AN ANALYSIS OF THE EFFECTS OF LEAN LOGISTICS ON THE CURRENT AIR FORCE REPARABLE PIPELINE: A SIMULATION STUDY

THESIS

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THESIS

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Tracey L. Hill
William N. Walker
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Abstract

This research investigates the effect of Lean Logistics proposals on the current Air Force reparables pipeline. First, Lean Logistics proposes reducing reparable asset levels stocked at operating bases and relocating many of these assets at an intermediate supply point located at the depot. Secondly, Lean Logistics proposes large reductions in asset transportation time between the bases and the depot. Finally, Lean Logistics proposes streamlining the depot repair process such that depot repair times are significantly reduced.

Computer simulation is used as a tool to perform a 3X3 full factorial experiment to determine the effect of asset levels, depot repair time, and transportation time on aircraft availability and transportation costs. Results indicate that neither the Lean Logistics nor current pipeline configuration is the optimal performer. However, results do indicate that Lean Logistics outperforms the current reparables pipeline in terms of aircraft availability and in terms of total cost of assets in the system vs. cost of transporting those assets through the system.
AN ANALYSIS OF THE EFFECTS OF LEAN LOGISTICS ON THE CURRENT AIR FORCE REPARABLE PIPELINE: A SIMULATION STUDY

I. INTRODUCTION

General Issue

Lean Logistics (LL) is a relatively new logistics concept developed to streamline reparable asset repair, asset stockage, and transportation segments of inventory management. Personnel at the Air Force Materiel Command (AFMC) have proposed this system as a response to budget cuts and force reductions in order to become more cost efficient and more mission effective. LL proposes consolidation of a large portion of the assets currently stocked at base level to an intermediate supply point that will manage such reparable assets for several bases. LL also proposes to greatly reduce transportation times, decreasing the overall length of the pipeline. Additionally, LL proposes to streamline the depot repair and remanufacturing function. Personnel at AFMC anticipate that the combined effects of these actions will lower overall inventory costs (HQ AFMC Slide Package, 1993). This research analysed the effects of applying LL concepts on fully mission capable aircraft and the costs associated with transporting and storing needed assets.
Background

There are many reasons that Air Force personnel are making such concerted efforts toward streamlining existing systems. The Soviet threat has had a major impact on United States (US) defense decision making for over four decades. The US continually prepared for both a nuclear attack and a short warning invasion of Western Europe that would leave little time for preparation. During this period, the defense strategy required large US combat forces to operate in forward locations at high states of combat readiness to confront a numerically superior enemy. With the collapse and disintegration of the Soviet Union and Warsaw Pact, the US is the only remaining super power. Even considering that the future political situation remains uncertain for the former Soviet Union and its allies, there are, in all likelihood, no new threats that can measure up to the old menace.

There are, however, plenty of other potential challenges to face. In the absence of Soviet control, there have been serious disagreements concerning the boundaries of the former Soviet republics and a resurgence of national and ethnic conflicts. The Middle East continues to be an area of turmoil. In Asia, tension exists between India, Pakistan and China. In Latin America, numerous conflicts threaten stability. Open conflict continues in Africa (Rich, 1991). To handle these challenges, the overall strategy has shifted
toward smaller US force levels both at home and overseas with lower operating tempos. The US is structuring its forces to have the ability to win two simultaneous regional conflicts (Nunn, 1992).

Coincident with the end of the cold war, this nation faces unprecedented national debt and massive annual deficits that demand a comprehensive solution. Taking advantage of the opportunities afforded by the diminished superpower rivalry, part of this comprehensive solution has been to pursue reductions in the defense budget. To this end, the Secretary of Defense has initiated a bottom-up defense review to transition the military services to a leaner force structure for post cold war challenges (HQ AFMC Slide Package, 1993).

The Department of Defense (DoD) is currently undergoing an extensive drawdown of military forces. The drawdown includes closing hundreds of installations, deactivating a third of the Army's divisions, mothballing 20 percent of the Navy's ships, removing 70 percent of the country's strategic nuclear warheads from deployed status, and deactivating one quarter of the Air Force's tactical fighter wings (Nunn, 1992).

Facing these increasingly stringent fiscal constraints, the Air Force is developing more efficient methods of managing reparable assets. Recently, DoD and Air Force agencies seem to be adopting more of a "business-like"
mentality in resource management. Just-In-Time (JIT) methods of inventory management are one popular way that private industry has been managing its resources (Gray and Smeltzer, 1989:746). These methods have shown themselves to be extremely efficient for many businesses over the last few decades (Osborne and Gaebler, 1993:xv-xxii).

The LL concept is still somewhat nebulous. It focuses on consolidating existing inventories, reducing reparable asset transportation times, and streamlining reparable depot repair actions. Yet, the Air Force employs a wide variety of weapon systems for many specific purposes in a diverse set of locations. LL personnel anticipate that changing the way in which the reparable asset pipeline and repair process are managed will greatly reduce asset requirements, maintain an established level of weapon system performance, and will equate to significant reparable cost avoidance. As such, the LL concept is a policy, or combination of theories that will be applied to each weapon system according to the unique requirements of that weapon system. This research uses the B-1 weapon system and a simulation to examine the effects of Lean Logistics on fully mission capable aircraft, as well as costs associated with transporting these required assets (HQ AFMC Talking Paper, 1993).
Specific Problem

Lean Logistics is a philosophy of operation that seeks to improve the responsiveness of the Air Force logistics pipeline by consolidating the reparable asset pipeline and streamlining the flow of assets through the repair process. However, in order for the change to the new policy to be positive, it is important that consolidating the pipeline and changing depot repair processes do not degrade current weapon system performance.

First, LL proposes to introduce a Intermediate Supply Point (ISP) to the existing system and relocate the majority of base assets at this facility. Relocating assets will theoretically provide asset managers with greater flexibility in distributing assets and possibly reduce the overall number of assets required in the system to maintain the same number of fully mission capable aircraft.

The second major proposition of LL is to reduce the transportation time standards for reparable shipment to base from the depot and retrograde shipment from the base to the depot. This reduction in transportation time is the main thrust that reduces asset requirements in the overall system. The reduced transportation time compresses the pipeline, and thus minimizes asset needs during resupply.

The third major thrust of LL is to streamline the current depot repair cycle process. The current method of depot reparable asset repair requires that item managers meet on a
quarterly basis to decide which assets will be inducted into repair that quarter. LL proposes to use the Distribution and Repair in Variable Environments (DRIVE) system on a bi-weekly basis to compute a prioritized list of the assets requiring repair that will most improve overall fleet fully mission capable aircraft. The list generated by DRIVE is then used to decide which assets are selected for induction into repair (Abell, 1992:10-12). Therefore, the new system proposes review of asset requirements on a much more frequent basis to maintain a more responsive system. In addition, the Theory of Constraints will be applied to the actual repair processes in order to gain insight about potential consequences of specific changes in the logistics system (HQ AFMC Slide Package, 1994).

This research analysed the effects of applying LL concepts on the number of servicable assets in assigned aircraft and warehouses, as well as the costs associated with transporting needed assets. The system introduces three fundamental changes to current pipeline operations. However, those three changes imply a shift of paradigm in pipeline management. Identification of the level of improvement that Lean Logistics will administer in system performance will help LL personnel to better perform cost benefit analyses on whether the investments to implement LL are worth the benefits derived in the long run.
Investigative Questions

The following are questions about Lean Logistics that this research will answer:
1. What are the specific effects on estimated the number of fully mission capable aircraft, within the context of the various experimental treatments, of varying asset stock level, transportation time, and depot repair time?
2. What are the specific effects on the cost of transporting the assets in the system, within the context of the various experimental treatments, of reducing asset stock level, transportation time, and depot repair time?

Limitations of the Study

This research was designed to analyze the effects of consolidating assets at an intermediate supply point and reducing transportation time and depot repair time as proposed under the LL concept. Listed below are the limitations that defined the scope of this research.
1. A peacetime environment was assumed. Desert Storm showed that logistics pipeline operations are modified considerably during wartime (Adams and others, 1993:20-21). The assumption of a peacetime environment allowed the research to obtain stability and consistency in findings in order to draw valid conclusions. Peacetime operations had the greatest probability of providing consistent actions and results.
2. Only continental United States (CONUS) movement of
reparable assets for the B-1 weapon system were considered. This weapon system was chosen because of its use at a limited number of Air Force locations. Study of such a limited weapon system allowed for more comprehensive data collection on the movement and repair of assets for the weapon system as a whole. However, this limits the study in the respect that conclusions or findings only pertain to the weapon system studied and not to all Air Force weapon systems.

3. The repair and remanufacture activity within the depot was simplified to the use of repair capability rates, condemnation rates, and repair times. Closer examination of the depot maintenance function would have vastly changed the scope of the problem. Therefore, the depot repair process and reparable repair times required were assumed as given and correct. The various shop flows were translated into different repair times which are more easily handled for this research. Thus, this assumption limits the findings of the study in that specific depot repair activities may, in fact, significantly affect pipeline activities. Thus, this assumption limits the findings of the study in that specific depot repair activities may, in fact, significantly affect pipeline activities.

4. Only the top five demand reparable components of the B-1 were used in the simulation. The study of five line items provided adequate data to make an assessment of the activity
of the top demand reparables for the B-1 aircraft. These five assets were chosen through the use of Dyna-METRIC assessment model. Dyna-METRIC is a model used to analytically forecast how component support processes will affect military weapon system's wartime capability (Pohlen, 1994).

5. The various rates, durations, probabilities, and levels used as parameters in the research were gathered from models and databases used in current Air Force reparable pipeline operations.

Specifically, transportation times were drawn from the Uniform Materiel Movement and Issue Priority System (UMMIPS) Standards. Traditional depot repair times were gathered from the Recoverable Consumption Item Requirements System (D-041) and manipulated according to assertions in the LL proposal to derive the LL levels. Initial asset levels at the various warehouses were calculated from existing pipeline formulas used in USAF reparable item management. Elements needed for these formulas were drawn from the D-041 database. All values were assumed to be accurate depictions of pipeline operations.

The research alters three independent variables at three levels to determine results of two dependent variables. Simulation was used to model the pipeline with its given limitations. An analysis of variance test was then performed to show the differences between treatments with
respect to the dependent variables.

Organization of the Research

Chapter two of this thesis will review available literature on Lean Logistics, data collection strategies applicable to the research, and current requirements computations strategies and tools applicable to today's Air Force repairable item management. Chapter three will describe how simulation and non-parametric analysis of variance tools were used in deriving data and statistical findings. Chapter four enumerates the findings of compiled data, and chapter five lists conclusions, recommendations, and reasons such conclusions were drawn.
Introduction.

This chapter provides a review of the literature pertaining to Lean Logistics and subjects needed to perform this study. Specifically, the chapter begins with a brief background on the traditional logistics pipeline and its components. It then proceeds with an introduction to Lean Logistics and its evolution, followed by its underlying theories. The LL philosophy is described in some detail, followed by data collection strategies used in the research. Finally, the chapter concludes with descriptions of current USAF requirements computation tools and theories.

Logistics and the Traditional Reparable Pipeline.

Logistics. The reparable pipeline is best understood when viewed as a major logistics process flow. Before fully understanding the pipeline, one must be able to understand the term logistics. The following definitions provide different viewpoints of the term and its application in the field.

The seven Rs definition of logistics is often cited as getting "the right product, in the right quantity and in the right condition, at the right place, at the right time, for the right customer, at the right cost." (Coyle and others, 1992:6). The Council of Logistics Management definition,
cited by Blanchard in *Logistics Engineering and Management*, is as follows:

Logistics is the process of planning, implementing, and controlling the efficient, effective flow and storage of raw materials, in-process inventory, finished goods, services and related information from point of origin to point of consumption (including inbound, outbound, internal, and external movements) for the purposes of conforming to customer requirements. (Blanchard, 1992: 3)

The Society of Logistics Engineers, cited by Coyle in *The Management of Business Logistics*, defines logistics in this way:

The area of support management used throughout the life of the product or system to efficiently utilize resources assuring the adequate consideration of logistics elements during all phases of the life cycle so that timely influence on the system assures an effective approach to resource expenditures. (Coyle and others, 1992:8)

*Pipeline.* Given all its various inputs and internal functions, the Air Force logistics system's end product is war fighting capability. It is often referred to in common language as the "Pipeline." The analogy of a pipeline is useful to visualize the flow of assets through the logistics system in much the same way that liquid flows through a physical pipeline. A physical pipeline has properties such as routing, volume, and length. The routing shows the movement of assets through the various functions and processes of the logistics system. The volume indicates the quantities of assets in the system, and the length of the
pipeline denotes the times involved with moving assets from one point in the system to another (Bond and Ruth, 1989:5). Figure 1. depicts the overall logistics pipeline and how the various segments relate to one another. The Air Force logistics pipeline consists of the acquisition, depot, base, and disposal subsystems. These subsystems contain the following components: supply, maintenance and distribution (Bond and Ruth, 1989:3). The subsystems and components, taken together with the intervening transportation legs, comprise a basic view of the Air Force logistics pipeline.

Figure 1. The Overall Logistics Pipeline (Bond and Ruth, 1989).
Acquisition Pipeline Segment. The acquisition pipeline is divided into three primary activities: (1) the development of an acquisition plan, (2) the contracting process, and (3) industrial capacity and its effects on procurement lead time. When creating an acquisition plan, experts must use a requirements determination system to establish a statement of need. Reparable assets comprise less than twenty percent of the USAF inventory, but they by far exceed all other assets in dollar investment. Therefore, it is important that the statement of need is accurate so as not to overspend government dollars or understate requirements. Statements of need are established on the basis of historical demand, taking into consideration life cycle costs and other pertinent factors about the asset. After establishments are determined, a required delivery date is established and the contracting process begins. The development of an acquisition plan contributes to administrative lead time (Bond and Ruth, 1989:137).
The contracting process consists of acquisition planning, source selection, and contract administration phases (See Figure 2) (Templin, 1993). Acquisition planning was described above. The source selection process tries to efficiently select and award contracts, thereby minimizing total procurement costs. The contract administration process follows procedures designed to force contractor compliance in order to keep asset deliveries on schedule and maintain established contract prices. The contracting process also contributes significantly to administrative lead time. Industrial capacity refers to the US industrial
base's ability to manufacture and distribute military spares. This aspect of the acquisition pipeline often serves as a constraint to asset receipt. A lack of selection in available contractors or limited production capacity from existing contractors often deters completion of established contracts, thus increasing production lead time (Bond and Ruth, 1989:140).

The acquisition pipeline is very important to overall Air Force pipeline operations, and is often ignored in pipeline analysis (Bond and Ruth, 1989:140). This is the starting point from which all other pipeline segments stem. If its activities are not performed as planned, there is little that the base and depot can do to overcome difficulties.

Depot Pipeline Segment. The depot segment of the AF reparables pipeline is comprised of five Air Logistic Centers (ALCs), each one providing similar maintenance and supply functions. The maintenance activities can be summarized into two categories: overhaul of weapon systems and repair or remanufacture of reparable assets. The depot level constitutes the highest level of maintenance, and supports the accomplishment of tasks above and beyond the capabilities available at the base level. Typically, the depot is a specialized, fixed repair facility supporting a number of systems and equipment. Complex equipment and environmental controls are often present (Blanchard,
1992:116). The storage and issue supply functions stock
supplies in two ways: those used by the ALC and those used
by the bases supported by that ALC.

"Depot maintenance accounts for a large share of total
assets held in the pipeline and for a significant portion of
the pipeline time used while assets are repaired and
returned to field usage." (Bond and Ruth, 1989:96). The
flow of reparable assets within the depot subsystem is
similar to the flow within the base subsystem. Parts arrive
from bases and other depots for repair and are held until
the production shops are ready for them. Batch processing
has been the traditional form of process technology utilized
in the repair and remanufacture of reparable. Batch
production processes are used to produce small lot sizes of
similar products. Products are processed in batches with
short production runs using essentially the same sequence of
operations (Evans, 1993:128). However, for different types
of reparables, the shop flow can be quite diverse, using
different sequences, machines, and resulting in a vast range
of repair times. Once the production shops have performed
corrective actions, the parts are routed back to depot
supply and are available to fill demands from the various
bases (Bond and Ruth, 1989:98). Figure 3. provides a basic
view of the Depot Repair Pipeline.
Base Pipeline Segment. Organizations at the base level are generally considered to be the customers or users of the pipeline because of their direct and immediate impact on mission accomplishment and combat readiness. Base requirements and demands determine what is currently in the pipeline and what will be in the pipeline in the future. The base segment of the reparables pipeline is composed primarily of maintenance and supply activities.
These activities can be summarized by what is known as the base repair cycle. During preventive or corrective maintenance, a maintenance technician identifies an unserviceable part and places a demand for that part on the base supply function. If the part is on hand, base supply issues that part for the repair of the aircraft, engine, or similar end item. The faulty part is evaluated by the base maintenance function to determine if it can be repaired at the base. If the part is repaired at the base, it is then returned to base supply to satisfy future demand. If the part is not repaired, it is either condemned and returned to base supply or returned to base supply as Not Repairable This Station (NRTS). Condemned assets are sent to the Defense Reutilization and Marketing Service (DRMS) for salvage. NRTS assets are sent to the appropriate depot for higher levels of repair or remanufacture. When an asset is condemned or turned in NRTS, a demand is placed on the depot for that part to replenish base supply stockage levels (Bond and Ruth, 1989:25-29).

Disposal Pipeline Segment. This portion of the logistics pipeline is introduced when an asset reaches its "twilight period." If neither the base nor the depot have repair capability for a failed asset, then it is classified as salvage. Assets that have been condemned, can no longer be repaired or reused, are sent to the Defense Reutilization and Marketing Service. Once an asset becomes DRMS
property, it remains at that location until another user is found, it is donated to a qualified organization, or is sold to the general public. Assets that cannot be redistributed to the public are usually demilitarized before shipment (Bond and Ruth, 89:142-143).

Transportation Pipeline Segment. The intervening transportation segments between the primary subsystems in the pipeline are often considered in terms of time. This is because the longer it takes to transport an item to its final destination, the more safety stock is necessary to be kept on hand to prevent stock outs and the subsequent reduction in mission capability. The largest factors affecting transportation times are the modes of transportation and the priority given to the item. According to Air Force Regulation 75-1, Transportation of Material, the mode of transportation is selected to get the asset of interest to its destination within the Uniform Materiel Movement and Issue Priority System (UMMIPS) time standards at the lowest cost. The UMMIPS establishes a priority system between depots and base-level supply organizations. According to Air Force Manual 67-1, Basic AF Supply Procedures, UMMIPS uses priority designators to demonstrate the importance of requisitions. A cumulative delivery time is established for each priority designator (AFM 67-1, 1986). Table 1. shows UMMIPS Time Standards in Calendar Days for current transportation standards. The far
right hand column shows the standard for the amount of time each activity in the order and ship time should take. The D-041 database uses this total order and ship time of 22 days as its standard for reparable asset stockage policy computations.

Table 1. UMMIPS Time Standards in Calendar Days

<table>
<thead>
<tr>
<th>Priority Designator Edit Req.</th>
<th>PD 01-08</th>
<th>PD 01-08</th>
<th>PD 01-15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipeline Time Segment</td>
<td>RDD of 999, N, M</td>
<td>RDD of 444, 555, 777</td>
<td>Blank RDD</td>
</tr>
<tr>
<td>Requisition Submission</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Passing Action</td>
<td>.5</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>ICP Availability Determination</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Depot Storage Site and/or Base Processing and Packaging</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Transportation Hold and CONUS Intransit</td>
<td>1</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Receipt Take-up by Requisitioner</td>
<td>.5</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Total Order and Ship Time</td>
<td>5</td>
<td>9</td>
<td>22</td>
</tr>
</tbody>
</table>

The various modes of transportation available to a transportation officer can be divided into two categories: surface and air. The surface modes are trucks, railroads, bus, postal service, and parcel service. The primary advantages for trucks and railroad, under the right conditions, are high accessibility and low cost, respectively. Air carriers have the primary advantage of low transit time (Coyle, 1992:203).
Lean Logistics and its Evolution.

Each one of the segments of the logistics pipeline plays an important role in the responsiveness of the overall system. The fundamental structure of the current logistics pipeline is not affected by the changes proposed under Lean Logistics. However, various operations within the depot, base, and transportation pipeline segments are virtually re-engineered under LL to meet the fiscal challenges imposed in today's political and economic environment (AFMC Slide Package, 1993).

Governmental budget cuts have affected employees throughout the DoD. Headquarters AFMC determined that its overall repair requirements for 1993 were $1.66 billion, but the command was only funded for $1.4 billion. Further, 1993 procurement requirements were calculated at $1.85 billion, with funding levels at only $410 million. Action had to be taken to avoid degradation of logistics support due to lack of asset availability (AFMC Slide Package, 1994).

RAND Corporation of California regularly performed studies for the Air Force and DoD to assist in improving logistics operations. In the latter part of 1992, the Air Force logistics directorate (AF/LG) asked RAND to examine modern business practices and determining how they could be applied in the Air Force to minimize resource investments required for the maintenance of today's reparable logistics pipeline. RAND proposed conceptual ideas on how the Air
Force could use the Theory of Constraints and Just-In-Time practices to improve reparable depot repair processes and pipeline activities (RAND, 1992).

In February of 1993, RAND briefed the results of their study to a working group consisting of senior level members of the Air Staff and various major commands. It was at this point that the term "Lean Logistics" was coined, and the experts began defining specifically what it would do. From that point, RAND continued performing studies on the various portions of the depot repair process, and became more detailed in its analysis of how exactly the various concepts of LL would affect the pipeline (RAND, 1993).

Lean Logistics Philosophy. Lean Logistics has become one of the latest concepts for effecting large improvements in reparable item management within the Air Force. Although there are many proposed structural, organizational, and systemic changes in reparable management under LL, AFMC personnel assert that successful implementation of Lean Logistics will require a fundamental change in the way logistics personnel think. For example, the focus of management attention must shift from inputs to outcomes. That is to say, rather than ensuring a high utilization rate on a given machine or in a given shop, managers and workers will need to focus on repairing the right assets at the right time in the right quantities to satisfy demands. The
Air Staff describes LL as follows:

• Lean Logistics is a focused project to integrate state-of-the-art business practices across logistics.
• It will improve and streamline policy, processes, and management structures which drive costs and investments in logistics infrastructure.
• The end result is a smaller logistics infrastructure providing strong, less costly weapon system support to operational users, in peace and war. (HQ USAF Slide Package, 1994)

Information in Figure 4 is drawn from a briefing package prepared for General Yates in January of 1994. It outlines some of the "selling factors" of Lean Logistics (HQ USAF Slide Package, 1994). Table 2 compares some elements of traditional repairable pipeline management to the proposed LL methods of pipeline management.

- Speeding up the repair, procurement, and transportation processes to provide parts on demand.
- Reducing base level spares/consolidating inventories.
- Involving the MAJCOM in repair and distribution of parts.
- An ongoing process of continuous improvement.
- Focusing on customer orientation /involvement and adopting Just-In-Time practices.
- Doing all these things to provide better support at lower costs.

Figure 4. Factors Defining Lean Logistics
Table 2. Comparison Between Traditional and LL Pipeline Management.

<table>
<thead>
<tr>
<th>Pipeline Factor</th>
<th>Traditional Pipeline Mgt</th>
<th>LL Pipeline Mgt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation Time (serviceable and</td>
<td>Follows UMMIPS standards (22 days)</td>
<td>Proposes 1 to 2 day CONUS shipment and 3 day overseas shipment</td>
</tr>
<tr>
<td>retrograde)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depot Repair Process</td>
<td>Assets to be inducted into repair are reviewed quarterly and</td>
<td>DRIVE used bi-weekly to determine which assets will increase aircraft</td>
</tr>
<tr>
<td></td>
<td>decided by item managers</td>
<td>availability the most. Assets inducted according to this list.</td>
</tr>
<tr>
<td>Depot Repair Times</td>
<td>Averaged 54 days</td>
<td>Will average 10 days</td>
</tr>
<tr>
<td>Asset Consolidation</td>
<td>Majority of assets located at the bases; more assets needed</td>
<td>Assets withdrawn to an Intermediate Supply Point; less assets needed to</td>
</tr>
<tr>
<td></td>
<td>to sustain the system</td>
<td>sustain the system</td>
</tr>
</tbody>
</table>

The Air Force's transition into a Lean Logistics operation will require significant marketing efforts to all affected personnel. As with any major organizational change, a "buy-in" period must be established so that operators and managers of the system understand what they are doing and agree that it is in their best interest and for the betterment of the whole (HQ USAF Slide Package, 1994).

With respect to depot level maintenance practices, LL seeks to introduce Theory of Constraints and Just-In-Time concepts into the repair and remanufacture of repairable
assets to reconfigure the production process from a "push" system to a "pull" or demand based system. Under LL, the Major Commands (MAJCOM) will have greater authority to distribute remanufactured assets leaving the depots according to MAJCOM priorities. All of the distribution activities are performed to meet aircraft availability goals, lower inventory levels, reduce costs, and create simpler and more responsive operations (HQ AFMC Slide Package, 1993). Lean Logistics tackles virtually every aspect of the pipeline, with the exception of the acquisition process. At the time of this writing, LL did not involve any changes to the acquisition process. As such, the first segment of the pipeline that is examined closely is the depot segment.

The Theory of Constraints. The primary change that LL institutes in the depot involves the repair process. LL attempts to override old asset repair practices with a relatively new production management theory called the Theory of Constraints. "The principle objective of constraint management, or Theory of Constraints, is to establish a process of continuous improvement through synchronized manufacturing." (Evans, 1993: 595). The operation with the least relative capacity is called the constrained resource. Constrained resources dictate the capacity and flexibility of the entire production operation. A constraint is any resource that prevents obtaining higher
levels of performance. For example, a constraint could be a limited capacity of a machine or work center, inflexible management or policies, or a labor shortage. Once the constraint has been identified, management focuses attention and resources on that constraint to link it directly to market demand and reduce its negative impact on the system. Once attention has been focused on the constraint, all other operations are scheduled on the basis of the constrained resource since it limits production to its capacity (Evans, 1993:595-596).

Just-In-Time Philosophy. In a Just-In-Time (JIT) system, an item is produced Just-In-Time for it to be used by the next process in the system. A primary goal under JIT is to reduce the costs associated with maintaining inventory to a minimum, or in other words reduce the costs associated with maintaining inventory to a minimum. JIT reduces inventory through the use of small lot, synchronized production of a leveled plan. JIT is often noted at a "pull" approach to inventory management. This "pull" approach is contrary to conventional "push" inventory systems.

With the pull approach, a work center withdraws the required items for its production from the preceding work center. Then, the preceding work center would produce the exact quantity to replace parts withdrawn and would withdraw its required components from its own preceding work stations. This approach starts from the final assembly and goes back to all preceding work
centers including suppliers and vendors. (Gray and Smeltzer, 1989:746)

In comparison to traditional inventory management, JIT reduces inventories, employs shorter production runs, minimizes waiting lines, uses short consistent lead times, and relies on high quality components (Coyle and others, 1992:240). A JIT production schedule must be smooth and repetitive. Otherwise, inventory levels would have to be increased to compensate for the variations. This would be contrary to the primary goal of JIT. (Gray and Smeltzer, 1989:747).

**LL and the Depot Activities.** LL and depot activities incorporate Theory of Constraint (TOC) philosophies to minimize the amount of time spent fixing reparable assets. Under traditional batch processing methods of reparable assets at the depots, repair required an average of 54 days to return an asset to an available status within the system. Using TOC and focusing attention on streamlining depot repair processes, Lean Logistics plans to reduce repair times to 10 days (LL Slide Package, 1993). AFMC studies indicate that the majority of "depot repair cycle time" is actually time the asset spends waiting in repair and transportation queues waiting to be inducted into repair. LL proposes to focus repair attention and resources on those assets that will improve aircraft availability for various weapon systems. Therefore, although there will be more
setup and preparation involved for the repair of each asset on a unit repair basis, critical assets will be repaired more quickly. This will drive up the efficiency and effectiveness of the depot repair process with respect to aircraft availability (HQ AFMC Slide Package, 1994).

**LL and the Depot to Base Interface.** The primary changes proposed under LL in the depot to base interface segments involve the introduction of fast transportation and an intermediate supply warehouse. Figure 5 shows the depot to base interface, as well as the amount of time needed for each function under the traditional and LL systems.

![Diagram of depot to base interface](image)

Figure 5. Interface of Depot and Base Activities With Transportation Times.
Fast Transportation. Fast transportation simply means that reparable assets ordered from depot will be shipped to the requiring base within one to three days, depending on the location of the base. Continental United States bases should receive assets in one or two days, while overseas shipments may require up to three days. Reduced in-transit times will result in higher shipment costs but will offer savings by decreasing the number of assets required in the pipeline to maintain necessary asset availability. Figure 6 depicts the traditional transportation pipeline on the left, given its various transportation modes. The right-hand diagram shows the more immediate transportation methods proposed by LL.

Intermediate Supply Points. There are several theories behind establishing an intermediate supply warehouse (ISP). The primary reason, however, is that it allows the Air Force to minimize the number of reparable assets in the system by reducing the number of stocked reparables at any given base and positioning the ISP at a place where it can respond to base demands more rapidly than before. In order to minimize initial capital investments, headquarters AFMC personnel are discussing the idea of co-locating ISPs with current depot storage facilities. This approach shifts the focus on asset management primarily to the transportation facet of the proposal (HQ AFMC Slide Package, 1994). Reparable assets
constitute the majority of the Air Force asset investment by far, so it is imperative that these assets are managed properly.

**Inventory Drives Infrastructure**

- **Base Processes**
  - Large Inventories
  - Slow Transportation
  - Batch Repair
  - Long Queues
  - High Cost

- **Base Processes Have:**
  - Big Operating Stocks
  - Big Spares Kits

- **Depot Processes**

**Reduced Inventory/Reduced Infrastructure**

- **Base Processes**
- **Characteristics:**
  - Small Inventories
  - Optimum Repair Flow
  - Rapid Delivery
  - Continuous Improvement

- **Depot Processes**

**Figure 6. A Pictorial View of Traditional and LL Transportation Methods and Modes**
Figure 7. Traditional vs. LL Reparables Management.
Data Collection Strategies.

The design of a study is its plan for fulfilling the objectives and answering the questions of a study. When defining an experimental design, a researcher has many options in choosing tools for evaluating the problem and its potential solutions. The Lean Logistics concept basically re-engineers old methods of reparable item repair and transportation throughout the USAF pipeline. Therefore, a researcher must choose a method of evaluating the LL system that is best suited for its unique characteristics. The following section discusses several alternatives in evaluating this research, and briefly cites its validity or lack thereof to LL.

Survey. Surveying, in a fundamental sense, is questioning subjects and recording their responses for analysis. The primary strength of this technique is its versatility. Information of all types can be gathered through questioning-information such as opinions, attitudes, intentions, and expectations. Also, surveys tend to be efficient and economical in that a few carefully worded questions can quickly gather information that would take more time using another method of data collection. However, this technique has its drawbacks. The quality of information depends upon the respondent's willingness to cooperate. The respondent may not have the knowledge the researcher is seeking or may misinterpret the question.
Another potential problem with surveys is experimenter problems. An experimenter may ask the wrong questions, or be ambiguous about the exact nature of the information desired in a response. Further, an experimenter may ask questions in a biased manner, so that the respondent is coerced into a specific answer that is in line with a preconceived set of findings an experimenter wishes to show (Emory and Cooper, 1991:318-319).

Finally, the respondent may intentionally provide false information. A survey is most appropriately used in a situation where the respondent is uniquely qualified to provide the required information. Surveys can be performed by face to face interview, by telephone, by mail, or by some combination of these methods (Emory and Cooper, 1991:318-319). Surveying would not appear to be an extremely efficient method of evaluating the effects of LL on the current reparables pipeline, primarily because LL had not yet been implemented throughout the Air Force. As such, the only legitimate survey study that could be done at this point would be an analysis of people's opinions of LL implementation.

Observation. Observation can be thought of as the monitoring of non behavioral and behavioral activities. Non behavioral observation includes record analysis, physical condition analysis, and physical process analysis. Record analysis is one of the more prevalent forms of observation.
research. It may involve historical, current, public, or private records. Physical condition analysis may include studies of plant safety compliance, or an analysis of inventory conditions. Physical process analysis may involve time/motion studies of a manufacturing process, traffic flow, paperwork flow, or information flow of various organizations or systems. Behavioral observation includes nonverbal analysis, linguistic analysis, extra linguistic analysis, and spatial analysis. Nonverbal behavior involves body movement and motor expressions. Examples of linguistic behavior observation are the study of a sales presentation content, how much information is conveyed in training session, or the interaction process that takes place between two people. Communication can also take place on an extra linguistic level. Extra linguistic activity includes voice, temporal, interaction, and verbal stylistic dimensions. Spatial analysis is the study of how persons relate physically to others, organize the territory around them, and how they maintain distances between themselves and others (Emory and Cooper, 1991:401-402).

The observational method of data collection has several advantages or strengths. For example, there are many types of information that can only be gathered through observation such as records and mechanical processes. An event can be recorded as it happens in its natural environment. Original data can be collected at the time it occurs. Information
that most participants would ignore can be collected such as dates, times, and locations. Finally, observation is less intrusive than questioning, producing less bias. Like other techniques, this method has its weaknesses. It is often difficult to predict where and when the event of interest will occur. Observation can be slow and expensive. Reliable results are limited to data directly monitored. The research environment is suited to subjective assessments in that exercise of controls may produce biases. Finally, observation is a limited way to learn about events that occurred in the past or at distant locations (Emory and Cooper, 1991:402-403).

Additionally, the relationship between the observer and the subject must be considered. This relationship can be viewed from three different perspectives: directness of observation, concealment, and participation. Direct observation is where the observer is physically present to monitor the event. Indirect observation is where recording is accomplished by mechanical, photographic, or electronic means. When the presence of the observer is known, there is a risk of atypical activity by the subjects. Concealment of the observer reduces this risk, but may bring up questions of ethics. Participation produces a dual demand on the observer. Participation may interfere with recording and recording may interfere with participation (Emory and Cooper, 1991:404-405). In evaluating the LL system, similar
problems exist with surveying and observation. The concepts have not been fully developed or implemented, which makes it extremely difficult to observe any kind of research data.

Experimentation. Simply stated, experiments are studies that involve intervention by the researcher.

Experimentation as a data collection method has several strengths. This method comes closer than any other to demonstrating causality—changes in one variable attributed to changes in another. This stems from the researchers' ability to manipulate the independent variables. Contamination from extraneous variables can be controlled more effectively than with other methods. The convenience and cost of an experiment can be superior to other methods. Repeating the experiment under different conditions leads to an average effect of the independent variable. However, experimentation has its drawbacks. The artificial setting of the laboratory is one of the primary disadvantages. Generalization about population behavior derived from behavior found in samples can pose problems (Emory and Cooper, 1991:417-418). Experimentation would be a feasible method of evaluating the LL system from the perspective that
it is not fully implemented, and the researcher could manipulate a specific scenario for examination. However, the researcher must take care in emulating the system the way it is intended, and not in a manner that makes it easy for study.

Simulation. In their book "Discrete-Event System Simulation," Banks and Carson cite several characteristics and advantages of using simulation as a research technique (see Figure 8).
1. Once a model is built, true experimental control can be exercised over the variables of interest.
2. The model can be easily altered by the experimenter, and experiments can be run repeatedly at low cost and high speed.
3. Simulation methods are easier to apply than analytical methods, and data collection is less difficult.
4. Analytical models require many simplifying assumptions; effects of variables cannot be controlled/measured.
5. When modeling unknown conditions, analytical models require extrapolation beyond the range of data; in these instances, simulation is often the only way to obtain data estimates under the proposed conditions of interest.
6. In some cases, simulation is the only analytical technique available to provide insight to the problem.

Figure 8. Advantages of Simulation as a Research Technique.

Simulation models are designed to imitate real-world situations to the extent that conclusions drawn about data collected are indicative of a given situation.

In its broadest sense, computer simulation is the process of designing a mathematical-logical model of a real system and experimenting with this model on a computer. Thus simulation encompasses a model building process as well as the design and implementation of an appropriate experiment involving that model. These experiments, or simulations, permit inferences to be drawn about systems.

- Without building them, if they are only proposed systems;
• Without disturbing them, if they are operating systems that are costly or unsafe to experiment with;
• Without destroying them, if the object of an experiment is to determine their limits of stress. (Pritsker, 1986)

In other words, the system described is simplified and logically mapped. When evaluating a developmental system, it is difficult to perform accurate analysis on the overall system, primarily because all needed information is usually not known. Lean Logistics is such a developmental system. This research used historical data from existing reparables databases and manipulated it through the use of pipeline formulas to derive Lean Logistics levels.

In this study, historical demand activity and asset stock levels could be determined relatively easily for the desired time periods. However, asset transportation costs as assigned on a per unit basis were not tracked in the modern Air Force. Moreover, there is no historical data to be obtained anywhere about the behavior of assets in the reparable pipeline under the LL concept, mainly because it has not actually been implemented yet. Several LL test studies have been performed on various weapon systems at various bases, but data from these tests can hardly be used to represent general peacetime reparable asset activity. This research is designed to review peacetime asset behavior under both systems and compare the performance levels of each (HQ AFMC Slide Package, 1994).
Current Requirements Computation Tools and Theories.

This research evaluated traditional and LL reparable asset activity in a simulated pipeline. Many tools and databases are maintained in today's Air Force that assist inventory managers in evaluating pipeline performance and help show needs for improvement. The following discussion provides a description of some of the tools and databases relevant to managing reparable assets for the B-1 in the current Air Force.

The Dyna-METRIC Model. The Dyna-METRIC model is a simulation tool used to assist AF personnel in determining assets needed to support a wartime or deployment scenario. This model analytically forecasts how asset support processes will affect wartime capability as measured by aircraft availability. Although Dyna-METRIC is primarily used for computing wartime flying needs and activity, a scenario can be established to assist in peacetime calculations. The data derived for this study were based upon peacetime activity (Isaacson and others, 1988:1-10).

Dyna-METRIC considers the activity of the shop replacement units (SRUs) that affect breakage or repair of line replacement units (LRUs). This research does not consider activity of the SRUs in the pipeline for simulation of repair and resupply, but Dyna-METRIC considered SRU activity to determine which assets were critical to
supporting the B-1. Dyna-METRIC identified twenty problem items for each location that maintained any B-1 aircraft. Criticality of assets was then averaged across all bases supporting the B-1 to determine which five assets were the most critical for the entire weapon system. Once the most critical assets were identified, the D041 database at HQ AFMC was queried for the information necessary for input into the simulation model used for this research (Isaacson and others, 1988:1-10).

The Recoverable Consumption Item Requirements System (D041) Database. The D041 database is used to compute annual reparable asset buys and repairs for peacetime, steady state Air Force flying activity. Steady state flying activity refers to the point in time in which flying activity remains relatively constant over time. The information in this system reflects peacetime activity. All needed stock number historical data was drawn from the D041 system for input into the simulation model used in this research. The following data element definitions were all drawn from Air Force Materiel Command Regulation 57-4, the Recoverable Consumption Item Requirements System (D041).

Administrative Lead Time Months: This number represents actual lead time months plus seven days converted back into months. Nine months is the maximum value allowed for this data element.
Production Lead Time Months: Represents actual contractor production time converted into months. The maximum value for this element is 99 months, and the minimum value is one month.

Pipeline Days: This consists of three elements: base order and shipping time days, base repair cycle days, and depot repair cycle days.

Order and Shipping Time Days (O&ST): This represents the authorized number of days worth of stock that has been approved on hand at the operating bases to cover the order and ship time pipeline days. It is the time span expressed in calendar days, from the date of the start of a requisition of a serviceable item until its receipt by the requesting activity.

Actual base O&ST days are averaged if there are five or more transactions within an eight quarter period of all stock numbers within the intermediate and substitute group. This means that if there are any transactions on the line replacement unit, any of its shop replacement units, or any applicable substitutes for either of these, the value will be calculated.

Base Repair Cycle Days: The authorized number of days worth of stock that has been approved to be on hand at the operating bases to cover the base repair cycle days. These days represent times, expressed in calendar days, from the date when an unserviceable item is removed from the weapon.
system until it is made serviceable in base maintenance and
is ready for reissue. Actual base repair cycle days are
averaged if there are five or more transactions within an
eight quarter period of all stock numbers within the
intermediate and substitute group.

Depot Repair Cycle Days: The authorized peacetime
number of days worth of stock that has been approved to be
in the pipeline to cover stock returning to depot for repair
action. These days represent the time, expressed in
calendar days, from the time of removal of an unserviceable
item from the weapon system on which it was installed, until
the time the item is made serviceable through repair by
organic or contractor overhaul facility.

Actual depot repair cycle days are averaged if there
are five or more transactions within an eight quarter period
of all stock numbers within the intermediate and substitute
group. Depot repair cycle days consists of base processing
days, reparable in-transit days, supply to maintenance days,
shop flow days, and serviceable turn-in days.

Base Processing Days: Covers the time, in calendar
days, from the time an item is removed from the weapon
system, bench checked, processed through base supply, to the
time it is ready for shipment.

Reparable Intransit Days: Covers the time, in
calendar days, from the shipment by base supply to the
receipt by the source of repair.
Supply to Maintenance Days: Covers the time, in calendar days, from the receipt of the unserviceable asset in depot supply to the maintenance shop's issue of a work order for the repair of an unserviceable item.

Shop Flow Days: Covers the time, in calendar days, normally required to repair an item, from the date the reparable is input for repair to the date of the serviceable output.

Serviceable Turn-In Days: Covers intransit time, in calendar days, that applies to the processing of serviceable items from the source of repair to supply.

Total Organizational and Intermediate Maintenance Demand Rate (TOIMDR): Represents the current quarter's total organizational and intermediate maintenance failures per 100 flying hours that occurred during operational use of an aircraft or system. The rate represents the number of base repairs plus the number of assets returned to depot plus base condemnations that have occurred.


Percent of Assets Not Repaired This Station (NRTS): The percent of assets returned to depot for repair.

Base Percent Condemned: The percent of assets condemned at base (only applies to assets that can be condemned at field level).
Depot Percent Condemned: The percent of assets condemned at depot.

Repair Cost: The average cost to repair a reparable item. This includes the cost of the shop replacement unit and other resources required to repair the item.

Inventory at Multiple Locations-The Square Root Rule.

One of the general concepts of consumable item management is that when asset distribution is consolidated into one location, a smaller overall number of assets is required to support existing facilities, given that demand rates remain constant. The square root rule can be shown as follows:

\[ X_2 = X_1 \sqrt{n_1 / n_2} \]

where:

- \( n_1 \) = the number of existing facilities,
- \( n_2 \) = the number of future facilities,
- \( X_1 \) = total inventory in existing facilities, and
- \( X_2 \) = total inventory in future facilities.

Hill showed that consolidation of reparable assets can result in significant savings to the Air Force in the form of investment outlays (Hill, 1993). This may be argued by pointing out that reparable assets are managed differently than consumable assets in today's Air Force. Reparables are repaired and reused, while consumables are discarded. However, this research examines only the asset levels at the
base and intermediate supply points. Asset levels at the depot are treated as given and constant (Tersine, 1994).

Chapter Summary

The literature review covered several definitions of logistics and discussed how the concept of a pipeline is used to visualize the flow of assets through the logistics system. Discussion then summarized the acquisition, depot, base, and disposal pipeline subsystems and the intervening transportation segment, highlighting the flow of assets in each. The review then examined the goals, changes and desired outcomes proposed under the Lean Logistics concept and how the Theory of Constraints and Just-In-Time principles relate to LL. Finally, it provided an account of different data collection strategies and the use of simulation in modeling systems and how it applies to this study.

Overview of Chapter Three

Chapter Three begins with a discussion of the importance of the factors chosen for this study, followed by the specific hypotheses to be examined. It outlines the research design, to include the factors and levels of the independent and dependent variables involved in the research. Issues concerning population and sample selection
are iterated, followed by an in-depth review of the simulation design. The chapter concludes with notes on issues surrounding the non-parametric ANOVA tools used for statistical analysis of data.
III. METHODOLOGY

Introduction

This research compared Lean Logistics USAF reparable pipeline activities to those of the traditional USAF reparable pipeline to determine which performed better with respect to two dependent variables. The performance measures of interest were fully mission capable aircraft and transportation cost. This chapter reiterates the investigative questions identified in chapter one and explains their importance as individual elements to the overall study. It then delineates the specific hypotheses developed to help determine whether the Lean Logistics system would perform better than the current system with respect to the dependent variables. The methodology will allow the research to show whether Lean Logistics accomplishes its objectives in reducing costs and maintaining or improving the number of fully mission capable aircraft in a fleet.

The method used to perform this study was simulation. Chapter two briefly described the characteristics and advantages of simulation as a modeling tool. This chapter describes the simulation design and characteristics in detail.

Finally, this chapter describes the statistical evaluation methods that were used in the study. Due to the nature of the data, a nonparametric analysis of variance was
performed to test for significant differences between the means of 27 treatments. Nonparametric alternatives to paired-t testing were then performed to indicate the significance of the differences.

Importance of Factors to be Studied

Chapter 1 identified the investigative questions used to determine whether LL will be an improvement over the traditional pipeline. This section explains the reasons for posing each individual question and its importance to the overall study.

1. What are the specific effects on fully mission capable aircraft, within the context of the various treatments, of varying asset stock levels, transportation time, and depot repair time? LL proposes that consolidating assets and reducing depot repair times and transportation times translates into reduced asset requirements in the overall system. The experiment varies these factors and measures affect fully mission capable aircraft at any given time and on average. The number of fully mission capable aircraft is one of the primary indicators that Air Force logisticians use in assessing the success of their operations.

2. What are the specific effects on the cost of transporting assets in the system, within the context of the
various experimental treatments, of varying asset stock levels, transportation time, and depot repair time? The importance of decreasing the number of assets held in warehouses is whether that asset reduction translates into a dollar savings, and the magnitude of the savings. Currently, headquarters AFMC personnel assert that LL propositions will result in a savings of $69 million in annual buy and repair requirements for repairable B-1 assets in fiscal year 1994. The $69 million figure represents a cost avoidance for buying assets to replace those condemned from the system. As a result, less assets will be needed in the overall system to maintain the current level of performance (HQ AFMC Slide Package, 1994).

The research provided answers to questions about current and LL pipeline performance with respect to fully mission capable aircraft and transportation cost. It also demonstrated system performance for numerous intermediate pipeline configurations between the current and LL configurations. These alternative pipeline configurations were developed by varying asset stock levels, depot repair time, and transportation time. The answers to these investigative questions also showed whether LL fulfilled its original intentions.
Specific Hypotheses

The hypotheses tested for each of the dependent variables is described here. The methods of statistical evaluation for each tested hypothesis are more thoroughly described in their own section of this chapter.

1. The first hypothesis tested relates to fully mission capable aircraft and reads as follows:

Ho: Lean Logistics maintains the same or lower level of fully mission capable aircraft as the current reparables pipeline.

Ha: Lean Logistics maintains a greater level of fully mission capable aircraft than the current reparables pipeline.

It is expected that LL will require a smaller number of reparables in the system in order to maintain the same level of fully mission capable aircraft. Quick analysis of current pipeline formulas (discussed later in this chapter) indicates that less items need to be stocked at a warehouse if the time it takes to order and receive a part is significantly reduced (Pohlen, 1994). Therefore, the outcome expected for the null hypothesis is rejection.

2. The second hypothesis relates to the transportation cost and is stated below:

Ho: Lean Logistics requires the same or less of a transportation dollar investment than the current pipeline system.
Ha: Lean Logistics requires a greater transportation dollar investment than the current pipeline system.

Again, the null hypothesis is expected to be rejected. Transportation cost is expected to increase with the implementation of Lean Logistics. Faster transportation will cost more on a per unit basis and smaller inventories of spare reparables at the retail level should also require more frequent shipments. Therefore, it logically follows that overall system transportation cost would be greater under the LL philosophy.

Research Design

This research examined the effects of three independent variables altered at three levels on two dependent variables. Values for some variables were drawn from existing Air Force databases, while others were derived to suit the needs of the research. The following sections describe the specifics of these variables, including the manner in which they were computed.

Independent Variables. The independent variables chosen for this study are transportation time, depot repair time, and asset stock level.

Origin of Independent Variable Levels. Each of these three variables was chosen because it represents a major thrust of Lean Logistics. The research intended to show how these main thrusts affected the reparables pipeline
with respect to fully mission capable aircraft and overall transportation cost of items in the system. Table 3 outlines the factors and levels analyzed in the research.

<table>
<thead>
<tr>
<th>Factor/Treatment Level</th>
<th>HIGH</th>
<th>MEDIUM</th>
<th>LOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation Time</td>
<td>UMMIPS</td>
<td>Average of Current and LL Models</td>
<td>Lean Logistics Levels</td>
</tr>
<tr>
<td>Depot Repair Time</td>
<td>Current Model</td>
<td>Average of Current and LL Models</td>
<td>Lean Logistics Levels</td>
</tr>
<tr>
<td>Asset Stock Level</td>
<td>No Consolidation</td>
<td>Some Consolidation</td>
<td>Maximum Consolidation</td>
</tr>
</tbody>
</table>

Values for each of these factors were specifically derived from reparable asset pipeline and stockage formulas used in the management of today's Air Force reparation. The values were also derived with the assistance of information found in Lean Logistics point papers and the B-1 portion of the D-041 database for both traditional and Lean Logistics considerations. The following sections describe the theories and formulas underlying the values used in the initial conditions of the simulation model (D-041 Database, 1994).

Transportation Time Levels. Transportation time was studied at three levels. The high level represents the current logistics pipeline. This value was derived from the UMMIPS standards (see chapter 2, Table 1) (AFM 67-1, 1986). The low level represents the amount of time Lean Logistics
proposes as the standard order and ship time for CONUS movement of reparable assets (HQ AFMC Slide Package, 1994). The medium level of transportation cost is the average of the high and low levels.

Traditional transportation levels were represented by the UMMIPS standard of 22 days, and was standard across all stock numbers. Again, traditional levels represented the high treatment for the factor. Lean Logistics represented the low level of treatment for the factor. The new theories assert that transportation will only take one to two days within the U.S. and three days for overseas shipments. Therefore, the low level of treatment for transportation became two days for all stock numbers. As with depot repair times, the medium treatment of transportation times was derived by averaging the high and low treatment levels values (LL Slide Package, 1994). Table 4 shows these values, and Figure 9 shows the locations of the bases and the depot used in this study.

![Figure 9. Base and Depot Locations](image-url)
Depot Repair Time Levels. Traditional depot repair time levels were drawn from B-1 data in the March 1994 database (D-041 Database, 1994). Traditional levels represented the high level for this factor. Lean Logistics theories assert that eighty-five percent of the time that an asset requires for depot repair is queue time (LL Slide Package, 1994). Therefore, the low level of treatment was fifteen percent of the time that it takes for asset repair under theories of traditional pipeline management.

The medium treatment level was then established as an average of the high and low treatment levels. This medium level was inserted as a type of sensitivity analysis to show how responsive the outputs were to changes in depot repair times. Table 4 shows the various initial conditions used for the five stock numbers at each applicable level.

<table>
<thead>
<tr>
<th>NSN</th>
<th>Traditional Depot Repair Cycle Time</th>
<th>Medium Depot Repair Cycle Time</th>
<th>LL Depot Repair Cycle Time</th>
</tr>
</thead>
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<tr>
<td>6615 01 269 5439</td>
<td>51</td>
<td>31</td>
<td>10</td>
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<tr>
<td>6615 01 036 3198</td>
<td>21</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>6605 01 252 9480</td>
<td>53</td>
<td>32</td>
<td>11</td>
</tr>
<tr>
<td>6615 01 271 9168</td>
<td>23</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>6620 01 265 2887</td>
<td>46</td>
<td>28</td>
<td>9</td>
</tr>
</tbody>
</table>

Depot repair time is the same as the data element "depot repair cycle days" as defined in the D-041 database (see Chapter II).
The high level of depot repair time is the value for this data element as found in the D-041 database. For example, the D-041 database states that for an HML, it takes an average of 51 days to repair the asset. This value is unique to each stock number, but has been averaged across all B-1 bases (D-041 Database, 1994). Lean Logistics proposed reducing the average depot repair cycle time from 54 days to 10 days. This is an 81 percent reduction in repair time (HQ AFMC Slide Package, 1994). As such, the low level of treatment was averaged to 20 percent of the value used as the high treatment. Therefore, under the low level of treatment, the HML that traditionally would take 51 days to repair would theoretically take only 10 days to repair with the employment of LL practices. Again, the medium level of treatment is the average of the high and low treatments. Thus, the HML under this treatment takes an average of 31 days to repair. Table 7 thoroughly outlines the repair times used for each of the studied assets.

**Asset Stock Levels.** Asset stock levels were calculated using current USAF standard base supply system (SBSS) pipeline model formulas (Pohlen Notes, 1994). The high level represents the current number of assets in the system. Asset stock levels were calculated for base and depot for the high level of this factor. Medium asset stock levels were calculated using the same pipeline formulas and represent the asset distribution that will exist under LL.
practices. Order and ship times and depot repair cycle times were altered in the calculations to derive the applicable values for base and intermediate supply point asset stock levels.

The lowest asset stock level is a unique approach to establishing reparable asset stock levels. Chapter two discusses the square root rule as it applies to consumable asset stockage. Although this research examines reparable asset behavior, a related study demonstrated that this consumable concept applied to reparable asset behavior could result in significant asset and investment reductions (Hill, 1993). Therefore, the square root rule was applied to asset stock levels at the intermediate supply point to derive the low level of asset stockage.

The levels of this factor were set with the assistance of the B-1 segment of the D-041 database. The following formula was used to calculate the needed pipeline quantity of assets (Pohlen Notes, 1994):

\[
\text{Pipeline Stock} = Q = (\text{DDR} \times \text{PBR} \times \text{RCT}) + \left( (\text{DDR} \times (1-\text{PBR}) \times \text{OST}) \right) + \left( (\text{DDR} \times (1-\text{PBR}) \times \text{NCT}) \right)
\]

where

- DDR = Daily Demand Rate
- PBR = Percent of Base Repair
- RCT = Repair Cycle Time
- OST = Order and Ship Time
- NCT = Time required to determine the asset cannot be repaired at base.
The actual total base stock requirements (TSR) were then determined using the following formula:

\[ TSR = \text{Trunc}(Q + \sqrt[3]{Q} + .5) \]

This formula for total stock requirement assumes an 85 percent stockage effectiveness and 95 percent fill rate of the asset for which the formula is applied (AIM 67-1, Vol II, Part Two: 19-24). The theory behind these formulas also assumes that depot always has a serviceable asset on the shelf when a request is initiated. As such, retrograde asset shipment and depot repair times are assumed to be zero. It is for these reasons that the values derived from calculations are used to initialize the model (Pohlen Notes, 1994).

The varicous elements of the pipeline stock formula were gathered from historical data found in the March 1994 version of the D-041 database. The following sections describe how data was input into the formulas for each of the base asset stock levels and the intermediate asset stock levels.

Values derived from theoretical pipeline formulas were used for input into the simulation model for several reasons. First, it was impossible to obtain actual stock levels at the intermediate supply points because no actual ISPs have been established for the B-1 weapon system. Since
real data could not be obtained for each asset at each level (retail to wholesale) of stock, pipeline models were used to maintain consistency across the study.

The second reason pipeline formulas were used across all storage levels and assets is that these formulas imply a certain level of performance by translating to a given fill rate and stockage effectiveness expectation. The stock numbers selected for the study were the five most critical assets warehoused at Oklahoma City Air Logistics Center. The very fact that they were the most critical assets implies that they would not be able to maintain the desired effectiveness levels established in the pipeline formulas. Consequently, using the stock levels identified in the D-041 database would not provide researchers any insight as to the effectiveness level the D-041 figure provided. Therefore, pipeline formulas were used to establish stock levels at all warehouses to maintain consistency and an identifiable level of performance. Appendix A shows the numbers input into the model for each data element of each stock number.

**Base Stock - Traditional Levels.** These values were calculated from raw data found in the D-041 database. Asset demand rates for each base were calculated from the demand rate given in the D-041 multiplied by the number of flying hours for the base in question. Pipeline stock was then calculated for each base and used to
determine the total base stockage requirement (D-041 Database, 1994).

Table 5. Initial Conditions for Traditional Base Asset Stock Levels.

<table>
<thead>
<tr>
<th>NSN</th>
<th>Dyess Base Stock Level</th>
<th>Ellsworth Base Stock Level</th>
<th>Grand Forks Base Stock Level</th>
<th>McConnell Base Stock Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>6615012695439</td>
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<td>1</td>
<td>1</td>
</tr>
<tr>
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<td>2</td>
</tr>
<tr>
<td>6615012719168</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>6620001265287</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Base Stock – LL Levels. These values were calculated by reducing the order and ship time for each asset to one. Lean Logistics proposes that CONUS asset movement will be either one or two days from depot, so the model reflects such a change. (LL Slide Package, 1993)

Table 6. Initial Conditions for LL Base Asset Stock Levels.

<table>
<thead>
<tr>
<th>NSN</th>
<th>Dyess Base Stock Level</th>
<th>Ellsworth Base Stock Level</th>
<th>Grand Forks Base Stock Level</th>
<th>McConnell Base Stock Level</th>
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<td>1</td>
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<tr>
<td>6620001265287</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

ISP Stock – No Asset Consolidation. The asset level derived for this intermediate stock level was calculated through the use of the following formula:
\[ MISP_{Med} = \sum_{n=1}^{4} (BSR_{Trad}) - \sum_{n=1}^{4} (BSR_{LL}) \]

where

\( MISP = \) Medium Intermediate Stock Level
\( BSR_{Trad} = \) Traditional Base Stockage Requirements
\( BSR_{LL} = \) LL Base Stockage Requirements.

**ISP Stock - Asset Consolidation.** This level employed the use of the \( \sqrt{N} \) rule. The section describing the theory behind the square root rule indicates the formula used to determine the level of asset consolidation possible. For the purposes of this research, the following formula was used:

\[ MISP_{Lev} = MISP_{Med}(\sqrt{1/4}) \]

Tables 5 through 7 indicate the actual values determined for each of the stock levels at base and the intermediate supply point (Pohlen Notes, 1994).

**Depot Stock.** Depot stock levels were calculated by using a modified version of the formula used for base asset stock levels. The following formula was used to calculate depot pipeline quantities for each base (Pohlen Notes, 1994):

\[ \text{Pipeline Stock} = Q = ((\text{DDR}) \times (\text{PBR}) \times (\text{DRCT})) + ((\text{DDR}) \times (1-\text{PBR}) \times (\text{OST})) + ((\text{DDR}) \times (1-\text{PBR}) \times (\text{NCT})) \]

where
DDR = Daily Demand Rate
PBR = Percent of Base Repair
DRCT = Depot Repair Cycle Time
OST = Order and Ship Time
NCT = Time required to determine the asset cannot be repaired at base.

Pipeline quantities for each asset at each base were then multiplied by the NRTS quantities and added across all bases to derive the overall depot pipeline quantity.

\[ Depot \ Q = \sum_{all \ bases} ((Base \ NRTS \ Rate) \times (Base \ Q)) \]

The depot pipeline quantity was then input into the formula for total stock requirement in order to obtain the depot stock level.

\[ TSR = Trunc(Q + \sqrt{3Q} + 0.5) \]

Table 7 shows the values for initial depot conditions as calculated from these formulas, as well as ISP medium and low asset stock levels.

Table 7. Initial Conditions for ISP and Depot Asset Stock Levels.

<table>
<thead>
<tr>
<th>NSN</th>
<th>ISP Medium Stock Level</th>
<th>ISP Low Stock Level</th>
<th>Depot Stock Level</th>
</tr>
</thead>
<tbody>
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<td>6615012695439</td>
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<td>1</td>
<td>4</td>
</tr>
<tr>
<td>6615010363198</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>6605012529480</td>
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<td>3</td>
<td>9</td>
</tr>
<tr>
<td>6615012719168</td>
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<td>1</td>
<td>4</td>
</tr>
<tr>
<td>6620012652887</td>
<td>4</td>
<td>2</td>
<td>7</td>
</tr>
</tbody>
</table>
The high level for the asset consolidation factor only involved the use of traditional base asset stock levels. The medium treatment combined the LL base stock levels with the medium ISP stock levels. Low factor levels were established by warming up the model with LL base stock levels and low ISP stock levels.

**Dependent Variables.** The following sections describes the dependent variables of interest to this research.

*Fully mission capable aircraft.* Fully mission capable aircraft is an important indicator of the operational readiness of the fleet. For purposes of this research, a jet without a serviceable asset was assumed to be unavailable for flight. In order to calculate fully mission capable aircraft for this study, the number of assets available for flight was divided by the number of authorized aircraft. This calculation was tabulated over time, so that an average fully mission capable aircraft figure could be derived.

*Transportation Cost.* The overall cost of transporting assets in the system was measured for each treatment of the experiment. The cost to transport a needed asset within the system was expected to increase under the Lean Logistics concept. Express or overnight shipment costs more than standard shipment. However, it is possible that the increased transportation cost may be off-set by significant decreases in asset outlays. Currently, LL
personnel maintain that it would take twenty years of shipping assets through fast transportation in order to surpass the reduction in asset outlays that LL will affect (HQ AFMC Slide Package, 1994).

For purposes of this study, per unit transportation cost is dependent upon the amount of time taken to ship an asset one way from the base to the depot or from the depot to the base. Transportation costs were assigned for each of the applicable levels, bases, and stock numbers. Transportation personnel at Dyess Air Force Base quoted a cost of $1.75 per pound for fast transportation. Traditional transportation methods are assigned only 37 percent of that cost. Traditional per pound asset shipment costs for were calculated using the following formula:

\[ Cost_{rad} = \frac{($1.75(37\%))}{\text{miles to depot}} \]

The per pound per unit price of shipment for each asset was then multiplied by the unit's weight and its distance from the Oklahoma City depot. Table 8 shows the shipment cost derived for each asset at each base under traditional methods of calculation.
Table 8. Traditional Asset Shipment Cost Values.

<table>
<thead>
<tr>
<th>NSN</th>
<th>Dyess</th>
<th>Ellsworth</th>
<th>Grand Forks</th>
<th>McConnell</th>
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<tr>
<td>6615 01 269 5439</td>
<td>12.95</td>
<td>77.70</td>
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<td>18.13</td>
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<tr>
<td>6615 01 036 3198</td>
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<tr>
<td>6615 01 271 9168</td>
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<td>93.63</td>
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</tr>
<tr>
<td>6620 01 265 2887</td>
<td>21.37</td>
<td>128.21</td>
<td>128.21</td>
<td>29.91</td>
</tr>
</tbody>
</table>

Similarly, the formula used to calculate per pound LL transportation shipment costs was as follows:

\[\text{Cost}_{\text{LL}} = \frac{\$1.75}{\# \text{miles to depot}}\]

Again, this figure is multiplied by the weight of the asset and its distance to depot in order to obtain the shipment cost used in the research. Table 9 shows the values calculated for shipment of assets using fast transportation as required by LL.

Table 9. LL Asset Shipment Cost Values.

<table>
<thead>
<tr>
<th>NSN</th>
<th>Dyess</th>
<th>Ellsworth</th>
<th>Grand Forks</th>
<th>McConnell</th>
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<td>57.75</td>
<td>346.50</td>
<td>346.50</td>
<td>80.85</td>
</tr>
</tbody>
</table>

Medium levels of asset shipment costs were derived by averaging the traditional and LL values. Table 10 shows these figures.
Population and Sampling Plan. The following section describes the population and samples used for collection of data in the research.

Population Selection. The population of items used in this study included all reparable assets found on the B-1 aircraft. Lean Logistics will not impose strict guidelines across all weapon systems, as each weapon system has unique characteristics that must be considered in its management. For example, some weapon systems are located at many bases throughout the Air Force, both CONUS and overseas. Some weapon systems employ the use of contract maintenance exclusively on their reparable assets and would not require an intermediate supply point for support.

This study sought a weapon system that would require an ISP and was limited in scope, primarily within the CONUS. The B-1 fulfilled these requirements in that its four locations were located in the CONUS. Given this, all the locations are likely to be supported by one ISP. Such a situation allows for thorough study of the entire weapon system via examination of activity at one ISP.
Sample Selection. The sample chosen for this study includes 5 reparable Line Replaceable Units (LRUs). The B-1 historical database for the last eight quarters was extracted from Headquarters Materiel Command computers and used to run the Dyna-METRIC model. The Dyna-METRIC runs produced a prioritized list of all reparable B-1 assets. The top five assets, based on criticality, and managed, repaired and stored by Oklahoma City Air Logistics Center (ALC) were chosen for the study. Assets were chosen from only one depot in order to minimize the complexity of the research. However, the assets chosen from Oklahoma City also were among the most critical of all reparables on the B-1 fleet.

Simulation Design. Since the LL concept was in its developmental stages, historical data on system performance did not exist. Therefore, the qualities of a simulation model were deemed to be well-suited to the requirements of this research. The lack of availability of intermediate supply point data, the ability to manipulate several variables within the model and determine outcomes, and the ability to show a causal relationship between the independent and dependent variables of the models led to choosing simulation as the research technique. Appendix B offers a fundamental pictorial view of the model used for this simulation. It also describes the step by step logic used in deriving the model.
The major time segments of the traditional reparable pipeline include depot maintenance, transfer of assets from the depot to base level, and transfer of assets in need of repair from the base to the depot. The newly proposed pipeline will include the depot maintenance function, transfer of assets to the intermediate supply point, transfer of serviceable assets from the intermediate supply point to the base, and transfer of assets in need of repair directly back to the depot.

A facet of creating a sound simulation model was to formulate solid and practical assumptions about the current supply system and the system to be used under Lean Logistics. In order to do this, only a manageable segment of the traditional and Lean Logistics pipelines was reviewed. This segment included fixed information about the pipeline leading from depot to the intermediate supply point, but did not specifically address detailed activity within the depot supply or maintenance functions.

In order to accomplish the objectives of the research, three independent variables were identified: transportation time, depot repair time, and asset stock level. The simulation was built to model aircraft demands, as well as requisition and asset flow. The focus was to build valid assumptions about the various segments of the pipeline and methods of demand data calculations.
Model Acceptability. Model acceptability refers to the extent to which the model satisfies the needs of the user. It is more important than model verification or validation, but can be defined in part in terms of the two issues (Kraus, 1994).

Validation. Model validation substantiates whether the model represents the system under consideration to the level of detail required. It establishes that the desired correspondence exists between the model and the real system (Pritsker, 1986:11).

The concept of validation should be considered one of degree and not one of an either-or notion; it is not a binary decision variable where the model is valid or invalid. It is not at all certain that it is ever theoretically possible to establish if we have an absolutely valid model; even if we could, few managers would be willing to pay the price...As the degree of validity of the model increases, so too will its development cost. (Shannon, 1975:208)

Model validation generally falls into two broad areas: subjective and statistical validation techniques (Balci, 1989:67). The model used in this research was validated using a subjective technique known as face validation. Under this technique, "people knowledgeable about the system under study, based upon their estimates and intuition, subjectively compare model and system behaviors to judge whether the model and its results are reasonable" (Balci, 1989:68).
For this research, personnel from the Logistics Management Agency (LMA) were solicited for a face validation of the model. The LMA and RAND corporation of California are the primary agencies used in preliminary LL studies. LMA personnel are kept well aware of LL proposals and changes as they occur. These personnel also serve as the operations research experts to advise LL decision makers. The most frequent methodology used in their studies is simulation, so it was determined that these personnel were suitable for use in validating the model used for this research (Nicholson, 1994 and Lynch, 1994).

Verification. Model verification is "the process of establishing that the computer program executes as intended" (Pritsker, 1986:11). Where validation deals with building the right model to accurately represent the system, verification deals more with translating the validated model into executable code with sufficient accuracy. The various techniques for simulation model verification can be classified into six categories: informal, static, dynamic, symbolic, constraint, and formal analysis. The level of mathematical formality and complexity of these verification techniques increases as one progresses from the informal to the formal analyses (Whitner and Balci, 1989:559).

The simulation model used in this research was verified using an informal analysis technique. This type of analysis...
technique is one of the most common verification approaches. It is called informal because of the heavy reliance on human reasoning and subjectivity without strict mathematical formality - not due to a lack of structure or guidelines. Informal analysis techniques typically are not difficult to perform and require very little computer resources. The particular informal analysis technique utilized to verify the model used in this research was the desk checking method. Desk checking is performed as the model is developed and before the model is tested. Additionally, independent parties were involved to enhance the reliability and completeness of the technique (Whitner and Balci, 1989:561-562).

In addition to the informal analysis, a dynamic analysis was performed to further verify the simulation model used in this research. "Verification by dynamic analysis is accomplished by evaluating the model during its execution. As the model is exercised, its behavior is observed and information about its execution gathered" (Whitner and Balci, 1989:563). It can provide conclusive proof that the model works as intended. The particular dynamic analysis used to further verify the model used in this research was the bottom-up testing method. In bottom-up testing, as each submodel or module is built, it is thoroughly tested. After the submodels or modules have been tested, they are integrated and tested again. This process
continues until the complete model has been integrated and tested (Whitner and Balci, 1989:563-564).

For this research, the model was built for five stock numbers at four B-1 bases. During verification, the model was tested one segment at a time. For example, a gate mechanism was used in modeling to allow requisitions to be processed. One of the first tests performed was done to determine if the gate mechanism worked properly. Then, the model was elaborated to include activity for one stock number at one base. Once that portion of the model worked as intended, information for all five stock numbers at one base were input. Output was generated on this segment of the model and decoding was performed until this portion of the model worked well.

Finally, activity for all five stock numbers at all five bases was simulated. Test output was gathered and analyzed, and then the actual model used for this research was finalized. The activities described above were performed with the assistance of LMA and Air Force Institute of Technology staff personnel. Their expertise in the field and in simulation modeling was paramount to building a sound model for this study (Nicholson, 1994, and Kraus, 1994).

Initial Conditions. Initial conditions of the model refer to the values that are input into the model at the start of the simulation. Most values are derived from historical data collected through existing logistics
programs. However, since LL is a new concept, existing theoretical models were used in some cases to generate potential starting points. The three main factors that were varied in the model were depot repair cycle time, transportation time, and asset stock level.

**Steady State Behavior.** Most simulation models are run with the goal of studying steady state conditions. "By equilibrium or steady-state, we mean a condition of regularity or stability in which opposing forces or influences are balanced." (Shannon, 1975:183). However, in most stochastic models there is a period of transient behavior resulting from the effects of the initial conditions. The challenge is to reduce the bias introduced by the initial conditions. There are at least three ways to decrease the initial bias:

1. Use long enough computer runs so that the data from the transient period are insignificant relative to the data from the steady-state condition.

2. Throw out or exclude some appropriate part of the initial period of the run from our considerations.

3. Choose initial starting conditions that are more typical of the steady-state condition and thus reduce the transient period. (Shannon, 1975:182)

For the purposes of this research, both options two and three were used. Initial starting conditions that were typical of steady-state conditions were derived as outlined in the previous section and input into the simulation model.
Two methods were then used together to determine when equilibrium had been achieved. First, the pipeline model was run for three simulated years so that output measurement data could be gathered and charted in time series plots. Moving averages of estimated fully mission capable aircraft were collected at ten day intervals over three simulated years. The point in the time series plots where a particular measurement's moving average no longer changed significantly over time marked the end of the transient period. Figure 10 displays the time series plot.

![Time Series Plot of Estimated Fully Mission Capable Aircraft Moving Averages](image)

Figure 10. Time Series Plot of Estimated Fully Mission Capable Aircraft Moving Averages

A visual check of the time series plots showed that the data values stabilized within one year. An additional safety
factor of two was employed to ensure that initial bias did not affect the collection of data.

To provide rigorous support for the first method of determining when equilibrium had been achieved, an autocorrelation procedure was used to create an auto-correlation plot for the same measure of performance (estimated fully mission capable aircraft). Under this method, the longest period in which the data are significantly correlated is calculated and then deleted from the beginning of each run. The same data points used to create the time series plot were used to create the autocorrelation plots at a 95% confidence interval. Figure 11 shows the autocorrelation plot.

<table>
<thead>
<tr>
<th>LAG</th>
<th>CORR.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-0.016</td>
</tr>
<tr>
<td>2</td>
<td>0.014</td>
</tr>
<tr>
<td>3</td>
<td>-0.013</td>
</tr>
<tr>
<td>4</td>
<td>0.022</td>
</tr>
<tr>
<td>5</td>
<td>-0.002</td>
</tr>
<tr>
<td>6</td>
<td>-0.005</td>
</tr>
<tr>
<td>7</td>
<td>-0.001</td>
</tr>
<tr>
<td>8</td>
<td>-0.014</td>
</tr>
<tr>
<td>9</td>
<td>0.018</td>
</tr>
<tr>
<td>10</td>
<td>-0.016</td>
</tr>
<tr>
<td>11</td>
<td>0.008</td>
</tr>
<tr>
<td>12</td>
<td>-0.013</td>
</tr>
<tr>
<td>13</td>
<td>0.026</td>
</tr>
<tr>
<td>14</td>
<td>0.005</td>
</tr>
<tr>
<td>15</td>
<td>0.009</td>
</tr>
</tbody>
</table>

Figure 11. Autocorrelation Plot of Estimated Fully Mission Capable Aircraft

The autocorrelation plot shows that for the worst case the series becomes stationary very quickly. This supports
the first method of using a visual check on the time series plot of moving averages and adding a safety factor to ensure that data was collected from an equilibrium condition. Statistical arrays were cleared at the two year mark of each simulation run.

**Number of Replications.** "Perhaps the most important decision faced by the analyst is to determine the size of the sample." (McClave and Benson, 1991:318). If the variance is unknown, a useful approach is to run a pilot study to collect an estimate of the variance and then compute the total number of observations required (Shannon, 1975:189).

For the purposes of this research, each treatment of the pipeline model was run for three simulated years for thirty replications during the pilot study. The data obtained during the initial two simulated year transient period was discarded as discussed in the previous section. Additionally, common random number seeds were utilized for each replication across treatments to minimize the introduction of unnecessary variance.

After a preliminary sample was taken from the pilot study, the necessary number of observations was calculated for the performance measure of estimated fully mission capable aircraft at each treatment using the following formula:
The largest number of replications for the various performance measures and different treatments was calculated to be 6.9285, which was well below the 30 replications performed for data collection.

**Statistical Analysis Tools Used**

A researcher must decide what kinds of testing procedures to use on the data that has been collected. Classical or parametric procedures may be used or the researcher may choose to use nonparametric procedures. The basic assumptions underlying the parametric testing procedures are that

1) Each of the probability distributions is normal.
2) Each probability distribution has the same variance (standard deviation).
3) The observations for each factor level are random observations from the corresponding probability distribution and are independent of the observations for any other factor level. (Neter and Wasserman, 1974:426)
These classical procedures require stringent adherence to the above assumptions and are valid only if these assumptions hold (Berenson and Levine, 1989:511).

When the classical methods of testing are not applicable, non-parametric methods can be used (Berenson and Levine, 1989:511). In recent years strong efforts have been made to develop these robust techniques. These non-parametric testing methods work well for a large variety of population distributions (Snedecor and Cochran, 1980:135). They also have many advantages, some of which are as follows:

1. Non-parametric methods may be used on all types of data - qualitative data (nominal scaling), data in rank form (ordinal scaling), as well as data that have been measured more precisely (interval or ratio scaling).
2. Non-parametric methods make fewer, less stringent assumptions (which are more easily met) than do the classical procedures. Hence, they enjoy wider applicability and yield a more general, broad-based set of conclusions.
3. Depending on the particular procedure selected, non-parametric methods may be equally (or almost) as powerful as the classical procedure when the assumptions of the latter are met, and when they are not met may be quite a bit more powerful. (Berenson and Levine, 1989:513)

To determine which method of testing to use, parametric or non-parametric, the data collected from the experiment must be tested to ascertain whether it conforms to the assumptions underlying the classical procedures.
Test for Normality. The Wilk-Shapiro/Rankit Plot was utilized to test the collected data for normality. This procedure produces a rankit plot of the variable and the Shapiro-Francia statistic is calculated. "Systematic departure of the rankit plot from a linear trend indicates non-normality, as does a small value for the Wilk-Shapiro statistic." (Statistix, 1992:247). The rankit plots for the data collected during this experiment was found to depart from a linear trend and, therefore, exhibits non-normality. The rankit plots can be seen in Appendix D.

Kruskal-Wallis One-Way Analysis of Variance. Since the data populations were shown to be non-normal, the F test was inappropriate. "One possibility then is to use the Kruskal-Wallis test based on the ranks of the observations." (Neter and Wasserman, 1974:520). The Kruskal-Wallis One-Way Analysis of Variance is a non-parametric test that tests for differences among the means of several groups (Statistix, 1992:106). The null hypothesis is that the mean is the same for each of the groups. Additionally, when five or more samples are taken for each group, the Kruskal-Wallis statistic approximates a $\chi^2$ random variable. If the Kruskal-Wallis statistic is greater than the $\chi^2$, the null hypothesis is rejected (Neter and Wasserman, 1974:520).

Statistix also provides a mean rank for each group, or for this research each treatment. The data was then sorted
based on the mean ranks of the treatments and the different treatments.

*Rank-Sum Test*. When two independent random samples are to be used to compare two populations, and the *t* statistic is inappropriate for making the comparison, the Rank Sum test can be used to test the hypothesis that the probability distributions associated with the two populations are equivalent. The test statistic is based on the total of the ranks of the two samples, the rank sums. If the two rank sums are nearly equal, this implies that the distributions that the samples were drawn from are the same. If the two rank sums are very different, this implies that the distributions that the samples were drawn from are different (McClave and Benson, 1991:954-955). For the purposes of this research, the two sample sizes exceeded the standard tables so the following formulas were used:

\[ Z = \left( \frac{|\mu - T| - 0.5}{\sigma} \right) \]

where

\[ \mu = n_1(n_1+n_2+1)/2 \quad \text{and} \quad \sigma = \sqrt{n_1n_2}/6 \]

For this research, \( \mu \) was calculated to be 915 and \( \sigma \) was calculated to be 67.64 for both fully mission capable aircraft and transportation cost.

*Chapter Summary*
This chapter discussed the importance of the factors studied in the research, followed by the specific hypotheses posed on these factors. It outlined the research design, including the specific variables studied and their importance. Factors and levels of the variables studied were discussed, followed by detailing of research population and sample considerations. Simulation design was explained, to include information on the length and number of simulation runs. Finally, the chapter gave a brief overview of the statistical analysis tools used for the research.

Overview of Chapter Four

Chapter four discusses the findings and analysis of model outputs. It begins with a description of the outcome of the methodology and then details data findings and analysis.
IV. Results and Analysis

Introduction

This chapter presents the results and analysis of the data collected using the methodology described in Chapter III. First, confounds to the research are discussed, then the results of the experiment are presented in chart format. The next section of the chapter is arranged according to the investigative questions presented in Chapter I. Within this second section, the first area of analysis to be discussed is the effects of the different treatments of asset stock level, depot repair time, and transportation time on fully mission capable aircraft. Then the analysis involved with testing the related hypothesis is shown followed by an exploratory analysis. Next, a similar discussion concerning transportation cost is presented. Finally, the chapter concludes with a summary of results of the two areas of inquiry.

Confounds to Research

After the simulation model had been run through all its replications for the various treatments, the data was found to suffer from non-normality and non-homogeneity of variances. As discussed in Chapter III, these characteristics called for an analysis through the use of non-parametric methods. The non-parametric forms of
analysis are generally considered to be less powerful than the standard parametric procedures.

Due to the use of non-parametric analysis, the investigative questions stated in Chapter I could not be directly answered. Specifically, a parametric general analysis of variance would have allowed the dependent variables to be analyzed in terms of each independent variable and would have addressed interaction effects. Unfortunately, the non-parametric Kruskal-Wallis One-Way analysis of variance could only be used to analyze the dependent variables in terms of one factor. It was decided to analyze the dependent variables in terms of the various treatments because the treatments represented different combinations of the independent variables.

Data Collection Outcome

After the simulation model had been run through all the replications for the various treatments, the data was organized according to treatment and performance measure. The data from the experiment is summarized below in Table 11.
Table 11. Simulation Output Data Treatment Means

<table>
<thead>
<tr>
<th>TREATMENTS</th>
<th>AA MEAN</th>
<th>AA STDV</th>
<th>TC MEAN</th>
<th>TC STDV</th>
</tr>
</thead>
<tbody>
<tr>
<td>HHH</td>
<td>96.64</td>
<td>0.19</td>
<td>68685.26</td>
<td>2461.28</td>
</tr>
<tr>
<td>HLM</td>
<td>97.69</td>
<td>0.08</td>
<td>128054.50</td>
<td>3688.46</td>
</tr>
<tr>
<td>HHL</td>
<td>96.20</td>
<td>0.05</td>
<td>186369.68</td>
<td>4614.21</td>
</tr>
<tr>
<td>HMH</td>
<td>98.20</td>
<td>1.41</td>
<td>68178.98</td>
<td>2197.92</td>
</tr>
<tr>
<td>HMM</td>
<td>97.65</td>
<td>0.12</td>
<td>128412.18</td>
<td>3322.49</td>
</tr>
<tr>
<td>HML</td>
<td>96.13</td>
<td>0.06</td>
<td>182856.93</td>
<td>5333.20</td>
</tr>
<tr>
<td>HLH</td>
<td>95.00</td>
<td>0.39</td>
<td>69309.51</td>
<td>2517.59</td>
</tr>
<tr>
<td>HLM</td>
<td>97.80</td>
<td>0.05</td>
<td>127694.19</td>
<td>3901.01</td>
</tr>
<tr>
<td>HLL</td>
<td>98.17</td>
<td>0.07</td>
<td>183778.78</td>
<td>6540.17</td>
</tr>
<tr>
<td>MMH</td>
<td>94.36</td>
<td>0.25</td>
<td>68371.60</td>
<td>1892.86</td>
</tr>
<tr>
<td>MMH</td>
<td>96.56</td>
<td>0.16</td>
<td>128715.01</td>
<td>3214.15</td>
</tr>
<tr>
<td>MHL</td>
<td>98.14</td>
<td>0.06</td>
<td>184980.42</td>
<td>3743.41</td>
</tr>
<tr>
<td>MMH</td>
<td>94.83</td>
<td>0.19</td>
<td>68380.68</td>
<td>1987.78</td>
</tr>
<tr>
<td>MMM</td>
<td>96.84</td>
<td>0.12</td>
<td>128880.17</td>
<td>4835.25</td>
</tr>
<tr>
<td>MML</td>
<td>97.87</td>
<td>0.06</td>
<td>183375.68</td>
<td>5741.05</td>
</tr>
<tr>
<td>MLH</td>
<td>94.36</td>
<td>0.25</td>
<td>68371.60</td>
<td>1892.86</td>
</tr>
<tr>
<td>MLM</td>
<td>96.88</td>
<td>0.08</td>
<td>129255.90</td>
<td>4546.95</td>
</tr>
<tr>
<td>MLL</td>
<td>97.91</td>
<td>0.06</td>
<td>180638.80</td>
<td>5805.20</td>
</tr>
<tr>
<td>LHH</td>
<td>93.68</td>
<td>0.34</td>
<td>68649.69</td>
<td>1734.24</td>
</tr>
<tr>
<td>LHM</td>
<td>96.32</td>
<td>0.14</td>
<td>127637.07</td>
<td>3483.32</td>
</tr>
<tr>
<td>LHL</td>
<td>98.15</td>
<td>0.05</td>
<td>185192.96</td>
<td>4159.13</td>
</tr>
<tr>
<td>LMH</td>
<td>94.27</td>
<td>0.28</td>
<td>68852.76</td>
<td>2115.41</td>
</tr>
<tr>
<td>LMM</td>
<td>96.84</td>
<td>0.11</td>
<td>125322.67</td>
<td>3183.16</td>
</tr>
<tr>
<td>LML</td>
<td>97.62</td>
<td>0.08</td>
<td>183325.72</td>
<td>5353.70</td>
</tr>
<tr>
<td>LLH</td>
<td>95.00</td>
<td>0.39</td>
<td>69309.51</td>
<td>2517.59</td>
</tr>
<tr>
<td>LLM</td>
<td>96.86</td>
<td>0.09</td>
<td>129162.24</td>
<td>3547.96</td>
</tr>
<tr>
<td>LLL</td>
<td>97.91</td>
<td>0.06</td>
<td>180638.80</td>
<td>5805.20</td>
</tr>
</tbody>
</table>

Table 11 condensed the data points corresponding to the thirty replications for each treatment to a single mean value and standard deviation for each performance measure. The actual 810 data points for each performance measure can be found in Appendix E. The next section of the chapter is arranged according to the investigative questions presented in Chapter I.
Fully Mission Capable Aircraft

Investigative Question 1. What are the specific effects on fully mission capable aircraft, within the context of the various treatments, of varying asset stock level, transportation time, and depot repair time?

The non-parametric Kruskal-Wallis One-Way ANOVA was used to rank the performance of the various treatments with respect to fully mission capable aircraft. For the purposes of this research, the $\chi^2$ value was determined to be 42.56 for an $\alpha$ of 0.05 and 29 degrees of freedom. (Neter and Wasserman, 1974:807) Upon running the Kruskal-Wallis procedure, the Kruskal-Wallis statistic for fully mission capable aircraft was computed to have a value of 721.5. Clearly, the null hypothesis can be rejected. There is at least one treatment whose distribution is not the same as the others. Table 12 shows the initial results of running the Kruskal-Wallis ANOVA. The statistical analysis for this test can be seen in Appendix F.

Related Hypothesis.

Ho: Lean Logistics maintains the same or lower level of fully mission capable aircraft as the current reparable pipeline.

Ha: Lean Logistics maintains a greater level of fully mission capable aircraft than the current reparables pipeline.
Table 12. KW Treatment Mean Ranks for Fully Mission Capable Aircraft.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mean Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>LHL</td>
<td>690.20</td>
</tr>
<tr>
<td>MHL</td>
<td>686.80</td>
</tr>
<tr>
<td>NLL</td>
<td>680.00</td>
</tr>
<tr>
<td>MML</td>
<td>677.40</td>
</tr>
<tr>
<td>LML</td>
<td>668.40</td>
</tr>
<tr>
<td>HML</td>
<td>667.90</td>
</tr>
<tr>
<td>LLL</td>
<td>652.80</td>
</tr>
<tr>
<td>MLL</td>
<td>652.80</td>
</tr>
<tr>
<td>LLM</td>
<td>419.10</td>
</tr>
<tr>
<td>MLM</td>
<td>417.60</td>
</tr>
<tr>
<td>MML</td>
<td>414.20</td>
</tr>
<tr>
<td>MMM</td>
<td>411.60</td>
</tr>
<tr>
<td>HMM</td>
<td>411.10</td>
</tr>
<tr>
<td>MLM</td>
<td>404.80</td>
</tr>
<tr>
<td>LMM</td>
<td>400.80</td>
</tr>
<tr>
<td>HHL</td>
<td>399.50</td>
</tr>
<tr>
<td>HHM</td>
<td>399.50</td>
</tr>
<tr>
<td>LMM</td>
<td>370.90</td>
</tr>
<tr>
<td>LLH</td>
<td>142.90</td>
</tr>
<tr>
<td>HLH</td>
<td>142.90</td>
</tr>
<tr>
<td>LMH</td>
<td>142.50</td>
</tr>
<tr>
<td>LHH</td>
<td>139.40</td>
</tr>
<tr>
<td>HHH</td>
<td>134.40</td>
</tr>
<tr>
<td>MMH</td>
<td>134.20</td>
</tr>
<tr>
<td>MLH</td>
<td>128.40</td>
</tr>
<tr>
<td>MHH</td>
<td>128.40</td>
</tr>
<tr>
<td>HHH</td>
<td>126.60</td>
</tr>
</tbody>
</table>

The Rank Sum Test was used to test if the fully mission capable aircraft distributions for the treatments representing the current reparables pipeline (HHH) and the
pipeline (MLL) differed. The statistical analysis is shown below in Figure 12.

<table>
<thead>
<tr>
<th>SAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRT</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>HHH</td>
</tr>
<tr>
<td>MLL</td>
</tr>
<tr>
<td>TOTAL</td>
</tr>
</tbody>
</table>

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 6.646
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.0000
TOTAL NUMBER OF VALUES THAT WERE TIED 53
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001
CASES INCLUDED 60  MISSING CASES 0

Figure 12. Rank Sum Test for Current Reparables Pipeline and LL Fully Mission Capable Aircraft

The Z-value for this test was computed to be 6.645. Therefore, the null hypothesis of this Rank Sum test was rejected, meaning that the two distributions are different.

Exploratory Analysis. After the mean ranks for each treatment were obtained from the Kruskal-Wallis One-Way AOV, the treatments were sorted by their mean ranks in descending order. This was done as an exploratory analysis to help focus future research. Conclusions cannot be drawn from this particular analysis. The Rank Sum test was performed between the adjacent treatments to determine if the differences in distributions were significant within the 95
percent confidence interval. Table 13 shows the results of the Rank Sum tests. This table suggests that there are many adjacent treatments whose distributions for fully mission capable aircraft are statistically different, as indicated by the asterisks.
Table 13. Rank Sum Test Results for Fully Mission Capable Aircraft.

<table>
<thead>
<tr>
<th>Treatment Pairs</th>
<th>Rank</th>
<th>Observed Z-value</th>
<th>Significant Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>LHL MHL</td>
<td>851.5</td>
<td>0.9314</td>
<td></td>
</tr>
<tr>
<td>MHL HLL</td>
<td>786.5</td>
<td>1.8923</td>
<td>*</td>
</tr>
<tr>
<td>HLL MHL</td>
<td>627.5</td>
<td>4.2430</td>
<td>*</td>
</tr>
<tr>
<td>MML LML</td>
<td>870.5</td>
<td>0.6505</td>
<td></td>
</tr>
<tr>
<td>LML HML</td>
<td>670.0</td>
<td>3.6147</td>
<td>*</td>
</tr>
<tr>
<td>HLL LLL</td>
<td>652.5</td>
<td>3.8734</td>
<td>*</td>
</tr>
<tr>
<td>LLL MLL</td>
<td>915.0</td>
<td>-0.0073</td>
<td></td>
</tr>
<tr>
<td>MLL LLM</td>
<td>465.0</td>
<td>6.6454</td>
<td>*</td>
</tr>
<tr>
<td>LLM MLM</td>
<td>764.0</td>
<td>2.2250</td>
<td>*</td>
</tr>
<tr>
<td>MLM MMM</td>
<td>873.5</td>
<td>0.6061</td>
<td></td>
</tr>
<tr>
<td>MMM MNN</td>
<td>726.0</td>
<td>2.7868</td>
<td>*</td>
</tr>
<tr>
<td>MHH HMM</td>
<td>475.0</td>
<td>6.4976</td>
<td>*</td>
</tr>
<tr>
<td>HHH HLM</td>
<td>786.0</td>
<td>1.8997</td>
<td>*</td>
</tr>
<tr>
<td>HLM LHM</td>
<td>465.0</td>
<td>6.6454</td>
<td>*</td>
</tr>
<tr>
<td>LHM HHL</td>
<td>465.0</td>
<td>6.6454</td>
<td>*</td>
</tr>
<tr>
<td>HHL HHH</td>
<td>480.0</td>
<td>6.4237</td>
<td>*</td>
</tr>
<tr>
<td>HHM LMM</td>
<td>479.5</td>
<td>6.4311</td>
<td>*</td>
</tr>
<tr>
<td>LMM LLL</td>
<td>477.5</td>
<td>6.4606</td>
<td>*</td>
</tr>
<tr>
<td>LLH HLL</td>
<td>915.0</td>
<td>-0.0073</td>
<td></td>
</tr>
<tr>
<td>HLL LMM</td>
<td>646.5</td>
<td>3.9621</td>
<td>*</td>
</tr>
<tr>
<td>LMM LHH</td>
<td>793.0</td>
<td>1.7962</td>
<td>*</td>
</tr>
<tr>
<td>LHH HHH</td>
<td>469.5</td>
<td>6.5789</td>
<td>*</td>
</tr>
<tr>
<td>HHH MMM</td>
<td>512.5</td>
<td>5.9432</td>
<td>*</td>
</tr>
<tr>
<td>MMM MNN</td>
<td>724.5</td>
<td>2.8089</td>
<td>*</td>
</tr>
<tr>
<td>MLH MHA</td>
<td>915.0</td>
<td>-0.0073</td>
<td></td>
</tr>
<tr>
<td>MHM MHH</td>
<td>486.0</td>
<td>6.3350</td>
<td>*</td>
</tr>
</tbody>
</table>
Transportation Cost

This section reviews the findings for the second investigative question of this research.

Investigative Question 2. What are the specific effects on the cost of transporting the assets in the system, within the context of the various treatments, of varying asset stock level, transportation time, and depot repair time?

The non-parametric Kruskal-Wallis One-Way ANOVA was used to test the performance of the various treatments with respect to transportation cost. For the purposes of this research, the $\chi^2$ value was determined to be 42.56 for an $\alpha$ of 0.05 and 29 degrees of freedom. (Neter and Wasserman, 1974:807) Upon running the Kruskal-Wallis procedure, the Kruskal-Wallis statistic for transportation cost was computed to have a value of 721.5. Clearly, the null hypothesis can be rejected. There is at least one treatment whose distribution in no the same as the others. Table 14 shows the initial results of running the Kruskal-Wallis ANOVA. The statistical analysis for this test can be seen in Appendix F.
Table 14. KW Treatment Mean Ranks for Transportation Costs.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mean Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td></td>
</tr>
<tr>
<td>HHH</td>
<td>126.6</td>
</tr>
<tr>
<td>MMM</td>
<td>128.4</td>
</tr>
<tr>
<td>MLL</td>
<td>128.4</td>
</tr>
<tr>
<td>MMH</td>
<td>134.2</td>
</tr>
<tr>
<td>HMH</td>
<td>134.4</td>
</tr>
<tr>
<td>LHH</td>
<td>139.4</td>
</tr>
<tr>
<td>LMM</td>
<td>142.5</td>
</tr>
<tr>
<td>HLM</td>
<td>142.9</td>
</tr>
<tr>
<td>LLM</td>
<td>142.9</td>
</tr>
<tr>
<td>LMM</td>
<td>370.9</td>
</tr>
<tr>
<td>HHM</td>
<td>399.5</td>
</tr>
<tr>
<td>LHM</td>
<td>400.8</td>
</tr>
<tr>
<td>HLM</td>
<td>404.8</td>
</tr>
<tr>
<td>HMM</td>
<td>411.1</td>
</tr>
<tr>
<td>HMM</td>
<td>411.6</td>
</tr>
<tr>
<td>MMM</td>
<td>414.2</td>
</tr>
<tr>
<td>MLL</td>
<td>417.6</td>
</tr>
<tr>
<td>LLM</td>
<td>419.1</td>
</tr>
<tr>
<td>LLL</td>
<td>652.8</td>
</tr>
<tr>
<td>MLL</td>
<td>652.8</td>
</tr>
<tr>
<td>HLL</td>
<td>667.9</td>
</tr>
<tr>
<td>LML</td>
<td>668.4</td>
</tr>
<tr>
<td>MML</td>
<td>667.4</td>
</tr>
<tr>
<td>HLL</td>
<td>680.0</td>
</tr>
<tr>
<td>MHL</td>
<td>686.8</td>
</tr>
<tr>
<td>LHL</td>
<td>690.2</td>
</tr>
<tr>
<td>HHL</td>
<td>703.3</td>
</tr>
</tbody>
</table>
Related Hypothesis.

Ho: Lean Logistics requires the same or less of a transportation dollar investment than the current pipeline system.

Ha: Lean Logistics requires a greater transportation dollar investment than the current pipeline system.

The Rank Sum test was used to test if the transportation cost distributions for the treatments representing the current reparables pipeline (HHH) and the LL pipeline (MLL) differed. The statistical analysis is shown below in Figure 13.

<table>
<thead>
<tr>
<th>TRT</th>
<th>RANK SUM</th>
<th>SIZE</th>
<th>U STAT</th>
<th>MEAN RANK</th>
</tr>
</thead>
<tbody>
<tr>
<td>HHH</td>
<td>465.00</td>
<td>30</td>
<td>0.0000</td>
<td>15.5</td>
</tr>
<tr>
<td>MLL</td>
<td>1365.0</td>
<td>30</td>
<td>900.00</td>
<td>45.5</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1830.0</td>
<td>60</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 6.646
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.0000

CASES INCLUDED 60  MISSING CASES 0

Figure 13. Rank Sum Test for Current Reparables Pipeline and LL Transportation Cost
The Z-value for this test was computed to be 6.645. Therefore, the null hypothesis of this rank sum test was rejected, meaning that the two distributions are different.

**Exploratory Analysis.** After the mean ranks for each treatment were obtained from the Kruskal-Wallis One-Way AOV, the treatments were sorted by their mean ranks in ascending order. This was done as an exploratory analysis to help focus future research. Conclusions cannot be drawn from this particular analysis. The rank sum test was then performed between the adjacent treatments to determine if the differences in distributions were significant within the 95 percent confidence interval. Table 15 shows the results of the Rank-sum tests.

This table shows that there are relatively few adjacent treatments whose distributions for transportation cost are statistically different, as indicated by the asterisks. The analysis suggests that there may be three groupings of transportation cost. The treatments within these three groups may no be statistically different as far as transportation cost is concerned. The statistical analysis for these tests can be seen in appendix F.
Table 15. Rank Sum Test Results for Transportation Cost.

<table>
<thead>
<tr>
<th>TREATMENTS</th>
<th>RANK SUM</th>
<th>Z</th>
<th>SIGNIFICANT DIFFERENCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>HMH MHM</td>
<td>909</td>
<td>0.081312833</td>
<td></td>
</tr>
<tr>
<td>MHH MLH</td>
<td>915</td>
<td>-0.00739208</td>
<td></td>
</tr>
<tr>
<td>MLH MMH</td>
<td>886</td>
<td>0.421348315</td>
<td></td>
</tr>
<tr>
<td>MMH HHM</td>
<td>910</td>
<td>0.066528681</td>
<td></td>
</tr>
<tr>
<td>HHH LLH</td>
<td>911</td>
<td>0.05174453</td>
<td></td>
</tr>
<tr>
<td>LHH LHJ</td>
<td>915</td>
<td>0.15523359</td>
<td></td>
</tr>
<tr>
<td>LMH HLH</td>
<td>909</td>
<td>0.081312833</td>
<td></td>
</tr>
<tr>
<td>HLH LLH</td>
<td>915</td>
<td>-0.00739208</td>
<td></td>
</tr>
<tr>
<td>LLH LLM</td>
<td>465</td>
<td>6.64547605</td>
<td>*</td>
</tr>
<tr>
<td>LMM HHM</td>
<td>808</td>
<td>1.574512123</td>
<td></td>
</tr>
<tr>
<td>HMH LHM</td>
<td>914</td>
<td>0.007392076</td>
<td></td>
</tr>
<tr>
<td>LHM HLM</td>
<td>907</td>
<td>0.110881135</td>
<td></td>
</tr>
<tr>
<td>HLM HMM</td>
<td>898</td>
<td>0.243938498</td>
<td></td>
</tr>
<tr>
<td>HMM MMM</td>
<td>914</td>
<td>0.007392076</td>
<td></td>
</tr>
<tr>
<td>MMM MMH</td>
<td>905</td>
<td>0.140449438</td>
<td></td>
</tr>
<tr>
<td>MMH MMM</td>
<td>905</td>
<td>0.140449438</td>
<td></td>
</tr>
<tr>
<td>MMM MLM</td>
<td>914</td>
<td>0.007392076</td>
<td></td>
</tr>
<tr>
<td>LLM LLL</td>
<td>465</td>
<td>6.64547605</td>
<td>*</td>
</tr>
<tr>
<td>LLL LML</td>
<td>915</td>
<td>-0.00739208</td>
<td></td>
</tr>
<tr>
<td>MLL LMM</td>
<td>863</td>
<td>0.761383797</td>
<td></td>
</tr>
<tr>
<td>HML LML</td>
<td>908</td>
<td>0.096096984</td>
<td></td>
</tr>
<tr>
<td>LML MML</td>
<td>876.5</td>
<td>0.561797753</td>
<td></td>
</tr>
<tr>
<td>MML HLL</td>
<td>900</td>
<td>0.214370195</td>
<td></td>
</tr>
<tr>
<td>HLL MHL</td>
<td>898</td>
<td>0.243938498</td>
<td></td>
</tr>
<tr>
<td>MHL LHL</td>
<td>896</td>
<td>0.273506801</td>
<td></td>
</tr>
<tr>
<td>LHL HHL</td>
<td>860</td>
<td>0.805736251</td>
<td></td>
</tr>
</tbody>
</table>

Chapter Summary

This chapter presented the results and analysis of the data collected using the methodology described in Chapter III. First, confounds to the research were discussed and the results of the experiment were presented. Then the effects of the different treatments of asset stock level, depot repair time, and transportation time on fully mission
capable aircraft were tested. Next, the test of the related hypothesis was shown followed by an exploratory analysis. Finally, a similar discussion concerning transportation cost was presented.

Overview of Chapter Five

The next chapter begins with an interpretation of the findings of the research and continues by evaluating those findings with respect to statistical and practical considerations. Next, the cost of operating such systems is outlined for varying degrees of asset stock level and transportation time. The chapter then identifies several options for further research, followed by a thesis summary.
V. Conclusions and Recommendations

Introduction

This chapter discusses the conclusions drawn from the research. First, the findings are summarized and then interpreted from a management perspective. Finally, recommendations for future research are presented.

Summary of Findings

This section examines the results of the specific hypotheses that the research intended to answer.

Fully Mission Capable Aircraft. It was hypothesized that the treatment representing LL (MLL) would provide a higher percentage of fully mission capable aircraft than the treatment representing the current reparables pipeline (HHH). In order to compare the HHH and MLL treatments from a statistical perspective, the Rank Sum test was applied and the null hypothesis for the Rank Sum procedure was rejected. The distributions for fully mission capable aircraft from the two treatments were found to be statistically different.

Transportation Cost. It was hypothesized that the treatment representing LL (MLL) would provide a higher transportation cost than the treatment representing the current reparables pipeline (HHH). In order to compare the HHH and MLL treatments from a statistical perspective, the Rank Sum test was applied and the null hypothesis for the Rank Sum procedure was rejected. The distributions for
transportation cost of the two treatments were also found to be statistically different.

**Interpretation of Findings**

**Fully Mission Capable Aircraft.** Now that a statistical difference between the treatment means had been established, it was necessary to interpret this difference into useful information for a logistics manager. Recall from Chapter IV that the IL treatment mean for fully mission capable aircraft was 97.91 percent, which was higher than the current reparables pipeline treatment mean of 96.64 percent. Out of a fleet of 84 aircraft, this difference of 1.27 percent represents one additional fully mission capable (FMC) aircraft available under LL policies.

One additional FMC aircraft is certainly of significance to an aircraft manager located at any one of the bases considered in this research. For example, at Grand Forks, one additional FMC aircraft translates to an increase in their mission capable rate of 6.25 percent. This could represent quite an increase in combat capability. Based solely on the improved FMC percentage, all other things equal, Lean Logistics is the preferable reparables pipeline configuration.

**Transportation Cost.** Since a statistical difference between the treatment means has been established, it is necessary to interpret this difference into useful
information for a logistics manager. Recall from Chapter IV that the LL treatment mean for transportation cost was $180,638.80, which was much higher than the current reparables pipeline treatment mean of $68,685.26. The LL treatment mean for transportation cost was more than twice that of the current reparables pipeline. Based solely on transportation cost, it would seem that the current reparables pipeline is preferable to LL.

However, an exploration of the cost trade-off between asset consolidation and reduced transportation times for the various treatments is worthwhile at this point. Table 16 shows an estimated cost to operate the various treatments studied in this research. Note that only the asset stock level and transportation time factors were considered. Deprec repair time, although varied, did not have a direct impact on the number of assets in the system or the cost of transporting those assets.

Table 16. System Cost Analysis.

<table>
<thead>
<tr>
<th>TRTMT</th>
<th>TRANS COST</th>
<th>ASSET COST</th>
<th>TOTAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>H X H</td>
<td>68,678.84</td>
<td>10,025,963.52</td>
<td>10,094,642.36</td>
</tr>
<tr>
<td>H X M</td>
<td>128,125.99</td>
<td>10,025,963.52</td>
<td>10,154,089.51</td>
</tr>
<tr>
<td>H X L</td>
<td>183,461.97</td>
<td>10,025,963.52</td>
<td>10,209,425.49</td>
</tr>
<tr>
<td>M X H</td>
<td>68,678.84</td>
<td>10,025,963.52</td>
<td>10,094,642.36</td>
</tr>
<tr>
<td>M X M</td>
<td>128,125.99</td>
<td>10,025,963.52</td>
<td>10,154,089.51</td>
</tr>
<tr>
<td>M X L</td>
<td>183,461.97</td>
<td>10,025,963.52</td>
<td>10,209,425.49</td>
</tr>
<tr>
<td>L X H</td>
<td>68,678.84</td>
<td>09,045,377.37</td>
<td>09,114,056.21</td>
</tr>
<tr>
<td>L X M</td>
<td>128,125.99</td>
<td>09,045,377.37</td>
<td>09,173,503.36</td>
</tr>
<tr>
<td>L X L</td>
<td>183,461.97</td>
<td>09,045,377.37</td>
<td>09,228,839.34</td>
</tr>
</tbody>
</table>
The differences in transportation cost are tremendously demagnified when overall asset cost is considered. In other words, the research reflects a given level of FMC aircraft and the investment cost of having enough asset on the shelves to support that performance level.

Although the capability was built into the simulation model, asset condemnation activity was not used. The database used for information contained within the model listed condemnation rates for all B-1 line replaceable units to be zero. In order to draw conclusions about cost trade-offs between the LL and traditional systems, the required annual investments for transportation and asset outlays should be compared. In other words, the additional cost of assets requiring replacement due to condemnation from the system should be compared to the differences in the applicable transportation costs. Reference Table 16. The difference between the H X H and M X L transportation time treatments is approximately $115,000 per year. Therefore, if more than $115,000 in assets require replacement each year, then the LL system would cost less per annum than LL.

Recommendations for Further Research

There are abundant possibilities for further research concerning comparisons of Lean Logistics and current reparables pipeline operations, a few of which are outlined below.
As a direct extension of this thesis, research could be performed to group treatments with fully mission capable aircraft treatment means that are not statistically different. For example, if the grouping with the highest FMC aircraft mean consisted of five different treatments, cost analysis could be performed to determine which treatment would be the least expensive to operate. This treatment would be the preferred pipeline configuration since it provided the highest fully mission capable aircraft percentage for the least cost.

For this future research option, the same experimental design could be utilized with the same independent and dependent variables. Additionally, the same simulation model could be run through many more replications per treatment. This larger number of samples may help to reduce the problems experienced in this research with normality and equality of variance.

As suggested in a previous section of this chapter, the number of reparables requiring replacement due to condemnations during the year may play an important role in determining whether it is cost effective to adopt a pipeline configuration such as LL. It may be beneficial to evaluate LL pipeline behavior in response to varying the condemnation rate for a reparable of interest. If enough samples are taken, a regression model could be constructed to predict the costs associated with a given reparable for a given
weapon system as the weapon system ages. Since the B-1 is still a relatively new weapon system, it may be suitable for a study of this nature.

For this future research option, the independent variables would be condemnation rate of the reparable of interest and pipeline configuration (LL or current). The dependent variable would be estimated cost to operate the system (transportation cost + asset outlays). The experimental design could be 2 X N factorial, where the N is a large number of different levels for the condemnation rate factor. After the regression models were built for each pipeline configuration, the condemnation rate could be predicted for the reparable that would make it worthwhile to transition to a LL pipeline configuration.

Chapter Summary

This chapter discussed the conclusions drawn from the research. First, the findings were summarized. Next, they were interpreted from a management perspective. Finally, some recommendation for future research were presented.

Thesis Summary

This research demonstrated that there is a significant difference between the performance of the current reparable logistics pipeline and that proposed under Lean Logistics with respect to aircraft availability and transportation.
cost. It further demonstrated that there are possibilities other than the pure treatments of the traditional or LL system that garner better aircraft availability and transportation cost performance. This research provided a baseline simulation model other researchers can use to test the two systems against one another, and provided some fundamental findings about the performance of the LL system as it would be used for B-1 aircraft.
Appendix A: Glossary

**Base level** - Those agencies designed specifically to support the base at which it is located. In many cases the headquarters or depot-level functions are co-located with base-level functions. Base-level supply will refer only to those functions performed in support of the assigned base. This is considered the retail level of asset management.

**Concurrent Demand** - Asset demand that occurs in conjunction with demand of other applicable bases over time.

**Depot** - That level that supports both the base and the intermediate supply points. This is considered the wholesale level of asset management.

**Intermediate Supply Point/Warehouse** - The LL consolidation point of all assets repositioned from bases. Located at the depot.

**Non-concurrent Demand** - Asset demand that occurs independent of the demand of other bases over time.

**Reparables** - Assets that are considered to be more economical to repair and re-manufacture than to dispose of and repurchase.

**Retail** - Used interchangeably with the term base level.

**Stockage Levels** - The predetermined quantity of a specific reparable asset to be stored at a given location, whether that be at a base, depot, or intermediate supply warehouse.

