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THESIS

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Abstract

Simulation is a useful technique for engineers and operations researchers. One of the primary advantages of simulation models is that they are able to provide users with practical feedback when analyzing real-world systems. This thesis builds a discrete event simulation of the sortıe generatıon process, to help decision makers in performing analyses regarding quantity of manpower, bottlenecks in supply and maintenance activities; as well as utilization of maintenance manpower, cost and number of sorties produced in a specific time. We only model one aircraft system with four Line Replacement Units (LRU), but any system and its LRUs can be included in our simulation. Our analysis focuses on eight Measures of Effectiveness (MOE) from our simulation. The final simulation provides a reasonable representation of many, but not all, characteristics of the sortie generation process. It is a preliminary simulation tool for further research on the sortie generation process in the Turkish Air Force, and provides decision-makers with the ability to analyze the sortie generation process in support of future decisions.

Acknowledgments

I would like to express my sincere appreciation to my faculty advisor, Dr. J.O. Miller. I am grateful for the enlightenment and encouragement throughout this research. I would, also, like to thank all my instructors for their teaching efforts.

Bahadir Aykiri

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I. Introduction

Background and Problem Statement

Turkey is taking an increased role in the international environment, and carrying its area of interest and sphere of influence beyond its boundaries. Turkey is rising as a decisive power in regional matters and influential actor in global affairs.

The Turkish Air Force (TURAF) provides unique capabilities that Turkey needs in adopting the vision to be the "Most Powerful Air and Space Power of its Region" (Turkish, 2014). Turkish Air Force supports this vision under the guidelines of six strategic goals given below.

- Possessing strong corporate culture and qualified manpower
- Improving independent operational capabilities reinforced by indigenous systems
- Ability to carry out effective missions in required time and geography
- Transforming information and decision superiority to operational superiority
- Providing continuous operational support until final outcome
- Establishing Turkish Military Aviation style with our education system

The Air Force's primary force application tools are aircraft. These aircraft are operated and supported by a host of personnel across a variety of organizations. From a logistics perspective, the strategies focus on manpower in mission-related maintenance activities, decision support systems to provide superior advantage of using information in logistics-related decision making process, and logistics activities which includes planning and carrying out the employment and maintenance of these aircraft systems and their resources.

New weapon systems create new concepts in logistics, especially in maintenance. Due to these changes in logistics concepts, air forces should adapt their systems to use resources and manpower effectively. For example, TURAF is starting to use The F-35A Lightning II (Joint Strike Fighter-JSF) which requires modified logistics processes due to advancement such as prognostics.

Due to complexities and challenges of adapting new concepts, TURAF needs tools that allow analysis and evaluation of new operational and logistics concepts. This thesis builds a simulation tool that models the sortie generation process in TURAF. This tool is developed to help decision makers in performing analyses to determine whether these concepts provide benefits over current systems.

Research Objectives/Questions

This study develops a discrete event simulation to help decision makers in performing analyses regarding quality and quantity of manpower, bottlenecks in supply and maintenance activities; as well as cost and number of sorties produced in a specific time.

The key research questions addressed by this research include:

1. What are the effects of manpower on the number of sorties?
2. What are the effects of supply resources on the number of sorties?
3. Where are the bottlenecks in the sortie generation process?
4. How does the number of sorties generated at a base change when current acquisition system parameters change?

Research Focus

Military Logistics is the science of planning and carrying out the movement and maintenance of forces (NATO, 2008). In its most comprehensive sense, military logistics is military operations which deal with:

- Design and development, acquisition, storage, movement, distribution, maintenance, evacuation, and disposal of materiel;
- Transport of personnel;
- Acquisition or construction, maintenance, operation, and disposition of facilities;
- Acquisition or furnishing of services;
- Medical and health service support.

Despite a multitude of these areas, this research focuses on logistics activities related to sortie production in TURAF. These activities include aircraft maintenance and their subsystems, acquisition and distribution of spare parts, and planning of these activities.

Methodology

The sortie generation process in TURAF is modeled with a focus on the activities performed by Maintenance and Supply Squadrons. In this study, historical supply and maintenance data of an F-16 Squadron are used with statistical analysis techniques in order to create the simulation model. Outputs of the model are validated with subject matter experts.

Limitations

Sortie generation is a complex process with a variety of stochastic elements and influences from multiple sources. Due to this complexity, interactions regarding activities between different sources except maintenance and supply are neglected. In addition, we are only explicitly modeling a selected set of maintenance and supply processes.

Implications

Simulation is a useful technique for engineers and operations researchers. One of the primary advantages of simulation models is that they are able to provide users with practical feedback when analyzing real-world systems. This feedback allows the decision makers to determine the correctness and efficiency of a decision before the system is actually constructed or changed. In real life it sometimes takes years and/or costs large amounts of money to determine the effects of a system change.

This research models the sortie generation process in TURAF through use of a simulation tool to provide valuable information for decision makers at the base level and provide assistance with the generation and execution of a flying schedule. With the advantages of a simulation model our study of the sortie generation process provides great value to TURAF.

Preview

This chapter provides an overview of the problem statement, research objective, and the research questions and methodology. Chapter II presents a review of the existing literature on the sortie generation process. Chapter III describes the data used to meet the research objectives, as well as the data analysis and model development. Chapter IV provides our analysis and findings of the study while Chapter V provides conclusions and recommendations for further research.

II. Literature Review

Chapter Overview

This chapter examines research conducted in the area of the sortie generation process. In addition, this chapter reviews discrete event simulation, defense related aircraft maintenance and the associated supply chain, along with simulation models and simulation projects in each of these areas.

Discrete Event Simulation

Discrete Event Simulation (DES) is a methodology to simulate dynamic systems based on a series of sequential events (Banks et al., 2005). Each event occurs at an instant in time and signals a change of state in the system. The DES process is based on events, state variables, and a calendar or event list to schedule events. The simulation starts with the first event in the event list, and then other scheduled events are processed as the simulation progresses. The time advance of the simulation varies and is characterized by the scheduled events in the event list. Typically an event , such as an entity arrival, schedules another event, such as an end of service, with specific conditions and time delay (Ouerghi, 2008).

Computer-based discrete-event simulation has long been a tool for analysis of logistics and supply chain systems (Manuj, Mentzer, and Bowers, 2009). The capability of simulation to include stochastic variables makes simulation a powerful research and decision-making tool. Computer-based discrete-event simulation enhances our understanding of logistics and supply chain systems by offering the flexibility to understand system behavior when cost parameters and policies are changed (Rosenfield, Copacino and Payne, 1985).

Sortie Generation Process

The sortie generation process is the cycle of inspection, service, flight and maintenance used to maintain a viable air force wing (AFLMA, 1991). In AFI21-101 sortie generation is defined as a process by which mission capable aircraft are generated in a minimum amount of time, during peacetime or wartime, through separate maintenance, logistics and munition tasks or by concurrent servicing operations. Combat sortie generation may include fueling, munitions/ammunition loading/unloading, aircraft reconfiguration, technical order inspections, and other servicing requirements.

The basic sortie generation process has remained constant over the past few decades. An aircraft flies a sortie, lands, taxis to a parking location, and receives service from a ground crew. The aircrew then debriefs the maintenance personnel and the aircraft is checked for failures. If none exist, it is scheduled and then prepared for the next mission, taxis out, and takes off for another sortie. If a failure occurs, the aircraft is sent to unscheduled maintenance, and several other actions are conducted to repair the aircraft in the most expeditious manner (Faas, 2003).This cyclical process is repeated according to the daily flying schedule or until either a failure occurs or phase maintenance is required. Figure 1 illustrates this general process.

Due to the fact that the sortie generation problem is not new, there have been many studies from different aspects of the sortie generation process. These research efforts have employed many methods, including discrete event simulation, Markov decision analysis, and neural networks (Iakovidis, 2005). The next section examines some of these simulation studies in the area of sortie generation.

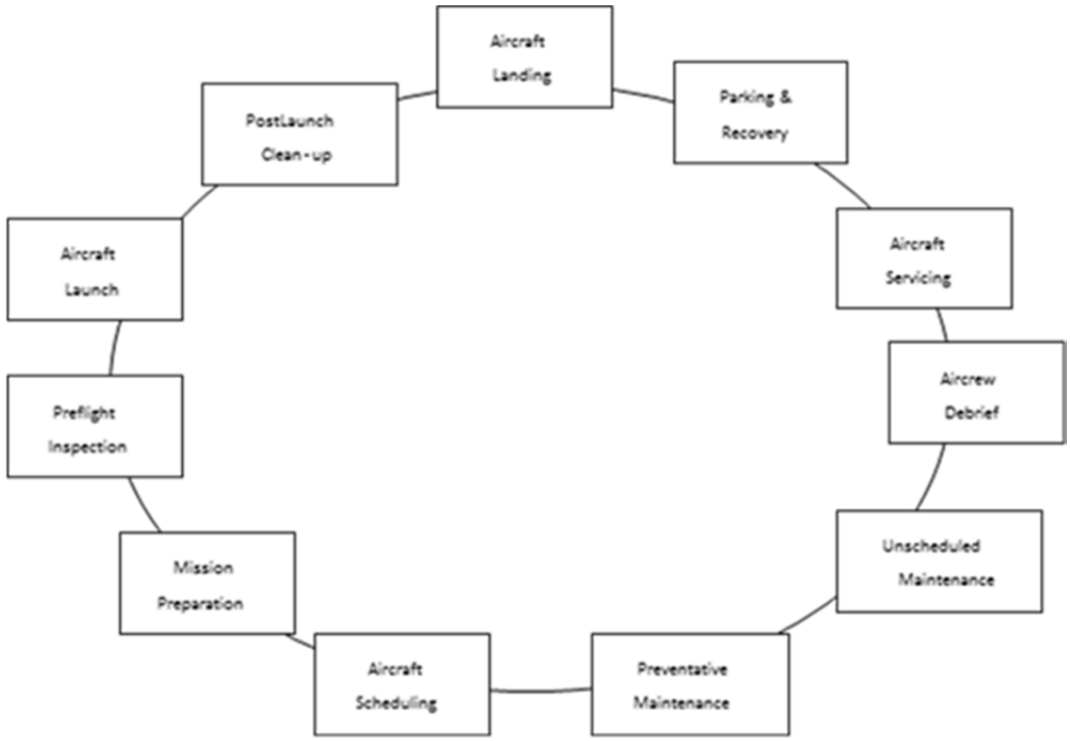


Figure 1. Sortie Generation Process (Faas, 2003)

Simulation Studies of the Sortie Generation Process

Although several simulation studies have been conducted in the area of sortie generation process, two AFIT theses are directly related with the sortie generation process and similar to this research. The rest of this section highlight those previous studies which are the work of former Graduate Operations Research students.

Faas (2003) explored the impact of Autonomic Logistics System (ALS) concept on the aircraft sortie generation process. He built a discrete event simulation model to replicate the sortie generation process and the future ALS in order to measure its effect on the sortie generation process. The model is built in Arena® with a graphical user interface (GUI) to allow the user to change any of the twenty-two different parameters prior to each replication. The setting of one variable on the graphical user interface defines whether the ALS is on or off. The model used actual data of F-16 aircraft and the four Line Replaceable Units (LRU) of radar system.

His model consists of fifteen functional areas including Create, Mission Preparation, Preflight Inspection, Aircraft Launch, Flying, Landing, Unscheduled Maintenance and Supply. Entities travel through the stations located in these functional areas. Although the model measured seventeen logistics performance metrics, Faas used Mission Capable Rate, Not-mission Capable for Maintenance and Supply, and Flying Scheduling Effectiveness as performance metrics to observe differences between baseline and ALS model.

While Faas focused on the effect of ALS function on the sortie generation, MacKenzie (2010) focused on a different aspect of the sortie generation process and constructed a model to explore the effects of differing levels of maintenance manning on sortie production capability. He examined those effects on the resulting Combat Mission Readiness (CMR) of a typical F-16 squadron. The model for this research was developed around the sortie generation process and centers on activities performed by a typical Aircraft Maintenance Squadron. He used four different types of maintainers with three different skill levels. The key focus for the analysis with this model was the effects of varied levels of maintenance manpower, both in terms of sortie production and maintainer utilization. He replicated his model with different manning combinations.

These studies evaluate sortie production with a different focus and measures performance through different metrics. Faas'(2003) model contains not only maintenance activities but also supply chain activities whereas MacKenzie(2010) focused only maintenance specialty and manpower. However, Faas didn't measure the effect of manpower in his model. This research does not consider ALS and is a mixture of Faas' and MacKenzie's studies with more detailed supply activities. The next section highlights simulation studies focused on supply chain activities.

Simulation Studies of Supply Chain Management

The Council of Supply Chain Management Professionals (CSCMP) defines supply chain management as "the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities" (CSCMP, 2010).

Simulation is a powerful tool to identify potential opportunities for improvement in logistics organizations (Cao et al., 2003). Due to the wide variety of supply chains and their extreme impact on a business' efficiency, computer-based discrete-event simulation has long been used as a common tool for analysis of supply chain activities. Simulation provides an excellent and cheap way to understand the interactions between logistics performance metrics (Cheng et al., 2008).

Parson (2010) develops a discrete event simulation to investigate factors which influence Total Non-Mission Capable [due to] Supply (TNMCS) rates for the B-1B by modeling the key processes within the Air Force supply chain. TNMCS is a key metric used by leadership to evaluate effectiveness of the spares supply chain. He used an experimental design for analyzing the output of his discrete event simulation to identify and quantify the results of the factors. He modeled the B-1 spares supply chain which supports a fleet of aircraft at a single air base and focused on the investigation of TNMCS rates as a function of customer wait time, depot stockage effectiveness (SE), and time between unscheduled aircraft failures. The focus is not on the supply requirements for scheduled or daily maintenance actions, but on Code 3 aircraft landings.

Although his study is not directly related with the sortie generation process, his study provides guidance on building supply-chain processes used for this research. In addition, his results may be used for different simulation scenarios in this research.

Other Simulation Projects of the Sortie Generation Process

The studies reviewed in previous sections were conducted by academic organizations. This section will highlight other simulation projects that have been conducted in the area of sortie generation by non-academic organizations.

Logistics Composite Model (LCOM)

Although more than one simulation tool exists, LCOM is a large government-operated simulation tool that provides excellent manpower prediction (Faas, 2003). The Logistics Composite Model (LCOM) was created in the late 1960's through a joint effort of The Rand Corporation and the Air Force Logistics Command. The original purpose of LCOM was to provide a policy analysis tool to relate base-level logistics resources with each other and with sortie generating capability. Logistics resources modeled in LCOM include maintenance people, spare parts, and aerospace ground equipment (Fisher et al., 1968). LCOM is a flexible model with a number of user controlled variables. The interaction of the factors can be studied in virtually any level of detail (AFHRL, 1990). LCOM simulation logic is described in Figure 2. LCOM measures of effectiveness include:

- Operations (e.g. sorties flown, missions cancelled)
- Activities (e.g. average time to complete, resource wait time)
- Personnel
- Supply
- Shop repair
- Equipment
- Aircraft number (Faas, 2003)

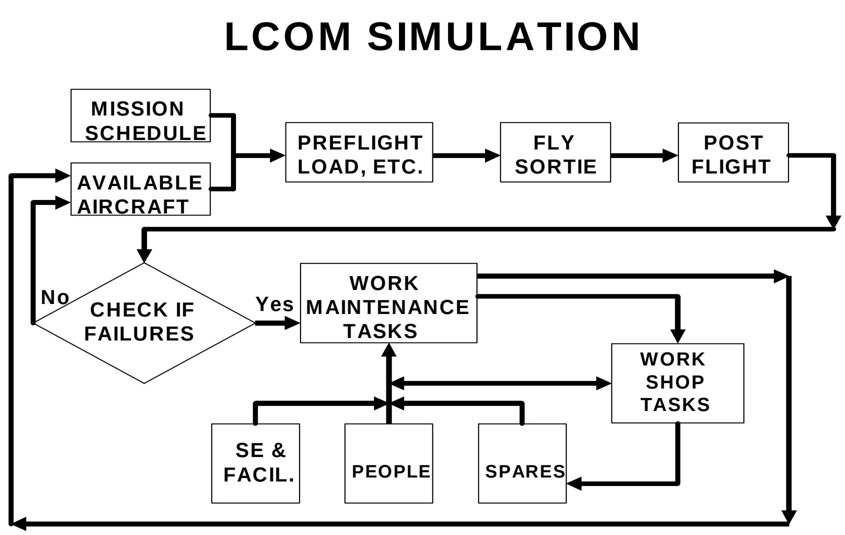


Figure 2. LCOM Simulation Logic

SIMFORCE

The Scalable Integration Model for Objective Resource Capability Evaluations (SIMFORCE) was built by Kelley Logistics Support Services and is written in the Arena® software language. SIMFORCE simulates the wing level logistics activities to include manpower, equipment, and facilities constraints. It was built to allow decision makers to formulate what-if problems and analyze maintenance manpower utilization rates. The model output, shown below, provides the necessary information required to make critical decisions (Goosard, Brown, Powers and Crippen, 1999).

- Resource utilization by resource by day.
- Resource utilization by resource overall.
- Average wait time for a resource by day.
- Number of times a resource is required vs. number of times available overall.
- Total average time delay between scheduled and actual take-offs.
- Total cost of parts and fuel.
- Total dollars spent or dollars remaining.
- Total sorties flown by day.

LCOM and SIMFORCE are commercial simulations and designed and built by software companies and engineers. Although there are limited details on these simulation products, both are key references for modeling the sortie generation process. These sources provide help with the design stage of our model for this research.

LogSAM (Smiley, 1997).

The Logistics Simulation and Analysis Model (LogSAM™) is built by Synergy

Inc. LogSAM™ also simulates the aircraft sortie generation process. The model is broken down into several modules: aircraft generation, sortie generation, preflight and launch, and post flight evaluation. Added features include its ability to schedule sorties based on the Air Tasking Orders (ATO). These ATOs describe what targets to attack along with numbers and types of aircraft to use. Synergy has also expanded LogSAM™ to include a module called LogBase™. LogBase™ simulates enemy attacks and the effect those attacks have on sortie generation capability. Both LogSAM™ and LogBase™ are interesting applications but are more applicable for a wartime simulation.

Performance Metrics

Metrics are important and provide critical tools to be used by managers to measure an organization's effectiveness and efficiency. Moreover, metrics are roadmaps that let you determine where you've been, where you're going, and how you're going to get there.

Air Force Logistics Management Agency produced *The Metrics Handbook for Maintenance Leaders,* which is an encyclopedia of maintenance metrics. It includes an overview to metrics, a brief description of things to consider when analyzing fleet statistics, an explanation of data that can be used to perform analysis, a detailed description of each metric, and a formula to calculate the metric. It also includes an explanation of the metric's importance and relationship to other metrics (AFLMA, 2002). In Chapter 3 of this handbook, Maintenance metrics are divided into five main categories. These categories are flying related, maintenance related, supply related, shop related and air mobility command only related metrics. The metrics handbook also provides additional guidance on scheduling, work force management, sortie generation, and maintenance performance.

Iakovidis (2005) identifies the most important scheduling philosophies and the more meaningful metrics that capture the long-term health of the fleet and maintenance effectiveness. He generated a stochastic simulation model to model the sortie generation process, and used a full-factorial designed experiment to identify statistically significant differences among the proposed scheduling philosophies.

Although his study is in the area of sortie generation process, his study is not directly related with this research, since scheduling is not included in this research. However, Iakovidis' analysis in performance metrics used in previous studies is very valuable. He defined the most meaningful metrics for sortie production. Since our research simulates the sortie generation process, the model built for this research must provide outputs to measure the simulation's performance. The metrics given in Iakovidis' research and *The Metrics Handbook for Maintenance Leaders* provide guidance on measuring supply and maintenance performance for our research.

Conclusion

Simulation provides an excellent tool for analyzing systems with many components and complex interactions and serves as an effective alternative to physical experimentation. It is often difficult or impractical to test different strategies on large, complex systems such as those for aircraft maintenance and logistics (Mathew et al., 2005).

Our literature review indicates that several simulation tools have been developed to investigate the sortie generation process. Additionally, there are simulation models that investigate maintenance and supply chain processes separately. When commercial simulation tools, which provide very extensive information to decision makers, are excluded, the studies on sortie generation process in military areas focus on maintenance process with minor supply chain activities. None of the studies reviewed included Material Requirement Planning (MRP) systems which help forecast future demand.

Although there are several simulation tools and studies in this area, each simulation is unique and includes different processes and system dynamics. This research models the sortie generation process in the Turkish Air Force (TURAF) through a simulation model developed to capture the desired system dynamics in order to provide valuable information for decision makers at the base level for the generation and execution of the flying schedule.

III. Methodology

Chapter Overview

This chapter describes the sortie generation simulation model built for this research. The following sections contain data collection, the input analysis that was conducted on data sets, the definitions of simulation terms, and model development of the simulation built to represent the aircraft sortie generation process defined in Figure 1 from Chapter 1.

Terms in Simio

Simio is powerful simulation software that allows us to read/write data from/to external data sources such as Microsoft Excel and use that data to drive our model. Simio offers features for viewing our outputs through the use of a pivot grid that enables us to sort, filter, and pivot your output data. Also Simio provides to define experiments with multiple scenarios and have them automatically run in parallel on a multi-core processor. A brief discussion of the terms used in Simio as components of a simulation model is presented in the next sections.

Entities

An entity in Simio may be thought of as "players" in a simulation. These items define a dynamic object that can be created and destroyed, move over a network of links and nodes, and enter/exit fixed objects through their associated nodes. The entities used in this model and their definitions are shown in Table 1.

Table 1. Entity Descriptions

Entity Name	Description
Fighter_Entity	Fighter_Entity represents an aircraft. 20 Fighter_Entity are created at the start of each replication of the simulation. They move through processes and never leave the simulation replication.
Failure_Entity	Failure_Entity is a logic entity representing an aircraft part failure. A Failure_Entity is created when a failure occurs and is destroyed when repaired.
ERRC_N	ERRC_N entity represents consumable spare parts. These spares cannot be repaired.
ERRC_P	ERRC_N entity represents repairable spare parts. These spares can be repaired and reused.
MRP_Entity	MRP_Entity is a logic entity representing the state of a MRP query and update. MRP_Entity is created once every four months and is destroyed after calculations are performed.
Sortie_Entity	Sortie_Entity represents the different missions which are flown in a base. This entity flows through the simulation with different numbers of Fighter_Entity since each mission needs different numbers of aircraft.
Order_Entity	Order_Entity represents orders after the MRP calculates spares requirements. This entity delays the simulation replication according to purchasing time and increases spares quantities in a central depot by order quantity.

States

In Simio, states are represented as dynamic variables that are updated during the simulation and reflect some characteristic of the system and entities. States can be defined for the model (model states) or for the entities (entity states). A model state is a global variable whereas an entity state is a unique local variable for each individual entity. Table 2 shows the entity states defined for our model and which states are dynamically updated and tracked by our different types of entities. A check mark in a cell indicates that this entity type (column) tracks this entity state (row).

Table 2. States of Entities

Entity States	Fighter	Failure	ERRC_N	ERRC_P	MRP	Order
Aircraft_Number	√	√				
Failure_State	√					
Failure_State_index	√					
Failure_Part_Number		√	√	√		
I_have_a_Failure	√	√				
Number_of_Failure	√	√				
Order_Part_Number					√	√
Order_Part_Quantity					√	√

Resources

The Resource object typically represents a physical asset such as a person or a machine that can be seized and released by entities. Entities in a Simio simulation typically require some sort of service to be performed and this service almost universally requires the use of some sort of limited resource. Crew chiefs and service teams are some resources used in this research.

Events

Kelton (2007) defines an event as "something that happens at an instant of (simulated) time that might change attributes [Entity States], variables [Model States] or statistical accumulators". In our Simio simulation, an event represents some change in the state of our modeled system such as a part failure or an order being placed.

Model Development

Our research models twenty F-16 fighters at a notional base in Turkey over a five year timeframe through the use of Simio simulation software. The model consists of several functional areas that interact with others. Figure 3 shows the general flow of the model and functional areas. Each functional area includes processes that entities move through. The following sections discuss these functional areas and the associated processes. Since we were unable to obtain data from an operational base in Turkey, the process times used in this model were based upon Faas (2003).

Model Initialization

The twenty aircraft entities are created in the model at the start of each replication. After a Fighter_Entity is created, a unique aircraft number is assigned to the entity. These entities wait for a mission in the aircraft pool or move to another process according to our simulation logic. Since our model doesn't include phase inspection, fighters in the aircraft pool are processed in first in first out (FIFO) order. A mission can require more than one aircraft. For our discussion, we refer to a single aircraft since the processes are the same for each aircraft assigned to a given mission.

Mission Preparation

This process represents activities which maintenance personnel perform to make an aircraft ready for a specific mission. Although mission preparation consists of multiple activities like refueling and weapon loading, these activities are considered as one activity. The mission preparation process seizes a ServiceTeam resource and delays a Fighter_Entity.

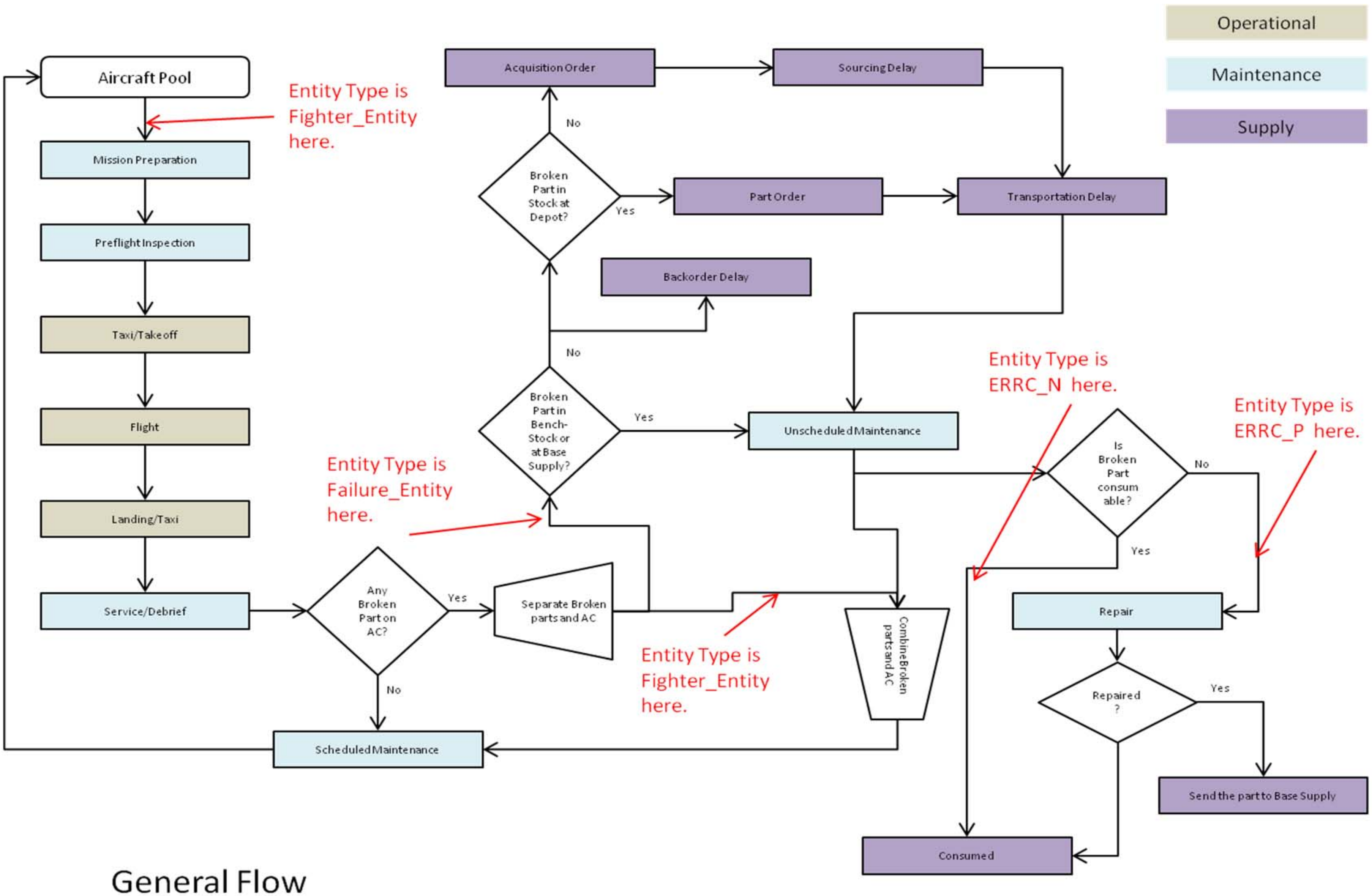


Figure 3. General Flow of the Simulation

Preflight Inspection

After the mission preparation process, aircraft are ready for the preflight inspection by the crewchief. This process represents the final inspection before flight. During preflight inspection, a crewchief checks the aircraft for external failures and helps the pilot to start engine and check systems. In our simulation model this process seizes a crewchief and delays a Fighter_Entity. When the Fighter_Entity leaves the process, the clock is started for the flight hours. Because failure times depend on flight hours, this is done to keep track of flying time of LRUs. These records are compared to current simulation time during the ground and flight activities and trigger a failure when the appropriate number of flight hours is reached during the simulation.

Taxi/Takeoff

After preflight inspection is done, the aircraft is ready for flight. The aircraft leaves the parking area and goes to the runway by using taxi ways. Since more than one aircraft could be taxiing at the same time, taxi way is not considered as a resource. This process does seize a runway resource and delay aircraft. During the time spent on these activities, the simulation checks failure times every minute for ground failures. If a ground failure happens and there is no additional aircraft available, the aircraft releases the runway, aborts the mission and moves to the aircraft pool. If a ground failure happens and there is an aircraft available, the aircraft releases the runway and waits for the spare aircraft to be ready. After the spare aircraft is ready, the aircraft seizes the runway, takeoffs, and releases the runway.

Flight

After the aircraft takeoffs, the flight process starts. This process simulates the time that the aircraft spends to accomplish a mission. Several checks and assignments are made in this process as shown in Figure 4.

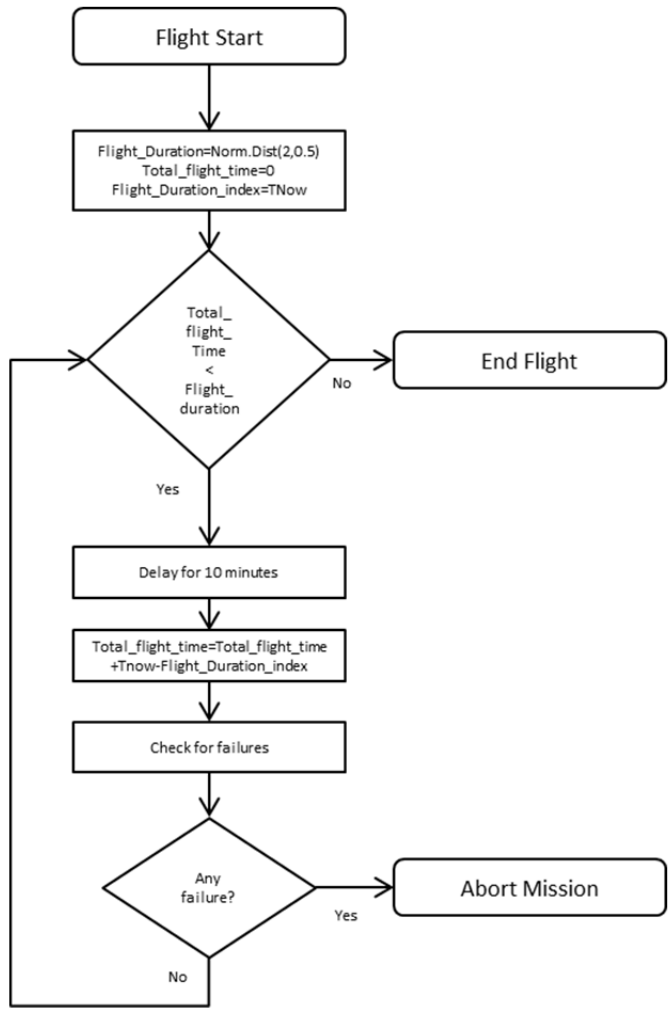


Figure 4. Flight Process Flow Chart

After the aircraft enters this process, an assignment is made from the normal distribution with mean 2 hours and standard deviation of 0.5 hours for flight duration. The process delays the aircraft for the flight duration time. During this delay the simulation checks failure times every 15 minutes. If there is a failure, the mission is aborted and the aircraft goes to the landing process. This abort is recorded to measure the effectiveness of the flight schedule. Otherwise the aircraft accomplishes the mission and goes to the landing process.

Landing/Taxi

This process is similar to the 'Taxi/Takeoff' process. The aircraft seizes the runway after the flight process is done. If there is no available runway resource, the aircrafts continues flight until the runway is available. After seizing the runway, the process delays the aircraft. This delay simulates the landing time and engine checks after landing.

Service and Debrief

The aircraft enters the 'Service and Debrief' process after 'Landing/Taxi' process. The flowchart of this process is shown in Figure 5.

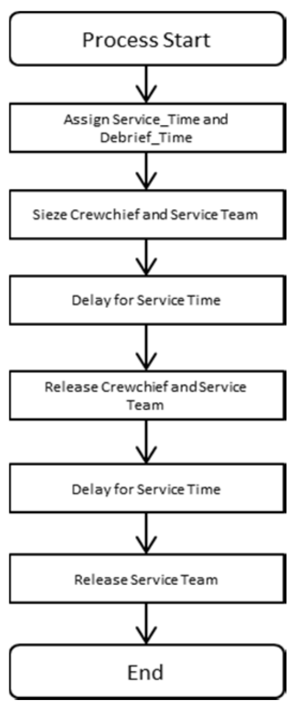


Figure 5. Service and Debrief Process Flow Chart

The process assigns service and debriefs times. These times are in minutes from a triangular (TRI)[with minimum, mode, and maximum times as shown] distribution, TRI(45, 60, 75) for service and TRI(10,15,20) for debrief. After assigning times, the process seizes a crewchief and a service team. First the process delays an aircraft for the service time. Then the crewchief is released and the process delays the aircraft for the debrief time. After the second delay, the process releases the service team and the aircraft goes to failure checking before leaving the ‘Service and Debrief’ process.

Failure checking is a zero time process that compares the current simulation time to the next failure time of parts on an aircraft. The flowchart of this process is shown in Figure 6.

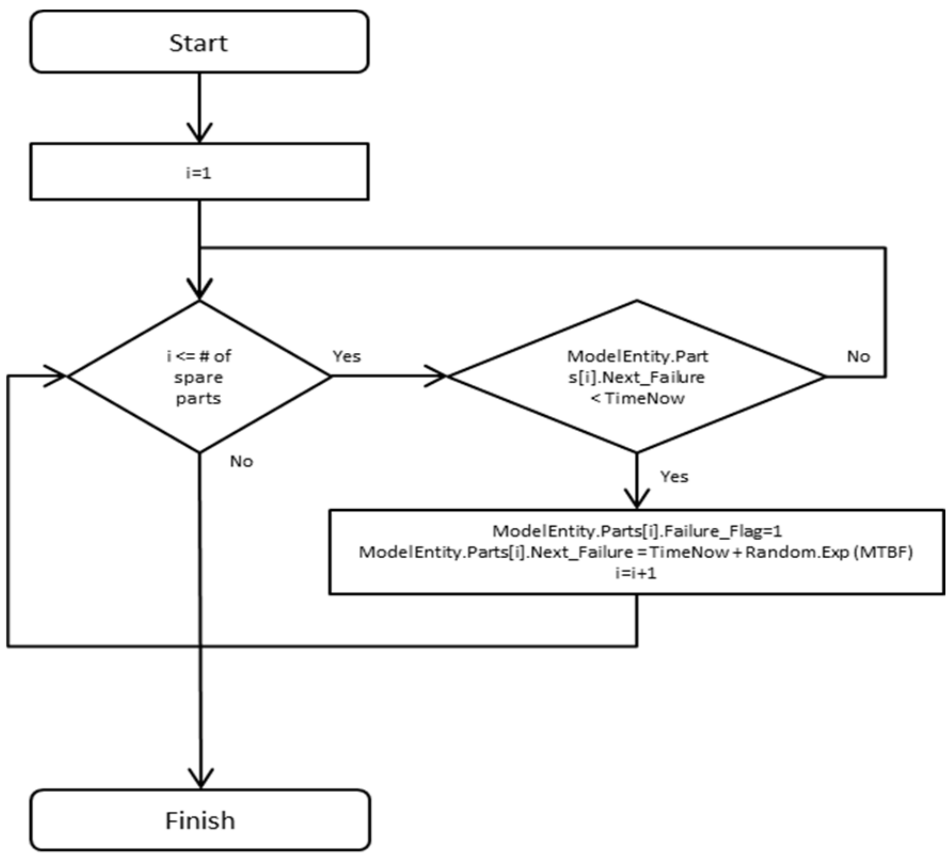


Figure 6. Failure Checking Process Flow Chart

If the next failure time of a part is less than the current time, the Failure_Flag variable of this part is assigned as '1'. After assigning the Failure_Flag variable, the failure checking process assigns a random time to the next failure time of the broken part. If no failure is present for any parts on an aircraft, the aircraft goes to the next process. If a failure exists, the aircraft goes to the 'Unscheduled Maintenance' process.

Unscheduled Maintenance

This process is one the most complicated and important parts of our simulation since maintenance and supply times are recorded in this process. Although unscheduled maintenance process is a simple process by itself, keeping the records correctly makes this process complicated, since the process interacts and communicates with other processes.

As mentioned previously, if an aircraft has a failure or failures, the aircraft goes to 'Unscheduled Maintenance' process. However, before entering this process, a Fighter _Entity creates new entities named 'Failure_Entity'. Each new entity represents a part failure on the aircraft. After creating the entities for failures, the Fighter_Entity goes to an area to wait for replacing or repairing broken parts. Newly created entities go into the sub-processes of the 'Unscheduled Maintenance' process. General flow of the 'Unscheduled Maintenance' process is shown in Figure 7.

Since each Failure_Entity represents a broken part on an aircraft, each 'Failure_Entity' checks inventory before entering the 'Unscheduled Maintenance' process. If the part which is represented by a 'Failure_Entity' is available on shop bench stock, the entity goes to the 'Unscheduled Maintenance' process. If not, the entity checks base inventory. If there is a part available, the simulation delays the entity to simulate transfer time of the part from the supply organization.

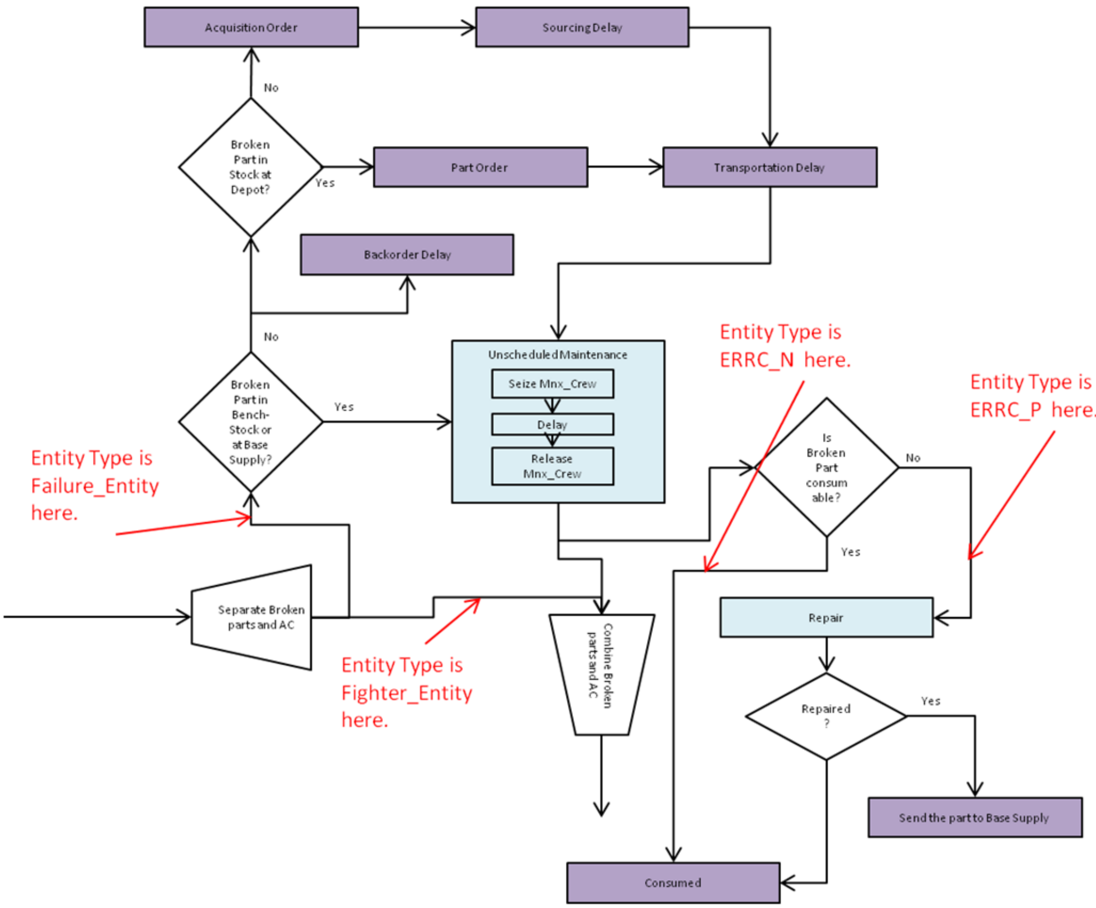


Figure 7. