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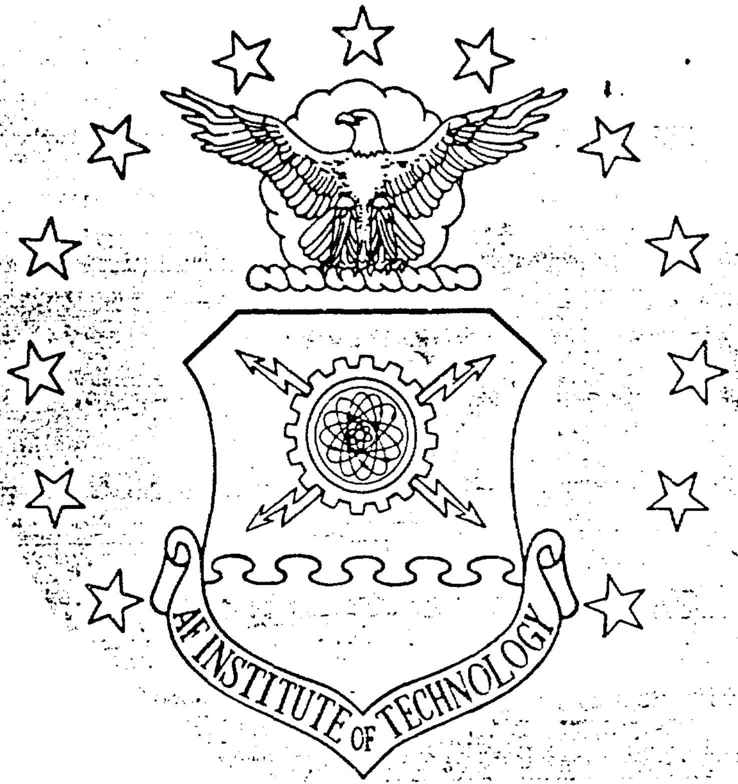

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AFIT/GLM/LSM/88S-15

APPLYING THE MINIATURE DYNA-METRIC MODEL FOR SEGMENTING WAR READINESS SPARES KITS: A USER'S GUIDE

THESIS

Robert C. DeGroot, Captain, USAF

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THESIS

Presented to the Faculty of the School of Systems and Logistics
of the Air Force Institute of Technology
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Master of Science in Logistics Management

Robert C. DeGroot, B.S.
Captain, USAF

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Preface

This thesis could not have been possible without the assistance of a number of outstanding people. First, I would like to thank my faculty advisor, Mr. Patrick Bresnehan, for his expert guidance and willingness to let me learn and grow from this experience. A special word of thanks to Captain Bob Burleson, of the Air Force Logistics Management Center, who helped me conceptualize this research and who also provided the important supply data so critical to this effort. Additionally, from the AFIT faculty, Captain John Sullivan helped in explaining the intricacies of the Dyna-METRIC model, while Captain Dave Peterson provided some much needed literature on Dyna-METRIC. Mr. George Zeck, Ms. Barb Weiland, and Lieutenant Lisa Oster, all from HQ AFLC, were important sources of information and wartime logistics expertise.

Finally, I would like to thank my wife, Joyce, for her patience and understanding during the long "thesis nights" of the spring and summer of 1988. And to my oldest daughter, Rebecca, yes, Daddy's thesis is finally done and you can have the computer back now!

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ABSTRACT

The purpose of this research was to validate the feasibility of applying the Miniature Dyna-METRIC inventory model for segmenting Air Force War Readiness Spares Kits (WRSK). WRSK segmentation is an authorized USAF policy designed to allocate the often large thirty support day WRSKs into smaller subsets; this technique reduces the initial airlift support requirement, as well as minimizes potential loss or damage to critical wartime sustainability resources.

The study had two basic objectives: (1) Validate Miniature Dyna-METRIC's segmentation predictions against the results of the 1987 HQ Tactical Air Command F-15 combat operations exercise, Coronet Warrior. (2) Design a User's Guide for the base-level WRSK manager to explain and apply the automated WRSK segmentation experimental design. A sample WRSK of sixty-one spares drawn from the Coronet Warrior exercise and an unclassified operational scenario were input into the model in an attempt to calculate the quantities required for three experimental WRSK segments. Two sets of spares failure rates were applied, the D029 worldwide average and the adjusted failure rates resulting from Coronet Warrior. The model's predictions were then compared against the spares usage data from Coronet Warrior.

Miniature Dyna-METRIC failed to segment the sample VRSK within the stated accuracy criterion. The D029 demand rates predicted segments that were well below 50 percent accurate, while the Coronet Warrior demand rates, although better estimates than D029, also were less than 50 percent accurate. The key model assumption of spares failing in a regular, linear manner on the basis of flying hours was questionable for this sample since twenty-five of the sample items had non-linear failure patterns during Coronet Warrior. Since the model could not optimally segment the sample VRSK, a User's Guide for applying the research methodology was not recommended.

Future research in this area should concentrate on using the Dyna-METRIC Microcomputer Analysis System (DMAS), which is an improved version of Miniature Dyna-METRIC; additionally, there are a number of upcoming VRSK operational exercises for other weapon systems which should provide a wealth of spares usage data. More empirical testing, using larger VRSK samples and the DMAS model, is required before a conclusive decision can be made about the feasibility of applying automated VRSK segmentation at base-level.

APPLYING THE MINIATURE DYNA-METRIC MODEL FOR SEGMENTING WAR READINESS SPARES KITS: A USER'S GUIDE

I. INTRODUCTION

Purpose

The purpose of this research is to evaluate the feasibility of using the microcomputer version of the Dyna-METRIC model, commonly called Miniature or Mini Dyna-METRIC, to segment War Readiness Spares Kits (WRSK) for both real world contingencies and operational deployment exercises. Currently, no standard methodology exists in the Air Force to apportion WRSKs into subsets, called segments, to support limited contingencies or small scale deployments (15:15). Segmenting War Readiness Spares Kits is not a required Air Force policy; however, Major Commands (MAJCOMs) can elect to use WRSK segmentation at their option (14:16). This study will test the capability of Mini Dyna-METRIC to adequately predict the consumption of recoverable aircraft spares in a number of representative deployment support periods, as well as test the model's results against the results of a Tactical Air Command 1987 simulated "combat operations" exercise, Coronet Warrior (8:36-38). If the test shows that this proposed technique proves adequate for the specified purposes, a User's Guide, targeted towards the base level VRSK manager, will be designed and attached as an appendix to this study. The automated VRSK segmentation capability proposed in this research directly supports one of the current projects in the Air Force Logistics Management Center's War Reserve Materiel Master Plan (15:iii).

Background

The United States Air Force has the difficult and uncertain task of planning for wartime operations while at peace. The daily routine of supporting and training our forces from fixed, well-equipped bases will almost certainly be upset when we transition into a hostile or "bare base" environment. The Air Force has two important logistics missions in peacetime that will directly affect the expected combat capability of our forces. These two missions have different time perspectives yet both affect our implied, (as perceived by our enemies), deterrent military posture. First, we must have operationally ready forces, "the ability of forces, units, weapon systems, and equipments to deliver the outputs for which they were designed, including the ability to deploy and employ without unacceptable delays"(1:1-1). The second mission is sustainability, which is "the staying power of our forces...often measured in days"(1:1-1).

Obviously, these two components of military power are related. Ready forces that can't be sustained for extended combat are just as unacceptable as sustainable forces we don't have ready when hostilities begin. The more immediate logistics challenge of maintaining daily readiness, which is the predominant function of base level units, is sometimes given priority over the long-range logistics process of planning for sustainable combat operations (11:1). The readiness mission is less complex to fulfill because the operational environment is known and we can forecast logistics requirements with more certainty. Conversely, the uncertainty surrounding wartime can make combat logistics support planning, at best, an inexact science. In an effort to minimize the materiel uncertainties of wartime logistics support, the Air Force has developed the War Reserve Materiel (WRM) concept.

WRM is the extra, or additive, materiel required to augment peacetime assets to completely support the forces, missions, and activities reflected in USAF war plans. WRM assets include munitions, Petroleum/Oils/Lubricants (POL), consumables, equipment, rations, and spares that are stockpiled in advance of their need (12:1-46). As such, WRM can be categorized as a type of decoupling stock, because it allows combat units to have an immediately available reserve of materiel assets that "decouples" the unit from the normal logistics resupply pipeline (31:8). This initial capability to operate as a logistically self-sufficient unit is designed to allow the wholesale logistics system the lead time to change its focus to wartime support. WRM may be prepositioned with the combat units or stored at the depots (14:19).

To provide the initial wartime supply support, the Air Force prepositions spare parts in a War Readiness Spares Kit (WRSK),

> an air transportable package of WRM spares, repair parts and related maintenance supplies required to support planned wartime or contingency operations of a weapon or support system for a specified period of time pending resupply (14:49).

WRSKs are segregated from peacetime spares while in storage and are normally configured on pallets for immediate movement. The WRSK is also tailored to the wartime role of the supported unit, in order to sustain protracted operations in the event of hostilities. WRSK kits also have a secondary yet very important purpose. They are used to support deployment exercises, which are a vital combat training tool for both operations and logistics personnel (14:14-16).

However, since the WRSKs are designed to support full unit operations for the first thirty days of combat, deploying the thirty day WRSK for a small scale deployment of either less aircraft and/or operating days is not practical. The Air Force, therefore, has authorized the technique of segmenting WRSK kits into several parts, based on the number of support days required (14:16). For example, a Tactical

Air Command F-15 VRSK, designed to support twenty-four aircraft for thirty wartime days, could be segmented into three parts that would support flying operations for days one through seven, days eight through fifteen, and days sixteen through thirty, respectively. Each segment could then support all twenty-four aircraft for that period of time; similarly, the VRSK could be segmented to support a lesser amount of aircraft for any time duration less than thirty days. It's important to note that the integrity of the thirty day VRSK is not violated; the segmentation process, in effect, sets up several smaller VRSK kits within the thirty day VRSK (14:15-16).

The current approach to segmenting VRSKs is not based on scientific methods, but is a "non-optimal" procedure. The operational commands use their experienced maintenance technicians to predict the range and quantity of spare parts they expect to use during the several phases of a contingency. These predictions are then used to segment VRSKs in advance of deployment. The natural tendency is to overestimate spares requirements, a "just in case" approach (15:15).

Research Objective

The Air Force Logistics Management Center (AFLMC) has suggested a more optimal method for segmenting VRSKs is needed. The AFLMC approach to this problem is to use the

Dyna-METRIC model to segment VRSKs based on historical usage rates (15:15). Dyna-METRIC, the Dynamic Multi-Echelon Technique for Recoverable Item Control, is a RAND developed analytical model designed to predict, given an initial stock of recoverable spares, how many aircraft will remain fully mission capable during the first thirty days of wartime operations. The Dyna-METRIC user can vary the operational environment, the amount of VRSK stock, the number of support days, and the maintenance concept to best match the desired scenario. The model predicts, within a user-defined confidence bound, the amount of WRSK stock needed to optimally support any operational mission (26:iv). The AFLMC wishes to use a less complex version of this model, called Mini Dyna-METRIC, to test this approach. Mini Dyna-METRIC offers several advantages over Dyna-METRIC for supply users at the field level: PC compatibility, much smaller memory requirements, and simplified input/output procedures (13:1).

Justification

As specified in AFR 400-24, segmentation of War Readiness Spares Kits is an authorized policy option for MAJCOMs. This technique provides a means for deploying the least amount of VRSK spares to support a stated operational need. Given that the Air Force will continue to rely primarily on small-scale deployment exercises for operational combat training, a systematic method to configure VRSKs into optimal support segments is required (23:27).

The application of of Mini Dyna-METRIC to the problem of optimally segmenting VRSKs has many positive implications, including reduced airlift cost, shorter VRSK deployment preparation times, faster post-deployment inventory verification, fewer deployed supply personnel, and less risk of losing scarce resources to theft or destruction (15:15).

Problem Statement

There is a need to determine if Mini Dyna-METRIC can adequately predict spares consumption in a F-15 VRSK at discrete points in several modeled operational support periods, as well as compare model output results "side by side" to the results of an actual deployment exercise, Coronet Warrior. An associated requirement is to determine if the model will produce recommended VRSK stockage levels for each tested support interval. If these two conditions are met, a standard Air Force methodology for segmenting War Readiness Spares Kits using Mini Dyna-METRIC will be designed and recommended for Air Force adoption.

Research Questions

1. Can the Mini Dyna-METRIC computer model be applied to the problem of optimally segmenting War Readiness Spares Kits?
2. Given that Mini Dyna-METRIC is a viable tool for segmenting VRSKs, can the model input procedures

and output analysis techniques be incorporated into an easily understood and applied User's Guide for base-level supply personnel?

Scope

War Readiness Spares Kits contain both recoverable and consumable spare parts (12:1-46). Recoverables are high-value, centrally procured assets optimally designed to be repaired, or "recovered", upon failure (10:92). Consumables are expendable items which are consumed when used or which lose their identity through incorporation into or attachment upon another assembly (12:1-21).

This research effort will focus on WRSK recoverables only, since the Mini Dyna-METRIC model only considers recoverable spares in its computations (26:vi-viii). Consumable items in the current Air Force supply system do not have several of the elements (Demands per Flying Hour, Repair Cycle Time, Awaiting Parts Time, and Percentage of Base Repair) Mini Dyna-METRIC uses to predict WRSK spares consumption. Consequently, the evaluation of WRSK consumables in this research is not feasible (26:2).

Consumables in Air Force WRSKs do not represent a sizable investment in terms of number of units or cost when compared to WRSK recoverables. For example, in a representative F-15 WRSK data base provided by HQ AFLC/MMMR, only 20 percent of the authorized units were consumables and they represented only 6 percent of total VRSK cost (32). Additionally, consumables are generally characterized as low weight, low volume assets. Current Air Force policy allows each MAJCOM to determine the range and depth of consumables in their VRSKs, which differs from the central AFLC computations for VRSK recoverables (15:9). Since consumables are not major users of VRSK storage space, the MAJCOMS are in the best position to determine if segmentation is appropriate for consumables, and if so, the proper technique to use.

Another limitation of Mini Dyna-METRIC is the inability to adequately predict the stockage levels of Shop Replacement Units (SRUs), which are the key subcomponents used in repairing Line Replacement Units (LRUs) (13:39). LRUs are aircraft system components designed to be easily removed and replaced, thus bringing the aircraft quickly back to an operational state. The LRU may then be repaired at base level if authorized or returned to the next highest echelon for repair (12:1-29).

In RRR (Remove, Repair and Replace) VRSKs, the SRUs, along with deployed Automatic Test Equipment, are used to repair the LRUs that fail. The repaired LRUs are then either returned to the VRSK or used to repair an aircraft. Therefore, RRR VRSKs tend to have only a few in quantity of the LRUs authorized in the VRSK and many SRUs, while RR (Remove and Replace) VRSKs tend to have a larger quantity of each authorized LRU and no SRUs. However, RRR VRSKs can have a mixture of both RR and RRR spares, while RR WRSKs will have only RR type spares.

Consequently, the WRSK segmentation procedure applied and validated in this research will only apply to RR WRSKs, since Mini Dyna-METRIC cannot predict the stockage levels of the SRUs, which are probably the most critical elements of spares support in a RRR WRSK. The Air Force currently uses the RR WRSK concept for the F-16, C-130, A-10, and B-52 aircraft, while RRR WRSKs are used for the F-15 and F-111 weapon systems (2:28).

Acronym Definitions

This thesis contains numerous Air Force unique acronyms that should be defined for any reader unfamiliar with their meanings. These definitions are listed in Appendix A.

II. LITERATURE REVIEW

Overview

This chapter provides an overview of the USAF War Reserve Materiel (WRM) logistics concept, the purpose and composition of the the four WRM spares elements, and an outline of War Readiness Spares Kit (WRSK) planning principles and requirements computation systems. A discussion of the Dyna-METRIC and Mini Dyna-METRIC inventory models that were applied in this research is also included; this will provide a background of the most current tools available for logistics planners to predict WRSK requirements and capability.

War Reserve Materiel

Major General Howard M. Estes, Jr., in a 1983 Air Force Journal of Logistics article, emphasized that the logistics infrastructure of the USAF does not exist primarily to provide efficient peacetime support, but to enable the Air Force to fight and win wars (18:2). To accomplish our mission, we need to find methods to logistically support our forces to provide the maximum assurance of victory. The Air Force uses War Reserve Materiel for ensuring our combat forces are capable of protracted operations. WRM assets are the supplies and equipment we need as a fighting force to sustain the conflict as well as smooth the transition for the logistics system from peace to war (14:1-2). WRM assets include munitions, POL, spares, consumables, rations, and equipment (12:1-46).

The Air Force determines requirements for WRM through a number of different forecasting systems, however the overall source of WRM authorizations, also called WRM levels, is the HQ USAF War Mobilization Planning (WMP) Documents. The WMP plans are a continually updated series of wartime plans that includes threat and intelligence assessments, combat force structure, detailed deployment taskings, and logistics requirements (14:14). WMP-1, the Logistics Annex, contains the guidance each command level needs to determine their WRM requirements as well as assess their current WRM capability and existing shortfalls (14:14).

WRM Spares

VRM spares are in four distinct stockpile categories that depend on the ultimate user, the wartime mission, and the wartime phase. These categories are War Readiness Spares Kits (WRSK), Base Level Self-Sufficiency Spares (BLSS), Other War Reserve Materiel (OWRM), and Follow-on Spares Kits (FOSK). The categories represent prepositioned assets (WRSK and BLSS), wholesale assets (OWRM), and follow-on stocks (FOSK) (14:14).

The Air Force prepositions spares at units with a combat mission to provide immediately available resources for sustained operations. War Readiness Spares Kits (WRSK) are air transportable spares packages that move with the combat unit as it deploys to the wartime location. A WRSK is designed to provide a maximum of thirty days of dedicated support before resupply (14:14). Conversely, Base Self-Sufficiency Spares (BLSS) are authorized for units that "fight in-place" from their home bases. Primarily for in-theater forces, a BLSS package is not mobile (14:14).

Other War Reserve Materiel (OVRM) spares represent the difference between the total wartime spares requirement and any pre-positioned WRM spares. OVRM, stored at the Air Logistics Centers, is designed to augment WRSK, BLSS, and peacetime stocks until the industrial base can support the war effort (14:19). OVRM spares levels can fluctuate as overall WRM spares requirements and funding change (32).

Follow-on Spares Kits (FOSK) are in some ways a hybrid of both WRM and peacetime operating stocks (POS). FOSK assets will resupply the combat units that originally deployed with their WRSK kit. However, these FOSK kits are built up from peacetime assets, generally about ten to fifteen days after a conflict has begun. The FOSK is then sent as a WRSK resupply package after thirty days of operations (14:17).

VRSK Planning Factors

The USAF Supply Manual, AFM 67-1, states, "the primary focus of the AF supply system will be on support to AF weapon systems in a wartime environment...dispersed units...may need to operate independently for a short time" (12:1-131). The primary purpose of a War Readiness Spares Kit is to ensure adequate spares support for USAF units with a combat mission. In effect, the VRSK is "Base Supply" for our combat units in the initial days of war (14:14).

There are a number of important logistics issues that must be considered before a VRSK has its authorized spares levels computed. First, the VRSK must be computed against a unit's most demanding wartime mission. This concept ensures any less demanding mission will also be supportable (14:14). Another important consideration is the unit's wartime maintenance concept. A WRSK can be authorized as either a Remove, Repair, and Replace kit (RRR kit) or a Remove and Replace (RR kit). The capability to repair failed parts at the wartime location strongly influences the depth (quantity) of spares in a VRSK kit (14:15-16). The range of assets in a VRSK is determined by each weapon system's Minimum Essential Subsystem List (MESL). The MESL lists the critical subsystems, for example, fire control, radar navigation, or electronic countermeasures, that must be mission capable for successful operations. Only spares applicable to MESL subsystems are normally authorized in a WRSK (14:14).

There are a number of important assumptions and principles that a VRSK planner must take into account before the computation process actually begins:

a. The same demand distribution assumptions used to compute peacetime spares are used to compute WRSK spares, unless evidence exists to support the use of other factors (14:14). For example, Electronic Counter-Measure systems in combat aircraft are not used during peacetime to the same extent they will be in wartime. The failure patterns of ECM spares in peacetime, therefore, are not representative of their expected wartime failures. The Air Staff has authorized an ECM Adjustment Factor in WRSK computations to account for this difference (15:12).

b. The assumption of continuous resupply of the WRSK after thirty days is used (14:15).

c. Repair cycle times must be used when computing RRR WRSK kits. If wartime repair cycle times have not been projected or are unavailable, then peacetime average repair cycle times are assumed, unless the MAJCOM justifies a longer exception repair cycle time (14:15).

d. Cannibalization success rates and ease of cannibalization should be used in WRSK computations. If individual item cannibalization rates are not available, then a 100 percent success rate is assumed. However, cannibalization is not considered an alternative source of supply, but a last resort measure for reducing WRSK stockouts (14:15)

e. Indenture relationships between Line Replacement Units (LRUs) and Shop Replacement Units (SRUs), which could also be described as a "parent and child" or an "assembly and subassembly" relationship among certain WRSK spares, must be considered, especially within the context of each unit's intermediate maintenance capability (14:14).

f. On-hand and on-order assets must be visible to the WRSK planner in an effort to "baseline" WRSK computations (14:14).

g. Weapon system modification programs that will affect WRSK spares should be considered by the WRSK planner (14:15).

h. WRSK investment (recoverable) spares should be standardized across units supporting the same weapon system type (14:15).

i. The War Mobilization Plan (WMP) is the source for the operational scenario (sorties and flying hours) the WRSK is designed to support. This scenario must be used to compute a WRSK that will adequately support operations at the least cost (14:15-16).

WRSK Computation Systems

The Air Force Logistics Command (AFLC) has used a marginal analysis technique, called the D029 War Readiness Spares Kit/Base Level Self-Sufficiency Spares Computation System, to calculate WRSK spares requirements since April

1980 (27:9). The Conventional Computation system used prior to the D029 was relatively simplistic and very labor intensive; a WRSK was computed by first determining a WRSK candidate list based on five decision rules. These rules included the probability of demand within the support period, mission essentiality, the physical size of the asset, maintenance level authorized, and the remove and replace time. A WRSK "finalist" had to have a probability of demand greater than 10 percent, had to cause a not mission/partially mission limiting condition, had to be smaller than the standard airlift cargo pallet's dimension, had to be a non-depot only reparable item, and had to have a remove and replace time of less than twenty-four hours (28:10-12).

After the WRSK candidate list was finalized, AFLC used two simple formulas to compute the quantities (28:14):

a) <u>RR (Remove and Replace) Kit</u>:

$$D \times QPA \times R \qquad (1)$$

where D = the Organizational and Intermediate Maintenance Demand rate (failure rate)

QPA = the Quantity per Application

R = the WRSK projected support requirement (wartime flying hour program)

b) <u>RRR (Remove, Repair, and Replace) kit</u>:

$$(DD \times QPA \times R) + (BR \times QPA \times RC) \qquad (2)$$

where DD = the Organizational and Intermediate Maintenance Depot demand rate

BR = the percentage of base repair

RC = the base repair cycle time

After the VRSK quantities were calculated by the weapon system manager (SM), the WRSK candidate list was forwarded to the applicable AFLC item managers for their review of asset availability products. After internal AFLC coordination, the WRSK candidate list would then be sent to the applicable MAJCOM for the negotiation process. The SM and the MAJCOM would then negotiate additions, deletions, and quantity changes to the WRSK; however, the weapon system manager retained final approval for the WRSK authorizations (28:14).

There were several Air Force studies in the 1970s that focused on improving the computations for War Readiness Spares Kits. Obviously, War Reserve Materiel was extracting a significant "opportunity cost" from the Air Force budget dollar (22:30-31). Indeed, by 1975, the Air Force investment in WRM alone amounted to $3.2 billion (21:12).

Probably the most influential WRSK study, in the context of today's D029 WRSK computation system, was the 1975 Saber Readiness Delta Report, which was suggested by the Air Force Deputy Chief of Staff for Systems and Logistics. The Saber Report, conducted by the Air Force Assistant Chief of Staff for Studies and Analysis, was an attempt to identify ways of lowering WRSK investment costs without reducing WRSK effectiveness. Using computer simulation, various maintenance and resupply policies were evaluated against an A-7D and a F-4E WRSK. The criterion for WRSK effectiveness was the number of planned sorties actually flown (5:1-4).

The major hypothesis of Saber Readiness Delta was the attempt to design an optimal VRSK based upon the sortie rate criterion. Using computer simulation, an estimate of the marginal number of sorties per dollar value invested was found. The items having the largest marginal value were then added to the conventionally computed VRSK to form the "marginal analysis" VRSK. The study concluded,

> It was found that a more effective and more efficient VRSK could be designed than the ones currently authorized. Consequently, a method was developed for determining the composition of a VRSK based upon marginal cost-effectiveness analysis. The new method was found to permit substantial reduction in VRSK investment costs, with no degradation in the level of support provided by the VRSK (5:3).

This conclusion was tested by the Tactical Air Command (TAC) in May and June of 1975. Using two squadrons of eighteen F-4D aircraft, TAC conducted simulated wartime operations for thirty days, with one squadron using the "conventional" VRSK and the other squadron using the "marginal analysis" VRSK (9:1-19).

The results showed that while both kits could support the wartime flying hour program, the marginal analysis kit provided better overall support,

> From a standpoint of maximizing sorties and flying hour capability, the optimized VRSK was slightly better than the manually computed VRSK in that its deficiencies would have resulted in one less aircraft grounded. Also, the remaining VRSK units and a lesser number of zero balances in the marginal analysis VRSK would provide more sortie capability in the event of extended use of the VRSK (9:19).

D029 Marginal Analysis System

The current Air Force method for computing War Readiness Spares Kits uses a marginal analysis technique, the D029 system, to produce an "optimal" WRSK. Marginal analysis tests the benefits of a decision in terms of its costs. For WRSK computations, the Air Force structures the kit by evaluating the benefits gained per dollar cost of each potential item, and adds those items to the kit that provide the most benefit (7:A20-1).

The D029 system uses two parameters to measure the benefit of having WRSK assets for the combat mission: expected stock due-outs, E(SDO), and the expected number of not mission capable aircraft, E(NMC). The E(SDO) statistic measures the expected number of times a demand for a WRSK spare will be unsatisfied, while the E(NMC) statistic measures the expected number of aircraft missing a WRSK item at some point during the support period (7:A20-1). It is important to note that the D029 attempts to minimize the effect of both parameters on WRSK capability, but the computation algorithm is not constrained by an upper limit on total WRSK cost. Costs are only considered after an "optimal" WRSK is calculated, and even then the limit is only on the spares budget dollars available. WRSK requirements may be authorized as valid needs by the D029 computation system, yet not immediately funded for purchase (32). The D029 also incorporates a fixed safety level value into the requirements computation. This additive factor was a big improvement over the old Conventional Computation system as each WRSK item now had a portion of "safety stock" to guard against higher than expected demand (7:A20-18).

AFLC currently uses a goal of 25 percent not mission capable (NMC) aircraft in all WRSK computations. This goal is called the "Direct Support Objective" (14:14). In aircraft availability terms, we should expect the WRSK to support three out of four aircraft or better during the support timeframe. There is no fixed lower limit for the expected stock due-out parameter; however, an upper bound of 99 percent stockage effectiveness is used in the computation. Expected stock due-outs cannot be less than 1 percent of total WRSK transactions when deployed (14:15).

The D029 is a three step algorithmic process:

a. <u>Conventional Computation</u>: This first step is similar to the conventional method. Each potential WRSK item, after meeting the rules for making the "candidates" list, is calculated, using the conventional formulas, (equations 1 or 2). This value is called the "expected value" quantity (7:A20-18).

b. <u>Safety Level Computation</u>: After each item has an expected value quantity, the square root of this number is added to the expected value. For example, if the expected value was 5 each, then 2.236 would be added for a quantity of 7 each. The D029 system uses the normal rounding convention of 0.5. This new quantity is called the "conventional" quantity. After all potential WRSK items have conventional quantities, this "kit" is evaluated in D029 to establish E(NMC) and E(SDO) goals. Since the E(NMC) parameter is the Direct Support Objective goal of 25 percent or less not mission capable aircraft, the parameter of interest is the E(SDO) (7:A20-18).

c. <u>Final Marginal Analysis Computation</u>. This is the point where the final WRSK quantities are computed. This step is initialized by bringing the "expected value" quantities into the computation first at their unrounded values. This provides a "floor" or minimum quantity for the kit. The fixed safety level quantities are then added to the floor quantities incrementally and manipulated using marginal analysis to reach or better the E(NMC) and E(SDO) goals achieved by the "conventional quantity" kit. This final step assures a lower cost WRSK that is equally or more effective than the conventional quantity WRSK (7:A20-18).

Any computational system is only as good as the results obtained. Table I shows the results of a D029 run, obtained from AFLC/MMMR, for a twenty-four aircraft WRSK kit for a Tactical Air Command F-15 squadron (32).

Table I

Sample Tactical Air Command F-15 D029 VRSK Computation

KIT TYPE	ITEMS	UNITS	E(NMC)	E(SDO)	COST(M$)
No Kit	-	-	17.51	1248	-
Conventional	1829	2672	6.48	300	39.5
SL Kit	1829	3520	4.22	88	46.8
MA Kit	1829	3116	6.46	228	31.8

(32)

The savings in potential VRSK investment costs without a resulting decrease in potential effectiveness are quite impressive. The use of marginal analysis in the D029 system resulted in an F-15 VRSK that was a major improvement over the conventionally computed WRSK. While the E(NMC) aircraft were approximately equal, there was a 24 percent decrease in E(SDO) and a 19.4 percent decrease in VRSK investment cost.

Although the safety level kit would give a weapon system, potentially, the best wartime support, the 47 percent greater investment cost for only two additional fully mission capable aircraft is considered an acceptable trade-off by both the

Air Staff and AFLC (32). Additional considerations are the fact that this "sample" cost savings could be extrapolated across the entire range of authorized Air Force WRSKs to yield substantially decreased investment; also, the D029 marginal analysis kit only slightly exceeds the Air Staff mandated Direct Support Objective of 75 percent mission capable aircraft, while the safety level kit gives a 9 percent increase over the Direct Support Objective at a 46 percent increase in cost. Another strong consideration is the airlift requirement for deploying WRSKs; the obvious need is for the smallest and cheapest possible WRSK that still provides a stated level of availability and performance (32).

Dyna-METRIC

The RAND Corporation developed analytical logistics model, Dynamic Multi-Echelon Technique for Recoverable Item Control (Dyna-METRIC), is designed to forecast future aircraft operational performance through a mathematical evaluation of the available wartime logistics resources and associated support processes. Dyna-METRIC is used to assess the capability of forces, as well as predict requirements and possible logistics limiting factors. The model incorporates the most dynamic and stressful wartime element, time, as the central factor in simulating the wartime logistics system (26:4-7). The model can handle a wide variety of logistics system configurations, ranging from a single base to a multiple base theater of operations. Each base has an in-house repair facility which may have various test and repair capabilities. This base repair facility may be augmented (though it is not necessary to run the model) with a Central Integrated Repair Facility (CIRF). Wholesale logistics support from the depot is represented as existing outside the model. The depot is seen as an infinite source of supply some order and ship time (OST) away (19:22).

Dyna-METRIC uses traditional measures of supply performance, such as resource counts (fill rates, on-hand VRM) and support process delay times (repair time, pipeline time, order and ship time) to forecast how these factors would affect the capability of aircraft weapon systems. The model then assesses how these traditional supply support measures would relate to two USAF operational performance measures, aircraft availability and fully mission capable sorties flown. Moreover, the assessment is performed in the simulated dynamic wartime surge environment, which provides a better prediction of wartime capability than earlier models, which assumed a "steady-state" system environment (26:3-9).

Dyna-METRIC models aircraft logistics support systems as a series of inter-connected pipelines through which aircraft recoverable spares flow as they are repaired or replaced. Each pipeline segment is characterized by either a random or deterministic delay time that arriving spares must spend in the pipeline before exiting the segment. These delay times, especially the repair times, will usually vary among spares probabalistically, while some pipeline delay times may be fixed by the modeler.

As depicted in Figure 1, the different echelons in Dyna-METRIC include the base, the consolidated intermediate repair facility (CIRF) and the depot. The base echelon includes two segments, base supply and the base repair facility. The CIRF echelon includes the CIRF supply and the CIRF repair shops. The pipeline segments can flow both away from and towards the aircraft. As aircraft recoverable spares, called Line Replacement Units (LRU), fail during operations, they are removed from the aircraft and replaced with a serviceable spare from supply stock, if available. If a serviceable LRU is immediately available, the aircraft is returned to operational readiness with minimal delay.

However, if a spare LRU is not available, the LRU is placed in a back-order status and repair of the aircraft is delayed. The LRU is then sent to the appropriate repair shop, depending on the initial severity of the malfunction. If a simple adjustment is the only repair action required, then the LRU is repaired in the base repair shop and returned to supply stock. However, if the repair requires more complicated test equipment, the LRU is sent to the CIRF for the repair work. Sometimes the failure is so severe the LRU must be returned to the depot for repair. Dyna-METRIC can model all three LRU repair possibilities (26:14-15).

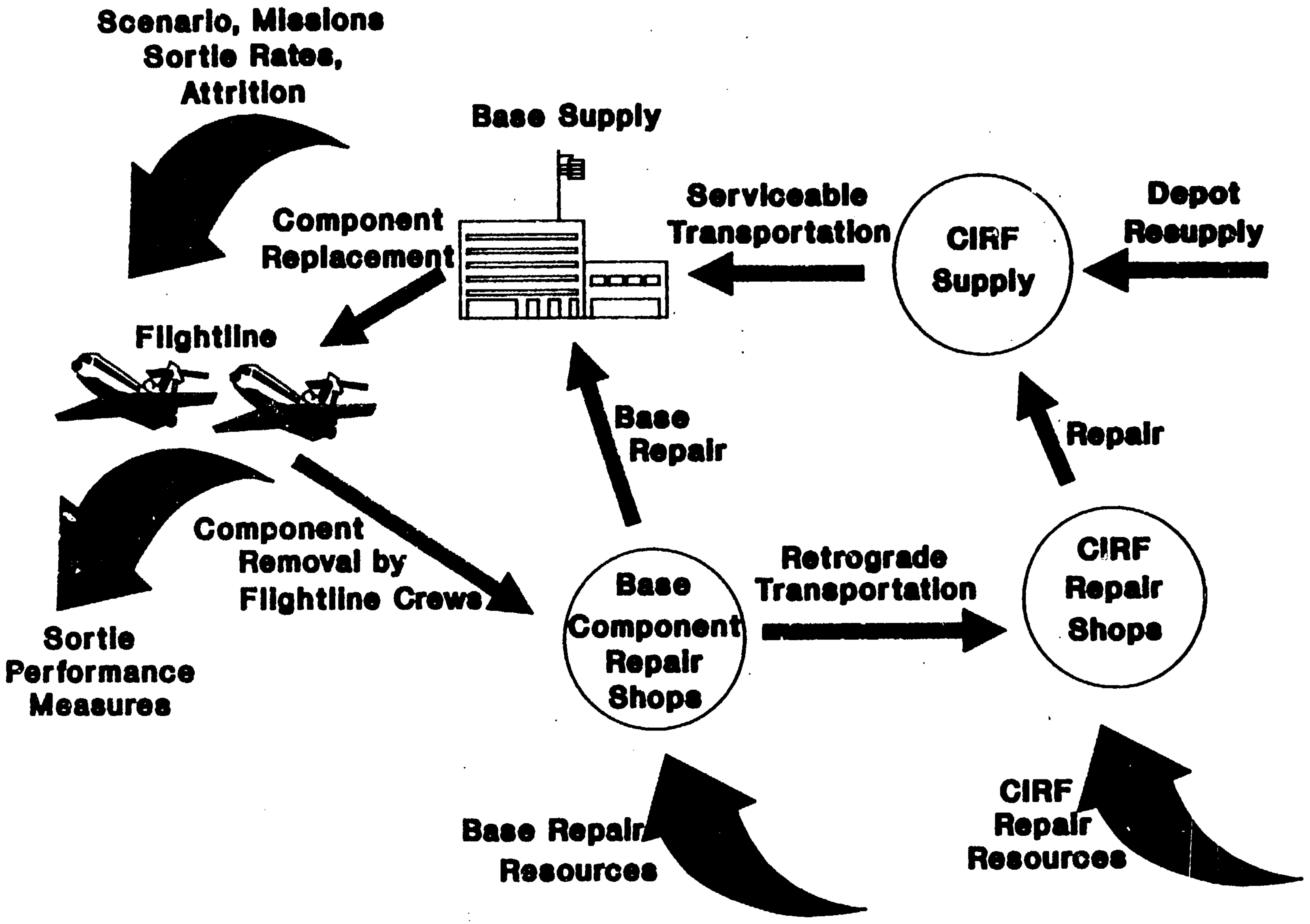

Figure 1. Aircraft Logistics Support Network (26:10)

The model also measures the CIRF repair process through an assessment of the indenture relationship of LRUs and their subcomponents, Shop Replacement Units (SRUs). When LRU repair begins, test equipment may be used in either the base repair shops or the CIRF to isolate the problem subcomponents, which are the SRUs. Repair of the LRU is accomplished by the CIRF removing and replacing the defective SRUs; the now serviceable LRU is returned to supply stock or returned to the aircraft. The failed SRU(s) is either repaired at the CIRF or returned to the next highest echelon, the depot (26:14-15).

The key equation in Dyna-METRIC computes each aircraft spare's expected pipeline size, or equivalently, the quantity of each spare component that should be expected in each segment of the pipelines of the aircraft logistics support system. This computation is based on the modeled time-dependent flying activity, the flying dependent spares failures caused by that activity, the time-dependent availability and delays associated with transportation and repair at the CIRF and base, the probability a spare cannot be repaired at each echelon, and the time delay for depot resupply. Dyna-METRIC then totals these pipeline amounts to arrive at the overall expected pipeline size (19:22-23). The modeler can use this expected pipeline size as a forecast for the number of spare components that will be required to sustain aircraft operations. This forecasting capability of the pipeline segments was the key parameter used to predict spares consumption at different points in time in the attempt to segment War Readiness Spares Kits.

Dyna-METRIC Assumptions

Like all computer models, Dyna-METRIC contains assumptions which help simplify the model's representation of reality. Gage and Ogan provide a discussion of these assumptions in their 1983 Air Force Journal of Logistics article. They mention two basic underlying assumptions. First, the spares quantities input into the model are assumed to comprise all the possible events that might ground an aircraft; crew operational errors or bit and piece part availability are not considered as possible reasons for grounding an aircraft. Second, the model assumes the information (operational scenario and spares) input by the user is correct (19:22-23).

They also describe the eight major Dyna-METRIC assumptions:

1. The actual sorties will never exceed the demanded sorties: The modeler establishes a scenario file which states demanded sortie levels. The model then computes how many sorties can be flown given the operational scenario and available spares. However, the model output will create the impression, when the results are graphically portrayed against

the demands, of a combat unit barely meeting the demanded missions, when the unit may in fact be able to support many more sorties (19:23).

2. Demanded sorties, not actually flown sorties, determine the consumption of spares: The model uses the number of sorties that are planned to be flown combined with the demand rate information to determine how many of each part will fail. If the actual number of sorties that can be flown by the fully mission capable aircraft falls below the desired or planned number input by the user, Dyna-METRIC will continue to consume spares as though all of the required missions, were in fact, flown (19:22-23).

3. The NMCS figures do not necessarily mean grounded aircraft: The model assumes any aircraft that lacks one or more parts is grounded and unable to perform any missions. Partially mission capable (PMC) aircraft are not considered to exist. As a result, the NMCS figures may be possibly be overstated and therefore, misleading. The modeler needs to analyze which parts, in fact, are grounding items (19:23).

4. There are ample repair facilities to perform all repair operations: The model assumes no backlog ever develops in the maintenance shops. Each reparable item immediately flows to an available technician who then begins repair (19:23).

5. The repair and demand processes are independent: In Dyna-METRIC, the flight line, the repair shops, and base supply operate independently. The repair shops repair strictly on a first-in, first-out basis without regard to the supply position of the item or requirements for the grounded aircraft (19:23).

6. Demand rates vary only with flying intensity: The model assumes a linear relationship between the amount of hours flown and the mean number of parts that fail. In other words, the mean number of parts that break is a constant times the total flying hours. A Dyna-METRIC variable called "linear" can be specified to increase or decrease the failure rate to flying hour ratio, however the linearity between demands and flying hours remains intact (19:23).

7. The depot is an infinite source of stock: Dyna-METRIC assumes every depot resupply requirement will be supplied according to the probability distribution of the user input order and ship time. There are no out-of-stock conditions at the depot (19:23).

8. The CIRF pipeline distributes stocks to bases based on cumulative flying hours: The CIRF sends parts to the bases strictly according to the cumulative flying hours of each base. The more a base flies in relation to the other bases supported by the CIRF, the more stocks are shipped into it by the CIRF (19:23).

Miniature Dyna-METRIC

Dyna-METRIC itself has over 15,000 lines of computer code and requires a large mainframe computer like the Honeywell 6000. Additionally, the memory required exceeds the capacity of the Phase IV mainframes now in place at most Air Force bases. Even those bases with the necessary hardware to run Dyna-METRIC are faced with competing users and the resultant time lag for model results (13:1). For these reasons, the Air Force Logistics Management Center developed the Mini-Dyna-METRIC version of Dyna-METRIC.

This microcomputer version is highly flexible for the base level user. It can be run on both the standard Z-100 and Z-248 Air Force microcomputers; classified logistics assessments can be run on the Z-150 Tempest microcomputer. While the smaller model has more flexibility, it also has some inherent limitations. Mini Dyna-METRIC can only simulate one base at a time, and is limited to a VRSK of 2,000 line items or less, 100 aircraft or less, and a wartime scenario of 30 days or less (13:1). This limited capability would not allow higher command levels to assess their overall wartime capability efficiently, but Mini Dyna-METRIC is highly suitable for base wartime capability assessments.

Mini Dyna-METRIC Assumptions

Mini Dyna-METRIC incorporates all of the model assumptions noted in the Dyna-METRIC section except for the final assumption about the CIRF distribution of stocks back to the bases on the basis of their cumulative flying hours. Since Mini Dyna-METRIC can model only one base at a time, this assumption does not hold (13:45-48).

However, there are three additional assumptions noted in the literature. First, the transportation pipelines are continuous; the model assumes transportation is always available to ship reparables from the base to the depot, and if resupply is modeled, transportation is always available to ship serviceable stock from the depot to the base (13:47).

Secondly, all parts can be cannibalized completely and indiscriminately. All cannibalizations are successful and cannibalization actions do not redirect maintenance resources from repairing other broken spares. There are no system accessibility problems when cannibalizing nor is there any need to retain a broken spare on an aircraft for weight and balance requirements (13:47).

Finally, the variance to mean ratio for the distribution of repair pipeline size is assumed to be one, which corresponds to a Poisson distribution. The full Dyna-METRIC model has the capability to redefine this variance to mean ratio, which changes the corresponding probability distribution. If the variance to mean ratio is changed to less than one, the model uses the binomial distribution; a value greater than one corresponds to a negative binomial distribution (20:26). However, Mini Dyna-METRIC doesn't allow a variance to mean ratio other than one (13:48).

Dyna-METRIC and Mini Dyna-METRIC Applications

Reske and McClish described the usage of Dyna-METRIC for structuring Mission Support Kits (MSK) to support deploying fighter aircraft squadrons (30:25). A MSK is defined as:

> ...expendable supply and spare parts including aircraft spares...required to support a unit or a segment of a unit and to sustain continued operation during temporary duty away from home base or at places where support is not available. ...MSK items are obtained from...and...considered a part of base stocks...Preparation and maintenance of the MSK listing will be the responsibility of the applicable major command (12:1-30).

MSKs differ from WRSKs primarily because of their temporary nature and their composition from peacetime operating stocks (POS).

They used Dyna-METRIC to select a mix of spare parts that would, given a a user-specified confidence level, meet a user-specified performance goal when flown against a given flying scenario. They considered a sample data base base of ten F-16 aircraft spares that included items essential to airborne activity (fire control, radar), flight (engine), and safety (oxygen regulators). The operational scenario modeled was a twelve aircraft deployment for thirty days with each F-16 flying one sortie each day for 1.3 hours. All twelve F-16s were assumed Fully Mission Capable (FMC) prior to the deployment. There was no cannibalization allowed on the SRUs contained in any of the ten F-16 spares and maintenance was limited to remove and replace (RR) actions only at the remote location of the deployment (30:25).

Utilizing several Dyna-METRIC options, they computed two initial MSKs, the first based on optimizing a back-order goal and the second to achieve a Not Mission Capable Supply (NMCS) goal. Reske and McClish found the second MSK achieved greater overall confidence of making the goal of less than 9 percent of the F-16s NMCS at any point during the deployment (85 percent vs 39 percent). While the NMCS optimized MSK had more than double the units in the back-order goal MSK, the total cost of the NMCS MSK was only 13 percent higher. They discussed the reason for this large difference, the marginal analysis algorithm in Dyna-METRIC; they also mentioned the disadvantage of marginal analysis, which is not all spares get equal protection against stockouts. Lower priced spares tend to be allocated more readily by Dyna-METRIC than more expensive spares, since they give the greatest reductions in NMCS per unit cost (30:25-26).

Reske and McClish developed an alternative approach to the Dyna-METRIC marginal analysis algorithm by setting the unit costs of all ten spares to a constant value. Their "adjusted" NMCS MSK now had ten less units as well as an increase in "unadjusted" cost of $5 million; yet, this MSK also reached an 85 percent confidence level of making the 9 percent NMCS goal. They noted the increase in cost was only the associated inventory value and was not actual procurement costs, since MSKs are assembled from existing stocks (30:26-27).

They also demonstrated how the various Dyna-METRIC options can be used selectively for certain items, first to generate individual spares requirements; and then using the resulting MSK to assess the overall logistics system's performance. They also experimented with MSKs constrained by airlift capacity or asset availability. They noted the possibility of using an asset's actual volume or weight in place of the unit cost to build a MSK that would meet the performance goal while minimizing total MSK volume or weight (30:28).

Reske describes his methodology of using Dyna-METRIC to pre-palletize WRSK or MSK spares to support flight operations in a low-intensity conflict. Using Dyna-METRIC in the requirements computation mode, he demonstrates the model's capability to predict spares failures in a relatively low flying hours scenario, which would be representative of low-intensity operations (29:18).

He uses the example of a TAC squadron which has its WRSK segmented into two parts: the initial support element (first seven support days) and the tactical support element (days eight through thirty). He notes how this segmentation is often done by aircraft maintenance technicians, who use their knowledge and past experience to decide the quantities. He then overlaid the squadron's wartime sustained sortie rate into Dyna-METRIC and evaluated the results of the segmentation, in terms of one specific LRU (29:18-19).

Reske than compared the model's spares predictions against the TAC maintenance technician predictions for the one LRU during the first seven days of operations. His example describes how an error in failure predictions could cause a substantial loss of sortie generation capability. He then lists the benefits of using Dyna-METRIC to predetermine palletization based on expected usage: a WRSK airlift priority system parameter, the protection of valuable assets from possible destruction, better asset visibility because of of deploying "only what's needed", more rapid identification and replacement of destroyed spares, and the capability to prioritize repair of failed assets for reconstituting WRSKs (29:18-19).

Gage and Ogan describe the 1984 Air Force Logistics Management Center developed Miniature Dyna-METRIC model and give their concept of how and when the model could be applied by base-level logistics managers. They comment on how Mini Dyna-METRIC can be used to evaluate a number of different "what-if" scenarios in the attempt to assess logistics capabilities in the form of <u>expected</u> operational performance (20:24).

After describing Mini Dyna-METRIC's input and output files, they mention four possible applications: incremental logistics support, transportation analysis, air base attack scenario, and the possible variable consumption of spares. For example, the authors describe how an air base attack could be simulated by adjusting repair cycle times, stockage quantities, and the number of assigned aircraft. Weather or other environmental factors at the deployed location could be simulated by increasing or decreasing spares failure rates. Resupply policy could be modeled by adjusting order and ship times to evaluate the best time to begin resupply. Gage and Ogan also concentrated on how Mini Dyna-METRIC should be considered as a management tool and not as a replacement for human analysis and judgement (20:26).

Dyna-METRIC VRSK Computation

Blazer discusses the 1987 Air Force Logistics Command initiative which explored the possibility of using Dyna-METRIC to compute VRSKs in lieu of the current D029 VRSK requirements system. He mentions how Dyna-METRIC more closely resembles the expected wartime environment than the D029 system, because Dyna-METRIC models the wartime demand and repair environment more closely and more accurately considers the important indenture relationship of LRUs and SRUs. He describes how D029 does not optimize aircraft availability, because it attempts to minimize the weighted average of aircraft not mission capable supply (NMCS) and supply backorders. As the number of NMCS aircraft in the D029 computation approches the specified goal, the NMCS weighting factor becomes smaller and the backorder reduction weighting factor becomes larger. As such, D029 tends to recommend the stockage of items that reduce backorders relatively more than items needed to produce mission-capable aircraft (2:26). He mentions how D029 incorrectly treats all items in a VRSK as LRUs, which overstates the impact the lack of an SRU has on aircraft availability. Dyna-METRIC considers the important LRU-SRU indenture relationship much more effectively, because the model correctly assumes the "indirect" nature of SRUs; that is, the lack of an SRU will not necessarily ground an aircraft. He also describes how Dyna-METRIC can consider a limited funding constraint, which could be used to find the best mix of VRSK spares to buy with a fixed budget (2:26-27).

Blazer shows the advantages of using Dyna-METRIC for computing VRSKs for units that will deploy with an intermediate repair capability. A sample F-15 VRSK of 325 line items at a cost of $26.1 million was computed by Dyna-METRIC versus a D029 VRSK of 565 line items at a cost of $35.5 million. The Dyna-METRIC VRSK met the stated performance goal, at almost half the number of line items and a reduction in cost of $9.4 million. Blazer also discusses how Dyna-METRIC eliminates many of the items D029 stocked at a level of only one or two, and also reduces the stock levels of many SRUs (2:26-27).

AFLC began to use Dyna-METRIC to compute VRSK requirements in March 1988 for the F-16, F-111, and F-15. Barring any unforeseen problems, the command hopes to expand the process to other aircraft VRSKs in the fall of 1988.

Blazer also mentions how AFLC is prototyping ways to use Dyna-METRIC for determining which WRSK spares to buy under budgetary constraints, determining BLSS requirements, and for further reducing WRSK costs through optimizing the mix of LRUs and SRUs (2:27).

Coronet Warrior

The Tactical Air Command is probably the most experienced operational user of Dyna-METRIC in the Air Force today. For example, TAC uses the model in its own unique logistics assessment and requirements program, TAC PACERS II. Each TAC unit has access to Dyna-METRIC and can perform assessments of unit capability, as well as estimate spares requirements for scheduled exercises (6:5-1).

In 1987, TAC decided to test the validity of Dyna-METRIC as a requirements and assessment tool through a simulated "combat operations" exercise, Coronet Warrior. The exercise scenario included one full squadron of twenty-fout F-15 aircraft, which flew wartime sortie rates for thirty days at a forward location. The F-15 unit's RRR WRSK was the only source of supply support available; additionally, Automatic Test Equipment was deployed and operational by the third day of the exercise. Authorized strength levels of aircraft maintenance personnel were used throughout the exercise in an effort to match the expected environment. The command made every attempt to completely replicate the operational scenario the F-15 would fly in wartime, and also recreated the combat logistics support network the weapon system required for sustained operations. One notable exception was the issue of Partially Mission Capable (PMC) aircraft, which are not recognized by the Dyna-METRIC model. In Coronet Warrior, only FMC aircraft were allowed to fly, since the main purpose of the exercise was to validate the model and its underlying assumptions (6:5-3,5-5).

Before the exercise began, TAC used the actual WRSK assets to predict (via Dyna-METRIC) the sortie capability of the F-15 unit. However, since these available assets gave a predicted 96.7 percent sortie capability, TAC adjusted eleven WRSK item's stock levels downward to bring the WRSK down to a C-2 sustainability rating. Using Dyna-METRIC's "problems parts" capability, TAC reduced the stock levels of those items most likely to ground aircraft. The command wanted to use a less than fully capable WRSK to reflect the probability that the time required to "robust" the WRSK to a fully capable state would not likely be available in a wartime situation. After the stock levels were reduced, the model predicted the WRSK would support 91 percent of the planned wartime sorties (6:5-7). In fact, the F-15 squadron was able to fly 98 percent of the planned wartime flying hours at the average sortie duration of 1.8 hours (6:5-8).

TAC also found that their pre-exercise predictions of RR spares usage were generally consistent with actual exercise results; however, the model significantly understated the spares requirements for RRR items. Dyna-METRIC Version 3.04 treats the repair process as an ideal situation, where repair resources (test equipment and technicians) are always immediately available. Coronet Warrior results showed that this assumption is unlikely; the actual repair process was more erratic and priority decisions had to be made as competing demands for repair queued up (6:5-12). This assumption also contributed to a higher than predicted cannibalization rate for RRR spares (6:5-13). Version 4.4 of Dyna-METRIC has a test equipment feature which may better represent the competition among spares that are repaired by a common piece of test equipment. This enhancement should help improve the prediction accuracy for RRR spares for future assessments and exercises (6:5-17).

One of the major results of Coronet Warrior was the evaluation of the peacetime demand rates that are used by AFLC in the D029 WRSK Computation System to forecast WRSK spares levels. The exercise found that the simulated wartime flying scenario generated spares failure patterns that were not consistent with the D029 demand rate; in other words, many items failed less than D029 predicted and some items failed more than D029 predicted. In fact, the RRR spares failed more than expected, yet the flexibility of the deployed Automatic Test Equipment to repair them kept grounded aircraft at an acceptable rate (6:5-19). The exercise report also noted that unit specific demand rates (in lieu of the worldwide D029 aggregate demand rate) gave good estimates of the actual exercise demand rates (6:5-20).

Summary

This chapter has developed the Air Force concept of War Reserve Material, especially as it pertains to War Readiness Spares Kits. The Dyna-METRIC analytical inventory model was discussed at length, and several of the logistics applications where the model has been used were outlined. The Mini Dyna-METRIC model applied in this research was also reviewed and the model's assumptions and limitations were also described in depth. The TAC sponsored Coronet Warrior exercise was also reviewed; the results of this Dyna-METRIC validation exercise will form the basis for measuring the Mini Dyna-METRIC WRSK segmentation procedure proposed in this research effort.

III. RESEARCH METHODOLOGY

Overview

The methodology developed for this research consists of identifying selected F-15 Remove and Replace WRSK spares and determining whether the Mini Dyna-METRIC inventory model can successfully allocate the WRSK stock levels into several distinct segments over a representative wartime period of operations. Once these spares are identified and then allocated by Mini Dyna-METRIC, the model's segmentation results will be measured against the results of the 1987 TAC Dyna-METRIC validation exercise, Coronet Warrior, in an effort to validate model output.

This research methodology required three distinct elements to properly evaluate Mini Dyna-METRIC as a segmentation tool. First, a model that would adequately represent the expected wartime environment as well as be easy to use, responsive, and reliable for the base level WRSK manager was required. Mini Dyna-METRIC was selected because it simulates the wartime logistics system favorably, it is compatible with the standard Air Force small computers, and its operation is very user-friendly (menu-driven, with no computer programming experience necessary). Secondly, a wartime operational scenario, combined with a realistic data base of selected WRSK spares, was needed to model the logistics performance of a front-line aircraft weapon system under its own uniquely assigned wartime mission. An F-15 WRSK spares data base and a Weapon System Management Information System (WSMIS) operational scenario provided by AFLMC/LGS satisfied this methodology element. Finally, an experimental design was required to fully investigate and answer the two research questions proposed in Chapter One. The initial step of this methodology element was to select the Requirements Calculation mode of the model as the technique used to predict spares consumption over the thirty day WRSK evaluation period. The second step was to run the model using various statistical confidence levels and two sets of spares failure rates in an attempt to best match the results of Coronet Warrior.

The two proposed research questions are answered through the execution of this design using Mini Dyna-METRIC, the F-15 WRSK data base, and the WSMIS wartime operational scenario. The model's WRSK segmentation results are presented in Chapter Four in tabular format for ease of comparison and interpretation.

Evaluation Model

Mini Dyna-METRIC was used as the evaluation tool in this research. This model is a microcomputer version of the Rand Corporation Dyna-METRIC analytical inventory model and is designed to be used at the Air Force base level for both stock requirements computations and logistics performance assessments.

The full Dyna-METRIC model is a validated, state of the art mathematical inventory model that uses dynamic queuing equations to forecast how logistics support processes would affect aircraft units' capability in the dynamic wartime environment (26:8). Although the size of the logistics network modeled is scaled down significantly, the microcomputer version still retains much of the logistics prediction power of the full model; however, a notable exception is the inability to adequately predict the stockage levels for SRUs (13:39).

The AFLMC User's Guide to Mini Dyna-METRIC provides an extensive discussion of the model's limitations and requirements. Mini Dyna-METRIC can model only one base per run, for up to 30 days per run, employing up to 100 aircraft per run, and with a limit of 1000 each on LRUs and SRUs (13:1). The model's input information falls into two categories: operational and parts. The operational information elements include the number of aircraft, the number of sorties per aircraft, the flying hours per sortie, and the maximum sorties per aircraft. Each of these elements is expressed in units of days, and the operational scenario input file allows up to fifteen variations of one, several, or all of the elements within a thirty day model run (13:2,11). The parts information elements include the part name (stock number), the quantity per application, the demands per flying hour, the repair cycle time, the percent of base repair, the order and ship time, and the on-hand stock. The repair cycle time, percent of base repair, order and ship time, and on-hand stock can be varied for individual parts up to fifteen times within a thirty day model run (13:2,13). This capability to vary both the operational scenario and the parts information allows the a great deal of flexibility in structuring a logistics support system that reflects real world constraints in capacity and/or resources.

Model Assumptions

Mini Dyna-METRIC, like any mathematical model, uses certain assumptions to simplify the interrelationships among many potentially variable factors. These assumptions are grouped into three categories: scenario, repair, and pipeline. For a more in-depth discussion of these limitations, the reader is referred to the AFLMC User's Guide for Mini Dyna-METRIC, July 1985 (13).

A. Scenario Assumptions:

1. Demanded sorties, not actually flown sorties, determine the consumption of spares.
2. The Fully Mission Capable (FMC) figures do not mean all mission capable aircraft.

B. Repair Assumptions:

1. There are ample repair facilities to perform all repair operations.

2. The repair processes and the demand processes are independent.

C. Pipeline Assumptions:

1. The depot is an infinite source of stock.
2. The transportation pipelines are continuous.
3. All parts can be cannibalized completely and indiscriminately.
4. The variance to mean ratio for the distribution of repair pipeline size is one.

The applicability of these assumptions to the specific experimental design used in this research will be discussed later in this chapter in the section that provides research methodology limitations.

Research Data Base and Scenario

A Report of Coronet Warrior Data on Aircraft Reparable Components D029 WRSK (Serial No. 0F015COT2400) dated 17 September 1987 was obtained from HQ AFLC/XRSA. This report contained the 629 WRSK line items (300 LRUs and 329 SRUs) that were actually deployed during Coronet Warrior; additionally, it listed the transaction information (demands, turn-ins, repairs, awaiting parts time, repair cycle time) that occurred in aggregate during the exercise. HQ AFLC/XRSA also provided two Coronet Warrior Dyna-METRIC files that were used in-house for various assessment applications in the AFLC CREATE computer system; these listings provided indicative WRSK data, like stock number, type of item (RR LRU, RRR LRU, or SRU), and unit cost. AFLMC/LGS provided the Mini Dyna-METRIC parts input files for the 629 Coronet Warrior line items, with both the D029 worldwide demand rates and the adjusted demand rates that resulted from the exercise. As a crosscheck on the worldwide demand rates, a D029 simulation run dated 29 February 1988 for the same F-15 WRSK was received from HQ AFLC/MMMR. Finally, HQ AFLC/XRSA also provided a listing of Coronet Warrior transaction data by day, which showed the actual demand history for each WRSK spare during the exercise.

The generic F-15 operational scenario (unclassified) used in this research was also provided by AFLMC/LGS. Table II shows the experimental scenario in Mini Dyna-METRIC file format.

Table II

Mini Dyna-METRIC
F-15 WSMIS Scenario

WARTIME DAYS = 30

BEGIN DAY	ACFT	RQS	MAXS	FHPS
PEACE	24	0	3.5	1.8
1	24	2.3	3.5	1.8
8	24	1.1	3.5	1.8

This scenario consists of a single base supporting one wing of twenty-four F-15 aircraft. Peacetime is initialized at zero requested sorties (RQS), which means the F-15 wing is in a stand-down, non-flying mode. This technique is used to ensure full initial wartime aircraft availability, since the model will "fly" any requested peacetime sorties and aircraft may become NMCS and therefore unavailable for wartime. The F-15 wing flies an initial wartime surge of 2.3 sorties per aircraft, per day for the first seven days of operations and then tapers off to 1.1 sorties per aircraft, per day for the remaining twenty-three days. The sortie duration (FHPS) remains constant at 1.8 hours per sortie and the maximum sortie rate (MAXS) is 3.5 sorties per aircraft per day. Under this wartime scenario, the wing should be capable of flying 55.2 expected sorties during the surge period (twenty-four aircraft * 2.3 requested sorties per aircraft). Expected sorties for the remaining twenty-three days are 26.4 (twenty-four aircraft * 1.1 requested sorties). The flying hours for each day can be found by multiplying the expected sorties by 1.8 flying hours. This operational profile matches the same scenario used to evaluate the F-15 weapon system by the Weapon System Management Information System (WSMIS) wartime sustainability rating system (17:2-10). More importantly, it also closely parallels the flying hours performed during Coronet Warrior (approximately 1789 flying hours vs 1800 actual exercise flying hours) (6:5-8).

Data Base Preparation

The major step involved in data base preparation was identifying the Coronet Warrior WRSK RR LRUs that were used during the exercise. The Dyna-METRIC listings and the Report of Coronet Warrior Reparable Aircraft Components provided by AFLC were the source documents used to select the research sample data base of sixty-one F-15 RR LRUs. Appendix B lists the sample data base in National Stock Number sequence. The next preparation step was to check the two sets of demand rates to be used for the Mini Dyna-METRIC segmentation runs. The HQ TAC Coronet Warrior report was used as the basic source for the exercise demand rates; these rates were also cross checked for accuracy against the AFLC Coronet Warrior Dyna-METRIC files. The D029 demand rates were initially taken from the AFLMC provided Mini Dyna-METRIC parts files; they were checked against the D029 simulation products for accuracy. Appendix C lists the sample data base in terms of the D029 and Coronet Warrior demand rates per flying hour.

The creation of two Mini Dyna-METRIC parts files was required after selecting the research sample data base. Each parts file was identical, except for one key element, demands per flying hour. The first parts file contained the sixty-one sample items with D029 worldwide demand rates, while the second parts file contained the sample items with Coronet Warrior demand rates. Mini Dyna-METRIC uses eight supply data elements within the parts information file to define individual spares. Table III shows a sample VRSK item in Mini Dyna-METRIC format, which the reader may use to better understand how these elements were applied in this research.

Table III

Mini Dyna-METRIC Sample VRSK Item

```
5865 01 086 1001    DPFH = 0.00057    QPA = 1    COST = 2601
   PEACE    PBR = 0.000    BRT = 4.00    OST = 99.00    STK = 0
       1    PBR = 0.000    BRT = -1.0    OST = -1.00    STK = 0
```

The first supply data element is the name of the LRU, in this case the National Stock Number of the item. The second element (DPFH) is the demands for the item per flying hour. The third element (QPA) is the Quantity per Application, which is the count of the item on the aircraft. The fourth item (COST) is the part's unit cost.

The next four supply data elements are expressed in terms of time and can be varied up to fifteen times during the wartime operational period, if desired. Each day's parts information will take precedence until superceeded by new parts information on a succeeding day. The last wartime day with new parts information will have precedence from that day until the final day of the modeled scenario.

For these four elements, each part was initialized at some peacetime activity. In this research, all sample items had zero percentage of base repair during peacetime, so the initial PBR field is zero. The BRT field is the base repair time, or repair cycle time, which is the time an item is unavailable for use because it is undergoing testing, repair, or preparation for off-base shipment to a higher echelon for repair. The normal BRT was used for this field for the peacetime activity. The OST is the order and ship time, which is the time that expires from ordering a part until receipt from the source of supply. The OST was initialized at ninety-nine days during peacetime for all research sample items. While this figure is certainly not representative of normal peacetime activity, this exaggerated number was used to ensure the WRSK does not receive any resupply stock during the 30 days of modeled wartime operations. The STK field is the amount of available stock. For both peacetime and the modeled wartime activity, zero WRSK stock was assumed to be on-hand.

The last line in Table III is wartime Day One parts information. The percentage of base repair remained zero for all sample items during the wartime period. The BRT field was changed to a negative value (-1) because no time would be expended testing or repairing the sample RR items during wartime; essentially, unserviceable spares would be quickly packaged for evacuation and returned to the depot when WRSK resupply began. The OST field is also a negative value; again this was done to ensure no resupply during the wartime period. The stock available on Day One was set to zero.

The parts information on Day One had precedence throughout the entire thirty days of modeled wartime operations. The Mini Dyna-METRIC parts files were designed to model a RR VRSK consisting of sixty-one LRUs; these assets were not authorized base level repair and would not receive any resupply during wartime. The parts files were used in conjunction with the generic F-15 WSMIS operational scenario in the effort to measure the pipeline size (equivalently, the number of failures) of each sample VRSK item at three different points in time during the thirty wartime days.

Experimental Design

Collecting and screening data, as well as incorporating this data into three Mini Dyna-METRIC input files proved to be a major undertaking. However, the experimental design used to test the two research questions is relatively simple and straight forward.

The first design step was to select representative timeframes that could be used to allocate the sample VRSK data base into three segments. The decision to create three segments was made to simulate on a small scale whether reductions in airlift requirements could be gained through incremental staging of the VRSK into the wartime area of operations, while at the same time retaining the logistics capability of supporting the operational scenario. This reduction in airlift needs could possibly be quantified by comparing the weight and cube of the initial VRSK segment versus the same factors for the entire VRSK. However, the primary purpose of this research is allocating a VRSK into segments for optimal mission support; actually measuring any cost or capacity savings in VRSK airlift through the use of segmentation is beyond the scope of this research. The three experimental VRSK segments selected were: Segment One (Wartime Days One through Ten), Segment Two (Wartime Days Eleven through Twenty-one), and Segment Three (Wartime Days Twenty-two through Thirty).

The second experimental design step was to specify which of the two logistics prediction techniques available in Mini Dyna-METRIC to use for the segmentation runs. The Requirements Calculation mode was selected for several reasons. First, this segmentation experiment was designed to calculate the amount of VRSK stock used in a realistic wartime setting. Conversely, in the Capability Assessment mode, the model predicts the capability to support an operational scenario given an initial stock of spares. The Requirements Calculation mode was appropriate because the model segmentation runs could be executed with no on-hand VRSK stock, which allowed easier interpretation of the key experimental design parameter, the expected pipeline size of each sample VRSK item. Secondly, no attempt was made to measure whether or not the sample VRSK could in fact support the given operational scenario. The spares requirements for a real world VRSK are computed against each combat unit's most demanding wartime mission; therefore, this experiment assumes the sample VRSK will in fact support the wartime mission. Since the requested sorties and not actually flown sorties is the input operational factor in the model that determines the failure of VRSK spares, the expected pipeline size of each item is insensitive to whether or not the experimental scenario is supportable or unsupportable; the pipeline size would have the same value under both circumstances (13:45). If Mini Dyna-METRIC proves to be an appropriate model for segmenting VRSKs, the model output (pipelines sizes) could then be applied against the authorized VRSK levels to allocate the VRSK into required segments.

The next design step was to specify two Mini Dyna-METRIC Requirements Calculation parameters: the Fully Mission Capable Aircraft Goal and the Confidence level. AFR 400-24, War Reserve Materiel Policy, requires a FMC Aircraft Goal of 75 percent during the wartime support period. This goal, also called the Direct Support Objective, is designed to ensure VRSK spares requirements are calculated to give 75 percent or greater aircraft availability (14:14). Accordingly, 75 percent was used as the FMC Aircraft Goal for all eight segmentation runs. Four different statistical confidence levels were applied: .50, .80, .90, and .99. These values were chosen arbitrarily to explore whether or not there would be significant changes in each sample item's expected pipeline size under different statistical confidences.

The final design step was to structure the model segmentation runs. Eight different runs, using the same operational scenario input file (Table II) and the two different parts input files (Appendices D and E), were attempted. Table IV lists the parameters for the model runs.

Table IV

Experimental
WRSK Segment Runs

	DEMAND RATES	FMC GOAL	CONFIDENCE LEVEL	WARTIME DAYS
1.	D029	.75	.50	30
2.	D029	.75	.80	30
3.	D029	.75	.90	30
4.	D029	.75	.99	30
5.	CW *	.75	.50	30
6.	CW *	.75	.80	30
7.	CW *	.75	.90	30
8.	CW *	.75	.99	30

* Coronet Warrior

Before the eight model segmentation runs were accomplished, the Coronet Warrior demand history by day listing was used to allocate the sample into the three experimental VRSK segments, which are listed in Appendix F. Each model run was then executed for the full thirty day wartime support period. This technique was used because Mini Dyna-METRIC has very flexible parts output file access capabilities. For example, the model can list each sample item's pipeline size for each day of the support period or for selected days within the support period. This method was much easier than accomplishing three distinct runs for each set of input parameters, which would equate to twenty-four individual model runs.

After the segmentation model runs were completed, the sample VRSK was allocated into the three experimental segments by using the expected pipeline size as an indicator of spares usage. For example, if the pipeline size for a WRSK spare was 2.1 at the end of ten days and 5.6 at the end of twenty-one days, then two units were allocated to Segment One and three units were placed in Segment Two. This methodology was consistently applied to all model runs; a spare was always allocated to the lowest integer value of the pipeline size. Since the pipeline size is a cumulative value, the value at the end of twenty-one days had to be subtracted from the value at the end of ten days to find the Segment Two quantity; similarly the pipeline size at the end of thirty days had to be subtracted from the pipeline size at twenty-one days to determine the Segment Three quantity. At this point, the model's segmentation results were then tabulated and compared against the segmented Coronet Warrior results.

Research Question One, "Can the Mini Dyna-METRIC computer model be applied to the problem of optimally segmenting War Readiness Spares Kits?", could then be answered through the evaluation of the eight model segmentation runs' accuracy against the Coronet Warrior exercise data. The basic criterion for accuracy was correct forecasts, i.e., a correct forecast was made when the model's predictions matched the actual exercise results. The model's accuracy was measured using a simple rate formula: correct forecasts divided by the number of forecasts. An 80 percent correct forecast rate or better was pre-determined to be an acceptable level of accuracy for each experimental segment. This level of accuracy would provide the capability of satisfying four out of five WRSK demands during the support period and would also minimize the impact of having to cannibalize spares to keep aircraft fully mission capable.

In order to answer Research Question Two, "Given that Mini Dyna-METRIC is a viable tool for segmenting WRSKs, can the model input procedures and output analysis techniques be incorporated into an easily understood and applied User's Guide for base-level supply personnel?", the model must meet the accuracy criterion developed to ensure a relatively strong prediction capability. The actual process of determining objectives, developing a logical sequence for explaining the model's input/output files, and creating a meaningful sample segmentation problem for the User's Guide is not difficult; however, the validated model results are required before this question can be evaluated and answered.

Methodology and Design Limitations

A discussion of the applicable Dyna-METRIC and Mini Dyna-METRIC assumptions in the context of this research design, as well as a description of the the most limiting inherent assumptions associated with the WRSK sample data base is required; this will allow a realistic interpretation of the validity of the results. With the limitation that this proposed WRSK segmentation procedure only applies to RR WRSKs, many of the assumptions associated with the repair and transportation aspects of the model do not apply in this research.

As previously noted, the requested sorties in the scenario input file is the determining factor in the consumption of spares over the given scenario. If the available aircraft cannot support the requested sorties at any time due to spares shortages, the model will still "break" parts as if the requested sorties were in fact flown. Therefore, this assumption is probably the most applicable to this particular research, since the primary concern is how many spares are consumed over the wartime support period, and not whether the sample VRSK can in fact support the scenario effectively. The other assumption of importance is that spares demand rates vary only with flying intensity. Since the model segmentation runs face a wartime scenario with an heavy initial surge of sorties that then tapers off to a "steady state" demand for requested sorties, the comparison of Coronet Warrior spares consumption results to the model's results should be a real world test of this model assumption.

The most limiting research specific assumption is that the VRSK data base is a representative sample of Air Force RR WRSKs. Since the sample was drawn from a F-15 RRR WRSK, the range of RR items available to conduct the segmentation runs was certainly much less than if the sample was taken from a RR WRSK. Another possibly limiting factor is that only 26 percent (sixteen of sixty-one) of the sample spares are associated with aircraft avionics systems; realistically, the avionics systems in a weapon system supported by a RR WRSK would likely have a much larger share of the WRSK line items, both in terms of range and depth. Since Coronet Warrior was the only realistic RR WRSK spares usage data available at the time of this research, the overall results reached in this research may not be entirely conclusive due to the small and possibly unrepresentative RR WRSK sample.

IV. RESULTS

Overview

The results of the eight Mini Dyna-METRIC segmentation model runs discussed in Chapter Three will be presented in tabular format. Each table will contain a summary of the actual Coronet Warrior exercise spares usage by experimental segment as compared to Mini Dyna-METRIC's segmentation predictions. Each summary table will also list the accuracy results achieved, as well as other meaningful information to assist in results evaluation. An interpretation of the significance of the experimental results will next be provided, which will be used to answer the two proposed research questions. A short summary of experimental results will then be presented, which will lead to the research conclusions and recommendations provided in Chapter Five.

Initial Results Analysis

The model's parts output file menu item "View LRU Data" was used to find the expected pipeline size for each sample WRSK item for each day. The first four model runs were performed using the D029 demand rates input file and the WSMIS wartime scenario under four statistical confidence levels (.50, .80, .90, and .99); the last four model runs used the Coronet Warrior demand rates input files and the

VSMIS wartime scenario, again under the same four statistical Confidence levels.

The initial analysis of each set of Mini Dyna-METRIC segmentation runs showed the confidence level was not a significant parameter in the calculation of the expected pipeline size. For each set of parts data, the expected pipeline size was identical for all four confidence levels. However, if the output file menu item "View New LRU stockage" was queried, the confidence level became very significant. At higher confidences, Mini Dyna-METRIC recommended increasingly higher stockage for each WRSK spare in the two parts input files. However, this recommended LRU stockage quantity was significantly understated in the early stages of each run. Table V provides an example of this deficiency.

Table V

New LRU Stockage
Segment One

Demand Rates	Confidence Level	MDM Items/Units	CW Actual Items/Units
D029	.50	1/1	36/71
D029	.80	1/5	36/71
D029	.90	3/11	36/71
D029	.99	9/37	36/71
CW *	.50	0/0	36/71
CW *	.80	0/0	36/71
CW *	.90	0/0	36/71
CW *	.99	11/25	36/71

* Coronet Warrior

The utility of the New LRU Stockage portion of Mini Dyna-METRIC's Requirements Calculation mode for segmenting WRSKs is doubtful. This portion of the model uses a marginal analysis algorithm for stocking the LRUs that give the greatest increase in aircraft availability per unit cost, which means lower cost items tend to receive more stock protection than higher cost items (13:39). It suggests stocking components in order to approach the target Direct Support Objective goal at minimal cost (26:29). The cost of an item is seldom correlated with aircraft availability; demands should be the driving factor for stockage decisions. Additionally, the Direct Support Objective of 75 percent FMC aircraft "gives" the model an available source of spares from the 25 percent remaining aircraft (in this case, six F-15s), which are allowed to become NMCS; Mini Dyna-METRIC will exhaust these cannibalized assets as the primary supply source before recommending any new stockage for a WRSK asset. Finally, the New LRU Stockage technique only lists a recommended quantity of WRSK stock levels; it does not provide the expected pipeline size of each WRSK line item.

Table V depicts an increase in maintenance workload at the point in time where approximately 46 percent of the entire wartime sortie commitment is required. This first WRSK segment is clearly the most critical because the transition to a new and probably hostile operating environment will be stressful enough for logistics support personnel; compounding this situation with inadequate initial spares support is unacceptable. The Mini Dyna-METRIC User's Guide notes that if the minimum amount of stock required to support a scenario is desired, then the modeler must explicitly begin with zero stock on-hand (13:39). The eight segmentation runs were all accomplished with zero stock, yet the recommended stockage quantities were still significantly understated. For example, in the D029 run at .99 confidence, only 1 out of 9 WRSK forecasts was accurate; 2 predictions were below actual usage, while 6 predictions were above actual usage. One asset's model forecast for Segment One was 13 units in excess of the actual usage experienced during Coronet Warrior. The Coronet Warrior run at .99 confidence was equally poor. Only 1 forecast was accurate of the 11 items recommended for stockage. The inaccuracy of those WRSK items even recommended for stockage (11 percent and 9 percent) and the inability to predict items with at least one demand (9 for D029 and 11 for Coronet Warrior versus 37 actually used in the first 10 days of Coronet Warrior) argued strongly against using the New LRU Stockage capability of Mini Dyna-METRIC for segmenting WRSKs.

Consequently, the "View LRU Data" portion of Mini Dyna-METRIC was the primary technique used to apply the comparison of model segmentation predictions against the actual spares usage experienced during Coronet Warrior. This technique also parallels the current AFLC Dyna-METRIC WRSK requirements computation methodology, where the thirty day pipeline quantity is used as a "floor" to reduce backorders and consequently, cannibalizations (2:27-28).

D029 Segmentation Results

As previously noted, the confidence level was an insignificant parameter in computing the expected pipeline size for each sample VRSK item. Table VI shows the results of the D029 model run for Segment One (Days One through Ten), which was identical for all four confidence levels.

Table VI

D029 Demand Rates
Segment One

	Mini Dyna-METRIC	Coronet Warrior
Line Items	30	36
Units	124	71

36 Forecast Errors

25 Correct Forecasts

ACCURACY = 25/61 = 40.98%

The D029 demand rates significantly overstated the VRSK spares requirements for Segment One. 25 percent of the forecast errors were for 2 or more units, with 3 large errors of 18, 18, and 20 units, respectively. Conversely, there were 12 VRSK line items that had 1 demand in the first 10 days of Coronet Warrior, yet the model predicted no usage for these 12 items. Another sample item had 3 demands during the exercise, but Mini Dyna-METRIC predicted this item would not be used. Additionally, there were 5 other sample line items that had model predictions that were for quantities less than actual usage. These inaccurate model predictions would have potentially led to 22 cannibalizations to support the sortie surge of the first 10 days of operations.

Table VII lists the results of the Segment Two D029 run, for supporting wartime days Eleven through Twenty-One.

Table VII

D029 Demand Rates
Segment Two

	Mini Dyna-METRIC	Coronet Warrior
Line Items	40	30
Units	98	49

41 Forecast Errors

20 Correct Forecasts

ACCURACY - 20/61 = 32.79%

Mini Dyna-METRIC again overstated the spares requirements for Segment Two when using the D029 demand rates. The VRSK units in the expected pipeline were exactly double the actual Coronet Warrior usage. The model predicted demands for 20 line items without corresponding exercise usage, with 3 items having large errors of 7, 8, and 12 units. Additionally, there was 1 sample item with 21 expected failures, but only 4 units actually failed. There were 10 line items with at least 1 failure between days 11 and 21, but the model failed to predict usage for all 10 items. Also, there were 9 line items with forecasted demands that were short of actual exercise demands. The D029 WRSK Segment Two forecast would have potentially required 21 cannibalizations, only a marginal improvement over the forecast for Segment One.

Table VIII presents the results of the D029 model run for Segment Three, which supports wartime days 22 through 30.

Table VIII

D029 Demand Rates
Segment Three

	Mini Dyna-METRIC	Coronet Warrior
Line Items	35	32
Units	71	46

35 Forecast Errors

26 Correct Forecasts

ACCURACY - 26/61 = 42.62%

Mini Dyna-METRIC's overall D029 forecast for WRSK Segment Three was more accurate than the forecasts for Segments One and Two, yet the model once again overestimated spares requirements. Fourteen spares had expected pipeline sizes greater than or equal to 1, but the Coronet Warrior exercise experienced zero demands for these line items. Four sample items had model predictions greater than exercise demands, with 2 of these items having large forecast errors of 9 units each. Eleven sample items had 1 demand during the last phase of the 30 day exercise, yet the model predicted no usage. Additionally, Mini Dyna-METRIC forecasted segment quantities for 6 line items that were short of actual exercise demands. For Segment Three, 83 percent of the WRSK forecast errors (29 of 35) were either plus or minus 1 unit, which led to a closer aggregate forecast of WRSK segment quantities.

Coronet Warrior Segmentation Results

The spares demand rates used in the four sets of Coronet Warrior model runs were adjusted on the basis of the actual WRSK failures experienced during the exercise. Once again, the confidence level parameter was not a significant factor in the model's computation of the expected pipeline size; therefore, the results for all four of the Coronet Warrior runs were identical when the "View LRU Data" output file menu item was queried. Table IX presents the results of the Coronet Warrior demand rates model run for Segment One, for the crucial initial wartime support period.

Table IX

Coronet Warrior Demand Rates
Segment One

	Mini Dyna-METRIC	Coronet Warrior
Line Items	35	36
Units	57	71

31 Forecast Errors

30 Correct Forecasts

ACCURACY - 30/61 = 49.18%

Mini Dyna-METRIC's Segment One forecast using the Coronet Warrior demand rates was more accurate (by 9 percent) than the D029 forecast for the initial WRSK segment. However, the model's accuracy rate was still below 50 percent; the aggregate spares requirement in WRSK units was underestimated for the crucial first phase of wartime operations. Ten sample items had at least 1 exercise demand, but the model did not predict these demands. Twelve line items had predicted segment quantities that varied from the actual Coronet Warrior demands, and for 10 of these items Mini Dyna-METRIC understated the initial spares requirements.

Conversely, 9 line items had no exercise demands, while the model predicted 1 demand for each item. Of the 31 forecast errors, 87 percent (27 of 31) were either over or short 1 unit, and the largest forecast error noted on any sample line item was a shortage of 3 units. Even though the accuracy rate is higher and the aggregate WRSK segment quantities are relatively close, 22 cannibalizations would be possibly required if WRSK Segment One was configured using these forecasts.

Table X lists the model's predictions for WRSK Segment Two, designed to support wartime days 11 through 21.

Table X

Coronet Warrior Demand Rates
Segment Two

	Mini Dyna-METRIC	Coronet Warrior
Line Items	24	30
Units	38	49

33 Forecast Errors

28 Correct Forecasts

ACCURACY - 28/61 = 45.90%

By using the Coronet Warrior demand rates, Mini Dyna-METRIC improved its forecast accuracy rate for Segment Two by over 13 percent, but forecast accuracy remained under 50 percent. Fifteen sample items had exercise demands of at least 1 unit which the model failed to predict. Nine line items had pipeline predictions that differed from Coronet

Warrior's demands, and 7 of these items were understated. Additionally, 9 sample VRSK items had no exercise demands, yet Mini Dyna-METRIC predicted demands. Of the model's 33 forecast errors, 75 percent were for 1 unit. Potential cannibalizations were 25 units, a moderate (25 vs 21) increase over the D029 Segment Two forecast.

Table XI depicts the results of the final Coronet Warrior VRSK Segment, which provides spares support for wartime days 22 through 30.

Table XI

Coronet Warrior Demand Rates
Segment Three

	Mini Dyna-METRIC	Coronet Warrior
Line Items	61	32
Units	72	46

35 Forecast Errors

26 Correct Forecasts

ACCURACY - 26/61 = 42.62 %

The accuracy rate for Mini Dyna-METRIC's forecast for Segment Three was identical for both sets of demand rates. Unlike the predictions for the two previous Coronet Warrior segments, the model overestimated the spares quantities for the final days of wartime operations. Twenty-nine sample items had no exercise demands, yet the model predicted at least 1 requirement for each of these items. Six of the sample VRSK items had quantity variances between the model's predictions and Coronet Warrior usage. The majority of Mini Dyna-METRIC's forecast errors for Segment Three were for 1 unit, with only 4 errors greater than or equal to 2 units. Additionally, the potential cannibalizations required totaled only 9 VRSK units, which was the lowest figure noted for any of the predicted segments.

Analysis

Research Question One. The first research question asked whether Mini Dyna-METRIC could be used to optimally segment War Readiness Spares Kits. Table XII summarizes the segmentation accuracy results achieved by the model.

