the KC-46 with its freighter like interior configuration. These organizations, Organizations A and D, assign approximately 60 to 70 personnel to perform the C-checks. However, the quantity of personnel dedicated to passenger-configured cabins can offset the addition requirement to inspect the refueling equipment and bladders that are unique to the KC-46. To gain a perspective of what may be required for KC-46 refueling equipment and bladders, KC-135 maintenance planning estimates are used. KC-135 planners estimate that it takes 950 hours to complete depot maintenance on refueling equipment and bladders (AFLCMC, 2013). Therefore, additional technicians may be required for the KC-46 beyond the suggested quantities utilized for air-freight configured B-767 maintenance by the interviewee organizations. Organization G, an organization that operates passenger configured aircraft, indicated that they dedicate 21 personnel just to the cabin of the aircraft and that quantity could be a starting place for estimating the personnel requirement differences between a passenger configured B-767 C-check and KC-46 aircraft C-check.

Another noteworthy item is that two of the organizations interviewed, Organizations A and F, assign technicians to work specific zones of the aircraft. A zone represents space assigned to a quantity of personnel to complete work cards as part of the C-check package. That means that they are assigning the maximum number of personnel without causing an issue of getting in one another's way. Both organizations assign the same quantity of personnel, roughly 60 to 70, to complete the C-check. If all 60 to 70

personnel are divided up evenly amongst shifts this equates to roughly 20 to 23 personnel per shift per aircraft. The 60 to 70 personnel quantity agrees with the quantity of personnel assigned to complete PDM maintenance on the KC-135. Assigning 60 to 70 personnel to complete C-check maintenance for the KC-46 may be a sufficient place to start but in order to validate those numbers a model should be developed that considers that amount flow days required to accomplish KC-46 C-check maintenance. This is further discussed in the discussion response section of Interview Question 5.

(4) What is the ratio of technicians to supervisors?

Table 4.5. Responses to Question 4

Organization	Technician to Supervisor Ratio
A	12 technicians to 1supervisor
B	10 technicians to 1 supervisor
C	6 - 8 technicians to 1 supervisor
D	15-20 technicians to 1 supervisor
E	25 technicians to 1 supervisor
F	12 technicians to 1 supervisor
G	35 technicians 1 supervisor
OC-ALC	15 technicians to 1 supervisor

Organization A –

Organization A ratio is 12 technicians to 1 supervisor (refer to table 4.5.). They used lead technicians in the past, but as part of a cost cutting measure they decided to eliminate lead technician positions. Prior to the change the supervisor filled a more management-like position to handle human resource requirements and did not necessarily have to be a technical expert, whereas the lead was a senior experienced technician who ran the crew. Now the supervisor holds both roles and performs both functions (Org. A Representative, 2013).

Organization B –

Organization B has a goal ratio of 10 technicians to 1 supervisor, and the manager elaborates more on what that means (refer to table 4.5.). He explains that in some cases the ratio differs based on the skill group type. For a lower skill group type like what is assigned to interior cabin work, his organization's ratio is 15 technicians to one supervisor. Organization B performs maintenance for multiple different organizations, so they have a set goal ratio in order to provide standardization to their organization. They also try to sustain the same ratio for their inspectors, in other words those who can sign and approve completed work, (a requirement driven by FAA regulation). There are 10 maintenance technicians to approximately 1 inspector (Org. 1B Representative and Org. 2B Representative, 2013).

Organization C –

The manager representative for Organization C defines his supervisors as lead technicians. After the manager representative explains what it means to be a supervisor at his organization, he indicates that their ratio falls between 6 to 8 technicians to one supervisor, but can be as high as 15 to 1(refer to table 4.5.). The ratio reduces when the organization sees fit to provide more supervision, and this is applicable in such areas as structures maintenance. Interiors maintenance will have a higher a ratio because it requires less supervision (Org. C Representative, 2013).

Organization D –

Organization D dedicates 15 to 20 technicians to one supervisor. One other thing to consider is that within this ratio they also have lead technicians (refer to table 4.5.). The supervisors will have a number of lead mechanics that are more directly supervising

the crew. The lead technicians are working members of the crew with senior experience and provide lower level coordination whereas supervisors maintain oversight. Organization D's manager representative further explains that they assign one inspector per aircraft to ensure that Organization D is meeting the care level and maintenance requirements of its customers (Org. D Representative, 2013).

Organization E –

Organization E sets its ratio of maintenance technicians to supervisor is 25 to 1(refer to table 4.5.). Within that ratio, they have a sub-ratio of 9 technicians to 1 lead technician (Org. E Representative, 2013).

Organization F –

Organization F's ratio is 1 supervisor to 12 technicians (refer to table 4.5.) (Org. F Representative, 2013).

Organization G –

Organization G assigns 35 personnel to 1 supervisor for their B-767 C-check maintenance lines (refer to table 4.5.) (Org. G Representative, 2013).

OC-ALC –

A rule of thumb that OC-ALC follows is to assign 15 technicians to 1 supervisor (refer to table 4.5.) (OC ALC Representatives 1 and 2, 2013).

Discussion

The ratio difference between organizations varies greatly. One reason for the difference is how each organization defines or understands the definition of a supervisor. Some see this position as the one who provides oversight and fills more of a managerial role whereas others see this role as more of a lead technician who has senior level

experience and also works alongside the crew. However, what they have in common is that they require their supervisors to hold A&P certificates whereas supervisors who oversee maintenance for the KC-135 do not. This may be an area of consideration for the KC-46 program, especially with its plans to "meet the intent" of FAA regulations. The KC-135 supervisor to technician ratio falls near the middle of all the ratios the other organizations provide. This ratio, 1 to 15, seems supportable for C-check maintenance of the KC-46, but it also depends on the experience level of the technicians, and how work is divided amongst the different skill groups.

The organizations that perform B-767 C-check maintenance vary their ratios for lower and higher skilled groups, both require less supervision. KC-46 maintenance planners need to define how they break up skill groups and maintenance crews and how they assign technicians to supervisors. Another ratio that the researcher discusses further in the reading is how many A&P certificated personnel to non-certificated personnel are to make up the KC-46 workforce. The higher the quantity of A&P certificated personnel is, assuming appropriate backgrounds and experience, the higher the ratio of technicians to supervisor can be.

(5) How long does it take to perform the C-check?

Table 4.6. Responses to Question 5

Organization	Light C-Check Maintenance Time Length	Heavy C-Check Maintenance Time Length
A	14 days	42 days or 22,000 hours
B	4 to 5 days or 4000 hours	32 days
C	15 to 20 days	38 to 42 days
D	14 days	28 to 31 days
E	4000 hours	Response not provided
F	Response not provided	Response not provided
G	8 to 12 days, average of 10 days or 7000 to 9200 hours	20 to 28 days
OC-ALC	60 month cycle PDM maintenance, 116 flow days or 33,000 hours	

Organization A –

A light C-check can take 14 days, and a heavy check can take 42 days. The quantity of hours for the light check is not provided but the manager representative does mention a 42-day check equates to about 22,000 hours. Organization A makes mention of a structural beam in the aft wheel well. Organization B refers to it as the "pickle bar" and Organization A refers to it as a fail-safe bracket. Organization A developed a fail-safe program that tracks and monitors this particular part, and they have one on display in the technicians' work area for referencing purpose. If this particular part shows any wear or corrosion, Organization A adds several more unplanned days to remedy the situation. It can take 22 days to remove, repair, and reattach the fail-safe bracket (Org. A Representative, 2013).

Organization B –

Organization B counts on a light C-check taking five days or with a basis in what is required for the work card package 4,000 hours. A heavy C-check in their organization can take 32 days to complete and the amount of hours for the work package increases greatly from the light C-check. However, between a light C-check and a heavy C-check there are multiple other levels. The representatives did not clarify how many C-check levels they perform, but do refer to a C16 C-check, thus suggesting that there may be16 different levels of C-checks performed by their organization.

A heavy C-check for Organization B typically occurs every 3,000 hours of operation and checks between are considered lighter. In addition to the time it takes to perform the C-check, additional man-hours could be required based on non-routine findings. In the case of Organization B its customers typically request additional work be

done while the aircraft is down. Non-routine findings can add as many as 7 to 10 days to the total required to return the aircraft back to the customer. Finally, manager representatives for Organization B point out a specific item to watch out for in regard to the B-767 they refer to as the "pickle fork," also brought up by Organization A manager representative. The pickle fork is a 14-foot structural beam that is located in the aft wheel well between the wing and fuselage. The issue with this item is that it is susceptible to corrosion. This is an important item because if any issues are found with it, it must be removed and either repaired or replaced. The process to remove and reinstall this beam can take between 22 and 24 days, in addition to the time required to perform the C-check (Org. 1B Representative and Org. 2B Representative, 2013).

Organization C –

A light C-check can take 15 to 20 days whereas a heavy C-check takes 38 to 42 days. Organization C's manager representative mentions that these time lengths depend on whether the customer requests modifications to the aircraft, whether or not there are any additional air worthiness directives or engineering orders and or whether or not if dent mapping is required. Dent mapping is FAA directed and requires that the technicians count every scratch and dent found on the aircraft (Org. C Representative, 2013).

Organization D –

Organization D plans the length of its C-check process duration based on what the customer wants. If the customer needs a heavy check done in two weeks, then Organization D will staff its personnel accordingly to complete the work. However, a

typical light C-check for them takes approximately 14 days and a heavy C-check takes between 28 and 31 days (Org. D Representative, 2013).

Organization E –

The representative for Organization E elaborates that the amount of time taken to complete the C-check is based on how the work package is divided up. He is not very clear on how long it takes his organization to complete a C-check, but his comments suggest that it takes 4,000 hours, and this is assuming that he is referring to a light C-check (Org. E Representative, 2013).

Organization F –

The representative from Organization F does not specify an amount of time, but his response is that the specific amount depends upon the type of C-check (Org. F Representative, 2013).

Organization G –

Two different lengths of time are provided because Organization G specifies response for two different levels of C-checks. One time length is for light C-checks and the process can last between 8 to 12 days with an average of 10 days. The number of days provided is based on task card packages that total between 7,000 and 9,200 man-hours respectively. A heavier check can last between 20 and 28 days and applies to more in depth task cards (Org. G Representative, 2013).

OC-ALC –

OC-ALC performs programed depot maintenance on the KC-135, which is a different maintenance program than the program followed to perform maintenance on the B-767. A possible reason is that the KC-135 is also a much older aircraft requiring a

more intensive repair process. For the B-767, during the C-check process, particularly the light C-checks, more of an inspection is taking place to assess the airworthiness of the aircraft. If issues are found, they are addressed. However, KC-135 aircraft come to the ALC every 60 months to be completely overhauled. The aircraft is stripped and repainted, the engines are overhauled, and technicians perform major structural repairs to service the fuselage and wings. The whole process takes 116 flow days, which equates to about 31,000 hours (OC ALC Representative Panel, 2013).

Discussion

All of the organizations interviewed, with the exception of the KC-135 organization, operate 24 hours per day, 7 days per week. The KC-135 Organization operates five days per week and covers two eight-hour shifts per day. Half of the organizations are equipped with union labor that can restrict the flexibility of managers to rapidly expand operations, whereas the other half do not have organized unions within their labor pool and are able to hire personnel temporarily to cover rapid operation expansion. Non-labor union organizations can meet customers' requirements to accomplish C-check maintenance within a particular time frame because they are able to easily adjust their staff levels in accordance with how soon the customer needs his or her aircraft returned. However, the organizations that employ unionized labor primarily perform maintenance on their own fleet of aircraft and are more able to control the timing of when maintenance initiates and completes. Therefore, it turns out that the unit of measurement primarily provided, number of days, does not provide adequate information to determine the length of any particular type of C-check for the KC-46. The manager representative from Organization B mentions that a better unit of measure is the number

of man-hours required to complete the work. A common quantity of hours that the interviewed organizations provide for a light C-check is 4,000 hours and for a heavy C-check, one organization suggests that it takes 22,000 hours.

Therefore, due to the inconsistency of the quantity of time it takes to accomplish light and heavy C-checks a model is developed to normalize the data with the intent to provide a more adequate basis for comparison with PDM flow days of the KC-135. Days are converted into hours by factoring 24 hour operations over a 7 day workweek period, but with exception, KC-135 workflow that operates 16 hours per day 5 days a week. Table 4.7., Work Flow Days Conversion Matrix, provides the hour quantities for light C-checks and heavy C-checks for each organization converted from the C-check length of days quantities provided in Table 4.6. However, the data in this form may not reflect how long the C-check takes, because it is not factoring in the quantity of personnel associated with performing the C-check and how productive they are. Data from two more tables (refer to Table 4.4., Responses to Question 3 and Table 4.12., Responses to Question 12) are required to convert C-check flow days into quantities of maintenance hours. In the cases where tables provide ranges, averages are calculated, but with the exception of when technician or time quantities are specified for light and heavy C-checks. Refer to Table 4.7., Workflow Time Conversion Matrix, to see the calculations.

Table 4.7. Workflow Time Conversion Matrix
(NP refers to not provided and N/A refers to not applicable)

Org.	Shift Qty./24 hrs	Yield Factor (Yield/8)	Light C-check Tech Qty.	Days	Hours	Actual Hours	Heavy C-check Tech Qty.	Days	Hours	Actual Hours
A	3	.95	70	14	7,448	NP	70	42	22,344	22,000
B	3	.8125	40	5	1300	4,000	200	32	41,600	NP
C	3	.828125	50	18	5,963	NP	100	40	26,500	NP
D	3	.8125	25	14	2,275	NP	50	30	9,750	NP
E	3	.85	140	NP	NP	4,000	140	NP	NP	NP
F	3	NP	≥ 60	NP	NP	NP	≥ 60	NP	NP	NP
G	3	.775	106	10	6,572	7,000 to 9,200	106	24	18,402	NP
OC-ALC	2	.625	N/A	N/A	N/A	N/A	58	116	33,640	33,000
	MIN	.775	25	MIN	1,300	MIN	50	MIN	9,750	
	MAX	.95	140	MAX	7,448	MAX	200	MAX	41,600	
	Average	.84	70	Average	4,712	Average	104	Average	23,194	

MIN MAX & Average tech quantities, hour quantities and yield factors do not include OC-ALC
Equation: Days * 24 hours * Yield Factor * (Light or Heavy C-check Tech Qty. / Shift Qty./day)
Note: OC – ALC equation differs
Days * 16 hours* Yield Factor * (Light or Heavy C-check Tech Qty. / Shift Qty./day)

After completing the calculations for Table 4.7., the researcher is able to identify a range in the hour quantities for accomplishing light and heavy C-checks. When maintenance technician quantities (refer to table 4.4.) and yield values (refer to table 4.12.) are factored in the calculations, the range of hours for completion of a light C-check are between 1,300 hours and 7,448 hours with a range average of 4,712 hours. One insight is gleaned from comparing Organization B's calculated hours with the actual light C-check hour quantity that it provided. The actual quantity, 4000 hours, differs greatly from the calculated quantity, 1,300 hours. This suggests that perhaps the quantity of days provided or quantity of personnel associated with a light C-check for the calculation may not match with what is factored in the actual hours provided. Another probable cause may be due to the interviewee not providing specific personnel quantities as related to the C-check type (e.g., light or heavy). Personnel quantity ranges were given instead. On the other hand, the calculated quantity for Organization G appears to be relatively close to the actual C-check hours its representative provided (refer to Table

4.7.). Utilizing both observations as a focal point leads the researcher to believe that flow days, or the amount of consecutive days it takes to accomplish work, can be used to determine the quantity of hours required to accomplish a C-check if the factors (e.g., yield, and technician quantities) used in the calculation are accurately portrayed.

Utilizing the same calculations steps applied for light C-check ranges provides the following heavy C-check range: 9,750 hours to 41,600 hours with a range average of 23,194 hours. Organization A provided the only actual heavy C-check hours, 22,000 hours (refer to table 4.6.) and it resembles the calculated hours provided in Table 4.7. The insight for this observation appears to match that which was identified for light C-checks. C-check hour calculations appear to be adequate if the quantity of personnel associated with performing the work matches up with the established flow days.

Another insight draws from the expansive ranges provided for light and heavy C-checks and suggests, perhaps, that each organization may have a different definition of the length of time required to complete a light or heavy C-check. This leads the researcher to utilize C-check range averages to provide another point of reference for how long it takes to complete a light or heavy C-check. If averages are applied, a light C-check can take 4,712 hours and the work is accomplished by an average of 70 personnel (refer to Table 4.7.). A heavy C-check can take 23,194 hours to complete with an average of 104 personnel accomplishing the work (refer to Table 4.7.). Surprisingly, these calculated averages for light and heavy C-checks are consistent with actual values provided by a few of the Interviewee organizations. However, Organization G's actual light C-check value range provided (e.g. 7,000 to 9,200 hours) is higher than the average light C-check value calculated (e.g. 4,712), but this range may be reflective of a different

level of light C-check than what the other organizations are providing. Therefore, the most common light C-check time length provided, 4,000 hours, is selected as the base figure for determining the length of time to conduct light C-check maintenance on the KC-46. The heavy C-check range average is also utilized as a basis for establishing how long a KC-46 heavy C-check takes. However, Organization B's calculated heavy C-check time length may be skewing the range average (refer to Table 4.7.) and is therefore may cause the range average to be too high. Therefore, 22,000 hours is chosen as the base for determining KC-46 heavy C-check time lengths. Unfortunately, these light and heavy C-check base figures do not capture all of the maintenance hours that may be necessary to perform a KC-46 specific C-check, so the next paragraph provides additional details that need to be considered.

None of the calculated estimates in Table 4.7., with exception of what is calculated for OC-ALC, factor in the extra time it takes to perform maintenance on the refueling equipment and bladders of the KC-46. Therefore, estimates for accomplishing KC-135 bladder and refueling equipment maintenance hours are added into the C-check hour length calculation to reflect more reasonable estimates for how long KC-46 C-checks will take. One setback is that the source for KC-135 bladder and refueling equipment maintenance hours comes from PDM estimates. PDM performed on KC-135 maintenance appears to be more like heavy C-check maintenance in terms of hours of completion, so the 950 hours dedicated to refueling equipment, and bladders may not be a reasonable estimate for the length of time it takes to perform this maintenance when accomplishing a light C-check. A work around for providing these estimates is to assign

each C-check level a percent weight quantity and multiply this quantity by the 950 hours before adding to the base C-check time length.

The researcher weights a heavy C-check at 1 to include all of the same hours as estimated for KC-135 refueling equipment and bladder maintenance. For a light C-check, (assuming less is involved to complete refueling equipment and bladder maintenance for this level of C-check), the researcher selects some lesser weight that would reduce the amount of maintenance hours required to complete the work. However, in order to determine this weight estimate the researcher needs to include one more piece of information. KC-46 maintenance planners are projecting to do four levels of C-checks C1, C2, C3, and C4. C1 is considered a light C-check, C4 is considered a heavy C-check, and C2 and C3 fall in between light and heavy C-checks. These C-checks are planned to be progressive in nature building upon one another as the aircraft comes in each time for C-check maintenance (AFLCMC/WKCSI, 2013). Therefore, working backwards from what is already identified (e.g., C-4 the heaviest C-check) weights are assigned in the following manner: C4 weight of 1, C3 a weight of .75, C2 a weight of .5 and C1 a weight of .25. These weights will allow the researcher to formulate estimates for determining how long each level of maintenance will take. Although this discussion does not address the quantity of hours taken to accomplish C2 and C3, the next chapter will cover logic for determining these estimates and relate them to establishing workforce requirements.

Prior to proceeding to the next interview question, a few more topics are discussed because of how they can affect the amount of time it takes to complete C-check maintenance. Organization C identified the need for a focus on dent and scratch mapping of the aircraft in order to fulfill a FAA directive. Organizations A and B suggested the

need to set up a program to track and monitor the fail-safe bracket found in the aft wheel well that attaches to the wing and fuselage. Finally, the best source for determining the quantities of hours it takes to accomplish a C-check is the Maintenance Planning Document that the OEM provides.

(6) What training programs are required to maintain the proficiency of your technicians?

Organization A –

The manager representative for Organization A is not specific but mentions that his technicians receive systems initial training once they have worked in the organization for a while. Then they complete a systems proficiency training course. They also conduct computer-based training on an annual basis that focuses on safety, procedures, and paperwork processes. Lastly, they maintain a robust OJT training program to provide hands-on training to the technicians who are previously hired with little or no experience. This is due in part to their tendency to hire A&P certificated personnel recently graduated from vocational technical schools (Org. A Representative, 2013).

Organization B –

Organization B ensures personnel are trained in the following areas: 40 to 80 hours of General Familiarization training (GEN FAM), training directed by customers, which can include Electrical Wiring Interconnect System (EWIS), Extended Twin Engine Operating System (ETOPS), Category (CAT) I/II. GEN FAM training is for a particular airframe type to provide technicians with general maintenance background. EWIS training has a focus on basic electronics and electricity and it is instruction on how to run a wire, how to connect it and a general understanding of how to apply caution. ETOPS is

a safety program that requires specific procedures to be followed to ensure the safe operation of the twin-engine aircraft upon completion of any maintenance. For example, the same technician cannot work on both engines of a twin-engine aircraft. CAT I/II are initial training required for all technicians who perform maintenance on the B-767, with a refresher course administered annually to maintain proficiency (Org. 1B Representative and Org. 2B Representative, 2013).

Organization C –

Organization C, like Organization B, directs training for its technicians according to what their customers require. One of the specific training programs administered is Required Inspection Items (RII) for critical components, a 40-hour GEN FAM course. Although more is required, these were the only training course the manager representative mentions (Org. C Representative, 2013).

Organization D –

Organization D requires EWIS training and it instructs technicians on how to protect and clean electrical wiring. There also is a GEN FAM class for all technicians, which is specific to the type of aircraft that a technician is assigned to work. Training is also provided to each technician according to his or her skill group. There are courses for those working on avionics, the interior, or cabin of the aircraft and other skill group areas. Additionally, A&P certificated personnel and inspectors are required to complete a 40 to 80 hour course by type of aircraft. Inspectors go through RII training. Finally, everyone is required to complete an Organization D specific 8-hour human factors training course (Org. D Representative, 2013).

Organization E –

Organization E bases their training on what they do for the B-757 under the assumption that all of the technicians hold A&P certificates. The manager representative does not provide many details but does mention that a general airframe specific familiarization course is provided to all of the maintenance technicians prior to them working on any aircraft (Org. E Representative, 2013).

Organization F –

Organization F hires all A&P certified mechanics; therefore, any training it provides assumes the technicians hold A&P certificates. The maintenance technicians are provided with GEN FAM training for the aircraft and additional details are not provided for any other training courses (Org. F Representative, 2013).

Organization G –

Organization G provides the following training programs to their personnel to ensure proficiency: Fleet Qualification, a weeklong indoctrination of a particular aircraft fleet for avionics and general maintenance technician skill groups; a weeklong Avionics Course for avionics technicians; a General course for those working sheet metal or aircraft systems; OJT training provided throughout career for flight control rigging, composite repairs and sheet metal, EWIS training for avionics wiring inspection; Human Factors Training; 5S training, a lean management concept that fosters a neat and orderly workplace; Engine Run Qualifications for engine runs and taxing (directed to specific personnel); Lower Minimums Program training which is for avionics technicians to ensure that aircraft flying ETOPS missions are functioning properly; Electronic Manuals Training; Reduced Vertical Separation Minimum training ; Electronic Static Discharge

training which is for personnel working around static ports; and RII training (Org. G Representative, 2013).

OC-ALC –

The OC-ALC established 900 certification tasks for the KC-135, and personnel accomplish the certification tasks based on their assigned job. A majority of these task certifications are accomplished once unless the technician decertifies or a task is considered a special skill. There are 23 special skill certification tasks for the KC-135, and technicians assigned to accomplish these certifications are periodically required to show that they continue to maintain the skills to complete the task at the required quality level. "Special Skills Qualification (SSQ) are skills so specialized that they require extensive technical knowledge and proficiency. Most of these skills are governed by military specifications or higher-level regulatory guidance, are safety related, or have a significant impact on cost" (OC ALC Representatives 1 and 2, 2013).

Discussion

Many of the training programs that the interviewed originations specify focus on either safety or awareness. The GEN FAM is a standardized program that provides a maintenance technician with general understanding of the airframe they are assigned to service. The OC-ALC provides KC-135 familiarization training to its technicians but scopes it only to the tasks that the technician is assigned to perform. The other organizations interviewed also break training into task specific areas but only after the technicians receive general familiarization of the aircraft. Majorities of their personnel if not all, depending upon the organization, hold A&P licenses and could potentially be expected to perform anyone of the required maintenance tasks. However, if a training

model similar to the KC-135 is followed for the KC-46, the program managers will need to scope personnel familiarization to their specific job requirements. The same can also apply to all of the other training programs found common amongst the different organizations, EWIS, CAT I/II/, ETOPS, RII, human factors training, Lower Minimums Program (LMP), and Reduced Vertical Separation Minimum, (RVSM). Some of these programs already exist in one form or another in OC-ALC. However, programs such as ETOPS, EWIS, and others come as a result of FAA regulation. ETOPS is a FAA driven safety program, which directs certain maintenance procedures to ensure aircraft operability over extended range and EWIS is a result of the FAA treating aircraft wiring as a system, something that should be routinely inspected and monitored to ensure the continued safe operation of the aircraft (Federal Aviation Administration). In some cases, the Air Force will not be required to create and follow programs, but if it intends to "meet the intent" of FAA regulation, these programs need to be instituted into the KC-46 maintenance program.

(7) What is the average experience level of your technicians when first hired?

Table 4.8. Responses to Question 7

Organization	Years of experience when first hired (source)
A	8 to 1 0 years of experience (not defined)
B	Less than 1 year to 30 years (not defined)
C	Less than 1 year (Vo-Tech grad or apprentice)
D	Greater than 2 years of experience (not defined)
E	7 to 20 years of experience (not defined)
F	2 to 5 years of experience (not defined)
G	Less than 1 year (military or Vo-Tech grad)
OC-ALC	0 to 20 + years of experience (Vo-tech, military)

Organization A –

Organization A hires technicians with between 8 and 10 years of experience (Org. A Representative, 2013).

Organization B –

Organization B seeks out the most experienced technicians available in the market, and occasionally they are able to hire technicians recently laid off from major air carrier MROs. Typically, these technicians have many years of experience. However, according to the manager representative from Organization B, the current job market makes it hard to find experienced technicians. Now they have to settle for hiring technicians with very little experience, even straight from A& P school (Org. 1B Representative and Org. 2B Representative, 2013).

Organization C –

Organization C hires technicians from two different backgrounds. Either the individual has gained experience through completion of an A&P certificate program through a Vo-Tech school or he is hired with no experience and placed in an apprenticeship program internal to Organization C. The apprentice process can take between 1 to 10 years to train someone to the desired level of proficiency. The Vocational Technical school (Vo-Tech) students are hired either when they graduate or while they are attending classes with a projected graduation date. Therefore, personnel are being hired with either minimal or no experience (Org. C Representative, 2013).

Organization D –

Organization D hires personnel with at least 2 years of experience performing maintenance on large transport category aircraft who hold at least one FAA license or preferably two (Org. D Representative, 2013).

Organization E –

Organization E considers itself to be a premium employer and thus is able to attract personnel with between 7 and 20 years of experience. On rare occasion an individual is hired straight out of a Vo-Tech school, but they must have some connections to the organization to make this happen. A more probable case would be someone working within the organization in a non-maintenance position who is able to obtain an A&P license on his or her own time. They also will hire personnel who have years of Air Force experience (Org. E Representative, 2013).

Organization F –

Organization F hires technicians with between two to five years of experience (Org. F Representative, 2013).

Organization G –

At Organization, G most of the technicians hired during their last hiring cycle had one year or less of experience. However, these personnel were brought on to fill positions in the back shops that were vacated due to personnel with seniority changing jobs to work directly on aircraft. Historically, Organization G has hired many A&P certified technicians recently graduated from Vo-Tech schools and with minimal experience or personnel with background in military aviation maintenance (Org. G Representative, 2013).

OC-ALC –

OC-ALC has a few sources for hiring personnel. They partner with local Vo-Tech schools to bring on A&P certificated technicians through an On-the-Job training program. The program requires participants to complete 640 hours of hands-on training

before they fill fulltime positions. The ALC also brings on either retiring or separating active duty personnel with aircraft maintenance experience. An average is not calculated and tracked for the amount of years in experience these personnel have when first hired, but the gap is between 0 years of experience for the Vo-tech school grads and 20 plus years for the retiring active duty Air Force personnel (OC ALC Representatives 1 and 2, 2013).

Discussion

The purpose of this question was to capture the levels of experience that each organization integrates into its labor pool. Lower initial experience implies that more supervision and quality control may be required to ensure maintenance is performed correctly. The reader should reference the difference in initial experience level between organizations when comparing responses to the next two interview questions. Generally, most of the personnel hired have little or no experience, with only a few of the organizations able to hire personnel with high experience levels. Initially, the program managers for the KC-46 program will most likely need to rely on hiring personnel with little aircraft maintenance experience, directly from a Vo-Tech school and or experienced personnel coming off active duty military service. One other option they may have is hire personnel internal to OC-ALC, possibly those that become overage to the KC-135 program as aircraft are retired. Another item to consider is that the organizations hiring personnel with little experience do this not just because they are limited on available options, but because they already have a wide variety of experience within their workforce and can handle influx of lower experience. Their experienced technicians can ensure the consistency of the maintenance quality. The KC-46 program is new and will

require a completely new staff of technicians. Initially, experienced technicians, possibly those already holding A&P licenses, should be hired. Then once the C-check line has time to mature into a stable process OC-ALC can afford to hire less experienced personnel. The experienced A&P certificated personnel for the KC-46 program would be helping to meet FAA directives to support "meets the intent." They also could be the future supervisors within the organization as maintenance operations expand.

(8) What certification requirements if any are required for technicians to be hired?

Table 4.9. Responses to Question 8

Organization	Certification requirements to be hired
A	A&P certificates preferred but at minimum A certificate
B	Preference for A&P certificates or repairman certificates, but not required
C	A&P certificates preferred & Supervisors/Inspectors hold A&P Certificates, or repairman certificates
D	A&P certificates required unless hired in apprentice program or to only perform cabin maintenance
E	A&P certificates required
F	A&P certificates required
G	A&P certificates or seniority where a part 121 program applies
OC-ALC	A&P certificates optional

Organization A –

Organization A does not require technicians to hold both A&P licenses unless they are being hired to work on power plants, but they do, at a minimum, require an A license (Org. A Representative, 2013).

Organization B –

Organization B prefers to hire personnel with A&P certificates, but it is not a minimum requirement for employment. However, all inspection and supervisory personnel must be certificated, because they must sign for work if a technician does not hold any certificates. Another avenue that Organization B follows is to request a

repairman's certificate for a technician that they feel has sufficient experience to perform work at the desired rating. Once this certificate is granted, the technician can then sign for his own work and others, but within a narrow scope of a skill group. Organization B has repairman certificated personnel filling supervisory positions in interiors, avionics, welding, composite repair, and structures. In most other cases work performed by non-certificated personnel is signed for by someone who holds an A&P license (Org. 1B Representative and Org. 2B Representative, 2013).

Organization C –

Organization C stipulates that its inspectors hold A&P certificates and its lead or supervisory positions hold either A&P licenses or a repairman certificate. A repairman certificate is obtained when the facility applies for it through the FAA. The type of work that the certificate authorizes the holder to sign for is limited, but a few examples are non-destructive test, interiors, etc. (Org. C Representative, 2013).

Organization D –

Organization D usually only hires technicians if they hold both A&P certificates. However, they relax this requirement if there are vacancies in their interiors crew. Working exclusively in the cabin of the aircraft does not require a person to be certificated. They also hire a small crew of apprentices who are finishing training at a Vo-Tech school with a projected graduation date. They are only hired if they are recommended by the school (Org. D Representative, 2013).

Organization E –

Organization E requires A&P certificates (Org. E Representative, 2013).

Organization F –

Organization F requires A&P certificates (Org. F Representative, 2013).

Organization G –

The requirement for Organization G is that personnel hold A&P licenses. However, they do have a small percentage of personnel without A&P licenses who through seniority were able to promote out of back shop jobs to aircraft maintenance positions. Someone who holds A&P certificates must sign for any work that these technicians do. This is facilitated through a Code of Federal Regulation part 121 maintenance program that allows a certificated technician to sign for the work that a non-certificated technician accomplishes (Org. G Representative, 2013).

OC-ALC –

The Air Force does not mandate that applicants hold A&P certificates and thus OC-ALC follows the same guideline, but it along with the other ALCs see value in hiring technicians who hold them. As explained earlier, the OC-ALC partners with local Vo-Tech schools to hire technicians that have A&P licenses, but they also hire personnel from active duty military service who may or may not have earned their A&P licenses (OC ALC Representatives 1 and 2, 2013).

Discussion

In order to work for a commercial airline maintenance organization it is becoming more of a necessity to hold an A&P license. Organization E's manager representatives mentions that the FAA has pushed commercial airline MROs in that direction. In contrast, third party commercial MROs are making business decisions to cut down on costs by finding alternatives to hiring strictly A&P certificated technicians. The

alternatives involve ensuring that supervisors, inspectors, and lead technicians hold A&P certificates or the maintenance facility applies for repairmen certificates to cover a scope of certain skill groups with the rest of the technicians being non-certificated. By doing this, subordinate technicians do not have to be licensed to perform the work, and their supervisors sign for them when complete. This model is practiced because organizations do not have to pay technicians as much as those who hold certificates. However, OC-ALC is not regulated by the FAA nor are they confined to hiring only A&P certificated technicians. The issue is how the Air Force wants to meet intent of FAA regulations with the KC46A. It may not be such a bad idea to start building job requirements that call for A&P certificated personnel in key specific positions. They may be needed to sign for the work that non-certificated personnel complete. The right mixture of certificated to non-certificated is up for debate, but at least a few positions, especially supervisory or lead technician positions, should be coded to require A&P certificates.

(9) What methods or procedures are followed to divide work amongst the technicians to perform the C-check?

Table 4.10. Responses to Question 9

Organization	Division of work amongst technicians and category
A	Generalist technicians are assigned to aircraft zones
B	Personnel are assigned to specific task groups – task centric
C	Personnel are assigned to specific trade groups - partially task centric
D	Personnel are assigned to specific task groups – task centric
E	Structured skill groups but technicians are generalists
F	Generalist technicians are assigned to aircraft zones
G	Light check: technicians are generalists; Heavy check: specific task assignments at manager's discretion
OC-ALC	Personnel are assigned to specific skill sets or task groups – task centric

Organization A –

Organization A employs all A&P certificated technicians and they utilize a zonal approach to divide the work up amongst the technicians because they are considered generalists. They also give discretion to the supervisors to assign personnel where they see fit. The supervisors typically assign subordinates to jobs for which they have a depth of experience and background (Org. A Representative, 2013).

Organization B –

Organization B assigns technicians to specific skill groups and assigns each skill group task cards to complete the C-check. The skill groups include inspectors, A&P licensed technicians, avionics, structures, interiors, composites, and fuels. They consider these the main skill groups and further divide them into specialty groups. They have a strut improvement program, which assigns personnel to just taking the pylons off and completing work mandated by airworthiness directives to strengthen them from cracking. For instance, they also have a specialized group that combines structures, avionics, and A&P licensed technicians. Finally, they listed a few more jobs that technicians are assigned to including machinists, composites, radio instrument, structural repair, and interior furnishing. Organization B explains that they organize their personnel fairly similarly to how the Air Force does (Org. 1B Representative and Org. 2B Representative, 2013).

Organization C –

Organization C divides its technicians into trade groups and provides the following categories: Airframe Powerplant General (APG) cards, structures, avionics, composites, and interiors. APG cards is a group that performs work on any of the

systems of the aircraft (e.g., hydraulics, rigging flight controls, etc.), and the other groups are self-explanatory. The process for completing work is sequenced in the following steps: a work scope is issued, the aircraft is checked based on task cards, it is opened up, cleaned, and then inspectors inspect preliminary cards. If the inspectors come up with any non-routine findings, they generate additional tasks for the skill groups to complete. Organization C has a team (e.g., production trade team) determine which parts are needed to fix the issues, the issues are fixed by the production mechanics, and then A&P certificated inspectors will "buy off on the repairs." The phrase "buy off on the repairs," refers how Organization C ensures that A&P licensed technician sign for the work. They have a 100 percent buy back policy because not all of their technicians are A&P certificated, meaning that A&P certificated technicians take responsibility for all work completed by non-certificated technicians when they sign for the work (Org. C Representative, 2013).

Organization D –

Organization D breaks up its personnel into production-oriented crews based on skills. Skills are divided into an interiors group, avionics group which also performs the primary work on the electrical and wiring systems, A&P group which deals with the mechanical systems on the aircraft, and structures group. Personnel are assigned to a particular group based on their experience and background (Org. D Representative, 2013).

Organization E –

Organization E sees a financial need to generalize its personnel. Their technicians all hold A&P licenses and are qualified to perform any task required to complete a C-

check. However, although their technicians are considered maintenance generalists, they are still assigned to specific skill groups. They divide personnel up into four specific groups: A&Ps, avionics, structures and sheet metals, and interior repair. Organization E has union representation within its workforce, so there is a delicate balance between specialization and generalization. If they specialize too much, costs become prohibitive to operations, but they also realize that they need a way to structure the work for their generalists. By setting up their structure in this manner, it offers flexibility for the organization to move personnel where needed, and personnel can change skill sets as desired (Org. E Representative, 2013).

Organization F –

All of the maintenance technicians for Organization F are A&P certificated and therefore are utilized as maintenance generalists. The aircraft is broken up into zonal areas and the supervisor has discretion in assigning who performs which task cards to complete the C-check (Org. F Representative, 2013).

Organization G –

Organization G has a specific way to divide work amongst technicians for light and heavy C-checks. A light C-check is a simpler process therefore they have generalist maintenance technicians work the entire system. Then within the cabin of the aircraft, work is even simpler so they supplement their generalist maintenance technicians who hold A&P licenses with what they call maintenance technician support personnel. These personnel may also hold A&P licenses, but their work is restricted to cabin and non-primary structure only and due to that, they are not paid a premium wage for holding

A&P licenses. Maintenance technician support personnel are typically junior-level employees.

When heavy C-checks are performed, the work is divided in similar fashion to light C-checks but with an extra layer of division among general classifications for the technicians. The manager has discretion over work assignment, and personnel performing specific tasks. For example, technicians may be assigned to work only sheet metal, or to work on only structures or systems. Then, once the technicians are complete with their specific tasks, they may be cross-utilized for other tasks until the C-check is complete (Org. G Representative, 2013).

OC-ALC –

The OC-ALC employs specialized maintenance technicians and they divide them up amongst skill sets. The logic behind how they are divided is based on the individual technician's abilities. Technicians are assigned to the skill set for which they are most capable (OC ALC Representatives 1 and 2, 2013).

Discussion

There are many dynamics on how the workforce is divided to complete maintenance at each organization, and these dynamics are based on labor union agreements, technician experience, technician qualifications, workspace available to accomplish the tasks, task cards, and cost. However, in general there appears to be only two different ways of dividing up personnel. The first and most common among the interviewed organizations are dividing personnel into skill groups which promotes specialization though many of the organizations hire personnel qualified to work in all areas. The A&P license qualifies personnel to perform general aircraft maintenance. The

other method is to divide work according to zonal locations on the aircraft and is facilitated by technicians holding qualifications in all areas and being more generalized.

Not all of the organizations interviewed have organized labor unions, but a couple of the ones that do explain that they need to balance technician specialization and generalization in order to keep costs down. Their labor union agreements permit them to assign personnel to specific skill groups but with the understanding that personnel can be temporarily cross-utilized in other skill groups if required. This ensures that technicians are remaining productive until the work is complete. Organization B specializes its personnel in specific skill groups like the other organizations, and there was no mention of whether the workforce was unionized, but they only rarely cross-utilize personnel. They merely move skill group crews to another aircraft once they are complete rather than requiring them to assist the other skill groups. This requires a backlog of work in the repair facility, and Organization B can do this because they have several maintenance lines set up in their hangars with aircraft parked nose to tail.

Zonal work, a different approach is applied by Organization A and F functions because their technicians are all A&P certificated and their supervisors know them well enough to be able to assign them to where they will produce quality work. It appears that applying a Zonal work division method may require a more mature workforce, highly experienced in performing C-check maintenance. Since the KC-46 program will require a new workforce, it appears that following a task centric method, such as that utilized by the KC-135 program, may be the most applicable. A zonal concept may only work once the KC-46 program establishes a mature check line. When C-checks are initiated for the KC-46, the workload may not be substantial and personnel will have little or no

experience working with this type of aircraft. Therefore, an appropriate direction may be to establish some form of task-centric model but with flexibility to cross utilize personnel, which suggests a minimal amount of multi-skilling may be necessary up front. Overtime, the KC-46 program can move its model more towards a purely task-centric model once work is substantial and personnel have gained the experience to form a mature C-check line. When this happens, a nose to tail concept with the flexibility of moving skill groups to new work once complete can maintain desired productivity levels while costs can remain low.

(10) What is the ratio of Airframe and Powerplant Certified mechanic technicians to Non-Certified mechanic technicians?

Table 4.11. Responses to Question 10

Organization	Ratio of A&P certificated technicians to non-certificated technicians
A	Generally 10 to 0 A&P certificated to non-certificate but 10 to 6 for structures crew
B	65 %of technicians hold A&P certificates or repairman certificates
C	25% of technicians hold A&P certificates & 5 % hold repairman certificates
D	80 % of technicians hold A&P certificates
E	99 % of technicians hold A&P certificates
F	Almost no non-A&P-certificated -technicians (Percent not specified)
G	99 % of technicians hold A&P certificates
OC-ALC	20 % of technicians hold A, P or both certificates

Organization A –

Organization A has a 10 to 0 ratio of certificated technicians to non-certificated technicians, however they see a change in the future that will decrease that ratio down to 10 to 1. A different ratio applies to their structures technicians and within this particular crew, the ratio is 5 to 3 (Org. A Representative, 2013).

Organization B –

Organization B's labor pool is comprised of 65 percent A&P certificated technicians or technicians that hold repairman's certificates. However, they would like to

see that ratio increase and do have programs in place to help their non-certificated technicians earn their licenses. They offer a $1 per hour pay increase for each certificate earned and it opens up the opportunity for a newly certificated technician to apply for supervisory positions (Org. 1B Representative and Org. 2B Representative, 2013).

Organization C –

At Organization C, 30 percent of the technicians are either A&P certificated or hold repairman certificates. The difference is 25 percent are A&P certificated and 5 percent hold repairman licenses. However, the representative manager for Organization C explains that this percentage fluctuates based on the hiring and firing of technicians (Org. C Representative, 2013).

Organization D –

At Organization D, 80 percent of its technicians are A&P certificated (Org. D Representative, 2013).

Organization E –

At Organization E, 99 percent of its technicians that touch the aircraft hold A&P certificates with a slightly lower percent if including all of the technicians in the organization. The manager representative explains that his facility has an even higher ratio of certificated personnel to non-certificated personnel. Only two technicians out of all of his staff do not hold A&P certificates (Org. E Representative, 2013).

Organization F –

The representative manager for Organization F did not specify a ratio but did mention that there are almost no non-A&P-certificated technicians in his organization (Org. F Representative, 2013).

Organization G –

Organization A has at least a 99 to 1 ratio of certificated A&P technicians to non-certificated technicians (Org. G Representative, 2013).

OC-ALC –

Of all technicians assigned to work on KC-135s at OC-ALC, approximately 20 percent hold either an A certificate, a P certificate or both. (OC ALC Representatives 1 and 2, 2013)

Discussion

A majority of the third party commercial MRO organizations have a lower percentage of technicians that hold A&P certificates whereas most if not all of the technicians for the commercial carrier maintenance organizations hold A&P certificates. Organization E's manager representative explains that the FAA is pushing commercial carrier maintenance technicians toward holding A&P licenses. Code of Federal Regulation (CFR) part 145.151b explains that a certificated repair station (or airline maintenance organization) must "provide qualified personnel to plan, supervise, perform, and approve for return to service the maintenance, preventative maintenance, or alterations performed under the repair station certificate and operations specifications" (GPO, 2014). In part c of the same section, it further explains that the repair station must have sufficient number of personnel with proper experience and training. These repair stations still have the option to utilize non-certificated personnel but they must also have sufficient "training, knowledge [and] experience or [have passed a] practical test" (GPO, 2014) . The third party commercial MROs make the business decision to hire less A&P certificated technicians to keep costs down, and it turns out they are able to do

maintenance cheaper than the commercial carriers. CFR part 145.217b also suggests another reason why third party commercial MROs hire less A&P certificated personnel. It provides guidance that allows for contract maintenance providers (third party commercial MROs) to utilize non-certificated personnel to perform maintenance as long as "the certificated repair station (airline organization) remains directly in charge of the work performed" (GPO, 2014).

A majority of the commercial carrier organizations interviewed admit that they cannot compete on cost with the commercial MROs and thus have outsourced many of their maintenance requirements. For example, Organization E no longer performs C-check maintenance on its B-767 aircraft because they find it cheaper to outsource to a third part MRO. Therefore, the KC-46 maintenance program may not need to hire all A&P certificated personnel. This decision, will be better informed, however, when the KC-46 program decides whether to maintain the KC-46 "meets the intent" of FAA regulations or not. If it is maintained in this manner then an appropriate ratio of A&P certificated personnel to non-certificated personnel will need to be discovered. Perhaps initially, the ratio should be higher in favor of A&P certificated personnel with less over time as maintenance operations are developed and mature. The reason for more certificated personnel is that the initial personnel hired should be the ones to form and develop the C-check line for the KC-46. Later, they can move into supervisory and lead technician positions as more personnel are hired to keep up with expanding operations. Operations will expand because the Air Force will be receiving new KC-46s from the OEM over an extended period until the final aircraft is delivered. In addition, new

aircraft should require less maintenance at the beginning of their life cycle with requirements growing over time.

(11) What are the types of costs (direct and indirect) associated with costing the C-check activity?

Organization A –

Organization A factors utility bills, the lease on their hangar, the lease on the airpark (where they are located), management salaries, and technician wages into the costs of C-check activity. Although there is more that goes into it, these are the only ones mentioned. However, the manager representative does clarify that his organization needs to charge at a rate to his customers so that they can earn a 40 percent profit margin to pay for their overhead. The overhead includes management salaried positions. They work backwards from this target margin by looking at what the market can bear to determine what they can charge (Org. A Representative, 2013).

Organization B –

The manager representative for Organization B is unable to provide a response to this interview question. It falls outside his realm of responsibility (Org. 1B Representative and Org. 2B Representative, 2013).

Organization C –

As a third party MRO, Organization C essentially sells man-hours. They look at the hours invested in accomplishing the work their customers require and through that, they are able to calculate cost. The manager representative did not provide the types of activities they internally factor to determine C-check activity cost, but he did provide the rates at which he bills customers. They sell man-hours at two different rates, a lower

competitive rate and a higher premium rate per hour. These rates cover employees' salaries, benefits, overhead, and other miscellaneous costs. The manager representative explains that due to Organization C's rates as compared with their competitors, commercial carriers are outsourcing more and more. This is because, according to him, commercial carrier maintenance rates are as high as $75 to $80 per hour. He feels that the higher cost of work accomplished by the unionized commercial carriers has driven the airlines to outsource much of the work they could do themselves (Org. C Representative, 2013).

Organization D –

The representative manager for Organization D explains that labor rates and materials are the main direct costs factored into C-check activities which are billed directly to the customer. However, significant indirect costs include tooling, equipment, engineering services, facility operation including airport rents and facility maintenance, and salaries of the administrative staff. There are also costs associated with safety and environmental controls including controls to protect the surrounding areas from the wastes produced as part of aircraft maintenance activities (Org. D Representative, 2013).

Organization E –

The representative for Organization E admits that the finance office for his organization tracks this information, but then he adds his opinion of what is factored in the cost of the C-check activity. He lists facility costs, fully burdened labor rates, tooling, support vehicles, airport rents, shop supplies, and utilities. He also explains why his organization is unable to compete in terms of cost compared to a third party commercial MRO. In his explanation, he uses the example of cost differences in facilities. His

organization has high facility costs because of their centralized maintenance location whereas a third party commercial MRO like Organization B may not have high facility costs. They decentralize maintenance operation locations and construct smaller facilities thus driving down overall costs and allowing them to charge lower rates (Org. E Representative, 2013).

Organization F –

The representative manager from Organization F pointed to two different costs that he feels comprise most of what makes up C-check activity cost. Those costs are manpower which includes work related to checking and servicing the interior of the aircraft. He mentions that 40 percent of their work is tied up in interior work whereas 20 percent is related to structural repairs (Org. F Representative, 2013).

Organization G –

The representative manager for Organization G gave a broad overview of what is factored into their C-check cost calculations. The only direct cost he provides is the hourly wage for the technicians performing the maintenance and though materials should also be included it was not mentioned. He then provides several different indirect costs including crew chief wages, management wages, purchasing activities, engineering activities, stock handlers wages, production control activities, quality assurance activities, facility upkeep, rent, utilities, vacation, dock clean up, finance activities and general benefits paid out to employees. Organization G calculates that their indirect rates equate to almost double of what their direct rates are (Org. G Representative, 2013).

OC-ALC –

The OC-ALC starts by factoring in labor and materials cost, as the direct costs included in the rates they charge to perform KC-135 PDM. Then indirect costs are included in this rate, including production overhead, which is partially comprised of annual leave, training time, shop cleanup, and personnel on standby. Production overhead also encompasses the costs associated with a prime vendor contract to stock bins with consumable supply items like rivets, nuts and bolts. One other thing OC-ALC factors into its rate that other organizations may not need to consider relates to providing time for employees to exercise as part of a Fit-For-Life wellness program (OC ALC Representative 3, 2013).

Discussion

The main direct costs are labor and materials, and indirect costs deal with overhead. Each organization differs slightly in what they call overhead, but in a general sense they all speak to management salaries, facility upkeep, rent, and any other costs associated with aircraft maintenance operations. One item of note is that the third party commercial MROs are attempting to sell man-hours when they advertise maintenance rates. These organizations are able to quickly determine their position within the market place, assuming that these rates accurately capture organization costs and provide a margin for profits, because they establish their own rates. The commercial carriers outsource work to the third party commercial MROs because that the third party MRO rates are more competitive than their own rates. KC-46 planners at OC-ALC should consider defining an hourly rate much like the third party commercial MROs to determine how their maintenance costs compare with commercial options. A well-

developed rate provides a foundation to determine how to make improvements or smartly outsource the portions of work for which the facility cannot compete with others with regard to cost.

(12) Are your maintenance technicians multi-skilled? If yes, for how long and what affect has it had on your efficiencies?

Table 4.12. Responses to Question 12

Organization	Workforce is task centric or multi-skilled	Work accomplished in 8 hour shift
A	Multi-skilled work force with primary & secondary skill	Goal to maintain 95 % hours billable
B	Technicians are in skill groups – task centric	6.5 hours of an 8 hour shift are productive
C	Technicians are in skill groups – task centric	6.5 to 7 hours of an 8 hour shift are productive
D	Task centric but restricted cross utilization – partial hybrid	6.5 to 6.7 hours of an 8 hour shift are productive
E	Task centric but can cross utilize - hybrid	6.8 hours of an 8 hour shift are productive
F	Multi-skilled work force	No response
G	Task centric but can cross utilize - hybrid	6.2 hours of an 8 hour shift are productive
OC-ALC	Technicians are in skill groups – task centric	5 hours of an 8 hour shift are productive

Organization A –

Organization A employs a multi-skilled workforce that has capacity in a primary and (at least) a secondary skill. This enables them to cross-utilize personnel and assign them wherever they see fit. While on site, the researcher observed that many of the technicians working on the aircraft are older than the typical age of a technician just starting out thus inferring that Organization A employs an experienced workforce. This most likely allows them the flexibility to cross utilize personnel. The manager representative's response to impact on efficiencies is that their productive hours are high and they are able to keep their technicians continuously working. He explains that their goal is to maintain 95 percent of work hours billable to their customers, but he did not

elaborate on the quantity of hours his personnel are productive within an 8-hour shift (Org. A Representative, 2013).

Organization B –

Organization B's workforce is task centric. Their technicians work within skill groups, and though it may appear to restrict their flexibility, it does not. They have 13 maintenance lines set up with aircraft parked nose to tail, and this facilitates high productivity in their organization. Once a skill group completes work on one aircraft, they immediately shift to another aircraft to continue working. Organization B refers to this as variable staffing. The impact on efficiencies is that they are able to get 6.5 productive hours of work out of an 8-hour shift from each technician. They relentlessly seek to improve these efficiencies through a group of personnel in their organization dedicated to continuous process improvement (Org. 1B Representative and Org. 2B Representative, 2013).

Organization C –

Organization C is primarily task centric in nature. If a technician is trained in structures, that is all they do, and the same notion applies to the other skill groups. One exception is that through their apprentice program, they occasionally move training technicians around to different skill groups. The organization manager representative explains that his organization is able to achieve on average 6.5 to 7 productive work hours within an 8-hour shift per technician and suggests that it could be even more. He attributes these efficiencies to initiatives they implement to have everything available at the jet for the technicians to work continuously. Tech data and call stations are available

wirelessly onboard the aircraft and parts are delivered directly to the technicians where they are working and when they are needed (Org. C Representative, 2013).

Organization D –

Organization D assigns its technicians to specific skill groups and adds flexibility to its model by occasionally allowing its personnel to be cross utilized. However, cross utilization for Organization D means that the cross-utilized technician becomes an assistant to those primarily assigned to a skill group that is falling behind or just needs an extra set of hands and only until their work is caught up. When the question is posed about efficiencies, the manager representative explains that within third party commercial MROs there is a common practice to hire temporary work. This provides flexibility for the organization to expand operations during busy times and then downsize when the work slows down. Organization D, like the other third party commercial MRO organizations is subject to the peak and valley operations of the commercial carrier organizations. During busy flying periods, the commercial carriers have all of their aircraft flying passengers and the third party commercial MROs are left with little or no work to do. During these slow times, they reduce the number of temporary workers to a base crew of permanent employees and this has enabled them to capture 6.5 to 6.8 hours of productive work within an 8-hour shift per technician (Org. D Representative, 2013).

Organization E –

The technicians at Organization E are qualified to work in any skill group, but they are assigned to specific skill groups to accomplish work. No comments are made on how this impacts efficiencies but Organization E is able to produce 6.8 hours of work per

8-hour shift. However, the manager representative mentions that his organization restricts hiring to only experienced personnel (Org. E Representative, 2013).

Organization F –

Organization F considers all of its technicians multi-skilled, and they are utilized across the different skill groups. However, there is still supervisor discretion and the supervisors will assign personnel to the specific skill groups where they feel they are most competent. The researcher visited one of Organization F's facilities and noticed that a majority of the technicians working on the aircraft appeared to be older and more seasoned in the career field than perhaps someone just entering it. Organization F is most likely able to multi-skill and cross utilize personnel because of their experience and training. Unfortunately, no response is provided for how efficiencies are affected by Organization F's model of employing multi-skilled technicians (Org. F Representative, 2013).

Organization G –

Organization G assigns technicians to work in specific skill groups, so they do have the appearance of being a task centric organization. However, through agreements set with their labor unions, they have built flexibility into their model. The agreement allows them to cross utilize personnel in different skill groups for a temporary 14-day period when required. The organization can chose whoever they need for cross utilization and send them wherever they are required. This agreement provides them with more flexibility then they have ever had in the past.

The manager representative for Organization G feels that they are able to achieve as high as 6.5 hours of productive work within an hour shift per technician. However,

they have a goal yield of 6.2 hours of productive work so this quantity seems more reasonable to compare with other organization (Org. G Representative, 2013).

OC-ALC –

The maintenance technicians at OC-ALC are not considered multi-skilled. Technicians are assigned to specific skill groups (OC ALC Representatives 1 and 2, 2013). Productivity in an 8-hour shift at OC-ALC is determined utilizing a direct labor yield, and estimated productivity level achieved is close to 6.8 hours of work within an 8-hour shift. However, OC-ALC's Direct labor yield, though appears comparable to commercial standards, does not include the additional hours specific to the Air Force that direct technicians to accomplish non-maintenance oriented training, or allow for physical fitness time. When direct yield is combined with these extra non-maintenance hours, and indirect labor hours (leave, holidays, training hours, and etc.) the productive time is closer to 5 hours per 8-hour shift (AFSC/LGPM Representative, 2013).

Discussion

The responses to this question do not provide enough evidence to suggest whether multiskilling improves productivity and efficiency or not. However, what the responses do indicate is that each organization finds a way to improve productivity while operating within constraints. The commercial airline maintenance organizations tend to employ multi-skilled personnel more often than the third party commercial MROs. Evidence suggest that commercial airlines tend to multi-skill more for two reasons, 1) a majority of their technicians hold A&P licenses which qualifies them to do any work, and 2) their labor is unionized. In some cases labor union agreements restrict what commercial airlines can or cannot do. For example, third party commercial MROs can utilize

temporary employees to cover expanding operations whereas commercial airline maintenance organizations cannot. The FAA also has more influence in pushing the commercial airline maintenance organizations toward employing only A&P certificated personnel whereas the third party commercial MROs are able to get by with hiring less certificated personnel.

OC-ALC falls somewhere in between. Personnel are not required to hold A&P certificates, they use unionized labor, and it is being debated whether the ALC wants to allow FAA regulation govern KC-46 maintenance practices. A possible direction that can be taken for the KC-46 program is to maintain a task-specific orientation while also developing a minimal level of multi-skilling. Although a few of the organizations mention that they multi-skill, they still maintain a task centric model to a large degree. It is unavoidable to have at least some level of specialization, but that level depends on how much flexibility needs to be built into the model and how much output is required to keep each technician productive.

The first C-checks for the KC-46 are expected to be few and far between. The Air Force plans to take delivery of the aircraft from the OEM over an extended period and initially they may be less likely to identify non-routine maintenance findings because the aircraft will be so new. In response to these parameters, the KC-46 maintenance program needs a workforce that can be both multi-skilled and task centric. When all of the aircraft are delivered and maintenance requirements increase it will makes sense to specialize technicians in particular skill sets.

OC-ALC has attempted to employ multi-skilling practices in the past as is referenced in earlier chapters of this work, but the application remains elusive. The

commercial aviation maintenance organizations worked with their labor unions and established agreements that brought flexibility to their model. The KC-46 maintenance program may also need to work with labor union representatives to come up with an agreement that satisfies both parties and allows for a hybrid multi-skill, task-centric model.

Productivity and efficiencies in this context are not very comparable between the seven interviewee organizations and OC-ALC. The seven-interviewee organizations do not clarify what goes into the calculation of productive hours per shift. Because of that, it makes it difficult to compare these hour quantities without knowing whether the representatives are referring to direct labor hours, indirect labors hour or a combination of both. Furthermore, the personnel at the ALC follow different rules and may be required to do more with their time on-the-clock outside of actual aircraft maintenance than are the other organizations. Lastly, maintenance practices for the KC-135 differ from the maintenance practices for the B-767. Therefore, once data is available perhaps an additional study can be conducted to determine the productivity of a KC-46 maintenance technician multi-skilling, task-centric hybrid model.

Cross-Case & Cross-Interview Question Comparison

Table 4.13. Cross-Case & Cross Interview Question Comparison Matrix
(NP refers to not provided and N/A refers to not applicable)

Org.	Size (personnel)	Number of Clientele	B-767 years of Experience	B-767 Qty. per year	Light C-check Qty. of personnel	Heavy C-check Qty. of personnel	Tech. to Sup. Ratio	Calculated Light C-check Hours
A	260	13 airline & cargo transport organizations	9 years	54 to 113 aircraft	70	70	12 to 1	7,448
B	1300	NP	23 years	30 to 60 aircraft	40	200	10 to 1	1300
C	1000 to 1200	3 core customers & all of the major air carriers	13 years	0 to 5 aircraft	40 to 60	100	6 -8 to 1	5,963
D	400 reg. & up to 1000 temporary workers	6 airline & cargo transport orgs.	10 years	3 to 4 aircraft	20	60	15-20 to 1	2,275
E	438	NP	NP	NP	140	140	25 to 1	NP
F	NP	Only internal to the org. maintenance provided	20 years	NP	≥ 60	≥ 60	12 to 1	NP
G	1350	NP	1 to 26 years	129 aircraft	106	106	35 to 1	6,572
OC-ALC	1340 (KC-135)	N/A	N/A	90 KC-135 aircraft	N/A	58 (PDM)	15 to 1	N/A

Table 4.13. Cross-Case & Cross Interview Question Comparison Matrix (continued)

Org.	Calculated Heavy C-check Hours	Years of Experience when 1st hired	Ratio of A&Ps	Division of work	Hiring Requirements	Task Centric or Multi-skilled	Yield (out of 8 hour shift)
A	22,344	8 to 10	10 to 0 10 to 6 structures	Zonal	At least A certificate	Multi-skilled (primary/ secondary skill)	.95
B	41,600	>1 to 30	65%	Task Groups	Preference for A&P or repairman certificate	Task centric	.8125
C	26,500	> 1	25% 5% repairman	Trade Groups	Preference for A&P or repairman certificate	Partial hybrid	.828125
D	9,750	< 2	80%	Task Groups	A&P required unless hired in apprenticeship program	Partial hybrid	.8125
E	NP	7 to 20	99%	Skill Groups	A&P certificates	Hybrid	.85
F	NP	2 to 5	Almost no non-A&P	Zonal	A&P certificates	Multi-skilled	NP
G	18,402	< 1	99%	Task Groups	A&P certificates or seniority	Hybrid	.775
OC-ALC	33,640 (PDM)	0 to < 20	20%	Task Groups	A&P certificates optional	Task centric	.625

Table 4.13., Cross-Case & Cross Interview Question Comparison Matrix, is representative of a last opportunity the researcher takes to glean any additional insights

by comparing the case organizations in terms of all of the inputs they provide. The approach for analyzing these inputs is to look for patterns by going line-line through the comparison matrix and grouping similar attributes. The hope is to identify organization trends and how they may relate to OC-ALC's organizational characteristics. In order to facilitate this analysis, observations are listed and insights discussed.

1. Size of the organization in terms of personnel is not indicative of the quantity of B-767s supported.

Organization A, a third party commercial MRO, is small in terms of personnel, but is capable of supporting at least 113 B767s, which is the second highest quantity provided. This may be due in part to Organization A specializing in B-767 maintenance whereas the other organizations may perform maintenance on more aircraft than just the B-767. Size of an organization may in terms of personnel may be indicative of the type of staffing model utilized. While interviewing Organization D's representative, he commented about third party commercial MROs. He explained that it is common for these organization types to have a core set of permanent party personnel and then adjust manning numbers in response to fluctuations in the workload with contract temporary technicians (Org. D Representative, 2013). The Organization D representative is not affiliated with Organization A, but he does provide an explanation for why a small third party MRO may be able to support so many B-767s.

2. The years of maintenance experience when first hired, appears to have little impact on the technician to supervisor ratios whereas the ratio levels of A&P certificated mechanics do.

The organizations with the lowest level of A&P certificated technicians in their workforces tend to have higher levels of supervision. This most likely is based in the

organization requiring supervision to sign for work performed by non-certificated personnel.

3. The division of work seems to be influenced by whether or not a zonal approach is applied and if the technicians are multi-skilled or not.

The organizations that divide work by trade or skill group have a workforce model that is either task centric or a hybrid, which incorporates some multi-skilling. The two organizations that claim to apply a zonal approach to divide the work, use a multi-skilled workforce. These organizations also have high ratios of A&P certificated personnel and tend to hire technicians with more initial experience.

4. Yield ratios tend to be higher in the organizations with the higher levels of experience performing B-767 maintenance and who utilize hybrid-staffing models that incorporate a mixture of multi-skilled and task centric personnel.

It's perhaps obvious that experience levels can have a positive effect on yield, however what was more interesting is that those organizations that combined multi-skilling with task centric staff models were able to achieve high yield levels. A task centric model is extremely effective when the volume of work is high and consistent, because technicians can become efficient at what they do over time through task specialization. However, workload is not always consistent or technicians working in different skill groups may finish at different times, and more flexibility may be needed. A model that employs purely multi-skilled personnel provides flexibility, because technicians are capable to work in more than one area and this capability seems to be needed when an organization has inconsistent workload. Combining a task centric model with a multi-skilling model forms a hybrid. This leverages the benefits of both types and this is perhaps why Organization C, D, and E may be achieving similar levels of yield.

The comparison of all of the inputs across the seven commercial MRO organizations helped to pinpoint a few trends that these organizations are exhibiting. The hope was to have identified characteristics that led the researcher to relate maintenance practices of any the commercial MROs with that of OC-ALC. Although a few patterns were found in the analysis, the researcher was unable to find how one organization may be more beneficial than another when identifying an organization to benchmark. The gain from comparing all of the inputs was that the research was able to identify more evidence for supporting the need to take a strategic approach in developing the workforce. This can help an organization achieve high levels of efficiency and effectiveness. The next section goes into additional comments provided by the interviewee organizations.

Interviewee Additional Remarks

Organization A –

While visiting Organization A, observations were made of how they use their space to conduct B-767 C-checks. There are multiple hangars onsite that can easily accommodate the aircraft but one hangar in particular is too small. The aircraft could not pull in without striking either the walls or roof of this hanger. However, Organization A came up with a plan to make the aircraft fit. They lowered the struts, deflated the tires to a minimum level, and removed the wing tips and a portion of the tail. After accomplishing all of these tasks the aircraft fit with only two to three feet to spare between the walls and roof of the hanger. Their accomplishment led to the creation of a

checklist that is now followed every time a B-767 aircraft needs to use this smallest hanger.

Organization B –

The manager representative for Organization B suggests that the best source for researching personnel maintenance requirements is found within the third party commercial MRO industry. He explains that an airline maintenance organization would handle things differently because they are not profit oriented and they do some things that would be detrimental to his organization's profit base. He also suggests that if commercial outsourcing is pursued for the KC-46, a FAR part 12-type contract is more applicable to a near-commercial platform like the KC-46 (Org. 1B Representative and Org. 2B Representative, 2013).

Organization C –

The manager representative recommends paying extra close attention to the maintenance programs such as EWIS or ETOPS. The FAA is continuously making changes to these programs, especially to corrosion prevention measures, aircraft wiring and aging aircraft mandated inspections. He also talks about how repair assessments can drive up an airline's costs especially as the aircraft gets older and drives how long an air carrier can fly an aircraft. The example he provides refers to an aircraft that Organization H flew during the Vietnam War which had bullet hole damage. When a repair assessment was done, all of the old repairs completed during that period had to be redone because they did not meet current FAA standards. Lastly, he mentions the importance of looking at the interval for completing major checks on the aircraft. He recommends that

heavy maintenance should occur typically every 18 months but can be extended up to 24 months (Org. C Representative, 2013).

Organization D –

The manager representative suggests that the conditions and environment the airplane is operating under need to be looked at in conjunction with the maintenance program. He mentions this because his customers bring in airplanes with wide variations of conditions and variation in their individual maintenance programs. He also explains that if outsourcing is pursued for the KC-46 maintenance program, planners should consider the longevity of the perspective contracting organizations and how well they can support themselves and others (Org. D Representative, 2013).

Organization E -

The manager representative suggests that it is cost competitive to do something on your own rather than going to a third party. He clarifies this comment by explaining that, "third parties have their cost down so far that it is hard to compete with them, so you have to compete on quality." His organization has expensive labor but all of their other expenses are relatively low so they see efficiencies in doing the maintenance on their own rather than outsourcing (Org. E Representative, 2013).

Organization F –

No additional comments provided.

Organization G –

According to Organization G, when an aircraft reaches its 12 to 15th year in operation maintenance costs significantly increase. The major components such as the

gears and engines start to need major work and the avionics system requires upgrades (Org. G Representative, 2013).

Summary

Chapter 5 is comprised of responses to the research tool applied to the gathered data. Each respondent provides their expert opinion in terms of the organization that they represent. These responses are complied, compared and inference is made with the intent to find answers to the original research questions posed in Chapter 1. The chapter then concludes with additional interviewee remarks that the researcher feels contribute to the context of the research project. The next chapter refers to the inferences made in this chapter and provides the researcher's conclusions.

V. Conclusions and Recommendations

Background

Chapter 4 provides the basis for this chapter; it gives benchmarking guidance from seven commercial aviation maintenance organizations and a background of maintenance operations at OC-ALC for a similar sized aircraft. This chapter condenses that guidance and background with a goal of offering recommendations for the KC-46 maintenance program. However, prior to listing the recommendations the researcher reviews and discusses the motives for this research, the research questions, and research question responses.

Research Purpose

The research process spans over several months during which, many conversations are held, an abundance of data gathered, and many hours spent to process and interpret the data. The journey led the researcher in many directions, but the chosen course fulfills a specific purpose. Chapter 1 provides this purpose and it is reiterated here. The purpose is to determine the requirements necessary to develop a workforce that can initiate depot maintenance for the KC-46. This statement is perhaps too broad because of the complicated nature of aircraft maintenance, but the researcher recognizes this and therefore focuses his work in three areas: workforce planning, workforce integration to new work, and the secondary effects of workforce expansion to management. Results of this research are important because the KC-46 maintenance program planners need to know what to expect when the first aircraft arrives to depot for service. The next section reviews how the researcher scopes his focus to specific questions and then provides a discussion of the responses he finds.

Investigative Question Discussion & Responses

Originally identified in Chapter 1, six questions serve as a means to guide the researcher in achieving his purpose. The first question:

> **(RQ1) How many personnel are required to activate C-check operations for the KC-46?**

Inference made of the responses provided by interviewee organizations (reference Chapter 5) suggest that a wide range in the number of personnel can be used to begin KC-46 C-check maintenance. This data does not provide sufficient evidence to pinpoint the exact number of required personnel. However, zonal maintenance, applicable to Organizations A and F, provides a different perspective. These organizations assign a quantity of personnel that can effectively work on one aircraft without getting into one another's way, 60 to 70 personnel to one aircraft. These quantities reflect coverage for three shifts over a 24-hour period. In order to clarify response to (RS1) the researcher takes a further step to scale the quantity of personnel required in terms of per shift and per aircraft. Therefore, 60 to 70 personnel divided up equates to approximately 20 to 23 personnel assigned to one aircraft per shift. In addition, an additional factor is presented by Organization A. They consider the desired quantity of production man-hours in a 24-hour period and this also helps determine how many personnel to assign to the aircraft. They are able to produce 400 man-hours per day with 70 personnel assigned to an aircraft. Although OC-ALC does not operate 24 hours per day and has only two shifts, the 60 to 70 personnel agrees with the number assigned to perform maintenance on the KC-135. It is also consistent with the quantities provided by Organizations B, C, and D. The KC-46 maintenance program can start by assigning 30 to 35 personnel per shift and

per aircraft but adjustments to the total number per aircraft can be made once a desired quantity of production man-hours and flow days is established. Response to (RQ 6) provides further insight for determining technician quantities when considering production man-hours and flow days. Through the combination of these additional parameters to the suggested quantities of personnel (refer to Table 4.4) further refines what workforce quantities may be necessary for KC-46 C-check maintenance.

(RQ2) How are KC-46 maintenance technicians employed; task centric, generalist, or a hybrid?

Questions 9 and 12 from the interview research tool utilized to gain responses from the interviewee organizations (reference Chapter 4) help clarify response to (RQ2). The responses vary of whether or not the KC-46 C-check line should be made up of task-centric or generalist maintenance technicians. The commercial airline MROs claim to use more maintenance generalists, whereas the third party commercial MROs use more task-centric maintenance technicians. However, when specifics are discussed it is found that the airline MROS typically assign their "generalist" personnel to perform specific tasks. A minor difference is in how flexible supervisors are in allowing the technicians to choose where they work. In some cases the technicians choose which skill group they join and they tend to work in areas where they have the most experience or they are capable of working in many areas and want to maintain their different skill group competencies. In another case, the supervisor has discretion to determine where technicians are assigned each day. Ultimately the same work is completed, it just depends on how an organization' personnel structure is set up and the type of flexibility they need to accomplish their maintenance objectives. The technicians who perform

maintenance on the KC-135 are assigned to specific skill sets and thus follow a task-centric model. C-check maintenance for the KC-46 is planned to be performed by technicians also located at OC-ALC, therefore this model would seem the easiest to apply because it is already integral to operations, but evidence suggests that more flexibility is needed.

Throughout the interview process, the represented commercial aviation maintenance organizations routinely expressed that they could not compete in terms of cost with the third party commercial MROs. These organizations, with one exception, all follow a task centric model. They have a smaller ratio of A&P certificated personnel to non-certificate personnel, and they build flexibility into their technician model by hiring temporary technicians to fill in when operations need to expand rapidly. These personnel are laid off once operations reduce to minimal levels. This offers flexibility to these organizations and they are able to keep costs down but organizations that have workforces consisting primarily of unionized labor are not able to follow these same practices.

The commercial airline maintenance organizations have unionized labor and have found alternative ways to add flexibility into their workforce models. The main way they do this is to hire personnel who are mostly or all A&P certificated, meaning that they are qualified to perform any of the C-check work. They continue to follow a form of a task-centric method but not in the same way that the third party commercial MROs do. Interviewee responses suggest that they use a hybrid model, one in which generalist technicians with multiple certifications are assigned to one skill group so supervisors have the discretion to cross utilize their personnel in different skill sets when needed.

This model offers flexibility and can save on personnel costs while leveraging the benefits of specializing technicians in specific skill sets.

OC-ALC does not employ primarily A&P certificated technicians, nor does it utilize temporary labor. Therefore, what model makes the most sense for the KC-46? A strictly task-centric model would be facilitated by the current model and culture found at OC-ALC but that does not mean it is the way ahead. The initial volume of work does not justify the hiring of only task-centric technicians. On the other-hand, hiring strictly generalist A&P certificated maintenance technicians does not make sense either. There are no positions at the ALC requiring generalist A&P certificated technicians and KC-46 managers would need to work closely with union representatives to make this an option.

Third party commercial MROs follow FAA regulation by employing an adequate blend of A&P certificated and to non-A&P certificated personnel. They ensure that key supervisory positions are filled with technicians who hold A&P licenses or repairman certificates so they can sign for any completed work. OC-ALC exhibits characteristics that fall in between commercial airline MROs and third party commercial MROs. It uses unionized labor that restricts some flexibility, while at the same time the FAA has less sway in its maintenance personnel practices.

Therefore, in response to research question two the KC-46 maintenance program should follow a hybrid model. Hiring a blend of A&P licensed and non-licensed maintenance technicians offers the ability to be cross-utilized while the demand for routine work grows. Initially the ratio of A&P certificated personnel should be high because the amount work will be low. A higher blend will enable supervisors the ability to utilize fewer personnel to do more until there is sufficient work in the future to justify

reducing the ratio of A&P certificated personnel by hiring more non-certificated personnel. The initial higher ratio of A&P certificated personnel offers the KC-46 maintenance program the opportunity to identify and prepare personnel for supervisory positions as C-check lines expand and when more non-certificated personnel are hired. Interviewee responses suggest that the following skill set assignments be developed: inspectors, aircraft systems (e.g., hydraulics, etc.), avionics, structures, interior repair, composites, and fuels. The KC-135 maintenance program adds a boom and fuel bladder skill set, an additional area for which technicians will need to be trained to perform KC-46 maintenance.

(RQ3) What ongoing training programs are required to support activating KC-46 maintenance?

The interviewee responses suggest that a GEN FAM program be developed to provide initial general awareness and indoctrination of the technicians to the KC-46. This program should at minimum include EWIS training, which provides avionics personnel background in wiring inspection, Category I, and II training, and ETOPS training. Additionally, a refresher course is administered annually to maintain proficiency in Category I, and II training. Then an engine run and taxi qualification program is necessary to ensure adequate personnel are trained and available to support the KC-46 for final maintenance checks prior to returning the aircraft to operation status. A lower minimums training program is needed to provide training for the technicians that oversee the ETOPS aircraft flying standards. Next, a reduced vertical separation minimum training program should be available to train personnel who monitor systems that allow an aircraft to fly within FAA directed minimal altitudes and then finally a

required inspection items program needs to be developed (Federal Aviation Administration, 2011). Many more training programs are conducted by the interviewee organizations, but theses seem to be standard across aviation maintenance. The researcher discovered afterward that these programs are directed by FAA guidance. Refer to Chapter 5, question 6 for further clarification of programs not listed here.

(RQ4) Is the C-check considered part of the OC-ALC's Core Competencies?

The C-check is a maintenance method to ensure the health and continued operability of an aircraft and is common across the maintenance industry to include those organizations interviewed for this project. Furthermore, most of the commercial aircraft in operation receive support through a maintenance C-check program. To this end, the KC-46 program intends to apply the C-check method for its heavy maintenance of the KC-46 at OC-ALC. Now, this raises the issue of whether performing this maintenance practice is a core competency for OC-ALC. United States Code Title 10 section 2464 provides guidance on what is considered a core competency. This section is rather lengthy, therefore only key statements are provided here.

> *(a) NECESSITY FOR CORE DEPOT-LEVEL MAINTENANCE AND REPAIR CAPABILITIES.—(1) It is essential for national security that the Department of Defense maintain a core depot-level maintenance and repair capability, as defined by this title, in support of mission-essential weapon systems or items of military equipment needed to directly support combatant command operational requirements and enable the armed forces to execute the strategic, contingency, and emergency plans prepared by the Department of Defense, as required under section 153(a) of this title.*

(2) This core depot-level maintenance and repair capability shall be Government-owned and Government-operated, including the use of Government personnel and Government-owned and government-operated equipment and facilities, throughout the lifecycle of the weapon system or item of military equipment involved to ensure a ready and controlled source of technical competence and resources necessary to ensure effective and timely response to a mobilization, national defense contingency.

(subsections 3 and 4 of (a) skipped)

(b) WAIVER AUTHORITY

(subsection 1 of (b) skipped)

(2) The first time a weapon system or other item of military equipment described in subsection (a) is determined to be a commercial item for the purposes of the exception under subsection (c), the Secretary of Defense shall submit to Congress a notification of the determination, together with the justification for the determination. The justification for the determination shall include, at a minimum, the following:

(A) The estimated percentage of commonality of parts of the version of the item that is sold or leased in the commercial marketplace and the version of the item to be purchased by the Department of Defense.

(B) The value of any unique support and test equipment and tools needed to support the military requirements if the item were maintained by the Department of Defense.

(3) In this subsection, the term ‘‘commercial item’’ means an end-item, assembly, subassembly, or part sold or leased in substantial quantities to the general public and purchased by the Department of Defense without modification in the same form that they are sold in the commercial marketplace, or with minor modifications to meet Federal Government requirements.

(d) LIMITATION ON CONTRACTING.—(1) Except as provided in paragraph (2), performance of workload needed to maintain a core depot-level maintenance and repair capability identified by the Secretary under subsection (a)(3) may not be contracted for performance by non-Government personnel under the procedures and requirements of Office of Management and Budget Circular A-76 or any successor administrative regulation or policy (hereinafter in this section referred to as ‘‘OMB Circular A-76’’) (Simmons II, 2011).

Maintenance for the KC-46 falls somewhere in the middle between what can be waivered and what would be considered a core capability. The KC-46 is derived from a commercial platform, and only specific portions of the aircraft are military specific. The potential exists for the availability of commercial contracts to support C-check operations for this aircraft. When Organization B's representatives were interviewed, a suggestion was brought up about how to help maintain the KC-46. They stated that if maintenance outsourcing is pursued that the Air Force should pursue a contract that is commercially oriented, a FAR part 12. However, Air Force decision makers have already made a conscious decision to organically-manage the maintenance for the KC-46. With that, core competencies need to be developed within the government to support this decision. OC-ALC does not perform C-check maintenance at this time, but with the arrival of the

KC-46, it will need to activate operations. Therefore, in the present, the response to (RQ4) is that no, C-check is not, but in the near future the C-check process will become a core competency.

(RQ5) How many management personnel are required to activate depot operations?

The response to this question relates to supervisory level management, not upper level management that oversees the entire maintenance operation process. A supervisor is defined, according to the KC-135 maintenance organization, as someone who has senior level maintenance experience and is placed in a position to direct onsite maintenance operations for a particular aircraft (OC-ALC Representative 1, 2013). Commercial maintenance organizations also place personnel in supervisory positions that have senior level experience, but in addition, they also require these individuals to hold either A&P licenses or repairman certificates. This is to ensure that supervisors are set up with qualifications to oversee their subordinates and to sign for work completed if the subordinates do not hold licenses or certificates. With the definition of management personnel clarified for the intent of this research, the researcher can now address the number of supervisors required to activate KC-46 maintenance operations. Responses to interview question four (reference Chapter 4) focus on this topic by detailing maintenance technician to supervisor ratios.

Interviewee respondents provide a broad range of responses. The ratios start as low as 10 to 1 and go all the way up to 35 to 1. OC-ALC's ratio of technicians to supervisors is 15 to 1and falls close to the middle of the range of other responses. This spread is most likely the result of there being two different types of MROS in the study,

commercial airline MROs and third party commercial MROs. The commercial airline MROs (who employ mostly A&P certificated personnel) had higher technician to supervisor ratios and the third party commercial MROs (who have lower ratios of A&P certificated personnel) had lower technician to supervisor ratios. Additionally when responses to interview question 10, which regards the ratio of A&P certificated technicians to non-A&P certificated technicians, are compared with responses to interview question 4, the organizations with the lowest supervisor to technician ratios also have the lowest A&P certificated to non-certificated technician ratio (Organizations B and C). Organizations B and C admit that they intentionally hire less certificated maintenance technicians to keep costs down since they do not have to pay these technicians as much as A&P certificated technicians. Meanwhile they must fill supervisory positions with certificated personnel to sign for the work that the non-certificated personnel accomplish.

On the other hand, supervisors for KC-135 maintenance are not required to hold A&P certificates and in addition are not required to sign for the work of non-certificated subordinates. For this reason and perhaps one other, the level of experience of the technicians, enables the 15 to 1 ratio. However, assuming the KC-46 maintenance program decides to "meet the intent" of FAA regulations, supervisors will need to be certificated. In this case, a 15 to 1 ratio may not provide adequate supervision at least in the initial stages of KC-46 C-check maintenance. KC-46 maintenance will be new for OC-ALC, and technicians performing the work may lack experience (even if they hold A&P certificates). Therefore, a 10 to 1 ratio seems more reasonable because it adds additional supervision at the beginning until the C-check line matures to assure quality in

the process. During this time, technicians and supervisors are afforded the opportunity to gain experience and become competent at what they do. After technicians gain experience, they may need less supervision and when this occurs, KC-46 planners can adjust technician to supervisor ratios as required.

(RQ6) What is required to expand operations after depot activation?

While KC-46s age there will be a correlated increase in maintenance requirements over time. Each of the interviewee commercial organizations comment that heavy C-checks are required once an interval of time has passed following light C-checks (reference interview question 5 in Chapter 4). These types of checks are more intensive, require higher man-hours and tie up more resources. The interview organizations also explain that heavy C-checks require technicians to specialize more in specific skill groups to maintain the aircraft. During these types of C-checks, the possibility of identifying non-routine findings that may be difficult to troubleshoot increases. Therefore, what OC-ALC can expect after KC-46 depot activation, is that the program will need to work toward specializing personnel in skill groups. The rate at which this occurs correlates with the induction of KC-46s into the USAF fleet and with increased heavy maintenance requirements as aircraft age. The KC-46 Program Office provided an additional source of information key to developing a satisfactory response to (RQ 6).

