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Aerospace Ground Equipment Management's Impact on Home-Station Sortie Production

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

THESIS

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AFIT/GLM/ENS/03-01

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THESIS

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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 arguement 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 21st 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, sited 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 reseach. 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'Fearna

Capt O'Fearna 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'Fearna planned to compare those requirements to the current levels and pare down the deployment requirements in an effort to reduce the logistics tail (O'Fearna, 1999).

Capt O'Fearna 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'Fearna chose not to model AGE reliability based upon previous research citing a weak correlation between AGE reliability and PCM.

O'Fearna 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'Fearna, 1999)

Festejo

Capt Festejo provided follow-on research to Capt O'Fearna 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 Halvicek'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, forth, and fifth digit of the WUC, alphabetic and numeric characters are used to designated 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).

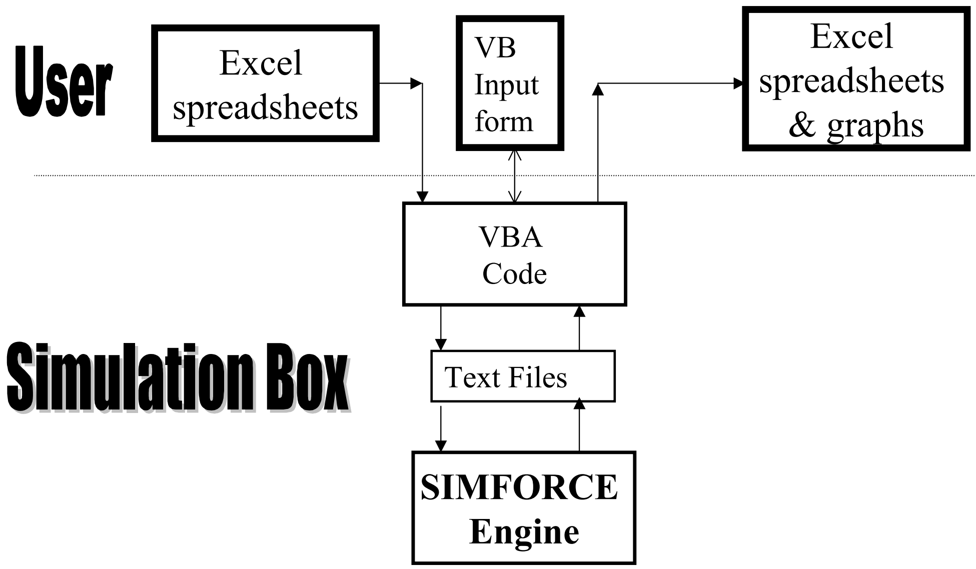


Figure 1. SIMFORCE System Architecture (KLSS, 2002)

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

Step Name	Fly Step?	Chance of Break
Crew Chief Walk Around	○	1%
Air Crew Pre-Flight	○	1%
Fly Mission	●	1%
Debrief	○	21%
Unload	○	0%
Configure	○	0%
Fuel Load	○	1%
Weapons Load	○	1%
Software Load	○	1%
Post Flight	○	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 Forced 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

ID	Purpose	Term
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 possibly 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	○	1%	1.0	-60	1
Air Crew Pre-Flight	○	1%	1.0		
Fly Mission	◉	1%	1.0		
Debrief	○	21%	1.0		
Unload	○	0%	1.0		
Configure	○	0%	1.0		
Fuel Load	○	1%	1.0		
Weapons Load	○	1%	1.0	-60	1
Software Load	○	1%	1.0		
Post Flight	○	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 score	
	Pooled	Allocated
Condition 1		
410 Home		
420 Home		
430 Home		
440 Home		
Condition 2		
410 Deployed		
420 Home		
430 Home		
440 Home		
Condition 3		
410 Deployed		
420 Deployed		
430 Home		
440 Home		
Condition 4		
410 Deployed		
420 Deployed		
430 Deployed		
440 Home		
Condition 5		
410 Deployed		
420 Deployed		
430 Deployed		
440 Deployed		

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 realty, 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:

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

Where:

$\overline{d}$ = 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

3. 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

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?

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 20th 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)

Purpose	Term	MTBF	MTTR
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

Not Available Results	**Pooled**	**Wait Time Results**	**Pooled**
Resource	**Non Available Total**	**Resource**	**Wait Time Total**
-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
Not Available Results	**Allocated**	**Wait Time Results**	**Allocated**
Resource	**Non Available Total**	**Resource**	**Wait Time Total**
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 420th was able to fly more sorties with allocated AGE. This is best explained by understanding that the 420th has the same compliment of AGE as the other two 18 PAA squadrons; however, they maintain 23 total aircraft while the 430th and 440th maintain only 22 each.

Squadron 410 Deployed

With the 410th 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

	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
1 Deploy											
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

Not Available Results	**Pooled**	**Wait Time Results**	**Pooled**
Resource	**Non Available Total**	**Resource**	**Wait Time Total**
-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
Not Available Results	**Allocated**	**Wait Time Results**	**Allocated**
Resource	**Non Available Total**	**Resource**	**Wait Time Total**
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 420th 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 410th and 420th 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 420th. It appeared very unlikely that simply changing the AGE configuration would result in such a drastic drop in production. Further investigation revealed that the 420th, 430th, and 440th 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 420th aircraft were all rendered unserviceable within the 90-day scenario, due to the lack of hydraulic mules to repair the aircraft.