Table XII

Mini Dyna-METRIC
VRSK Segmentation Accuracy

Demand Rates	VRSK Segment	Forecast Accuracy
D029	1	40.98%
CW	1	49.18%
D029	2	32.79%
CW	2	45.90%
D029	3	42.62%
CW	3	42.62%

When measured against the 80 percent accuracy criterion established in the research methodology, both the D029 and the Coronet Warrior demand ratas failed to predict the experimental VRSK segments adequately. The best forecast accuracy achieved was for the Coronet Warrior Segment One, with almost half the exercise demands predicted by Mini Dyna-METRIC. The Coronet Warrior rates also provided a 13 percent increase in accuracy for Segment Two, and equaled the D029 forecast for Segment Three. While the exercise adjusted demand rates did result in more accurate predictions, this result was not unexpected. The D029 demand rate is usually derived from the D041 Recoverable Consumption Item Requirements System, which provides a long term average of the worldwide demand for a particular spare (7:A20-2). In effect, the D029 rate "smoothes" the average demand rate over many operating locations and for some VRSK items, across different weapon system applications. However, a MAJCOM may provide any base level usage data during annual AFLC/MAJCOM VRSK Reviews to serve as a check or validation on the D041 demand rate, if the command feels the D041 rate is not a representative failure rate. When a MAJCOM elects to use other than the D041 failure rate, their own unique failure rate is normally applied by AFLC when computing WRSK requirements (12:14-41). A MAJCOM may provide their own failure rate for a particular item for several reasons, for example, different mission profiles or weather conditions.

The TAC Coronet Warrior exercise provided an example of this adjusted demand rate technique, because all sixty-one RR WRSK sample items used in this research had exercise failure rates that differed, in some cases significantly, from the worldwide D041 averages. When the Coronet Warrior demand rates were applied to compute a thirty day WRSK, Mini Dyna-METRIC was very capable of predicting the asset quantities required; the model predicted 167 units would fail when 166 units in fact were exercise failures. Conversely, the Mini Dyna-METRIC thirty day WRSK using D029 failure rates was only 24.6 percent accurate (fifteen of the forecasts were correct). However, the model's inability to accurately predict the point in time, for both sets of demand rates, when spares would fail is the most obvious deficiency when considering the WRSK segmentation problem.

One of the major Mini Dyna-METRIC model assumptions is that aircraft spares fail in a linear manner; in other words, the more flying activity, the more likely spares will fail and enter the pipeline. The expected pipeline size for all sixty-one sample WRSK items incrementaly increased from Day One through Day Thirty of the modeled WSMIS operational scenario. The pipeline size for each sample item increased at a higher rate during the first seven surge days and then increased at a less higher rate for the remaining twenty-three wartime days. Table XIII depicts an example of this linear failure pattern.

Table XIII

Expected Pipeline Size
Sample Item Number 40

DAY	PIPELINE	DAY	PIPELINE
1	0.2	16	2.6
2	0.5	17	2.7
3	0.7	18	2.8
4	0.9	19	2.9
5	1.1	20	3.0
6	1.4	21	3.1
7	1.6	22	3.2
8	1.7	23	3.3
9	1.8	24	3.4
10	1.9	25	3.5
11	2.0	26	3.6
12	2.1	27	3.8
13	2.2	28	3.9
14	2.3	29	4.0
15	2.5	30	4.1

As Table XIII portrays, the expected pipeline size increased by 0.2 to 0.3 units from Day 1 through Day 7, and then increased more slowly (0.1 to 0.2 units) during the remaining wartime days. Accordingly, using the stated research methodology, 1 spare was allocated to Segment One, 2 spares to Segment Two, and the final spare to the last Segment. However, the actual Coronet Warrior spares demand pattern was 3 units in the first 10 days, no usage for days 11 through 21, and 1 unit in the last 9 days of the exercise. This particular item had 1 failure on Day 6, 2 failures on Day 8, and 1 failure on Day 25.

This sample VRSK item was representative of all the sample items that had inaccurate Mini Dyna-METRIC forecasts; the model could not adequately predict the consumption patterns of VRSK spares during a realistic wartime exercise, even when the exercise failure rates were substituted in the model for the normal D029 failure rates. While the model could very accurately estimate the overall VRSK units required for the thirty day exercise, the actual failure patterns of the sample items were often irregular within that period. For example, 8 sample items experienced their Coronet Warrior demands in the last 9 days of the exercise, well after the initial sortie surge and the subsequent leveling of flying operations. Eleven sample items recorded all their failures between Days 11 and 21. Six sample items had "early and late" failure patterns, like Sample Item 50, which had 3 failures in the initial 10 days, no failures in the next 10 days, and 5 failures in the last 9 days.

While these failure patterns might only represent a random variation from a more linear average failure pattern, the inaccuracies noted in this research effort between Mini Dyna-METRIC's segmentation predictions and the Coronet Warrior experience does not provide a reasonable expectation of success when using the model for configuring VRSK segments. Additionally, the inability to change the spares failure linearity assumption within the Mini Dyna-METRIC model did not allow the opportunity to explore other variance to mean ratio alternatives, which could have provided additional VRSK segment forecasts for further evaluation. Moreover, the exercise only represented one sample data point of simulated wartime VRSK usage and as such, should be viewed as a starting point in examining VRSK usage patterns. Coronet Warrior should not be considered the only source of possible VRSK segmentation validation tools; the technique of segmentation holds the promise of substantial savings in wartime airlift requirements and lessened risk of exposing valuable resources to loss or damage. More empirical testing of this methodology, using other weapon systems and larger samples, is required before a conclusive decision can be reached about using Mini Dyna-METRIC or other computer models to recommend VRSK segments.

Consequently, Research Question One was not answered satisfactorily. Mini Dyna-METRIC failed to predict the experimental VRSK segments within the stated research accuracy criterion of 80 percent. The "non-linear" failure patterns of many of the research sample items during the Coronet Warrior exercise was the primary factor which caused the inaccurate VRSK segment forecasts.

Research Question Two. The second research question asked if, given that Mini Dyna-METRIC was a viable tool for segmenting War Readiness Spares Kits, could a base-level User's Guide be written to explain and apply this research methodology to the VRSK segmentation problem. This question was obviously contingent upon the successful validation of Research Question One. Since the results of the experimental model segment runs were not conclusive, this research question also cannot be answered satisfactorily.

Summary

The inability of Mini Dyna-METRIC to successfully segment War Readiness Spares Kits under the stated research methodology was demonstrated and portrayed through a tabular presentation of experimental results. The model predicted linear failure patterns for each sample VRSK item, under both sets of demand rates. However, the actual VRSK failures experienced during Coronet Warrior often did not follow this regular linear pattern. The research accuracy for the D029 rates were well below 50 percent, while the Coronet Warrior demand rates, although better estimates of VRSK failures than D029, also were below 50 percent accurate.

While Mini Dyna-METRIC was not successfully applied in this research effort, there are several future logistics developments which could be used to conduct follow-on research in this important supply support area. Chapter Five provides a detailed discussion of the overall research conclusions, as well as recommendations for future research.

V. SUMMARY, CONCLUSIONS, and RECOMMENDATIONS

Overview

This chapter will summarize the key elements of this research and present the overall conclusions by Research Question reached in the effort to optimally segment VRSKs using the Mini Dyna-METRIC model. Several recommendations for follow-on research will also be discussed, which should be pursued because of their applicability for further testing of automated VRSK segmentation on a larger scale for different aircraft weapon systems.

Summary of Research Effort

War Readiness Spares Kits provide key resources for a USAF combat unit in the crucial first thirty days of a conflict. However, the sheer size of many aircraft VRSKs, in terms of weight and volume, requires substantial airlift support, which will likely become a scarce commodity during a major conflict. Additionally, the time required to prepare and load a VRSK, as well as the potential for damage or loss of the VRSK assets during or after deployment, are high logistics risk factors. The technique of segmenting VRSKs into several smaller spares support packages, which can then be deployed incrementaly to the operating location, can help mitigate these risks.

This research was undertaken to test one of the VRSK issues identified in the Air Force Logistics Management Center's VRSK/BLSS/FOSK Master Plan. The AFLMC wanted to validate the use of the Mini Dyna-METRIC inventory model for VRSK segmentation and if successful, write a User's Guide for the base-level VRSK manager to apply the model for this task. The HQ TAC 1987 exercise, Coronet Warrior, was used as the "real world" VRSK usage data to validate the results of the model's segmentation predictions.

Mini Dyna-METRIC was employed to allocate a sample VRSK of sixty-one F-15 RR LRUs into three experimental segments, which would be used to support wartime days One through Ten, Eleven through Twenty-one, and Twenty-two through Thirty, respectively. The VRSK sample was configured to model a RR VRSK, consisting of 61 LRUs, with no base level repair at the wartime location and which also would not receive any resupply stock during the first thirty days of operations. The generic F-15 VSMIS wartime operational scenario (unclassified) was used to simulate the wartime sortie commitment. The key parameter used to estimate the quantities in each VRSK segment was the expected pipeline size of each sample item at the end of ten, twenty-one and thirty days. The expected pipeline size represents the model's forecast of the number of failures for each asset at that point in time, which then can be used to estimate the amount of VRSK spares required for each segment. The model was executed using two sets of spares demand rates, the D029 worldwide average rate, and the adjusted spares demand rates resulting from the Coronet Warrior exercise. Eight model segmentation runs were attempted, with each set of demand rates run in the model's Requirements Calculation mode at four different statistical confidence levels. The results of the model segmentation runs were then allocated into the three segments and compared to the actual VRSK usage during the Coronet Warrior exercise, which had also been allocated into the experimental segments. The criterion for accuracy was a simple rate formula: correct forecasts divided by the number of forecasts. A correct Mini Dyna-METRIC forecast for each sample spare was made when the model predicted the quantity of stock required by segment that matched the actual usage experienced during the same Coronet Warrior segment. An accuracy rate of 80 percent or higher for each segment was determined to be the basis for a successful application of the model for VRSK segmentation; this level of accuracy would provide the capability of satisfying four out of five VRSK demands during the support period and would also minimize the impact of having to cannibalize spares to maintain aircraft readiness.

Conclusions

Research Question One. The validation results of this research showed that Mini Dyna-METRIC was unable to optimally predict the three VRSK segments within the stated accuracy criterion. The D029 demand rates were well below 50 percent accurate in estimating the VRSK segments, while the Coronet Warrior demand rates, while slightly more accurate, were still below 50 percent accurate. The model assumes that spares failures will vary only on the basis of flying hours. This assumption was illustrated by the faster rate of increase for the pipeline size of each sample item during the first seven day sortie surge of the modeled WSMIS scenario. The rate of pipeline size increase for the next twent-three days of relatively stable flying was about half that of the initial surge. Since approximately 46 percent of the scenario flying hours were accomplished in the first seven days, the model computes each spare's pipeline size to account for that rate of flying. This effect is often called the "linearity" assumption of the model.

However, when the model's segmentation results were compared against the Coronet Warrior "real world" results, this linearity assumption was frequently violated. The spares failure patterns of twenty-five of the sixty-one sample spares had failure patterns that were obviously non-linear in nature, which was the strongest contributing factor to the the model's inaccurate VRSK segment forecasts.

Thus, Research Question One was not answered conclusively. An accuracy rate of below 50 percent, even when the most recent F-15 spares failure data from Coronet Warrior was employed in Mini Dyna-METRIC, led to the conclusion the model could not optimally segment the sample VRSK for the critical wartime sustainability mission. However, the small size of the sample VRSK, the fact that Coronet Warrior VRSK failure data is only one data point, and the limited representation of avionics spares within the sample are factors that might conceivably bias these results. This research is not conclusive evidence that automated VRSK segmentation using computer modeling techniques is not a viable logistics tool. Future research, using larger samples and more capable versions of Dyna-METRIC, should be continued in this important wartime supply support area.

Research Question Two. In order to answer this research question, a conclusive answer to the first research question was required. While not successful in the attempt to segment the sample VRSK accurately, the use of Mini Dyna-METRIC in terms of the data required for this research was very easy. The majority of the required supply data is available to base-level managers; the only element not readily available is the demands per flying hour data element, which could be supplied by the MAJCOM. The operational scenario the VRSK is designed to support could be supplied by the local Logistics Plans Office or the MAJCOM. Using a small computer to perform this task is not above the capability of a reasonably experienced supply technician. The advent of the small computer as a day to day tool in the Base Supply environment should be viewed as an advantage because any potential VRSK Segmentation User's Guide will likely be used by technicians and managers with a working knowledge of computers. This experience should help because the Guide can then concentrate on VRSK segmentation procedures and not on basic computer skills.

Recommendations

The Tactical Air Command is continuing to pursue the validation of the Dyna-METRIC model as a VRSK requirements and capability assessment tool. Coronet Warrior II was conducted from 10 May through 8 June 1988. This exercise tested the wartime capability of one F-16 squadron of twenty-four aircraft at Shaw AFB, South Carolina. The F-16s employed in Coronet Warrior II were supported by a RR VRSK. TAC is also expected to field an A-10 VRSK exercise, tentatively titled Coronet Warrior III, in early 1989. The A-10 weapon system also uses the RR VRSK concept. Additionally, the Strategic Air Command has scheduled a wartime deployment exercise, Bull Rider, in August 1988. This operational test will use seven B-52s and a RR VRSK at a simulated bare base location (25).

These exercises should yield a valuable source of VRSK usage data under simulated wartime conditions for three frontline weapon systems. Mini Dyna-METRIC could be used under the same experimental design developed in this research or other alternative designs with much bigger sample WRSKs in an effort to optimally segment VRSKs. The preliminary results achieved in this research are not conclusive evidence that automated VRSK segmentation is infeasible; similar research using these exercises as validation tools should yield much higher confidence in any WRSK segmentation results because a larger and more representative sample from a "pure" RR VRSK would be available. Both HQ AFLC/MM and HQ AFLC/XR are actively involved in the planning, data collection and analysis of these important logistics exercises. The VRSK data and failure rates should be easily obtainable by any potential researcher.

Another important breakthrough in logistics modeling is the recent release of Dyna-METRIC Version 4. This expanded version is designed to model worldwide logistics support, with such enhancements as multiple depots, a new level of indenture below SRUs, multiple aircraft types, and the capability to constrain the component repair process. Another important enhancement is the ability to vary the demand process, with the capability to model either time-varying demands or a sortie/flying hour based demand rate (24:2-3).

A small computer version of Dyna-METRIC Version 4, called the Dyna-METRIC (4.4) Microcomputer Analysis System (DMAS), is under development and is currently being released in increments to selected Air Force users. DMAS uses the enhance capabilities of Version 4 through a modeling range of a single base with two or more CIRFs and depots. A DMAS run can support thirty wartime days and is designed primarily to provide a unit-level tool for exception reporting relative to the formal VSMIS VRSK sustainability rating system. DMAS can also be used to compute exercise kit requirements and other base level analyses of logistics capability. Like Mini Dyna-METRIC, DMAS is menu-driven program, but it will be much more flexible for the base level user. For example, supply data can be down-loaded from the Standard Base Supply computer on disk and up-loaded to DMAS. This alleviates the need to create and edit the large parts files that Mini Dyna-METRIC requires (16:3-6,16).

When the DMAS model is released Air Force wide, the Air Force Logistics Management Center should consider developing a DMAS User's Guide. The Mini Dyna-METRIC User's Guide could be adapted for DMAS, since many of the logistics concepts and supply data elements are similar between the two models. Additionally, the AFLMC could change their automated WRSK segmentation project to use the DMAS model. This would increase the project's scope from strictly RR WRSKs to all Air Force WRSKs. The constrained repair capability feature in DMAS will allow the use of RRR WRSKs as potential samples for future segmentation research, with the F-15 WRSK data from Coronet Warrior an obvious first source.

The issue of linear spares failure patterns is an ongoing concern in the Air Force logistics community. For example, HQ AFLC/MM is currently working on an Analysis of Real-War Data, using both Southeast Asia and Israeli data, to attempt to gain insight into the differences between peacetime and wartime demand rates (8:39-40). The results of this analysis should help define some relationships between the stress of wartime operations and spares failure rates. This thesis has shown that the assumed linear relationship between flying hours and demands of Mini Dyna-METRIC is not always true for some spares over short time intervals. While Dyna-METRIC Version 4 retains this relationship, the opportunity to model alternative variance to mean ratios (VTMR), which will change the expected pipeline size for a component, is available. Selected spares within a given WRSK may have a demand distribution other than Poisson. With the DMAS model, these spares could be independently evaluated under different VTMRs, compared against actual WRSK usage data, and alternative segment predictions made. The advent of DMAS should allow future research to focus on testing different VTMR alternatives for WRSK segmentation predictions. However, the Dyna-METRIC Version 4 RAND Report still cautions that the mean removal rate for aircraft components, and the variation about that mean, change over time and are difficult to predict. RAND is also developing prototype models that more adequately represent the uncertainty of component demand, which are expected to be incorporated into future Dyna-METRIC versions (24:2).

Final Comments

The results of this thesis should not be considered conclusive evidence that automated VRSK segmentation is a risky and uncertain procedure. A wealth of VRSK usage data under simulated wartime conditions for several aircraft weapon systems will be available by mid 1989; further empirical testing of this research design or suitable alternative designs should be actively pursued because of the large potential reduction in wartime logistics risk. Finally, senior Air Force leaders should not overlook the fact that any computer model's VRSK segment predictions are only forecasts of expected wartime conditions; the human factors of knowledge and experience gained from years of working on aircraft weapon systems should be strongly considered as inputs when planning for the segmentation of War Readiness Spares Kits.

APPENDIX A: ACRONYM DEFINITIONS

AFLC - Air Force Logistics Command
AFLMC - Air Force Logistics Management Center

BLSS - Base Level Self-Sufficiency Spares
BRT - Base Repair Time

CIRF - Central Integrated Repair Facility

DPFH - Demands per Flying Hour

FMC - Fully Mission Capable
FOSK - Follow-on Spares Kit

LRU - Line Replacement Unit

MAJCOM - Major Command
MESL - Minimum Essential Subsystem List
MSK - Mission Support Kit

NMC - Not Mission Capable
NMCS - Not Mission Capable Supply

OST - Order and Ship Time
OWRM - Other War Reserve Materiel

PBR - Percentage of Base Repair
PMC - Partially Mission Capable
POL - Petroleum, Oils, and Lubricants

QPA - Quantity per Application

RR - Remove and Replace
RRR - Remove, Repair, and Replace

SM - System Manager
SRU - Shop Replacement Unit

TAC - Tactical Air Command

VTMR - Variance to Mean Ratio

WMP - War Mobilization Plan
WSMIS - Weapon System Management Information System
WRM - War Reserve Materiel
WRSK - War Readiness Spares Kit

APPENDIX B: RESEARCH SAMPLE DATABASE IN NSN SEQUENCE

LRU	STOCK NUMBER	CV ACTUAL DEMANDS	AUTHORIZED VRSK QTY
1	1560 01 056 4844	1	1
2	1560 01 075 3550	1	5
3	1560 01 142 6673	1	2
4	1650 00 288 6044	3	11
5	1650 00 371 5854	1	8
6	1650 01 018 1073	2	2
7	1650 01 018 9089	3	3
8	1650 01 050 3491	1	1
9	1650 01 052 4890	1	1
10	1650 01 065 3500	7	7
11	1650 01 065 7768	5	5
12	1650 01 091 2313	1	2
13	1650 01 096 4603	2	9
14	1650 01 112 5786	3	2
15	1650 01 173 9697	3	4
16	1650 01 119 8269	2	8
17	1660 00 123 9587	2	6
18	1660 00 273 8669	1	2
19	1660 00 327 7052	2	2
20	1660 00 367 9453	1	2
21	1660 00 567 8852	6	9
22	1660 01 021 4822	1	6

LRU	STOCK NUMBER	CW ACTUAL DEMANDS	AUTHORIZED WRSK QTY
23	1660 01 021 5625	1	4
24	1660 01 035 9636	5	5
25	1680 01 065 2355	1	5
26	1680 01 118 5195	6	5
27	2835 01 020 7249	3	3
28	2835 01 034 6948	1	8
29	2835 01 091 2433	5	6
30	2840 01 102 8596	2	4
31	2840 01 128 8437	1	11
32	2840 01 143 3254	19	91
33	2840 01 155 9148	2	59
34	2840 01 118 2941	7	38
35	2915 00 537 0336	1	2
36	2915 01 009 7932	3	5
37	2915 01 035 0276	2	6
38	2915 01 035 3771	3	4
39	2915 01 137 6551	1	3
40	2915 01 180 0246	4	7
41	2925 01 022 8332	2	4
42	2925 01 118 2149	4	7
43	2995 01 099 5028	1	2
44	4820 00 305 0289	4	5
45	4820 01 152 6285	1	3
46	5865 01 086 1000	2	6

LRU	STOCK NUMBER	CV ACTUAL DEMANDS	AUTHORIZED WRSK QTY
47	5865 01 086 1001	5	7
48	5865 01 086 1002	1	2
49	5895 00 340 9619	1	4
50	5985 01 030 4159	8	23
51	6115 00 469 0710	3	9
52	6340 01 077 2900	1	5
53	6605 00 314 2536	1	5
54	6610 00 134 2260	3	4
55	6610 00 296 3574	3	3
56	6610 00 329 3495	3	4
57	6610 01 093 3356	1	3
58	6615 01 149 7475	1	2
59	6620 01 034 4539	1	32
60	6645 00 076 3050	2	4
61	6680 01 068 4284	1	5

APPENDIX C: RESEARCH SAMPLE DATABASE DEMAND RATES

LRU	STOCK NUMBER	EXERCISE DEMAND RATE	D029 DEMAND RATE
1	1560 01 056 4844	.00057	.00044
2	1560 01 075 3550	.00057	.00125
3	1560 01 142 6673	.00029	.00018
4	1650 00 288 6044	.00043	.00092
5	1650 00 371 5854	.00014	.00042
6	1650 01 018 1073	.00057	.00019
7	1650 01 018 9089	.00171	.00104
8	1650 01 050 3491	.00057	.00032
9	1650 01 052 4890	.00029	.00007
10	1650 01 065 3500	.00200	.00111
11	1650 01 065 7768	.00143	.00128
12	1650 01 091 2313	.00029	.00030
13	1650 01 096 4603	.00057	.00193
14	1650 01 112 5786	.00086	.00028
15	1650 01 173 9697	.00171	.00203
16	1650 01 119 8269	.00057	.00222
17	1660 00 123 9587	.00057	.00065
18	1660 00 273 8669	.00029	.00053
19	1660 00 327 7052	.00114	.00058
20	1660 00 367 9453	.00057	.00019
21	1660 00 567 8852	.00343	.00268
22	1660 01 021 4822	.00029	.00093

LRU	STOCK NUMBER	EXERCISE DEMAND RATE	D029 DEMAND RATE
23	1660 01 021 5625	.00057	.00085
24	1660 01 035 9636	.00286	.00209
25	1680 01 065 2355	.00019	.00027
26	1680 01 118 5195	.00343	.00269
27	2835 01 020 7249	.00171	.00144
28	2835 01 034 6948	.00057	.00364
29	2835 01 091 2433	.00286	.00293
30	2840 01 102 8596	.00057	.00052
31	2840 01 128 8437	.00029	.00217
32	2840 01 143 3254	.00036	.00122
33	2840 01 155 9148	.00004	.00077
34	2840 01 118 2941	.00013	.00041
35	2915 00 537 0336	.00029	.00014
36	2915 01 009 7932	.00171	.00094
37	2915 01 035 0276	.00057	.00154
38	2915 01 035 3771	.00086	.00027
39	2915 01 137 6551	.00057	.00073
40	2915 01 180 0246	.00114	.00200
41	2925 01 022 8332	.00057	.00049
42	2925 01 118 2149	.00114	.00129
43	2995 01 099 5028	.00029	.00031
44	4820 00 305 0289	.00229	.00085
45	4820 01 152 6285	.00057	.00035
46	5865 01 086 1000	.00114	.00140

LRU	STOCK NUMBER	EXERCISE DEMAND RATE	D029 DEMAND RATE
47	5865 01 086 1001	.00286	.00269
48	5865 01 086 1002	.00057	.00035
49	5895 00 340 9619	.00057	.00105
50	5985 01 030 4159	.00229	.00439
51	6115 00 469 0710	.00086	.00193
52	6340 01 077 2900	.00029	.00059
53	6605 00 314 2536	.00057	.00114
54	6610 00 134 2260	.00171	.00101
55	6610 00 296 3574	.00171	.00053
56	6610 00 329 3495	.00171	.00081
57	6610 01 093 3356	.00057	.00054
58	6615 01 149 7475	.00057	.00069
59	6620 01 034 4539	.00029	.00750
60	6645 00 076 3050	.00114	.00097
61	6680 01 068 4284	.00057	.00095

APPENDIX D: MINI DYNA-METRIC PARTS INPUT FILE WITH D029 DEMAND RATES

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1.  1560 01 056 4844  DPFH = 0.00044  QPA = 1  COST = 49423
      PEACE  PBR = 0.000   BRT = 5.00  OST = 99.00  STK = 0
          1  PBR = 0.000   BRT = -1.0  OST = -1.00  STK = 0

2.  1560 01 075 3550  DPFH = 0.00125  QPA = 1  COST =  2905
      PEACE  PBR = 0.000   BRT = 2.00  OST = 99.00  STK = 0
          1  PBR = 0.000   BRT = -1.0  OST = -1.00  STK = 0

3.  1560 01 142 6673  DPFH = 0.00018  QPA = 2  COST = 17792
      PEACE  PBR = 0.000   BRT = 5.00  OST = 99.00  STK = 0
          1  PBR = 0.000   BRT = -1.0  OST = -1.00  STK = 0

4.  1650 00 288 6044  DPFH = 0.00092  QPA = 4  COST =  7916
      PEACE  PBR = 0.000   BRT = 6.00  OST = 99.00  STK = 0
          1  PBR = 0.000   BRT = -1.0  OST = -1.00  STK = 0

5.  1650 00 371 5854  DPFH = 0.00042  QPA = 4  COST =  1545
      PEACE  PBR = 0.000   BRT = 6.00  OST = 99.00  STK = 0
          1  PBR = 0.000   BRT = -1.0  OST = -1.00  STK = 0

6.  1650 01 018 1073  DPFH = 0.00019  QPA = 2  COST =  4973
      PEACE  PBR = 0.000   BRT = 5.00  OST = 99.00  STK = 0
          1  PBR = 0.000   BRT = -1.0  OST = -1.00  STK = 0

7.  1650 01 018 9089  DPFH = 0.00104  QPA = 1  COST = 13907
      PEACE  PBR = 0.000   BRT = 6.00  OST = 99.00  STK = 0
          1  PBR = 0.000   BRT = -1.0  OST = -1.00  STK = 0

8.  1650 01 050 3491  DPFH = 0.00032  QPA = 1  COST = 57185
      PEACE  PBR = 0.000   BRT = 6.00  OST = 99.00  STK = 0
          1  PBR = 0.000   BRT = -1.0  OST = -1.00  STK = 0

9.  1650 01 052 4890  DPFH = 0.00007  QPA = 2  COST =  4944
      PEACE  PBR = 0.000   BRT = 6.00  OST = 99.00  STK = 0
          1  PBR = 0.000   BRT = -1.0  OST = -1.00  STK = 0

10. 1650 01 065 3500  DPFH = 0.00111  QPA = 2  COST =  3835
      PEACE  PBR = 0.000   BRT = 2.00  OST = 99.00  STK = 0
          1  PBR = 0.000   BRT = -1.0  OST = -1.00  STK = 0

11. 1650 01 065 7768  DPFH = 0.00128  QPA = 2  COST = 24875
      PEACE  PBR = 0.000   BRT = 6.00  OST = 99.00  STK = 0
          1  PBR = 0.000   BRT = -1.0  OST = -1.00  STK = 0
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12. 1650 01 091 2313  DPFH = 0.00030  QPA = 2  COST = 11124
       PEACE  PBR = 0.000  BRT = 3.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

13. 1650 01 096 4603  DPFH = 0.00193  QPA = 2  COST = 44678
       PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

14. 1650 01 121 5786  DPFH = 0.00028  QPA = 2  COST = 10758
       PEACE  PBR = 0.000  BRT = 5.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

15. 1650 01 173 9697  DPFH = 0.00203  QPA = 1  COST= 158593
       PEACE  PBR = 0.000  BRT = 5.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

16. 1650 01 190 8269  DPFH = 0.00222  QPA = 2  COST = 40296
       PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

17. 1660 00 123 9587  DPFH = 0.00065  QPA = 2  COST =  1752
       PEACE  PBR = 0.000  BRT = 4.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

18. 1660 00 273 8669  DPFH = 0.00053  QPA = 2  COST = 15965
       PEACE  PBR = 0.000  BRT = 3.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

19. 1660 00 327 7052  DPFH = 0.00058  QPA = 1  COST =  5651
       PEACE  PBR = 0.000  BRT = 5.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

20. 1660 00 367 9453  DPFH = 0.00019  QPA = 1  COST =   839
       PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

21. 1660 00 567 8852  DPFH = 0.00268  QPA = 1  COST =  1952
       PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

22. 1660 01 021 4822  DPFH = 0.00093  QPA = 2  COST =  4668
       PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

23. 1660 01 021 5625  DPFH = 0.00085  QPA = 1  COST =  2408
       PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

24. 1660 01 035 9636  DPFH = 0.00209  QPA = [illegible]  COST = 22866
       PEACE  PBR = 0.000  BRT = 6.00  OST [illegible]  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST [illegible]  STK = 0
```

```
25. 1680 01 065 2355  DPFH = 0.00027  QPA = 3  COST =  1828
     PEACE  PBR = 0.000  BRT = 5.00   OST = 99.00  STK = 0
         1  PBR = 0.000  BRT = -1.0   OST = -1.00  STK = 0

26. 1680 01 118 5195  DPFH = 0.00269  QPA = 1  COST =  1077
     PEACE  PBR = 0.000  BRT = 6.00   OST = 99.00  STK = 0
         1  PBR = 0.000  BRT = -1.0   OST = -1.00  STK = 0

27. 2835 01 020 7249  DPFH = 0.00144  QPA = 1  COST = 38110
     PEACE  PBR = 0.000  BRT = 6.00   OST = 99.00  STK = 0
         1  PBR = 0.000  BRT = -1.0   OST = -1.00  STK = 0

28. 2835 01 034 6948  DPFH = 0.00364  QPA = 1  COST = 60309
     PEACE  PBR = 0.000  BRT = 6.00   OST = 99.00  STK = 0
         1  PBR = 0.000  BRT = -1.0   OST = -1.00  STK = 0

29. 2835 01 091 2433  DPFH = 0.00293  QPA = 1  COST= 102205
     PEACE  PBR = 0.000  BRT = 6.00   OST = 99.00  STK = 0
         1  PBR = 0.000  BRT = -1.0   OST = -1.00  STK = 0

30. 2840 01 102 8596  DPFH = 0.00052  QPA = 2  COST =  4917
     PEACE  PBR = 0.000  BRT = 6.00   OST = 99.00  STK = 0
         1  PBR = 0.000  BRT = -1.0   OST = -1.00  STK = 0

31. 2840 01 128 8437  DPFH = 0.00217  QPA = 2  COST =  5843
     PEACE  PBR = 0.000  BRT = 5.00   OST = 99.00  STK = 0
         1  PBR = 0.000  BRT = -1.0   OST = -1.00  STK = 0

32. 2840 01 143 3254  DPFH = 0.00122  QPA = 30 COST =   381
     PEACE  PBR = 0.000  BRT = 6.00   OST = 99.00  STK = 0
         1  PBR = 0.000  BRT = -1.0   OST = -1.00  STK = 0

33. 2840 01 155 9148  DPFH = 0.00077  QPA = 30 COST =  1571
     PEACE  PBR = 0.000  BRT = 6.00   OST = 99.00  STK = 0
         1  PBR = 0.000  BRT = -1.0   OST = -1.00  STK = 0

34. 2840 01 180 2941  DPFH = 0.00041  QPA = 30 COST =   421
     PEACE  PBR = 0.000  BRT = 6.00   OST = 99.00  STK = 0
         1  PBR = 0.000  BRT = -1.0   OST = -1.00  STK = 0

35. 2915 00 537 0336  DPFH = 0.00014  QPA = 2  COST =  4634
     PEACE  PBR = 0.000  BRT = 6.00   OST = 99.00  STK = 0
         1  PBR = 0.000  BRT = -1.0   OST = -1.00  STK = 0

36. 2915 01 009 7932  DPFH = 0.00094  QPA = 1  COST =   533
     PEACE  PBR = 0.000  BRT = 6.00   OST = 99.00  STK = 0
         1  PBR = 0.000  BRT = -1.0   OST = -1.00  STK = 0

37. 2915 01 035 0276  DPFH = 0.00154  QPA = 2  COST = 17187
     PEACE  PBR = 0.000  BRT = 6.00   OST = 99.00  STK = 0
         1  PBR = 0.000  BRT = -1.0   OST = -1.00  STK = 0
```

```
38. 2915 01 035 3771  DPFH = 0.00027  QPA = 2  COST =  1694
      PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
          1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

39. 2915 01 137 6551  DPFH = 0.00073  QPA = 1  COST =  7195
      PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
          1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

40. 2915 01 180 0246  DPFH = 0.00200  QPA = 2  COST = 32909
      PEACE  PBR = 0.000  BRT = 5.00  OST = 99.00  STK = 0
          1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

41. 2925 01 022 8332  DPFH = 0.00049  QPA = 2  COST =  3143
      PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
          1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

42. 2925 01 180 2149  DPFH = 0.00129  QPA = 2  COST =  8909
      PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
          1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

43. 2995 01 099 5028  DPFH = 0.00031  QPA = 2  COST =  7727
      PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
          1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

44. 4820 00 305 0289  DPFH = 0.00085  QPA = 1  COST =   474
      PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
          1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

45. 4820 01 152 6285  DPFH = 0.00035  QPA = 1  COST =  1144
      PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
          1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

46. 5865 01 086 1000  DPFH = 0.00140  QPA = 1  COST =  1907
      PEACE  PBR = 0.000  BRT = 5.00  OST = 99.00  STK = 0
          1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

47. 5865 01 086 1001  DPFH = 0.00269  QPA = 1  COST =  2601
      PEACE  PBR = 0.000  BRT = 4.00  OST = 99.00  STK = 0
          1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

48. 5865 01 086 1002  DPFH = 0.00035  QPA = 1  COST =  2138
      PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
          1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

49. 5895 00 340 9619  DPFH = 0.00105  QPA = 1  COST =  4198
      PEACE  PBR = 0.000  BRT = 4.00  OST = 99.00  STK = 0
          1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

50. 5985 01 030 4159  DPFH = 0.00439  QPA = 2  COST =  2620
      PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
          1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0
```

```
51. 6115 00 469 0710  DPFH = 0.00193  QPA = 2  COST = 12822
         PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
             1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

52. 6340 01 077 2900  DPFH = 0.00059  QPA = 2  COST =  3649
         PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
             1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

53. 6605 00 314 2536  DPFH = 0.00114  QPA = 1  COST =  2013
         PEACE  PBR = 0.000  BRT = 3.00  OST = 99.00  STK = 0
             1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

54. 6610 00 134 2260  DPFH = 0.00101  QPA = 1  COST =  4307
         PEACE  PBR = 0.000  BRT = 3.00  OST = 99.00  STK = 0
             1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

55. 6610 00 296 3574  DPFH = 0.00053  QPA = 1  COST =   939
         PEACE  PBR = 0.000  BRT = 5.00  OST = 99.00  STK = 0
             1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

56. 6610 00 329 3495  DPFH = 0.00081  QPA = 1  COST =  1214
         PEACE  PBR = 0.000  BRT = 3.00  OST = 99.00  STK = 0
             1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

57. 6610 01 093 3356  DPFH = 0.00054  QPA = 1  COST =  3399
         PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
             1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

58. 6615 01 149 7475  DPFH = 0.00069  QPA = 1  COST = 13596
         PEACE  PBR = 0.000  BRT = 2.00  OST = 99.00  STK = 0
             1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

59. 6620 01 034 4539  DPFH = 0.00750  QPA = 2  COST =  4041
         PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
             1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

60. 6645 00 076 3050  DPFH = 0.00097  QPA = 1  COST =   562
         PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
             1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

61. 6680 01 068 4284  DPFH = 0.00095  QPA = 1  COST =   855
         PEACE  PBR = 0.000  BRT = 4.00  OST = 99.00  STK = 0
             1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0
```

APPENDIX E: MINI DYNA-METRIC PARTS INPUT FILE WITH CORONET WARRIOR DEMAND RATES

```
1.  1560 01 056 4844  DPFH = 0.00057  QPA = 1  COST = 49423
       PEACE  PBR = 0.000  BRT = 5.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

2.  1560 01 075 3550  DPFH = 0.00057  QPA = 1  COST =  2905
       PEACE  PBR = 0.000  BRT = 2.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

3.  1560 01 142 6673  DPFH = 0.00029  QPA = 2  COST = 17792
       PEACE  PBR = 0.000  BRT = 5.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

4.  1650 00 288 6044  DPFH = 0.00043  QPA = 4  COST =  7916
       PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

5.  1650 00 371 5854  DPFH = 0.00014  QPA = 4  COST =  1545
       PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

6.  1650 01 018 1073  DPFH = 0.00057  QPA = 2  COST =  4973
       PEACE  PBR = 0.000  BRT = 5.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

7.  1650 01 018 9089  DPFH = 0.00171  QPA = 1  COST = 13907
       PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

8.  1650 01 050 3491  DPFH = 0.00057  QPA = 1  COST = 57185
       PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

9.  1650 01 052 4890  DPFH = 0.00029  QPA = 2  COST =  4944
       PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

10. 1650 01 065 3500  DPFH = 0.00200  QPA = 2  COST =  3835
       PEACE  PBR = 0.000  BRT = 2.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

11. 1650 01 065 7768  DPFH = 0.00143  QPA = 2  COST = 24875
       PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0
```

```
12. 1650 01 091 2313  DPFH = 0.00029  QPA = 2  COST = 11124
        PEACE  PBR = 0.000  BRT = 3.00  OST = 99.00  STK = 0
            1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

13. 1650 01 096 4603  DPFH = 0.00057  QPA = 2  COST = 44678
        PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
            1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

14. 1650 01 121 5786  DPFH = 0.00086  QPA = 2  COST = 10758
        PEACE  PBR = 0.000  BRT = 5.00  OST = 99.00  STK = 0
            1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

15. 1650 01 173 9697  DPFH = 0.00171  QPA = 1  COST= 158593
        PEACE  PBR = 0.000  BRT = 5.00  OST = 99.00  STK = 0
            1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

16. 1650 01 190 8269  DPFH = 0.00057  QPA = 2  COST = 40296
        PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
            1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

17. 1660 00 123 9587  DPFH = 0.00057  QPA = 2  COST =  1752
        PEACE  PBR = 0.000  BRT = 4.00  OST = 99.00  STK = 0
            1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

18. 1660 00 273 8669  DPFH = 0.00029  QPA = 2  COST = 15965
        PEACE  PBR = 0.000  BRT = 3.00  OST = 99.00  STK = 0
            1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

19. 1660 00 327 7052  DPFH = 0.00114  QPA = 1  COST =  5651
        PEACE  PBR = 0.000  BRT = 5.00  OST = 99.00  STK = 0
            1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

20. 1660 00 367 9453  DPFH = 0.00057  QPA = 1  COST =   839
        PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
            1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

21. 1660 00 567 8852  DPFH = 0.00343  QPA = 1  COST =  1952
        PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
            1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

22. 1660 01 021 4822  DPFH = 0.00029  QPA = 2  COST =  4668
        PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
            1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

23. 1660 01 021 5625  DPFH = 0.00057  QPA = 1  COST =  2408
        PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
            1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

24. 1660 01 035 9636  DPFH = 0.00286  QPA = 1  COST = 22866
        PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
            1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0
```

```
25. 1680 01 065 2355  DPFH = 0.00019  QPA = 3  COST =  1828
       PEACE  PBR = 0.000  BRT = 5.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

26. 1680 01 118 5195  DPFH = 0.00343  QPA = 1  COST =  1077
       PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

27. 2835 01 020 7249  DPFH = 0.00171  QPA = 1  COST = 38110
       PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

28. 2835 01 034 6948  DPFH = 0.00057  QPA = 1  COST = 60309
       PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

29. 2835 01 091 2433  DPFH = 0.00286  QPA = 1  COST= 102205
       PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

30. 2840 01 102 8596  DPFH = 0.00057  QPA = 2  COST =  4917
       PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

31. 2840 01 128 8437  DPFH = 0.00029  QPA = 2  COST =  5843
       PEACE  PBR = 0.000  BRT = 5.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

32. 2840 01 143 3254  DPFH = 0.00036  QPA = 30 COST =   381
       PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

33. 2840 01 155 9148  DPFH = 0.00004  QPA = 30 COST =  1571
       PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

34. 2840 01 160 2941  DPFH = 0.00013  QPA = 30 COST =   421
       PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

35. 2915 00 537 0336  DPFH = 0.00029  QPA = 2  COST =  4634
       PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

36. 2915 01 009 7932  DPFH = 0.00171  QPA = 1  COST =   533
       PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

37. 2915 01 035 0276  DPFH = 0.00057  QPA = 2  COST = 17187
       PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
           1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0
```

```
38. 2915 01 035 3771  DPFH = 0.00086  QPA = 2  COST =  1694
     PEACE  PBR = 0.000  BRT = 6.00   OST = 99.00  STK = 0
         1  PBR = 0.000  BRT = -1.0   OST = -1.00  STK = 0

39. 2915 01 137 6551  DPFH = 0.00057  QPA = 1  COST =  7195
     PEACE  PBR = 0.000  BRT = 6.00   OST = 99.00  STK = 0
         1  PBR = 0.000  BRT = -1.0   OST = -1.00  STK = 0

40. 2915 01 180 0246  DPFH = 0.00114  QPA = 2  COST = 32909
     PEACE  PBR = 0.000  BRT = 5.00   OST = 99.00  STK = 0
         1  PBR = 0.000  BRT = -1.0   OST = -1.00  STK = 0

41. 2925 01 022 8332  DPFH = 0.00057  QPA = 2  COST =  3143
     PEACE  PBR = 0.000  BRT = 6.00   OST = 99.00  STK = 0
         1  PBR = 0.000  BRT = -1.0   OST = -1.00  STK = 0

42. 2925 01 180 2149  DPFH = 0.00114  QPA = 2  COST =  8909
     PEACE  PBR = 0.000  BRT = 6.00   OST = 99.00  STK = 0
         1  PBR = 0.000  BRT = -1.0   OST = -1.00  STK = 0

43. 2995 01 099 5028  DPFH = 0.00029  QPA = 2  COST =  7727
     PEACE  PBR = 0.000  BRT = 6.00   OST = 99.00  STK = 0
         1  PBR = 0.000  BRT = -1.0   OST = -1.00  STK = 0

44. 4820 00 305 0289  DPFH = 0.00229  QPA = 1  COST =   474
     PEACE  PBR = 0.000  BRT = 6.00   OST = 99.00  STK = 0
         1  PBR = 0.000  BRT = -1.0   OST = -1.00  STK = 0

45. 4820 01 152 6285  DPFH = 0.00057  QPA = 1  COST =  1144
     PEACE  PBR = 0.000  BRT = 6.00   OST = 99.00  STK = 0
         1  PBR = 0.000  BRT = -1.0   OST = -1.00  STK = 0

46. 5865 01 086 1000  DPFH = 0.00114  QPA = 1  COST =  1907
     PEACE  PBR = 0.000  BRT = 5.00   OST = 99.00  STK = 0
         1  PBR = 0.000  BRT = -1.0   OST = -1.00  STK = 0

47. 5865 01 086 1001  DPFH = 0.00286  QPA = 1  COST =  2601
     PEACE  PBR = 0.000  BRT = 4.00   OST = 99.00  STK = 0
         1  PBR = 0.000  BRT = -1.0   OST = -1.00  STK = 0

48. 5865 01 086 1002  DPFH = 0.00057  QPA = 1  COST =  2138
     PEACE  PBR = 0.000  BRT = 6.00   OST = 99.00  STK = 0
         1  PBR = 0.000  BRT = -1.0   OST = -1.00  STK = 0

49. 5895 00 340 9619  DPFH = 0.00057  QPA = 1  COST =  4198
     PEACE  PBR = 0.000  BRT = 4.00   OST = 99.00  STK = 0
         1  PBR = 0.000  BRT = -1.0   OST = -1.00  STK = 0

50. 5985 01 030 4159  DPFH = 0.00229  QPA = 2  COST =  2620
     PEACE  PBR = 0.000  BRT = 6.00   OST = 99.00  STK = 0
         1  PBR = 0.000  BRT = -1.0   OST = -1.00  STK = 0
```

```
51. 6115 00 469 0710  DPFH = 0.00086  QPA = 2  COST = 12822
          PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
              1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

52. 6340 01 077 2900  DPFH = 0.00029  QPA = 2  COST =  3649
          PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
              1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

53. 6605 00 314 2536  DPFH = 0.00057  QPA = 1  COST =  2013
          PEACE  PBR = 0.000  BRT = 3.00  OST = 99.00  STK = 0
              1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

54. 6610 00 134 2260  DPFH = 0.00171  QPA = 1  COST =  4307
          PEACE  PBR = 0.000  BRT = 3.00  OST = 99.00  STK = 0
              1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

55. 6610 00 296 3574  DPFH = 0.00171  QPA = 1  COST =   939
          PEACE  PBR = 0.000  BRT = 5.00  OST = 99.00  STK = 0
              1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

56. 6610 00 329 3495  DPFH = 0.00171  QPA = 1  COST =  1214
          PEACE  PBR = 0.000  BRT = 3.00  OST = 99.00  STK = 0
              1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

57. 6610 01 093 3356  DPFH = 0.00057  QPA = 1  COST =  3399
          PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
              1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

58. 6615 01 149 7475  DPFH = 0.00057  QPA = 1  COST = 13596
          PEACE  PBR = 0.000  BRT = 2.00  OST = 99.00  STK = 0
              1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

59. 6620 01 034 4539  DPFH = 0.00029  QPA = 2  COST =  4041
          PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
              1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

60. 6645 00 076 3050  DPFH = 0.00114  QPA = 1  COST =   562
          PEACE  PBR = 0.000  BRT = 6.00  OST = 99.00  STK = 0
              1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0

61. 6680 01 068 4284  DPFH = 0.00057  QPA = 1  COST =   855
          PEACE  PBR = 0.000  BRT = 4.00  OST = 99.00  STK = 0
              1  PBR = 0.000  BRT = -1.0  OST = -1.00  STK = 0
```

APPENDIX F: CORONET WARRIOR SPARES USAGE BY SEGMENTS

LRU	SEGMENT ONE	SEGMENT TWO	SEGMENT THREE	TOTAL
1	0	0	1	(1)
2	1	0	0	(1)
3	1	0	0	(1)
4	3	0	0	(3)
5	1	0	0	(1)
6	0	2	0	(2)
7	1	1	1	(3)
8	0	1	0	(1)
9	1	0	0	(1)
10	3	2	2	(7)
11	1	4	0	(5)
12	0	0	1	(1)
13	0	0	2	(2)
14	1	1	1	(3)
15	2	0	1	(3)
16	1	0	1	(2)
17	0	1	1	(2)
18	0	1	0	(1)
19	0	2	0	(2)
20	0	1	0	(1)
21	3	2	1	(6)
22	1	0	0	(1)

LRU	SEGMENT ONE	SEGMENT TWO	SEGMENT THREE	TOTAL
23	0	0	1	(1)
24	3	2	0	(5)
25	1	0	0	(1)
26	3	2	1	(6)
27	2	0	1	(3)
28	0	0	1	(1)
29	2	0	3	(5)
30	1	1	0	(2)
31	0	1	0	(1)
32	10	4	5	(19)
33	1	0	1	(2)
34	6	0	1	(7)
35	1	0	0	(1)
36	0	2	1	(3)
37	2	0	0	(2)
38	0	3	0	(3)
39	0	0	1	(1)
40	3	0	1	(4)
41	1	1	0	(2)
42	1	2	1	(4)
43	0	0	1	(1)
44	2	1	1	(4)
45	1	0	0	(1)
46	0	1	1	(2)
47	1	2	2	(5)

LRU	SEGMENT ONE	SEGMENT TWO	SEGMENT THREE	TOTAL
48	1	0	0	(1)
49	0	0	1	(1)
50	3	0	5	(8)
51	1	0	2	(3)
52	0	0	1	(1)
53	0	1	0	(1)
54	1	2	0	(3)
55	3	0	0	(3)
56	0	2	1	(3)
57	0	1	0	(1)
58	0	1	0	(1)
59	1	0	0	(1)
60	0	1	1	(2)
61	0	1	0	(1)

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VITA

Captain Robert C. DeGroot was born on 12 October 1954 in Summit, New Jersey. He graduated from Summit High School in 1972 and enlisted in the United States Air Force in January 1976. He served as an Inventory Management Specialist at Loring Air Force Base, Maine until August 1980. He received a Bachelor of Science degree in Business Management in May 1979 from Unity College in Unity, Maine. He entered Officers Training School in September 1980 and was commissioned in December 1980.

His initial assignment was at Plattsburgh Air Force Base, New York, where he served as the Maintenance Materiel Control Officer and as the Supply Materiel Management Officer. In January 1984, he was reassigned to Barter Island DEW Station, Alaska, where he served as the Alaskan Region Quality Assurance Evaluator. In January 1985, he was assigned to Headquarters, Eighth Air Force, Barksdale Air Force Base, Louisiana, where he was the Weapon System Support Division Chief and Chief of the Materiel and Operations Support Branch. He entered the School of Systems and Logistics, Air Force Institute of Technology, in May 1987.

Captain DeGroot is married to the former Joyce L. Moll of Summit, New Jersey. They have three daughters, Rebecca, Emily, and Sarah.

Permanent Address: 96 Orchard Street
Summit, New Jersey 07901

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School of Systems and Logistics
Air Force Institute of Technology (AU)
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ABSTRACT

The purpose of this research was to validate the feasibility of applying the Miniature Dyna-METRIC inventory model for segmenting War Readiness Spares Kits (WRSK). WRSK segmentation is a USAF policy designed to allocate WRSKs into smaller subsets; this technique reduces the initial airlift support requirement, and also minimizes potential loss or damage to critical wartime assets.

The study had two basic objectives: (1) Validate Miniature Dyna-METRIC's segmentation predictions against the results of the 1987 HQ Tactical Air Command F-15 WRSK exercise, Coronet Warrior. (2) Design a User's Guide for the base-level WRSK manager to apply automated WRSK segmentation. A sample WRSK of sixty-one F-15 spares and an unclassified operational scenario were used to calculate the quantities required for three experimental WRSK segments. Two sets of spares failure rates were applied, the D029 worldwide average and the adjusted Coronet Warrior failure rates. Mini Dyna-METRIC's predictions were then compared against the Coronet Warrior spares usage data.

Miniature Dyna-METRIC failed to segment the sample WRSK within the stated accuracy criterion of 80 percent for both sets of failure data. The key model assumption of spares failing in a regular, linear manner on the basis of flying hours was questionable since twenty-five spares had non-linear failure patterns during Coronet Warrior. Since the model could not optimally segment the sample WRSK, a User's Guide for applying the research methodology was not recommended.

Future research should concentrate on the Dyna-METRIC Microcomputer Analysis System (DMAS), an improved version of Miniature Dyna-METRIC; additionally, a number of upcoming WRSK exercises for other weapon systems should provide a wealth of spares usage data. More empirical testing, using larger WRSK samples and the DMAS model, is recommended before a conclusive decision can be made about the feasibility of automated WRSK segmentation.