



**AEROSPACE GROUND EQUIPMENT MANAGEMENT'S IMPACT ON HOME-  
STATION SORTIE PRODUCTION**

THESIS

Michael A. Bayer, Captain, USAF

AFIT/GLM/ENS/03-01

**DEPARTMENT OF THE AIR FORCE  
AIR UNIVERSITY**

**AIR FORCE INSTITUTE OF TECHNOLOGY**

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**Wright-Patterson Air Force Base, Ohio**

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THESIS

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Michael A. Bayer, BS

Captain, USAF

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Michael A. Bayer, BS

Captain, USAF

Approved:

\_\_\_\_\_  
Stephan P. Brady, Lt Col, USAF (Advisor)

\_\_\_\_\_  
Date

\_\_\_\_\_  
Stephen M. Swartz, Lt Col, USAF (Reader)

\_\_\_\_\_  
Date

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Michael A. Bayer

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### **Abstract**

Since the Air Force began its evolution into an Expeditionary Air Force, much effort has been expended in attempt to optimize the compositions of each Air Expeditionary Force (AEF) and the manner in which an AEF deploys. Air Force plans were previously based upon deploying 24-ship Unit Type Codes (UTC), although a 12-ship deployment is more prevalent in today's environment. In an effort to eliminate the anomalies between planned and actual deployment composition, the Air Staff directed in 2002 that all fighter UTCs be *right-sized* to reflect current, planned requirements (Headquarters United States Air Force, 2002). The directive stipulated the development of UTCs in a building block fashion so that a squadron would be poised to deploy one lead package of aircraft, with potential follow-on packages. This plan would make it possible for an entire UTC to be tasked to one organization, while allowing the unit to continue limited operations at home station (Headquarters United States Air Force, 2002).

Given these deployment requirements, reduced numbers of Aircraft Ground Equipment (AGE) will remain to support the aircraft remaining at home-station. This research consists of a discrete event simulation to determine an effective manner in which to manage the remaining support equipment to maximize sortie production capabilities by varying the AGE management concepts, quantity of AGE remaining on-station, and the number of aircraft remaining on-station.

# **AEROSPACE GROUND EQUIPMENT MANAGEMENT'S IMPACT ON HOME-STATION SORTIE PRODUCTION**

## **I. Introduction**

### **Background**

Prior to the break up of the Soviet Union, the United States amassed a great deal of forces outside of its boundaries, either in anticipation of, or in effort to deter conflict. As late as 1987, 41 Air Force wings were positioned outside of the United States (Air Force Historical Research Agency, 2002). With the end of the cold war came the realization that the security environment had vastly changed. Gone were the days of known adversaries, openly advertising their intent to destroy the United States; replaced by the unpredictable challenges of the post-cold war environment consisting of rogue nations possessing weapons of mass destruction, terrorism, and considerable ethnic tensions. As the *cold war* concluded, the United States Air Force (USAF) began a drawdown in numbers of both personnel and bases. The challenges of the drawdown, in combination with the changed security environment, forced the Department of Defense (DOD) to rethink methods and alternatives for deploying, employing, and sustaining forward located forces.

The Air Force once used a strategy of forward-based presence and pre-positioned equipment and supplies, but a new strategy has evolved, built upon the vision of global engagement. Currently, the preponderance of forces are not forward based in-theater,

rather are positioned within the borders of the United States, ready to deploy to areas of crisis. As this new strategy evolved, the number of overseas based Air Force wings dropped to 16 (Air Force Historical Research Agency, 2002).

Out of this vision grew the concept of the Air Expeditionary Force (AEF), a package of 30 to 40 aircraft that national command authorities can deploy on short notice (Looney, 1996). Since its inception, much effort has been expended in optimizing the compositions of each AEF and the manner in which an AEF deploys. Concern continued to grow as it became more apparent that the United States was becoming increasingly more involved in small-scale contingencies (SSCs), rather than major theater war (MTW). Air Force contingency plans are still based upon a squadron size deployment, originally developed for MTW, though the prevalent area of military involvement tends to be SSC. In other words, Air Force plans are based upon deploying 24-ship Unit Type Codes (UTC), although a 12-ship deployment is more prevalent.

This anomaly not only makes the deployment process difficult due to the constant fragmenting of UTCs prior to deployment, but also makes planning future contingencies difficult due to the disparity between planned and actual unused resources.

In an effort to eliminate the anomalies caused by the incorrectly sized UTCs, the Air Staff directed in 2002 that all fighter and intratheater airlift UTCs be *right-sized* to reflect current, planned requirements (Headquarters United States Air Force, 2002). The directive stipulated the development of UTCs in a building block fashion so that a squadron would be poised to deploy one lead package of aircraft and potentially one or two follow-on packages. This plan would make it possible for an entire UTC to be

tasked to one organization, while allowing the unit to continue limited operations at home station (Headquarters United States Air Force, 2002).

Currently, a new concept is under development, using the newly right-sized UTCs to build force modules, in attempt to optimize the AEF deployment process. Under this concept, the AEF will deploy in phases, beginning with the deployment of personnel required to simply open an airfield, culminating in the presence of a combat force and supporting infrastructure capable of sustained operations. In theory, the deployment process will be greatly simplified as hundreds of UTCs are aligned under modules according to the functions they are designed to perform. Since the modules are based upon right-sized UTCs, the combat aviation unit will deploy the lead package, and only deploy follow-on packages if necessary.

### **Problem Statement**

Guidance from the Air Staff states that an entire UTC should be capable of tasking to one organization, while limited operations continue at home station. F-16 aircrew require an extensive number of training flight hours in order to establish and maintain qualifications in many different mission profiles. Additionally, home station aircraft are often susceptible to additional taskings, to include providing for homeland defense capability. Decision-makers need to ensure non-deployed units (or the portion of deployed units not included in the deployed UTC) are able sustain limited operations home station using the support equipment left behind.

## **Research Question**

Each combat wing consists of a given number flying squadrons; in most cases this number is three or four squadrons each consisting of between 18 and 24 aircraft.

Additionally, each wing is afforded a certain amount of Aircraft Ground Equipment (AGE) to support operations. The wing can opt to allocate equipment to each squadron, used solely to support that squadron's aircraft, or pool the risk by keeping the equipment aggregated, providing support to each squadron as needed.

Given the requirement to send sufficient support equipment to support a 12-ship package, possibly followed by subsequent 6-ship packages, a reduced number of AGE will remain to support home-station flying. What is the most effective manner in which to manage the remaining support equipment to maximize flying operations at home station?

## **Investigative Questions**

To successfully analyze effective support equipment management, the following questions must be addressed:

1. What quantities of support equipment are possessed by F-16 units?
2. How is the support equipment currently allocated?
3. What quantities of support equipment are required to support a 12-ship, austere-base, deployment?
4. The following questions must also be answered to provide the simulation model the necessary input data:
  - What are the failure and repair rates of the possessed support equipment?

- What are the failure probabilities of an aircraft during each stage of the sortie generation process?
- What are the failure probabilities of each aircraft system, given an aircraft has experienced a failure?
- What are the support equipment requirements to support the repair of each system failure?

### **Data Sources and Analysis**

Several types of data are required in order to answer these questions and propose a solution that exemplifies the most effective management of support equipment in supporting home station flying commitments. The first investigative question involves ascertaining the current quantities of support equipment possessed by an F-16 unit. A review of an active duty, combat tasked F-16 unit's *Table of Allowances* (TA) provides insight into the level of support equipment maintained.

The second question is answered by surveying an active F-16 unit as to how their support equipment is allocated. The third question is answered by conducting a review of the unit's Logistics Plan (LOGPLAN). The review should be limited to the support equipment required to support the initial 12-ship, austere-base deployment.

Question four is answered by gathering data. Aircraft failure and repair data is found within the Consolidated Aircraft Maintenance System (CAMS), while support equipment failure and repair data is obtained from interviews with experts in the field.

## **Methodology**

The Air Force Research Laboratory (AFRL) contracted Kelly Logistics Support Systems (KLSS) to develop a tool capable of evaluating the impact of user specified operational tempos on logistics resource constraints and sortie rates. Scalable Integration Model For Objective Resource Capacity Evaluations (SIMFORCE) was developed to predict the probable maintenance resource needs based upon operational missions. Most useful is its ability to predict the effects of reduced or increased levels of resources on the number of sorties produced. SIMFORCE will be used to simulate the sortie production environment.

SIMFORCE was developed to be used at the wing level and can be used to analyze different scenarios at any Air Force Base (AFB) deemed appropriate. Shaw AFB, an active duty, combat F-16 wing will serve as a model for this research. The first phase is that of gathering data. Interviews of the wing's Aircraft Ground Equipment (Age) flight supervision are accomplished to quantify the support equipment mix as listed on the TA and the current equipment allocation method, in order to answer questions one and two. Next an interview of Shaw AFB's Installation Deployment Officer (IDO) is conducted, answering question three by verifying the support equipment requirement for the wing's 12 PAA deployment. Question four requires the gathering of CAMS data to provide the percentage of aircraft failures occurring at each stage of the generation process. CAMS data is further scrutinized to find the failure probability of each system by Work Unit Code (WUC). AGE utilization along with failure and repair rates are gathered during the Literature Review and by way of interviewing the AGE Flight

Superintendent at Shaw AFB. This data is used as input data and parameters for SIMFORCE in order to obtain output data for analysis.

### **Scope and Assumptions**

This study's approach is applicable to any weapons system; however, this analysis models F-16 units possessing at least 18 primary assigned aircraft. Additionally, since this study is concerned with sortie production capability at a given base, aircraft failure and repair data is representative of operations at Shaw AFB, as opposed to the F-16 community at large.

The model used for analysis was not developed in the process of this research, rather was selected from a list of simulation software, primarily due to its ease of use, availability of technical support, and recommendation by research sponsorship. Previous research in the area of AGE modeling was studied and benchmarked to as great an extent as practical. SIMFORCE is throughout the study to simulate different operational scenarios, with guidance provided by the SIMFORCE user's guide (KLSS, 2002). Carrico, in his study, produced an extremely beneficial matrix of AGE usage assumption, sorted by Work Unit Code (WUC) (Carrico, 1996a). All other simulation model inputs were retrieved from CAMS, as confirmed by KLSS personnel.

AGE failures are treated at the system level for each AGE type. Documentation of previous AGE failure and repair analysis is limited. There is certainly a need for study of current AGE reliability, to include failure and repair rates.

This study investigates how differences in AGE management philosophies and quantities affect sortie production capabilities. The AGE under consideration is limited to the following powered aircraft ground equipment:

High-Pressure Air Compressor—MC-1A

Low-Pressure Air Compressor—MC-2A

Liquid Nitrogen Servicing—N2 cart

Cooling Air—AM32C-10

Electrical Power Generator—AM32A-60

Hydraulic Test Stand—MJ-2A

External Lighting Unit—NF-2D

SIMFORCE can be used to calculate or predict a broad range of areas, using any number of resources in support of the aircraft generation schedule. Since this research focuses on the impact of AGE, only the above stated units are input as resources. All other resources to include personnel, vehicles, tools, facilities, and equipment are assumed unconstrained, meaning that they are considered available upon request, without delay, and do not affect the results of the simulation.

Though ARENA is a relatively powerful simulation, KLSS has built in numerous limitations to offset complexity of running SIMFORCE. The source code, imbedded in ARENA, for SIMFORCE is proprietary in nature, and cannot be manipulated by the user. Additionally, many reports and the user's ability to alter the input variables normally available when using ARENA, are unavailable to the researcher.

## **Summary**

Chapter I of this thesis has provided the reader with the background issues precipitating such a study. The background was followed by a clear statement of the problem that was used to develop the research question. A number of investigative questions were proposed to aid in answering the research question, followed by an explanation of the scope and limitations of the thesis. Chapter II provides an in-depth review of existing literature and terminology pertaining to this topic. Chapter III details the methods used to analyze the data in order to answer the investigative and research questions. Chapter IV provides the findings of the study, while Chapter V discusses the conclusions, recommendations, and areas worthy of further research.

## **II. Literature Review**

### **Introduction**

This chapter reviews the terminology used and the existing literature pertaining to this research effort. Initially, this chapter provides an overview of the Expeditionary Air Force (EAF) concept, to include its history and evolution. The definitions of Unit Type Codes (UTCs) and their uses are discussed, followed by a discussion of Force Modules (FMs) and how UTCs are used in their development. AGE is defined and discussed as it pertains to this study, followed by a review of previous research accomplished in this area. Finally, work unit codes and the SIMFORCE model are introduced.

### **Expeditionary Air Force**

The Cold War, although a time of great danger, had a predictable, certain, and stable environment where rivals typically used conventional, symmetric means of attack and planning. Since there was a continuous threat from a known opponent, the Department of Defense (DOD) had access to large amounts of resources prepositioned in the planned area of operations. The end of the *Cold War* ushered a change in the United States' security environment. Where the U.S. was once one of few world superpowers, it has since found itself as the sole superpower, surrounded by smaller, regional powers (Galway, 1999).

Today's threats to national security are discontinuous, rapidly changing, dynamic, unconventional, and unpredictable, with adversaries who will likely seek asymmetric means of attacking U.S. interests due to America's conventional

military superiority. The realization that the traditional approach used during the predictable cold war era would not effectively resolve the unpredictable challenges of the post-cold war environment, coupled with the decline of resource availability (personnel and budget), and the reduction of bases and personnel in overseas locations led to the USAF's Expeditionary Air Force (AEF) concept. This was a paradigm shift away from solely focusing on MTW's massive deployments of personnel and cargo over a long build-up time window in an attempt to meet a large-scale, well-armed enemies in conventional warfare. Instead, focus is on tailored, lean, and rapid-response deployments of CONUS based forces to anywhere in the world to meet theater specific requirements across "the full spectrum of military possibilities" (Cohen, 1998).

The USAF implemented the EAF concept to provide greater flexibility and rapid deployability of highly capable forces with fewer resources for global engagement in peacetime, crisis, and war (Looney, 1996). It is based on the Air Force's allocation of units into several Air Expeditionary Forces (AEFs), of roughly equivalent capabilities, able to rotate deployment responsibilities. AEF units are expected to conduct air operations independently for the first seven days until logistic sustainment capability is established (Godfrey, 1998).

The EAF concept is designed to be a highly capable, tailorable force able to deploy worldwide from any location. The tailorability of force packages continues to be a *work in progress*. The EAF was originally designed to be completely self-contained, virtually eliminating the need for prepositioned assets

at forward deployed locations; however, the trade-off between propositioned equipment and the deployment footprint is an ongoing issue (Galloway, 1999).

It should be noted that the expeditionary concept is not a concept new to the 1990's, rather a concept utilized by military organizations for centuries. General Billy Mitchell conceived the idea of constructing brigades capable of aerial bombardment, pursuit, and attack aircraft as early as 1920. His argument was that it would prove valuable to maintain an efficient strategic reserve able to fly quickly to a distant threat. In the early 1990's, General Merrill McPeak developed the Composite Wing, a wing composed of a mix of different type aircraft providing an effective force practice.

General John Jumper constructed a temporary, mixed-aircraft force, capable of rapid deployment with a minimal footprint and sustainment of operations for short durations. The high operational and personnel tempo of these air units persuaded the Chief of Staff of the Air Force (CSAF) to reorganize the entire Air Force into ten AEFs designed to respond to lighter-end, or SSCs (Titus, 1999).

Brigadier General Looney refers to an AEF as a 30-40 aircraft unit that national command authorities have at their disposal for short-notice deployment to diffuse a crisis, increase airpower capability in a region, or maintain airpower capability in a region. In order to provide that responsive capability with the decreased forward stationed presence, the USAF must rely on a rapid deployment

capability. The goal is to be able to launch combat aircraft in theater within 48 hours of the deployment execution order (Looney, 1996).

The Expeditionary Aerospace Force (EAF) concept is how the Air Force is organized, trained, and equipped to meet the national security challenges of the 21<sup>st</sup> Century and supports two fundamental principles: first, to provide trained and ready forces for national defense and second, to meet national commitments through a structured approach which enhances total force readiness and sustainment (Department of the Air Force, 1999).

The USAF organizes the majority of its total force into ten AEFs, two on-call Aerospace Expeditionary Wings (AEWs), and five Lead Mobility Wings (LMWs). Day-to-day operations and deployed operational commitments are met with the two scheduled AEFs and one on-call AEW. Again, this is day-to-day operations; anything beyond these commitments constitutes a surge, requiring a degree of reconstitution upon surge completion. Surge operations begin when requirements exceed the capabilities of two AEFs and one on-call unit. At this point, the parameters for day-to-day operations are no longer applicable, to include the notion of one 90-day deployment per 15 months. Upon completion of a surge period, the forces must transition to pre-surge activities, and possibly reduced commitment levels, to facilitate reconstitution of forces (Department of the Air Force, 1999).

The AEF life cycle during day-to-day operations is 15-months. Since the cycle has no starting point, we can assume, notionally, that AEFs one and two

have deployment responsibilities January through March of a given year. Upon relief from AEFs three and four, AEFs one and two return to home-station in April, where they spend the following 10 months training and recuperating from the rigors of deployment activities. The subsequent two months are then spent preparing to deploy on the next AEF deployment rotation (Department of the Air Force, 1999).

Former Secretary of the Air Force, Whitten Peters, cited that the benefits of a properly structured AEF are many. Firstly, only 20 percent of the forces will be deployed, while 80 percent are available at home station for training. Secondly, since each unit knows what AEF they support, personnel are able to plan for upcoming duty, supposedly increasing morale and retention. Thirdly, by providing this schedule, access to the total force is enhanced since the reserve forces will also be able to plan for upcoming commitments (Peters, 2000).

The AEF concept has been successfully executed numerous times. The first three AEF deployments to Bahrain, Jordan, and Qatar attained the bulk of their tasked sorties and were each able to launch their first sortie within 24 hours of landing in theater. An item of significance is the fact that each of the airfields maintained a well-developed infrastructure (Titus, 2002). The Air Force Journal of Logistics states that an AEF deployment without the use of prepositioned assets is unattainable under the current logistics processes. It further states that the bombs on target with 48 hours of an execution order criteria is only achievable when deploying to a near fully operational airfield, much like those of Bahrain,

Qatar, and Jordan (Galway, 1999). Deployment to an austere location can obviously lengthen the process.

Secretary Peters cited success in Operation Allied Force, noting that the USAF deployed to 21 separate expeditionary bases and provided 93 percent of replacement parts to forward bases within 3.7 days. He further pointed out that AEF fighting forces were able to achieve a 92 percent mission capable rate; however, he doesn't provide information pertaining to how long it took to get bombs on target (Peters, 2000:2).

## **Unit Type Codes**

### *Definition*

Perhaps the easiest way to define the concept of UTCs is to address them with perspective to the systems to which they are interrelated with and support. The Joint Operation and Execution System (JOPES) is an integrated command and control system used for conventional planning, enabling combatant commanders to determine the best methods for accomplishing the tasks assigned by the Joint Chiefs of Staff (JCS) (Department of the Air Force, 1998). It provides the capability to rapidly build new plans or maintain existing plans, while allowing effective management of assets, across the spectrum of operations (mobilization, deployment, employment, sustainment, redeployment). During the plan development phase, the combatant commander's staff and staffs of the service components develop a detailed transportation-feasible flow of resources into the theater in support of the strategic concept. During this phase, the appropriate forces are selected and placed in the deployment timeline to coincide

with in-theater requirements. The combat and support units, along with equipment and supply support information is stored in the Time-Phased Force and Deployment Data (TPFDD) file. The development phase concludes when an Operational Plan (OPLAN), to include the TPFDD, is forwarded to the Chairman of the Joint Chiefs of Staff (CJCS) for review and approval (Department of the Air Force, 1998).

Upon approval of the joint TPFDD, each of the associated components is responsible for providing their tasked requirements. Much like the joint planning process, the Air Force planning process is quite involved and complex, in part due to the number of systems and their interrelationships. A simplified explanation is possible by describing the process, beginning with the Unit Type Code (UTC). A UTC description is a five-digit alphanumeric code assigned to each type unit in the armed forces, which allows the unit to be categorized into a class with units having common distinguishing characteristics. These UTCs are the basic building blocks for determining manpower and logistics support requirements (Department of the Air Force, 1998). Each UTC description has an associated Mission Capability (MISCAP) Statement which defines the mission the UTC is capable of performing. The Manpower Detail and Logistics Detail (LOGDET) lists the specific manpower and passenger/equipment movement requirements, respectively, to support the UTC (Department of the Air Force, 1998).

The Manpower and Equipment Force Packaging System (MEFPAK) provides for developing and describing the above mentioned UTCs and provides a

listing of all standard force packages by UTC. The UTCs are collected in two components of MEFPAK: the Manpower Force Packaging System (MANFOR) and the Logistics Force Packaging System (LOGFOR). These two components are also components of the Contingency Operation/Mobility Planning and Execution System (COMPES) (Department of the Air Force, 1998).

COMPES is the Air Force operations planning system supporting JOPES. It integrates planning data with operations, logistics, manpower, and personnel processes so that planners can develop and access near-real-time data from service and joint systems. JOPES provides the information with which COMPES defines detail and tailoring. COMPES uses many different modules to maintain accurate readiness data and force accountability, and is linked to the USAF War and Mobilization Plan (WMP) system (Department of the Air Force, 1998).

WMP provides the Air Staff and commanders with policies and planning factors. WMP is used to match facilities, personnel, and materials to wartime activities and consists of 5 volumes:

WMP1--Basic Plan and Supporting Annexes

WMP2--Plans Listing and Summary

WMP3--Combat and Support Forces

WMP4--Wartime Aircraft Activity

WMP5--Basic Planning Factors and Data

Additionally, WMP consists of the WMP System, an automated planning tool that includes an integrated database containing WMP and the Air Force Wide UTC Availability and Tasking Summary (AFWUS). There is also a component TPFDD module that allows commands to build UTCs, using Core UTC packages (CUPs), which is in turn uploaded into JOPES. Since the WMP System is integrated into COMPES, changes made in COMPES updates WMP3 data and the TPFDD database in JOPES (Department of the Air Force, 1998).

#### *Core UTCs*

The Core UTC package concept is a methodology used to improve the overall combat capability of the Air Force. The package links specific sourced UTCs to the individual aviation squadrons that provide the necessary functions required to deploy and fight as a unit. The Core UTC package contains specific UTCs from a variety of functional areas to provide the needed command and support functionality. This structure allows a combat unit to deploy anytime, anyplace, and provide the capability to fight in a major regional conflict (Department of the Air Force, 1998).

There are fundamental package types: the Lead Core UTC Package and the Follow-on Core UTC Package. The lead package is designed to be capable of supporting the combat aviation unit with little or no added support at locations configured as bare-base to Main Operating Base (MOB). The lead core package can be planned to a MOB-type bed down and tailored at OPLAN execution to fit the actual location requirements. The follow-on Core UTC package augments

and supports the lead package and is unable to bed down independently in its normal configuration (Department of the Air Force, 1998).

Each core package is subdivided into elements. The Combat Core element includes the combat and combat support UTCs unique to each supporting MAJCOM and each specific linked aviation unit, while the Support Core element is comprised of support UTCs that are bed down dependent, but not necessarily dictated by the type or number of aircraft at the location (Department of the Air Force, 1998). Each Core module is treated as an individual force module and maintained in a master database.

#### *Right Sized UTCs*

An area of continuing concern in AEF planning is the fact that successful AEFs require scalable, tailorable UTCs. However, current UTCs on file are large, developed for MTW, and require substantial tailoring upon reception of a tasking order before deployment execution.

In 2001, the Air Staff drafted a message to supplement AFMAN 10-401, directing the redesign of aviation UTCs, to include the supporting maintenance and munitions UTCs. The message gave specific guidance for fighter and intra-theater airlift units to develop modular, scalable UTCs. Specifically, the UTCs must be *right-sized* (Headquarters United States Air Force, 2001).

The current UTCs are based upon a squadron-sized deployment, which translates to 18-24 aircraft, the size sent to fight a MTW. As of late however, the

United States has found itself in an environment where Small Scale Contingencies (SSC) and steady-state rotations are the norm.

The Air Staff defined *right-sized* by stating that it must provide a building block capability, as opposed to large UTC that must be fragmented before execution. A right sized UTC will be developed to provide a capability for use across a full spectrum of operations, ranging from SSC to MTW.

The plan called to build initial 12-ship UTCs, capable of deploying to any conflict independently, followed by 6-ship follow-on UTCs to augment in theater capability if needed. However, it should be noted that the 6-ship UTC development has been delayed pending further discussion (Pagel, 2002).

The *right sized* UTC should be global, meaning that it can be deployed to any Area of Responsibility (AOR) and also be unit sized so that the entire UTC can be tasked to single unit, but still allow the organization to maintain limited flight operations at home-station.

The right sized concept has been under constant revision. The message referenced previously addressed only aviation UTCs and didn't include support type UTCs. The concept of limited home-station operations is also unclear. There is discussion as whether to even operate a wing that is under heavy deployment tasking, or simply shut down all flight operations for the duration of the deployment (Pagel, 2002). In either case, the right-sizing of the UTC process is on-going in an effort to align UTC composition with the newest Force Module (FM) Concept.

## **Force Modules**

The Secretary of Defense, Donald Rumsfeld, in his annual report to the President of the United States and Congress emphasized that the tenants of the United State's defense plan must based upon dealing with uncertainty. Where the U.S. policy previously focused on nations known to threaten the interests of the United States, today's plan must be hallmarked by adapting to surprise. The United States is unable to predict with substantial confidence who will threaten the nation, but is able to identify trends that provide a potential adversary with a given capability. Instead of planning to fight a specific enemy in a specific region, the U.S. now develops plans to combat unexpected crisis by structuring the forces to combat a capability, rather than an enemy. This capability-based approach relies on the ability to anticipate growing capabilities, and maintain a highly lethal, deployable force to combine with the existing forward stationed forces capable of swiftly defeating the enemy (Rumsfeld, 2002).

### *Definition*

Force Modules (FMs) are defined as planning and executions tools used to define combinations of force capabilities linked together by software contained in JOPES. An FM consists of a combination of combat units, along with required support units and supplies, capable of sustaining operations for a minimum of 30 days. Once a TPFDD is completed, any combination of forces can be linked together through JOPES software, allowing for rapid extraction and manipulation in response to changes in execution planning. JOPES software allows the

modification of existing OPLANS or rapid TPFDD building in the case of a “no-plan” situation (Department of the Air Force, 1998).

### *The New FM*

Without the use of FMs, planners must literally source hundreds of UTCs across many bases in order to load a single TPFDD in JOPES. The FM concept is not a new concept. CUPs were defined as FMs and AEFs were attempts to construct ten units of equal capability for each of the ten AEFs (Pagel, 2002). The UTCs required to support each AEF were to be linked, thereby smoothing the AEF deployment process.

One of the problems noted with the AEF planning process was that the UTCs were not “right-sized”. Many of the aviation UTCs, to include maintenance and munitions, were still based on squadron-sized deployments, consisting of up to 24 aircraft. As previously stated, the current sizes of deployments are approximately 12 aircraft. Additionally, the combat support UTCs were developed without a common framework. For instance, some may be developed based upon a 1000 Population at Risk (PAR), while others are based upon a greater or lesser number. There was no known collective effort to integrate the functions.

Since right-sizing the UTCs was not the norm, modular, scalable approaches were not needed. The FMs were built to be full encompassing and planners were required to tailor *on the fly* once a deployment order was given (Pagel, 2002). Under the current FM concept, the UTCs have been, or are in the

process of being, right-sized. Rather than planning with large UTCs and tailoring down *on the fly*, the new FM is structured to meet the minimum deployment requirements at an austere location with fewer aircraft, building up the deployment size only if warranted. The deployment template provides a standardized method of deployment enabling the provision of capability to meet the requirements of an SSC, while remaining modular and scalable to accommodate special mission requirements or operational environments (Pagel, 2002).

There are currently five FMs under development that are defined by function. UTCs are linked to the appropriate FM according to the mission they will complete.

**Open the Airbase**—this module is designed to be the first into the site in order to conduct a site assessment. Often they will deploy prior to the execution order (C+0). They are responsible for the initial establishment of minimum security, communications, and command and control (C2). This module is the initial deployment regardless of the follow-on mission or aircraft type. This module is scaled down, and designed to depart the site after turning over to the C2 and Establish the Airbase modules.

**C2**—this module is designed to arrive at C+0 to assume C2 responsibilities and establish a deployed command structure.

**Establish the Airbase**—this module provides initial capabilities to set up and operate key systems needed to execute the airbase’s assigned mission capabilities and to set up and operate key systems needed to execute the assigned mission.

**Generate the mission**—this is the aviation package. It is designed to arrive at approximately C+54, allowing the airbase to reach Initial Operating Capability (IOC). Each module consists of operations, maintenance, and additional mission support specific to the aircraft type. They should be able to conduct mission within 36 hour of arrival. The fighter module is the topic of this research and consists of 12 aircraft.

**Operate the Airbase**—this module is the designed to sustain the airbase for a minimum of 30 days, at which time sustainment capability (not an FM) is planned to arrive.

In theory, the new FM concept has many advantages. Firstly, it presents Air Force forces by functional capability, a concept readily understandable by the joint community. Additionally, it provides a clearly aligned force structure that allows for simplified sequencing. Rather than sequencing hundreds of UTCs, only five FMs are sequenced. Since each module is aligned by capability, it ensures the combat forces, expeditionary combat support (ECS), and C2 come together as one. Finally, since the UTCs are tied to FMs and FMs are our baseline deployment measurement, it will become readily apparent to senior leadership

when the Air Force is out of capability. For example, if there are only eight Operate the Airbase modules established Air Force wide, and six are already deployed, then there is only the capability to operate at two other locations. However, if there are no Generate the Mission modules available, than there is obviously no need to set up or operate the other two airbases.

In the development of the modules, what capability is needed in each instance is identified, and then the attempt to source the UTC is accomplished. If it is possible, the entire module will be sourced from the same unit, but in many cases, the module will contain UTCs from many different bases (Pagel, 2002).

Once again, this is simply a new method of short notice deployment. The idea is to deploy in phases, beginning with personnel to establish U.S. presence by opening the airfield, culminating in an infrastructure capable of supporting sustained air operations. In theory the deployment process should be greatly simplified as hundreds UTCs are aligned under modules by function. As a deployment timeline progresses, combat units will deploy aircrew and aircraft into the theater. In many instances, the unit will deploy a moderate number of aircraft, then follow-up with additional aircraft to bolster capability.

### **Aircraft Ground Equipment (AGE)**

AGE is most easily defined as a type of support equipment used in the servicing and maintenance of aircraft. Often times when an aircraft is under inspection or repair, the operation of various aircraft systems is warranted. In order to operate aircraft systems, there are two options: 1) operate the systems using electric and hydraulic power provided by the aircraft or 2) use AGE equipment to provide the electric or hydraulic power.

Additionally, cooling air is often required to cool equipment operating on the ground, heat may be needed to warm a cabin, pneumatic pressure needed to start an engine or service systems, or lighting required simply to aid in the maintenance or inspection process.

The first option, operating aircraft systems has benefits and drawbacks. Of benefit is that the power is always available when needed, so long as the aircraft is available, and the needed power system is not malfunctioning. However, these systems are extremely costly to operate and more costly to repair upon failure than the AGE counterpart. The second option is that of using AGE. AGE is relatively inexpensive to operate, less expensive to repair, and often more reliable than the aircraft system.

Due to the nature of the aircraft maintenance business, a type of AGE will be required any time maintenance is performed on the aircraft. For this reason alone, AGE availability can have a huge impact on the success of a flying mission. However, not all AGE is required to support an aircraft type. Since this thesis is limited to F-16 units, only the powered AGE most often used by the F-16 maintenance personnel will be modeled. This list includes:

- High-pressure Air Compressor (Hi pack)—MC-1A
- Low-pressure Air Compressor (Low pack)—MC-2A
- Liquid Nitrogen Servicing (Nite) Cart—N2 cart
- Cooling Air (C-10)—AM32C-10
- Electrical Power Generator (Dash 60)—AM32A-60
- Hydraulic Test Stand (Mule)—MJ-2A

- External Lighting Unit (Light-all)—NF-2D

## **Previous Studies**

### *Carrico*

Capt Carrico performed a study of Multi-Function Aerospace Support Systems (MASS) in an effort to seek opportunities to improve the overall aircraft maintenance process by developing a MASS unit capable of providing for the functions of multiple legacy AGE units. Carrico used the Integrated Model Development Environment (IMDE) simulation software to model current AGE usage when supporting fighter aircraft sortie generation (Carrico, 1996b).

IMDE was developed on the heels of the Logistics Composite Model (LCOM), a simulation program developed and validated with 1970's technology. Validated sets of sortie generation processes are available in LCOM databases, and once converted, serve as input data for IMDE. The conversion of already validated LCOM databases simplified Carrico's data gathering process (Carrico, 1996a).

In the course of his study, Carrico developed a Work Unit Code (WUC) matrix in an effort to identify which AGE units were required to support different aspects of aircraft maintenance. This matrix consisted of a list of WUCs from LCOM tasks cross referenced to the AGE units required to accomplish each task. This matrix was developed and validated with the assistance of maintenance personnel (Carrico, 1996a).

In modeling AGE reliability in IMDE, Carrico based the mean time between failure (MTBF) of a unit upon an exponential distribution and the mean time to repair (MTTR) a unit upon a lognormal distribution. These are also the LCOM standards. However, it should be noted that in Carrico's experiments, all AGE units shared the same MTBF and MTTR rates. Simulations were run with MTBFs ranging from 20 to 10,000 hours and MTTRs ranging from 2 to 20 hours (Carrico, 1996a). Carrico emphasized the point that these rates are only estimates and further studies would be warranted should the true values differ significantly from those used in the experiment (Carrico, 1996a).

The original implementation of the model used *fly-when-ready* conditions and provided results consisting of AGE utilization and pending requests for those units. The AGE utilization rates ranged from only 26 to 35 percent when based upon table of allowance quantities. These rates proved of little interest for AGE utilization was far short of full capacity, and there were no long waits for equipment that could significantly contribute to lengthy repair delays. For this reason, Carrico altered the experiment to incorporate an LCOM scheduled mission generator and studied different factor's influence upon percent of cancelled missions (PCM) (Carrico, 1996a).

When the AGE MTBF was varied between 20 to 10,000 hours, AGE utilization only decreased from 49.2 percent to 46.78 percent. Additionally, the PCM increased from 2.7 percent to 2.8 percent. When MTTR was varied between 2 to 20 hours, AGE utilization only increased from 46.5 to 49 percent,

while PCM increased from 2.5 to 2.9 percent. Carrico thus concluded that AGE MTBF and MTTR didn't significantly affect the number of cancelled missions (Carrico, 1996a). This lack of sensitivity to MTBF and MTTR variations is most likely due to the aforementioned excess AGE capacity.

Carrico concluded that there were two factors that affected the estimated PCM; shortening the amount of time between scheduled missions and increasing the travel time required to deliver AGE to the aircraft (Carrico, 1996a).

#### *Havlicek*

Jeffery Havlicek used a modified version of Carrico's IMDE model to study the effects of four AGE related factors on aircraft availability and deployability. Havlicek varied AGE design configuration (MASS, legacy AGE, Combined Generator Air Condition, etc), AGE failure rates, AGE repair rates, and AGE travel times in order to evaluate the impact on the estimated PCM. A secondary goal was to evaluate the deployability of different AGE mixes based upon affects on PCM, airlift space requirements, and overall system costs (Havlicek, 1997).

Noting that previous research revealed AGE MTBFs exponentially distributed and MTTRs log normally distributed, he chose to use the rates published by Battelle, Inc for the AGE MTBF and MTTR and used the AGE matrix mentioned in Carrico's research to define AGE usage. It must be noted that where Carrico's study had all AGE units sharing common MTBF and MTTR rates, Battelle provided rates unique to each type of AGE. However, Battelle's

MTBF rates were substantially lower than those published in other research. For this reason Havlicek chose to vary the range of MTBF from the lowest value published by Battelle to double the highest value. In effect, some AGE units that could fail with a mean of 20 hours in the Carrico study could fail in one hour in the Havlicek study. In addressing AGE MTTR, Havlicek used means of one and four, with a standard deviation of 10 percent of the mean. This range encompassed the estimates used by both Battelle and Carrico. The transport of AGE to the aircraft was modeled as both 15 and 45 minutes. All other data required for IMDE was provided by LCOM databases (Havlicek, 1997).

When Havlicek originally attempted verification between his model and that of Carrico, the results differed by 3.9%. At first glance, he attributed the difference to not fully understanding Carrico's input parameters. However, further investigation revealed an anomaly between the average sortie duration published in Carrico's work and the actual values input in the model. Upon reconciliation, the results were essentially equivalent (Havlicek, 1997).

With the new sortie duration, new AGE reliability rates, and AGE requirements based upon the table of allowances, Havlicek performed the simulation numerous times, manipulating each of the factors under study. He found that all factors produced practical and statistical differences in the PCM, to include MTBF and MTTR, but sensitivity was most significant when addressing the interactions of the factors. When Havlicek varied the factors and interactions, the differences in PCMs varied from 1.9 percent to 9.1 percent. At first glance,

this seemed a virtually insignificant amount, but further thought revealed that this equated to an addition 50 sorties during the 30-day period. Due to the differences evidenced by the interactions, Havlicek concludes that more study should be devoted to AGE MTBF, MTTR, and transport times in order to truly predict the effects on PCM (Havlicek, 1997).

Havlicek also concluded that the Combined Generator Air Conditioner was the least expensive option up to 27 deployments. Beyond that, MASS became the least expensive option (Havlicek, 1997).

#### *O’Fearn*

Capt O’Fearn created a queuing simulation in Awesim in attempt to identify essential AGE required to deploy in an AEF deployment. After identification of essential requirements, O’Fearn planned to compare those requirements to the current levels and pare down the deployment requirements in an effort to reduce the logistics tail (O’Fearn, 1999).

Capt O’Fearn opted to model AGE transport during his research, but rather than using 15 or 45 minute transport times as done in previous research, he used a triangular distribution, with a 5 minute lower limit, 30 minute upper limit, and 15 minute mean. He used calendar year 1998 data obtained from Mountain Home AFB to model aircraft failure and repair. AGE required for each repair was based upon expert opinion. O’Fearn chose not to model AGE reliability based upon previous research citing a weak correlation between AGE reliability and PCM.

O’Fearn stated that his results were based upon incomplete AGE data, explaining deficiencies in the demand reported for common AGE for many tasks. He, however concludes, that the current baseline AGE package can be reduced while maintaining the Flying Scheduling Effectiveness (FSE) (O’Fearn, 1999)

*Festejo*

Capt Festejo provided follow-on research to Capt O’Fearn addressing the utilization of Modular Aircraft Support System (MASS) and conventional AGE and the affects on FSE during the first seven days of an AEF deployment (Festejo, 2000).

Festejo modeled the affects of AGE/MASS transport time, as well as MASS reliability on FSE in an effort to determine the appropriate MASS mixture maximizing the number of missions flown while minimizing the logistics footprint. Two different travel times were studied, both with triangular distributions. One had a 5-minute minimum, 15-minute average, and 30-minute maximum, while the other had a 30-minute minimum, 45-minute average, and 60 minute maximum. The second set of times represented travel time to the aircraft and back to the shop (Festejo, 2000).

The MTBFs assigned to the MASS and AGE units were too high to result in failure during the first seven days of the deployment. As a remedy, Festejo reduced the rates of failure to values low enough to induce failure during the simulation so that AGE reliability’s impact on FSE could be studied.

Festejo concluded that MASS/AGE transport time was insignificant in the study, contrary to Halvick's findings, possibly due to the travel time distributions used in this study and the model's methodology for scheduling resources not producing high AGE utilization rates. He also found that the future MASS would have to have an extremely low MTBF or high MTTR in order to affect FSE. Festejo stated concluded that replacing current AGE with MASS modules reduces the deployment footprint while maintaining the overall FSE.

#### *MacKenna*

Capt MacKenna sought to illuminate areas in analyzing AGE needs to assist in determining adequate AGE levels (MacKenna, 2001). MacKenna focused his attention on refining and/or demonstrating a methodology for assessing AGE utilization in a given a scenario, noting the impact on mission capability. This was accomplished by using LCOM, a discrete-event simulation model to analyze aircraft launches and time spent waiting for AGE units. MacKenna varied AGE inventory, MTBF, and MTTR in an effort to identify both excess and shortfalls in AGE resources (MacKenna, 2001).

MacKenna's focus was to analyze the number of Self-Generating Nitrogen Servicing Carts (SGNSC) needed to support operations by analyzing the resulting PCMs to show the effect of different levels of AGE. LCOM was used to drive demand for SGNSC used to determine capacity and utilization of the units.

The MTBF for the SGNSC is not available from engineering data, but Air Combat Command (ACC) provided an expected MTBF of 500 hours and MTTR

of 2 hours derived by expert opinion. MacKenna tested the MTBF values 50, 100 and 500 hours exponentially distributed, and a lognormally distributed MTTR with a standard deviation 29 percent of the mean (MacKenna, 2001).

The results revealed that in supporting a flying schedule using five SGNSCs the flying schedule was sufficiently supported while the AGE was 29 percent utilized. When the number of SGNSCs was reduced to three, support of the flying schedule was not significantly affected, but the average wait time for the SGNSC increased significantly. Altering the MTBF provided no statistical or practical change in the results.

When the simulation was altered to support a *fly when ready* schedule, the results were very similar; however, since there was no schedule to support when using a *fly when ready* scenario, only wait times were analyzed. Reductions in the numbers of SGNSCs produced significant increases in wait time; however, altering the SGNSCs MTBF produced a statistical, but not practical difference in wait times (MacKenna, 2001). The lack of sensitivity to different MTBFs is most likely due to low utilization rates of the units, revealing an abundance of unused capacity.

### **Work Unit Codes**

CAMS is used to track maintenance actions on Air Force aircraft and drones. In order to standardize entries, codes of been developed for recording type of maintenance performed, action taken, when the discrepancy or task was discovered, and the type of malfunction that occurred. In addition, Work Unit Codes (WUC) are used to identify

what system, subsystem, and part on which the task is being performed (United States Air Force, 1976).

The WUC consists of up to five digits, the first two of which identify the major system. The next two digits designate the next two levels of subassembly, while the last digit identifies the third level subassembly, which is the actual part or component. When identifying only the major system, the last three digits will be filled with zeros. For the third, fourth, and fifth digit of the WUC, alphabetic and numeric characters are used to designate each of the next three level assemblies. This notation allows 33 separate identifiers at each level (United States Air Force, 1976).

A technical order referred to as the WUC manual lists each of the codes applicable to each aircraft and drone in the Air Force Inventory as approved by the Air Logistics Center Systems Manager.

## **Scalable Integration Model for Objective Resource Capacity Evaluation (SIMFORCE)**

### *Overview*

There has been numerous simulation softwares developed to simulate aircraft generation models in order to show how changing any number of factors pertaining to the generation process affects production capability and resource utilization. Many of the models proved valuable planning tools; unfortunately, many were also deemed not user-friendly. The Air Force Research Laboratory (AFRL) contracted KLSS to design a simulation model usable by personnel in the field.

Their product was SIMFORCE, a quick-response, affordable desktop tool used to evaluate the impact of user specified operations tempos on logistics resource constraints and sortie rates (KLSS, 2002). SIMFORCE predicts maintenance resource needs based on operational missions. It can be used to predict the effect of either reducing or increasing the quantity of resources and provide the estimated resource use and availability over time, while also providing estimated trends on sortie rates and costs. Like other simulation models, its is intended to be used as a decision making tool, but not to optimize resource mixes or levels.

SIMFORCE was developed within ARENA software, using a standard input, process, and output model. The input is provided via Excel workbooks and a Visual Basic form. All simulation processing is performed by Arena, and output is processed and distributed in Excel workbook format (KLSS, 2002:4). Figure one exhibits the information flow.

In order to operate SIMFORCE, the user must provide information to be used in the simulation. The Excel workbook provides the avenue for the input defining the flying squadron, according to status, operations tempo, and maintenance requirements. Each flying squadron maintains its own flying schedule, also provided by the user. The user must also provide information regarding resources to be used, to include failure and repair rates. The Visual Basic form allows the user to define the direct path and workbook name. It should be noted that each of the workbook pages can be tailored significantly to fit the user's needs (KLSS, 2002).

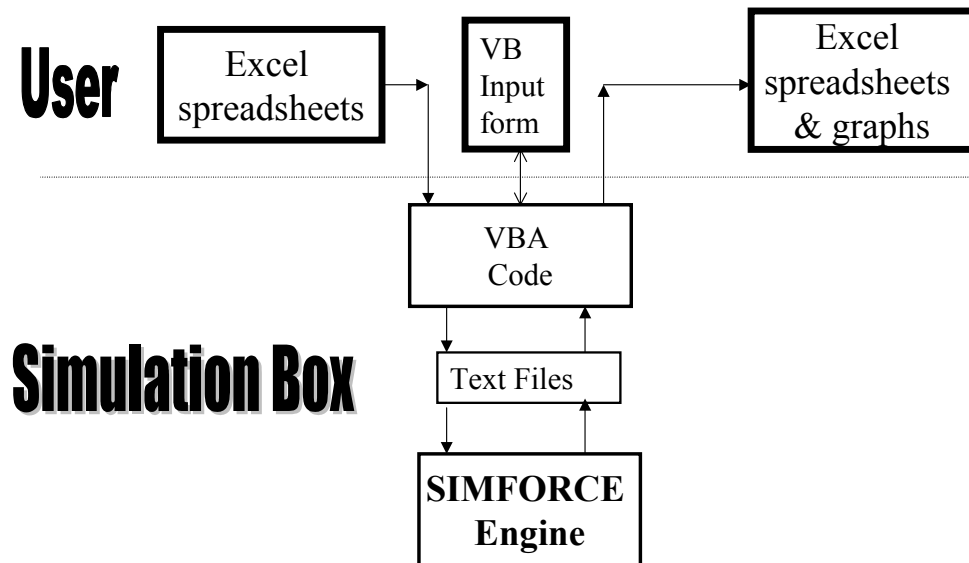


Figure 1. SIMFORCE System Architecture (KLSS, 2002)

Arena performs the SIMFORCE based simulation in accordance with the parameters set on the input sheet. During the simulation, each flying squadron will fly its own schedule for a set amount of workdays. Two of the most readily noticeable limitations are the fact that the flying schedule cannot be changed during the simulation and that the environment is only simulated during the flying week. In other words, if the user inputs a 5-day flying week, the same schedule will be flown each of the 5 days. In addition, no work is performed on the other 2 days of the week. This is not a true to life situation, for squadron flying schedules often change day-to-day, and maintenance is normally performed on those days that aircraft are not flying, particularly in an F-16 unit.

During the simulation, each aircraft goes through a user-defined process. Figure two displays the steps that an F-16 undergoes in order to fly a mission as defined by KLSS.

**STEP DEFINITION BY MDS: F16**

| <b>Step Name</b>       | <b>Fly Step?</b>                 | <b>Chance of Break</b> |
|------------------------|----------------------------------|------------------------|
| Crew Chief Walk Around | <input type="radio"/>            | 1%                     |
| Air Crew Pre-Flight    | <input type="radio"/>            | 1%                     |
| Fly Mission            | <input checked="" type="radio"/> | 1%                     |
| Debrief                | <input type="radio"/>            | 21%                    |
| Unload                 | <input type="radio"/>            | 0%                     |
| Configure              | <input type="radio"/>            | 0%                     |
| Fuel Load              | <input type="radio"/>            | 1%                     |
| Weapons Load           | <input type="radio"/>            | 1%                     |
| Software Load          | <input type="radio"/>            | 1%                     |
| Post Flight            | <input type="radio"/>            | 6%                     |

Figure 2. Sortie Generation Step Identification

During each step of the process, resources are utilized. In order for the step to be initiated, all the required resources must be available. If one or more of the resources are not available because they are in use by another aircraft or inoperable, the start of the step will be delayed until the needed resources are available.

For each of the steps in the generation process there is a probability that the aircraft will experience a failure. In the case of aircraft failure, each system listed by WUC, is scanned independently to identify the system or systems responsible for the

aircraft failure. The aircraft failure can be caused by a single system, multiple systems, or can be a false failure (commonly known as a could not duplicate or CND). For each system that has failed, the user can direct that each part of the system be checked to see if that is the failed part. This is simply used to determine the cost of the failure and identify the part delivery time. Since this research is not concerned with parts costing or supply system effectiveness, all parts required for repair are assumed available and incur the same delivery time logic as established by KLSS. KLSS uses a lognormal theoretical distribution with a 45-minute mean delivery time (KLSS, 2002).

For each failed system, a repair must be accomplished. Each repair requires one or more resources that must be available in order to begin the repair cycle. Once the repair is accomplished, the generation process can continue.

The resources utilized by SIMFORCE are user defined. They can take the form of personnel, equipment, vehicles, or facilities. In all cases, the resources are assigned a failure probability and a mean time to repair. When a resource has failed, it will be unavailable for use until the repair cycle is completed.

SIMFORCE outputs are provided automatically upon completion of the desired number of replications. KLSS has simplified the reports greatly by porting specified output data to Excel worksheets, where it can be viewed as raw data or in graphical format. The user can quickly see sorties per day, aircraft statistics, resource utilization, parts failure data, and cost data. The statistical power provided by Arena output reports are disabled by KLSS in favor of the simplified Excel reports.

SIMFORCE appears to be a user-friendly system, as evidenced by the simple nature of inputs required and easy readability of the output reports. In reducing SIMFORCE's complexity, KLSS has converted simulation into a "black-box" program, whereas the user provides the inputs, is not able to view the simulation model in action, and receives a predetermined amount of output data. In order to make SIMFORCE usable by maintenance managers, much of the power and flexibility provided by ARENA has been disabled. With this in mind, SIMFORCE may prove usable for field level estimations, but should be used in conjunction with a more powerful simulation model when making critical decisions or conducting in-depth analysis.

## **Summary**

This chapter presented a review of the terminology used in the course of this research and of the existing literature pertaining to this topic. The EAF concept was first described providing the framework for understanding how U.S. Air Force deploy. UTCs and FMs were then discussed as they pertain to an EAF deployment. In order to provide understanding as to the importance of support equipment, AGE and its role in aircraft maintenance was described. Research accomplished previously in this area of study was then discussed, laying the foundation for the explanation of SIMFORCE, to include its origins of development, input requirements, operation, and output reports.

### **III. Methodology**

#### **Chapter Overview**

This chapter discusses the research process methodology used to answer the research question presented in Chapter 1. First, the research design will be discussed, followed by a discussion of the simulation model used for this study, to include the development of the model, objects within the simulation, the resources used by the objects, and the simulation experiment process. The chapter concludes with a description of the methods used to analyze the SIMFORCE results.

#### **Research Design**

The method used to answer the research question was composed of three phases. The first phase was to define and obtain any input data required by the simulation software. SIMFORCE inputs are in Excel Workbook format. The input data of concern consisted of objects of the simulation, resources used by the objects, and the process that the objects undergo during the simulation. Phase 2 consisted of utilizing the simulation model to provide estimated sortie production capability and AGE utilization for each treatment. In phase three, the results of each simulation were evaluated to identify any differences in sortie production capability.

#### **SIMFORCE**

##### *Model Development*

SIMFORCE is described as a “quick response, affordable, desktop tool that can be used to evaluate the impact of user specified operation tempos on logistics resource constraints and sortie rates” (KLSS, 2002).

One of its primary advantages over other simulation software is its user-friendliness, because user expertise requirements are restricted to Excel. ARENA is designed as a white-box software, in that all objects and processes are visible to the operator throughout the simulation. In the process of creating SIMFORCE, KLSS has converted the program into what can be described as a black-box, whereas inputs are provided yet the simulation process is obscured from user visibility. Even so, the ease of manipulation is an overwhelming advantage to operators who are not experts in the art of simulation.

The artificial world of the simulation environment is populated by objects. In SIMFORCE, the objects are the aircraft possessed by the flying squadrons. Each of the aircraft assigned to the simulation combine with the other aircraft to form a pool of aircraft available for tasking. Once tasked, the aircraft enters the generation process, defined in SIMFORCE by ten default steps previously identified in Chapter II, each step presenting a possibility of aircraft failure (KLSS, 2002). If at any of these steps the aircraft experiences a failure, the step is halted until the aircraft is repaired.

Resources provide services facilitating the aircraft repair. Table one lists the seven types of AGE identified as resources within SIMFORCE.

Table 1. Age Modeled in SIMFORCE

| <b>ID</b> | <b>Purpose</b>                 | <b>Term</b> |
|-----------|--------------------------------|-------------|
| MC-1A     | High Pressure Air Compressor   | Hi-Pack     |
| MC-2A     | Low Pressure Air Compressor    | Lo-Pack     |
| N2 Cart   | Liquid Nitrogen Servicing Cart | Nite Cart   |
| AM32A-60  | Electrical Power Generator     | Dash 60     |
| MJ-2A     | Hydraulic Test Stand           | Mule        |
| NF-2D     | Lighting Units                 | Lite All    |
| AM32C-10  | Cooling Air                    | C-10        |

An aircraft can require one or more types of resources simultaneously for the accomplishment of scheduled and unscheduled maintenance; however, the aircraft will only use one of each type of AGE required. Carrico created a matrix linking AGE requirements to the 3-digit WUC linked with LCOM action taken codes for F-16's (Carrico, 1996a). Since SIMFORCE utilizes resources based upon 2-digit WUCs, this research will assign AGE simulating a worst case scenario; if any 3-digit WUC task requires a resource, the resource will be required for a 2-digit failure. For instance, if there are four tasks under the 11000 system, three requiring high-pressure compressed air and one not, then the hi pack will be assigned to WUC 11000 100 percent of the time.

#### *Simulation Objects*

Aircraft were the objects simulated within SIMFORCE. The organization of aircraft is defined by the user, and this research modeled 94 aircraft of the same Mission Design Series (MDS), subdivided into the following four squadrons:

Squadron 410—27 aircraft

Squadron 420—23 aircraft

Squadron 430—22 aircraft

Squadron 440—22 aircraft

Each aircraft selected to fly during the simulation underwent a series of steps constituting the sortie production process. The Crew Chief Walk Around and Weapons Load each required a -60 to complete the step. This signified the need for a power-on systems check before flight and after the up-load of munitions. For each step in the process there was a possibility that the aircraft will experience a failure, expressed as the probability listed under the Chance of Break column of Figure 3.

**STEP DEFINITION BY MDS: F16**

| Step Name              | Fly Step?                        | Chance of Break | Break Time Factor | Resource Needed | Resource Quantity |
|------------------------|----------------------------------|-----------------|-------------------|-----------------|-------------------|
| Crew Chief Walk Around | <input type="radio"/>            | 1%              | 1.0               | -60             | 1                 |
| Air Crew Pre-Flight    | <input type="radio"/>            | 1%              | 1.0               |                 |                   |
| Fly Mission            | <input checked="" type="radio"/> | 1%              | 1.0               |                 |                   |
| Debrief                | <input type="radio"/>            | 21%             | 1.0               |                 |                   |
| Unload                 | <input type="radio"/>            | 0%              | 1.0               |                 |                   |
| Configure              | <input type="radio"/>            | 0%              | 1.0               |                 |                   |
| Fuel Load              | <input type="radio"/>            | 1%              | 1.0               |                 |                   |
| Weapons Load           | <input type="radio"/>            | 1%              | 1.0               | -60             | 1                 |
| Software Load          | <input type="radio"/>            | 1%              | 1.0               |                 |                   |
| Post Flight            | <input type="radio"/>            | 6%              | 1.0               |                 |                   |

Figure 3. Steps Workbook in SIMFORCE

If an aircraft broke during any given step, SIMFORCE then determined which system, identified from a list of two-digit WUCs assigned to the MDS, caused the fault. The probability of each system causing the failure was expressed as a percentage of occurrences that the aircraft fails for that particular system. The fault could be caused by a single system, a group of two or more systems, or no system. For each system failure, a mean time to repair (MTTR) was assigned to the resources required to repair the system. The MTTR was obtained from CAMS and was expressed as lognormally distributed (KLSS, 2002).

#### *Resources*

SIMFORCE has the capability to include up to 200 resources, categorized as personnel, equipment, vehicles, or facilities (KLSS, 2002). As previously stated in Chapter I, this research was designed to study the impact of seven different types of powered AGE, used by aircraft for both scheduled and unscheduled events. The user is able to assign resources required to accomplish any number of events, to include the completion of the production process or repair of non-mission capable aircraft. Carrico's matrix was used in this research to assign AGE resources required to complete unscheduled maintenance events.

Like aircraft, AGE units were also capable of failure; however, a reliable source of the proper AGE data has proved difficult to locate. Three different sources within the F-16 communities, ranging from System Program Office (SPO) personnel to maintainers, were contacted during the research process in an effort to capture AGE failure and repair data. In each case, the task was either too difficult or time-consuming to accomplish

during a timeframe reasonable to complete the research. The failure and repair data eventually was derived from the expert opinions of maintenance personnel in the field (Knopp, 2002).

### *Simulation Process*

The purpose of the study was to evaluate and determine the most effective AGE management techniques, paying particular attention to home-station operations concurrent with partial deployed operations. The two methods of AGE management under investigation were pooled and allocated configurations. Under pooled conditions, all AGE was maintained in a central location and available for use by any of the squadrons attached to the flying wing. Allocated conditions existed when the AGE was allocated to each squadron for use only by that squadron. This study looked at numerous different deployment conditions ranging from no aircraft deployed to each squadron participating with 12-ship deployments. Table two illustrates the various deployment conditions and AGE configurations analyzed during this research.

Table 2. Conditions of Study

|                            | Z s c o r e |                   |
|----------------------------|-------------|-------------------|
|                            | P o o l e d | A l l o c a t e d |
| <b>C o n d i t i o n 1</b> |             |                   |
| 4 1 0 H o m e              |             |                   |
| 4 2 0 H o m e              |             |                   |
| 4 3 0 H o m e              |             |                   |
| 4 4 0 H o m e              |             |                   |
| <b>C o n d i t i o n 2</b> |             |                   |
| 4 1 0 D e p l o y e d      |             |                   |
| 4 2 0 H o m e              |             |                   |
| 4 3 0 H o m e              |             |                   |
| 4 4 0 H o m e              |             |                   |
| <b>C o n d i t i o n 3</b> |             |                   |
| 4 1 0 D e p l o y e d      |             |                   |
| 4 2 0 D e p l o y e d      |             |                   |
| 4 3 0 H o m e              |             |                   |
| 4 4 0 H o m e              |             |                   |
| <b>C o n d i t i o n 4</b> |             |                   |
| 4 1 0 D e p l o y e d      |             |                   |
| 4 2 0 D e p l o y e d      |             |                   |
| 4 3 0 D e p l o y e d      |             |                   |
| 4 4 0 H o m e              |             |                   |
| <b>C o n d i t i o n 5</b> |             |                   |
| 4 1 0 D e p l o y e d      |             |                   |
| 4 2 0 D e p l o y e d      |             |                   |
| 4 3 0 D e p l o y e d      |             |                   |
| 4 4 0 D e p l o y e d      |             |                   |

Each simulation used SIMFORCE's *Fly Max Aircraft* schedule logic. With this logic, every available aircraft in the squadron was flown, beginning at the start time input by the user. This model represented what can be considered a home station *surge* in order to produce the most sorties possible with the available resources (KLSS, 2002:19).

SIMFORCE allows the user to identify the status of each aircraft at the beginning of the simulation. Aircraft did not undergo phased inspection for the purposes of this study since phased inspection impact on sortie production is not being explored. All aircraft in this study underwent the same generation process steps.

The simulation was run for 90 days in order to simulate the duration of a typical AEF deployment (Department of the Air Force, 1999). Kelton mentions that most simulation models have a starting point where the model is in an empty-and idle state; however, this is normally not a true representation of reality, especially in the sortie production environment. If statistics are gathered while the model is transitioning from idle to steady state, the model will tend to understate the eventual congestion and be biased toward low values of performance (Kelton, 2002). This is known as initialization bias. ARENA software allows the user to utilize a warm-up period to bring the model to steady state operation, but this feature had been disabled by KLSS. Another option to negate the effects of the bias is to ensure that the model is not configured empty and idle at initialization. This can be accomplished in SIMFORCE by allowing the aircraft to be set at predetermined status before initialization. Unfortunately, there was no method to preset the resources in a similar fashion, meaning that each AGE unit's MTBF clock started at time zero on each replication.

Initially, thirty replications of each situation was accomplished to base the final statistics so the stochastic nature of the SIMFORCE output could be best understood. Thirty replications provided thirty estimates of maximum sortie production capability, a means to test for normality, and the ability to calculate z and t scores.

### **Method of Analysis**

The object of this research was to analyze AGE management methods to decide which method, pooled or allocated, provided for maximum sortie production. The null hypothesis was that differing the AGE management method would produce no difference in average total sortie production capability at a 95% confidence level. The following test statistic was used:

$$z^* = \frac{\bar{x} - \bar{y}}{\sqrt{\frac{s_x^2}{n} + \frac{s_y^2}{m}}}$$

Where:

$\bar{x}$  = the mean daily sortie production with pooled AGE

$\bar{y}$  = the mean daily sortie production with allocated AGE

$z^*$  = the z- score

$s_x^2$  = the sample variance of pooled AGE

$s_y^2$  = sample variance of allocated AGE

$n$  = sample size of pooled AGE

$m$  = sample size of allocated AGE

If the absolute valued z score exceeded 1.96, there was insufficient evidence to accept the null hypothesis and conclude there was a statistical difference in the average total sorties produced when using different AGE management methods. If the absolute valued z score was less than 1.96, there was sufficient evidence to accept the null hypothesis.

Since the first day of the first run in both treatments may have started with the same random number within SIMFORCE, a paired t test was accomplished to ensure the results were based upon independent samples. In this test, the data consisted of n independent selected pairs ( $X_n, Y_n$ ), so the differences between each pair would also be independent from one another ( $D_n = X_n - Y_n$ ). The null hypothesis was that differing the AGE management method would produce no difference in average total sortie production capability at a 95% confidence level. The following test statistic was used:

$$t^* = \frac{\bar{d} - \bar{\Delta}}{s_D / \sqrt{n}}$$

Where:

$\bar{d}$  = the mean difference in sortie production capability

$t^*$  = the z- score

$s_D$  = the sample standard deviation

n = sample size

If the absolute valued t score exceeded approximately 2.045 for a 30 sample test, 2.009 for a 50 sample test, or 1.985 for a 75 sample test, there was insufficient evidence to accept the null hypothesis and conclude there was a statistical difference in the average

total sorties produced when using different AGE management methods. If the absolute valued t score was less than the appropriate statistic as listed above, there was sufficient evidence to accept the null hypothesis. Both the z and t tests were accomplished in accordance with guidance provided by Devore (Devore, 2000).

### **Summary**

This chapter discussed the research process methodology used to answer the research question presented in Chapter 1, beginning with the research design. Next the simulation model used for this study was discussed, to include the development of the model, objects within the simulation, the resources used by the objects, and the simulation experiment process. The chapter concluded with a description of the method used to analyze the SIMFORCE results.

## **IV. Analysis and Results**

### **Chapter Overview**

This chapter answers each of the four investigative questions and ultimately answers the research question of interest. Each of the investigative questions are addressed. The research question is then answered by providing the results of the simulation experiments beginning with all squadrons operating home station and then incrementally deploying squadrons until all four squadrons have aircraft and resources at deployed locations.

### **Investigative Questions One and Two**

1. What quantities of required support equipment are possessed by F-16 units?
2. How is the support equipment allocated currently?

The first question required a review of the unit's TA. Rather than seek out a source to provide a copy of the TA, a series of telephone interviews were conducted with the flight commander, flight chief, and assistant flight chief of Shaw's AGE flight, in order to ascertain the numbers of support equipment possessed (Bays, Jacobs, Knapp, 2002).

In the course of the interviews, the second question was addressed. Currently, the AGE is allocated, each of the flying squadrons having a portion of the equipment to support their own flying operations. The equipment is still "owned and maintained" by the Equipment Maintenance Squadron, but the units are pre-positioned within each flying squadron. Table three illustrates the current allocation of AGE equipment.

Table 3. Compilation of AGE Resources and Allocation (Bays, Knopp, Jacobs, 2002)

| Purpose                        | Term      | Total in Wing | 410 | 420 | 430 | 440 |
|--------------------------------|-----------|---------------|-----|-----|-----|-----|
| Electrical Power Generator     | Dash 60   | 45            | 12  | 11  | 11  | 11  |
| Cooling Air                    | C-10      | 39            | 12  | 9   | 9   | 9   |
| High Pressure Air Compressor   | Hi-Pack   | 10            | 4   | 2   | 2   | 2   |
| Low Pressure Air Compressor    | Lo - Pack | 22            | 7   | 5   | 5   | 5   |
| Liquid Nitrogen Servicing Cart | Nite Cart | 13            | 4   | 3   | 3   | 3   |
| Hydraulic Test Stand           | Mule      | 9             | 3   | 2   | 2   | 2   |
| Lighting Units                 | Lite All  | 52            | 13  | 13  | 13  | 13  |

### Investigative Question Three

- What quantities of support equipment are required to support a 12-ship, austere-base, deployment?

The Installation Deployment Officer (IDO) at Shaw AFB provided the answer to the third investigative question. The following information is a compilation of AGE required to deploy in support of any squadron's 12-ship "right-size" UTC deployment as provided by the IDO (Cluff, 2002).

Table 4. Units Required for a 12-ship AEF Deployment

|                 | Electrical Power Generator | Cooling Air | High Pressure Air Compressor | Low Pressure Air Compressor | Liquid Nitrogen Servicing Cart | Hydraulic Test Stand | Lighting Units |
|-----------------|----------------------------|-------------|------------------------------|-----------------------------|--------------------------------|----------------------|----------------|
| Term            | Dash 60                    | C-10        | Hi-Pack                      | Lo - Pack                   | Nite Cart                      | Mule                 | Lite All       |
| Total to Deploy | 6                          | 6           | 1                            | 3                           | 2                              | 2                    | 6              |

### Investigative Question Four

- The following questions must also be answered to provide the simulation model the necessary input data:
  - What are the failure and repair rates of the possessed support equipment?
  - What are the failure probabilities of an aircraft during each stage of the sortie generation process?
  - What are the failure probabilities of each aircraft system, given an aircraft has experienced a failure?

- What are the support equipment requirements to support the repair of each system failure?

Investigative question four was separated into sub-questions, requiring the failure probabilities of both aircraft and each type of AGE equipment, MTTR for aircraft and each type of AGE equipment, and the AGE required in order to repair each of the aircraft. This is the information required as input for SIMFORCE to model the sortie production environment.

Obtaining failure and repair information for AGE information proved the most difficult task undertaken during the research process. Investigation, as well as prior knowledge, revealed that AGE failure and repair data were maintained within the maintenance records as documented in CAMS. Unfortunately, locating a person with the knowledge, time, and willingness to provide the amount of data needed for analysis proved a fruitless endeavor. Telephonic interviews with the 20<sup>th</sup> EMS AGE assistant flight chief provided these values based upon expert opinion. These data are represented using “days” as the unit of measurement and are displayed in Table five (Jacobs).

Table 5. MTBF and MTTR of Studied AGE Units (Jacobs, 2002)

| <b>Purpose</b>                 | <b>Term</b> | <b>MTBF</b> | <b>MTTR</b> |
|--------------------------------|-------------|-------------|-------------|
| Electrical Power Generator     | Dash 60     | 14          | 2           |
| Cooling Air                    | C-10        | 21          | 2           |
| High Pressure Air Compressor   | Hi-Pack     | 21          | 2           |
| Low Pressure Air Compressor    | Lo - Pack   | 21          | 1           |
| Liquid Nitrogen Servicing Cart | Nite Cart   | 14          | 2           |
| Hydraulic Test Stand           | Mule        | 10          | 3           |
| Lighting Units                 | Lite All    | 30          | 1           |

The failure probability of an aircraft during each stage of the sortie generation process was investigated and provided by KLSS. This involved looking through CAMS data in order to sort out aircraft failures by *When Discovered Codes* (WDC). The results were previously exhibited in Figure two.

KLSS also provided the MTBF and MTTR of each of the aircraft systems, given that the aircraft had experienced a failure. These rates were obtained by analysis of CAMS data. The probability of failure is simply the percentage of failed aircraft that are failed for a particular system. The system MTTR parameters are described in lognormal distributions. Once again, this data is applicable to each aircraft in the simulation and is displayed in Table six (KLSS, 2002).

Table 6. Aircraft Systems MTBF and MTTR

| SYSTEMS BY MDS:  |              | F-16         |
|------------------|--------------|--------------|
| System Unique ID | System       | Failure Rate |
| 11000            | AIRFRAME     | 2.7%         |
| 12000            | CREW STAT    | 0.7%         |
| 13000            | LAND GEAR    | 1.3%         |
| 14000            | FLT CONT     | 0.8%         |
| 23000            | ENGINE       | 0.5%         |
| 24000            | AUX PWR      | 0.6%         |
| 27000            | ENGINE       | 1.5%         |
| 41000            | ENVIRON      | 0.4%         |
| 42000            | ELECTRIC     | 0.8%         |
| 44000            | LIGHTING     | 0.3%         |
| 45000            | PNEU         | 0.2%         |
| 46000            | FUEL         | 1.2%         |
| 47000            | OXYGEN       | 0.2%         |
| 49000            | MISC UTIL    | 0.0%         |
| 51000            | FLT INST     | 0.2%         |
| 55000            | MAL FUNC REC | 0.1%         |
| 62000            | VHF          | 0.1%         |
| 63000            | UHF          | 0.3%         |
| 64000            | INTERCOM     | 0.0%         |
| 65000            | IFF          | 0.1%         |
| 69000            | MISC COMM    | 0.1%         |
| 71000            | ILS/TACAN    | 0.2%         |
| 74000            | FIRE CONT    | 2.0%         |
| 75000            | WPNS DEL     | 2.2%         |
| 76000            | ECM          | 1.0%         |
| 91000            | SURVIVAL     | 0.1%         |
| 97000            | EXPLOSIVE    | 0.0%         |

In order to ensure proper utilization of AGE, identification of the proper AGE unit required to repair each aircraft system was accomplished. The Carrico study provided the bedrock for this information. Carrico's AGE matrix identifies the AGE units required to repair an aircraft as identified by the 3-digit WUC. SIMFORCE identifies failure at the 2-digit (system) level; therefore, the AGE matrix was reconstructed based on a worse case basis. If a unit were required for any task within the system, it would be used each time that system failed. Additionally, Carrico's matrix isolated the hi-pack for use on

three systems, yet never advocates the use of the lo-pack. Previous experience in the field reveals that the lo-pack is used far more often as a source of compressed air than a hi-pack. Fewer hi-packs are possessed for they are notoriously only used when high-pressure air is required, even though they are capable of providing low-pressure air as well. The lo-pack is used most often when low pressure air is required, and low-pressure air is required more often than high-pressure. High-pressure air, is most often needed for accumulators, at which time a liquid nitrogen cart would be used instead of a hi-pack. For this reason, any time compressed air was required, a hi-pack was identified for use 10 percent of the time, while the lo-pack was identified for use in 90 percent of the occurrences. Table seven shows the modified WUC matrix.

Table 7. WUC Matrix

|       |              |  | Hi Pack | Lo Pack | Nite Cart | C-10 | -60 | Mule | Lite All |
|-------|--------------|--|---------|---------|-----------|------|-----|------|----------|
| 11000 | AIRFRAME     |  | y       |         | y         |      |     |      |          |
| 12000 | CREW STAT    |  | y       |         |           |      |     |      |          |
| 13000 | LAND GEAR    |  |         |         |           | y    | y   | y    | y        |
| 14000 | FLT CONT     |  |         |         |           | y    | y   | y    |          |
| 23000 | ENGINE       |  |         |         |           |      |     |      |          |
| 24000 | AUX PWR      |  |         |         | y         | y    | y   | y    |          |
| 27000 | ENGINE       |  |         |         |           |      | y   |      |          |
| 41000 | ENVIRON      |  |         |         |           | y    | y   |      |          |
| 42000 | ELECTRIC     |  |         |         |           | y    | y   |      |          |
| 44000 | LIGHTING     |  |         |         |           | y    | y   |      |          |
| 45000 | PNEU         |  |         |         | y         | y    | y   | y    |          |
| 46000 | FUEL         |  | y       |         |           | y    | y   |      |          |
| 47000 | OXYGEN       |  |         |         |           | y    | y   |      |          |
| 49000 | MISC UTIL    |  |         |         |           | y    | y   |      |          |
| 51000 | FLT INST     |  |         |         |           |      | y   |      |          |
| 55000 | MAL FUNC REC |  |         |         |           | y    | y   |      |          |
| 62000 | VHF          |  |         |         |           |      | y   |      |          |
| 63000 | UHF          |  |         |         |           |      | y   |      |          |
| 64000 | INTERCOM     |  |         |         |           |      | y   |      |          |
| 65000 | IFF          |  |         |         |           | y    | y   |      |          |
| 69000 | MISC COMM    |  |         |         |           |      | y   |      |          |
| 71000 | ILS/TACAN    |  |         |         |           | y    | y   |      |          |
| 74000 | FIRE CONT    |  |         |         |           | y    | y   |      |          |
| 75000 | WPNS DEL     |  |         |         |           | y    | y   |      |          |
| 76000 | ECM          |  |         |         |           | y    | y   |      |          |
| 91000 | SURVIVAL     |  |         |         |           |      |     |      |          |
| 97000 | EXPLOSIVE    |  |         |         |           |      |     |      | y        |

## **Research Question**

In order to determine relative effectiveness of AGE management, flying operations were simulated in a variety of configurations. In one configuration AGE was maintained as a single pool of resources for all four squadrons to draw from, while the other configuration consisted of each of the squadron's allocation of a finite number of each type of AGE, restricted for use by only that squadron. In each of the configurations, treatments were applied beginning with a comparison of each squadron's average total sortie production when there were no deployments occurring, moving to a similar comparison with one 12 aircraft package and its required support equipment deployed. Each AGE management technique was compared at deployment levels ranging from no squadrons deployed to all four squadrons deployed. For the case of this study, a squadron was considered deployed when 12 of its aircraft were off station. If the absolute z score exceeded 1.96, it can be stated with 95% confidence that there was a difference between the mean total sortie production when AGE is pooled and when AGE is allocated to each squadron. A positive actual z score signified that average total sortie production was larger when the AGE was pooled and a negative actual Z score reflected that average total sortie production was larger with allocated AGE. The results of each simulation appeared distributed approximately normal when all assets were located home-station. However, as aircraft and AGE were deployed leaving squadrons to operate with lesser proportions of AGE, the results tended to accumulate large variances and appear to begin departing from normality. All results obtained using the z test were compared to the results of the t test, confirming sample independence.

### No Deployments

With no deployments, the comparison was between each squadron's total sortie production in a 90-day period when each squadron possessed its full complement of aircraft and AGE equipment. Thirty replications were simulated and the results are in table eight.

Table 8. Results From No Deployment Experiment

|           | xbar (pooled AGE) | y bar (allocated AGE) | std dev (pooled AGE) | n     | std dev (allocated AGE) | m     | t* score | t test Stat | Z* score | Z test Stat | Absolute |
|-----------|-------------------|-----------------------|----------------------|-------|-------------------------|-------|----------|-------------|----------|-------------|----------|
| No Deploy |                   |                       |                      |       |                         |       |          |             |          |             |          |
| 410       | 13329.20          | 13308.17              | 31.04                | 30.00 | 29.00                   | 30.00 | 2.98     | 2.045       | 2.71     | 1.96        | 2.71     |
| 420       | 11456.37          | 11505.07              | 27.30                | 30.00 | 32.61                   | 30.00 | -6.7     | 2.045       | -6.27    | 1.96        | 6.27     |
| 430       | 10972.70          | 10950.03              | 23.52                | 30.00 | 31.33                   | 30.00 | 3.58     | 2.045       | 3.17     | 1.96        | 3.17     |
| 440       | 10981.23          | 10959.80              | 30.67                | 30.00 | 33.33                   | 30.00 | 2.54     | 2.045       | 2.59     | 1.96        | 2.59     |

Additional factors considered were under which configuration were the largest occurrences of AGE non-availability and largest occurrences of time spent waiting on AGE as exhibited in table nine.

Table 9. AGE Non-availability and Wait Time With No Deployments

| <b>Not Available Results</b> | <b>Pooled</b>              | <b>Wait Time Results</b> | <b>Pooled</b>          |
|------------------------------|----------------------------|--------------------------|------------------------|
| <b>Resource</b>              | <b>Non Available Total</b> | <b>Resource</b>          | <b>Wait Time Total</b> |
| -60                          | 0                          | -60                      | 0                      |
| C-10                         | 0                          | C-10                     | 0                      |
| Mule                         | 0                          | Mule                     | 0                      |
| Hi                           | 0                          | Hi                       | 0                      |
| Lo                           | 0                          | Lo                       | 0                      |
| Lite                         | 0                          | Lite                     | 0                      |
| Nite                         | 0                          | Nite                     | 0                      |
| <b>Not Available Results</b> | <b>Allocated</b>           | <b>Wait Time Results</b> | <b>Allocated</b>       |
| <b>Resource</b>              | <b>Non Available Total</b> | <b>Resource</b>          | <b>Wait Time Total</b> |
| 430Mule                      | 120                        | 430Mule                  | 122.7                  |
| 440Mule                      | 110                        | 440Mule                  | 109.8                  |
| 440Nite                      | 71                         | 440Nite                  | 7.1                    |
| 420Mule                      | 34                         | 420Mule                  | 4.1                    |
| 410Mule                      | 1                          | 410Mule                  | 0.1                    |
| 420Hi                        | 1                          | 420Hi                    | 0.1                    |
| 410Nite                      | 1                          | 410Nite                  | 0.1                    |
| 420Nite                      | 1                          | 420Nite                  | 0.1                    |

Notice that AGE was always available when the resources were pooled, and no wait time accumulated, yet when allocated, each of the squadrons experienced at least one occurrence of AGE non-availability and wait time accumulated.

Another area of note is that the 420<sup>th</sup> was able to fly more sorties with allocated AGE. This is best explained by understanding that the 420<sup>th</sup> has the same compliment of AGE as the other two 18 PAA squadrons; however, they maintain 23 total aircraft while the 430<sup>th</sup> and 440<sup>th</sup> maintain only 22 each.

#### *Squadron 410 Deployed*

With the 410<sup>th</sup> deployed, a comparison was made between each squadron's total sortie production in a 90-day period when one squadron and its compliment of AGE were removed from the base. In the case of pooled AGE, the resources were removed from the single pool, while in allocated AGE configurations the AGE was simply removed from the deployed squadron's pool of resources. Once again, 30 replications were simulated. The results are in the following table.

Table 10. Results with One Squadron Deployed

| 1 Deploy | xbar (pooled AGE) | y bar (allocated AGE) | std dev (pooled AGE) | n     | std dev (allocated AGE) | m     | T* score | T test Stat | Z* score | Z test Stat | Absolute |
|----------|-------------------|-----------------------|----------------------|-------|-------------------------|-------|----------|-------------|----------|-------------|----------|
| 410      | 7477.93           | 7254.23               | 20.87                | 30.00 | 181.83                  | 30.00 | 6.38     | 2.045       | 6.69     | 1.96        | 6.69     |
| 420      | 11456.00          | 11517.23              | 21.69                | 30.00 | 32.72                   | 30.00 | -9.46    | 2.045       | -8.54    | 1.96        | 8.54     |
| 430      | 10968.70          | 10954.50              | 24.18                | 30.00 | 28.63                   | 30.00 | 2.39     | 2.045       | 2.08     | 1.96        | 2.08     |
| 440      | 10978.10          | 10952.07              | 28.31                | 30.00 | 30.12                   | 30.00 | 4.23     | 2.045       | 3.45     | 1.96        | 3.45     |

Again, take into account the following information concerning AGE non-availability and accumulated time waiting for a resource.

Table 11. AGE Non-availability and Wait Time With One Squadron Deployed

| <b>Not Available Results</b> | <b>Pooled</b>              | <b>Wait Time Results</b> | <b>Pooled</b>          |
|------------------------------|----------------------------|--------------------------|------------------------|
| <b>Resource</b>              | <b>Non Available Total</b> | <b>Resource</b>          | <b>Wait Time Total</b> |
| -60                          | 0                          | -60                      | 0                      |
| C-10                         | 0                          | C-10                     | 0                      |
| Mule                         | 0                          | Mule                     | 0                      |
| Hi                           | 0                          | Hi                       | 0                      |
| Lo                           | 0                          | Lo                       | 0                      |
| Lite                         | 0                          | Lite                     | 0                      |
| Nite                         | 0                          | Nite                     | 0                      |
| <b>Not Available Results</b> | <b>Allocated</b>           | <b>Wait Time Results</b> | <b>Allocated</b>       |
| <b>Resource</b>              | <b>Non Available Total</b> | <b>Resource</b>          | <b>Wait Time Total</b> |
| 440Mule                      | 128                        | 410Mule                  | 954                    |
| 430Mule                      | 119                        | 440Mule                  | 151.4                  |
| 410Mule                      | 89                         | 430Mule                  | 119.6                  |
| 420Mule                      | 37                         | 420Mule                  | 3.8                    |
| 440Hi                        | 22                         | 410Nite                  | 3.1                    |
| 410Nite                      | 19                         | 440Hi                    | 2.2                    |
| 440Nite                      | 17                         | 440Nite                  | 1.6                    |
| 420Nite                      | 2                          | 420Nite                  | 0.2                    |
| 410-60                       | 1                          | 410-60                   | 0.1                    |

The same applied to a one-deployment scenario that applied in a no deployment scenario. The 420<sup>th</sup> was able to fly a more sorties with its allocated compliment of AGE than with pooled; however, it came at the expense of significant accumulation of AGE non-availability and wait time.

#### *Squadrons 410 and 420 Deployed*

With the 410<sup>th</sup> and 420<sup>th</sup> deployed, a comparison was made between each squadron's total sortie production in a 90 day period when 12 aircraft from each squadron, and their compliments of AGE were removed from the base. In the case of pooled AGE, the resources were removed from the single pool, while in allocated AGE

configurations the AGE was removed from the deployed squadron's pool of resources.

Thirty replications were simulated and the results are in table 12.

Table 12. Results With Two Squadrons Deployed

|          | xbar (pooled AGE) | y bar (allocated AGE) | std dev (pooled AGE) | n     | std dev (allocated AGE) | m     | t* score | t test Stat | Z* score | Z test Stat | Absolute |
|----------|-------------------|-----------------------|----------------------|-------|-------------------------|-------|----------|-------------|----------|-------------|----------|
| 2 Deploy |                   |                       |                      |       |                         |       |          |             |          |             |          |
| 410      | 7484.07           | 7206.37               | 27.06                | 30.00 | 227.30                  | 30.00 |          |             | 6.64     | 1.96        | 6.64     |
| 420      | 5434.10           | 1413.50               | 13.63                | 30.00 | 482.59                  | 30.00 |          |             | 45.61    | 1.96        | 45.61    |
| 430      | 10969.07          | 10955.47              | 21.46                | 30.00 | 27.84                   | 30.00 |          |             | 2.12     | 1.96        | 2.12     |
| 440      | 10983.50          | 10937.73              | 20.98                | 30.00 | 88.67                   | 30.00 |          |             | 2.75     | 1.96        | 2.75     |

In each of the cases, the absolute z score revealed that there was a statistical difference in the mean total sortie production in each of the squadrons, while the actual z score revealed that pooled AGE configuration provides the higher total sortie counts.

One of the immediately noticeable problems was the severe loss of sortie production occurring within the 420<sup>th</sup>. It appeared very unlikely that simply changing the AGE configuration would result in such a drastic drop in production. Further investigation revealed that the 420<sup>th</sup>, 430<sup>th</sup>, and 440<sup>th</sup> each had only two hydraulic mules allocated to them, and the 12-ship deployment plan calls for both to be included in the squadron's deployment package. As evidenced by Figure four, the 420<sup>th</sup> aircraft were all rendered unserviceable within the 90-day scenario, due to the lack of hydraulic mules to repair the aircraft.

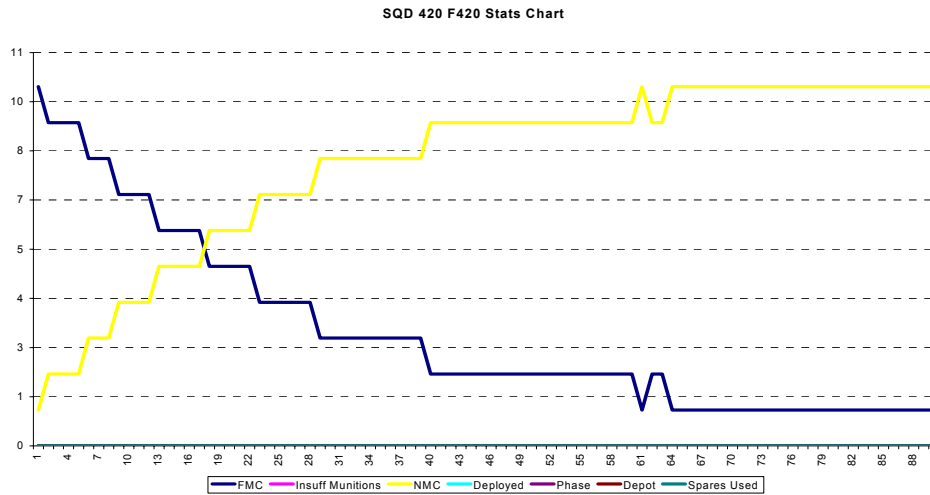


Figure 4. Squadron 420 Mission Capability

This same result happened in all runs that involved the deployment of the 420<sup>th</sup>, 430<sup>th</sup>, or 440<sup>th</sup>. Obviously, no flying wing would allow their fleet to become non-mission capable when the resources needed to prevent the case were available on base. For this reason, the simulations were accomplished again, this time allowing the 420<sup>th</sup> to use the 430<sup>th</sup>'s hydraulic mules. Due to this fact, t tests were only accomplished on experiments in which the mules were shared. The results are as follows:

Table 13. Results With Two Squadrons Deployed Sharing Mule

|          | xbar (pooled AGE) | y bar (allocated AGE) | std dev (pooled AGE) | n     | std dev (allocated AGE) | m     | t* score | t test Stat | Z* score | Z test Stat | Absolute |
|----------|-------------------|-----------------------|----------------------|-------|-------------------------|-------|----------|-------------|----------|-------------|----------|
| 2 Deploy |                   |                       |                      |       |                         |       |          |             |          |             |          |
| 410      | 7484.07           | 7235.90               | 27.06                | 30.00 | 237.68                  | 30.00 | 5.73     | 2.045       | 5.68     | 1.96        | 5.68     |
| 420      | 5434.10           | 5390.87               | 13.63                | 30.00 | 88.35                   | 30.00 | 2.64     | 2.045       | 2.65     | 1.96        | 2.65     |
| 430      | 10969.07          | 10953.40              | 21.46                | 30.00 | 33.42                   | 30.00 | 2.12     | 2.045       | 2.16     | 1.96        | 2.16     |
| 440      | 10983.50          | 10962.60              | 20.98                | 30.00 | 34.60                   | 30.00 | 2.71     | 2.045       | 2.83     | 1.96        | 2.83     |

The absolute z scores, once again revealed a difference in the mean sortie production capability between the AGE configurations, but in this case, the 420<sup>th</sup> was capable in producing 5930 sorties under the allocated AGE concept without degrading the 430<sup>th</sup>'s sortie production capability.

Looking into the issue of AGE non-availability and wait time, the following statistics were revealed:

Table 14. AGE Non-availability and Wait Time With Two Squadrons Deployed

| <b>Not Available Results</b> | <b>Pooled</b>              | <b>Wait Time Results</b> | <b>Pooled</b>          |
|------------------------------|----------------------------|--------------------------|------------------------|
| <b>Resource</b>              | <b>Non Available Total</b> | <b>Resource</b>          | <b>Wait Time Total</b> |
| Mule                         | 0                          | Mule                     | 0                      |
| -60                          | 0                          | -60                      | 0                      |
| C-10                         | 0                          | C-10                     | 0                      |
| Hi                           | 0                          | Hi                       | 0                      |
| Lo                           | 0                          | Lo                       | 0                      |
| Lite                         | 0                          | Lite                     | 0                      |
| Nite                         | 0                          | Nite                     | 0                      |
| <b>Not Available Results</b> | <b>Allocated</b>           | <b>Wait Time Results</b> | <b>Allocated</b>       |
| <b>Resource</b>              | <b>Non Available Total</b> | <b>Resource</b>          | <b>Wait Time Total</b> |
| 430Mule                      | 135                        | 410Mule                  | 984.5                  |
| 440Mule                      | 102                        | 420Nite                  | 287.3                  |
| 410Mule                      | 90                         | 430Mule                  | 135.2                  |
| 420Nite                      | 82                         | 440Mule                  | 106                    |
| 440Nite                      | 79                         | 420Hi                    | 17.7                   |
| 440Hi                        | 38                         | 440Nite                  | 7.9                    |
| 430Hi                        | 25                         | 440Hi                    | 5.7                    |
| 420Hi                        | 18                         | 430Hi                    | 5                      |
| 410Nite                      | 15                         | 410Nite                  | 1.6                    |
| 420C-10                      | 6                          | 420C-10                  | 0.6                    |
| 420Lo                        | 3                          | 420Lo                    | 0.3                    |

In the case of both the 410<sup>th</sup> and 420<sup>th</sup> squadrons deployed, if the wing were to allot the AGE to each of the four squadrons, each of the four squadrons would be affected in the area of AGE non-availability and wait time.

*Squadrons 410, 420, and 430 deployed*

In this case 12 aircraft and their compliments of AGE were removed from the production environment simulating that all three squadrons were deployed to three separate locations, leaving portions of their squadron home station to operate along with

the 440<sup>th</sup>, which was not deployed. To ensure that the 420<sup>th</sup> and 430<sup>th</sup> didn't allow their fleet to become non-mission capable due to the full deployment of their hydraulic mules, the 420<sup>th</sup> was allowed to use the 410<sup>th's</sup> remaining mule, while the 430<sup>th</sup> was allowed to use the 440<sup>th's</sup> mules. Table 15 reveals the results of a 30-replication experiment.

Table 15. Results of 30-Replication Experiment With Three Squadrons Deployed

| 3 Deploy | xbar (pooled AGE) | y bar (allocated AGE) | std dev (pooled AGE) | n     | std dev (allocated AGE) | m     | t* score | t test Stat | Z* score | Z test Stat | Absolute |
|----------|-------------------|-----------------------|----------------------|-------|-------------------------|-------|----------|-------------|----------|-------------|----------|
| 410      | 7482.10           | 7273.28               | 22.55                | 50.00 | 182.46                  | 50.00 | 8.09     | 2.009       | 8.03     | 1.96        | 8.03     |
| 420      | 5430.10           | 5406.62               | 20.18                | 50.00 | 73.64                   | 50.00 | 2.14     | 2.009       | 2.17     | 1.96        | 2.17     |
| 430      | 4939.92           | 4852.34               | 21.89                | 50.00 | 90.37                   | 50.00 | 6.24     | 2.009       | 6.66     | 1.96        | 6.66     |
| 440      | 10973.44          | 10952.94              | 27.44                | 50.00 | 37.40                   | 50.00 | 3.53     | 2.009       | 3.12     | 1.96        | 3.12     |

Notice that with so few aircraft in the simulation, the standard deviations associated with the 420<sup>th</sup> and 430<sup>th</sup> were excessive. For this reason, the number of replications were increased in an effort to reduce the variance. The results are as follows:

Table 16. Results Of 50-Replication Experiment With Three Squadrons Deployed

| 3 Deploy | xbar (pooled AGE) | y bar (allocated AGE) | std dev (pooled AGE) | n     | std dev (allocated AGE) | m     | t* score | t test Stat | Z* score | Z test Stat | Absolute |
|----------|-------------------|-----------------------|----------------------|-------|-------------------------|-------|----------|-------------|----------|-------------|----------|
| 410      | 7482.10           | 7273.28               | 22.55                | 50.00 | 182.46                  | 50.00 | 8.09     | 2.009       | 8.03     | 1.96        | 8.03     |
| 420      | 5430.10           | 5406.62               | 20.18                | 50.00 | 73.64                   | 50.00 | 2.14     | 2.009       | 2.17     | 1.96        | 2.17     |
| 430      | 4939.92           | 4852.34               | 21.89                | 50.00 | 90.37                   | 50.00 | 6.24     | 2.009       | 6.66     | 1.96        | 6.66     |
| 440      | 10973.44          | 10952.94              | 27.44                | 50.00 | 37.40                   | 50.00 | 3.53     | 2.009       | 3.12     | 1.96        | 3.12     |

With the reduced variance achieved by the additional replications, the results revealed that there were statistical differences in all cases. Additionally, the number of instances of AGE non-availability and amount of time spent waiting for an AGE unit was severely increased under the allocated AGE configurations, as shown in table 17.