**Wholesale** - Used interchangeably with the term depot level.
Appendix B: SLAM II Model

GEN,HILLWALKER,TESTHLH,31/7/1994,30,N,N,Y/N,Y/1,72;
LIMITS,30,20,15000;
INITIALIZE,,1095,Y;
INTLC,XX(2)=1,XX(3)=1,XX(4)=3,XX(5)=2,XX(6)=3;
INTLC,XX(31)=4,XX(32)=2,XX(33)=9,XX(34)=4,XX(35)=7;
INTLC,XX(40)=2,XX(41)=2,XX(42)=3,XX(43)=2,XX(44)=3;
INTLC,XX(50)=1,XX(51)=1,XX(52)=2,XX(53)=1,XX(54)=2;
INTLC,XX(60)=1,XX(61)=1,XX(62)=2,XX(63)=1,XX(64)=2;
INTLC,XX(1)=24,XX(7)=24,XX(8)=24,XX(9)=24,XX(10)=24;
INTLC,XX(45)=28,XX(46)=28,XX(47)=28,XX(48)=28,XX(49)=28;
INTLC,XX(55)=16,XX(56)=16,XX(57)=16,XX(58)=16,XX(59)=16;
INTLC,XX(55)=16,XX(66)=16,XX(67)=16,XX(68)=16,XX(69)=16;
TIMST,XX(105),EST ACPT AVAIL;
TIMST,XX(110),AV BS FILL RATE;
TIMST,XX(111),AV DS FILL RATE;
TIMST,XX(112),TRANS COST;
NETWORK:
RESOURCE/1,BLINK1(0),2;
RESOURCE/2,BLINK2(0),4;
RESOURCE/3,BLINK3(0),6;
RESOURCE/4,BLINK4(0),8;
RESOURCE/5,BLINK5(0),10;
RESOURCE/6,BLINK6(0),12;
RESOURCE/7,BLINK7(0),14;
RESOURCE/8,BLINK8(0),16;
RESOURCE/9,BLINK9(0),18;
RESOURCE/10,BLINK10(0),20;
RESOURCE/11,BLINK11(0),22;
RESOURCE/12,BLINK12(0),24;
RESOURCE/13,BLINK13(0),26;
RESOURCE/14,BLINK14(0),28;
RESOURCE/15,BLINK15(0),30;
RESOURCE/16,BLINK16(0),1;
RESOURCE/17,BLINK17(0),3;
RESOURCE/18,BLINK18(0),5;
RESOURCE/19,BLINK19(0),7;
RESOURCE/20,BLINK20(0),9;
RESOURCE/21,BLINK21(0),11;
RESOURCE/22,BLINK22(0),13;
RESOURCE/23,BLINK23(0),15;
RESOURCE/24,BLINK24(0),17;
RESOURCE/25,BLINK25(0),19;
RESOURCE/26,BLINK26(0),21;
RESOURCE/27,BLINK27(0),23;
RESOURCE/28,BLINK28(0),25;
RESOURCE/29,BLINK29(0),27;
RESOURCE/30,BLINK30(0),29;

; COMPUTE DEPENDENT VARIABLES OF INTEREST
;
CREATE,7,7,,,
ACTIVITY;
ASSIGN, XX(101) = XX(1) * XX(7) * XX(8) * XX(9) * XX(10) / 7962624;
ASSIGN, XX(102) = XX(45) * XX(46) * XX(47) * XX(48) * XX(49) / 17210368;
ASSIGN, XX(103) = XX(55) * XX(56) * XX(57) * XX(58) * XX(59) / 1048576;
ASSIGN, XX(104) = XX(65) * XX(66) * XX(67) * XX(68) * XX(69) / 1048576;
ASSIGN, XX(105) = XX(101) / 4 + XX(102) / 4 + XX(103) / 4 + XX(104) / 4;
ASSIGN, XX(106) = XX(2) / 5 + XX(3) / 5 + XX(4) / 15 + XX(5) / 10 + XX(6) / 15;
ASSIGN, XX(107) = XX(40) / 10 + XX(41) / 10 + XX(42) / 15 + XX(43) / 10 + XX(44) / 15;
ASSIGN, XX(108) = XX(50) / 5 + XX(51) / 5 + XX(52) / 10 + XX(53) / 5 + XX(54) / 10;
ASSIGN, XX(109) = XX(60) / 5 + XX(61) / 5 + XX(62) / 10 + XX(63) / 5 + XX(64) / 10;
ASSIGN, XX(110) = XX(106) / 4 + XX(107) / 4 + XX(108) / 4 + XX(109) / 4;
ASSIGN, XX(111) = XX(31) / 20 + XX(32) / 10 + XX(33) / 45 + XX(34) / 20 + XX(35) / 35;
ASSIGN, XX(112) = XX(21) + XX(22) + XX(23) + XX(24) + XX(25);
ACTIVITY;
TERMINATE;

; HML AT ELLSWORTH, TREATMENT HLH
; CREATE, EXPON(33.33),,1,1,
ACTIVITY/1, RLOGN(1, 0.3);
EHML ASSIGN, ATRIB(10) = RLOGN(51, 16), ATRIB(11) = 1.0, ATRIB(12) = 0.0;
ASSIGN, ATRIB(6) = 0.36, ATRIB(7) = 0.64, ATRIB(8) = RLOGN(22, 7);
ASSIGN, ATRIB(9) = 0.0, ATRIB(5) = RLOGN(5, 1), ATRIB(4) = 1, ATRIB(2) = 1;
ASSIGN, XX(1) = XX(1) - 1, 1;
ACTIVITY;
GOON, 2;
ACTIVITY/2;
ACTIVITY/3,,EHAA;
GOON, 1;
ACTIVITY/4,,XX(2) . LT. 1;
ACTIVITY/5,,XX(2) . GE. 1, EHAB;
AWAIT(2), BLINK1, 1;
ACTIVITY;
ALTER, BLINK1, -1, 1;
ACTIVITY;
FREE, BLINK1, 1;
ACTIVITY;
ASSIGN, XX(2) = XX(2) - 1, 1;
ACTIVITY/6, RLOGN(1, 0.33);
ASSIGN, XX(1) = XX(1) + 1, 1;
ACTIVITY;
TERMINATE;
EHAB ASSIGN, XX(2) = XX(2) - 1, 1;
ACTIVITY/7, RLOGN(1, 0.33);
ASSIGN, XX(1) = XX(1) + 1, 1;
ACTIVITY;
TERMINATE;
EHAA GOON, 1;
ACTIVITY/8;
ACTIVITY/9,,ATRIB(9), EHAC;
GOON, 1;
ACTIVITY/10, ATRIB(5), ATRIB(6);
ACTIVITY/11,,ATRIB(7), EHAD;
ASSIGN, XX(2) = XX(2) + 1, 1;
ACTIVITY;
TERMINATE;
EHAD GOON, 2;
ACTIVITY;

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ACTIVITY/13, DS;
ASSIGN, XX(21) = XX(21) + 77.70, 1;
ACTIVITY/12, ATRIB(8), DR;
EHAC ASSIGN, XX(11) = XX(11) + 1, 2;
ACTIVITY/14, DS;
ACTIVITY/15;
TERMINATE;
;
CREATE, 1, 1, 1, 1;
ACTIVITY;
EHAE GOON, 1;
ACTIVITY, 0.05, XX(2) .LT. 1. OR. NNQ(2) .EQ. 0, EHAE;
ACTIVITY, XX(2) .GE. 1. AND. NNQ(2) .GE. 1;
ALTER, BLINK1, 1, 1;
ACTIVITY, .05, EHAE;

SPLR AT ELLSWORTH, TREATMENT HLH
;
CREATE, EXPON(2U), 1, 1;
ACTIVITY/16, RLOGN(1, 0.3);
ESPL ASSIGN, ATRIB(10) = RLOGN(21, 6), ATRIB(11) = 1.0, ATRIB(12) = 0.0;
ASSIGN, ATRIB(6) = 0.68, ATRIB(7) = 0.32, ATRIB(8) = RLOGN(22, 7);
ASSIGN, ATRIB(9) = 0.0, ATRIB(5) = RLOGN(4, 1), ATRIB(4) = 2, ATRIB(2) = 1;
ASSIGN, XX(7) = XX(7) - 1, 1;
ACTIVITY;
GOON, 2;
ACTIVITY/17;
ACTIVITY/18, ESAA;
GOON, 1;
ACTIVITY/19, XX(3) .LT. 1;
ACTIVITY/20, XX(3) .GE. 1, ESAB;
AWATT(4), BLINK2, 1;
ACTIVITY;
ALTER, BLINK2, -1, 1;
ACTIVITY;
FREE, BLINK2, 1;
ACTIVITY;
ASSIGN, XX(3) = XX(3) - 1, 1;
ACTIVITY/21, RLOGN(1, 0.33);
ASSIGN, XX(7) = XX(7) + 1, 1;
ACTIVITY;
TERMINATE;

ESAB ASSIGN, XX(3) = XX(3) - 1, 1;
ACTIVITY/22, RLOGN(1, 0.33);
ASSIGN, XX(7) = XX(7) + 1, 1;
ACTIVITY;
TERMINATE;

ESAA GOON, 1;
ACTIVITY/23;
ACTIVITY/24, ATRIB(9), ESAC;
GOON, 1;
ACTIVITY/25, ATRIB(5), ATRIB(6);
ACTIVITY/26, ATRIB(7), ESAD;
ASSIGN, XX(3) = XX(3) + 1, 1;
ACTIVITY;
TERMINATE;

ESAD GOON, 2;
ACTIVITY;
ACTIVITY/28,,DS;
ASSIGN,XX(22)=XX(22)+124.32,1;
ACTIVITY/27,Atrib(8),,DR;

ESAC
ASSIGN,XX(12)=XX(12)+1,2;
ACTIVITY/29,,DS;
ACTIVITY/30;
TERMINATE;

; CREATE,1,,1,1,1;
ACTIVITY;

ESAE
GOON,1;
ACTIVITY,0.05,XX(3).LT.1.OR.NNQ(4).EQ.0,ESAE;
ACTIVITY,,XX(3).GE.1.AND.NNQ(4).GE.1;
ALTER,BLINK2,1,1;
ACTIVITY,0.05,,ESAE;

; INERT AT ELLSWORTH, TREATMENT HLH
;
CREATE,EXPON(10),,1,1,1;
ACTIVITY/31,RLOGN(1,0.3);

EINT
ASSIGN,Atrib(10)=RLOGN(53,17),Atrib(11)=1.0,Atrib(12)=0.0;
ASSIGN,Atrib(6)=0.53,Atrib(7)=0.47,Atrib(8)=RLOGN(22,7);
ASSIGN,Atrib(9)=0.0,Atrib(5)=RLOGN(5,1),Atrib(4)=3,Atrib(2)=1;
ASSIGN,XX(8)=XX(8)-1,1;
ACTIVITY;
GOON,2;
ACTIVITY/32;
ACTIVITY/33,,EIAA;
GOON,1;
ACTIVITY/34,,XX(4).LT.1;
ACTIVITY/35,,XX(4).GE.1,EIAB;
AWAIT(6),BLINK3,,1;
ACTIVITY;
ALTER,BLINK3,-1,1;
ACTIVITY;
FREE,BLINK3,1;
ACTIVITY;
ASSIGN,XX(4)=XX(4)-1,1;
ACTIVITY/36,RLOGN(1,0.33);
ASSIGN,XX(8)=XX(8)+1,1;
ACTIVITY;
TERMINATE;

EIAB
ASSIGN,XX(4)=XX(4)-1,1;
ACTIVITY/37,RLOGN(1,0.33);
ASSIGN,XX(8)=XX(8)+1,1;
ACTIVITY;
TERMINATE;

EIAA
GOON,1;
ACTIVITY/38;
ACTIVITY/39,,Atrib(9),EIAC;
GOON,1;
ACTIVITY/40,Atrib(5),Atrib(6);
ACTIVITY/41,,Atrib(7),EIAD;
ASSIGN,XX(4)=XX(4)+1,1;
ACTIVITY;
TERMINATE;

EIAD
GOON,2;
ACTIVITY/42;
ACTIVITY/44, DS;
ASSIGN, XX(23)=XX(23)+151.52, 1;
ACTIVITY/43, ATRIB(8), DR;
EIAE ASSIGN, XX(13)=XX(13)+1, 2;
ACTIVITY/45, DS;
ACTIVITY;
TERMINATE;

CREATE, 1, 1, 1, 1;
ACTIVITY;
EIAE GOON, 1;
ACTIVITY, 0.05, XX(4) .LT. 1 .OR. NNQ(6) .EQ. 0, EIAE;
ACTIVITY, XX(4) .GE. 1 .AND. NNQ(6) .GE. 1;
ALTER, BLINK3, 1, 1;
ACTIVITY, 0.05, EIAE;

FLAP AT ELLWORTH, TREATMENT HLH

CREATE, EXPON(16.67), 1, 1;
ACTIVITY/46, RLOGN(1, 0.3);
EFLP ASSIGN, ATRIB(10)=RLOGN(23, 7), ATRIB(11)=1.0, ATRIB(12)=0.0;
ASSIGN, ATRIB(6)=0.55, ATRIB(7)=0.45, ATRIB(8)=RLOGN(22, 7);
ASSIGN, ATRIB(9)=0.0, ATRIB(5)=RLOGN(3, 9), ATRIB(4)=4, ATRIB(2)=1;
ASSIGN, XX(9)=XX(9)-1, 1;
ACTIVITY;
GOON, 2;
ACTIVITY/47;
ACTIVITY/48, EFAA;
GOON, 1;
ACTIVITY/49, XX(5) .LT. 1;
ACTIVITY/50, XX(5) .GE. 1, EFAB;
AWAIT (8), BLINK4, 1;
ACTIVITY;
ALTER, BLINK4, -1, 1;
ACTIVITY;
FREE, BLINK4, 1;
ACTIVITY;
ASSIGN, XX(5)=XX(5)-1, 1;
ACTIVITY/51, RLOGN(1, 0.33);
ASSIGN, XX(9)=XX(9)+1, 1;
ACTIVITY;
TERMINATE;

EFAB ASSIGN, XX(5)=XX(5)-1, 1;
ACTIVITY/52, RLOGN(1, 0.33);
ASSIGN, XX(9)=XX(9)+1, 1;
ACTIVITY;
TERMINATE;

EFAA GOON, 1;
ACTIVITY/53;
ACTIVITY/54, ATRIB(9), EFAC;
GOON, 1;
ACTIVITY/55, ATRIB(5), ATRIB(6);
ACTIVITY/56, ATRIB(7), EFAD;
ASSIGN, XX(5)=XX(5)+1, 1;
ACTIVITY;
TERMINATE;

EFAD GOON, 2;
ACTIVITY/57;
ACTIVITY/59,, ,DS;
ASSIGN, XX(24) = XX(24) + 93.63, 1;
ACTIVITY/58, ATTRIB(8), DR;

EFAC
ASSIGN, XX(14) = XX(14) + 1, 2;
ACTIVITY/60, , DS;
ACTIVITY;
TERMINATE;

CREATE, 1, 1, 1, 1;
ACTIVITY;
EFAE
Goon, 1;
ACTIVITY, 0.05, XX(5) .LT. 1.0 OR. NNQ(8) .EQ. 0, EFAE;
ACTIVITY, XX(5) .GE. 1.0 AND. NNQ(8) .GE. 1.0;
ALTER, BLINK4, 1, 1;
ACTIVITY, 0.05, EFAE;

CONV AT ELLSWORTH, TREATMENT HLH

CREATE, EXPON(7.7), 1, 1, 1;
ACTIVITY/61, RLOGN(1, 0.33);

ECON
ASSIGN, ATTRIB(10) = RLOGN(46, 15), ATTRIB(11) = 1.0, ATTRIB(12) = 0.0;
ASSIGN, ATTRIB(6) = 0.73, ATTRIB(7) = 0.27, ATTRIB(8) = RLOGN(22, 7);
ASSIGN, ATTRIB(9) = 0.0, ATTRIB(5) = RLOGN(6, 2), ATTRIB(4) = 5, ATTRIB(2) = 1;
ASSIGN, XX(10) = XX(10) - 1, 1;
ACTIVITY;
Goon, 2;
ACTIVITY/62;
ACTIVITY/63, , ECAA;
Goon, 1;
ACTIVITY/64, , XX(6).LT.1;
ACTIVITY/65, , XX(6).GE.1, ECAB;
AWAIT(10), BLINK5, 1;
ACTIVITY;
ALTER, BLINK5, -1, 1;
ACTIVITY;
FREE, BLINK5, 1;
ACTIVITY;
ASSIGN, XX(6) = XX(6) - 1, 1;
ACTIVITY/66, RLOGN(1, 0.33);
ASSIGN, XX(10) = XX(10) + 1, 1;
ACTIVITY;
TERMINATE;

ECAB
ASSIGN, XX(6) = XX(6) - 1, 1;
ACTIVITY/67, RLOGN(1, 0.33);
ASSIGN, XX(10) = XX(10) + 1, 1;
ACTIVITY;
TERMINATE;

ECAA
Goon, 1;
ACTIVITY/68;
ACTIVITY/69, ATTRIB(9), ECAC;
Goon, 1;
ACTIVITY/70, ATTRIB(5), ATTRIB(6);
ACTIVITY/71, ATTRIB(7), ECAD;
ASSIGN, XX(6) = XX(6) + 1, 1;
ACTIVITY/72;
TERMINATE;

ECAD
Goon, 2;
ACTIVITY;
ACTIVITY/74,,DS;
ASSIGN,XX(25)=XX(25)+128,21,1;
ACTIVITY/73,ATRIB(8),,DR;
ECAC ASSIGN,XX(15)=XX(15)+1,2;
ACTIVITY/75,,DS;
ACTIVITY;
TERMINATE;
;
CREATE,1,,1,1,1;
ACTIVITY;
ECAE GOON,1;
ACTIVITY,0.05,XX(6),LT.1.OR.NNQ(10),EQ.0,ECAE;
ACTIVITY,,XX(6),GE.1.AND.NNQ(10),GE.1;
ALTER,BLINK5,1,1;
ACTIVITY,0.05,,ECAE;
;
DEPOT/ISP SUPPLY ACTIVITY
;
DS GOON,1;
ACTIVITY/76,,ATRIB(4),EQ.1;
ACTIVITY/77,,ATRIB(4),EQ.2,ZAFU;
ACTIVITY/78,,ATRIB(4),EQ.3,ZAFY;
ACTIVITY/79,,ATRIB(4),EQ.4,ZAGC;
ACTIVITY/80,,ATRIB(4),EQ.5,ZAGG;
AWAIT(12),BLINK6,,1;
ACTIVITY;
ALTER,BLINK6,-1,1;
ACTIVITY;
FREE,BLINK6,1;
ACTIVITY;
ASSIGN,XX(31)=XX(31)-1,1;
ACTIVITY,,ATRIB(2),EQ.1;
ACTIVITY,,ATRIB(2),EQ.2,ZAFO;
ACTIVITY,,ATRIB(2),EQ.3,ZAFP;
ACTIVITY,,ATRIB(2),EQ.4,ZAFQ;
GOON,1;
ACTIVITY;
ASSIGN,XX(21)=XX(21)+77.70,1;
ACTIVITY/81,ATRIB(8);
ASSIGN,XX(21)=XX(21)+1,1;
ACTIVITY;
TERMINATE;
;
ZAFO GOON,1;
ACTIVITY;
ASSIGN,XX(21)=XX(21)+12.95,1;
ACTIVITY,ATRIB(8);
ASSIGN,XX(40)=XX(40)+1,1;
TERMINATE;
;
ZAFP GOON,1;
ACTIVITY;
ASSIGN,XX(21)=XX(21)+77.70,1;
ACTIVITY,ATRIB(8);
ASSIGN,XX(50)=XX(50)+1,1;
TERMINATE;
;
ZAFQ GOON,1;
ACTIVITY;
ASSIGN,XX(21)=XX(21)+18.13,1;
ACTIVITY,ATRIB(8);

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ASSIGN, XX(60) = XX(60) + 1, 1;
TERMINATE;

ZAFU

AWAIT(14), BLINK7, , 1;
ACTIVITY;
ALTER, BLINK7, -1, 1;
ACTIVITY;
FREE, BLINK7, 1;
ACTIVITY;
ASSIGN, XX(32) = XX(32) - 1, 1;
ACTIVITY, , ATRIB(2) . EQ. 1;
ACTIVITY, , ATRIB(2) . EQ. 2, ZAFR;
ACTIVITY, , ATRIB(2) . EQ. 3, ZAFS;
ACTIVITY, , ATRIB(2) . EQ. 4, ZAFT;
GOON, 1;
ACTIVITY;
ASSIGN, XX(22) = XX(22) + 124.32, 1;
ACTIVITY/82, ATRIB(8);
ASSIGN, XX(3) = XX(3) + 1, 1;
ACTIVITY;
TERMINATE;

ZAFR

GOON, 1;
ACTIVITY;
ASSIGN, XX(22) = XX(22) + 20.72, 1;
ACTIVITY, ATRIB(8);
ASSIGN, XX(41) = XX(41) + 1, 1;
TERMINATE;

ZAFS

GOON, 1;
ACTIVITY;
ASSIGN, XX(22) = XX(22) + 24.32, 1;
ACTIVITY, ATRIB(8);
ASSIGN, XX(51) = XX(51) + 1, 1;
TERMINATE;

ZAFT

GOON, 1;
ACTIVITY;
ASSIGN, XX(22) = XX(22) + 29.01, 1;
ACTIVITY, ATRIB(8);
ASSIGN, XX(61) = XX(61) + 1, 1;
TERMINATE;

ZAFY

AWAIT(16), BLINK8, , 1;
ACTIVITY;
ALTER, BLINK8, -1, 1;
ACTIVITY;
FREE, BLINK8, 1;
'ACTIVITY;
ASSIGN, XX(33) = XX(33) - 1, 1;
ACTIVITY, , ATRIB(2) . EQ. 1;
ACTIVITY, , ATRIB(2) . EQ. 2, ZAFV;
ACTIVITY, , ATRIB(2) . EQ. 3, ZAFW;
ACTIVITY, , ATRIB(2) . EQ. 4, ZAFX;
GOON, 1;
ACTIVITY;
ASSIGN, XX(23) = XX(23) + 151.52, 1;
ACTIVITY/83, ATRIB(8);
ASSIGN, XX(4) = XX(4) + 1, 1;
ACTIVITY;
TERMINATE;

ZAFV

GOON, 1;
ACTIVITY;
ASSIGN, XX(23) = XX(23) + 25.25, 1;
ACTIVITY, ATRIB(8);
ASSIGN, XX(42) = XX(42) + 1, 1;
TERMINATE;

ZAFW GOON, 1;
ACTIVITY;
ASSIGN, XX(23) = XX(23) + 151.52, 1;
ACTIVITY, ATRIB(8);
ASSIGN, XX(52) = XX(52) + 1, 1;
TERMINATE;

ZAFX GOON, 1;
ACTIVITY;
ASSIGN, XX(23) = XX(23) + 35.35, 1;
ACTIVITY, ATRIB(8);
ASSIGN, XX(52) = XX(52) + 1, 1;
TERMINATE;

ZAGC AWAIT(18), BLINK9, 1;
ACTIVITY;
ALTER, BLINK9, -1, 1;
ACTIVITY;
FREE, BLINK9, 1;
ACTIVITY;
ASSIGN, XX(34) = XX(34) - 1, 1;
ACTIVITY, ATRIB(2).EQ.1;
ACTIVITY, ATRIB(2).EQ.2, ZAFZ;
ACTIVITY, ATRIB(2).EQ.3, ZAGA;
ACTIVITY, ATRIB(2).EQ.4, ZAGB;
GOON, 1;
ACTIVITY;
ASSIGN, XX(24) = XX(24) + 93.63, 1;
ACTIVITY, ATRIB(8);
ASSIGN, XX(5) = XX(5) + 1, 1;
TERMINATE;

ZAFZ GOON, 1;
ACTIVITY;
ASSIGN, XX(24) = XX(24) + 15.60, 1;
ACTIVITY, ATRIB(8);
ASSIGN, XX(43) = XX(43) + 1, 1;
TERMINATE;

ZAGA GOON, 1;
ACTIVITY;
ASSIGN, XX(24) = XX(24) + 93.63, 1;
ACTIVITY, ATRIB(8);
ASSIGN, XX(53) = XX(53) + 1, 1;
TERMINATE;

ZAGB GOON, 1;
ACTIVITY;
ASSIGN, XX(24) = XX(24) + 21.85, 1;
ACTIVITY, ATRIB(8);
ASSIGN, XX(63) = XX(63) + 1, 1;
TERMINATE;

ZAGG AWAIT(20), BLINK10, 1;
ACTIVITY;
ALTER, BLINK10, -1, 1;
ACTIVITY;
FREE, BLINK10, 1;
ACTIVITY;
ASSIGN, XX(35) = XX(35) - 1,1;
ACTIVITY, ATRIB(2).EQ.1;
ACTIVITY, ATRIB(2).EQ.2, ZAGD;
ACTIVITY, ATRIB(2).EQ.3, ZAGE;
ACTIVITY, ATRIB(2).EQ.4, ZAGF;
GOON, 1;
ACTIVITY;
ASSIGN, XX(25) = XX(25) + 128.21, 1;
ACTIVITY/85, ATRIB(8);
ASSIGN, XX(6) = XX(6) + 1, 1;
ACTIVITY;
TERMINATE;
ZAGD GOON, 1;
ACTIVITY;
ASSIGN, XX(25) = XX(25) + 21.37, 1;
ACTIVITY, ATRIB(8);
ASSIGN, XX(44) = XX(44) + 1, 1;
TERMINATE;
ZAGE GOON, 1;
ACTIVITY;
ASSIGN, XX(25) = XX(25) + 128.21, 1;
ACTIVITY, ATRIB(8);
ASSIGN, XX(54) = XX(54) + 1, 1;
TERMINATE;
ZAGF GOON, 1;
ACTIVITY;
ASSIGN, XX(25) = XX(25) + 29.91, 1;
ACTIVITY, ATRIB(8);
ASSIGN, XX(64) = XX(64) + 1, 1;
TERMINATE;
CREATE, 1, 1, 1, 1, 1;
ACTIVITY;
ZAFB GOON, 1;
ACTIVITY, 0.05, XX(31).LT. 1 .OR. NNQ(12).EQ.0, ZAFB;
ACTIVITY, XX(31).GE. 1 .AND. NNQ(12).GE. 1;
ALTER, BLINK6, 1, 1;
\ACTIVITY, 0.05, , ZAFB;
CREATE, 1, 1, 1, 1, 1;
ACTIVITY;
ZAFD GOON, 1;
ACTIVITY, 0.05, XX(32).LT. 1 .OR. NNQ(14).EQ.0, ZAFD;
ACTIVITY, XX(32).GE. 1 .AND. NNQ(14).GE. 1;
ALTER, BLINK7, +1, 1;
ACTIVITY, 0.05, , ZAFD;
CREATE, 1, 1, 1, 1, 1;
ACTIVITY;
ZAFE GOON, 1;
ACTIVITY, 0.05, XX(34).LT.1.OR.NNQ(18).EQ.0, ZAFE;
ACTIVITY, XX(34).GE.1.AND.NNQ(18).GE.1;
ALTER, BLINK9, 1, 1;
ACTIVITY, 0.05, ZAFE;

CREATE, 1, 1, 1, 1;
ACTIVITY;
ZAFJ GOON, 1;
ACTIVITY, 0.05, XX(35).LT.1.OR.NNQ(20).EQ.0, ZAFJ;
ACTIVITY, XX(35).GE.1.AND.NNQ(20).GE.1;
ALTER, BLINK10, 1, 1;
ACTIVITY, 0.05, ZAFJ;

DEPOT REPAIR ACTIVITY

DR GOON, 1;
ACTIVITY/86, ATRIB(4).EQ.1;
ACTIVITY/87, ATRIB(4).EQ.2, ZAHB;
ACTIVITY/88, ATRIB(4).EQ.3, ZAHD;
ACTIVITY/89, ATRIB(4).EQ.4, ZAHF;
ACTIVITY/90, ATRIB(4).EQ.5, ZAHG;
AWAIT(22), BLINK11, 1;
ACTIVITY;
ALTER, BLINK11, -1, 1;
ACTIVITY;
FREE, BLINK11, 1;
ACTIVITY/91, ATRIB(10), ATRIB(11);
ACTIVITY/92, ATRIB(12), ZAGZ;
ASSIGN, XX(31) = XX(31) +1, 1;
ACTIVITY;
TERMINATE;

ZAGZ ASSIGN, XX(11) = XX(11) +1, 1;
ACTIVITY;
TERMINATE;

ZAHB AWAIT(24), BLINK12, 1;
ACTIVITY;
ALTER, BLINK12, -1, 1;
ACTIVITY;
FREE, BLINK12, 1;
ACTIVITY/93, ATRIB(10), ATRIB(11);
ACTIVITY/94, ATRIB(12), ZAHF;
ASSIGN, XX(32) = XX(32) +1, 1;
ACTIVITY;
TERMINATE;

ZAHG ASSIGN, XX(12) = XX(12) +1, 1;
ACTIVITY;
TERMINATE;

ZAHD AWAIT(26), BLINK13, 1;
ACTIVITY;
ALTER, BLINK13, -1, 1;
ACTIVITY;
FREE, BLINK13, 1;
ACTIVITY/95, ATRIB(10), ATRIB(11);
ACTIVITY/96, 0, ZAHG;
ASSIGN, XX(33) = XX(33) +1, 1;
ACTIVITY;
TERMINATE;

ZAHG ASSIGN, XX(13) = XX(13) +1, 1;

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ACTIVITY;
TERMINATE;
ZAHF
WAIT(28),BLINK14,,1;
ACTIVITY;
ALTER,BLINK14,-1,1;
ACTIVITY;
FREE,BLINK14,1;
ACTIVITY/97,ATRIB(10),ATRIB(11);
ACTIVITY/98,,ATRIB(12),ZAHE;
ASSIGN,XX(34)=XX(34)+1,1;
ACTIVITY;
TERMINATE;
ZAHE
ASSIGN,XX(14)=XX(14)+1,1;
ACTIVITY;
TERMINATE;
ZAHG
WAIT(30),BLINK15,,1;
ACTIVITY;
ALTER,BLINK15,-1,1;
ACTIVITY;
FREE,BLINK15,1;
ACTIVITY/99,ATRIB(10),ATRIB(11);
ACTIVITY/100,,ATRIB(12),ZAHG;
ASSIGN,XX(35)=XX(35)+1,1;
ACTIVITY;
TERMINATE;
ZAHG
ASSIGN,XX(15)=XX(15)+1,1;
ACTIVITY;
TERMINATE;
/
CREATE,1,,1,1,1;
ACTIVITY;
ZAGP
GOON,1;
ACTIVITY,0.05,XX(31),GE.100.OR.NNQ(22),EQ.0,ZAGP;
ACTIVITY,XX(31),LT.100.AND.NNQ(22),GE.1;
ALTER,BLINK11,1,1;
ACTIVITY,0.05,,ZAGP;
/
CREATE,365,,1,,1;
ACTIVITY;
ASSIGN,ATRIB(13)=XX(11),XX(11)=0,1;
ACTIVITY,RNORM(730,73);
ASSIGN,XX(31)=XX(31)+ATRIB(13),1;
ACTIVITY;
TERMINATE;
/
CREATE,1,,1,1,1;
ACTIVITY;
ZAGQ
GOON,1;
ACTIVITY,0.05,XX(32),GE.100.OR.NNQ(24),EQ.0,ZAGQ;
ACTIVITY,XX(32),LT.100.AND.NNQ(24),GE.1;
ALTER,BLINK12,1,1;
ACTIVITY,0.05,,ZAGQ;
/
CREATE,365,,1,,1;
ACTIVITY;
ASSIGN,ATRIB(13)=XX(12),XX(12)=0,1;
ACTIVITY,RNORM(730,73);
ASSIGN,XX(32)=XX(32)+ATRIB(13),1;
ACTIVITY;
TERMINATE;
CREATE, 1,, 1,, 1;
ACTIVITY;
ZAGS
GOON, 1;
ACTIVITY, 0.05, XX(33) .GE. 100. OR. NNQ(26) .EQ. 0, ZAGS;
ACTIVITY, XX(33) .LT. 100. AND. NNQ(26) .GE. 1;
ALTER, BLINK13, 1, 1;
ACTIVITY, 0.05,, ZAGS;