The information provided by the Program Office projects the timeframe for which Boeing will deliver KC-46 aircraft to the Air Force and it covers a 12-year period. The researcher adds two years to this timeline (e.g., the initial aircraft delivery date) to account for the time when KC-46s will be in for depot maintenance for the first time. Table 5.1. provides these details.

Table 5.1. Timeline of KC-46 Initial Depot Maintenance (KC-46 Program Office, 2013)

Year	‘18	‘19	‘20	‘21	‘22	‘23	‘24	‘25	‘26	‘27	‘28	‘29	‘30
KC-46 Quantity	7	14	19	15	15	15	15	15	15	15	15	15	4

When aircraft arrive to the depot for the first time technicians will perform a C1 C-check and then the aircraft will return every other year for additional C-check maintenance. Each visit following the initial year of C-check maintenance will require an increase in inspection tasks. After C1 is C2, C3, and then finally C4. This process is repeated each time an aircraft undergoes all four levels of C-check maintenance. Eventually, all 179 KC-46s will be integrated into the Air Force inventory, and at this time, OC-ALC will need to arrange for an adequate amount of C-check lines and personnel to handle at least half of the 179 KC-46s per year.

The researcher acknowledges that he cannot provide an exact estimate of how many personnel and C-check lines may be needed to support at least half of the total delivered KC-46s with the data he has available, but he does provide recommendations of what may be needed in the next section. Overall, the KC-46 program needs to be prepared to expand its workforce, and gradually increase the quantity of C-check lines it simultaneously runs until at least the last KC-46 has undergone initial C4 C-check maintenance. Specific quantities for each C-check category depends on how many hours of work per day OC-ALC intends to produce and how effective they are at training and integrating new personnel into their workforce.

OC-ALC operates two eight-hour shifts per day and the facility is closed for Federal Holidays (11 days) and weekends (104 days). This leaves 250 days available for work to be performed and when this is multiplied with a yield factor (e.g., .625) and the

quantity of hours per day (e.g., 16 hours) it equates to 4,000 hours. Then this quantity is divided in two to determine attributable hours per maintenance technician per year. Now utilizing these calculations, the researcher can calculate estimates for KC-46 C-check maintenance flow days based on Table 4.7., Work Flow Time Conversion Matrix, calculations and the quantities of personnel suggested by the responses to Interview Question 3 in Chapter 4 (refer to Table 4.4.). Although, the list of calculations is already lengthy, one additional element is required. In Chapter 4 the researcher came up with a light C-check time length (e.g., 4,237.5 hours or base light C-check hours plus 25 percent of 950) and a heavy C-check time length, (e.g., 22,950 hours or base heavy C-check hours plus 950) but does not clarify how long each level of C-check will be take beyond just light and heavy C-checks. There are more C-check levels in between. Perhaps check C1 takes 4,238 hours and check C4 takes 22,950 hours. However, this does not consider the hours of work associated with C2 and C3. The next step then is to determine a logical time estimate for C2 and C3. The researcher understands that each level of C-check builds off the previous C-checks, therefore C1 hours are doubled to determine C2 (e.g., 4000 multiplied by 2 plus 50 percent of 950) and C2 is roughly doubled to determine C3 (e.g., 8000 multiplied by 2 plus 75 percent of 950). Table 4.7., Workflow Time Conversion Matrix, also provides calculations that agree with C2 values. Organization A's calculated light C-check value is 7,448 hours and Organization G's actual light C-check time length range is 7,000-9,200 hours. However, none of the calculations on Table 4.7. match estimates provided for C3 so 8000 multiplied by 2 plus 75 percent of 950 is relied upon to fill the gap in between C2 and C4. The researcher utilizes these C-check level estimates to calculate the quantity of work hours associated with incoming

KC-46s to OC-ALC and calculates flow days based on the quantity of technicians utilized per day (refer to Table 5.2).

Table 5.2. KC-46 C-check Flow Days Model

Year	Qty. of C1 hrs. / year	Techs / acft	Hrs. / day	Qty. of C2 hrs. / year	Techs / acft	Hrs. / day	Qty. of C3 hrs. / year	Techs / acft	Hrs. / day	Qty. of C4 hrs. / year	Techs / acft	Hrs. / day	Min flow days	Max flow days
'18	29,663	60 x 1	300 x 1	0	0	0	0	0	0	0	0	0	99	99
'19	59,325	60 x 1	300 x 1	0	0	0	0	0	0	0	0	0	198	198
'20	80,513	36 x 2	180 x 2	59,325	50 x 1	250 x 1	0	0	0	0	0	0	224	238
'21	63,563	50 x 1	250 x 1	118,650	50 x 2	250 x 2	0	0	0	0	0	0	238	255
'22	63,563	50 x 1	250 x 1	161,025	50 x 3	250 x 3	116,988	50 x 2	250 x 2	0	0	0	215	255
'23	63,563	50 x 1	250 x 1	127,125	50 x 2	250 x 2	233,975	70 x 3	350 x 3	0	0	0	223	255
'24	63,563	50 x1	250 x 1	127,125	50 x 2	250 x 2	317,538	70 x 4	350 x 4	160,650	70 x 2	350 x 2	227	255
Qty. – Quantity; ***acft*** – aircraft; ***x 2, 3*** or ***4*** found in ***Techs / acft*** column & ***Hours / day*** column – multiplier for quantity of C-check lines														

The calculated flow days in Table 5.2. are merely estimates but the table can serve as a model for developing workforce levels as maintenance operations increase with continual flow of new KC-46s into the Air Force inventory. The estimates reflect the capabilities of a flexible workforce with the ability to work in more than one area and shift from one C-check level to another. Flow days are calculated separately for each C-check line type and a minimum and maximum quantity of flow days is provided to show a range in completion for each C-check type. Staffing levels and C-check types quantities are varied in the model to ensure that flow days do not overly exceed the 250 days per year available for work. Any hours over 250 could lead one to believe that overtime may be required to ensure all of the work is done ,but the model does provide evidence to suggest that there is excess capacity in some of the C-check line completion times (refer to Table 5.2). Excess capacity on other C-check lines could be shifted to other the ones that have estimated flow days exceeding the 250 day per year limit. Overall, the quantity of personnel assigned to aircraft and the quantity of C-check lines can be adjusted in order to meet specific flow day goals and recommendation two

specifies a course of action for identifying the quantity of C-check lines required to support the KC-46.

Recommendations

1. The KC-46 maintenance program should plan to hire 30 maintenance technicians per shift to initiate C-check operations for the first KC-46 C-checks, which assumes that OC-ALC has two shifts. This quantity is the amount to assign to one aircraft. These personnel need to have experience and background in large transport aircraft, preferably with experience in more than one skill set. An increase in workload may affect this recommendation. Therefore, refer to Table 5.2, KC-46 Flow Days Model, for further suggested adjustments to the quantity of technicians assigned per aircraft based on C-check type and workload increase.

2. The KC-46 maintenance program should initiate one C1 C-check line in 2018 and sustain in 2019; expand one C1 C-check line and initiate one C2 C-check in 2020; decrease quantity of C1 C-check lines to one and expand C2 C-check line by one in 2021; sustain C1, expand C2 by one and initiate two C3 C-check lines in 2022; sustain C1, decrease C2 by one and expand C3 by one in 2023; sustain C1 and C2, expand C3 to four and initiate two C4 C-check lines in 2024; continue to expand into the following year. With the expansion of each C-check line, KC-46 workforce planners should increase workforce size. Figure 5.1. provides a projected graphical reference of the magnitude and complexity of support required. It focuses on the quantity of C-checks lines, C-check types and quantity of aircraft per year in depot until the first C4 C-check is performed in 2024. KC-46 C-check requirements continue to grow after 2024 but the researcher

prefers to limit projection up to when the first wave of KC-46s have completed all four C-checks because of a focus on C-check activation.

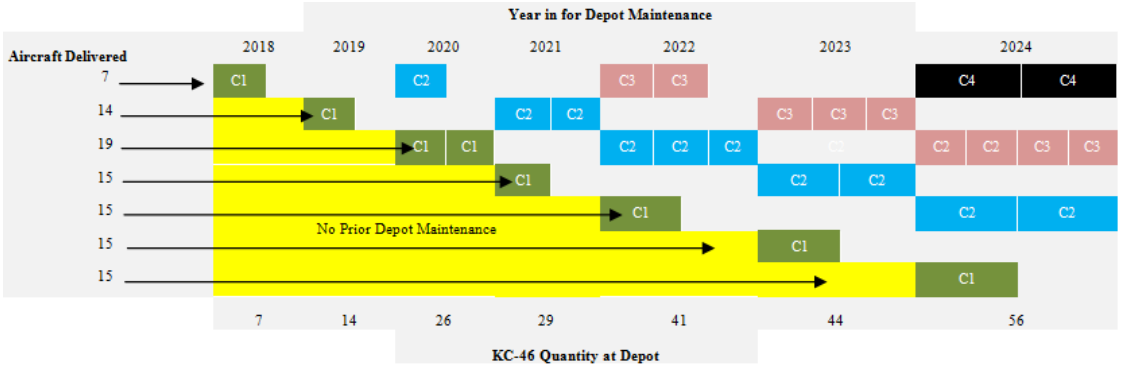

Figure 5.1. Projected C-check Maintenance Timeline (KC-46 Program Office, 2013)

3. Maintenance technicians should be assigned to specific skill sets for C-check maintenance but initially there needs to be some form of flexibility in the model. At first, the work force should consist of a higher blend of personnel who hold either A&P certificates repairmen certificates than the current OC-ALC workforce. The workforce should also offer the flexibility to cross utilize skill sets. Two third party commercial MROs have a range of 30 to 65 percent of A&P certificated personnel, and these are the organizations that the major airlines turn to trim costs. Lower costs suggest that these organizations operate more efficiently than the others, therefore they serve as beneficial example of how the KC-46 maintenance program can gain workforce efficiency.

4. The main skill sets that should be developed are inspectors, aircraft systems (e.g., hydraulics, wiring, etc.), avionics, structures, interior repair, composites, and fuels. Additionally, skill sets to perform fuel bladder and refueling equipment inspection and maintenance need to be developed for the KC-46.

5. Initially, the ratio of technicians to supervisors should be lower than the current ratio applied to the KC-135 (15 to 1) but can be increased as the C-check line matures. At the time of depot activation, technicians will have less experience performing maintenance on the KC-46, which will require that supervisors take additional quality assurance steps. Also, the added responsibility of "meeting the intent" of FAA regulations requires that supervisors sign for their subordinate's (who do not hold certificates or licenses) work. Interview responses suggest a ratio of 10 technicians to 1 supervisor may be appropriate. This number can vary based on the quantity of licensed individuals within a specific skill set and level of experience. Finally, all of the personnel filling supervisory roles should hold either A&P licenses or repairman certificates.

6. The KC-46 maintenance program needs to develop an initial training program that provides general background of the aircraft, a GEN FAM program. This program should include Category 1, 2, and 3 training, EWIS training, ETOPS training, and RII training. Category 1 and 2 training should be renewed annually. There also needs to be lower minimums training and reduced vertical separation minimum training programs. Though there are more training areas, these are the main ones identified.

Future Research

The research method applied to this project involves gathering information from organizations that provide maintenance for the commercial equivalent of the KC-46, except for the refueling equipment and fuel bladders. The resulting information provides recommendations for the KC-46 maintenance planners. This information describes a generalized estimate of personnel requirements and helps guide planners to select an appropriate personnel model for activating depot operations. However, what it does not

do is offer quantitative evidence. This type of evidence is currently available in the form of B-767 maintenance data, but this lacks detail related to refueling equipment and bladders. It was suggested at one point during the research gathering process that KC-10 maintenance data could fill this void. Maintenance for the KC-10 follows a MSG-3 program and thus technicians perform C-checks. Unfortunately, the data associated with K-10 C-check maintenance was found to be inaccessible to the researcher. Therefore, the topics presented in this document should be revisited once KC-46 maintenance data is available. Two types of data are sought after: actual C-check cost data and personnel yield data. The Air Force Sustainment Center (AFSC) captures personnel yield, or the measured efficiency and effectiveness of the workforce, for operations at the ALCs. In the future, this organization will be responsible for capturing this data for the KC-46 maintenance program. Then the KC-46 Program Office and Air Force data systems will be the best source for tracking down actual cost data for performing maintenance on this aircraft. In the proceeding paragraphs, suggestions are offered for how the data could be analyzed to continue this research.

Once C-check operations are active for the KC-46 then cost data should become available. That data can be used to conduct a cost benefit analysis of the C-check process. The KC-46 program office's desire is to manage an organically centered process, but it also wants to make decisions that make financial sense. Quantitative data can be used to support decisions of whether operations should continue utilizing strictly government personnel or whether portions of the maintenance process can be sourced to third party organizations. This is a research area that may need to be revisited often especially while C-check operations develop and mature.

Another area for which quantitative data is useful relates to workforce yield. OC-ALC produces a yield of around five hours of output in an eight hour shift whereas commercial maintenance organizations, including third party MROs, are producing a yield between six and seven hours of output within the same amount of time. This may be the result of the government, and thus OC-ALC following different guidelines than the commercial MROs or the way yield is measured may be different for commercial organizations. There may be more that is included in yield for OC-ALC than what the other organizations include. For example, OC-ALC includes providing adequate time for employees to complete additional training not directly related to their main responsibilities as maintenance technicians, as well as time for employees allotted for health and wellness purposes. This time being set aside for non-maintenance activities, has become a source of debate of how it affects yield, especially when comparing depot yield to that of commercial organizations. The arrival of a new aircraft to the ALC, the KC-46, provides opportunity for organization managers to revisit yield and identify ways to measure yield that is comparable to commercial organizations. A great place to start is to look at the yield numbers for the KC-46 C-check process once sufficient data is available and research how commercial aviation maintenance organizations are tracking yield. Once comparable data available is identified, the researcher can use this as way to determine what practices within industry are worthy of benchmarking to improve KC-46 workforce yield.

Summary

Chapter 6 provides the research sponsor with recommendations on how to proceed with developing a workforce to support KC-46 C-check maintenance. Case

study research was used to gather benchmarking data from organizations that perform maintenance on B767 aircraft, the derivative source of the KC-46. Identified practices and procedures applied by these organizations make up the sources for the recommendations in this report. The hope is that now the sponsoring organization of this research can take these recommendations and apply them, as they see fit, to activate KC-46 depot maintenance operations.