Table 17. AGE Non-Availability And Wait Time With Three Squadrons Deployed

| <b>Resource</b>              | <b>Non Available Total</b>           | <b>Resource</b>          | <b>Wait Time Total</b> |
|------------------------------|--------------------------------------|--------------------------|------------------------|
| Mule                         | 49                                   | Mule                     | 5.2                    |
| -60                          | 0                                    | -60                      | 0                      |
| C-10                         | 0                                    | C-10                     | 0                      |
| Hi                           | 0                                    | Hi                       | 0                      |
| Lo                           | 0                                    | Lo                       | 0                      |
| Lite                         | 0                                    | Lite                     | 0                      |
| Nite                         | 0                                    | Nite                     | 0                      |
| <b>Not Available Results</b> | <b>Allocated Non Available Total</b> | <b>Wait Time Results</b> | <b>Allocated</b>       |
| <b>Resource</b>              | <b>Total</b>                         | <b>Resource</b>          | <b>Wait Time Total</b> |
| 430Nite                      | 324                                  | 430Nite                  | 2874.1                 |
| 440Mule                      | 314                                  | 410Mule                  | 822.3                  |
| 410Mule                      | 90                                   | 430Hi                    | 441.9                  |
| 420Nite                      | 88                                   | 420Nite                  | 212.6                  |
| 430Lo                        | 87                                   | 440Mule                  | 146.3                  |
| 430Hi                        | 82                                   | 420Hi                    | 30                     |
| 430C-10                      | 78                                   | 430Lo                    | 10.9                   |
| 440Nite                      | 72                                   | 430C-10                  | 7.8                    |
| 410Nite                      | 29                                   | 440Nite                  | 7.2                    |
| 440Hi                        | 25                                   | 410Nite                  | 3.1                    |
| 420Hi                        | 18                                   | 440Hi                    | 2.5                    |
| 420C-10                      | 11                                   | 420C-10                  | 1.1                    |
| 420Lo                        | 9                                    | 420Lo                    | 0.9                    |

*All Squadrons Deployed*

In this scenario, 12 aircraft and their compliment of AGE were removed from each of the four flying squadrons, leaving them all to operate with reduced numbers of aircraft and resources. In the allocated AGE configuration, only squadron 410 had a hydraulic mule remaining at home station. All remaining aircraft were allowed to use this mule when needed for reasons previously stated. Once again, the number of replications were increased, this time to 75, in attempt to compensate for the reduced

number of aircraft in the simulation environment. The results are as follows in tables 18 and 19:

Table 18. Results Of 75-Replication Experiment With Four Squadrons Deployed

|          | xbar (pooled AGE) | y bar (allocated AGE) | std dev (pooled AGE) | n     | std dev (allocated AGE) | m     | T* score | T test Stat | Z* score | Z test Stat | Absolute |
|----------|-------------------|-----------------------|----------------------|-------|-------------------------|-------|----------|-------------|----------|-------------|----------|
| 4 Deploy |                   |                       |                      |       |                         |       |          |             |          |             |          |
| 410      | 7248.59           | 7245.48               | 171.70               | 75.00 | 182.22                  | 75.00 | 0.12     | 1.99        | 0.11     | 1.96        | 0.11     |
| 420      | 5265.35           | 5241.80               | 122.94               | 75.00 | 175.88                  | 75.00 | 1.02     | 1.99        | 0.95     | 1.96        | 0.95     |
| 430      | 4795.36           | 4704.64               | 101.99               | 75.00 | 145.88                  | 75.00 | 4.42     | 1.99        | 4.41     | 1.96        | 4.41     |
| 440      | 4785.00           | 4699.36               | 118.50               | 75.00 | 169.18                  | 75.00 | 3.56     | 1.99        | 3.59     | 1.96        | 3.59     |

Table 19. AGE Non-Availability And Wait Time With All Squadrons Deployed

| Not Available Results | Pooled              | Wait Time Results | Pooled          |
|-----------------------|---------------------|-------------------|-----------------|
| Resource              | Non Available Total | Resource          | Wait Time Total |
| Mule                  | 90                  | Mule              | 2958.1          |
| -60                   | 0                   | -60               | 0               |
| C-10                  | 0                   | C-10              | 0               |
| Hi                    | 0                   | Hi                | 0               |
| Lo                    | 0                   | Lo                | 0               |
| Lite                  | 0                   | Lite              | 0               |
| Nite                  | 0                   | Nite              | 0               |
| Not Available Results | Allocated           | Wait Time Results | Allocated       |
| Resource              | Non Available Total | Resource          | Wait Time Total |
| 410Mule               | 1400                | 410Mule           | 3058.9          |
| 440Nite               | 335                 | 430Nite           | 2798.2          |
| 430Nite               | 326                 | 440Nite           | 2718.3          |
| 420Nite               | 90                  | 430Hi             | 1081.9          |
| 440C-10               | 89                  | 440Hi             | 903.6           |
| 430Hi                 | 87                  | 420Nite           | 216.9           |
| 440Hi                 | 87                  | 420Hi             | 21.6            |
| 430Lo                 | 84                  | 430Lo             | 21.5            |
| 430C-10               | 83                  | 440C-10           | 11.2            |
| 440Lo                 | 76                  | 430C-10           | 8.4             |
| 420Hi                 | 24                  | 440Lo             | 7.6             |
| 410Nite               | 20                  | 410Nite           | 2.2             |
| 420C-10               | 18                  | 420C-10           | 1.8             |
| 420Lo                 | 8                   | 420Lo             | 0.8             |

In this situation, the results reveal that for the first two squadrons, there were indifference as to which AGE management concept to use, for the z and t scores revealed no statistical difference between mean sortie production capabilities. However, in the

case of the 430th and 440th, there remained a difference in favor of the pooled AGE concept.

## **Summary**

In this chapter, the investigative questions were first answered, beginning with the number and types of AGE maintained by a flying wing, along with the typical allocation of the units to each squadron. Equipment deployment requirements for a 12 aircraft deployment was then discussed, followed by a presentation of the failure and repair data necessary as input information for SIMFORCE. The chapter then provided the results from the simulation experiments where sortie production capability was compared between a pooled AGE configuration and an allocated AGE configuration. The treatments began with the flying wing participating in no deployments. Sortie production capabilities were compared, as the flying wing incrementally deployed 12 aircraft packages until each of the four flying squadrons had 12 aircraft and the required support equipment off-station.

## **V. Conclusions and Recommendations**

### **Chapter Overview**

This chapter begins with an analysis of the results provided in chapter four in order to draw conclusions as to which AGE management concept should be utilized. Recommendations follow, based upon the analysis and finally, areas of future research are discussed.

### **Conclusions**

This thesis examined the different methods used to manage an Air Force flying wing's pool of AGE, consisting of seven different types of units used in the aircraft sortie generation process. This study compared the estimated total sortie production capabilities of four different squadrons during a 90-day period, while manipulating AGE management methods and deployment levels. For the purpose of this study, the two techniques were either pooled AGE or AGE allocation to each of the four squadrons. Experiments began with no aircraft deployed and continued as each squadron experienced the deployment of 12 aircraft and the AGE required to support the deployment.

A synopsis of the statistical difference analysis is in table 20. It is readily apparent that there is a statistical difference between the means in 18 of the 20 situations, and as shown in chapter four, there are two instances in which the allocated AGE concept provided for higher average total sortie production. Does this imply that a wing should operate in a pooled AGE configuration in all but those two scenarios?

Table 20. Statistical Analysis Results

|           | xbar (pooled AGE) | y bar (allocated AGE) | Statistical Difference<br>in Between Means? |
|-----------|-------------------|-----------------------|---------------------------------------------|
| No Deploy |                   |                       |                                             |
| 410       | 13329.20          | 13308.17              | yes                                         |
| 420       | 11456.37          | 11505.07              | yes                                         |
| 430       | 10972.70          | 10950.03              | yes                                         |
| 440       | 10981.23          | 10959.80              | yes                                         |
| 1 Deploy  |                   |                       |                                             |
| 410       | 7477.93           | 7254.23               | yes                                         |
| 420       | 11456.00          | 11517.23              | yes                                         |
| 430       | 10968.70          | 10954.50              | yes                                         |
| 440       | 10978.10          | 10952.07              | yes                                         |
| 2 Deploy  |                   |                       |                                             |
| 410       | 7484.07           | 7235.90               | yes                                         |
| 420       | 5434.10           | 5390.87               | yes                                         |
| 430       | 10969.07          | 10953.40              | yes                                         |
| 440       | 10983.50          | 10962.60              | yes                                         |
| 3 Deploy  |                   |                       |                                             |
| 410       | 7482.10           | 7273.28               | yes                                         |
| 420       | 5430.10           | 5406.62               | yes                                         |
| 430       | 4939.92           | 4852.34               | yes                                         |
| 440       | 10973.44          | 10952.94              | yes                                         |
| 4 Deploy  |                   |                       |                                             |
| 410       | 7248.59           | 7245.48               | no                                          |
| 420       | 5265.35           | 5241.80               | no                                          |
| 430       | 4795.36           | 4704.64               | yes                                         |
| 440       | 4785.00           | 4699.36               | yes                                         |

The answer lies not in whether there are statistical differences between the mean production capabilities, but whether there are practical differences. Table 21 reveals that in many instances there are statistical differences, but the differences are relatively small and may not warrant the time and effort needed to alter the AGE management configuration.

Table 21. Practical Difference Analysis

|           | xbar (pooled AGE) | y bar (allocated AGE) | Statistical Difference<br>in Between Means? | Numerical<br>Difference | Practical Difference<br>Between the Means? |
|-----------|-------------------|-----------------------|---------------------------------------------|-------------------------|--------------------------------------------|
| No Deploy |                   |                       |                                             |                         |                                            |
| 410       | 13329.20          | 13308.17              | yes                                         | 21                      | no                                         |
| 420       | 11456.37          | 11505.07              | yes                                         | 49                      | yes                                        |
| 430       | 10972.70          | 10950.03              | yes                                         | 23                      | no                                         |
| 440       | 10981.23          | 10959.80              | yes                                         | 21                      | no                                         |
| 1 Deploy  |                   |                       |                                             |                         |                                            |
| 410       | 7477.93           | 7254.23               | yes                                         | 224                     | yes                                        |
| 420       | 11456.00          | 11517.23              | yes                                         | 61                      | yes                                        |
| 430       | 10968.70          | 10954.50              | yes                                         | 14                      | no                                         |
| 440       | 10978.10          | 10952.07              | yes                                         | 26                      | no                                         |
| 2 Deploy  |                   |                       |                                             |                         |                                            |
| 410       | 7484.07           | 7235.90               | yes                                         | 248                     | yes                                        |
| 420       | 5434.10           | 5390.87               | yes                                         | 43                      | yes                                        |
| 430       | 10969.07          | 10953.40              | yes                                         | 16                      | no                                         |
| 440       | 10983.50          | 10962.60              | yes                                         | 21                      | no                                         |
| 3 Deploy  |                   |                       |                                             |                         |                                            |
| 410       | 7482.10           | 7273.28               | yes                                         | 209                     | yes                                        |
| 420       | 5430.10           | 5406.62               | yes                                         | 23                      | no                                         |
| 430       | 4939.92           | 4852.34               | yes                                         | 88                      | yes                                        |
| 440       | 10973.44          | 10952.94              | yes                                         | 21                      | no                                         |
| 4 Deploy  |                   |                       |                                             |                         |                                            |
| 410       | 7248.59           | 7245.48               | no                                          | 3                       | no                                         |
| 420       | 5265.35           | 5241.80               | no                                          | 24                      | no                                         |
| 430       | 4795.36           | 4704.64               | yes                                         | 91                      | yes                                        |
| 440       | 4785.00           | 4699.36               | yes                                         | 86                      | yes                                        |

The definition of “practical difference” is truly subjective based upon a manager’s experience and understanding of local flying commitment requirements. For the purpose of example, I’ve established that an 10 additional sorties per month constitutes a practical difference; therefore, unless the difference between the means exceeds 30 sorties over a 90-day simulation, there will not be strong enough reason to spend the time and effort to change configuration. Table 22 shows the results of the practical difference analysis and establishes a proposed AGE management configuration.

Table 22. Analysis Results

|           | xbar (pooled AGE) | y bar (allocated AGE) | Statistical Difference<br>Between Means? | Numerical Difference<br>Between Means | Practical Difference<br>Between Means? |                                                    |
|-----------|-------------------|-----------------------|------------------------------------------|---------------------------------------|----------------------------------------|----------------------------------------------------|
| No Deploy |                   |                       |                                          |                                       |                                        |                                                    |
| 410       | 13329.20          | 13308.17              | yes                                      | 21.03                                 | no                                     | <b>Pooled AGE</b>                                  |
| 420       | 11456.37          | 11505.07              | yes                                      | 48.70                                 | yes                                    | 410/430/440 indifferent<br>420 allocated           |
| 430       | 10972.70          | 10950.03              | yes                                      | 22.67                                 | no                                     |                                                    |
| 440       | 10981.23          | 10959.80              | yes                                      | 21.43                                 | no                                     |                                                    |
| 1 Deploy  |                   |                       |                                          |                                       |                                        |                                                    |
| 410       | 7477.93           | 7254.23               | yes                                      | 223.70                                | yes                                    | <b>Pooled AGE</b>                                  |
| 420       | 11456.00          | 11517.23              | yes                                      | 61.23                                 | yes                                    | 430/440 indifferent<br>410 pooled<br>420 Allocated |
| 430       | 10968.70          | 10954.50              | yes                                      | 14.20                                 | no                                     |                                                    |
| 440       | 10978.10          | 10952.07              | yes                                      | 26.03                                 | no                                     |                                                    |
| 2 Deploy  |                   |                       |                                          |                                       |                                        |                                                    |
| 410       | 7484.07           | 7235.90               | yes                                      | 248.17                                | yes                                    | <b>Pooled AGE</b>                                  |
| 420       | 5434.10           | 5390.87               | yes                                      | 43.23                                 | yes                                    | 430/440 indifferent<br>410/420 pooled              |
| 430       | 10969.07          | 10953.40              | yes                                      | 15.67                                 | no                                     |                                                    |
| 440       | 10983.50          | 10962.60              | yes                                      | 20.90                                 | no                                     |                                                    |
| 3 Deploy  |                   |                       |                                          |                                       |                                        |                                                    |
| 410       | 7482.10           | 7273.28               | yes                                      | 208.82                                | yes                                    | <b>Pooled AGE</b>                                  |
| 420       | 5430.10           | 5406.62               | yes                                      | 23.48                                 | no                                     | 420/440 indifferent<br>410/430 pooled              |
| 430       | 4939.92           | 4852.34               | yes                                      | 87.58                                 | yes                                    |                                                    |
| 440       | 10973.44          | 10952.94              | yes                                      | 20.50                                 | no                                     |                                                    |
| 4 Deploy  |                   |                       |                                          |                                       |                                        |                                                    |
| 410       | 7248.59           | 7245.48               | no                                       | 3.11                                  | no                                     | <b>Pooled AGE</b>                                  |
| 420       | 5265.35           | 5241.80               | no                                       | 23.55                                 | no                                     | 410/420 indifferent<br>430/440 pooled              |
| 430       | 4795.36           | 4704.64               | yes                                      | 90.72                                 | yes                                    |                                                    |
| 440       | 4785.00           | 4699.36               | yes                                      | 85.64                                 | yes                                    |                                                    |

In the case where all aircraft are on station, squadrons 410, 430, and 440 are statistically affected by changes in the AGE management configuration, but practically, using the pooled concept only provides a mean difference of 22.67 sorties at most. The 420<sup>th</sup> can achieve 48.7 sorties more if they use the allocated AGE concept. However, the total statistical difference in favor of pooled AGE is 65.13 sorties compared to the 48.7 sortie difference with allocated; therefore, pooled AGE is warranted.

Once the 410<sup>th</sup> deploys, the 430<sup>th</sup> and 440<sup>th</sup> remain indifferent, the 410<sup>th</sup> prefers to pool, and the 420<sup>th</sup> prefers to allocate. If the AGE is pooled the 410<sup>th</sup> stands to fly 223.7 additional sorties, while the allocated AGE concept will provide only 61.23 additional sorties. Once again, the recommendation is to pool the AGE.

With the 410<sup>th</sup> and 420<sup>th</sup> deployed, it is readily apparent that those two squadrons have strong incentive to pool AGE, while the two non-deployed squadrons remain practically indifferent. Similarly, when the 410<sup>th</sup>, 420<sup>th</sup>, and 430<sup>th</sup> deploy, those three squadrons stand to produce more sorties home station while AGE is pooled, while the 440<sup>th</sup> remains practically indifferent.

In the last case, where all four squadrons have aircraft and equipment deployed, the 410<sup>th</sup> and 420<sup>th</sup> are statistically indifferent to the AGE management condition, while the 430<sup>th</sup> and 440<sup>th</sup> are capable of producing more sorties under the pooled concept.

In conclusion, pooling assets provides a slight advantage when all assigned aircraft and support equipment are home-station and the evidence in support of AGE pooling grows stronger as more assets are deployed. Finally, when all squadron's are disadvantaged by deployment, AGE pooling is still optimum, though to a lesser extent than previous.

## **Recommendations**

The United States Air Force is organized, equipped, and trained under the Expeditionary Aerospace Force Concept and is poised for deployment on a moments notice. Home-station operations should be aligned under that concept as well. It would prove counterproductive to establish home station operations under a management method that is so probable to change with little or no notice. The optimum AGE management configuration home-station, with reference to average total sortie production capability, is under a pooled asset concept. Evidence supporting this configuration grows stronger as units are deployed.

## **Further Research**

This study does not take into account AGE transport time. Pooling is the optimum configuration of your AGE, but precious aircraft time may be lost waiting on AGE to be delivered from the AGE pool. Prepositioning the AGE in advance to the actual need could in effect nullify the lag caused by the transport time. This is accomplished currently by the allocation of AGE; however, the number of each type of AGE allocated to the squadron ready line is based upon the number of aircraft possessed by each squadron, regardless of how many are scheduled to fly.

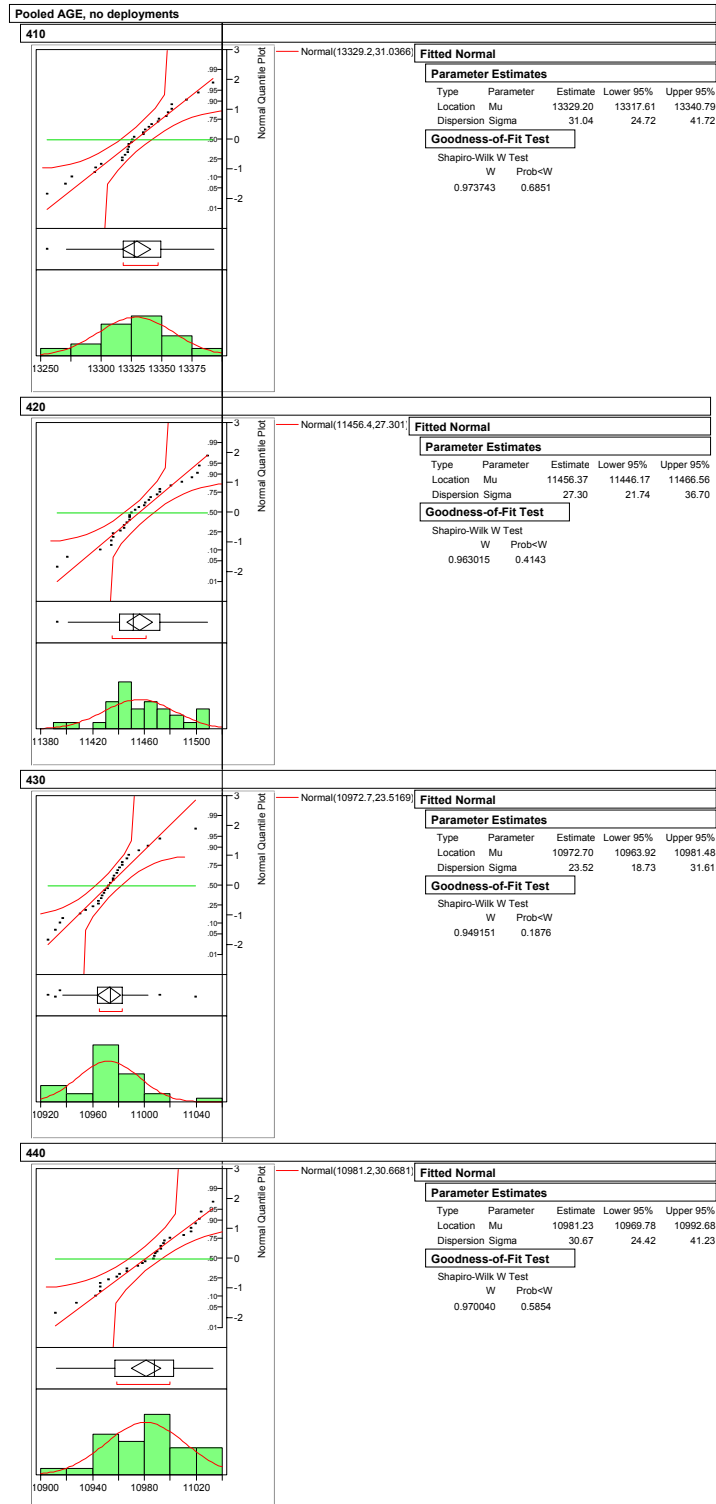
As pooling is the optimum configuration, optimum prepositioning of AGE is worthy of further study. Planning AGE prepositioning based upon the numbers of aircraft scheduled to land or due to fly the following day may reduce the numbers of AGE units required to be prepositioned, and possibly the total size of the AGE pool.

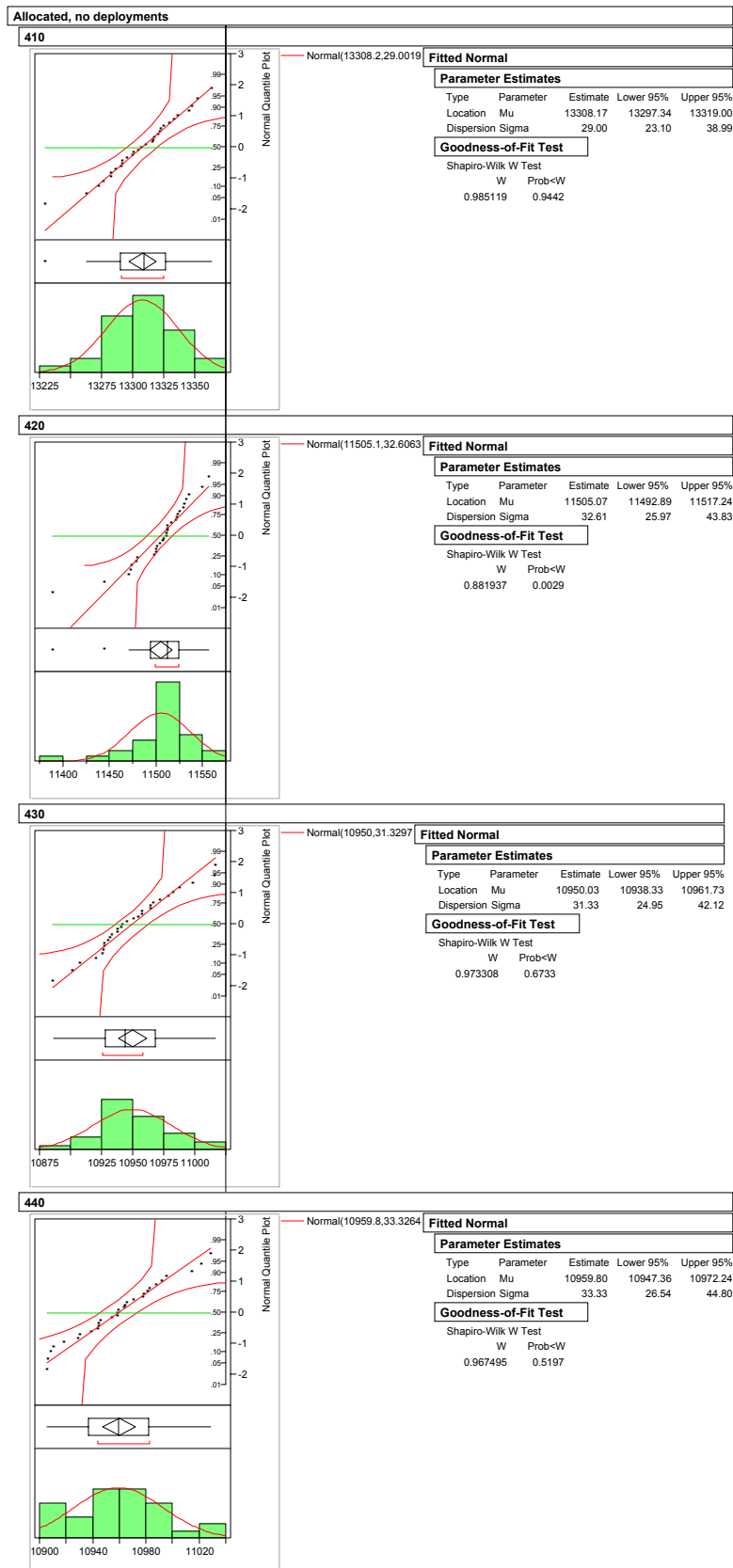
This study looked into F-16 operations at home station as the wing was supporting one or more AEF deployments. Another way to optimize home station sortie production capability may be to reduce the numbers of AGE required for deployment. The F-16 units in this study deployed as stand-alone units and were modeled to deploy with their full compliment of AGE equipment. In reality, an AEF deployment forms into an expeditionary wing composed of different MDS aircraft from different bases. Pooling AGE between these deployed units could certainly reduce the numbers of AGE required to deploy from each station. How to pool the AGE deployment requirements between all units assigned to common FMs may be worthy of additional study.

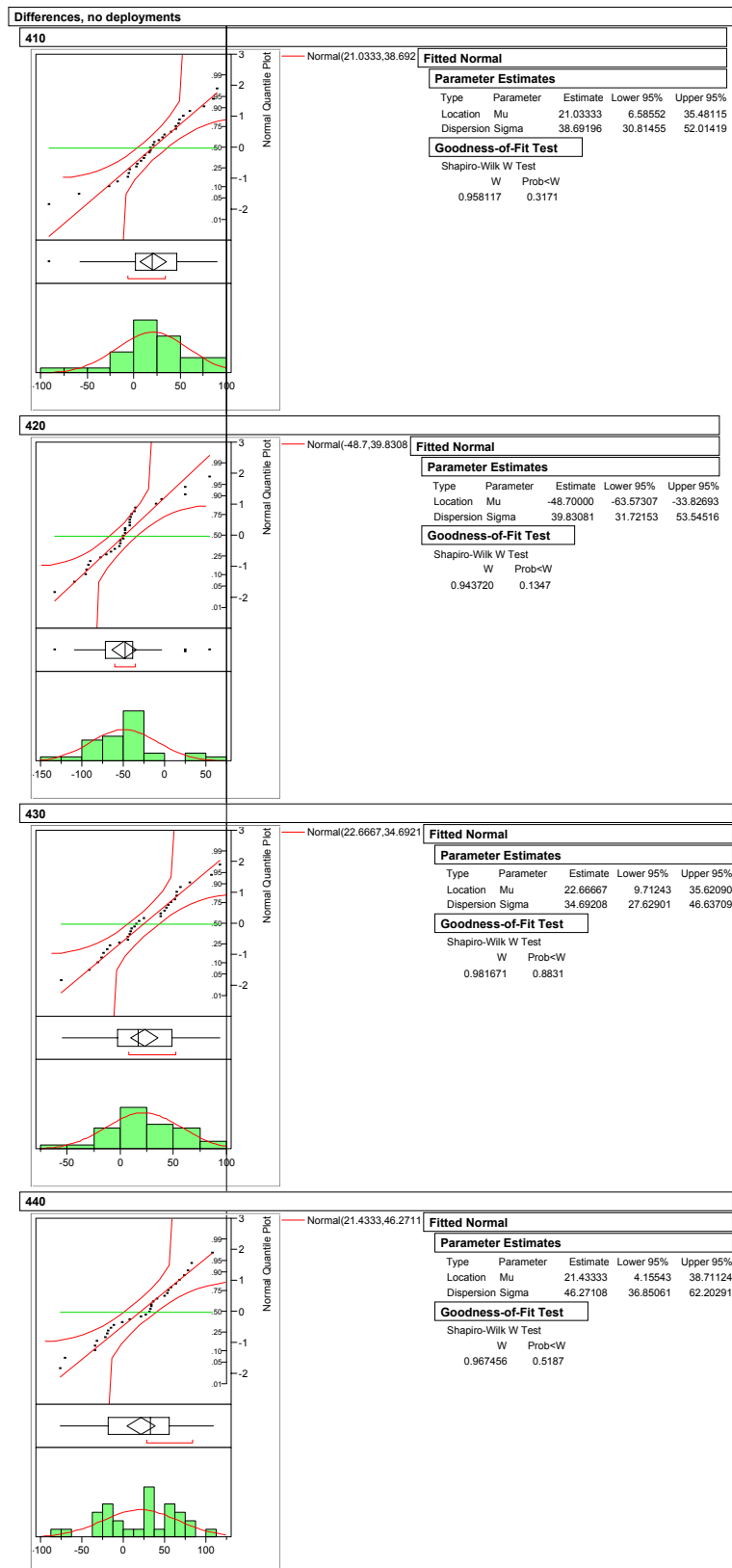
## **Summary**

This thesis was an attempt to analyze average total sortie production capabilities under the pooled AGE management concept and the allocated AGE management concept in an effort to determine the most effective AGE management concept. I believe this objective was met. The objective was not an effort to calculate the optimum AGE levels, nor determine whether sortie rates could be met, rather determine how to best utilize the AGE currently maintained in an effort to maximize home-station flying capability while the wing is supporting AEF deployments. The results have pointed out that resources are most effectively used under a pooled concept, but also expose the possibility that alternate methods of planning the dispersion of resources may reduce the size of the required AGE pool.