CREATE, 365,, 1,, 1;
ACTIVITY;
 ASSIGN, ATRIB(13) = XX(13), XX(13) = 0, 1;
ACTIVITY, RNORM(730, 73);
 ASSIGN, XX(33) = XX(33) + ATRIB(13), 1;
ACTIVITY;
TERMINATE;
CREATE, 1,, 1,, 1;
ACTIVITY;
ZAGU
GOON, 1;
ACTIVITY, 0.05, XX(34) .GE. 100. OR. NNQ(28) .EQ. 0, ZAGU;
ACTIVITY, XX(34) .LT. 100. AND. NNQ(28) .GE. 1;
ALTER, BLINK14, 1, 1;
ACTIVITY, 0.05,, ZAGU;

CREATE, 365,, 1,, 1;
ACTIVITY;
 ASSIGN, ATRIB(13) = XX(14), XX(14) = 0, 1;
ACTIVITY, RNORM(730, 73);
 ASSIGN, XX(34) = XX(34) + ATRIB(13), 1;
ACTIVITY;
TERMINATE;
CREATE, 1,, 1,, 1;
ACTIVITY;
ZAGX
GOON, 1;
ACTIVITY, 0.05, XX(35) .GE. 100. OR. NNQ(30) .EQ. 0, ZAGX;
ACTIVITY, XX(35) .LT. 100. AND. NNQ(30) .GE. 1;
ALTER, BLINK15, 1, 1;
ACTIVITY, 0.05,, ZAGX;

CREATE, 365,, 1,, 1;
ACTIVITY;
 ASSIGN, ATRIB(13) = XX(15), XX(15) = 0, 1;
ACTIVITY, RNORM(730, 73);
 ASSIGN, XX(35) = XX(35) + ATRIB(13), 1;
ACTIVITY;
TERMINATE;

HML AT DYE.SS, TREATMENT HLH
CREATE, EXPON(50), 1,, 1, 1;
ACTIVITY, RLOGN(1, 3);
DHML
 ASSIGN, XX(45) = XX(45) - 1, ATRIB(2) = 2, ATRIB(4) = 1, ATRIB(5) = RLOGN(5, 1);
 ASSIGN, ATRIB(6) = .36, ATRIB(7) = .64, ATRIB(8) = RLOGN(22, 7);
 ASSIGN, ATRIB(9) = 0.0, ATRIB(10) = RLOGN(51, 16), ATRIB(11) = 1.0;
ASSIGN, ATRIB(12) = 0.0, 1;
ACTIVITY;
GOON, 2;
ACTIVITY;
ACTIVITY,, DHAA;
GOON, 1;
ACTIVITY,, XX(40) .LT. 1;
ACTIVITY, XX(40) .GE. 1, DHAB;
AWAIT(1), BLINK16, 1;
ACTIVITY;
ALTER, BLINK16, -1, 1;
ACTIVITY;
FREE, BLINK16, 1;
ACTIVITY;
ASSIGN, XX(40) = XX(40) - 1, 1;
ACTIVITY, RLOGN(1, .3);
ASSIGN, XX(45) = XX(45) + 1, 1;
ACTIVITY;
TERMINATE;

DHAB
ASSIGN, XX(40) = XX(40) - 1, 1;
ACTIVITY, RLOGN(1, .3);
ASSIGN, XX(45) = XX(45) + 1, 1;
ACTIVITY;
TERMINATE;

DHAA
GOON, 1;
ACTIVITY;
ACTIVITY,, ATRIB(9), DHAC;
GOON, 1;
ACTIVITY, ATRIB(5), ATRIB(6);
ACTIVITY, ATRIB(7), DHAD;
ASSIGN, XX(40) = XX(40) + 1, 1;
ACTIVITY;
TERMINATE;

DHAD
GOON, 2;
ACTIVITY;
ACTIVITY,, DS;
ASSIGN, XX(21) = XX(21) + 12.95;
ACTIVITY, ATRIB(8), DR;

DHAC
ASSIGN, XX(11) = XX(11) + 1, 1;
ACTIVITY,, DS;
ACTIVITY;
TERMINATE;

CREATE, 1, 1, 1, 1;
ACTIVITY;

DHAE
GOON, 1;
ACTIVITY, 0.05, XX(40) .LT. 1 OR. NNQ(1) .EQ. 0, DHAE;
ACTIVITY,, XX(40) .GE. 1 AND. NNQ(1) .GE. 1;
ALTER, BLINK16, 1, 1;
ACTIVITY,, 0.05,, DHAE;

SPLR AT DYESS, TREATMENT HLH

CREATE, EXPO(33.33), 1, 1, 1;
ACTIVITY, RLOGN(1, .3);

DSPL
ASSIGN, XX(46) = XX(46) - 1, ATRIB(2) = 2, ATRIB(4) = 2, ATRIB(5) = RLOGN(5, 1);
ASSIGN, ATRIB(6) = .36, ATRIB(7) = 0.64, ATRIB(8) = RLOGN(22, 7);
ASSIGN, ATRIB(9) = 0.0, ATRIB(10) = RLOGN(21, 6), ATRIB(11) = 1.0;
ASSIGN, ATRIB(12) = 0.0, 1;
ACTIVITY;
GOON, 2;
ACTIVITY;
ACTIVITY,, DSAA;
GOON, 1;
ACTIVITY,, XX(41), LT, 1;
ACTIVITY,, XX(41), GE, 1, DSAB;
AWEAIT(3), BLINK17, 1;
ACTIVITY;
ALTER, BLINK17, -1, 1;
ACTIVITY;
FREE, BLINK17, 1;
ACTIVITY;
ASSIGN, XX(41) = XX(41) - 1, 1;
ACTIVITY, RLOGN(1, .3);
ASSIGN, XX(46) = XX(46) + 1, 1;
ACTIVITY;
TERMINATE;

DSAB
ASSIGN, XX(41) = XX(41) - 1, 1;
ACTIVITY, RLOGN(1, .3);
ASSIGN, XX(46) = XX(46) + 1, 1;
ACTIVITY;
TERMINATE;

DSAA
GOON, 1;
ACTIVITY;
ACTIVITY,, ATRIB(9), DSAC;
GOON, 1;
ACTIVITY, ATRIB(5), ATRIB(6);
ACTIVITY,, ATRIB(7), DSAD;
ASSIGN, XX(41) = XX(41) + 1, 1;
ACTIVITY;
TERMINATE;

DSAD
GOON, 2;
ACTIVITY;
ACTIVITY,, DS;
ASSIGN, XX(22) = XX(22) + 20.72;
ACTIVITY, ATRIB(8), DR;

DSAC
ASSIGN, XX(12) = XX(12) + 1, 1;
ACTIVITY,, DS;
ACTIVITY;
TERMINATE;

CREATE, 1,, 1, 1, 1,
ACTIVITY;

DSAE
GOON, 1;
ACTIVITY, 0.05, XX(41), LT, 1, OR, NNQ(3), EQ, 0, DSAE;
ACTIVITY,, XX(41), GE, 1, AND, NNQ(3), GE, 1;
ALTER, BLINK17, 1, 1;
ACTIVITY, 0.05,, DSAE;

CREATE, EXPON(14.29), 1, 1, 1,
ACTIVITY, RLOGN(1, .3);

DINE
ASSIGN, XX(47) = XX(47) - 1, ATRIB(2) = 2, ATRIB(4) = 3, ATRIB(5) = RLOGN(5, 1);
ASSIGN, ATRIB(6) = .36, ATRIB(7) = 0.64, ATRIB(8) = RLOGN(22, 7);
ASSIGN, ATRIB(9) = 0.0, ATRIB(10) = RLOGN(53, 17), ATRIB(11) = 1.0;
ASSIGN, ATRIB(12) = 0.0, 1;
ACTIVITY;
GOON, 2;
ACTIVITY;
ACTIVITY, /, DIA;
GOON, 1;
ACTIVITY, /, XX(42). LT. 1;
ACTIVITY, /, XX(42). GE. 1, DIA;
AWAIT(5), BLINK18, 1;
ACTIVITY;
ALTER, BLINK18, -1, 1;
ACTIVITY;
FREE, BLINK18, 1;
ACTIVITY;
ASSIGN, XX(42) = XX(42) - 1, 1;
ACTIVITY, RLOGN(1, .3);
ASSIGN, XX(47) = XX(47) + 1, 1;
ACTIVITY;
TERMINATE;

DIAB
ASSIGN, XX(42) = XX(42) - 1, 1;
ACTIVITY, RLOGN(1, .3);
ASSIGN, XX(47) = XX(47) + 1, 1;
ACTIVITY;
TERMINATE;

DIA
GOON, 1;
ACTIVITY;
ACTIVITY, /, ATRIB(9), DIA;
GOON, 1;
ACTIVITY, ATRIB(5), ATRIB(6);
ACTIVITY, /, ATRIB(7), DIA;
ASSIGN, XX(42) = XX(42) + 1, 1;
ACTIVITY;
TERMINATE;

DIAD
GOON, 2;
ACTIVITY;
ACTIVITY, /, DS;
ASSIGN, XX(23) = XX(23) + 25.25;
ACTIVITY, ATRIB(8), /, DR;

DIAC
ASSIGN, XX(13) = XX(13) + 1, 1;
ACTIVITY, /, DS;
ACTIVITY;
TERMINATE;

CREATE, 1, 1, 1, 1;
ACTIVITY;

DIAE
GOON, 1;
ACTIVITY, 0.05, XX(42). LT. 1. OR. NNQ(5). EQ. 0, DIA;
ACTIVITY, /, XX(42). GE. 1. AND. NNQ(5). GE. 1;
ALTER, BLINK18, 1, 1;
ACTIVITY, 0.05, /, DIAE;

; FLAP AT DYESS, TREATMENT II
;
CREATE, EXPON(25), 1, 1, 1;
ACTIVITY, RLOGN(1, .3);

DFA
ASSIGN, XX(48) = XX(48) - 1, ATRIB(2) = 2, ATRIB(4) = 4, ATRIB(5) = RLOGN(5, 1);
ASSIGN, ATRIB(6) = .36, ATRIB(7) = 0.64, ATRIB(8) = RLOGN(22, 7);
ASSIGN, ATRIB(9) = 0.0, ATRIB(10) = RLOGN(23, 7), ATRIB(11) = 1.0;
ASSIGN, ATRIB(12) = 0.0, 1;
ACTIVITY;
GOON, 2;
ACTIVITY;
ACTIVITY , DFAA;
GOON, 1;
ACTIVITY, XX(43) . LT. 1;
ACTIVITY, XX(47) . GE. 1, DFAB;
AWAIT (7), BLINK19, 1;
ACTIVITY;
ALTER, BLINK19, -1, 1;
ACTIVITY;
FREE, BLINK19, 1;
ACTIVITY;
ASSIGN, XX(43) = XX(43) -1, 1;
ACTIVITY, RLOGN (1, . 3);
ASSIGN, XX(48) = XX(48) +1, 1;
ACTIVITY;
TERMINATE;
DFAB ASSIGN, XX(43) = XX(43) -1, 1;
ACTIVITY, RLOGN (1, . 3);
ASSIGN, XX(48) = XX(48) +1, 1;
ACTIVITY;
TERMINATE;
DFAA GOON, 1;
ACTIVITY;
ACTIVITY, ATRIB (9), DFAC;
GOON, 1;
ACTIVITY, ATRIB (5), ATRIB (6);
ACTIVITY, ATRIB (7), DFAD;
ASSIGN, XX(43) = XX(43) +1, 1;
ACTIVITY;
TERMINATE;
DFAD GOON, 2;
ACTIVITY;
ACTIVITY, , DS;
ASSIGN, XX(24) = XX(24) +15. 60;
ACTIVITY, ATRIB (8), , DR;
DFAC ASSIGN, XX(14) = XX(14) +1, 1;
ACTIVITY, , DS;
ACTIVITY;
TERMINATE;
CREATE, 1, 1, 1, 1;
ACTIVITY;
DFAE GOON, 1;
ACTIVITY, 0. 05, XX(43) . LT. 1 OR. NNQ(7) . EQ. 0, DFAE;
ACTIVITY, , XX(43) . GE. 1 AND. NNQ(7) . GE. 1;
ALTER, BLINK19, 1, 1;
ACTIVITY, 0. 05, , DFAE;
;
; CREATE, EXPON (10), 1, 1;
; ACTIVITY, RLOGN (1, . 3);
DCON ASSIGN, XX(49) = XX(49) -1, ATRIB (2) = 2, ATRIB (4) = 5, ATRIB (5) = RLOGN (5, 1);
ASSIGN, ATRIB (6) = . 36, ATRIB (7) = 0. 64, ATRIB (8) = RLOGN (22, 7);
ASSIGN, ATRIB (9) = 0. 0, ATRIB (10) = RLOGN (46, 15), ATRIB (11) = 1. 0;
ASSIGN, ATRIB(12) = 0.0, 1;
ACTIVITY;
GOON, 7;
ACTIVITY;
ACTIVITY, , , DCA;
GOON, 1;
ACTIVITY, , , XX(44) LT 1;
ACTIVITY, , , XX(44) GE 1, DCAB;
AWAIT(9), BLINK20, 1;
ACTIVITY;
ALTER, BLINK20, -1, 1;
ACTIVITY;
FREE, BLINK20, 1;
ACTIVITY;
ASSIGN, XX(44) = XX(44) - 1, 1;
ACTIVITY, RLOGN(1, .3);
ASSIGN, XX(49) = XX(49) + 1, 1;
ACTIVITY;
TERMINATE;

DCAB
ASSIGN, XX(44) = XX(44) - 1, 1;
ACTIVITY, RLOGN(1, .3);
ASSIGN, XX(49) = XX(49) + 1, 1;
ACTIVITY;
TERMINATE;

DCAA
GOON, 1;
ACTIVITY;
ACTIVITY, ATRIB(9), DCAC;
GOON, 1;
ACTIVITY, ATRIB(5), ATRIB(6);
ACTIVITY, ATRIB(7), DCAD;
ASSIGN, XX(44) = XX(44) + 1, 1;
ACTIVITY;
TERMINATE;

DCAD
GOON, 2;
ACTIVITY;
ACTIVITY, , DS;
ASSIGN, XX(25) = XX(25) + 21.37;
ACTIVITY, ATRIB(8), DR;

DCAC
ASSIGN, XX(15) = XX(15) + 1, 1;
ACTIVITY, , DS;
ACTIVITY;
TERMINATE;

; CREATE, 1, 1, 1, 1;
ACTIVITY;

DCAE
GOON, 1;
ACTIVITY, 0.05, XX(44) LT 1 OR NNQ(9) EQ 0, DCAE;
ACTIVITY, XX(44) GE 1 AND NNQ(9) GE 1;
ALTER, BLINK20, 1, 1;
ACTIVITY, 0.05, DCAE;

; HML AT GRAND FORKS, TREATMENT HLH

; CREATE, EXPON(50), 1, 1;
ACTIVITY/1, RLOGN(1, 0.3);
GHML
ASSIGN, ATRIB(10) = RLOGN(51, 16), ATRIB(11) = 1.0, ATRIB(12) = 0.0;
ASSIGN, ATRIB(6) = 0.36, ATRIB(7) = 0.64, ATRIB(8) = RLOGN(22, 7);

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ASSIGN, ATRIB(9) = 0.0, ATRIB(5) = RLOGN(5, 1), ATRIB(4) = 1, ATRIB(2) = 3;
ASSIGN, XX(55) = XX(55) - 1, 1;
ACTIVITY;
GOON, 2;
ACTIVITY;
ACTIVITY,,,GHFA;
GOON, 1;
ACTIVITY,,,XX(50) .LT. 1;
ACTIVITY,,,XX(50) .GE. 1, GHEX;
AWAIT(11), BLINK21,,1;
ACTIVITY;
ALTER, BLINK21, -1, 1;
ACTIVITY;
FREE, BLINK21, 1;
ACTIVITY;
ASSIGN, XX(50) = XX(50) - 1, 1;
ACTIVITY, RLOGN(1, 0.33);
ASSIGN, XX(55) = XX(55) + 1, 1;
ACTIVITY;
TERMINATE;

GHEX ASSIGN, XX(50) = XX(50) - 1, 1;
ACTIVITY, RLOGN(1, 0.33);
ASSIGN, XX(55) = XX(55) + 1, 1;
ACTIVITY;
TERMINATE;

GHFA GOON, 1;
ACTIVITY;
ACTIVITY,,,ATRIB(9), GHEZ;
GOON, 1;
ACTIVITY, ATRIB(5), ATRIB(6);
ACTIVITY,,,ATRIB(7), GHEY;
ASSIGN, XX(50) = XX(50) + 1, 1;
ACTIVITY;
TERMINATE;

GHEY GOON, 2;
ACTIVITY;
ACTIVITY,,,DS;
ASSIGN, XX(21) = XX(21) + 77.70, 1;
ACTIVITY, ATRIB(8),, DR;

GHEZ ASSIGN, XX(11) = XX(11) + 1, 2;
ACTIVITY,,,DS;
ACTIVITY;
TERMINATE;

CREATE, 1,,1,,1;
ACTIVITY;

GHGR GOON, 1;
ACTIVITY, 0.05, XX(50) .LT. 1 .OR. NNQ(11) .EQ. 0, GHGR;
ACTIVITY,, XX(50) .GE. 1 AND. NNQ(11) .GE. 1;
ALTER, BLINK21, 1, 1;
ACTIVITY,,.05,,GHGR;

SPLR AT GRAND FORKS, TREATMENT HLH
CREATE, EXPON(50), 1, 1, 1;
ACTIVITY/1, RLOGN(1, 0.3);

GSFR
ASSIGN, ATRIB(10) = RLOGN(21, 6), ATRIB(11) = 1.0, ATRIB(12) = 0.0;
ASSIGN, ATRIB(6) = 0.68, ATRIB(7) = 0.32, ATRIB(8) = RLOGN(22, 7);
ASSIGN, ATRIB(9) = 0.0, ATRIB(5) = RLOGN(5, 1), ATRIB(4) = 2, ATRIB(2) = 3;
ASSIGN, XX(56) = XX(56) - 1, 1;
ACTIVITY;
GOON, 2;
ACTIVITY;
ACTIVITY,, GSFA;
GOON, 1;
ACTIVITY,, XX(51) .LT. 1;
ACTIVITY,, XX(51) .GE. 1, GSEX;
AWAIT(13), BLINK22,, 1;
ACTIVITY;
ALTER, BLINK22, -1, 1;
ACTIVITY;
FREE BLINK22, 1;
ACTIVITY;
ASSIGN, XX(51) = XX(51) - 1, 1;
ACTIVITY, RLOGN(1, 0.33);
ASSIGN, XX(56) = XX(56) + 1, 1;
ACTIVITY;
TERMINATE;

GSEX
ASSIGN, XX(51) = XX(51) - 1, 1;
ACTIVITY, RLOGN(1, 0.33);
ASSIGN, XX(56) = XX(56) + 1, 1;
ACTIVITY;
TERMINATE;

GSFA
GOON, 1;
ACTIVITY;
ACTIVITY,, ATRIB(9), GHEZ;
GOON, 1;
ACTIVITY, ATRIB(5), ATRIB(6);
ACTIVITY, ATRIB(7), GHEY;
ASSIGN, XX(51) = XX(51) + 1, 1;
ACTIVITY;
TERMINATE;

GSEY
GOON, 2;
ACTIVITY;
ACTIVITY,, DS;
ASSIGN, XX(22) = XX(22) + 124.32, 1;
ACTIVITY, ATRIB(8), DR;

GSEZ
ASSIGN, XX(12) = XX(12) + 1, 2;
ACTIVITY,, DS;
ACTIVITY;
TERMINATE;

CREATE, 1, 1, 1, 1, 1;
ACTIVITY;

GSGR
GOON, 1;
ACTIVITY, 0.05, XX(51) .LT. 1. OR. NNQ(13) .EQ. 0, GSGR;
ACTIVITY, XX(51) .GE. 1. AND. NNQ(13) .GE. 1;
ALTER, BLINK22, 1, 1;
ACTIVITY, 0.05, GSGR;

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;
;
CREATE,EXPON(25),1,1;
ACTIVITY/1,RLOGN(1,0.3);
GNRT ASSIGN,ATRIB(10)=RLOGN(53,16),ATRIB(11)=1.0,ATRIB(12)=0.0;
ASSIGN,ATRIB(6)=0.53,ATRIB(7)=0.47,ATRIB(8)=RLOGN(22,7);
ASSIGN,ATRIB(9)=0.0,ATRIB(5)=RLOGN(5,1),ATRIB(4)=3,ATRIB(2)=3;
ASSIGN,XX(57)=XX(57)-1,1;
ACTIVITY;
GOON,2;
ACTIVITY;
ASSIGN,ATRIB(9)=,GIFA;
GOON,1;
ACTIVITY,,XX(52).LT.1;
ACTIVITY,,XX(52).GE.1,GIEX;
AWAIT(15),BLINK23,1;
ACTIVITY;
ALTER,BLINK23,-1,1;
ACTIVITY;
FREE,BLINK23,1;
ACTIVITY;
ASSIGN,XX(52)=XX(52)-1,1;
ACTIVITY,RLOGN(1,0.33);
ASSIGN,XX(57)=XX(57)+1,1;
ACTIVITY;
TERMINATE;
GIEX ASSIGN,XX(52)=XX(52)-1,1;
ACTIVITY,RLOGN(1,0.33);
ASSIGN,XX(57)=XX(57)+1,1;
ACTIVITY;
TERMINATE;
GIFA GOON,1;
ACTIVITY;
ACTIVITY,,ATRIB(9),GIEZ;
GOON,1;
ACTIVITY,ATRIB(5),ATRIB(6);
ACTIVITY,,ATRIB(7),GIEX;
ASSIGN,XX(52)=XX(52)+1,1;
ACTIVITY;
TERMINATE;
GIEY GOON,2;
ACTIVITY;
ACTIVITY,,DS;
ASSIGN,XX(23)=XX(23)+1.51.52,1;
ACTIVITY,ATRIB(8),,DR;
GIEZ ASSIGN,XX(13)=XX(13)+1,2;
ACTIVITY,,DS;
ACTIVITY;
TERMINATE;
;
CREATE,1,1,1,1;
ACTIVITY;
GIGR GOON,1;
ACTIVITY,0.05,XX(52).LT.1.OR.NNQ(15).EQ.0,GIGR;
ACTIVITY,,XX(52).GE.1.AND.NNQ(15).GE.1;
ALTER,BLINK23,1,1;
ACTIVITY,.05,,GIGR;
FLAP AT GRAND FORKS, TREATMENT HLH

CREATE, EXPON(33.33), 1, 1;
ACTIVITY/1, RLOGN(1, 0.3);

GFLP
ASSIGN, ATRIB(10) = RLOGN(23, 7), ATRIB(11) = 1.0, ATRIB(12) = 0.0;
ASSIGN, ATRIB(6) = 0.55, ATRIB(7) = 0.45, ATRIB(8) = RLOGN(22, 7);
ASSIGN, ATRIB(9) = 0.0, ATRIB(5) = RLOGN(3, 5), ATRIB(4) = 4, ATRIB(2) = 3;
ASSIGN, XX(58) = XX(58) + 1, 1;
ACTIVITY;
GOON, 2;
ACTIVITY;
ACTIVITY,, GFFA;
GOON, 1;
ACTIVITY,, XX(53).LT.1;
ACTIVITY,, XX(53).GE.1, GFEX;
AWAIT(17), BLINK24,.1;
ACTIVITY;
ALTER, BLINK24, -1, 1;
ACTIVITY;
FREE, BLINK24, 1;
ACTIVITY;
ASSIGN, XX(53) = XX(53) - 1, 1;
ACTIVITY, RLOGN(1, 0.33);
ASSIGN, XX(58) = XX(58) + 1, 1;
ACTIVITY;
TERMINATE;

GFEX
ASSIGN, XX(53) = XX(53) - 1, 1;
ACTIVITY, RLOGN(1, 0.33);
ASSIGN, XX(58) = XX(58) + 1, 1;
ACTIVITY;
TERMINATE;

GFFA
GOON, 1;
ACTIVITY;
ACTIVITY,, ATRIB(9), GFEX;
GOON, 1;
ACTIVITY, ATRIB(5), ATRIB(6);
ACTIVITY,, ATRIB(7), GFEX;
ASSIGN, XX(53) = XX(53) + 1, 1;
ACTIVITY;
TERMINATE;

GFEX
GOON, 2;
ACTIVITY;
ACTIVITY,, DS;
ASSIGN, XX(24) = XX(24) + 93.63, 1;
ACTIVITY, ATRIB(8), DR;

GFZ
ASSIGN, XX(14) = XX(14) + 1, 2;
ACTIVITY,, DS;
ACTIVITY;
TERMINATE;

CREATE, 1, 1, 1, 1;
ACTIVITY;

GFGR
GOON, 1;
ACTIVITY, 0.05, XX(53).LT.1.OR.NNQ(17).EQ.0, GFGR;
ACTIVITY, XX(53).GE.1.AND.NNQ(17).GE.1;
ALTER, BLINK24, 1, 1;
ACTIVITY, .05, GFGR;

CONV AT GRAND FORKS, TREATMENT HLH

CREATE, EXPON(16.67), 1, 1;
ACTIVITY/1, RLOGN(1, 0.3);
GCON
ASSIGN, ATRIB(10) = RLOGN(46, 15), ATRIB(11) = 1.0, ATRIB(12) = 0.0;
ASSIGN, ATRIB(6) = 0.73, ATRIB(7) = 0.27, ATRIB(8) = RLOGN(22, 7);
ASSIGN, ATRIB(9) = 0.0, ATRIB(5) = RLOGN(5, 1), ATRIB(4) = 5, ATRIB(2) = 3;
ASSIGN, XX(59) = XX(59) - 1, 1;
ACTIVITY;
GOON, 2;
ACTIVITY;
ACTIVITY, , GCFA;
GOON, 1;
ACTIVITY, XX(54) .LT. 1;
ACTIVITY, XX(54) .GE. 1, GCEX;
AWAIT (19), BLINK25, 1;
ACTIVITY;
ALTER, BLINK25, -1, 1;
ACTIVITY;
FREE, BLINK25, 1;
ACTIVITY;
ASSIGN, XX(54) = XX(54) - 1, 1;
ACTIVITY, RLOGN(1, 0.33);
ASSIGN, XX(59) = XX(59) + 1, 1;
ACTIVITY;
TERMINATE;
GCEX
ASSIGN, XX(54) = XX(54) - 1, 1;
ACTIVITY, RLOGN(1, 0.33);
ASSIGN, XX(59) = XX(59) + 1, 1;
ACTIVITY;
TERMINATE;
GCFA
GOON, 1;
ACTIVITY;
ACTIVITY, , ATRIB(9), GCEZ;
GOON, 1;
ACTIVITY, ATRIB(5), ATRIB(6);
ACTIVITY, , ATRIB(7), GCEY;
ASSIGN, XX(54) = XX(54) + 1, 1;
ACTIVITY;
TERMINATE;
GCEY
GOON, 2;
ACTIVITY;
ACTIVITY, , DR;
ASSIGN, XX(25) = XX(25) + 128.21, 1;
ACTIVITY, ATRIB(8), DR;
GCEZ
ASSIGN, XX(15) = XX(15) + 1, 2;
ACTIVITY, , DS;
ACTIVITY;
TERMINATE;
;
CREATE, 1, 1, 1, 1;
ACTIVITY;
GCGR
GOON, 1;
ACTIVITY, 0.05, XX(54) .LT. 1 OR NNQ(19) .EQ. 0, GCGR;
ACTIVITY, XX(54).GE.1.AND.XNQ(19).GE.1;
ALTER, BLINK25, 1, 1;
ACTIVITY, .05, ,GCGR;

; HML AT McCONNELL, TREATMENT HLH
;
CREATE, EXPON(50), 1, 1;
ACTIVITY/, RLOGN(1, 0.3);
MHML ASSIGN, ATRIB(10)-RLOGN(51, 16), ATRIB(11)=1.0, ATRIB(12)=0.0;
ASSIGN, ATRIB(6)=0.36, ATRIB(7)=0.64, ATRIB(8)=RLOGN(22, 7);
ASSIGN, ATRIB(9)=0.0, ATRIB(5)=RLOGN(5, 1), ATRIB(4)=1, ATRIB(2)=4;
ASSIGN, XX(65)=XX(65)+1, 1;
ACTIVITY;
GOON, 2;
ACTIVITY;
ACTIVITY,, ,MHFA;
GOON, 1;
ACTIVITY,, XX(60).LT.1;
ACTIVITY,, XX(60).GE.1,MHEX;
AWAIT (21), BLINK26,, 1;
ACTIVITY;
ALTER, BLINK26, -1, 1;
ACTIVITY;
FREE, BLINK26, 1;
ACTIVITY;
ASSIGN, XX(60)=XX(60)-1, 1;
ACTIVITY, RLOGN(1, 0.33);
ASSIGN, XX(65)=XX(65)+1, 1;
ACTIVITY;
TERMINATE;
MHEX ASSIGN, XX(60)=XX(60)-1, 1;
ACTIVITY, RLOGN(1, 0.33);
ASSIGN, XX(65)=XX(65)+1, 1;
ACTIVITY;
TERMINATE;
MHFA GOON, 1;
ACTIVITY;
ACTIVITY,, ATRIB(9), MHEZ;
GOON, 1;
ACTIVITY, ATRIB(5), ATRIB(6);
ACTIVITY,, ATRIB(7), MHEY;
ASSIGN, XX(60)=XX(60)+1, 1;
ACTIVITY;
TERMINATE;
MHEY GOON, 2;
ACTIVITY;
ACTIVITY,, DS;
ASSIGN, XX(21)=XX(21)+18.13, 1;
ACTIVITY, ATRIB(8), , DR;
MHEZ ASSIGN, XX(11)=XX(11)+1, 2;
ACTIVITY,, DS;
ACTIVITY;
TERMINATE;
CREATE, 1, 1, 1, 1;
ACTIVITY;
MHGR GOON, 1;
CREATE, 1, 1, 1, 1;
ACTIVITY;

MSGR  GOON, 1;
ACTIVITY, 0.05, XX(61) .LT. 1. OR. NNQ(23) .EQ. 0, MSGR;
ACTIVITY, XX(61) .GE. 1. AND. NNQ(23) .GE. 1;
ALTER, BLINK27, 1, 1;
ACTIVITY, .05, MSGR;

INERT AT MCCONNELL, TREATMENT HLH

CREATE, EXPON(20), 1, 1;
ACTIVITY/1, RLOGN(1, 0.3);

MNRT ASSIGN, ATRIB(10) = RLOGN(53, 17), ATRIB(11) = 1.0, ATRIB(12) = 0.0;
ASSIGN, ATRIB(6) = 0.53, ATRIB(7) = 0.47, ATRIB(8) = RLOGN(22, 7);
ASSIGN, ATRIB(9) = 0.0, ATRIB(5) = RLOGN(5, 1), ATRIB(4) = 3, ATRIB(2) = 4;
ASSIGN, XX(67) = XX(67) - 1.1;
ACTIVITY;
GOON, 2;
ACTIVITY;
ACTIVITY,, MIFA;
GOON, 1;
ACTIVITY, XX(62) .LT. 1;
ACTIVITY, XX(62) .GE. 1, MIEX;
AWAIT (25), BLINK28, 1;
ACTIVITY;
ALTER, BLINK28, 1, 1;
ACTIVITY;
FREE, BLINK28, 1;
ACTIVITY;
ASSIGN, XX(62) = XX(62) - 1.1;
ACTIVITY, RLOGN(1, 0.33);
ASSIGN, XX(67) = XX(67) + 1.1;
ACTIVITY;
TERMINATE;

MIEX ASSIGN, XX(62) = XX(62) - 1.1;
ACTIVITY, RLOGN(1, 0.33);
ASSIGN, XX(67) = XX(67) + 1.1;
ACTIVITY;
TERMINATE;

MIFA GOON, 1;
ACTIVITY;
ACTIVITY,, ATRIB(9), MIEZ;
GOON, 1;
ACTIVITY, ATRIB(5), ATRIB(6);
ACTIVITY,, ATRIB(7), MIEX;
ASSIGN, XX(62) = XX(62) + 1.1;
ACTIVITY;
TERMINATE;

MIEX GOON, 2;
ACTIVITY;
ACTIVITY,, DS;
ASSIGN, XX(23) = XX(23) + 35.35, 1;
ACTIVITY, ATRIB(8), DR;

MIEZ ASSIGN, XX(13) = XX(13) + 1.2;
ACTIVITY,, DS;
ACTIVITY;
TERMINATE;
;
CREATE, 1, 1, 1, 1;
ACTIVITY;

MIGR
GOON, 1;
ACTIVITY, 0.05, XX(62).LT.1.OR.NNQ(25).EQ.0,MIGR;
ACTIVITY, XX(62).GE.1.AND.NNQ(25).GE.1;
ALTER, BLINK28, 1, 1;
ACTIVITY, 0.05, MIGR;

FLAP AT MCCONNELL, TREATMENT HLH
;
;
CREATE, EXPON(33.33), 1, 1;
ACTIVITY/1, RLOGN(1, 0.3);

MFLP
ASSIGN, ATRIB(10) = RLOGN(23, 7), ATRIB(11) = 1.0, ATRIB(12) = 0.0;
ASSIGN, ATRIB(6) = 0.55, ATRIB(7) = 0.45, ATRIB(8) = RLOGN(22, 7);
ASSIGN, ATRIB(9) = 0.0, ATRIB(5) = RLOGN(3, 5), ATRIB(4) = 4, ATRIB(2) = 4;
ASSIGN, XX(68) = XX(68) - 1, 1;
ACTIVITY;
GOON, 2;
ACTIVITY;
ACTIVITY,, MFFA;
GOON, 1;
ACTIVITY,, XX(63).LT.1;
ACTIVITY,, XX(63).GE.1,MFEX;
AWAIT(27), BLINK29, 1;
ACTIVITY;
ALTER, BLINK29, -1, 1;
ACTIVITY;
FREE, BLINK29, 1;
ACTIVITY;
ASSIGN, XX(63) = XX(63) - 1, 1;
ACTIVITY, RLOGN(1, 0.33);
ASSIGN, XX(68) = XX(68) + 1, 1;
ACTIVITY;
TERMINATE;

MFEX
ASSIGN, XX(63) = XX(63) - 1, 1;
ACTIVITY, RLOGN(1, 0.33);
ASSIGN, XX(68) = XX(68) + 1, 1;
ACTIVITY;
TERMINATE;

MFFA
GOON, 1;
ACTIVITY,
ACTIVITY,, ATRIB(9), MFEZ;
GOON, 1;
ACTIVITY, ATRIB(5), ATRIB(6);
ACTIVITY,, ATRIB(7), MFEX;
ASSIGN, XX(63) = XX(63) + 1, 1;
ACTIVITY;
TERMINATE;

MFEX
GOON, 2;
ACTIVITY;
ACTIVITY,, DS;
ASSIGN, XX(24) = XX(24) + 21.85, 1;
ACTIVITY, ATRIB(8), DR;

MFEZ
ASSIGN, XX(14) = XX(14) + 1, 2;
ACTIVITY,,DS;
ACTIVITY;
TERMINATE;
;
CREATE,1,1,1,1;
ACTIVITY;
MFR
GOON,1;
ACTIVITY,0.05,XX(63).LT.1.OR.NNQ(27).EQ.0,MFR;
ACTIVITY,,XX(63).GE.1.AND.NNQ(27).GE.1;
ALTER,BLINK29,1,1;
ACTIVITY,.05,,MFR;
;
CONV AT MCCONNELL, TREATMENT HLH
;
;
CREATE,EXPON(16.67),1,1,1;
ACTIVITY/1,RLOGN(1,0.3);
MCON
ASSIGN,ATRIB(10)=RLOGN(46,15),ATRIB(11)=1.0,ATRIB(12)=0.0;
ASSIGN,ATRIB(6)=0.73,ATRIB(7)=0.27,ATRIB(8)=RLOGN(22,7);
ASSIGN,ATRIB(9)=0.0,ATRIB(5)=RLOGN(5,1),ATRIB(4)=5,ATRIB(2)=4;
ASSIGN,XX(69)=XX(69)-1,1;
ACTIVITY;
GOON,2;
ACTIVITY;
ACTIVITY,,MCFA;
GOON,1;
ACTIVITY,,XX(64).LT.1;
ACTIVITY,,XX(64).GE.1,MCEX;
AWAIT(29),BLINK30,,1;
ACTIVITY;
ALTER,BLINK30,-1,1;
ACTIVITY;
FREE,BLINK30,1;
ACTIVITY;
ASSIGN,XX(64)=XX(64)-1,1;
ACTIVITY,RLOGN(1,0.33);
ASSIGN,XX(69)=XX(69)+1,1;
ACTIVITY;
TERMINATE;
MCEX
ASSIGN,XX(64)=XX(64)-1,1;
ACTIVITY,RLOGN(1,0.33);
ASSIGN,XX(69)=XX(69)+1,1;
ACTIVITY;
TERMINATE;
MCFA
GOON,1;
ACTIVITY;
ACTIVITY,,ATRIB(9),MCEZ;
GOON,1;
ACTIVITY,ATRIB(5),ATRIB(6);
ACTIVITY,,ATRIB(7),MCEY;
ASSIGN,XX(64)=XX(64)+1,1;
ACTIVITY;
TERMINATE;
MCEY
GOON,2;
ACTIVITY;
ACTIVITY,,DS;
ASSIGN,XX(25)=XX(25)+29.91,1;
ACTIVITY, ATRIB(8), DS;
MCEZ ASSIGN, XX(15) = XX(15) + 1, 2;
ACTIVITY, DS;
ACTIVITY;
TERMINATE;
CREATE, 1, 1, 1, 1;
ACTIVITY;
MCGR GON, 1;
ACTIVITY, 0.05, XX(64).LT.1.OR.NNQ(29).EQ.0, MCGR;
ACTIVITY, XX(64).GE.1.AND.NNQ(29).GE.1;
ALTER, BINK30, 1, 1;
ACTIVITY, .05, MCGR;
END;

MONTR, CLEAR, 730;
SEEDS, 1048015(1)/YES;
SIMULATE;
MONTR, CLEAR, 730;
SEEDS, 2236846(1)/YES;
SIMULATE;
MONTR, CLEAR, 730;
SEEDS, 2415348(1)/YES;
SIMULATE;
MONTR, CLEAR, 730;
SEEDS, 4216793(1)/YES;
SIMULATE;
MONTR, CLEAR, 730;
SEEDS, 3757039(1)/YES;
SIMULATE;
MONTR, CLEAR, 730;
SEEDS, 7792106(1)/YES;
SIMULATE;
MONTR, CLEAR, 730;
SEEDS, 9956272(1)/YES;
SIMULATE;
MONTR, CLEAR, 730;
SEEDS, 9630191(1)/YES;
SIMULATE;
MONTR, CLEAR, 730;
SEEDS, 8957914(1)/YES;
SIMULATE;
SEEDS, 0711997(1)/YES; SIMULATE;
MONTR, CLEAR, 730;
SEEDS, 5108512(1)/YES; SIMULATE;
MONTR, CLEAR, 730;
SEEDS, 0236821(1)/YES; SIMULATE;
MONTR, CLEAR, 730;
SEEDS, 0101154(1)/YES; SIMULATE;
MONTR, CLEAR, 730;
SEEDS, 5216253(1)/YES; SIMULATE;
MONTR, CLEAR, 730;
SEEDS, 0705697(1)/YES; SIMULATE;
MONTR, CLEAR, 730;
SEEDS, 066391(1)/YES; SIMULATE;
MONTR, CLEAR, 730;
SEEDS, 5416458(1)/YES; SIMULATE;
MONTR, CLEAR, 730;
SEEDS, 3263932(1)/YES; SIMULATE;
MONTR, CLEAR, 730;
SEEDS, 2933427(1)/YES; SIMULATE;
MONTR, CLEAR, 730;
SEEDS, 0248833(1)/YES; SIMULATE;
MONTR, CLEAR, 730;
SEEDS, 8152572(1)/YES; SIMULATE;
MONTR, CLEAR, 730;
SEEDS, 2967620(1)/YES; SIMULATE;
MONTR, CLEAR, 730;
SEEDS, 0074257(1)/YES; SIMULATE;
MONTR, CLEAR, 730;
SEEDS, 0536604(1)/YES; SIMULATE;
MONTR, CLEAR, 730;
SEEDS, 9192126(1)/YES; FIN;
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Appendix C: Description of the Simulation Model

Introduction

This appendix provides a basic description of the simulation model logic. The code and corresponding graphical representations discussed in this appendix are representative of the code as a whole. Many portions of the code repeat the same basic structure and use similar lines of code with only minor differences. The graphical representations are provided merely for ease of understanding. The actual experimental design involved reproducing the code found in Appendix B twenty seven times, with minor differences (one model for each treatment of the experimental design).

Attributes, Files, and Global Variables

The following tables show the attributes, files, and global variables used in the simulation code.

Table C-1. Attributes Used in the Simulation Code.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Attribute Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mark Time</td>
</tr>
<tr>
<td>2</td>
<td>Base where the entity originated</td>
</tr>
<tr>
<td>4</td>
<td>Type of repairable, i.e. HML, SPLR, INERT, FLAP, or CONV</td>
</tr>
<tr>
<td>5</td>
<td>Base repair cycle time</td>
</tr>
<tr>
<td>6</td>
<td>Percent base repair</td>
</tr>
<tr>
<td>7</td>
<td>Base NRTS rate</td>
</tr>
<tr>
<td>8</td>
<td>Transportation time</td>
</tr>
<tr>
<td>9</td>
<td>Base condemnation rate</td>
</tr>
<tr>
<td>10</td>
<td>Depot repair cycle time</td>
</tr>
<tr>
<td>11</td>
<td>Percent depot repair</td>
</tr>
<tr>
<td>12</td>
<td>Depot condemnation rate</td>
</tr>
<tr>
<td>13</td>
<td># new assets needed to replace condemned repairables</td>
</tr>
<tr>
<td>File Number</td>
<td>Purpose of File</td>
</tr>
<tr>
<td>-------------</td>
<td>---------------------------------------------------</td>
</tr>
<tr>
<td>2</td>
<td>MIL entities at Ellsworth AWAIT resource BLINK1</td>
</tr>
<tr>
<td>4</td>
<td>SPLR entities at Ellsworth AWAIT resource BLINK2</td>
</tr>
<tr>
<td>6</td>
<td>INERT entities at Ellsworth AWAIT resource BLINK3</td>
</tr>
<tr>
<td>8</td>
<td>FLAP entities at Ellsworth AWAIT resource BLINK4</td>
</tr>
<tr>
<td>10</td>
<td>CONV entities at Ellsworth AWAIT resource BLINK5</td>
</tr>
<tr>
<td>12</td>
<td>MIL entities at Depot/ISP supply AWAIT BLINK6</td>
</tr>
<tr>
<td>14</td>
<td>SPLR entities at Depot/ISP supply AWAIT BLINK7</td>
</tr>
<tr>
<td>16</td>
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</tr>
<tr>
<td>18</td>
<td>FLAP entities at Depot/ISP supply AWAIT BLINK9</td>
</tr>
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<td>20</td>
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</tr>
<tr>
<td>22</td>
<td>MIL entities at Depot repair AWAIT BLINK11</td>
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<tr>
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<td>CONV entities at Depot repair AWAIT BLINK15</td>
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</tr>
<tr>
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</tr>
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<td>INERT entities at Dyess AWAIT resource BLINK18</td>
</tr>
<tr>
<td>7</td>
<td>FLAP entities at Dyess AWAIT resource BLINK19</td>
</tr>
<tr>
<td>9</td>
<td>CONV entities at Dyess AWAIT resource BLINK20</td>
</tr>
<tr>
<td>11</td>
<td>MIL entities at Grand Fks AWAIT resource BLINK21</td>
</tr>
<tr>
<td>13</td>
<td>SPLR entities at Grand Fks AWAIT resource BLINK22</td>
</tr>
<tr>
<td>15</td>
<td>INERT entities at Grand Fks AWAIT resource BLINK23</td>
</tr>
<tr>
<td>17</td>
<td>FLAP entities at Grand Fks AWAIT resource BLINK24</td>
</tr>
<tr>
<td>19</td>
<td>CONV entities at Grand Fks AWAIT resource BLINK25</td>
</tr>
<tr>
<td>21</td>
<td>MIL entities at McConnell AWAIT resource BLINK26</td>
</tr>
<tr>
<td>23</td>
<td>SPLR entities at McConnell AWAIT resource BLINK27</td>
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<td>25</td>
<td>INERT entities at McConnell AWAIT resource BLINK28</td>
</tr>
<tr>
<td>27</td>
<td>FLAP entities at McConnell AWAIT resource BLINK29</td>
</tr>
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<td>29</td>
<td>CONV entities at McConnell AWAIT resource BLINK30</td>
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<td>Global Variable Definition</td>
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</tr>
<tr>
<td>7</td>
<td># of serviceable SPLRS in the fleet at Ellsworth</td>
</tr>
<tr>
<td>8</td>
<td># of serviceable INERTS in the fleet at Ellsworth</td>
</tr>
<tr>
<td>9</td>
<td># of serviceable FLAPS in the fleet at Ellsworth</td>
</tr>
<tr>
<td>10</td>
<td># of serviceable CONVS in the fleet at Ellsworth</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td># of serviceable EMLs at Ellsworth base supply</td>
</tr>
<tr>
<td>3</td>
<td># of serviceable SPLRS at Ellsworth base supply</td>
</tr>
<tr>
<td>4</td>
<td># of serviceable INERTS at Ellsworth base supply</td>
</tr>
<tr>
<td>5</td>
<td># of serviceable FLAPS at Ellsworth base supply</td>
</tr>
<tr>
<td>6</td>
<td># of serviceable CONVS at Ellsworth base supply</td>
</tr>
<tr>
<td>11</td>
<td># of EMLs condemned from the system</td>
</tr>
<tr>
<td>12</td>
<td># of SPLRS condemned from the system</td>
</tr>
<tr>
<td>13</td>
<td># of INERTS condemned from the system</td>
</tr>
<tr>
<td>14</td>
<td># of FLAPS condemned from the system</td>
</tr>
<tr>
<td>15</td>
<td># of CONVS condemned from the system</td>
</tr>
<tr>
<td>21</td>
<td>Transportation cost for EMLs between bases and the Depot/ISP</td>
</tr>
<tr>
<td>22</td>
<td>Transportation cost for SPLRS between bases and the Depot/ISP</td>
</tr>
<tr>
<td>23</td>
<td>Transportation cost for INERTS between bases and the Depot/ISP</td>
</tr>
<tr>
<td>24</td>
<td>Transportation cost for FLAPS between bases and the Depot/ISP</td>
</tr>
<tr>
<td>25</td>
<td>Transportation cost for CONVS between bases and the Depot/ISP</td>
</tr>
<tr>
<td>31</td>
<td># serviceable EMLs at the Depot/ISP supply</td>
</tr>
<tr>
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<td># serviceable SPLRS at the Depot/ISP supply</td>
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<tr>
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<td># serviceable INERTS at the Depot/ISP supply</td>
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<td>34</td>
<td># serviceable FLAPS at the Depot/ISP supply</td>
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<td>35</td>
<td># serviceable CONVS at the Depot/ISP supply</td>
</tr>
<tr>
<td>40</td>
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<td>43</td>
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</tr>
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</tr>
<tr>
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<td># of serviceable INERTS in the fleet at Dyess</td>
</tr>
<tr>
<td>48</td>
<td># of serviceable FLAPS in the fleet at Dyess</td>
</tr>
<tr>
<td>49</td>
<td># of serviceable CONVS in the fleet at Dyess</td>
</tr>
<tr>
<td>50</td>
<td># of serviceable EMLs at Grnd Fks base supply</td>
</tr>
<tr>
<td>Line</td>
<td>Description</td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
</tr>
<tr>
<td>51</td>
<td># of serviceable SPLRB at Grnd Fks base supply</td>
</tr>
<tr>
<td>52</td>
<td># of serviceable INIRTS at Grnd Fks base supply</td>
</tr>
<tr>
<td>53</td>
<td># of serviceable FLAPS at Grnd Fks base supply</td>
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<td>54</td>
<td># of serviceable CONVS at Grnd Fks base supply</td>
</tr>
<tr>
<td>55</td>
<td># of serviceable EML8 in the fleet at Grnd Fks</td>
</tr>
<tr>
<td>56</td>
<td># of serviceable SPLRS in the fleet at Grnd Fks</td>
</tr>
<tr>
<td>57</td>
<td># of serviceable INIRTS in the fleet at Grnd Fks</td>
</tr>
<tr>
<td>58</td>
<td># of serviceable FLAPS in the fleet at Grnd Fks</td>
</tr>
<tr>
<td>59</td>
<td># of serviceable CONVS in the fleet at Grnd Fks</td>
</tr>
<tr>
<td>60</td>
<td># of serviceable EML8 at McConnell base supply</td>
</tr>
<tr>
<td>61</td>
<td># of serviceable SPLRS at McConnell base supply</td>
</tr>
<tr>
<td>62</td>
<td># of serviceable INIRTS at McConnell base supply</td>
</tr>
<tr>
<td>63</td>
<td># of serviceable FLAPS at McConnell base supply</td>
</tr>
<tr>
<td>64</td>
<td># of serviceable CONVS at McConnell base supply</td>
</tr>
<tr>
<td>65</td>
<td># of serviceable EML8 in the fleet at McConnell</td>
</tr>
<tr>
<td>66</td>
<td># of serviceable SPLRS in the fleet at McConnell</td>
</tr>
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<td># of serviceable INIRTS in the fleet at McConnell</td>
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<tr>
<td>68</td>
<td># of serviceable FLAPS in the fleet at McConnell</td>
</tr>
<tr>
<td>69</td>
<td># of serviceable CONVS in the fleet at McConnell</td>
</tr>
<tr>
<td>101</td>
<td>Average acft availability at Ellsworth</td>
</tr>
<tr>
<td>102</td>
<td>Average acft availability at Dyess</td>
</tr>
<tr>
<td>103</td>
<td>Average acft availability at Grand Forks</td>
</tr>
<tr>
<td>104</td>
<td>Average acft availability at McConnell</td>
</tr>
<tr>
<td>105</td>
<td>Average acft availability across all bases</td>
</tr>
<tr>
<td>106</td>
<td>Average fill rate at Ellsworth</td>
</tr>
<tr>
<td>107</td>
<td>Average fill rate at Dyess</td>
</tr>
<tr>
<td>108</td>
<td>Average fill rate at Grand Forks</td>
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<td>109</td>
<td>Average fill rate at McConnell</td>
</tr>
<tr>
<td>110</td>
<td>Average fill rate across all bases</td>
</tr>
<tr>
<td>111</td>
<td>Average fill rate at Depot</td>
</tr>
<tr>
<td>112</td>
<td>Total transportation cost for all assets, all bases</td>
</tr>
</tbody>
</table>

**Model Description**

**Control Statements.** Refer to Figure C-1 for the following discussion. Lines 1 through 17 are merely the
necessary control statements that SLAM II uses to set up the run.

```
1 GEN,HILLWALKER,TESTRHH,31/7/1994,10,Y,Y,Y,Y,Y/1,72;
2 LIMITS,30,20,15000;
3 INITIALIZE,,1095,Y;
4 INTLC,X(2)=1,XX (3)=1,XX (4)=3,XX (5)=2,XX (6)=3;
5 INTLC,XX (31)=5,XX (32)=3,XX (33)=14,XX (34)=6,XX (35)=11;
6 INTLC,XX (40)=2,XX (41)=2,XX (42)=3,XX (43)=2,XX (44)=3;
7 INTLC,XX (50)=1,XX (51)=1,XX (52)=2,XX (53)=1,XX (54)=2;
8 INTLC,XX (60)=1,XX (61)=1,XX (62)=2,XX (63)=1,XX (64)=2;
9 INTLC,XX (1)=24,XX (7)=24,XX (8)=24,XX (9)=24,XX (10)=24;
10 INTLC,XX (45)=28,XX (46)=28,XX (47)=28,XX (48)=28,XX (49)=28;
11 INTLC,XX (55)=16,XX (56)=16,XX (57)=16,XX (58)=16,XX (59)=16;
12 INTLC,XX (65)=16,XX (66)=16,XX (67)=16,XX (68)=16,XX (69)=16;
13 TIMST,XX (105),EST FCFT AVAIL;
14 TIMST,XX (110),AV BS FILL RATE;
15 TIMST,XX (111),AV DS FILL RATE;
16 TIMST,XX (112),TRANS COST;
17 NETWORK;
```

**Figure C-1. Simulation Model Control Statements.**

*Initialize Statements.* Refer to Figure C-1, above, for the following discussion. Lines 4 through 12 of the code initialize the global variables of interest. The tables above define all the variables. Line 4 initializes the number of parts at Ellsworth base supply. Line 5 initializes the number of parts at depot supply/ISP. Line 6 initializes the number of parts at Dyess base supply. Line 7 initializes the number of parts at Grand Forks base supply. Line 8 initializes the number of parts at McConnell base supply. Line 9 initializes the number of parts in the fleet at Ellsworth. Line 10 initializes the number of parts in the fleet at Dyess. Line 11 initializes the number of parts in the fleet at Grand Forks. Line 12 initializes the number of parts in the fleet at McConnell.
<table>
<thead>
<tr>
<th>Line</th>
<th>RESOURCE/1, BLINK1(0), 2;</th>
</tr>
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<tbody>
<tr>
<td>19</td>
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<td>RESOURCE/3, BLINK3(0), 6;</td>
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<td>RESOURCE/4, BLINK4(0), 8;</td>
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<td>RESOURCE/5, BLINK5(0), 10;</td>
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<td>RESOURCE/6, BLINK6(0), 12;</td>
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<td>RESOURCE/7, BLINK7(0), 14;</td>
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<tr>
<td>25</td>
<td>RESOURCE/8, BLINK8(0), 16;</td>
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<td>RESOURCE/9, BLINK9(0), 18;</td>
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<td>RESOURCE/11, BLINK11(0), 22;</td>
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<td>RESOURCE/13, BLINK13(0), 26;</td>
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<tr>
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<td>RESOURCE/15, BLINK15(0), 30;</td>
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<td>RESOURCE/16, BLINK16(0), 1;</td>
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<td>RESOURCE/17, BLINK17(0), 3;</td>
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<td>RESOURCE/19, BLINK19(0), 7;</td>
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<td>37</td>
<td>RESOURCE/20, BLINK20(0), 9;</td>
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<td>38</td>
<td>RESOURCE/21, BLINK21(0), 11;</td>
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<td>47</td>
<td>RESOURCE/30, BLINK30(0), 29;</td>
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</tbody>
</table>

**Figure C-2. Resource Statements of the Simulation Model.**

**Resources.** Refer to Figure C-2, above, for the following discussion. The resource statements set the initial levels of the resources used in the model's "blinker mechanisms." The details of how the resource and "blinker mechanism" combination works will be explained in a later section of this appendix.

**Computation of Dependent Variables.** Refer to Figure __ for the following discussion. Lines 51 through 66 are the algebraic formulas used to compute the dependent variables.
Line 51 causes the computations to be performed every 7 simulated days. Lines 53 through 56

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>51</td>
<td>CREATE,7,7,;</td>
</tr>
<tr>
<td>52</td>
<td>ACTIVITY;</td>
</tr>
<tr>
<td>53</td>
<td>ASSIGN,XX(101)=XX(1)*XX(7)*XX(8)*XX(9)*XX(10)/7962624;</td>
</tr>
<tr>
<td>54</td>
<td>ASSIGN,XX(102)=XX(45)*XX(46)*XX(47)*XX(48)*XX(49)/17210368;</td>
</tr>
<tr>
<td>55</td>
<td>ASSIGN,XX(103)=XX(55)*XX(56)*XX(57)*XX(58)*XX(59)/1048576;</td>
</tr>
<tr>
<td>56</td>
<td>ASSIGN,XX(104)=XX(65)*XX(66)*XX(67)*XX(68)*XX(69)/1048576;</td>
</tr>
<tr>
<td>57</td>
<td>ASSIGN,XX(105)=XX(101)/4+XX(102)/4+XX(103)/4+XX(104)/4;</td>
</tr>
<tr>
<td>58</td>
<td>ASSIGN,XX(106)=XX(2)/5+XX(3)/5+XX(4)/15+XX(5)/10+XX(6)/15;</td>
</tr>
<tr>
<td>59</td>
<td>ASSIGN,XX(107)=XX(40)/10+XX(41)/10+XX(42)/15+XX(43)/10+XX(44)/15;</td>
</tr>
<tr>
<td>60</td>
<td>ASSIGN,XX(108)=XX(50)/5+XX(51)/5+XX(52)/10+XX(53)/5+XX(54)/10;</td>
</tr>
<tr>
<td>61</td>
<td>ASSIGN,XX(109)=XX(60)/5+XX(61)/5+XX(62)/10+XX(63)/5+XX(64)/10;</td>
</tr>
<tr>
<td>62</td>
<td>ASSIGN,XX(110)=XX(106)/4+XX(107)/4+XX(108)/4+XX(109)/4;</td>
</tr>
<tr>
<td>63</td>
<td>ASSIGN,XX(111)=XX(31)/20+XX(32)/15+XX(33)/10+XX(34)/45+XX(35)/20+XX(35)/35;</td>
</tr>
<tr>
<td>64</td>
<td>ASSIGN,XX(112)=XX(21)+XX(22)+XX(23)+XX(24)+XX(25);</td>
</tr>
<tr>
<td>65</td>
<td>ACTIVITY;</td>
</tr>
<tr>
<td>66</td>
<td>TERMINATE;</td>
</tr>
</tbody>
</table>

**Figure C-3. Computation of Dependent Variables.**

compute aircraft availability for Ellsworth, Dyess, Grand Forks, and McConnell, respectively. Line 57 computes aircraft availability across all the bases. Lines 58 though 63 were not needed. Line 64 totals transportation costs for all assets in the system.

**Asset Activity at the Base Level.** Refer to Figures C-4 and C-5 for the following discussion. This set of code was repeated with minor differences for each of the five assets of interest at each of the four bases. Line 70 creates a demand for a part (think of it as a broken part on the aircraft) based on the distribution and interarrival time. The broken part is removed from the aircraft in line 71. Lines 72 through 74 assign various attributes to the broken part that will be used downstream in the simulation model.
These attributes change from treatment to treatment, asset to asset.

```
70 CREATE,EXPON(33,33),1/1;
71 ACTIVITY/1,RLOGN(1,0.3);
72 ASSIGN, ATRIB(10)=RLOGN(51,16), ATRIB(11)=1.0, ATRIB(12)=0.0;
73 ASSIGN, ATRIB(5)=0.36, ATRIB(7)=0.64, ATRIB(8)=RLOGN(22,7);
74 ASSIGN, ATRIB(9)=0.0, ATRIB(5)=RLOGN(5,1), ATRIB(4)=1, ATRIB(2)=1;
75 ASSIGN, XX(1)=XX(1)-1/1;
76 ACTIVITY;
77 GOON,2;
78 ACTIVITY/2;
79 ACTIVITY/3,,EHAA;
80 GOON,1;
81 ACTIVITY/4,,XX(2).LT.1;
82 ACTIVITY/5,,XX(2).GE.1,EHAB;
83 AWAIT(2),BLINK1,,1;
84 ACTIVITY;
85 ALTER,BLINK1,-1,1;
86 ACTIVITY;
87 FREL,BLINK1,1;
88 ACTIVITY;
89 ASSIGN, XX(2)=XX(2)-1,1;
90 ACTIVITY/6,RLOGN(1,0.33);
91 ASSIGN, XX(1)=XX(1)+1,1;
92 ACTIVITY;
93 TERMINATE;
94 EHAB ASSIGN,XX(2)=XX(2)-1,1;
95 ACTIVITY/7,RLOGN(1,0.33);
96 ASSIGN,XX(1)=XX(1)+1,1;
97 ACTIVITY;
98 TERMINATE;
99 EHAA GOON,1;
100 ACTIVITY/8;
101 ACTIVITY/9,,ATRIB(9),EHAC;
102 GOON,1;
103 ACTIVITY/10,ATRIB(5),ATRIB(6);
104 ACTIVITY/11,,ATRIB(7),EHAD;
105 ASSIGN,XX(2)=XX(2)+1,1;
106 ACTIVITY;
107 TERMINATE;
108 EHAD GOON,2;
109 ACTIVITY;
110 ACTIVITY/13,,DS;
111 ASSIGN,XX(21)=XX(21)+77.70,1;
112 ACTIVITY/12,ATRIB(8),DR;
113 EHAC ASSIGN,XX(11)=XX(11)+1,2;
114 ACTIVITY/14,,DS;
115 ACTIVITY/15;
116 TERMINATE;
```

Figure C-4. Asset Activity at the Base Level.
The following is a list of characteristics assigned at this point:

- Depot repair cycle time
- Depot condemnation rate
- Base NRTS rate
- Base condemnation rate
- Asset allocation

After the necessary assignments have been made, the number of serviceable parts in the aircraft fleet is incremented in line 75. In line 77 the broken part is "split" into two entities, one which represents the requisition to base supply for a serviceable replacement.
part, and the other that continues as the broken asset. The broken part is sent to the base repair cycle via line 79.

Requisition path. The requisition takes line 81 if there is no spare asset available on the shelf at base supply. The requisition takes line 82 if there is a spare on the shelf at base supply. Line 83 causes requisitions to queue up FIFO and wait for the "blinker mechanism" to allow one requisition to be processed. As soon as a requisition is allowed to be processed, lines 84 through 88 resets the resource used in the "blinker mechanism" to its original level. Once the requisition is allowed to be processed, a part is taken off the shelf at base supply. Line 89 decrements the number of spares on the shelf at base supply. The serviceable asset is then installed in the aircraft via line 90 and line 91 then increments the number of serviceable assets in the fleet at the base.

If, when the part broke in the aircraft, a spare was available at base supply, the requisition jumps from line 82 down to line 94 where the spare is removed from the shelf at base supply and the number of spares on the shelf is decremented. The serviceable part is then installed in the aircraft in line 95. And the number of serviceable assets in the fleet at the base is incremented in line 96.

As stated previously, the broken parts, after being removed from the aircraft, are sent to the base repair cycle. The repair cycle starts at line 99. If the broken
part is to be condemned, it takes line 101. If the broken part will not be condemned, it gets repaired in line 103. If the part cannot be repaired at the base level, it takes line 104 where it is NRTS to depot repair. If the broken part was repaired at the base level, it jumps down from line 103 to line 105 where it is placed on the shelf at base supply and the number of spare on the shelf is incremented.

If the broken part could not be repaired at the base level, it jumps down from line 104 to line 108. Once again the broken part is "split" into a requisition and a broken part. The requisition for a replenishment asset is sent to depot supply via line 110. The broken part triggers line 111 where its transportation cost is tallied. The broken part is then sent to depot repair via line 112.

If the broken part was condemned at the base level, it jumps down from line 101 to line 113 where it is counted, and condemned (line 115 and 116). When a broken part is condemned a replenishment part is requisitioned from the depot supply. This is done in line 114.

*Blinker Mechanism.* Refer to Figure C-6 for the following discussion. Line 118 sends one entity through this small network to repeatedly check the conditions in lines 121 and 122. For example, in line 122, a requisition queued up in base supply is allowed to be processed if there is a spare on the shelf and there is a requisition in the

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The above discussion covers the activity of one type of asset at one base. Note that there are four bases each with five different types of assets. The above sections of code are repeated for each part at each base.

*Depot Supply.* Refer to Figures C-7 and C-8 for the following discussion. Requisitions to depot supply from the bases for the different types of assets arrive at depot supply at line 360. Lines 361 through 365 sort the incoming requisitions by type of asset. The first type of asset requisition queues up FIFO at line 366 and wait for a "blinker mechanism" to allow the requisitions to be processed. After a requisition is allowed to be processed, lines 367 through 370 reset the resource associated with the "blinker mechanism."
360 DS GQON, 1;
361 ACTIVITY/76, ATRIB(4) .EQ. 1;
362 ACTIVITY/77, ATRIB(4) .EQ. 2, ZAFU;
363 ACTIVITY/78, ATRIB(4) .EQ. 3, ZAFY;
364 ACTIVITY/79, ATRIB(4) .EQ. 4, ZAGC;
365 ACTIVITY/80, ATRIB(4) .EQ. 5, ZAGG;
366 WAIT(12), BLINK6, 1;
367 ACTIVITY;
368 ALTER, BLINK6, -1, 1;
369 ACTIVITY;
370 FREE, BLINK6, 1;
371 ACTIVITY;
372 ASSIGN, XX(31) = XX(31) - 1, 1;
373 ACTIVITY, ATRIB(2) .EQ. 1;
374 ACTIVITY, ATRIB(2) .EQ. 2, ZAFQ;
375 ACTIVITY, ATRIB(2) .EQ. 3, ZAFF;
376 ACTIVITY, ATRIB(2) .EQ. 4, ZAFQ;
377 GQON, 1;
378 ACTIVITY;
379 ASSIGN, XX(21) = XX(21) + 77.70, 1;
380 ACTIVITY/81, ATRIB(8);
381 ASSIGN, XX(2) = XX(2) + 1, 1;
382 ACTIVITY;
383 TERMINATE;
384 ZAFQ GQON, 1;
385 ACTIVITY;
386 ASSIGN, XX(21) = XX(21) + 12.95, 1;
387 ACTIVITY, ATRIB(8);
388 ASSIGN, XX(40) = XX(40) + 1, 1;
389 TERMINATE;
390 ZAFF GQON, 1;
391 ACTIVITY;
392 ASSIGN, XX(21) = XX(21) + 77.70, 1;
393 ACTIVITY, ATRIB(8);
394 ASSIGN, XX(50) = XX(50) + 1, 1;
395 TERMINATE;
396 ZAFQ GQON, 1;
397 ACTIVITY;
398 ASSIGN, XX(21) = XX(21) + 18.13, 1;
399 ACTIVITY, ATRIB(8);
400 ASSIGN, XX(60) = XX(60) + 1, 1;
401 TERMINATE;

Figure C-7. Depot Supply.

Figure C-8. Graphical Representation of Depot Supply.
Once the requisition has been released to be processed, the part is taken from the shelf at depot supply and the number of spares for that type of asset is decremented in line 372. Lines 373 through 376 sort the replenishment part according to which base requisitioned it. For example, if the part was ordered by Ellsworth the part jumps down from line 373 to line 377. Line 379 totals up the transportation cost. The part is shipped to the base via line 380 and line 381 increments the number of serviceable spares at the base supply.

The above discussion followed one asset into depot supply where it was sorted according to type of asset then shipped to the base that ordered it. The section of code that performs this process is repeated for each type of asset requisition. And then for each type of asset requisition, the replenishment part is sorted according to its destination base.

*Depot Repair.* Refer to Figure C-9 and C-10 for the following discussion. Broken parts arrive at the depot repair function from the bases at line 589. Lines 590 through 594 sort the broken parts according to type of asset. The first type of assets queue up FIFO at line 595 while they wait for a "blinker mechanism" to allow them to be repaired. For treatments with a high asset level factor, the "blinker mechanism" allows all assets to be repaired as
soon as they arrive. For treatments with medium and low asset level factors, the "blinker mechanism" only allows parts to be repaired if the intermediate supply points are below their authorized stockage level.

Once the asset is allowed to be repaired, lines 596 through 599 reset the resource associated with the "blinker mechanism."

The assets are repaired in line 600. The parts can be condemned in line 601. The assets that were repaired are placed on the shelf at depot/ISP supply via line 602 and the number of serviceable spares at depot/ISP supply is incremented.

The above discussion followed one broken part as it came into the depot repair function, was sorted according to type of asset, repaired or condemned, and placed on the shelf at depot/ISP supply. This section of code is repeated for each of the five different types of parts.

```
589 DR GOON,1;
590 ACTIVITY/86,,ATRIB(4).EQ.1;
591 ACTIVITY/87,,ATRIB(4).EQ.2,ZAHB;
592 ACTIVITY/88,,ATRIB(4).EQ.3,ZAHD;
593 ACTIVITY/89,,ATRIB(4).EQ.4,ZAHF;
594 ACTIVITY/90,,ATRIB(4).EQ.5,ZAHH;
595 AWAIT(22),BLINK11,-1,1;
596 ACTIVITY/MPLK11,1;
597 ALTER,BLINK11,-1,1;
598 ACTIVITY/;
599 FREE,BLINK11,1;
600 ACTIVITY/91,ATRIB(10),ATRIB(11);
601 ACTIVITY/92,ATRIB(12),ZAGZ;
602 ASSIGN,XX(31)=XX(31)+1,1;
603 ACTIVITY/;
604 TERMINATE;
605 ZAGZ ASSIGN,XX(11)=XX(11)+1,1;
606 ACTIVITY/;
607 TERMINATE;
```

Figure C-9. Depot Repair.
Figure C-10. Graphical Representation of Depot Repair.
Appendix D: Rankit Plots
## Appendix E: Output Data

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Appendix F: STATISTIX Output Files

Kruskal-Wallis One-Way AOV for Aircraft Availability.

STATISTIX 4.0
08/15/94, 20:23

KRUSKAL-WALLIS ONE-WAY NONPARAMETRIC AOV FOR AA BY TRT

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KRUSKAL-WALLIS STATISTIC 735.1333
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PARAMETRIC AOV APPLIED TO RANKS

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TOTAL NUMBER OF VALUES THAT WERE TIED 802
MAX. DIFF. ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 810    MISSING CASES 0

Rank Sum Tests for Adjacent Treatments of Aircraft
Availabilty.

STATISTIX 4.0
T, 08/15/94, 22:26

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 6.579
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.0000

TOTAL NUMBER OF VALUES THAT WERE TIED 43
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60    MISSING CASES 0
### RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

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**NORMAL APPROXIMATION WITH CONTINUITY CORRECTION**: 5.943

**TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION**: 0.0000

**TOTAL NUMBER OF VALUES THAT WERE TIED**: 48

**MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES**: 0.00001

**CASES INCLUDED**: 60  **MISSING CASES**: 0

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**TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION**: 0.0000

**TOTAL NUMBER OF VALUES THAT WERE TIED**: 56

**MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES**: 0.00001

**CASES INCLUDED**: 60  **MISSING CASES**: 0

175
### STATISTIX 4.0
T, 08/15/94, 22:10

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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 6.646
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.0000

TOTAL NUMBER OF VALUES THAT WERE TIED 48
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60 MISSING CASES 0

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### STATISTIX 4.0
T, 08/15/94, 22:16

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TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.0000

TOTAL NUMBER OF VALUES THAT WERE TIED 54
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CASES INCLUDED 60 MISSING CASES 0

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TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.0001

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MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60  MISSING CASES 0

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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 4.243
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TOTAL NUMBER OF VALUES THAT WERE TIED 59
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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION: 1.900
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION: 0.0575

TOTAL NUMBER OF VALUES THAT WERE TIED: 58
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES: 0.00001

CASES INCLUDED: 60  MISSING CASES: 0

---

### RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

<table>
<thead>
<tr>
<th>TRT</th>
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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION: 6.646
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION: 0.0000

TOTAL NUMBER OF VALUES THAT WERE TIED: 49
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES: 0.00001

CASES INCLUDED: 60  MISSING CASES: 0
### RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

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**NORMAL APPROXIMATION WITH CONTINUITY CORRECTION** 6.335

**TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION** 0.0000

**TOTAL NUMBER OF VALUES THAT WERE TIED** 44

**MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES** 0.00001

**CASES INCLUDED** 60  **MISSING CASES** 0

### RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

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**NORMAL APPROXIMATION WITH CONTINUITY CORRECTION** 6.498

**TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION** 0.0000

**TOTAL NUMBER OF VALUES THAT WERE TIED** 55

**MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES** 0.00001

**CASES INCLUDED** 60  **MISSING CASES** 0
### RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 1.796
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.0724

TOTAL NUMBER OF VALUES THAT WERE TIED 44
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60  MISSING CASES 0

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### RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 0.931
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.3516

TOTAL NUMBER OF VALUES THAT WERE TIED 59
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60  MISSING CASES 0
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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION \(-0.007\)

TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION \(0.9941\)

TOTAL NUMBER OF VALUES THAT WERE TIED 60
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60  MISSING CASES 0

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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION \(6.461\)

TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION \(0.0000\)

TOTAL NUMBER OF VALUES THAT WERE TIED 43
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60  MISSING CASES 0

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### RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

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**NORMAL APPROXIMATION WITH CONTINUITY CORRECTION** -0.007
**TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION** 0.9941

**TOTAL NUMBER OF VALUES THAT WERE TIED** 60
**MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES** 0.00001

**CASES INCLUDED** 60  **MISSING CASES** 0

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**NORMAL APPROXIMATION WITH CONTINUITY CORRECTION** 2.225
**TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION** 0.0261

**TOTAL NUMBER OF VALUES THAT WERE TIED** 58
**MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES** 0.00001

**CASES INCLUDED** 60  **MISSING CASES** 0
### RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 3.615
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.0003

TOTAL NUMBER OF VALUES THAT WERE TIED 58
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60  MISSING CASES 0

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### RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION -0.007
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.9941

TOTAL NUMBER OF VALUES THAT WERE TIED 60
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60  MISSING CASES 0
### RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 1.892
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.0584

TOTAL NUMBER OF VALUES THAT WERE TIED 58
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

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### RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 2.787
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.0053

TOTAL NUMBER OF VALUES THAT WERE TIED 55
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001
CASES INCLUDED 60   MISSING CASES 0

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184
RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 2.809
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.0050

TOTAL NUMBER OF VALUES THAT WERE TIED 54
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60  MISSING CASES 0

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 6.646
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.0000

TOTAL NUMBER OF VALUES THAT WERE TIED 58
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60  MISSING CASES 0
### RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

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**NORMAL APPROXIMATION WITH CONTINUITY CORRECTION** 0.606

**TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION** 0.5444

**TOTAL NUMBER OF VALUES THAT WERE TIED** 55

**MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES** 0.00001

**CASES INCLUDED** 60  **MISSING CASES** 0

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### RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR AA BY TRT

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**NORMAL APPROXIMATION WITH CONTINUITY CORRECTION** 0.651

**TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION** 0.5154

**TOTAL NUMBER OF VALUES THAT WERE TIED** 58

**MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES** 0.00001

**CASES INCLUDED** 60  **MISSING CASES** 0

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186
**Kruskal-Wallis One-Way AOV for Transportation Cost.**

STATISTIX 4.0  
T, 08/16/94, 21:06  
KRUSKAL-WALLIS ONE-WAY NONPARAMETRIC AOV FOR TC BY TRT

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**Kruskal-Wallis Statistic** 721.5043  
**P-value, using Chi-Squared Approximation** 0.0000  
**Parametric AOV Applied to Ranks**

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<tbody>
<tr>
<td>BETWEEN</td>
<td>26</td>
<td>3.950E+07</td>
<td>1.519E+06</td>
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<td>WITHIN</td>
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<td>4.790E+06</td>
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<tr>
<td>TOTAL</td>
<td>809</td>
<td>4.429E+07</td>
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</table>

**Total number of values that were tied** 186  
**Max. Diff. allowed between ties** 0.00001

187
Rank Sum Tests for Adjacent Treatments of Transportation Cost.

STATISTIX 4.0
T, 08/16/94, 23:24

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

<table>
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<tr>
<th>TRT</th>
<th>RANK SUM</th>
<th>SIZE</th>
<th>U STAT</th>
<th>MEAN RANK</th>
</tr>
</thead>
<tbody>
<tr>
<td>HHH</td>
<td>911.00</td>
<td>30</td>
<td>446.00</td>
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<tr>
<td>LHH</td>
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<td>454.00</td>
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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 0.052
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.9587

TOTAL NUMBER OF VALUES THAT WERE TIED 0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60    MISSING CASES 0

STATISTIX 4.0
T, 08/16/94, 23:40

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

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<tbody>
<tr>
<td>HHM</td>
<td>914.00</td>
<td>30</td>
<td>449.00</td>
<td>30.5</td>
</tr>
<tr>
<td>LHM</td>
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<td>30</td>
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<td>30.5</td>
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<td>1830.0</td>
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<td></td>
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</tbody>
</table>

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 0.007
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.9941

TOTAL NUMBER OF VALUES THAT WERE TIED 0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001
### RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

<table>
<thead>
<tr>
<th>TRT</th>
<th>RANK SUM</th>
<th>SIZE</th>
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<tbody>
<tr>
<td>HLH</td>
<td>915.00</td>
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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION: 0.907

TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION: 0.8073

TOTAL NUMBER OF VALUES THAT WERE TIED: 60
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES: 0.00001
CASES INCLUDED: 60  MISSING CASES: 0

---

### RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

<table>
<thead>
<tr>
<th>TRT</th>
<th>RANK SUM</th>
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</thead>
<tbody>
<tr>
<td>HLL</td>
<td>898.00</td>
<td>30</td>
<td>433.00</td>
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<td>MHL</td>
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</table>

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION: 0.244

TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION: 0.8073

TOTAL NUMBER OF VALUES THAT WERE TIED: 0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES: 0.00001
CASES INCLUDED: 60  MISSING CASES: 0
RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

<table>
<thead>
<tr>
<th>TRT</th>
<th>RANK SUM</th>
<th>SIZE</th>
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<tbody>
<tr>
<td>HLL</td>
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<td>433.00</td>
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</tr>
<tr>
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</table>

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 0.244
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.8073

TOTAL NUMBER OF VALUES THAT WERE TIED 0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

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<tr>
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<tr>
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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 0.244
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.8073

TOTAL NUMBER OF VALUES THAT WERE TIED 0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0
**STATISTIX 4.0**
*T, 08/16/94, 23:12*

**RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT**

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<tr>
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<td>909.00</td>
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</table>

**NORMAL APPROXIMATION WITH CONTINUITY CORRECTION** 0.081

**TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION** 0.9352

**TOTAL NUMBER OF VALUES THAT WERE TIED** 0

**MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES** 0.00001

**CASES INCLUDED** 60 **MISSING CASES** 0

---

**STATISTIX 4.0**
*T, 08/16/94, 23:57*

**RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT**

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</table>

**NORMAL APPROXIMATION WITH CONTINUITY CORRECTION** 0.096

**TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION** 0.9234

**TOTAL NUMBER OF VALUES THAT WERE TIED** 0

**MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES** 0.00001

**CASES INCLUDED** 60 **MISSING CASES** 0
### RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

<table>
<thead>
<tr>
<th>TRT</th>
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</tbody>
</table>

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 0.007
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.9941

TOTAL NUMBER OF VALUES THAT WERE TIED 0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60  MISSING CASES 0

---

<table>
<thead>
<tr>
<th>TRT</th>
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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 0.155
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.8766

TOTAL NUMBER OF VALUES THAT WERE TIED 0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60  MISSING CASES 0
RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

<table>
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<tr>
<th>TRT</th>
<th>RANK SUM</th>
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<th>MEAN RANK</th>
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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 0.806
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.4204

TOTAL NUMBER OF VALUES THAT WERE TIED 0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60  MISSING CASES 0

RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

<table>
<thead>
<tr>
<th>TRT</th>
<th>RANK SUM</th>
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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 0.111
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.9117

TOTAL NUMBER OF VALUES THAT WERE TIED 0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60  MISSING CASES 0
STATISTIX 4.0  
T, 08/16/94, 23:37

**RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT**

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</table>

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION: 6.646
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION: 0.0000

TOTAL NUMBER OF VALUES THAT WERE TIED: 0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES: 0.00001

CASES INCLUDED: 60  MISSING CASES: 0

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STATISTIX 4.0  
T, 08/16/94, 23:53

**RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT**

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<tr>
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</table>

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION: -0.007
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION: 0.9941

TOTAL NUMBER OF VALUES THAT WERE TIED: 60
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES: 0.00001

CASES INCLUDED: 60  MISSING CASES: 0
### RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

<table>
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<tr>
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</table>

Normal Approximation with Continuity Correction: 6.646
Two-Tailed P-Value for Normal Approximation: 0.0000

Total number of values that were tied: 0
Maximum difference allowed between ties: 0.00001

Cases included: 60  Missing cases: 0

### RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

<table>
<thead>
<tr>
<th>TRT</th>
<th>RANK SUM</th>
<th>SIZE</th>
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<th>MEAN RANK</th>
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<td>60</td>
<td></td>
<td></td>
</tr>
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</table>

Normal Approximation with Continuity Correction: 0.081
Two-Tailed P-Value for Normal Approximation: 0.9352

Total number of values that were tied: 0
Maximum difference allowed between ties: 0.00001

Cases included: 60  Missing cases: 0
### RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

<table>
<thead>
<tr>
<th>TRT</th>
<th>RANK SUM</th>
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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 0.562
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.5742

TOTAL NUMBER OF VALUES THAT WERE TIED 2
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60  MISSING CASES 0

---

### RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

<table>
<thead>
<tr>
<th>TRT</th>
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<th>MEAN RANK</th>
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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 1.575
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.1154

TOTAL NUMBER OF VALUES THAT WERE TIED 0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60  MISSING CASES 0
### RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

<table>
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<tr>
<th>TRT</th>
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<td>1830.00</td>
<td>60</td>
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<td></td>
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</tbody>
</table>

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION  -0.007
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION  0.9941

TOTAL NUMBER OF VALUES THAT WERE TIED  60
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES  0.00001

CASES INCLUDED 60  MISSING CASES 0

### RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

<table>
<thead>
<tr>
<th>TRT</th>
<th>RANK SUM</th>
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<th>MEAN RANK</th>
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<tr>
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</table>

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION  0.274
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION  0.7845

TOTAL NUMBER OF VALUES THAT WERE TIED  0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES  0.00001

CASES INCLUDED 60  MISSING CASES 0
### RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

<table>
<thead>
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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 0.140
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.8883

TOTAL NUMBER OF VALUES THAT WERE TIED 0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60  MISSING CASES 0

---

### RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 0.421
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.6735

TOTAL NUMBER OF VALUES THAT WERE TIED 0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60  MISSING CASES 0
### RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 0.761
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.4464

TOTAL NUMBER OF VALUES THAT WERE TIED 0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.0001

CASES INCLUDED 60   MISSING CASES 0

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### RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 0.007
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.9941

TOTAL NUMBER OF VALUES THAT WERE TIED 4
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60   MISSING CASES 0
### RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 0.067
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.9470

TOTAL NUMBER OF VALUES THAT WERE TIED 0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60  MISSING CASES 0

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### RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 0.214
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.8303

TOTAL NUMBER OF VALUES THAT WERE TIED 0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60  MISSING CASES 0
RANK SUM TWO-SAMPLE (MANN-WHITNEY) TEST FOR TC BY TRT

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NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 0.140
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION 0.8883

TOTAL NUMBER OF VALUES THAT WERE TIED 0
MAXIMUM DIFFERENCE ALLOWED BETWEEN TIES 0.00001

CASES INCLUDED 60  MISSING CASES 0
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Bibliography


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Vita

Captain Tracey L. Hill was born on 17 May 1967 in Athens, Pennsylvania. She graduated from Derry Area High School in Derry, Pennsylvania in 1985 and went on to attend the University of Pittsburgh. She graduated from the University of Pittsburgh with a Bachelor of Science in Business Administration in August of 1989. After receiving a reserve commission in the USAF, she was assigned to the 1st Tactical Fighter Wing, Langley AFB, VA where she served as the OIC, War Readiness Spares Kits Section. She attended the Supply Officer's Training Course at Lowry AFB in Denver, Colorado. In September of 1991, she was reassigned to the 8th Tactical Fighter Wing, Kunsan AB, Korea, where she served as the Flight Commander, Material Storage and Distribution, and the Flight Commander, Materiel Management. She entered the Graduate School of Logistics and Acquisition Management, Air Force Institute of Technology, in May 1993, and received a follow-on assignment to the Air Force Materiel Command Headquarters, LGI, Wright-Patterson Air Force Base, OH.

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Vita

Captain William N. Walker was born on 17 November 1966 in Taegu, South Korea. He graduated from Kubasaki High School in Okinawa, Japan in 1984 and went on to attend the University of Alabama. He graduated from the University of Alabama with a Bachelor of Science in Electrical Engineering and as Distinguished Graduate from AFROTC DET. 010 in May 1989. After receiving a reserve commission in the USAF, he attended the Aircraft Maintenance Officers Course at Chanute AFB, Illinois, graduating with Honors. In November 1989, he was assigned to the 405th Tactical Training Wing, Luke AFB, AZ where he served as OIC, Maintenance Plan Branch; OIC, Accessory Branch; and, finally, AOIC and OIC, 555 Fighter Squadron Maintenance. He entered the Graduate School of Logistics and Acquisition Management, Air Force Institute of Technology, in May 1993, and received a follow-on assignment to the Air Force Logistics Management Agency, Maintenance Directorate, Gunter Air Force Base, GA.

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Decatur, AL 35603
This research investigates the effect of Lean Logistics proposals on the current Air Force reparables pipeline. Lean Logistics proposes reducing repairable asset levels at operating bases, reducing transportation time between bases and depots, and reducing depot repair times. Computer simulation is used as a tool to perform a 3x3x3 full factorial experiment to determine the effects of the Lean Logistics proposals on fully mission capable aircraft and transportation cost. Results indicate that Lean Logistics outperforms the current reparables pipeline in terms of fully mission capable aircraft. A cost benefit analysis is performed to determine the trade offs between transportation costs and asset outlays.