Appendix A

Interview Questions

(1) How many years of experience performing B-767 C-checks?

(2) How many B-767s are supported per year?

(3) How many personnel per aircraft are required to perform the C-checks?

(4) What is the ratio of technicians to supervisors?

(5) How long does it take to perform the C-check?

(6) What training programs are required to maintain the proficiency of your technicians?

(7) What is the average experience level of your technicians when first hired?

(8) What certification requirements if any are required for technicians to be hired?

(9) What methods or procedures are followed to divide work amongst the technicians to perform the C-check?

(10) What is the ratio of Airframe and Powerplant Certified mechanic technicians to Non Certified mechanic technicians?

(11) What are the types of costs (direct and indirect) associated with costing the C-check activity?

(12) Are your maintenance technicians multi-skilled? If yes, for how long and what affect has it had on your efficiencies?

Bibliography

Works Cited

Abalateo, M. D., and Lee, J. R. (1993). *Benchmarking Practices of Air Cargo Carriers: a Case Study Approach.* Wright Patterson AFB: Air Force Institute of Technology.

AFLCMC. (2013, October 11). KC-135 FY14 PDM Tasks. Oklahoma City, Oklahoma.

AFLCMC/WKCSI. (2013, May 9). (J. C. Jensen, Interviewer).

AFLCMC/WKK. (2013, June 7). KC-46 Purchase Contract Discussion. (J. C. Jensen, Interviewer).

AFSC/LGPM Representative. (2013, October 16). Manpower Yield Discussion. (J. Jensen, Interviewer).

Air Force Materiel Command. (2007). *Strategic Source of Repair Determination for the KC-135 Replacement Tanker Aircraft.* Wright Patterson AFB: US Air Force.

Air Force Sustainment Center. (2013). *Air Force Sustainment Center Complex of the Future.* US Air Force (Draft).

Air University. (2012, April). *Air Force Airframe and Powerplant (A&P) Certification Program*. Retrieved July 25, 2013, from Community College of the Air Force: https://augateway.maxwell.af.mil/ccaf/certifications/a_and_p/.

Aircraft Technology Engineering and Maintenance Awards. (2013). *ATE&M Awards 2013*. Retrieved October 8, 2013, from https://www.faasafety.gov/content/Awards/DefaultAmt.aspx.

Cotten, A. (2007). *Seven Steps of Effective Workforce Planning.* Baltimore: IBM Center for The Business of Government.

Crowley, F. P. (2013, October 10). B-767/KC-46 MSG-3 ISC Background Briefing. Wright Patterson AFB, Ohio, US: AFLMC/WKCS Sustainment.

Department of USAF. (2011). *Update on Kc-46A and Legacy Aerial Refueling Aircraft Programs: Presentation to the House Armed Services Committee Sumbommittee on Seapower and Projection Forces US House of Representatives.* House Armed Services Committee.

Dietrich, B. (2006). Resource Planning for Business Services. *Communications of the ACM No. 7 Vol 49*, 62-64.

Dunn, G., Barone, J. C., and Peterson, L. E. (2003). Depot Reengineering Improving Support. *Air Force Journal of Logistics Vol 27 Spring*, 11-12.

Federal Aviation Administration. (2011). *Reduced Vertical Separation Minimum (RVSM) Monitoring Requirements.* FAA.

Federal Aviation Administration. (2012). *Advisory Circular 121-22C.* US Department of Transporation.

Federal Aviation Administration. (2013). *Mechanic Award Program*. Retrieved October 8, 2013, from FAA Safety Team: https://www.faasafety.gov/content/Awards/DefaultAmt.aspx.

Federal Aviation Administration. (n.d.). *Aircraft EWIS Best Practices Job Aid 2.0.* Retrieved Janary 29, 2014, from http://www.faa.gov/training_testing/training/air_training_program/job_aids/media/EWIS_job-aid_2.0_Printable.pdf.

Federal Service Impasse Panel. (1997). *Combined Source Set 1 Federal Service Impasse Panel Decisions.* Wright Patterson AFB: Air Force.

Francis, G., Hinton, M., Holloway, J., and Humphreys, I. (1999). Best Practice benchmarking: a Route to competitiveness? *Journal of Air Transport Managment 5*, 105-112.

G-14 Americas Aerospace Quality Standards Committee . (2009, January 15). *Quality Management Systems - Requirements for Aviation, Space and Defense Organizations*. Retrieved October 8, 2013, from SAE International: http://standards.sae.org/as9100c/.

Gates, S. M., Eibner, C., and Keating, E. G. (2006). *Civilian Workforce Planning in the Department of Defense Different Levels, Different Roles.* Arlington VA: Rand Corporation.

GPO. (2014, January 29). *Title 14: Aeronautics and Space Part 145 - Repair Stations.* Retrieved January 31, 2014, from Electronic Code of Federal Regulation: http://www.ecfr.gov/cgi-bin/text-idx?c=ecfr&sid=3919e29547ea3b17476f78679c9effcc&rgn=div5&view=text&node=14:3.0.1.2.19&idno=14#14:3.0.1.2.19.4.3.1.

Haas, C. T., Borcherding, J. D., Glover, R. W., Tucker, R. L., Rodriguez, A. M., and Gomar, J. (1999). *Planning and Scheduling a Multiskilled Workforce.* Austin : Center for Construction Industry Studies.

Hammer, M., and Champy, J. (1993). *Reengineering the Corporation a Manifesto for Business Revolution.* New York: Harper Business.

High Veloctiy Maintenance Team, USAF. (2010, February 26). *High Velocity Maintenance*. Retrieved November 5, 2013, from Robins Air Force Base: http://www.robins.af.mil/library/factsheets/factsheet.asp?id=10795.

House of Representatives . (2007). *National Defense Authorization Act for Fiscal Year 2008.* Washington: Government Printing Office.

House of Representatives. (2003). *National Defense Authorization Act for Fiscal Year 2004.* Washington: Government Printing Office.

House of Representatives. (2012). *National Defense Authorization Act for Fiscal Year 2013.* Washington: Government Printing Office.

HQ AFMC/A4F. (2011, August 15). Depot Maintenance of Aerospace Vehicles and Training Equipment. *Technical Manual TO 00-25-4*. Wright Patterson AFB, Ohio.

International Organization for Standardization. (n.d.). *About ISO*. Retrieved October 8, 2013, from ISO: http://www.iso.org/iso/home.htm.

KC-46 Program Office. (2013). *Beddown wit TAI.* Wright Patterson AFB: AFMC.

Langen, K. (2013, June 4). Meets the Intent. *Tanker Directorate*. Wright Patterson AFB, Ohio, US.

Levien, A. J. (2010). *Restructuring Depot Maintenance Occupational Series to Improve Flexibility.* Wright Patterson AFB: Air Force Institute of Technology.

Loredo, E. N., Pyles, R. A., and Snyder, D. (2007). *Programmed Depot Maintenance Capacity Assessment Tool Workloads, Capacity, and Availability* . Pittsburgh: RAND Corporation.

Misko, J. (2008). *Combining Formal, Non-formal, and Informal Learning for Workforce Skill Development.* Adelaide: Australian Industry Group.

OC ALC Representative 3. (2013, November 14). KC-135 Maintenance Costs. (J. Jensen, Interviewer).

OC ALC Representative Panel. (2013, November 7). Technician Requirements for KC-135 PDM. (J. Jensen, Interviewer).

OC ALC Representatives 1 and 2. (2013, November 18). Technician Requirements for KC-135 PDM. (J. Jensen, Interviewer).

OC-ALC Representative 1. (2013, November 18). Technician Requirements for KC-135 PDM. (J. Jensen, Interviewer).

OneAero-MRO. (2013). *News*. Retrieved October 8, 2013, from https://www.oneaero-mro.com/home/news.

Org. A Representative. (2013, October 29). Technician Requirements for B767 C-check. (J. Jensen, Interviewer).

Org. 1B Representative, and Org. 2B Representative. (2013, October 22). Technician requirements for B767 C-check. (J. Jensen, Interviewer).

Org. C Representative. (2013, November 8). Technician Requirements for B767 C-check. (J. Jensen, Interviewer).

Org. D Representative. (2013, November 21). Techncian Requirements for B767 C-check. (J. Jensen, Interviewer).

Org. E Representative. (2013, October 15). Technician Requirements for B767 C-check. (J. Jensen, Interviewer).

Org. F Representative. (2013, October 25). Technician Requirements for B767 C-check. (J. Jensen, Interviewer).

Org. G Representative. (2013, October 18). Technician Requirements for B767 C-check. (J. Jensen, Interviewer).

Org. H Representative. (2013, July 18). Organization H Maintenance Model. (J. C. Jensen, Interviewer).

Pynes, J. E. (2004). The Implementation of Workforce and Succession Planning in the Public Sector. *Public Personnel Management Vol 33 No. 4*, 394-409.

Rose, A. (2002). *RCM White Paper*. Retrieved November 14, 2013, from Cadick Corporation: http://www.mainsaver.com/pdf/Reliability_Centered_Maintenance_White_Paper.pdf.

Savas, E. S. (1987). *Privatization: The Quest for Value.* New Jersey: Chatham.

Schramm, W. (1971). *Notes on Case Studies of Instructional Media Projects.* Washington DC: Working paper for the Academy for Educational Development.

Simmons II, R. L. (2011). *Title 10, United States Code Armed Forces.* Washington: U.S. Government Printing Office.

Tegtmeier, L. A. (2013, June 26). *MRO*. Retrieved October 8, 2013, from Aviation Week: http://www.aviationweek.com/Article.aspx?id=/article-xml/awx_06_26_2013_p0-591584.xml&p=1#.

Tinker Public Affairs. (2012, August 28). *Oklahoma City Air Logistics Complex*. Retrieved August 8, 2013, from Tinker Air Force Base: http://www.tinker.af.mil/library/factsheets/factsheet.asp?id=8552.

US Department of Transportation. (2013, April 29). *Aviation Safety (AVS)*. Retrieved October 29, 2013, from Federal Aviation Administration : https://www.faa.gov/about/office_org/headquarters_offices/avs/.

US Department of Transportation. (2013, March 19). *Flight Standard National Field Office*. Retrieved November 1, 2013, from Federal Aviation Administration : http://www.faa.gov/about/office_org/headquarters_offices/avs/offices/afs/afs900/.

US Department of Transportation. (2013, March 19). *Introduction to Part 121 Air Carrier Certification*. Retrieved November 1, 2013, from Federal Aviation Administration: https://www.faa.gov/about/initiatives/atos/air_carrier/intro_to_part121_cert/.

US Department of Transportation. (2013, February 1). *Safety: The Foundation of Everything We Do*. Retrieved October 29, 2013, from Federal Aviation Administration: http://www.faa.gov/about/safety_efficiency/.

US Office of Personnel Management. (2013, July 18). *Aircraft Mechanic search results*. Retrieved August 8, 2013, from USAJOBS: https://www.usajobs.gov/JobSearch/Search/GetRefineControlResults?Keyword=aircraft+mechanic&Location=&SelectedRadiusOption=20&AutoCompleteSelected=true&search.x=0&search.y=0.

Vernez, G., Robbert, A. A., Massey, H. G., and Driscoll, K. (2007). *Workforce Planning and Development Processes A Practical Guide.* Santa Monica, CA: Rand Corporation.

Walter, D. (2000). Competency-based on-the-job training for aviation maintenance and inspection - a human factors approach. *International Journal of Industrial Ergonomics 26*, 249-259.

Woodside, A. G., and Wilson, E. J. (2003). Case Study Research Methods for Theory Building. *Journal of Business & Industrial Marketing Vol 18 No 6/7*, 493-508.

Yin, R. K. (2003). *Case Study Research Design and Methods third edition.* Thousand Oaks: Sage Publications Inc.

Vita

Captain Jacob C. Jensen graduated from Utah State University in 2008 earning a Bachelor of Science degree in Human Resource Management. After graduation, he was commissioned through the Detachment 860 AFROTC program and subsequently entered active duty status in January of 2009.

His first assignment was to Joint Base Andrews, Maryland in the 89th Aerial Port Squadron. Captain Jensen served as Flight Commander of Aircraft Services, as Flight Commander of Squadron Sustainment and lastly as the Director of Operations. While at Joint Base Andrews, Captain Jensen was recognized on three separate occasions as the 89th Wing Company Grade Officer of the quarter. He also was selected to participate in the Language Enabled Airmen Program, which has enabled his continuation of Portuguese and Spanish language study. Furthermore, Captain Jensen deployed to Ali Al Salem Air Base, Kuwait in 2011 to the 386th Expeditionary Logistics Readiness Squadron. His served as Distribution Flight Commander in support of Operation Enduring Freedom and Operation New Dawn. Finally, in October 2012, Captain Jensen entered the Logistics and Supply Chain Master's Program at the Graduate School of Engineering and Management, Air Force Institute of Technology. After graduation, he will be assigned to the 571st Mobility Support Advisory Squadron at Travis Air Force Base, California.

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14. ABSTRACT
The Air Force projects receiving new KC-46 aircraft in 2016 and headquarters is directing organic maintenance. Oklahoma City ALC is the depot projected to provide this support and plans to have aircraft onsite in 2018. However, maintenance requirements are currently unknown. Therefore, this research seeks to identify the requirements necessary to activate operations with a scope in workforce planning. The KC-46 is a B-767 derivative aircraft and planners are applying a commercial based program, MSG-3, which directs C-check series maintenance. This program is followed by organizations across industry who operate B-767s and the researcher seeks to find out what is involved by observing their practices. The research is case study based and encompasses responses from maintenance experts in eight organizations. Four are third-party MROs, three are airline MROs and the remaining organization is the KC-135 maintenance program from Oklahoma City ALC. Organization representatives are interviewed with intent to discover more about their workforce requirements, and responses are analyzed to formulate recommendations for KC-46 maintenance planners. Recommendations identify a per aircraft quantity of personnel required to initiate maintenance, a workforce expansion timeline, required workforce skill groups, a supervisor to technician ratio, a workforce model, and workforce training requirements.

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