## Appendix A.

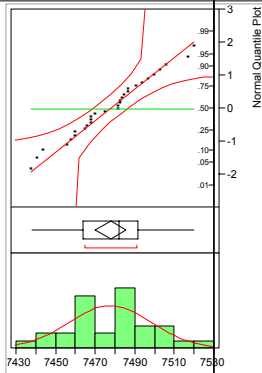






Pooled AGE, one deployment

410



Normal(7477.93,20.8739)

Fitted Normal

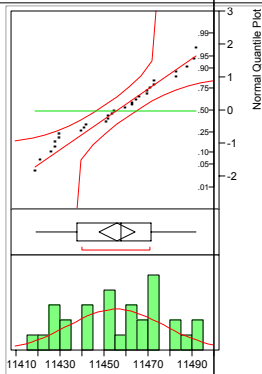
Parameter Estimates

| Type       | Parameter | Estimate | Lower 95% | Upper 95% |
|------------|-----------|----------|-----------|-----------|
| Location   | Mu        | 7477.933 | 7470.139  | 7485.728  |
| Dispersion | Sigma     | 20.874   | 16.624    | 28.061    |

Goodness-of-Fit Test

|                     |          |        |
|---------------------|----------|--------|
| Shapiro-Wilk W Test |          |        |
| W                   | 0.978119 | Prob<W |
|                     |          | 0.8008 |

420



Normal(11456.21,6922)

Fitted Normal

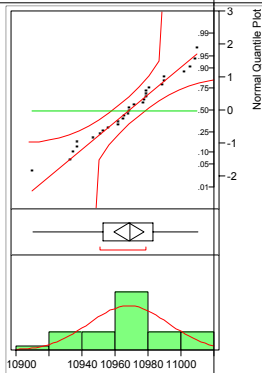
Parameter Estimates

| Type       | Parameter | Estimate | Lower 95% | Upper 95% |
|------------|-----------|----------|-----------|-----------|
| Location   | Mu        | 11456.00 | 11447.90  | 11464.10  |
| Dispersion | Sigma     | 21.69    | 17.28     | 29.16     |

Goodness-of-Fit Test

|                     |          |        |
|---------------------|----------|--------|
| Shapiro-Wilk W Test |          |        |
| W                   | 0.950284 | Prob<W |
|                     |          | 0.2009 |

430



Normal(10968.7,24.1791)

Fitted Normal

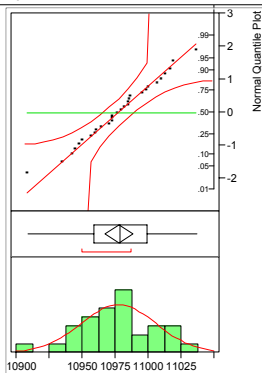
Parameter Estimates

| Type       | Parameter | Estimate | Lower 95% | Upper 95% |
|------------|-----------|----------|-----------|-----------|
| Location   | Mu        | 10968.70 | 10959.67  | 10977.73  |
| Dispersion | Sigma     | 24.18    | 19.26     | 32.50     |

Goodness-of-Fit Test

|                     |          |        |
|---------------------|----------|--------|
| Shapiro-Wilk W Test |          |        |
| W                   | 0.973726 | Prob<W |
|                     |          | 0.6847 |

440



Normal(10978.1,28.3091)

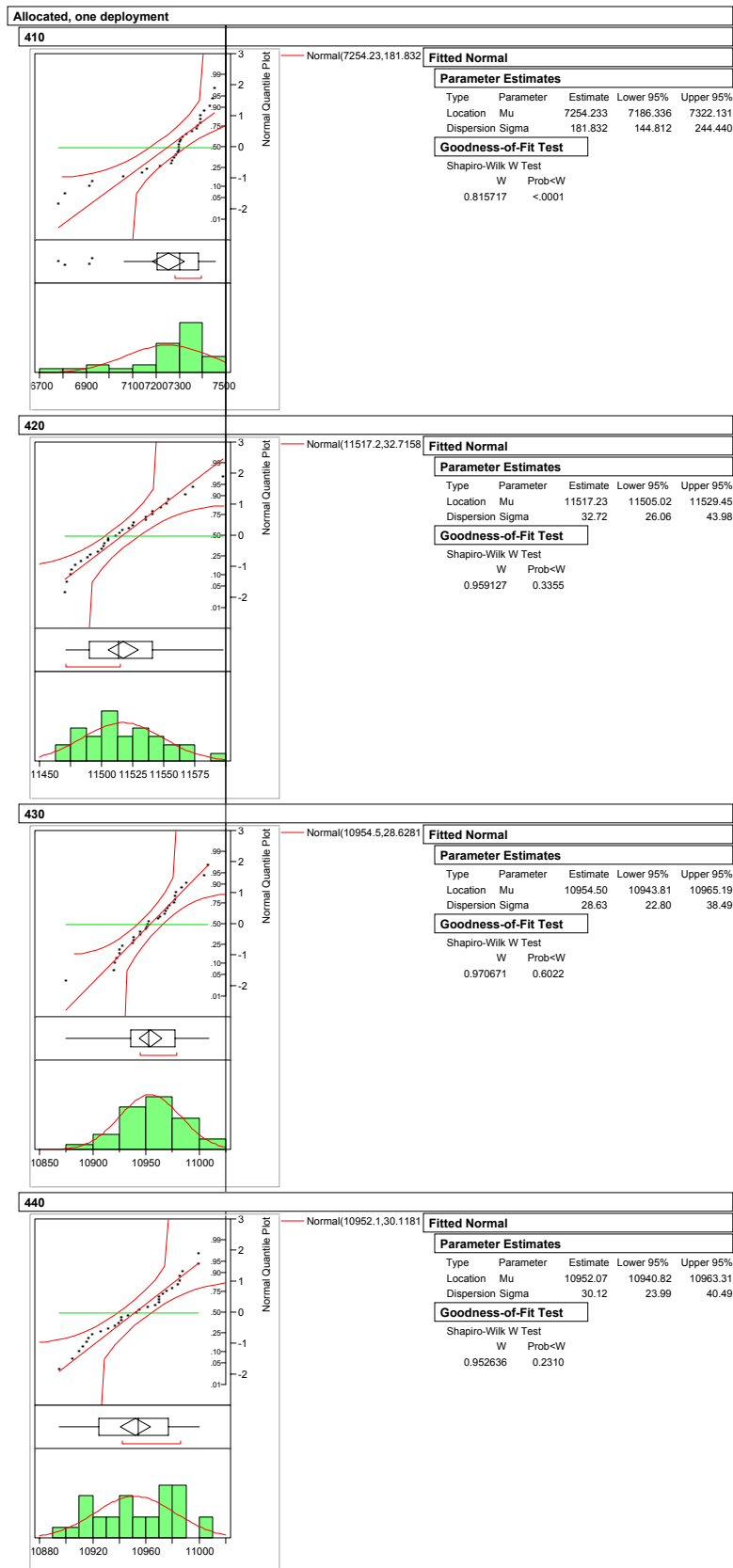
Fitted Normal

Parameter Estimates

| Type       | Parameter | Estimate | Lower 95% | Upper 95% |
|------------|-----------|----------|-----------|-----------|
| Location   | Mu        | 10978.10 | 10967.53  | 10988.67  |
| Dispersion | Sigma     | 28.31    | 22.55     | 38.06     |

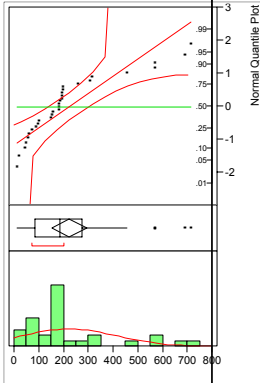
Goodness-of-Fit Test

|                     |          |        |
|---------------------|----------|--------|
| Shapiro-Wilk W Test |          |        |
| W                   | 0.991691 | Prob<W |
|                     |          | 0.9962 |



# Differences, one deployment

410



Normal(223.7,192.11)

Fitted Normal

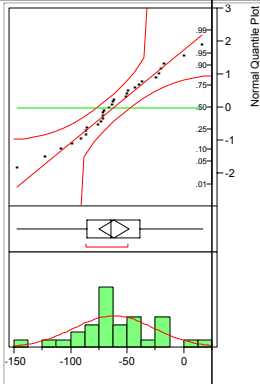
## Parameter Estimates

| Type       | Parameter | Estimate | Lower 95% | Upper 95% |
|------------|-----------|----------|-----------|-----------|
| Location   | Mu        | 223.7000 | 151.9650  | 295.4350  |
| Dispersion | Sigma     | 192.1099 | 152.9977  | 258.2563  |

## Goodness-of-Fit Test

|                     |        |
|---------------------|--------|
| Shapiro-Wilk W Test |        |
| W                   | Prob<W |
| 0.816013            | <.0001 |

420



Normal(-61.233,35.4398)

Fitted Normal

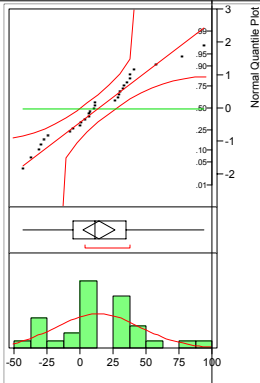
## Parameter Estimates

| Type       | Parameter | Estimate  | Lower 95% | Upper 95% |
|------------|-----------|-----------|-----------|-----------|
| Location   | Mu        | -61.23333 | -74.46677 | -47.99990 |
| Dispersion | Sigma     | 35.43978  | 28.22449  | 47.64224  |

## Goodness-of-Fit Test

|                     |        |
|---------------------|--------|
| Shapiro-Wilk W Test |        |
| W                   | Prob<W |
| 0.986603            | 0.9632 |

430



Normal(14.2,32.5697)

Fitted Normal

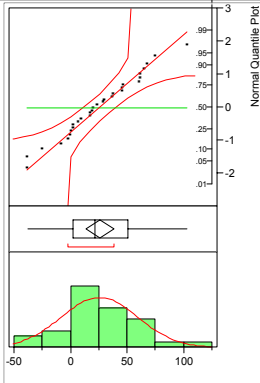
## Parameter Estimates

| Type       | Parameter | Estimate | Lower 95% | Upper 95% |
|------------|-----------|----------|-----------|-----------|
| Location   | Mu        | 14.20000 | 2.03827   | 26.36173  |
| Dispersion | Sigma     | 32.56971 | 25.93875  | 43.78396  |

## Goodness-of-Fit Test

|                     |        |
|---------------------|--------|
| Shapiro-Wilk W Test |        |
| W                   | Prob<W |
| 0.964665            | 0.4514 |

440



Normal(26.0333,33.6764)

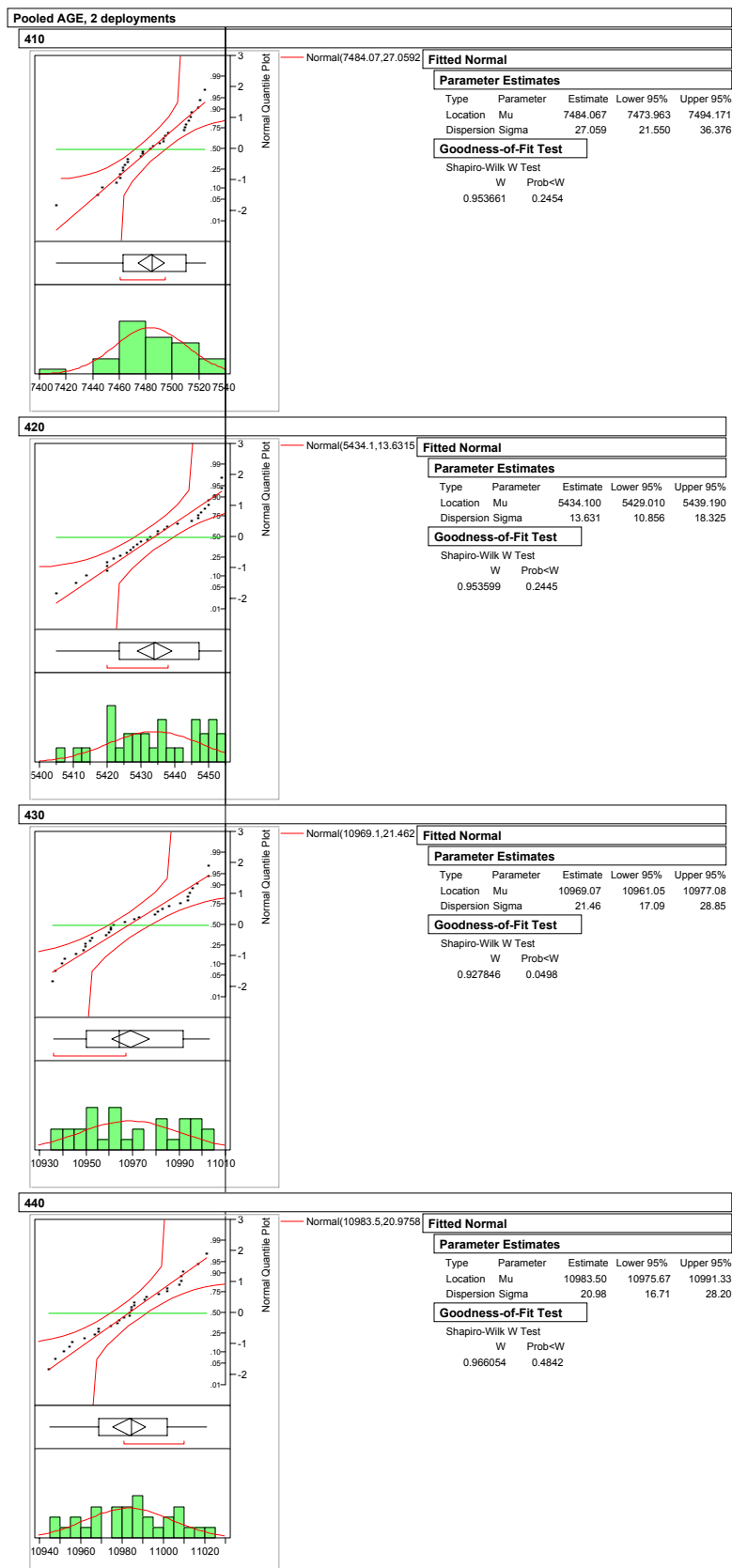
Fitted Normal

## Parameter Estimates

| Type       | Parameter | Estimate | Lower 95% | Upper 95% |
|------------|-----------|----------|-----------|-----------|
| Location   | Mu        | 26.03333 | 13.45835  | 38.60832  |
| Dispersion | Sigma     | 33.67644 | 26.82015  | 45.27174  |

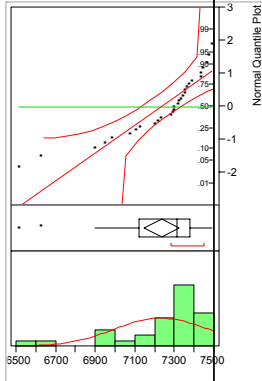
## Goodness-of-Fit Test

|                     |        |
|---------------------|--------|
| Shapiro-Wilk W Test |        |
| W                   | Prob<W |
| 0.979578            | 0.8365 |



Shared Mule, 2 deployments

410



Normal(7235.9,237.681)

Fitted Normal

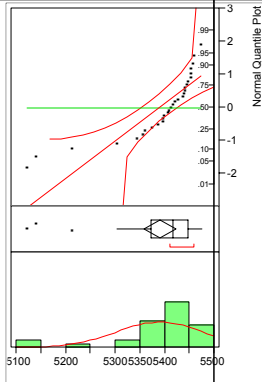
Parameter Estimates

| Type       | Parameter | Estimate | Lower 95% | Upper 95% |
|------------|-----------|----------|-----------|-----------|
| Location   | Mu        | 7235.900 | 7147.149  | 7324.651  |
| Dispersion | Sigma     | 237.681  | 189.291   | 319.518   |

Goodness-of-Fit Test

|                     |        |
|---------------------|--------|
| Shapiro-Wilk W Test |        |
| W                   | Prob<W |
| 0.829834            | 0.0001 |

420



Normal(5390.87,88.355)

Fitted Normal

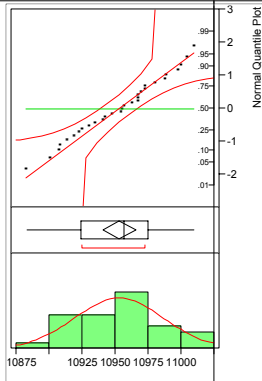
Parameter Estimates

| Type       | Parameter | Estimate | Lower 95% | Upper 95% |
|------------|-----------|----------|-----------|-----------|
| Location   | Mu        | 5390.867 | 5357.874  | 5423.859  |
| Dispersion | Sigma     | 88.355   | 70.367    | 118.777   |

Goodness-of-Fit Test

|                     |        |
|---------------------|--------|
| Shapiro-Wilk W Test |        |
| W                   | Prob<W |
| 0.740115            | <.0001 |

430



Normal(10953.4,33.4165)

Fitted Normal

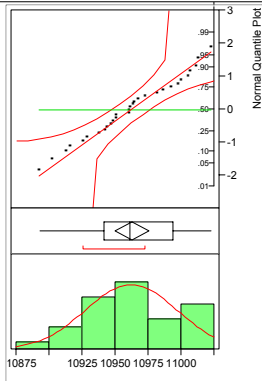
Parameter Estimates

| Type       | Parameter | Estimate | Lower 95% | Upper 95% |
|------------|-----------|----------|-----------|-----------|
| Location   | Mu        | 10953.40 | 10940.92  | 10965.88  |
| Dispersion | Sigma     | 33.42    | 26.61     | 44.92     |

Goodness-of-Fit Test

|                     |        |
|---------------------|--------|
| Shapiro-Wilk W Test |        |
| W                   | Prob<W |
| 0.973081            | 0.6671 |

440



Normal(10962.6,34.5968)

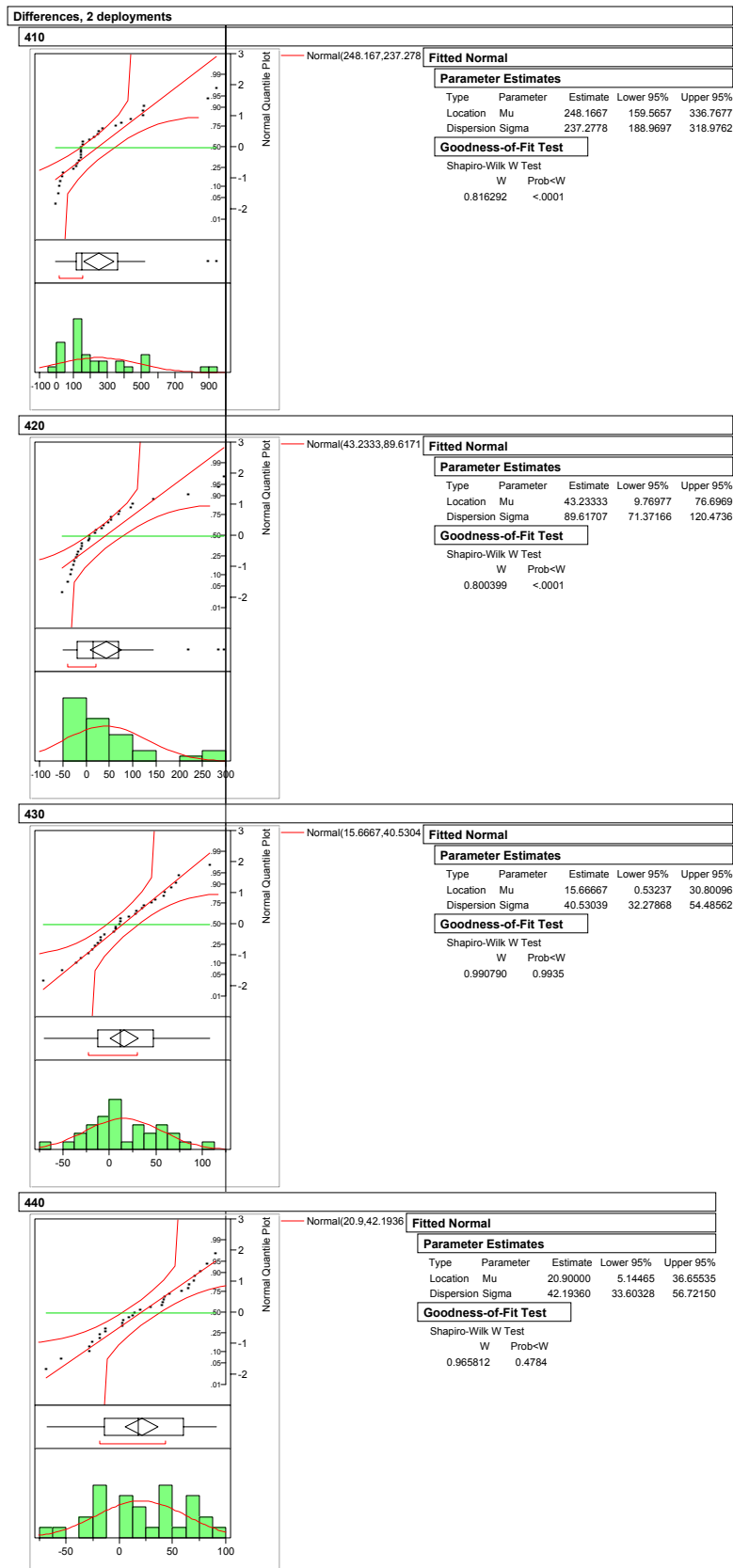
Fitted Normal

Parameter Estimates

| Type       | Parameter | Estimate | Lower 95% | Upper 95% |
|------------|-----------|----------|-----------|-----------|
| Location   | Mu        | 10962.60 | 10949.68  | 10975.52  |
| Dispersion | Sigma     | 34.60    | 27.55     | 46.51     |

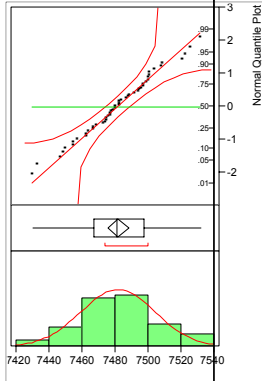
Goodness-of-Fit Test

|                     |        |
|---------------------|--------|
| Shapiro-Wilk W Test |        |
| W                   | Prob<W |
| 0.971537            | 0.6254 |



Pooled AGE, three deployments

410



Normal(7482.1,22.549)

Fitted Normal

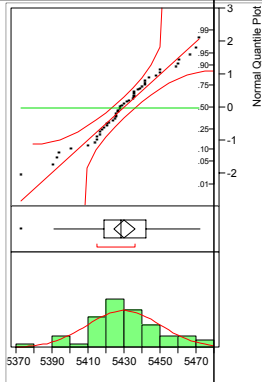
Parameter Estimates

| Type       | Parameter | Estimate | Lower 95% | Upper 95% |
|------------|-----------|----------|-----------|-----------|
| Location   | Mu        | 7482.100 | 7475.692  | 7488.508  |
| Dispersion | Sigma     | 22.549   | 18.836    | 28.099    |

Goodness-of-Fit Test

|                     |        |
|---------------------|--------|
| Shapiro-Wilk W Test |        |
| W                   | Prob<W |
| 0.983692            | 0.8527 |

420



Normal(5430.1,20.183)

Fitted Normal

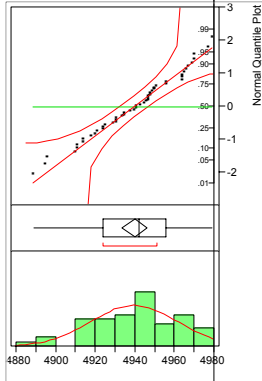
Parameter Estimates

| Type       | Parameter | Estimate | Lower 95% | Upper 95% |
|------------|-----------|----------|-----------|-----------|
| Location   | Mu        | 5430.100 | 5424.364  | 5435.836  |
| Dispersion | Sigma     | 20.183   | 16.860    | 25.151    |

Goodness-of-Fit Test

|                     |        |
|---------------------|--------|
| Shapiro-Wilk W Test |        |
| W                   | Prob<W |
| 0.973098            | 0.4760 |

430



Normal(4939.92,21.891)

Fitted Normal

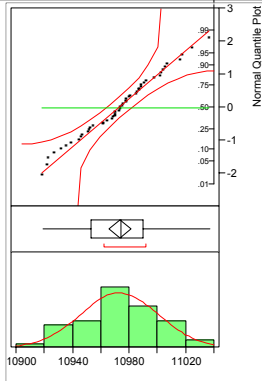
Parameter Estimates

| Type       | Parameter | Estimate | Lower 95% | Upper 95% |
|------------|-----------|----------|-----------|-----------|
| Location   | Mu        | 4939.920 | 4933.699  | 4946.141  |
| Dispersion | Sigma     | 21.891   | 18.286    | 27.279    |

Goodness-of-Fit Test

|                     |        |
|---------------------|--------|
| Shapiro-Wilk W Test |        |
| W                   | Prob<W |
| 0.967510            | 0.3073 |

440



Normal(10973.4,27.4391)

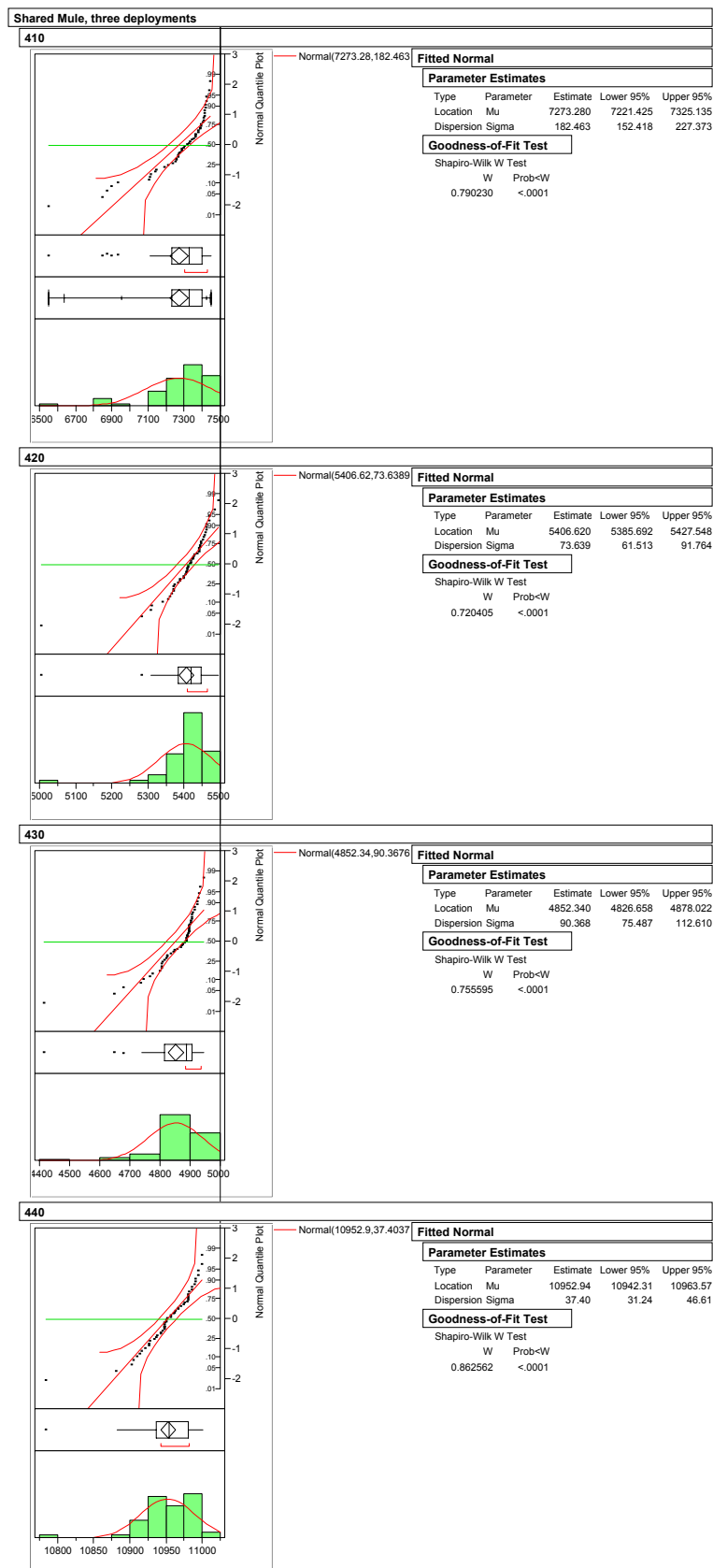
Fitted Normal

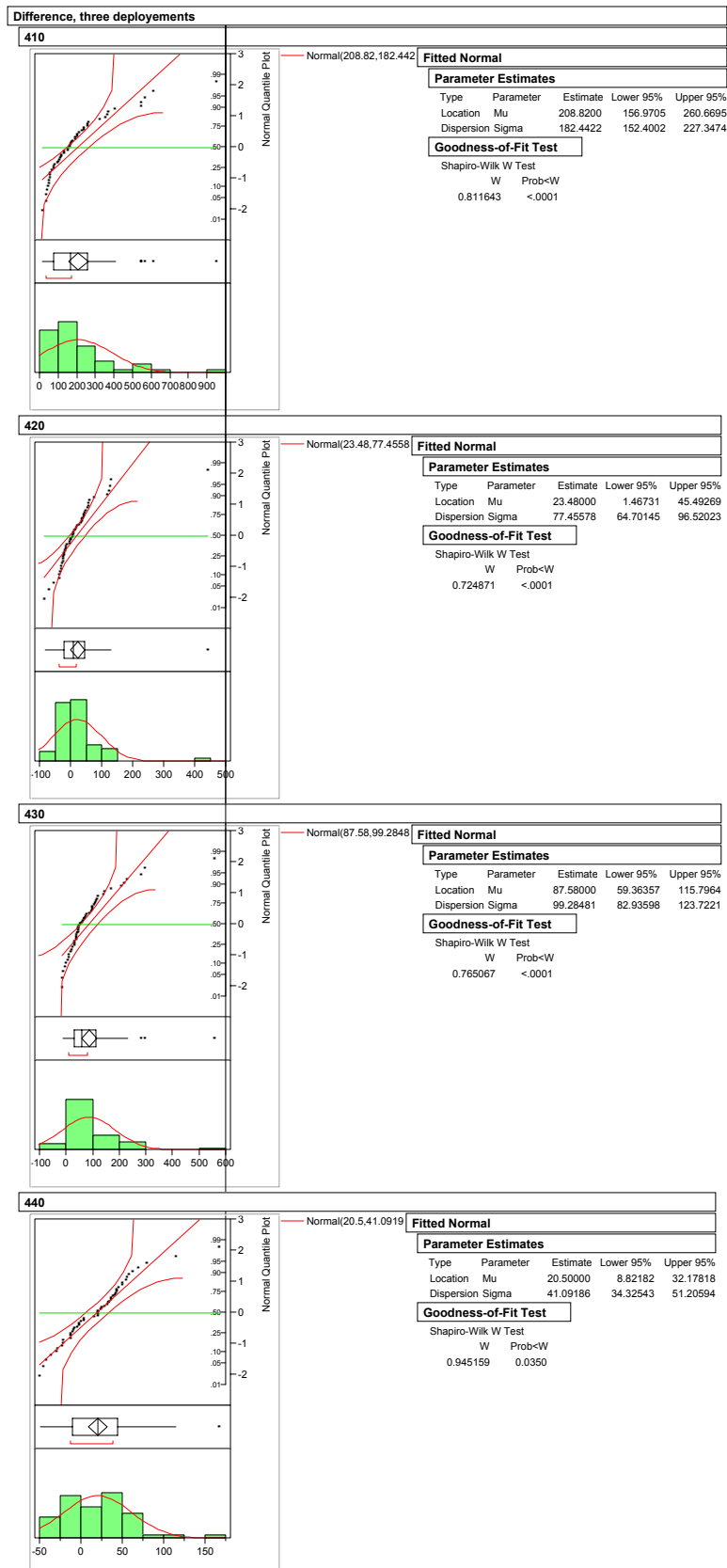
Parameter Estimates

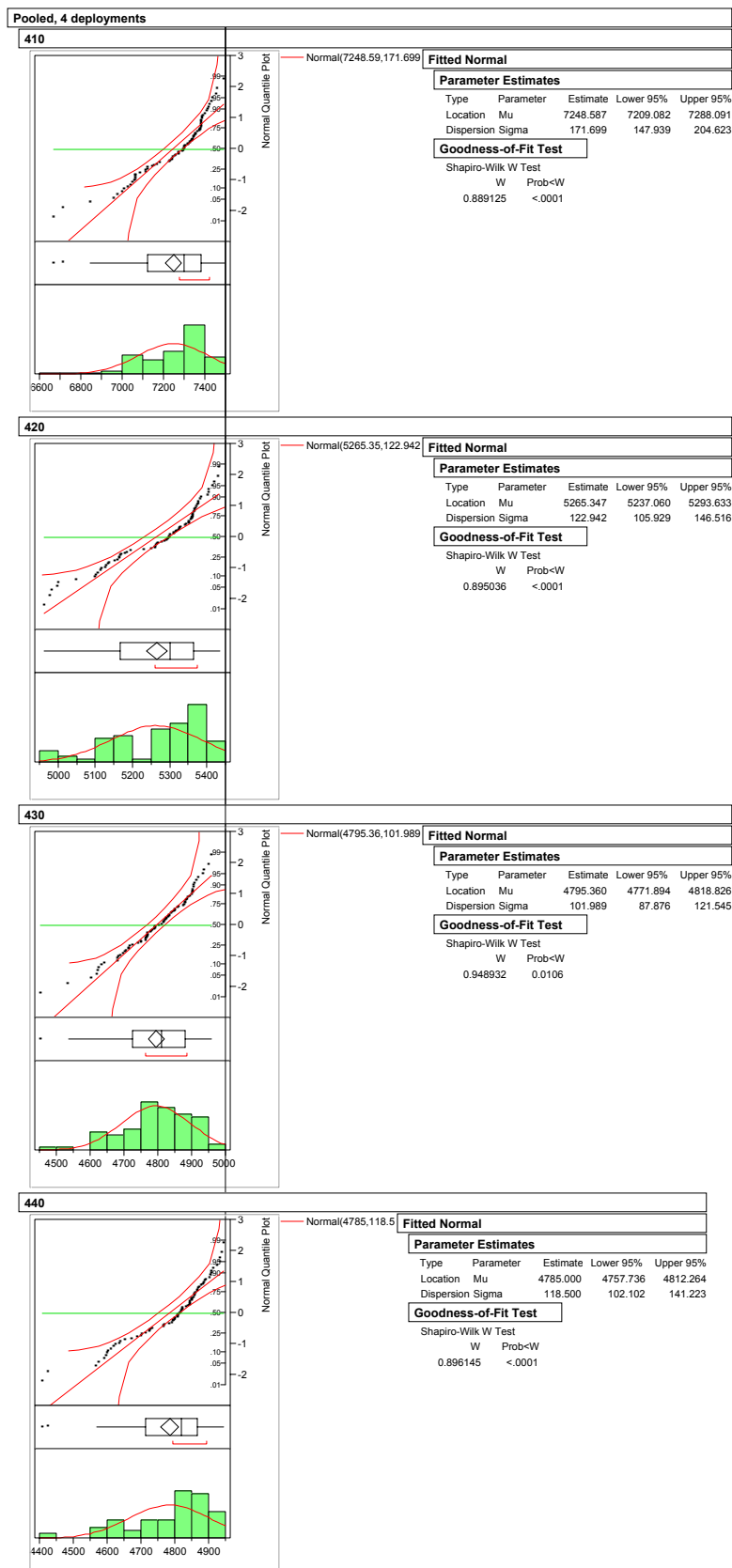
| Type       | Parameter | Estimate | Lower 95% | Upper 95% |
|------------|-----------|----------|-----------|-----------|
| Location   | Mu        | 10973.44 | 10965.64  | 10981.24  |
| Dispersion | Sigma     | 27.44    | 22.92     | 34.19     |

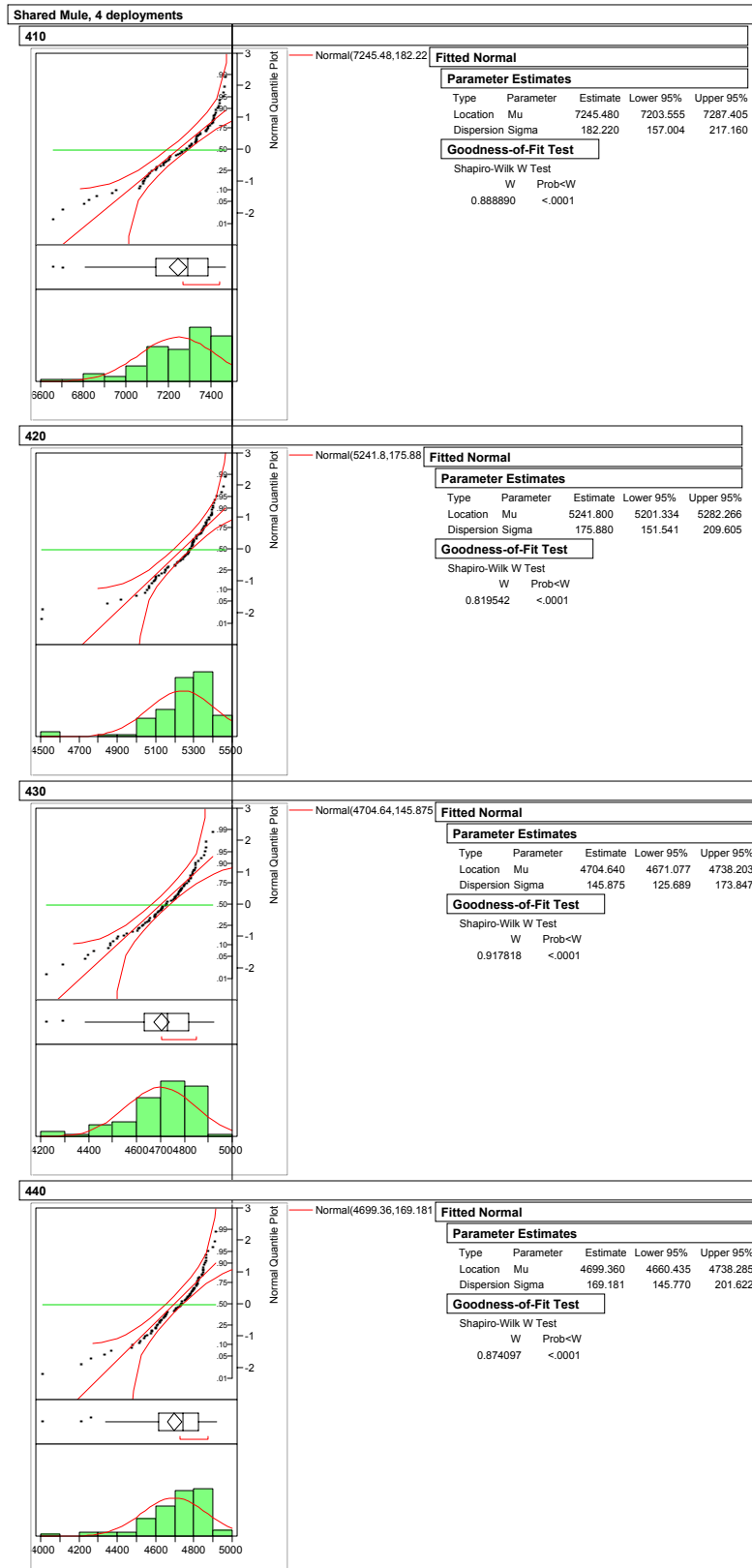
Goodness-of-Fit Test

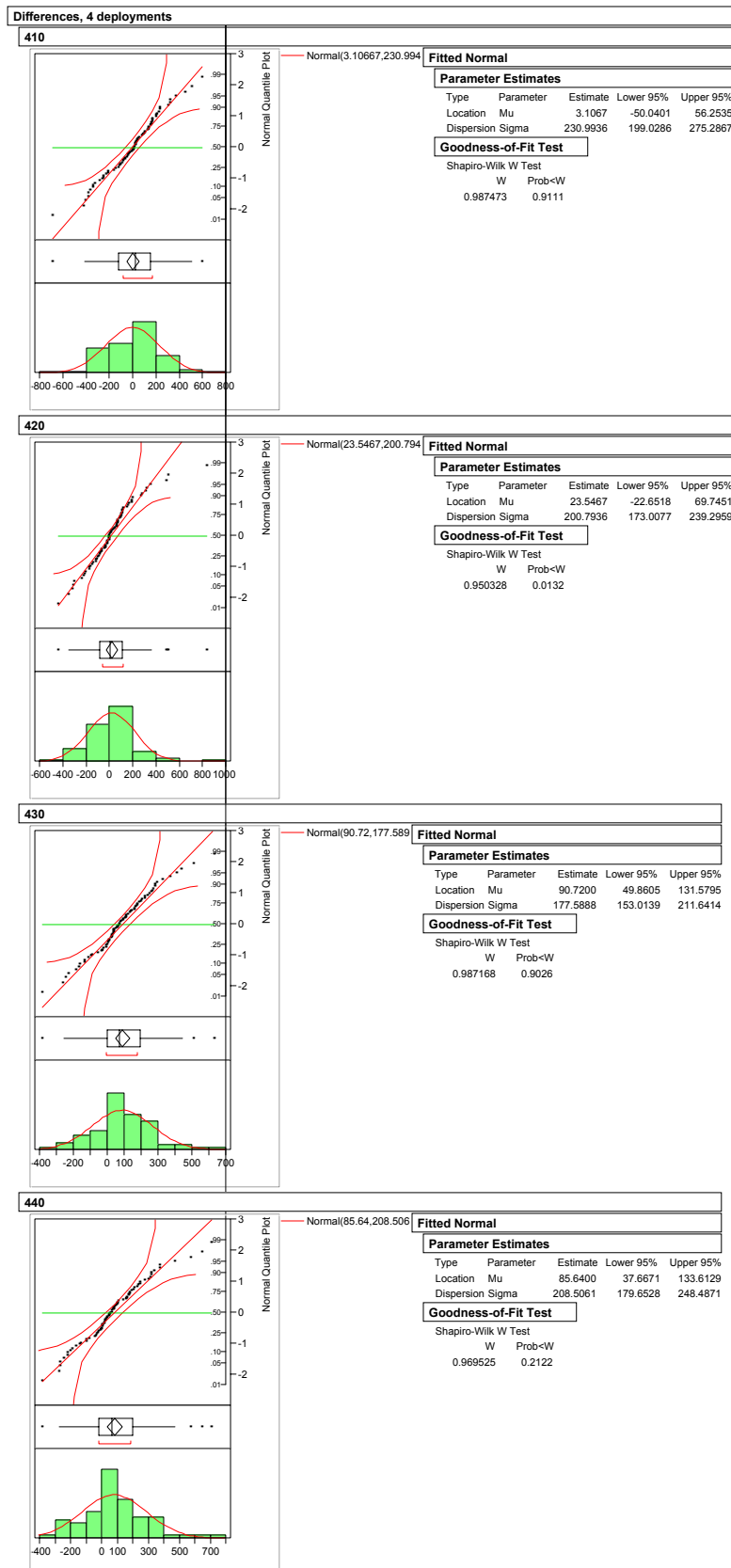
|                     |        |
|---------------------|--------|
| Shapiro-Wilk W Test |        |
| W                   | Prob<W |
| 0.979026            | 0.6925 |











## Appendix B.

| Pooled Age, no deployments |       |       |       |
|----------------------------|-------|-------|-------|
| 410th                      | 420th | 430th | 440th |
| 13323                      | 11501 | 11040 | 10967 |
| 13323                      | 11489 | 10969 | 10928 |
| 13342                      | 11461 | 10970 | 10975 |
| 13371                      | 11503 | 10965 | 11011 |
| 13326                      | 11445 | 10980 | 10987 |
| 13271                      | 11464 | 10976 | 11023 |
| 13256                      | 11449 | 10988 | 11024 |
| 13295                      | 11435 | 10972 | 10988 |
| 13359                      | 11401 | 10955 | 10943 |
| 13335                      | 11472 | 10981 | 10912 |
| 13348                      | 11472 | 10983 | 10993 |
| 13325                      | 11497 | 10967 | 10953 |
| 13354                      | 11481 | 10996 | 11020 |
| 13328                      | 11460 | 11003 | 10946 |
| 13335                      | 11445 | 10937 | 10979 |
| 13356                      | 11449 | 10961 | 10967 |
| 13337                      | 11426 | 10976 | 10990 |
| 13296                      | 11442 | 10926 | 10996 |
| 13359                      | 11453 | 10935 | 10959 |
| 13393                      | 11465 | 10987 | 11016 |
| 13318                      | 11436 | 10974 | 10989 |
| 13347                      | 11449 | 10932 | 11016 |
| 13322                      | 11509 | 11012 | 11000 |
| 13276                      | 11447 | 10983 | 10946 |
| 13320                      | 11393 | 10965 | 10995 |
| 13322                      | 11470 | 10973 | 10993 |
| 13340                      | 11435 | 10951 | 10981 |
| 13318                      | 11450 | 10968 | 10961 |
| 13300                      | 11436 | 10979 | 11033 |
| 13381                      | 11456 | 10977 | 10946 |

| 410                |           |
|--------------------|-----------|
| Mean               | 13329.2   |
| Standard Error     | 5.666477  |
| Median             | 13327     |
| Mode               | 13323     |
| Standard Deviation | 31.03657  |
| Sample Variance    | 963.269   |
| Kurtosis           | 0.370994  |
| Skewness           | -0.334512 |
| Range              | 137       |
| Minimum            | 13256     |
| Maximum            | 13393     |
| Sum                | 399876    |
| Count              | 30        |

| 420                |           |
|--------------------|-----------|
| Mean               | 11456.37  |
| Standard Error     | 4.984455  |
| Median             | 11451.5   |
| Mode               | 11449     |
| Standard Deviation | 27.30098  |
| Sample Variance    | 745.3437  |
| Kurtosis           | 0.327055  |
| Skewness           | -0.058927 |
| Range              | 116       |
| Minimum            | 11393     |
| Maximum            | 11509     |
| Sum                | 343691    |
| Count              | 30        |

| 430                |          |
|--------------------|----------|
| Mean               | 10972.7  |
| Standard Error     | 4.29358  |
| Median             | 10973.5  |
| Mode               | 10965    |
| Standard Deviation | 23.51691 |
| Sample Variance    | 553.0448 |
| Kurtosis           | 1.608142 |
| Skewness           | 0.36661  |
| Range              | 114      |
| Minimum            | 10926    |
| Maximum            | 11040    |
| Sum                | 329181   |
| Count              | 30       |

| 440                |           |
|--------------------|-----------|
| Mean               | 10981.23  |
| Standard Error     | 5.599196  |
| Median             | 10987.5   |
| Mode               | 10946     |
| Standard Deviation | 30.66806  |
| Sample Variance    | 940.5299  |
| Kurtosis           | -0.522906 |
| Skewness           | -0.309692 |
| Range              | 121       |
| Minimum            | 10912     |
| Maximum            | 11033     |
| Sum                | 329437    |
| Count              | 30        |

| Allocated AGE, no deployments |       |       |       |
|-------------------------------|-------|-------|-------|
| 410th                         | 420th | 430th | 440th |
| 13311                         | 11475 | 10946 | 10988 |
| 13301                         | 11536 | 10951 | 10906 |
| 13292                         | 11508 | 10999 | 10966 |
| 13325                         | 11513 | 10908 | 10983 |
| 13292                         | 11480 | 10938 | 10945 |
| 13277                         | 11517 | 10932 | 10964 |
| 13346                         | 11513 | 10934 | 10945 |
| 13263                         | 11471 | 10886 | 10919 |
| 13283                         | 11533 | 10972 | 10911 |
| 13317                         | 11512 | 10942 | 10931 |
| 13287                         | 11513 | 10983 | 10929 |
| 13316                         | 11550 | 10958 | 10971 |
| 13300                         | 11522 | 11017 | 10965 |
| 13305                         | 11501 | 10955 | 11022 |
| 13330                         | 11390 | 10921 | 10944 |
| 13337                         | 11526 | 11016 | 10978 |
| 13291                         | 11473 | 10965 | 10955 |
| 13283                         | 11481 | 10938 | 10959 |
| 13318                         | 11523 | 10927 | 11029 |
| 13307                         | 11557 | 10979 | 10907 |
| 13323                         | 11530 | 10928 | 10939 |
| 13364                         | 11509 | 10941 | 10982 |
| 13273                         | 11512 | 10958 | 10946 |
| 13334                         | 11501 | 10931 | 10979 |
| 13230                         | 11502 | 10926 | 10996 |
| 13348                         | 11445 | 10988 | 10909 |
| 13321                         | 11524 | 10928 | 11015 |
| 13322                         | 11499 | 10902 | 10992 |
| 13296                         | 11531 | 10965 | 10959 |
| 13353                         | 11505 | 10967 | 10960 |

| 410                |           |
|--------------------|-----------|
| Mean               | 13308.17  |
| Standard Error     | 5.294995  |
| Median             | 13309     |
| Mode               | 13292     |
| Standard Deviation | 29.00188  |
| Sample Variance    | 841.1092  |
| Kurtosis           | 0.567428  |
| Skewness           | -0.383249 |
| Range              | 134       |
| Minimum            | 13230     |
| Maximum            | 13364     |
| Sum                | 399245    |
| Count              | 30        |

| 420                |           |
|--------------------|-----------|
| Mean               | 11505.07  |
| Standard Error     | 5.95306   |
| Median             | 11512     |
| Mode               | 11513     |
| Standard Deviation | 32.60625  |
| Sample Variance    | 1063.168  |
| Kurtosis           | 4.413616  |
| Skewness           | -1.624603 |
| Range              | 167       |
| Minimum            | 11390     |
| Maximum            | 11557     |
| Sum                | 345152    |
| Count              | 30        |

| 430                |          |
|--------------------|----------|
| Mean               | 10950.03 |
| Standard Error     | 5.719996 |
| Median             | 10944    |
| Mode               | 10938    |
| Standard Deviation | 31.32971 |
| Sample Variance    | 981.5506 |
| Kurtosis           | 0.035065 |
| Skewness           | 0.362437 |
| Range              | 131      |
| Minimum            | 10886    |
| Maximum            | 11017    |
| Sum                | 328501   |
| Count              | 30       |

| 440                |           |
|--------------------|-----------|
| Mean               | 10959.8   |
| Standard Error     | 6.084539  |
| Median             | 10959.5   |
| Mode               | 10945     |
| Standard Deviation | 33.32639  |
| Sample Variance    | 1110.648  |
| Kurtosis           | -0.427142 |
| Skewness           | 0.188089  |
| Range              | 123       |
| Minimum            | 10906     |
| Maximum            | 11029     |
| Sum                | 328794    |
| Count              | 30        |

| Pooled AGE, 1 Deployment |       |       |       |
|--------------------------|-------|-------|-------|
| 410th                    | 420th | 430th | 440th |
| 7497                     | 11452 | 10990 | 10985 |
| 7468                     | 11483 | 10972 | 10986 |
| 7444                     | 11452 | 10981 | 11013 |
| 7438                     | 11473 | 10965 | 11007 |
| 7491                     | 11471 | 10969 | 10961 |
| 7456                     | 11470 | 10979 | 10971 |
| 7470                     | 11441 | 11006 | 10973 |
| 7482                     | 11430 | 10962 | 10977 |
| 7494                     | 11473 | 10978 | 11037 |
| 7465                     | 11470 | 10968 | 10985 |
| 7487                     | 11419 | 10937 | 10957 |
| 7458                     | 11460 | 10990 | 10973 |
| 7485                     | 11428 | 10947 | 11017 |
| 7520                     | 11465 | 10979 | 10945 |
| 7466                     | 11491 | 11009 | 10996 |
| 7483                     | 11463 | 10979 | 10935 |
| 7475                     | 11488 | 10956 | 10943 |
| 7482                     | 11455 | 10966 | 10948 |
| 7468                     | 11442 | 10969 | 10909 |
| 7500                     | 11454 | 10937 | 10987 |
| 7460                     | 11421 | 11002 | 10999 |
| 7441                     | 11430 | 10951 | 10960 |
| 7506                     | 11428 | 10935 | 11000 |
| 7487                     | 11492 | 10933 | 11010 |
| 7517                     | 11451 | 10953 | 10965 |
| 7460                     | 11440 | 10977 | 10982 |
| 7468                     | 11466 | 10962 | 10973 |
| 7483                     | 11426 | 10910 | 10950 |
| 7503                     | 11463 | 11010 | 10980 |
| 7484                     | 11483 | 10989 | 11019 |

| 410th              |           |
|--------------------|-----------|
| Mean               | 7477.93   |
| Standard Error     | 3.81      |
| Median             | 7482.00   |
| Mode               | 7468.00   |
| Standard Deviation | 20.87     |
| Sample Variance    | 435.72    |
| Kurtosis           | -0.35     |
| Skewness           | 0.03      |
| Range              | 82.00     |
| Minimum            | 7438.00   |
| Maximum            | 7520.00   |
| Sum                | 224338.00 |
| Count              | 30.00     |

| 420th              |           |
|--------------------|-----------|
| Mean               | 11456.00  |
| Standard Error     | 3.96      |
| Median             | 11457.50  |
| Mode               | 11452.00  |
| Standard Deviation | 21.69     |
| Sample Variance    | 470.55    |
| Kurtosis           | -1.02     |
| Skewness           | -0.10     |
| Range              | 73.00     |
| Minimum            | 11419.00  |
| Maximum            | 11492.00  |
| Sum                | 343680.00 |
| Count              | 30.00     |

| 430th              |           |
|--------------------|-----------|
| Mean               | 10968.70  |
| Standard Error     | 4.41      |
| Median             | 10969.00  |
| Mode               | 10979.00  |
| Standard Deviation | 24.18     |
| Sample Variance    | 584.63    |
| Kurtosis           | -0.04     |
| Skewness           | -0.30     |
| Range              | 100.00    |
| Minimum            | 10910.00  |
| Maximum            | 11010.00  |
| Sum                | 329061.00 |
| Count              | 30.00     |

| 440th              |           |
|--------------------|-----------|
| Mean               | 10978.10  |
| Standard Error     | 5.17      |
| Median             | 10978.50  |
| Mode               | 10973.00  |
| Standard Deviation | 28.31     |
| Sample Variance    | 801.40    |
| Kurtosis           | 0.08      |
| Skewness           | -0.17     |
| Range              | 128.00    |
| Minimum            | 10909.00  |
| Maximum            | 11037.00  |
| Sum                | 329343.00 |
| Count              | 30.00     |

| Allocated, one deployment |       |       |       |
|---------------------------|-------|-------|-------|
| 410th                     | 420th | 430th | 440th |
| 6927                      | 11502 | 10952 | 10984 |
| 7454                      | 11554 | 10977 | 10940 |
| 7289                      | 11476 | 10951 | 10967 |
| 7376                      | 11472 | 10938 | 10942 |
| 7294                      | 11491 | 10969 | 10986 |
| 7355                      | 11506 | 10978 | 10910 |
| 7162                      | 11484 | 10928 | 10955 |
| 7298                      | 11503 | 10921 | 10953 |
| 7310                      | 11536 | 10920 | 11000 |
| 7408                      | 11568 | 10939 | 10947 |
| 6915                      | 11541 | 10968 | 10895 |
| 7269                      | 11526 | 10978 | 10973 |
| 7334                      | 11489 | 10971 | 10970 |
| 7062                      | 11536 | 10972 | 10926 |
| 7393                      | 11512 | 11005 | 10976 |
| 7221                      | 11525 | 10945 | 10937 |
| 7280                      | 11574 | 10923 | 10913 |
| 7393                      | 11541 | 11009 | 10986 |
| 7273                      | 11517 | 10875 | 10917 |
| 6783                      | 11471 | 10926 | 10980 |
| 7300                      | 11506 | 10964 | 10970 |
| 7394                      | 11500 | 10988 | 10942 |
| 7306                      | 11479 | 10962 | 10932 |
| 7435                      | 11475 | 10926 | 11000 |
| 7318                      | 11598 | 10945 | 10962 |
| 7141                      | 11548 | 10984 | 10920 |
| 7444                      | 11515 | 10950 | 10970 |
| 7381                      | 11497 | 10939 | 10988 |
| 6810                      | 11553 | 10979 | 10905 |
| 7302                      | 11522 | 10953 | 10916 |

| 410th              |           |
|--------------------|-----------|
| Mean               | 7254.23   |
| Standard Error     | 33.20     |
| Median             | 7301.00   |
| Mode               | 7393.00   |
| Standard Deviation | 181.83    |
| Sample Variance    | 33062.87  |
| Kurtosis           | 1.35      |
| Skewness           | -1.46     |
| Range              | 671.00    |
| Minimum            | 6783.00   |
| Maximum            | 7454.00   |
| Sum                | 217627.00 |
| Count              | 30.00     |

| 420th              |           |
|--------------------|-----------|
| Mean               | 11517.23  |
| Standard Error     | 5.97      |
| Median             | 11513.50  |
| Mode               | 11506.00  |
| Standard Deviation | 32.72     |
| Sample Variance    | 1070.32   |
| Kurtosis           | -0.21     |
| Skewness           | 0.54      |
| Range              | 127.00    |
| Minimum            | 11471.00  |
| Maximum            | 11598.00  |
| Sum                | 345517.00 |
| Count              | 30.00     |

| 430th              |           |
|--------------------|-----------|
| Mean               | 10954.50  |
| Standard Error     | 5.23      |
| Median             | 10952.50  |
| Mode               | 10978.00  |
| Standard Deviation | 28.63     |
| Sample Variance    | 819.57    |
| Kurtosis           | 0.73      |
| Skewness           | -0.42     |
| Range              | 134.00    |
| Minimum            | 10875.00  |
| Maximum            | 11009.00  |
| Sum                | 328635.00 |
| Count              | 30.00     |

| 440th              |           |
|--------------------|-----------|
| Mean               | 10952.07  |
| Standard Error     | 5.50      |
| Median             | 10954.00  |
| Mode               | 10970.00  |
| Standard Deviation | 30.12     |
| Sample Variance    | 907.10    |
| Kurtosis           | -1.10     |
| Skewness           | -0.18     |
| Range              | 105.00    |
| Minimum            | 10895.00  |
| Maximum            | 11000.00  |
| Sum                | 328562.00 |
| Count              | 30.00     |

| Pooled Age, 2 deployments |       |       |       |
|---------------------------|-------|-------|-------|
| 410th                     | 420th | 430th | 440th |
| 7513                      | 5452  | 10994 | 10984 |
| 7448                      | 5427  | 10973 | 10998 |
| 7463                      | 5405  | 10998 | 11008 |
| 7486                      | 5422  | 10953 | 10975 |
| 7477                      | 5435  | 10986 | 10945 |
| 7494                      | 5420  | 10967 | 10992 |
| 7509                      | 5435  | 10995 | 10956 |
| 7463                      | 5449  | 10952 | 10952 |
| 7515                      | 5447  | 10950 | 10978 |
| 7467                      | 5430  | 10949 | 11002 |
| 7467                      | 5426  | 10961 | 11017 |
| 7413                      | 5441  | 10983 | 10962 |
| 7461                      | 5411  | 10994 | 10955 |
| 7497                      | 5420  | 10940 | 10979 |
| 7520                      | 5429  | 10980 | 10985 |
| 7494                      | 5450  | 10959 | 10984 |
| 7491                      | 5447  | 10960 | 11010 |
| 7444                      | 5428  | 10962 | 10986 |
| 7510                      | 5450  | 10941 | 10991 |
| 7465                      | 5438  | 10937 | 10985 |
| 7478                      | 5454  | 10946 | 11002 |
| 7461                      | 5424  | 10991 | 10986 |
| 7484                      | 5437  | 10950 | 10967 |
| 7525                      | 5414  | 10996 | 10969 |
| 7495                      | 5445  | 11003 | 11009 |
| 7511                      | 5448  | 10971 | 10969 |
| 7478                      | 5454  | 10981 | 10981 |
| 7458                      | 5433  | 11003 | 10948 |
| 7521                      | 5420  | 10936 | 11009 |
| 7514                      | 5432  | 10961 | 11021 |

| 410th              |           |
|--------------------|-----------|
| Mean               | 7484.067  |
| Standard Error     | 4.940318  |
| Median             | 7485      |
| Mode               | 7463      |
| Standard Deviation | 27.05924  |
| Sample Variance    | 732.2023  |
| Kurtosis           | -0.038763 |
| Skewness           | -0.45599  |
| Range              | 112       |
| Minimum            | 7413      |
| Maximum            | 7525      |
| Sum                | 224522    |
| Count              | 30        |

| 420th              |          |
|--------------------|----------|
| Mean               | 5434.1   |
| Standard Error     | 2.488756 |
| Median             | 5434     |
| Mode               | 5420     |
| Standard Deviation | 13.63148 |
| Sample Variance    | 185.8172 |
| Kurtosis           | -0.84642 |
| Skewness           | -0.2348  |
| Range              | 49       |
| Minimum            | 5405     |
| Maximum            | 5454     |
| Sum                | 163023   |
| Count              | 30       |

| 430th              |           |
|--------------------|-----------|
| Mean               | 10969.07  |
| Standard Error     | 3.918401  |
| Median             | 10964.5   |
| Mode               | 10994     |
| Standard Deviation | 21.46197  |
| Sample Variance    | 460.6161  |
| Kurtosis           | -1.344676 |
| Skewness           | 0.109228  |
| Range              | 67        |
| Minimum            | 10936     |
| Maximum            | 11003     |
| Sum                | 329072    |
| Count              | 30        |

| 440th              |           |
|--------------------|-----------|
| Mean               | 10983.5   |
| Standard Error     | 3.829633  |
| Median             | 10984.5   |
| Mode               | 10984     |
| Standard Deviation | 20.97577  |
| Sample Variance    | 439.9828  |
| Kurtosis           | -0.793842 |
| Skewness           | -0.099392 |
| Range              | 76        |
| Minimum            | 10945     |
| Maximum            | 11021     |
| Sum                | 329505    |
| Count              | 30        |

| Allocated Age, 2 deployments |       |       |       |
|------------------------------|-------|-------|-------|
| 410th                        | 420th | 430th | 440th |
| 7490                         | 5397  | 10935 | 10893 |
| 7301                         | 5443  | 10923 | 10951 |
| 7466                         | 5455  | 10931 | 10949 |
| 7338                         | 5455  | 10968 | 10993 |
| 7321                         | 5443  | 10957 | 11013 |
| 7356                         | 5124  | 10956 | 10962 |
| 7233                         | 5214  | 10988 | 10913 |
| 7108                         | 5441  | 10914 | 10965 |
| 7128                         | 5345  | 11000 | 11006 |
| 7222                         | 5454  | 10919 | 10998 |
| 6953                         | 5141  | 10970 | 10951 |
| 6900                         | 5387  | 10908 | 10987 |
| 7206                         | 5429  | 10973 | 10973 |
| 7301                         | 5459  | 11010 | 10964 |
| 7374                         | 5460  | 10968 | 10982 |
| 7368                         | 5415  | 10989 | 11012 |
| 7346                         | 5438  | 10948 | 11007 |
| 7297                         | 5408  | 10955 | 10903 |
| 7285                         | 5305  | 10963 | 10926 |
| 7449                         | 5448  | 10901 | 10943 |
| 7436                         | 5358  | 10981 | 10961 |
| 6516                         | 5418  | 10883 | 10916 |
| 7327                         | 5399  | 10968 | 10947 |
| 6629                         | 5423  | 11005 | 11023 |
| 7390                         | 5397  | 10998 | 10938 |
| 6989                         | 5376  | 10925 | 10929 |
| 7357                         | 5475  | 10909 | 10968 |
| 7438                         | 5411  | 10943 | 10961 |
| 7077                         | 5446  | 10941 | 11000 |
| 7476                         | 5362  | 10973 | 10944 |

| 410th              |          |
|--------------------|----------|
| Mean               | 7235.9   |
| Standard Error     | 43.39438 |
| Median             | 7311     |
| Mode               | 7301     |
| Standard Deviation | 237.6808 |
| Sample Variance    | 56492.16 |
| Kurtosis           | 2.589082 |
| Skewness           | -1.63571 |
| Range              | 974      |
| Minimum            | 6516     |
| Maximum            | 7490     |
| Sum                | 217077   |
| Count              | 30       |

| 420th              |           |
|--------------------|-----------|
| Mean               | 5390.867  |
| Standard Error     | 16.13134  |
| Median             | 5416.5    |
| Mode               | 5397      |
| Standard Deviation | 88.35498  |
| Sample Variance    | 7806.602  |
| Kurtosis           | 3.764898  |
| Skewness           | -2.030308 |
| Range              | 351       |
| Minimum            | 5124      |
| Maximum            | 5475      |
| Sum                | 161726    |
| Count              | 30        |