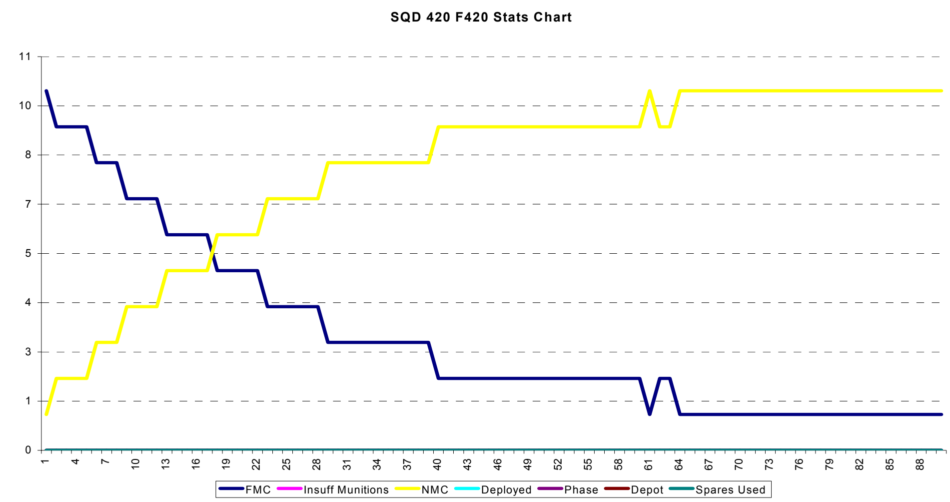


Figure 4. Squadron 420 Mission Capability

This same result happened in all runs that involved the deployment of the 420th, 430th, or 440th. 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 420th to use the 430th'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 420th was capable in producing 5930 sorties under the allocated AGE concept without degrading the 430th'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

Not Available Results	Pooled	Wait Time Results	Pooled
Resource	Non Available Total	Resource	Wait Time Total
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
Not Available Results	**Allocated**	**Wait Time Results**	**Allocated**
Resource	**Non Available Total**	**Resource**	**Wait Time Total**
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 410th and 420th 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 440th, which was not deployed. To ensure that the 420th and 430th didn't allow their fleet to become non-mission capable due to the full deployment of their hydraulic mules, the 420th was allowed to use the 410th's remaining mule, while the 430th was allowed to use the 440th's mules. Table 15 reveals the results of a 30-replication experiment.

Table 15. Results of 30-Replication Experiment With Three 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
3 Deploy											
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 420th and 430th 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

	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
3 Deploy											
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

Resource	Non Available Total	Resource	Wait Time Total
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
Not Available Results	**Allocated**	**Wait Time Results**	**Allocated**
Resource	**Non Available Total**	**Resource**	**Wait Time Total**
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 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 in Between Means?	Numerical Difference	Practical Difference 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 Between Means?	Numerical Difference Between Means	Practical Difference Between Means?	
No Deploy						
410	13329.20	13308.17	yes	21.03	no	**Pooled AGE**
420	11456.37	11505.07	yes	48.70	yes	410/430/440 indifferent 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	**Pooled AGE**
420	11456.00	11517.23	yes	61.23	yes	430/440 indifferent 410 pooled 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	**Pooled AGE**
420	5434.10	5390.87	yes	43.23	yes	430/440 indifferent 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	**Pooled AGE**
420	5430.10	5406.62	yes	23.48	no	420/440 indifferent 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	**Pooled AGE**
420	5265.35	5241.80	no	23.55	no	410/420 indifferent 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 420th 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 410th deploys, the 430th and 440th remain indifferent, the 410th prefers to pool, and the 420th prefers to allocate. If the AGE is pooled the 410th 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^{th} and 420^{th} 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^{th}, 420^{th}, and 430^{th} deploy, those three squadrons stand to produce more sorties home station while AGE is pooled, while the 440^{th} remains practically indifferent.

In the last case, where all four squadrons have aircraft and equipment deployed, the 410^{th} and 420^{th} are statistically indifferent to the AGE management condition, while the 430^{th} and 440^{th} 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 then 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.

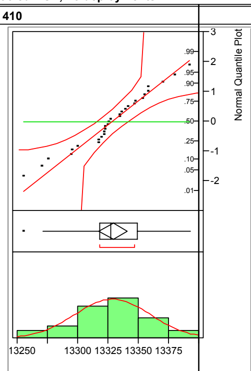
Summary

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, no deployments

410



Fitted Normal

Parameter Estimates

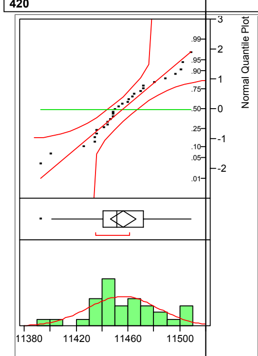
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	13329.20	13317.61	13340.79
Dispersion	Sigma	31.04	24.72	41.72

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.973743	0.6851

420



Fitted Normal

Parameter Estimates

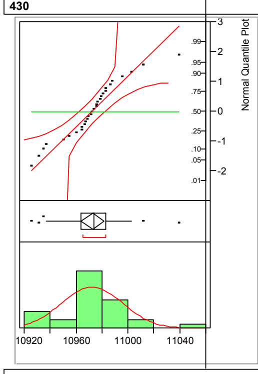
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	11456.37	11446.17	11466.56
Dispersion	Sigma	27.30	21.74	36.70

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.963015	0.4143

430



Fitted Normal

Parameter Estimates

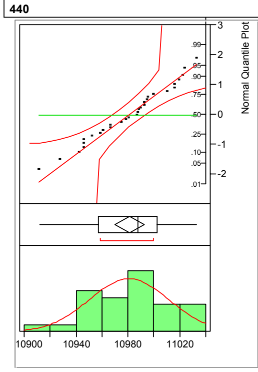
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	10972.70	10963.92	10981.48
Dispersion	Sigma	23.52	18.73	31.61

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.949151	0.1876

440



Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	10981.23	10969.78	10992.68
Dispersion	Sigma	30.67	24.42	41.23

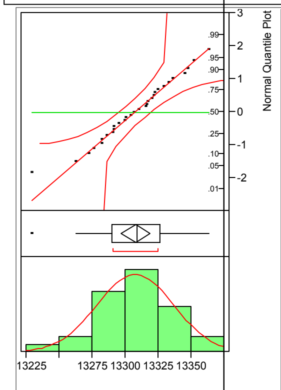
Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.970040	0.5854

Allocated, no deployments

410



Fitted Normal

Parameter Estimates

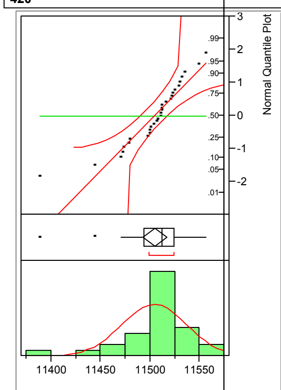
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	13308.17	13297.34	13319.00
Dispersion	Sigma	29.00	23.10	38.99

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.985119	0.9442

420



Fitted Normal

Parameter Estimates

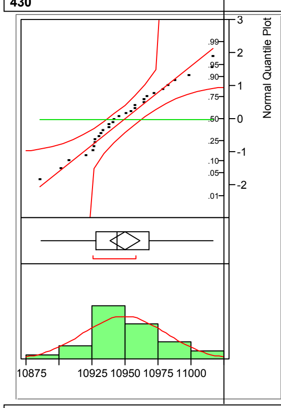
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	11505.07	11492.89	11517.24
Dispersion	Sigma	32.61	25.97	43.83

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.881937	0.0029

430



Fitted Normal

Parameter Estimates

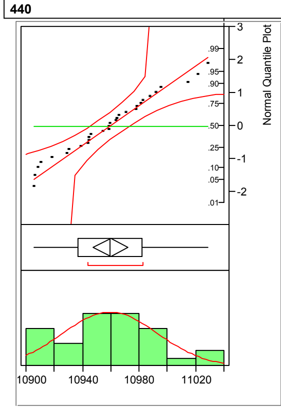
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	10950.03	10938.33	10961.73
Dispersion	Sigma	31.33	24.95	42.12

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.973308	0.6733

440



Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	10959.80	10947.36	10972.24
Dispersion	Sigma	33.33	26.54	44.80

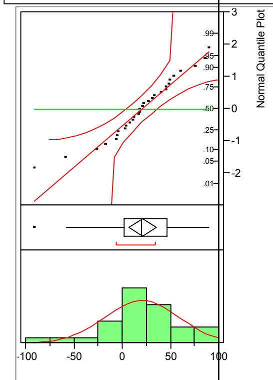
Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.967495	0.5197

Differences, no deployments

410



Normal(21.0333,38.692

Fitted Normal

Parameter Estimates

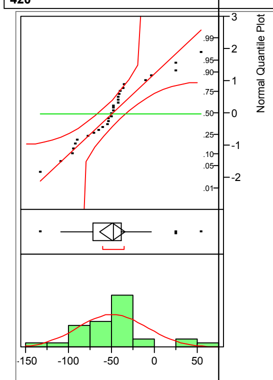
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	21.03333	6.58552	35.48115
Dispersion	Sigma	38.69196	30.81455	52.01419

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.958117	0.3171

420



Normal(-48.7,39.8308)

Fitted Normal

Parameter Estimates

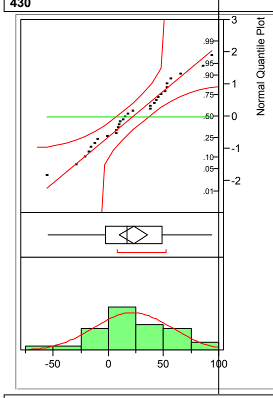
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	-48.70000	-63.57307	-33.82693
Dispersion	Sigma	39.83081	31.72153	53.54516

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.943720	0.1347

430



Normal(22.6667,34.6921

Fitted Normal

Parameter Estimates

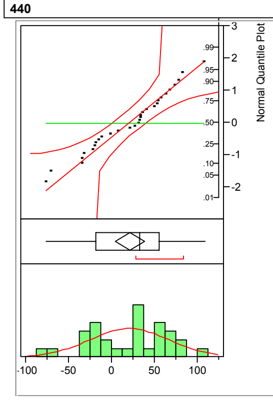
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	22.66667	9.71243	35.62090
Dispersion	Sigma	34.69208	27.62901	46.63709

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.981671	0.8831

440



Normal(21.4333,46.2711

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	21.43333	4.15543	38.71124
Dispersion	Sigma	46.27108	36.85061	62.20291

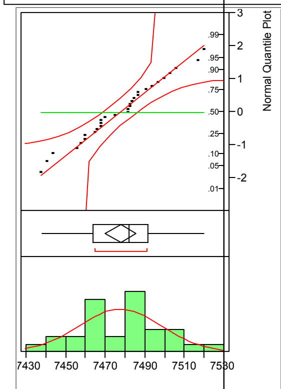
Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.967456	0.5187

Pooled AGE, one deployment

410



Normal(7477.93,20.8739)

Fitted Normal

Parameter Estimates

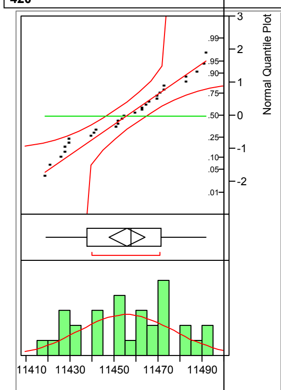
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	7477.933	7470.139	7485.728
Dispersion	Sigma	20.874	16.624	28.061

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.978119	0.8008

420



Normal(11456,21.6922)

Fitted Normal

Parameter Estimates

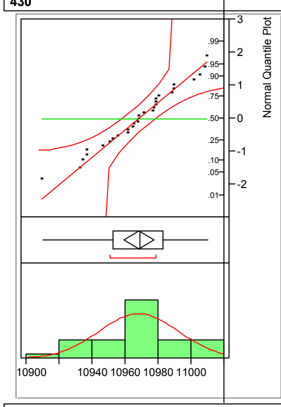
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	11456.00	11447.90	11464.10
Dispersion	Sigma	21.69	17.28	29.16

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.950284	0.2009

430



Normal(10968.7,24.1791)

Fitted Normal

Parameter Estimates

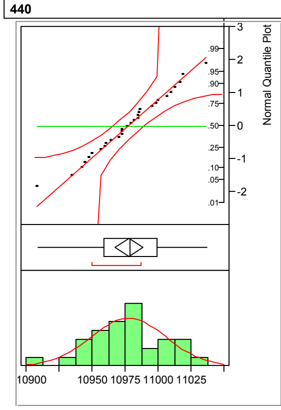
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	10968.70	10959.67	10977.73
Dispersion	Sigma	24.18	19.26	32.50

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.973726	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

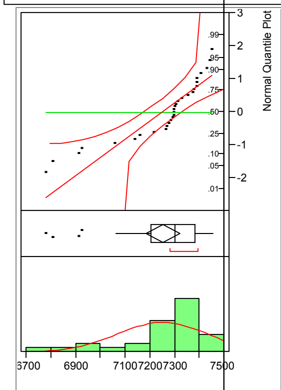
Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.991691	0.9962

Allocated, one deployment

410



Normal(7254.23,181.832

Fitted Normal

Parameter Estimates

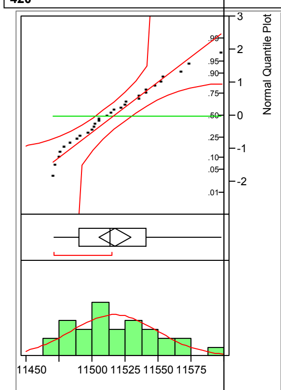
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	7254.233	7186.336	7322.131
Dispersion	Sigma	181.832	144.812	244.440

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.815717	<.0001

420



Normal(11517.2,32.7158

Fitted Normal

Parameter Estimates

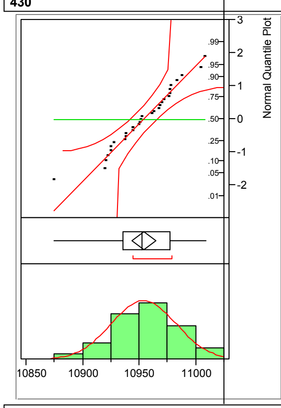
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	11517.23	11505.02	11529.45
Dispersion	Sigma	32.72	26.06	43.98

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.959127	0.3355

430



Normal(10954.5,28.6281

Fitted Normal

Parameter Estimates

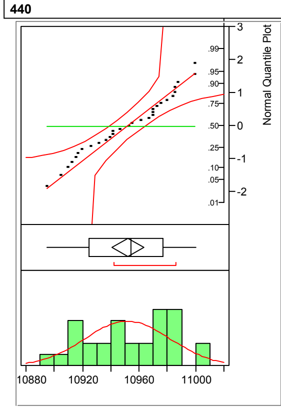
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	10954.50	10943.81	10965.19
Dispersion	Sigma	28.63	22.80	38.49

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.970671	0.6022

440



Normal(10952.1,30.1181

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	10952.07	10940.82	10963.31
Dispersion	Sigma	30.12	23.99	40.49

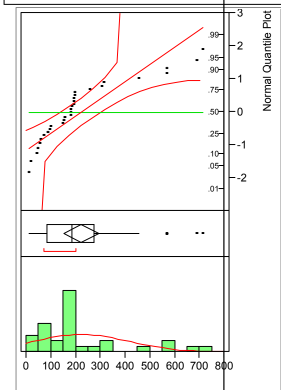
Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.952636	0.2310

Differences, one deployment

410



Normal(223.7,192.11

Fitted Normal

Parameter Estimates

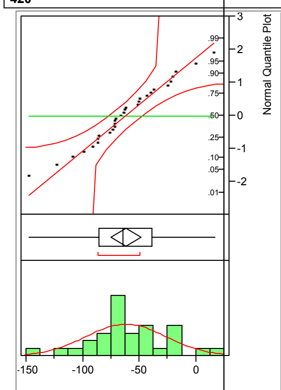
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	223.7000	151.9650	295.4350
Dispersion	Sigma	192.1099	152.9977	258.2563

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.816013	<.0001

420



Normal(-61.233,35.4398

Fitted Normal

Parameter Estimates

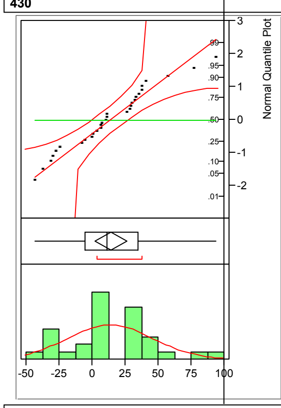
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	-61.23333	-74.46677	-47.99990
Dispersion	Sigma	35.43978	28.22449	47.64224

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

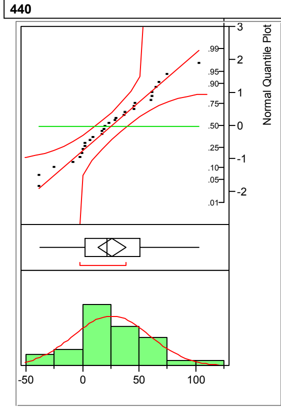
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	14.20000	2.03827	26.36173
Dispersion	Sigma	32.56971	25.93875	43.78396

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

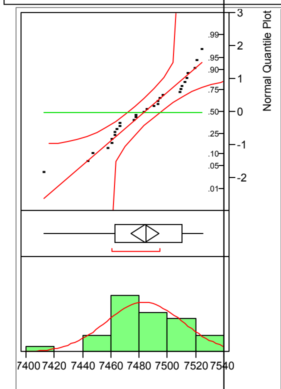
Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.979578	0.8365

Pooled AGE, 2 deployments

410



Normal(7484.07,27.0592)

Fitted Normal

Parameter Estimates

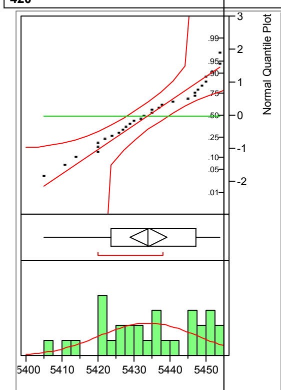
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	7484.067	7473.963	7494.171
Dispersion	Sigma	27.059	21.550	36.376

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.953661	0.2454

420



Normal(5434.1,13.6315)

Fitted Normal

Parameter Estimates

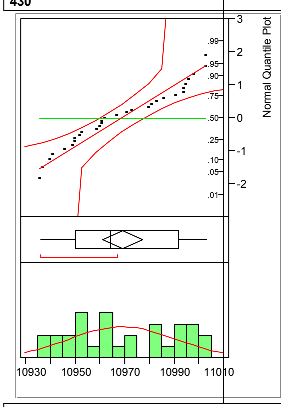
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	5434.100	5429.010	5439.190
Dispersion	Sigma	13.631	10.856	18.325

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.953599	0.2445

430



Normal(10969.1,21.462)

Fitted Normal

Parameter Estimates

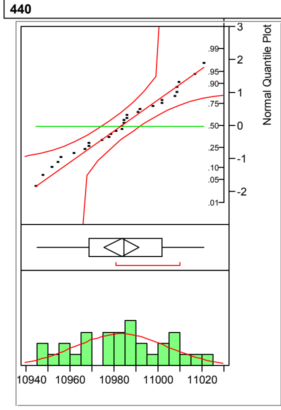
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	10969.07	10961.05	10977.08
Dispersion	Sigma	21.46	17.09	28.85

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.927846	0.0498

440



Normal(10983.5,20.9758)

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	10983.50	10975.67	10991.33
Dispersion	Sigma	20.98	16.71	28.20

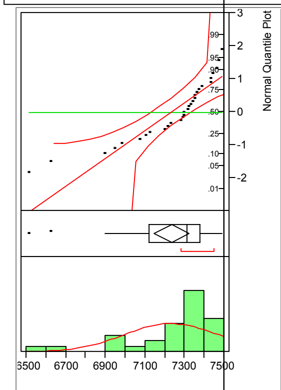
Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.966054	0.4842

Shared Mule, 2 deployments

410



Normal(7235.9,237.681

Fitted Normal

Parameter Estimates

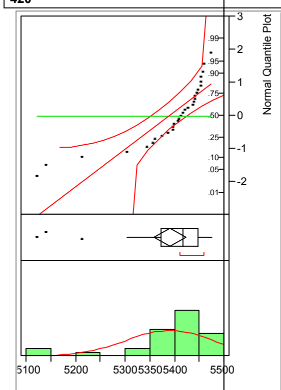
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	7235.900	7147.149	7324.651
Dispersion	Sigma	237.681	189.291	319.518

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

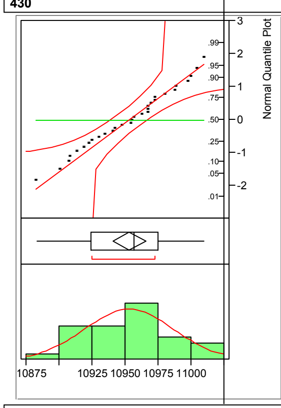
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	5390.867	5357.874	5423.859
Dispersion	Sigma	88.355	70.367	118.777

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.740115	<.0001

430



Normal(10953.4,33.4165

Fitted Normal

Parameter Estimates

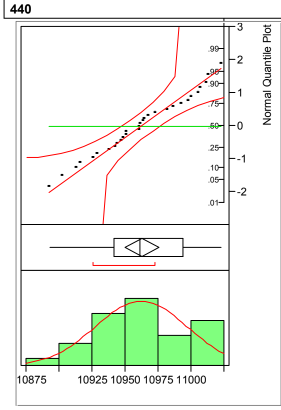
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	10953.40	10940.92	10965.88
Dispersion	Sigma	33.42	26.61	44.92

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

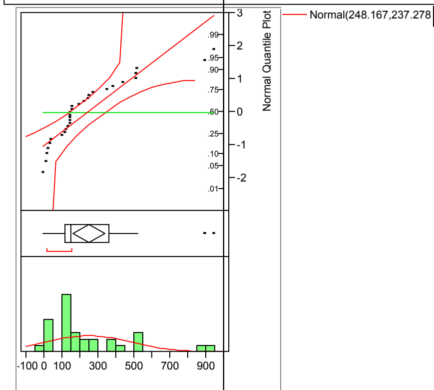
Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.971537	0.6254

Differences, 2 deployments

410



Fitted Normal

Parameter Estimates

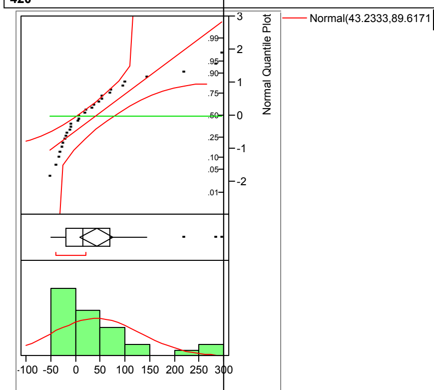
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	248.1667	159.5657	336.7677
Dispersion	Sigma	237.2778	188.9697	318.9762

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.816292	<.0001

420



Fitted Normal

Parameter Estimates

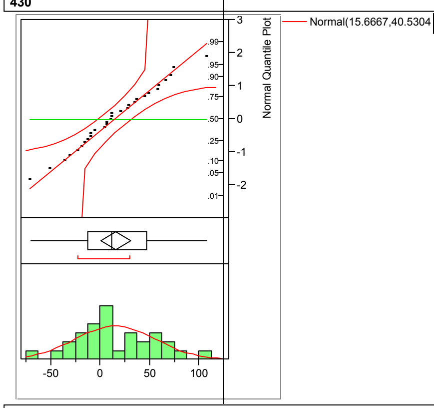
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	43.23333	9.76977	76.6969
Dispersion	Sigma	89.61707	71.37166	120.4736

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.800399	<.0001

430



Fitted Normal

Parameter Estimates

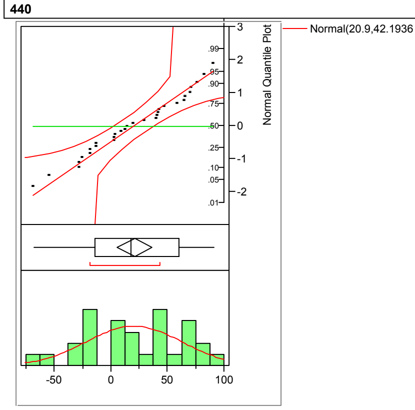
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	15.66667	0.53237	30.80096
Dispersion	Sigma	40.53039	32.27868	54.48562

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.990790	0.9935

440



Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	20.90000	5.14465	36.65535
Dispersion	Sigma	42.19360	33.60328	56.72150

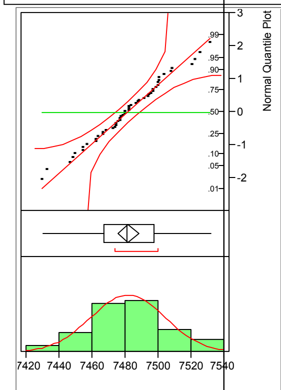
Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.965812	0.4784

Pooled AGE, three deployments

410



Normal(7482.1,22.549

Fitted Normal

Parameter Estimates

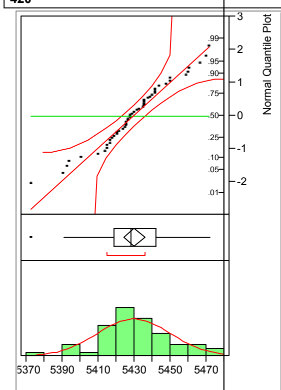
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	7482.100	7475.692	7488.508
Dispersion	Sigma	22.549	18.836	28.099

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.983692	0.8527

420



Normal(5430.1,20.1831

Fitted Normal

Parameter Estimates

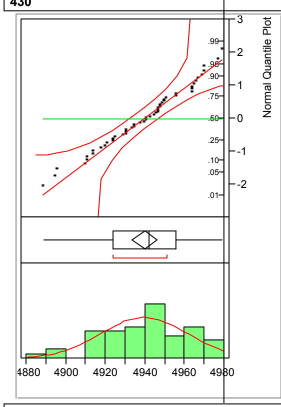
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	5430.100	5424.364	5435.836
Dispersion	Sigma	20.183	16.860	25.151

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

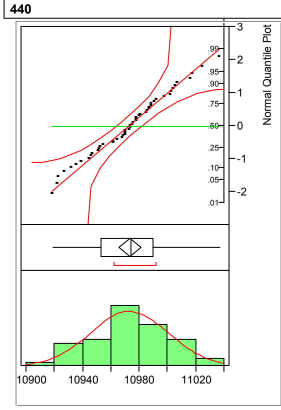
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	4939.920	4933.699	4946.141
Dispersion	Sigma	21.891	18.286	27.279

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

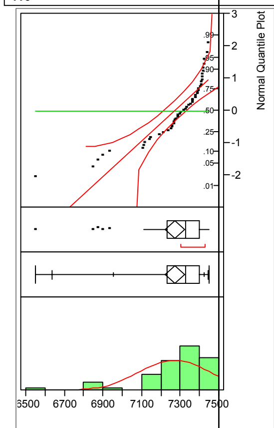
Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.979026	0.6925

Shared Mule, three deployments

410



Fitted Normal

Parameter Estimates

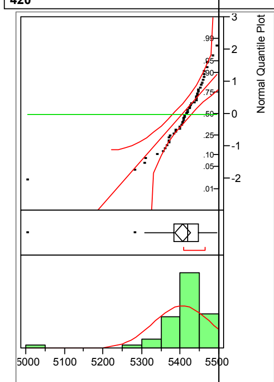
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	7273.280	7221.425	7325.135
Dispersion	Sigma	182.463	152.418	227.373