| 430th              |           |
|--------------------|-----------|
| Mean               | 10953.4   |
| Standard Error     | 6.100989  |
| Median             | 10956.5   |
| Mode               | 10968     |
| Standard Deviation | 33.41649  |
| Sample Variance    | 1116.662  |
| Kurtosis           | -0.747958 |
| Skewness           | -0.199326 |
| Range              | 127       |
| Minimum            | 10883     |
| Maximum            | 11010     |
| Sum                | 328602    |
| Count              | 30        |

| 440th              |           |
|--------------------|-----------|
| Mean               | 10962.6   |
| Standard Error     | 6.316481  |
| Median             | 10961.5   |
| Mode               | 10951     |
| Standard Deviation | 34.59679  |
| Sample Variance    | 1196.938  |
| Kurtosis           | -0.710281 |
| Skewness           | -0.099244 |
| Range              | 130       |
| Minimum            | 10893     |
| Maximum            | 11023     |
| Sum                | 328878    |
| Count              | 30        |

| Pooled Age, 3 deployments |       |       |       |
|---------------------------|-------|-------|-------|
| 410th                     | 420th | 430th | 440th |
| 7532                      | 5429  | 4914  | 10962 |
| 7521                      | 5439  | 4945  | 10922 |
| 7475                      | 5442  | 4925  | 10932 |
| 7483                      | 5470  | 4950  | 11007 |
| 7501                      | 5426  | 4921  | 10998 |
| 7501                      | 5436  | 4918  | 10985 |
| 7489                      | 5427  | 4940  | 11002 |
| 7473                      | 5428  | 4964  | 10952 |
| 7457                      | 5393  | 4924  | 11003 |
| 7523                      | 5438  | 4934  | 10955 |
| 7480                      | 5421  | 4889  | 10975 |
| 7483                      | 5417  | 4956  | 10969 |
| 7504                      | 5440  | 4920  | 10976 |
| 7477                      | 5450  | 4931  | 10986 |
| 7467                      | 5424  | 4941  | 11018 |
| 7496                      | 5373  | 4941  | 10936 |
| 7464                      | 5461  | 4911  | 10953 |
| 7484                      | 5394  | 4965  | 10989 |
| 7469                      | 5427  | 4950  | 10980 |
| 7509                      | 5448  | 4931  | 10970 |
| 7455                      | 5472  | 4964  | 10919 |
| 7508                      | 5428  | 4949  | 10989 |
| 7497                      | 5435  | 4943  | 10927 |
| 7433                      | 5459  | 4895  | 11037 |
| 7500                      | 5433  | 4979  | 10965 |
| 7463                      | 5410  | 4977  | 10946 |
| 7447                      | 5426  | 4967  | 10978 |
| 7495                      | 5417  | 4935  | 10970 |
| 7494                      | 5418  | 4935  | 10991 |
| 7480                      | 5391  | 4964  | 10962 |
| 7477                      | 5442  | 4970  | 10978 |
| 7467                      | 5436  | 4969  | 11004 |
| 7483                      | 5415  | 4929  | 10974 |
| 7479                      | 5426  | 4946  | 10947 |
| 7499                      | 5444  | 4914  | 11016 |
| 7500                      | 5460  | 4911  | 10951 |
| 7475                      | 5430  | 4947  | 10992 |
| 7430                      | 5425  | 4924  | 10987 |
| 7487                      | 5442  | 4956  | 10973 |
| 7463                      | 5436  | 4951  | 10981 |
| 7497                      | 5436  | 4948  | 11006 |
| 7455                      | 5419  | 4931  | 10945 |
| 7449                      | 5432  | 4970  | 10978 |
| 7526                      | 5414  | 4947  | 10970 |
| 7450                      | 5401  | 4896  | 10939 |
| 7488                      | 5450  | 4948  | 11025 |
| 7476                      | 5421  | 4910  | 10968 |
| 7474                      | 5422  | 4966  | 10974 |
| 7478                      | 5415  | 4938  | 10923 |
| 7492                      | 5467  | 4947  | 10987 |

| 410th              |           |
|--------------------|-----------|
| Mean               | 7482.1    |
| Standard Error     | 3.188916  |
| Median             | 7481.5    |
| Mode               | 7483      |
| Standard Deviation | 22.54904  |
| Sample Variance    | 508.4592  |
| Kurtosis           | 0.011062  |
| Skewness           | -0.058516 |
| Range              | 102       |
| Minimum            | 7430      |
| Maximum            | 7532      |
| Sum                | 374105    |
| Count              | 50        |

| 430th              |           |
|--------------------|-----------|
| Mean               | 4939.92   |
| Standard Error     | 3.095862  |
| Median             | 4942      |
| Mode               | 4964      |
| Standard Deviation | 21.89105  |
| Sample Variance    | 479.218   |
| Kurtosis           | -0.428196 |
| Skewness           | -0.320032 |
| Range              | 90        |
| Minimum            | 4889      |
| Maximum            | 4979      |
| Sum                | 246996    |
| Count              | 50        |

| 420th              |           |
|--------------------|-----------|
| Mean               | 5430.1    |
| Standard Error     | 2.85432   |
| Median             | 5428.5    |
| Mode               | 5436      |
| Standard Deviation | 20.18309  |
| Sample Variance    | 407.3571  |
| Kurtosis           | 0.719937  |
| Skewness           | -0.253717 |
| Range              | 99        |
| Minimum            | 5373      |
| Maximum            | 5472      |
| Sum                | 271505    |
| Count              | 50        |

| 440th              |           |
|--------------------|-----------|
| Mean               | 10973.44  |
| Standard Error     | 3.880475  |
| Median             | 10974.5   |
| Mode               | 10970     |
| Standard Deviation | 27.43911  |
| Sample Variance    | 752.9045  |
| Kurtosis           | -0.268879 |
| Skewness           | -0.040578 |
| Range              | 118       |
| Minimum            | 10919     |
| Maximum            | 11037     |
| Sum                | 548672    |
| Count              | 50        |

| Allocated Age, 3 deployments |       |       |       |
|------------------------------|-------|-------|-------|
| 410th                        | 420th | 430th | 440th |
| 7356                         | 5464  | 4897  | 10882 |
| 7113                         | 5362  | 4884  | 10958 |
| 7216                         | 5400  | 4858  | 10911 |
| 7330                         | 5426  | 4902  | 10975 |
| 7366                         | 5445  | 4807  | 10961 |
| 7367                         | 5425  | 4891  | 10951 |
| 7323                         | 5442  | 4900  | 10967 |
| 7302                         | 5373  | 4890  | 10784 |
| 7391                         | 5427  | 4818  | 10964 |
| 7409                         | 5390  | 4946  | 10957 |
| 7241                         | 5401  | 4899  | 10971 |
| 7365                         | 5410  | 4892  | 10948 |
| 6552                         | 5405  | 4933  | 10986 |
| 7149                         | 5006  | 4935  | 10927 |
| 7304                         | 5386  | 4897  | 10963 |
| 7292                         | 5389  | 4908  | 10981 |
| 6852                         | 5464  | 4898  | 10903 |
| 7440                         | 5357  | 4849  | 10943 |
| 7414                         | 5437  | 4918  | 10939 |
| 7449                         | 5471  | 4876  | 10927 |
| 7193                         | 5409  | 4680  | 10948 |
| 7292                         | 5309  | 4808  | 11001 |
| 7380                         | 5375  | 4895  | 10906 |
| 7383                         | 5459  | 4825  | 10922 |
| 7258                         | 5431  | 4768  | 10928 |
| 7271                         | 5464  | 4418  | 10995 |
| 6877                         | 5448  | 4748  | 10980 |
| 7392                         | 5445  | 4927  | 10949 |
| 7416                         | 5373  | 4823  | 10987 |
| 7273                         | 5410  | 4917  | 10983 |
| 7109                         | 5311  | 4929  | 10982 |
| 7427                         | 5421  | 4738  | 10948 |
| 6936                         | 5285  | 4888  | 10995 |
| 7421                         | 5367  | 4848  | 10946 |
| 7398                         | 5457  | 4904  | 10992 |
| 7419                         | 5485  | 4812  | 10992 |
| 7398                         | 5408  | 4909  | 10948 |
| 7413                         | 5414  | 4874  | 10937 |
| 7257                         | 5443  | 4925  | 11001 |
| 7426                         | 5418  | 4904  | 10952 |
| 7143                         | 5454  | 4803  | 10990 |
| 7345                         | 5442  | 4910  | 10967 |
| 6899                         | 5461  | 4890  | 10915 |
| 7262                         | 5496  | 4649  | 10944 |
| 7270                         | 5470  | 4807  | 10951 |
| 7335                         | 5420  | 4778  | 10981 |
| 7418                         | 5414  | 4909  | 10976 |
| 7280                         | 5373  | 4871  | 10981 |
| 7423                         | 5447  | 4837  | 10935 |
| 7119                         | 5342  | 4825  | 10917 |

|                    |           |
|--------------------|-----------|
| 410th              |           |
| Mean               | 7273.28   |
| Standard Error     | 25.80419  |
| Median             | 7326.5    |
| Mode               | 7292      |
| Standard Deviation | 182.4632  |
| Sample Variance    | 33292.82  |
| Kurtosis           | 4.499423  |
| Skewness           | -1.979349 |
| Range              | 897       |
| Minimum            | 6552      |
| Maximum            | 7449      |
| Sum                | 363664    |
| Count              | 50        |

|                    |           |
|--------------------|-----------|
| 430th              |           |
| Mean               | 4852.34   |
| Standard Error     | 12.77991  |
| Median             | 4889      |
| Mode               | 4897      |
| Standard Deviation | 90.36764  |
| Sample Variance    | 8166.311  |
| Kurtosis           | 10.28714  |
| Skewness           | -2.706111 |
| Range              | 528       |
| Minimum            | 4418      |
| Maximum            | 4946      |
| Sum                | 242617    |
| Count              | 50        |

|                    |           |
|--------------------|-----------|
| 420th              |           |
| Mean               | 5406.62   |
| Standard Error     | 10.41411  |
| Median             | 5419      |
| Mode               | 5464      |
| Standard Deviation | 73.63891  |
| Sample Variance    | 5422.689  |
| Kurtosis           | 17.51645  |
| Skewness           | -3.477857 |
| Range              | 490       |
| Minimum            | 5006      |
| Maximum            | 5496      |
| Sum                | 270331    |
| Count              | 50        |

|                    |           |
|--------------------|-----------|
| 440th              |           |
| Mean               | 10952.94  |
| Standard Error     | 5.289683  |
| Median             | 10954.5   |
| Mode               | 10948     |
| Standard Deviation | 37.4037   |
| Sample Variance    | 1399.037  |
| Kurtosis           | 7.307026  |
| Skewness           | -1.984399 |
| Range              | 217       |
| Minimum            | 10784     |
| Maximum            | 11001     |
| Sum                | 547647    |
| Count              | 50        |

| Pooled Age, 4 deployments |       |       |       |
|---------------------------|-------|-------|-------|
| 410th                     | 420th | 430th | 440th |
| 7382                      | 5363  | 4825  | 4810  |
| 7246                      | 5262  | 4780  | 4822  |
| 7495                      | 5434  | 4890  | 4911  |
| 6846                      | 5002  | 4535  | 4727  |
| 7277                      | 5327  | 4767  | 4824  |
| 7337                      | 5294  | 4835  | 4850  |
| 7427                      | 5361  | 4897  | 4798  |
| 7029                      | 5136  | 4782  | 4705  |
| 7118                      | 5049  | 4766  | 4594  |
| 7308                      | 5296  | 4764  | 4702  |
| 7303                      | 5292  | 4772  | 4812  |
| 7378                      | 5301  | 4880  | 4845  |
| 7184                      | 5168  | 4719  | 4569  |
| 7277                      | 5319  | 4820  | 4768  |
| 7044                      | 5270  | 4704  | 4714  |
| 7062                      | 5185  | 4683  | 4602  |
| 7088                      | 5318  | 4887  | 4845  |
| 7379                      | 5377  | 4818  | 4861  |
| 7422                      | 5342  | 4859  | 4809  |
| 7388                      | 5362  | 4909  | 4874  |
| 7404                      | 4998  | 4841  | 4861  |
| 7376                      | 5371  | 4804  | 4839  |
| 6979                      | 5127  | 4622  | 4604  |
| 7321                      | 5421  | 4959  | 4850  |
| 7000                      | 5104  | 4627  | 4425  |
| 7416                      | 5379  | 4922  | 4926  |
| 7320                      | 5279  | 4832  | 4796  |
| 7352                      | 5360  | 4794  | 4819  |
| 7169                      | 5108  | 4682  | 4637  |
| 7159                      | 5261  | 4686  | 4801  |
| 7331                      | 5354  | 4902  | 4890  |
| 7390                      | 5404  | 4886  | 4914  |
| 7292                      | 5363  | 4843  | 4869  |
| 7054                      | 5130  | 4644  | 4598  |
| 7385                      | 5352  | 4903  | 4936  |
| 7299                      | 5331  | 4882  | 4872  |
| 7346                      | 5312  | 4881  | 4856  |
| 7458                      | 5406  | 4952  | 4880  |
| 7413                      | 5374  | 4903  | 4868  |
| 6717                      | 5171  | 4812  | 4801  |
| 6962                      | 5099  | 4635  | 4613  |
| 7261                      | 5354  | 4862  | 4846  |
| 7347                      | 5312  | 4876  | 4894  |
| 7460                      | 5405  | 4936  | 4945  |
| 7340                      | 5300  | 4825  | 4907  |
| 7117                      | 5139  | 4623  | 4653  |
| 7301                      | 5197  | 4751  | 4845  |
| 7392                      | 5303  | 4916  | 4887  |
| 7236                      | 4963  | 4770  | 4809  |
| 7124                      | 5115  | 4699  | 4577  |
| 7440                      | 5430  | 4906  | 4936  |
| 7384                      | 5367  | 4852  | 4904  |
| 7435                      | 5369  | 4851  | 4909  |
| 7245                      | 5328  | 4823  | 4886  |
| 7013                      | 4978  | 4716  | 4690  |
| 7383                      | 5415  | 4904  | 4814  |
| 6671                      | 4983  | 4453  | 4627  |
| 7243                      | 5161  | 4726  | 4771  |
| 7342                      | 5324  | 4794  | 4850  |
| 7355                      | 5182  | 4769  | 4729  |
| 7067                      | 5117  | 4604  | 4735  |
| 7067                      | 5264  | 4691  | 4410  |
| 7355                      | 5382  | 4849  | 4862  |
| 7065                      | 5165  | 4790  | 4621  |
| 7230                      | 5357  | 4751  | 4823  |
| 7299                      | 5345  | 4819  | 4823  |
| 7368                      | 5386  | 4908  | 4941  |
| 7277                      | 5154  | 4784  | 4725  |
| 7257                      | 5231  | 4770  | 4786  |
| 7149                      | 5167  | 4714  | 4673  |
| 7126                      | 5286  | 4793  | 4794  |
| 7384                      | 5365  | 4835  | 4768  |
| 7065                      | 5267  | 4742  | 4641  |

| 410th              |           |
|--------------------|-----------|
| Mean               | 7248.587  |
| Standard Error     | 19.82613  |
| Median             | 7301      |
| Mode               | 7277      |
| Standard Deviation | 171.6993  |
| Sample Variance    | 29480.65  |
| Kurtosis           | 1.407238  |
| Skewness           | -1.204882 |
| Range              | 824       |
| Minimum            | 6671      |
| Maximum            | 7495      |
| Sum                | 543644    |
| Count              | 75        |

| 430th              |           |
|--------------------|-----------|
| Mean               | 4795.36   |
| Standard Error     | 11.77667  |
| Median             | 4812      |
| Mode               | 4825      |
| Standard Deviation | 101.989   |
| Sample Variance    | 10401.75  |
| Kurtosis           | 0.752454  |
| Skewness           | -0.825827 |
| Range              | 506       |
| Minimum            | 4453      |
| Maximum            | 4959      |
| Sum                | 359652    |
| Count              | 75        |

| 420th              |           |
|--------------------|-----------|
| Mean               | 5265.347  |
| Standard Error     | 14.19612  |
| Median             | 5301      |
| Mode               | 5363      |
| Standard Deviation | 122.942   |
| Sample Variance    | 15114.74  |
| Kurtosis           | -0.25493  |
| Skewness           | -0.822589 |
| Range              | 471       |
| Minimum            | 4963      |
| Maximum            | 5434      |
| Sum                | 394901    |
| Count              | 75        |

| 440th              |          |
|--------------------|----------|
| Mean               | 4785     |
| Standard Error     | 13.68322 |
| Median             | 4819     |
| Mode               | 4850     |
| Standard Deviation | 118.5002 |
| Sample Variance    | 14042.3  |
| Kurtosis           | 0.897808 |
| Skewness           | -1.09206 |
| Range              | 535      |
| Minimum            | 4410     |
| Maximum            | 4945     |
| Sum                | 358875   |
| Count              | 75       |

| Allocated Age, 4 deployments |       |       |       |
|------------------------------|-------|-------|-------|
| 410th                        | 420th | 430th | 440th |
| 7067                         | 4851  | 4492  | 4336  |
| 7113                         | 5294  | 4748  | 4645  |
| 7350                         | 5364  | 4778  | 4660  |
| 6705                         | 4508  | 4294  | 4015  |
| 7415                         | 5367  | 4874  | 4822  |
| 7334                         | 5397  | 4785  | 4824  |
| 7416                         | 5273  | 4645  | 4481  |
| 7239                         | 5274  | 4787  | 4708  |
| 7397                         | 5397  | 4922  | 4864  |
| 7342                         | 5262  | 4727  | 4798  |
| 7259                         | 5291  | 4707  | 4721  |
| 7334                         | 5318  | 4764  | 4735  |
| 7388                         | 5250  | 4680  | 4756  |
| 7104                         | 5348  | 4612  | 4740  |
| 7380                         | 5350  | 4884  | 4852  |
| 7419                         | 5397  | 4848  | 4816  |
| 7165                         | 5302  | 4693  | 4606  |
| 7424                         | 5206  | 4707  | 4850  |
| 7330                         | 5150  | 4764  | 4828  |
| 7148                         | 5170  | 4705  | 4771  |
| 7388                         | 5314  | 4828  | 4874  |
| 7142                         | 5296  | 4777  | 4771  |
| 7085                         | 4923  | 4613  | 4545  |
| 6809                         | 5100  | 4584  | 4666  |
| 7339                         | 5272  | 4563  | 4372  |
| 7407                         | 5273  | 4787  | 4549  |
| 7208                         | 5392  | 4792  | 4655  |
| 7289                         | 5295  | 4821  | 4779  |
| 7148                         | 5106  | 4710  | 4615  |
| 6829                         | 5105  | 4505  | 4476  |
| 7094                         | 5366  | 4732  | 4584  |
| 7288                         | 5335  | 4799  | 4728  |
| 7089                         | 5004  | 4401  | 4217  |
| 7470                         | 5162  | 4887  | 4864  |
| 7179                         | 5236  | 4387  | 4556  |
| 7333                         | 5254  | 4803  | 4764  |
| 7202                         | 5302  | 4755  | 4577  |
| 7303                         | 5286  | 4654  | 4626  |
| 6957                         | 5050  | 4491  | 4524  |
| 6938                         | 5070  | 4525  | 4632  |
| 7209                         | 5303  | 4768  | 4647  |
| 6661                         | 4515  | 4228  | 4266  |
| 7411                         | 5293  | 4728  | 4733  |
| 7466                         | 5402  | 4894  | 4904  |
| 7461                         | 5317  | 4843  | 4742  |
| 7434                         | 5372  | 4850  | 4918  |
| 7266                         | 5356  | 4655  | 4519  |
| 7178                         | 5206  | 4690  | 4654  |
| 7072                         | 5133  | 4486  | 4629  |
| 7280                         | 5409  | 4829  | 4818  |
| 7334                         | 5269  | 4724  | 4848  |
| 7412                         | 5094  | 4819  | 4851  |
| 7108                         | 5084  | 4626  | 4702  |
| 6867                         | 5279  | 4681  | 4851  |
| 7114                         | 5121  | 4550  | 4584  |
| 7442                         | 5342  | 4836  | 4803  |
| 7350                         | 5414  | 4836  | 4823  |
| 7330                         | 5156  | 4713  | 4796  |
| 7417                         | 5324  | 4762  | 4848  |
| 7188                         | 5068  | 4606  | 4708  |
| 7463                         | 5420  | 4860  | 4868  |
| 7310                         | 5218  | 4424  | 4791  |
| 7378                         | 5468  | 4847  | 4805  |
| 7440                         | 5383  | 4841  | 4784  |
| 7191                         | 5244  | 4678  | 4607  |
| 7267                         | 5344  | 4813  | 4624  |
| 7313                         | 5401  | 4631  | 4860  |
| 7246                         | 5214  | 4522  | 4821  |
| 7086                         | 5153  | 4774  | 4703  |
| 7123                         | 5057  | 4640  | 4605  |
| 7383                         | 5351  | 4678  | 4832  |
| 7213                         | 5459  | 4660  | 4761  |
| 7443                         | 5382  | 4830  | 4854  |

| 410th              |           |
|--------------------|-----------|
| Mean               | 7245.48   |
| Standard Error     | 21.04091  |
| Median             | 7289      |
| Mode               | 7334      |
| Standard Deviation | 182.2196  |
| Sample Variance    | 33203.98  |
| Kurtosis           | 1.354942  |
| Skewness           | -1.194538 |
| Range              | 809       |
| Minimum            | 6661      |
| Maximum            | 7470      |
| Sum                | 543411    |
| Count              | 75        |

| 420th              |           |
|--------------------|-----------|
| Mean               | 5241.8    |
| Standard Error     | 20.30885  |
| Median             | 5286      |
| Mode               | 5397      |
| Standard Deviation | 175.8798  |
| Sample Variance    | 30933.7   |
| Kurtosis           | 6.501134  |
| Skewness           | -2.133427 |
| Range              | 960       |
| Minimum            | 4508      |
| Maximum            | 5468      |
| Sum                | 393135    |
| Count              | 75        |

| 430th              |           |
|--------------------|-----------|
| Mean               | 4704.64   |
| Standard Error     | 16.84424  |
| Median             | 4728      |
| Mode               | 4787      |
| Standard Deviation | 145.8754  |
| Sample Variance    | 21279.64  |
| Kurtosis           | 1.061385  |
| Skewness           | -1.080874 |
| Range              | 694       |
| Minimum            | 4228      |
| Maximum            | 4922      |
| Sum                | 352848    |
| Count              | 75        |

| 440th              |           |
|--------------------|-----------|
| Mean               | 4699.36   |
| Standard Error     | 19.53539  |
| Median             | 4740      |
| Mode               | 4708      |
| Standard Deviation | 169.1815  |
| Sample Variance    | 28622.37  |
| Kurtosis           | 3.37099   |
| Skewness           | -1.578574 |
| Range              | 903       |
| Minimum            | 4015      |
| Maximum            | 4918      |
| Sum                | 352452    |
| Count              | 75        |

## Appendix C.

| T Test Results, no deployments |           |        |        |           |         |        |           |        |        |           |        |
|--------------------------------|-----------|--------|--------|-----------|---------|--------|-----------|--------|--------|-----------|--------|
| Pooled                         | Allocated | Diff   | Pooled | Allocated | diff    | Pooled | Allocated | diff   | Pooled | Allocated | diff   |
| 410th                          | 410th     |        | 420th  | 420th     |         | 430th  | 430th     |        | 440th  | 440th     |        |
| 13323                          | 13311     | 12.00  | 11501  | 11475     | 26.00   | 11040  | 10946     | 94.00  | 10967  | 10988     | -21.00 |
| 13323                          | 13301     | 22.00  | 11489  | 11536     | -47.00  | 10969  | 10951     | 18.00  | 10928  | 10906     | 22.00  |
| 13342                          | 13292     | 50.00  | 11461  | 11508     | -47.00  | 10970  | 10999     | -29.00 | 10975  | 10966     | 9.00   |
| 13371                          | 13325     | 46.00  | 11503  | 11513     | -10.00  | 10965  | 10908     | 57.00  | 11011  | 10983     | 28.00  |
| 13326                          | 13292     | 34.00  | 11445  | 11480     | -35.00  | 10980  | 10938     | 42.00  | 10987  | 10945     | 42.00  |
| 13271                          | 13277     | -6.00  | 11464  | 11517     | -53.00  | 10976  | 10932     | 44.00  | 11023  | 10964     | 59.00  |
| 13256                          | 13346     | -90.00 | 11449  | 11513     | -64.00  | 10988  | 10934     | 54.00  | 11024  | 10945     | 79.00  |
| 13295                          | 13263     | 32.00  | 11435  | 11471     | -36.00  | 10972  | 10886     | 86.00  | 10988  | 10919     | 69.00  |
| 13359                          | 13283     | 76.00  | 11401  | 11533     | -132.00 | 10955  | 10972     | -17.00 | 10943  | 10911     | 32.00  |
| 13335                          | 13317     | 18.00  | 11472  | 11512     | -40.00  | 10981  | 10942     | 39.00  | 10912  | 10931     | -19.00 |
| 13348                          | 13287     | 61.00  | 11472  | 11513     | -41.00  | 10983  | 10983     | 0.00   | 10993  | 10929     | 64.00  |
| 13325                          | 13316     | 9.00   | 11497  | 11550     | -53.00  | 10967  | 10958     | 9.00   | 10953  | 10971     | -18.00 |
| 13354                          | 13300     | 54.00  | 11481  | 11522     | -41.00  | 10996  | 11017     | -21.00 | 11020  | 10965     | 55.00  |
| 13328                          | 13305     | 23.00  | 11460  | 11501     | -41.00  | 11003  | 10955     | 48.00  | 10946  | 11022     | -76.00 |
| 13335                          | 13330     | 5.00   | 11445  | 11390     | 55.00   | 10937  | 10921     | 16.00  | 10979  | 10944     | 35.00  |
| 13356                          | 13337     | 19.00  | 11449  | 11526     | -77.00  | 10961  | 11016     | -55.00 | 10967  | 10978     | -11.00 |
| 13337                          | 13291     | 46.00  | 11426  | 11473     | -47.00  | 10976  | 10965     | 11.00  | 10990  | 10955     | 35.00  |
| 13296                          | 13283     | 13.00  | 11442  | 11481     | -39.00  | 10926  | 10938     | -12.00 | 10996  | 10959     | 37.00  |
| 13359                          | 13318     | 41.00  | 11453  | 11523     | -70.00  | 10935  | 10927     | 8.00   | 10959  | 11029     | -70.00 |
| 13393                          | 13307     | 86.00  | 11465  | 11557     | -92.00  | 10987  | 10979     | 8.00   | 11016  | 10907     | 109.00 |
| 13318                          | 13323     | -5.00  | 11436  | 11530     | -94.00  | 10974  | 10928     | 46.00  | 10989  | 10939     | 50.00  |
| 13347                          | 13364     | -17.00 | 11449  | 11509     | -60.00  | 10932  | 10941     | -9.00  | 11016  | 10982     | 34.00  |
| 13322                          | 13273     | 49.00  | 11509  | 11512     | -3.00   | 11012  | 10958     | 54.00  | 11000  | 10946     | 54.00  |
| 13276                          | 13334     | -58.00 | 11447  | 11501     | -54.00  | 10983  | 10931     | 52.00  | 10946  | 10979     | -33.00 |
| 13320                          | 13230     | 90.00  | 11393  | 11502     | -109.00 | 10965  | 10926     | 39.00  | 10995  | 10996     | -1.00  |
| 13322                          | 13348     | -26.00 | 11470  | 11445     | 25.00   | 10973  | 10988     | -15.00 | 10993  | 10909     | 84.00  |
| 13340                          | 13321     | 19.00  | 11435  | 11524     | -89.00  | 10951  | 10928     | 23.00  | 10981  | 11015     | -34.00 |
| 13318                          | 13322     | -4.00  | 11450  | 11499     | -49.00  | 10968  | 10902     | 66.00  | 10961  | 10992     | -31.00 |
| 13300                          | 13296     | 4.00   | 11436  | 11531     | -95.00  | 10979  | 10965     | 14.00  | 11033  | 10959     | 74.00  |
| 13381                          | 13353     | 28.00  | 11456  | 11505     | -49.00  | 10977  | 10967     | 10.00  | 10946  | 10960     | -14.00 |
| 410th                          | 410th     |        | 420th  | 420th     |         | 430th  | 430th     |        | 440th  | 440th     |        |
| mean                           |           | 21.03  |        |           | -48.70  |        |           | 22.67  |        |           | 21.43  |
| std dev                        |           | 38.69  |        |           | 39.83   |        |           | 34.69  |        |           | 46.27  |
| T stat                         |           | 2.05   |        |           |         |        |           |        |        |           |        |
| T score                        |           | 2.98   |        |           | -6.70   |        |           | 3.58   |        |           | 2.54   |
| Z stat                         |           | 1.96   |        |           |         |        |           |        |        |           |        |
| Z score                        |           | 2.71   |        |           | -6.27   |        |           | 3.17   |        |           | 2.59   |
| n                              |           | 30.00  |        |           |         |        |           |        |        |           |        |
| T hlf width                    |           | 14.45  |        |           | 14.87   |        |           | 12.95  |        |           | 17.28  |

| T Test Results, one deployment |           |        |        |           |        |        |           |       |        |           |       |
|--------------------------------|-----------|--------|--------|-----------|--------|--------|-----------|-------|--------|-----------|-------|
| Pooled                         | Allocated | Diff   | Pooled | Allocated | Diff   | Pooled | Allocated | Diff  | Pooled | Allocated | Diff  |
| 410th                          | 410th     |        | 420th  | 420th     |        | 430th  | 430th     |       | 440th  | 440th     |       |
| 7497                           | 6927      | 570    | 11452  | 11502     | -50    | 10990  | 10952     | 38    | 10985  | 10984     | 1     |
| 7468                           | 7454      | 14     | 11483  | 11554     | -71    | 10972  | 10977     | -5    | 10986  | 10940     | 46    |
| 7444                           | 7289      | 155    | 11452  | 11476     | -24    | 10981  | 10951     | 30    | 11013  | 10967     | 46    |
| 7438                           | 7376      | 62     | 11473  | 11472     | 1      | 10965  | 10938     | 27    | 11007  | 10942     | 65    |
| 7491                           | 7294      | 197    | 11471  | 11491     | -20    | 10969  | 10969     | 0     | 10961  | 10986     | -25   |
| 7456                           | 7355      | 101    | 11470  | 11506     | -36    | 10979  | 10978     | 1     | 10971  | 10910     | 61    |
| 7470                           | 7162      | 308    | 11441  | 11484     | -43    | 11006  | 10928     | 78    | 10973  | 10955     | 18    |
| 7482                           | 7298      | 184    | 11430  | 11503     | -73    | 10962  | 10921     | 41    | 10977  | 10953     | 24    |
| 7494                           | 7310      | 184    | 11473  | 11536     | -63    | 10978  | 10920     | 58    | 11037  | 11000     | 37    |
| 7465                           | 7408      | 57     | 11470  | 11568     | -98    | 10968  | 10939     | 29    | 10985  | 10947     | 38    |
| 7487                           | 6915      | 572    | 11419  | 11541     | -122   | 10937  | 10968     | -31   | 10957  | 10895     | 62    |
| 7458                           | 7269      | 189    | 11460  | 11526     | -66    | 10990  | 10978     | 12    | 10973  | 10973     | 0     |
| 7485                           | 7334      | 151    | 11428  | 11489     | -61    | 10947  | 10971     | -24   | 11017  | 10970     | 47    |
| 7520                           | 7062      | 458    | 11465  | 11536     | -71    | 10979  | 10972     | 7     | 10945  | 10926     | 19    |
| 7466                           | 7393      | 73     | 11491  | 11512     | -21    | 11009  | 11005     | 4     | 10996  | 10976     | 20    |
| 7483                           | 7221      | 262    | 11463  | 11525     | -62    | 10979  | 10945     | 34    | 10935  | 10937     | -2    |
| 7475                           | 7280      | 195    | 11488  | 11574     | -86    | 10956  | 10923     | 33    | 10943  | 10913     | 30    |
| 7482                           | 7393      | 89     | 11455  | 11541     | -86    | 10966  | 11009     | -43   | 10948  | 10986     | -38   |
| 7468                           | 7273      | 195    | 11442  | 11517     | -75    | 10969  | 10875     | 94    | 10909  | 10917     | -8    |
| 7500                           | 6783      | 717    | 11454  | 11471     | -17    | 10937  | 10926     | 11    | 10987  | 10980     | 7     |
| 7460                           | 7300      | 160    | 11421  | 11506     | -85    | 11002  | 10964     | 38    | 10999  | 10970     | 29    |
| 7441                           | 7394      | 47     | 11430  | 11500     | -70    | 10951  | 10988     | -37   | 10960  | 10942     | 18    |
| 7506                           | 7306      | 200    | 11428  | 11479     | -51    | 10935  | 10962     | -27   | 11000  | 10932     | 68    |
| 7487                           | 7435      | 52     | 11492  | 11475     | 17     | 10933  | 10926     | 7     | 11010  | 11000     | 10    |
| 7517                           | 7318      | 199    | 11451  | 11598     | -147   | 10953  | 10945     | 8     | 10965  | 10962     | 3     |
| 7460                           | 7141      | 319    | 11440  | 11548     | -108   | 10977  | 10984     | -7    | 10982  | 10920     | 62    |
| 7468                           | 7444      | 24     | 11466  | 11515     | -49    | 10962  | 10950     | 12    | 10973  | 10970     | 3     |
| 7483                           | 7381      | 102    | 11426  | 11497     | -71    | 10910  | 10939     | -29   | 10950  | 10988     | -38   |
| 7503                           | 6810      | 693    | 11463  | 11553     | -90    | 11010  | 10979     | 31    | 10980  | 10905     | 75    |
| 7484                           | 7302      | 182    | 11483  | 11522     | -39    | 10989  | 10953     | 36    | 11019  | 10916     | 103   |
| 410th                          | 410th     |        | 420th  | 420th     |        | 430th  | 430th     |       | 440th  | 440th     |       |
| mean                           |           | 223.70 |        |           | -61.23 |        |           | 14.20 |        |           | 26.03 |
| std dev                        |           | 192.11 |        |           | 35.44  |        |           | 32.57 |        |           | 33.68 |
| T stat                         |           | 2.05   |        |           |        |        |           |       |        |           |       |
| T score                        |           | 6.38   |        |           | -9.46  |        |           | 2.39  |        |           | 4.23  |
| Z stat                         |           | 1.96   |        |           |        |        |           |       |        |           |       |
| Z score                        |           | 6.69   |        |           | -8.54  |        |           | 2.08  |        |           | 3.45  |
| n                              |           | 30.00  |        |           |        |        |           |       |        |           |       |
| T hlf width                    |           | 71.73  |        |           | 13.23  |        |           | 12.16 |        |           | 12.57 |

| T Test Results, 2 deployments |           |        |        |           |       |        |           |       |        |           |       |
|-------------------------------|-----------|--------|--------|-----------|-------|--------|-----------|-------|--------|-----------|-------|
| Pooled                        | Allocated | diff   | Pooled | Allocated | diff  | Pooled | Allocated | diff  | Pooled | Allocated | diff  |
| 410th                         | 410th     |        | 420th  | 420th     |       | 430th  | 430th     |       | 440th  | 440th     |       |
| 7513                          | 7490      | 23     | 5452   | 5397      | 55    | 10994  | 10935     | 59    | 10984  | 10893     | 91    |
| 7448                          | 7301      | 147    | 5427   | 5443      | -16   | 10973  | 10923     | 50    | 10998  | 10951     | 47    |
| 7463                          | 7466      | -3     | 5405   | 5455      | -50   | 10998  | 10931     | 67    | 11008  | 10949     | 59    |
| 7486                          | 7338      | 148    | 5422   | 5455      | -33   | 10953  | 10968     | -15   | 10975  | 10993     | -18   |
| 7477                          | 7321      | 156    | 5435   | 5443      | -8    | 10986  | 10957     | 29    | 10945  | 11013     | -68   |
| 7494                          | 7356      | 138    | 5420   | 5124      | 296   | 10967  | 10956     | 11    | 10992  | 10962     | 30    |
| 7509                          | 7233      | 276    | 5435   | 5214      | 221   | 10995  | 10988     | 7     | 10956  | 10913     | 43    |
| 7463                          | 7108      | 355    | 5449   | 5441      | 8     | 10952  | 10914     | 38    | 10952  | 10965     | -13   |
| 7515                          | 7128      | 387    | 5447   | 5345      | 102   | 10950  | 11000     | -50   | 10978  | 11006     | -28   |
| 7467                          | 7222      | 245    | 5430   | 5454      | -24   | 10949  | 10919     | 30    | 11002  | 10998     | 4     |
| 7467                          | 6953      | 514    | 5426   | 5141      | 285   | 10961  | 10970     | -9    | 11017  | 10951     | 66    |
| 7413                          | 6900      | 513    | 5441   | 5387      | 54    | 10983  | 10908     | 75    | 10962  | 10987     | -25   |
| 7461                          | 7206      | 255    | 5411   | 5429      | -18   | 10994  | 10973     | 21    | 10955  | 10973     | -18   |
| 7497                          | 7301      | 196    | 5420   | 5459      | -39   | 10940  | 11010     | -70   | 10979  | 10964     | 15    |
| 7520                          | 7374      | 146    | 5429   | 5460      | -31   | 10980  | 10968     | 12    | 10985  | 10982     | 3     |
| 7494                          | 7368      | 126    | 5450   | 5415      | 35    | 10959  | 10989     | -30   | 10984  | 11012     | -28   |
| 7491                          | 7346      | 145    | 5447   | 5438      | 9     | 10960  | 10948     | 12    | 11010  | 11007     | 3     |
| 7444                          | 7297      | 147    | 5428   | 5408      | 20    | 10962  | 10955     | 7     | 10986  | 10903     | 83    |
| 7510                          | 7285      | 225    | 5450   | 5305      | 145   | 10941  | 10963     | -22   | 10991  | 10926     | 65    |
| 7465                          | 7449      | 16     | 5438   | 5448      | -10   | 10937  | 10901     | 36    | 10985  | 10943     | 42    |
| 7478                          | 7436      | 42     | 5454   | 5358      | 96    | 10946  | 10981     | -35   | 11002  | 10961     | 41    |
| 7461                          | 6516      | 945    | 5424   | 5418      | 6     | 10991  | 10883     | 108   | 10986  | 10916     | 70    |
| 7484                          | 7327      | 157    | 5437   | 5399      | 38    | 10950  | 10968     | -18   | 10967  | 10947     | 20    |
| 7525                          | 6629      | 896    | 5414   | 5423      | -9    | 10996  | 11005     | -9    | 10969  | 11023     | -54   |
| 7495                          | 7390      | 105    | 5445   | 5397      | 48    | 11003  | 10998     | 5     | 11009  | 10938     | 71    |
| 7511                          | 6989      | 522    | 5448   | 5376      | 72    | 10971  | 10925     | 46    | 10969  | 10929     | 40    |
| 7478                          | 7357      | 121    | 5454   | 5475      | -21   | 10981  | 10909     | 72    | 10981  | 10968     | 13    |
| 7458                          | 7438      | 20     | 5433   | 5411      | 22    | 11003  | 10943     | 60    | 10948  | 10961     | -13   |
| 7521                          | 7077      | 444    | 5420   | 5446      | -26   | 10936  | 10941     | -5    | 11009  | 11000     | 9     |
| 7514                          | 7476      | 38     | 5432   | 5362      | 70    | 10961  | 10973     | -12   | 11021  | 10944     | 77    |
| 410th                         | 410th     |        | 420th  | 420th     |       | 430th  | 430th     |       | 440th  | 440th     |       |
| mean                          |           | 248.17 |        |           | 43.23 |        |           | 15.67 |        |           | 20.90 |
| std dev                       |           | 237.28 |        |           | 89.62 |        |           | 40.53 |        |           | 42.19 |
| T stat                        |           | 2.05   |        |           |       |        |           |       |        |           |       |
| T score                       |           | 5.73   |        |           | 2.64  |        |           | 2.12  |        |           | 2.71  |
| Z stat                        |           | 1.96   |        |           |       |        |           |       |        |           |       |
| Z score                       |           | 5.68   |        |           | 2.65  |        |           | 2.16  |        |           | 2.83  |
| n                             |           | 30.00  |        |           |       |        |           |       |        |           |       |
| T hlf width                   |           | 88.59  |        |           | 33.46 |        |           | 15.13 |        |           | 15.75 |

| T Test Results, 3 deployments |           |        |        |           |       |        |           |       |        |           |       |
|-------------------------------|-----------|--------|--------|-----------|-------|--------|-----------|-------|--------|-----------|-------|
| pooled                        | Allocated | Diff   | pooled | Allocated | Diff  | pooled | Allocated | Diff  | pooled | Allocated | Diff  |
| 410th                         | 410th     |        | 420th  | 420th     |       | 430th  | 430th     |       | 440th  | 440th     |       |
| 7532                          | 7356      | 176    | 5429   | 5464      | -35   | 4914   | 4897      | 17    | 10962  | 10882     | 80    |
| 7521                          | 7113      | 408    | 5439   | 5362      | 77    | 4945   | 4884      | 61    | 10922  | 10958     | -36   |
| 7475                          | 7216      | 259    | 5442   | 5400      | 42    | 4925   | 4858      | 67    | 10932  | 10911     | 21    |
| 7483                          | 7330      | 153    | 5470   | 5426      | 44    | 4950   | 4902      | 48    | 11007  | 10975     | 32    |
| 7501                          | 7366      | 135    | 5426   | 5445      | -19   | 4921   | 4807      | 114   | 10998  | 10961     | 37    |
| 7501                          | 7367      | 134    | 5436   | 5425      | 11    | 4918   | 4891      | 27    | 10985  | 10951     | 34    |
| 7489                          | 7323      | 166    | 5427   | 5442      | -15   | 4940   | 4900      | 40    | 11002  | 10967     | 35    |
| 7473                          | 7302      | 171    | 5428   | 5373      | 55    | 4964   | 4890      | 74    | 10952  | 10784     | 168   |
| 7457                          | 7391      | 66     | 5393   | 5427      | -34   | 4924   | 4818      | 106   | 11003  | 10964     | 39    |
| 7523                          | 7409      | 114    | 5438   | 5390      | 48    | 4934   | 4946      | -12   | 10955  | 10957     | -2    |
| 7480                          | 7241      | 239    | 5421   | 5401      | 20    | 4889   | 4899      | -10   | 10975  | 10971     | 4     |
| 7483                          | 7365      | 118    | 5417   | 5410      | 7     | 4956   | 4892      | 64    | 10969  | 10948     | 21    |
| 7504                          | 6552      | 952    | 5440   | 5405      | 35    | 4920   | 4933      | -13   | 10976  | 10986     | -10   |
| 7477                          | 7149      | 328    | 5450   | 5006      | 444   | 4931   | 4935      | -4    | 10986  | 10927     | 59    |
| 7467                          | 7304      | 163    | 5424   | 5386      | 38    | 4941   | 4897      | 44    | 11018  | 10963     | 55    |
| 7496                          | 7292      | 204    | 5373   | 5389      | -16   | 4941   | 4908      | 33    | 10936  | 10981     | -45   |
| 7464                          | 6852      | 612    | 5461   | 5464      | -3    | 4911   | 4898      | 13    | 10953  | 10903     | 50    |
| 7484                          | 7440      | 44     | 5394   | 5357      | 37    | 4965   | 4849      | 116   | 10989  | 10943     | 46    |
| 7469                          | 7414      | 55     | 5427   | 5437      | -10   | 4950   | 4918      | 32    | 10980  | 10939     | 41    |
| 7509                          | 7449      | 60     | 5448   | 5471      | -23   | 4931   | 4876      | 55    | 10970  | 10927     | 43    |
| 7455                          | 7193      | 262    | 5472   | 5409      | 63    | 4964   | 4680      | 284   | 10919  | 10948     | -29   |
| 7508                          | 7292      | 216    | 5428   | 5309      | 119   | 4949   | 4808      | 141   | 10989  | 11001     | -12   |
| 7497                          | 7380      | 117    | 5435   | 5375      | 60    | 4943   | 4895      | 48    | 10927  | 10906     | 21    |
| 7433                          | 7383      | 50     | 5459   | 5459      | 0     | 4895   | 4825      | 70    | 11037  | 10922     | 115   |
| 7500                          | 7258      | 242    | 5433   | 5431      | 2     | 4979   | 4768      | 211   | 10965  | 10928     | 37    |
| 7463                          | 7271      | 192    | 5410   | 5464      | -54   | 4977   | 4418      | 559   | 10946  | 10995     | -49   |
| 7447                          | 6877      | 570    | 5426   | 5448      | -22   | 4967   | 4748      | 219   | 10978  | 10980     | -2    |
| 7495                          | 7392      | 103    | 5417   | 5445      | -28   | 4935   | 4927      | 8     | 10970  | 10949     | 21    |
| 7494                          | 7416      | 78     | 5418   | 5373      | 45    | 4935   | 4823      | 112   | 10991  | 10987     | 4     |
| 7480                          | 7273      | 207    | 5391   | 5410      | -19   | 4964   | 4917      | 47    | 10962  | 10983     | -21   |
| 7477                          | 7109      | 368    | 5442   | 5311      | 131   | 4970   | 4929      | 41    | 10978  | 10982     | -4    |
| 7467                          | 7427      | 40     | 5436   | 5421      | 15    | 4969   | 4738      | 231   | 11004  | 10948     | 56    |
| 7483                          | 6936      | 547    | 5415   | 5285      | 130   | 4929   | 4888      | 41    | 10974  | 10995     | -21   |
| 7479                          | 7421      | 58     | 5426   | 5367      | 59    | 4946   | 4848      | 98    | 10947  | 10946     | 1     |
| 7499                          | 7398      | 101    | 5444   | 5457      | -13   | 4914   | 4904      | 10    | 11016  | 10992     | 24    |
| 7500                          | 7419      | 81     | 5460   | 5485      | -25   | 4911   | 4812      | 99    | 10951  | 10992     | -41   |
| 7475                          | 7398      | 77     | 5430   | 5408      | 22    | 4947   | 4909      | 38    | 10992  | 10948     | 44    |
| 7430                          | 7413      | 17     | 5425   | 5414      | 11    | 4924   | 4874      | 50    | 10987  | 10937     | 50    |
| 7487                          | 7257      | 230    | 5442   | 5443      | -1    | 4956   | 4925      | 31    | 10973  | 11001     | -28   |
| 7463                          | 7426      | 37     | 5436   | 5418      | 18    | 4951   | 4904      | 47    | 10981  | 10952     | 29    |
| 7497                          | 7143      | 354    | 5436   | 5454      | -18   | 4948   | 4803      | 145   | 11006  | 10990     | 16    |
| 7455                          | 7345      | 110    | 5419   | 5442      | -23   | 4931   | 4910      | 21    | 10945  | 10967     | -22   |
| 7449                          | 6899      | 550    | 5432   | 5461      | -29   | 4970   | 4890      | 80    | 10978  | 10915     | 63    |
| 7526                          | 7262      | 264    | 5414   | 5496      | -82   | 4947   | 4649      | 298   | 10970  | 10944     | 26    |
| 7450                          | 7270      | 180    | 5401   | 5470      | -69   | 4896   | 4807      | 89    | 10939  | 10951     | -12   |
| 7488                          | 7335      | 153    | 5450   | 5420      | 30    | 4948   | 4778      | 170   | 11025  | 10981     | 44    |
| 7476                          | 7418      | 58     | 5421   | 5414      | 7     | 4910   | 4909      | 1     | 10968  | 10976     | -8    |
| 7474                          | 7280      | 194    | 5422   | 5373      | 49    | 4966   | 4871      | 95    | 10974  | 10981     | -7    |
| 7478                          | 7423      | 55     | 5415   | 5447      | -32   | 4938   | 4837      | 101   | 10923  | 10935     | -12   |
| 7492                          | 7119      | 373    | 5467   | 5342      | 125   | 4947   | 4825      | 122   | 10987  | 10917     | 70    |
| 410th                         | 410th     |        | 420th  | 420th     |       | 430th  | 430th     |       | 440th  | 440th     |       |
| mean                          |           | 208.82 |        |           | 23.48 |        |           | 87.58 |        |           | 20.50 |
| std dev                       |           | 182.44 |        |           | 77.46 |        |           | 99.28 |        |           | 41.09 |
| T stat                        |           | 2.01   |        |           |       |        |           |       |        |           |       |
| T score                       |           | 8.09   |        |           | 2.14  |        |           | 6.24  |        |           | 3.53  |
| Z stat                        |           | 1.96   |        |           |       |        |           |       |        |           |       |
| Z score                       |           | 8.03   |        |           | 2.17  |        |           | 6.66  |        |           | 3.12  |
| n                             |           | 50.00  |        |           |       |        |           |       |        |           |       |
| T hlf width                   |           | 51.83  |        |           | 22.01 |        |           | 28.21 |        |           | 11.67 |

| T Test Results, 4 deployments |           |        |       |           |        |       |           |        |       |           |        |
|-------------------------------|-----------|--------|-------|-----------|--------|-------|-----------|--------|-------|-----------|--------|
| pool                          | allocated |        | pool  | allocated |        | pool  | allocated |        | pool  | allocated |        |
| 410th                         | 410th     | diff   | 420th | 420th     | diff   | 430th | 430th     | diff   | 440th | 440th     | diff   |
| 7382                          | 7067      | 315    | 5363  | 4851      | 512    | 4825  | 4492      | 333    | 4810  | 4336      | 474    |
| 7246                          | 7113      | 133    | 5262  | 5294      | -32    | 4780  | 4748      | 32     | 4822  | 4645      | 177    |
| 7495                          | 7350      | 145    | 5434  | 5364      | 70     | 4890  | 4778      | 112    | 4911  | 4660      | 251    |
| 6846                          | 6705      | 141    | 5002  | 4508      | 494    | 4535  | 4294      | 241    | 4727  | 4015      | 712    |
| 7277                          | 7415      | -138   | 5327  | 5367      | -40    | 4767  | 4874      | -107   | 4824  | 4822      | 2      |
| 7337                          | 7334      | 3      | 5294  | 5397      | -103   | 4835  | 4785      | 50     | 4850  | 4824      | 26     |
| 7427                          | 7416      | 11     | 5361  | 5273      | 88     | 4897  | 4645      | 252    | 4798  | 4481      | 317    |
| 7029                          | 7239      | -210   | 5136  | 5274      | -138   | 4782  | 4787      | -5     | 4705  | 4708      | -3     |
| 7118                          | 7397      | -279   | 5049  | 5397      | -348   | 4766  | 4922      | -156   | 4594  | 4864      | -270   |
| 7308                          | 7342      | -34    | 5296  | 5262      | 34     | 4764  | 4727      | 37     | 4702  | 4798      | -96    |
| 7303                          | 7259      | 44     | 5292  | 5291      | 1      | 4772  | 4707      | 65     | 4812  | 4721      | 91     |
| 7378                          | 7334      | 44     | 5301  | 5318      | -17    | 4880  | 4764      | 116    | 4845  | 4735      | 110    |
| 7184                          | 7388      | -204   | 5168  | 5250      | -82    | 4719  | 4680      | 39     | 4569  | 4756      | -187   |
| 7277                          | 7104      | 173    | 5319  | 5348      | -29    | 4820  | 4612      | 208    | 4768  | 4740      | 28     |
| 7044                          | 7380      | -336   | 5270  | 5350      | -80    | 4704  | 4884      | -180   | 4714  | 4852      | -138   |
| 7062                          | 7419      | -357   | 5185  | 5397      | -212   | 4683  | 4848      | -165   | 4602  | 4816      | -214   |
| 7088                          | 7165      | -77    | 5318  | 5302      | 16     | 4887  | 4693      | 194    | 4845  | 4606      | 239    |
| 7379                          | 7424      | -45    | 5377  | 5206      | 171    | 4818  | 4707      | 111    | 4861  | 4850      | 11     |
| 7422                          | 7330      | 92     | 5342  | 5150      | 192    | 4859  | 4764      | 95     | 4809  | 4828      | -19    |
| 7388                          | 7148      | 240    | 5362  | 5170      | 192    | 4909  | 4705      | 204    | 4874  | 4771      | 103    |
| 7404                          | 7388      | 16     | 4998  | 5314      | -316   | 4841  | 4828      | 13     | 4861  | 4874      | -13    |
| 7376                          | 7142      | 234    | 5371  | 5296      | 75     | 4804  | 4777      | 27     | 4839  | 4771      | 68     |
| 6979                          | 7085      | -106   | 5127  | 4923      | 204    | 4622  | 4613      | 9      | 4604  | 4545      | 59     |
| 7321                          | 6809      | 512    | 5421  | 5100      | 321    | 4959  | 4584      | 375    | 4850  | 4666      | 184    |
| 7000                          | 7339      | -339   | 5104  | 5272      | -168   | 4627  | 4563      | 64     | 4425  | 4372      | 53     |
| 7416                          | 7407      | 9      | 5379  | 5273      | 106    | 4922  | 4787      | 135    | 4926  | 4549      | 377    |
| 7320                          | 7208      | 112    | 5279  | 5392      | -113   | 4832  | 4792      | 40     | 4796  | 4655      | 141    |
| 7352                          | 7289      | 63     | 5360  | 5295      | 65     | 4794  | 4821      | -27    | 4819  | 4779      | 40     |
| 7169                          | 7148      | 21     | 5108  | 5106      | 2      | 4682  | 4710      | -28    | 4637  | 4615      | 22     |
| 7159                          | 6829      | 330    | 5261  | 5105      | 156    | 4686  | 4505      | 181    | 4801  | 4476      | 325    |
| 7331                          | 7094      | 237    | 5354  | 5366      | -12    | 4902  | 4732      | 170    | 4890  | 4584      | 306    |
| 7390                          | 7288      | 102    | 5404  | 5335      | 69     | 4886  | 4799      | 87     | 4914  | 4728      | 186    |
| 7292                          | 7089      | 203    | 5363  | 5004      | 359    | 4843  | 4401      | 442    | 4869  | 4217      | 652    |
| 7054                          | 7470      | -416   | 5130  | 5162      | -32    | 4644  | 4887      | -243   | 4598  | 4864      | -266   |
| 7385                          | 7179      | 206    | 5352  | 5236      | 116    | 4903  | 4387      | 516    | 4936  | 4556      | 380    |
| 7299                          | 7333      | -34    | 5331  | 5254      | 77     | 4882  | 4803      | 79     | 4872  | 4764      | 108    |
| 7346                          | 7202      | 144    | 5312  | 5302      | 10     | 4881  | 4755      | 126    | 4856  | 4577      | 279    |
| 7458                          | 7303      | 155    | 5406  | 5286      | 120    | 4952  | 4654      | 298    | 4880  | 4626      | 254    |
| 7413                          | 6957      | 456    | 5374  | 5050      | 324    | 4903  | 4491      | 412    | 4868  | 4524      | 344    |
| 6717                          | 6938      | -221   | 5171  | 5070      | 101    | 4812  | 4525      | 287    | 4801  | 4632      | 169    |
| 6962                          | 7209      | -247   | 5099  | 5303      | -204   | 4895  | 4768      | -133   | 4613  | 4647      | -34    |
| 7261                          | 6661      | 600    | 5354  | 4515      | 839    | 4862  | 4228      | 634    | 4846  | 4266      | 580    |
| 7347                          | 7411      | -64    | 5312  | 5293      | 19     | 4876  | 4728      | 148    | 4894  | 4733      | 161    |
| 7460                          | 7466      | -6     | 5405  | 5402      | 3      | 4936  | 4894      | 42     | 4945  | 4904      | 41     |
| 7340                          | 7461      | -121   | 5300  | 5317      | -17    | 4825  | 4843      | -18    | 4907  | 4742      | 165    |
| 7117                          | 7434      | -317   | 5139  | 5372      | -233   | 4623  | 4850      | -227   | 4653  | 4918      | -265   |
| 7301                          | 7266      | 35     | 5197  | 5366      | -159   | 4751  | 4655      | 96     | 4845  | 4519      | 326    |
| 7392                          | 7178      | 214    | 5303  | 5206      | 97     | 4916  | 4690      | 226    | 4887  | 4654      | 233    |
| 7236                          | 7072      | 164    | 4963  | 5133      | -170   | 4770  | 4486      | 284    | 4809  | 4629      | 180    |
| 7124                          | 7280      | -156   | 5115  | 5409      | -294   | 4699  | 4829      | -130   | 4577  | 4818      | -241   |
| 7440                          | 7334      | 106    | 5430  | 5269      | 161    | 4906  | 4724      | 182    | 4936  | 4848      | 88     |
| 7384                          | 7412      | -28    | 5367  | 5094      | 273    | 4852  | 4819      | 33     | 4904  | 4851      | 53     |
| 7435                          | 7108      | 327    | 5369  | 5084      | 285    | 4851  | 4626      | 225    | 4909  | 4702      | 207    |
| 7245                          | 6867      | 378    | 5328  | 5279      | 49     | 4823  | 4681      | 142    | 4886  | 4851      | 35     |
| 7013                          | 7114      | -101   | 4978  | 5121      | -143   | 4716  | 4550      | 166    | 4690  | 4584      | 106    |
| 7383                          | 7442      | -59    | 5415  | 5342      | 73     | 4904  | 4836      | 68     | 4814  | 4803      | 11     |
| 6671                          | 7350      | -679   | 4983  | 5414      | -431   | 4453  | 4836      | -383   | 4627  | 4823      | -196   |
| 7243                          | 7330      | -87    | 5161  | 5156      | 5      | 4726  | 4713      | 13     | 4771  | 4796      | -25    |
| 7342                          | 7417      | -75    | 5324  | 5324      | 0      | 4794  | 4762      | 32     | 4850  | 4848      | 2      |
| 7355                          | 7188      | 167    | 5182  | 5068      | 114    | 4769  | 4606      | 163    | 4729  | 4708      | 21     |
| 7067                          | 7463      | -396   | 5117  | 5420      | -303   | 4604  | 4860      | -256   | 4735  | 4868      | -133   |
| 7067                          | 7310      | -243   | 5264  | 5218      | 46     | 4691  | 4424      | 267    | 4410  | 4791      | -381   |
| 7355                          | 7378      | -23    | 5382  | 5468      | -86    | 4849  | 4847      | 2      | 4862  | 4805      | 57     |
| 7065                          | 7440      | -375   | 5165  | 5383      | -218   | 4790  | 4841      | -51    | 4621  | 4784      | -163   |
| 7230                          | 7191      | 39     | 5357  | 5244      | 113    | 4751  | 4678      | 73     | 4823  | 4607      | 216    |
| 7299                          | 7267      | 32     | 5345  | 5344      | 1      | 4819  | 4813      | 6      | 4823  | 4624      | 199    |
| 7368                          | 7313      | 55     | 5386  | 5401      | -15    | 4908  | 4631      | 277    | 4941  | 4860      | 81     |
| 7277                          | 7246      | 31     | 5154  | 5214      | -60    | 4784  | 4522      | 262    | 4725  | 4821      | -96    |
| 7257                          | 7086      | 171    | 5231  | 5153      | 78     | 4770  | 4774      | -4     | 4786  | 4703      | 83     |
| 7149                          | 7123      | 26     | 5167  | 5057      | 110    | 4714  | 4640      | 74     | 4673  | 4605      | 68     |
| 7126                          | 7383      | -257   | 5286  | 5351      | -65    | 4793  | 4678      | 115    | 4794  | 4832      | -38    |
| 7384                          | 7213      | 171    | 5365  | 5459      | -94    | 4835  | 4660      | 175    | 4768  | 4761      | 7      |
| 7065                          | 7443      | -378   | 5267  | 5382      | -115   | 4742  | 4830      | -88    | 4641  | 4854      | -213   |
| 7384                          | 7302      | 82     | 5253  | 5229      | 24     | 4708  | 4802      | -94    | 4861  | 4779      | 82     |
| 7329                          | 7427      | -98    | 5375  | 5445      | -70    | 4938  | 4894      | 44     | 4836  | 4912      | -76    |
| 410th                         | 410th     |        | 420th | 420th     |        | 430th | 430th     |        | 440th | 440th     |        |
| mean                          |           | 3.11   |       |           | 23.55  |       |           | 90.72  |       |           | 85.64  |
| std dev                       |           | 230.99 |       |           | 200.79 |       |           | 177.59 |       |           | 208.51 |
| T stat                        |           | 1.99   |       |           |        |       |           |        |       |           |        |
| T score                       |           | 0.12   |       |           | 1.02   |       |           | 4.42   |       |           | 3.56   |
| Z stat                        |           | 1.96   |       |           |        |       |           |        |       |           |        |
| Z score                       |           | 0.11   |       |           | 0.95   |       |           | 4.41   |       |           | 3.59   |
| n                             |           | 75.00  |       |           |        |       |           |        |       |           |        |
| T hlf width                   |           | 53.08  |       |           | 46.14  |       |           | 40.81  |       |           | 47.91  |

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| 13. SUPPLEMENTARY NOTES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |             |                                   |                                  |                                                                       |                                                                                                   |
| 14. ABSTRACT<br><p>Since the Air Force began its evolution into an Expeditionary Air Force, much effort has been expended in attempt to optimize the compositions of each AEF and the manner in which an AEF deploys. Air Force plans were previously based upon deploying 24-ship Unit Type Codes (UTC), although a 12-ship deployment is more prevalent in today's environment. In an effort to eliminate the anomalies between planned and actual deployment composition, the Air Staff directed in 2002 that all fighter UTCs be <i>right-sized</i> to reflect current, planned requirements. The directive stipulates the development of UTCs in a <i>building block</i> fashion so that a squadron is poised to deploy one lead package of aircraft, with potential follow-on packages. This plan makes it possible for an entire UTC to be tasked to one organization, while allowing the unit to continue limited operations at home station.</p> <p>Given these deployment requirements, reduced numbers of Aircraft Ground Equipment (AGE) will remain to support the aircraft remaining at home-station. This research consists of a discrete event simulation to determine an effective manner in which to manage the remaining support equipment to maximize sortie production capabilities by varying the AGE management concepts, quantity of AGE remaining on-station, number of aircraft remaining on-station.</p> |             |                                   |                                  |                                                                       |                                                                                                   |
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| U                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | U           | U                                 | UU                               | 116                                                                   | 19b. TELEPHONE NUMBER (Include area code)<br>(937) 255-6565, ext 4367<br>(Stephan.Brady@afit.edu) |