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.790230	<.0001

420



Fitted Normal

Parameter Estimates

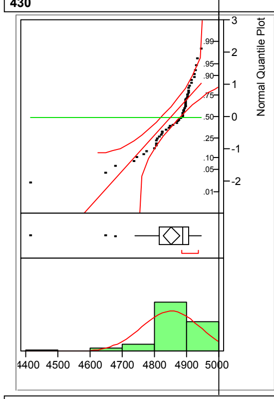
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	5406.620	5385.692	5427.548
Dispersion	Sigma	73.639	61.513	91.764

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.720405	<.0001

430



Fitted Normal

Parameter Estimates

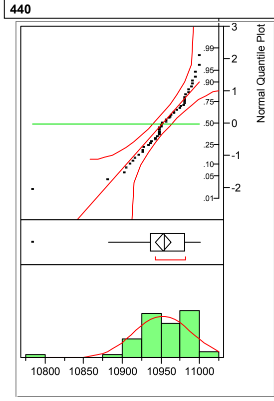
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	4852.340	4826.658	4878.022
Dispersion	Sigma	90.368	75.487	112.610

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.755595	<.0001

440



Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	10952.94	10942.31	10963.57
Dispersion	Sigma	37.40	31.24	46.61

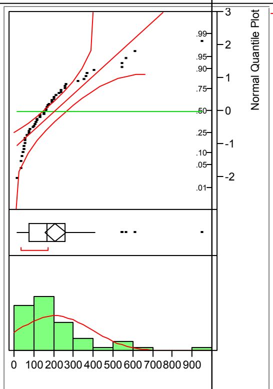
Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.862562	<.0001

Difference, three deployements

410



Fitted Normal

Parameter Estimates

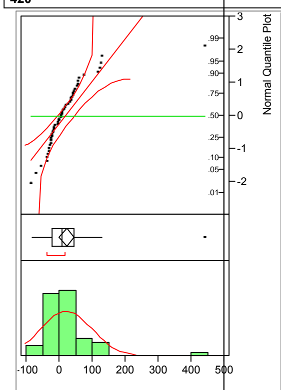
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	208.8200	156.9705	260.6695
Dispersion	Sigma	182.4422	152.4002	227.3474

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.811643	<.0001

420



Fitted Normal

Parameter Estimates

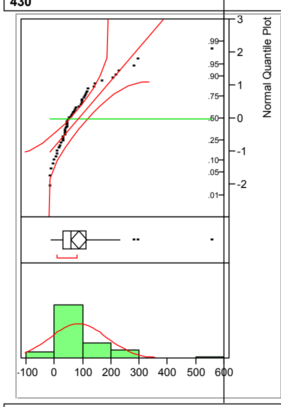
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	23.48000	1.46731	45.49269
Dispersion	Sigma	77.45578	64.70145	96.52023

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.724871	<.0001

430



Fitted Normal

Parameter Estimates

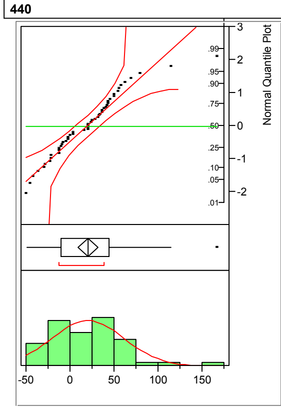
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	87.58000	59.36357	115.7964
Dispersion	Sigma	99.28481	82.93598	123.7221

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.765067	<.0001

440



Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	20.50000	8.82182	32.17818
Dispersion	Sigma	41.09186	34.32543	51.20594

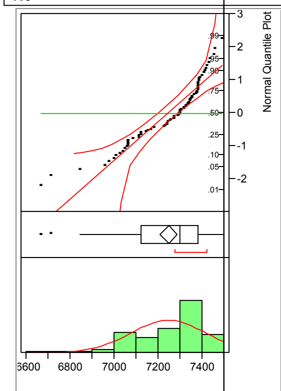
Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.945159	0.0350

Pooled, 4 deployments

410



Normal(7248.59,171.699

Fitted Normal

Parameter Estimates

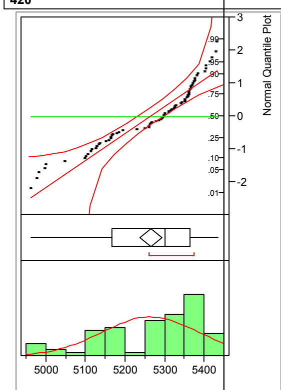
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	7248.587	7209.082	7288.091
Dispersion	Sigma	171.699	147.939	204.623

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.889125	<.0001

420



Normal(5265.35,122.942

Fitted Normal

Parameter Estimates

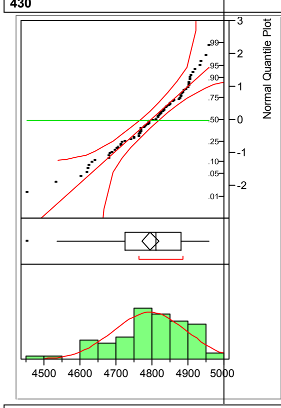
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	5265.347	5237.060	5293.633
Dispersion	Sigma	122.942	105.929	146.516

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.895036	<.0001

430



Normal(4795.36,101.989

Fitted Normal

Parameter Estimates

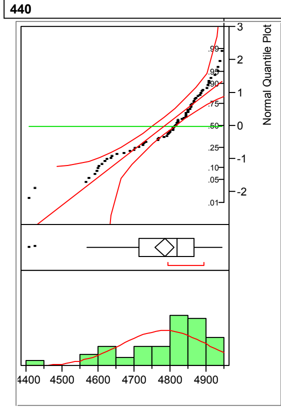
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	4795.360	4771.894	4818.826
Dispersion	Sigma	101.989	87.876	121.545

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.948932	0.0106

440



Normal(4785,118.5

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	4785.000	4757.736	4812.264
Dispersion	Sigma	118.500	102.102	141.223

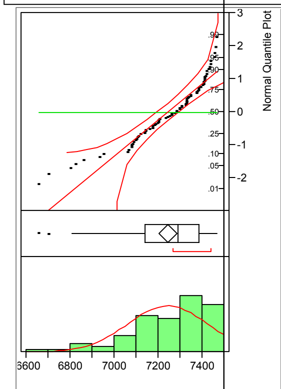
Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.896145	<.0001

Shared Mule, 4 deployments

410



Normal(7245.48,182.22

Fitted Normal

Parameter Estimates

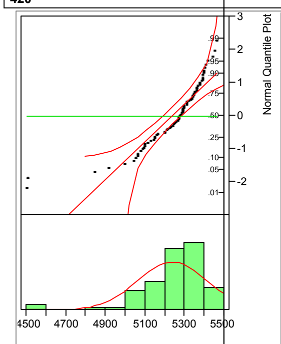
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	7245.480	7203.555	7287.405
Dispersion	Sigma	182.220	157.004	217.160

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.888890	<.0001

420



Normal(5241.8,175.88

Fitted Normal

Parameter Estimates

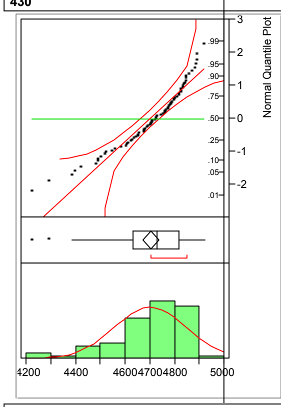
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	5241.800	5201.334	5282.266
Dispersion	Sigma	175.880	151.541	209.605

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.819542	<.0001

430



Normal(4704.64,145.875

Fitted Normal

Parameter Estimates

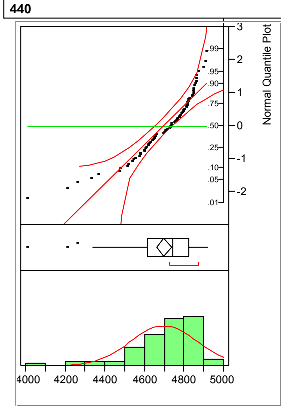
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	4704.640	4671.077	4738.203
Dispersion	Sigma	145.875	125.689	173.847

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.917818	<.0001

440



Normal(4699.36,169.181

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	4699.360	4660.435	4738.285
Dispersion	Sigma	169.181	145.770	201.622

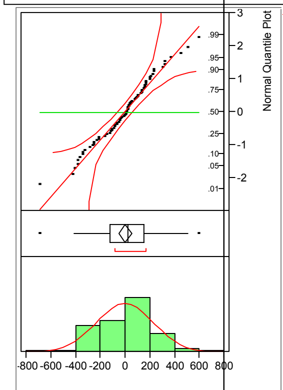
Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.874097	<.0001

Differences, 4 deployments

410



Fitted Normal

Parameter Estimates

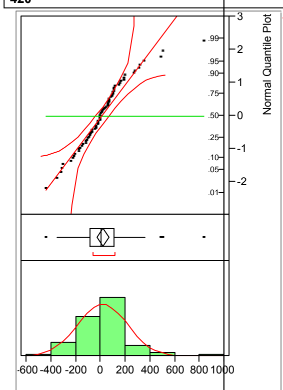
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	3.1067	-50.0401	56.2535
Dispersion	Sigma	230.9936	199.0286	275.2867

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.987473	0.9111

420



Fitted Normal

Parameter Estimates

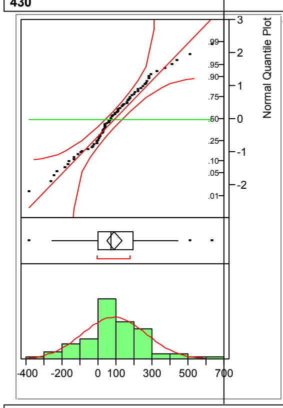
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	23.5467	-22.6518	69.7451
Dispersion	Sigma	200.7936	173.0077	239.2959

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.950328	0.0132

430



Fitted Normal

Parameter Estimates

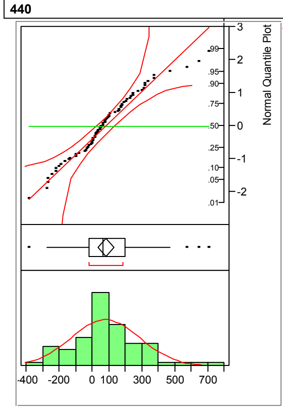
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	90.7200	49.8605	131.5795
Dispersion	Sigma	177.5888	153.0139	211.6414

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.987168	0.9026

440



Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	85.6400	37.6671	133.6129
Dispersion	Sigma	208.5061	179.6528	248.4871

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.969525	0.2122

Appendix B.

Pooled Age, no deployements			
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 deployements			
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

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

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

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

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

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

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

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

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

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 deployements											
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	4635	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	5356	-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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14. 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 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. The directive stipulates the development of UTCs in a *building block* 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.

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.

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Aerospace Ground Equipment, AGE management, Sortie Production

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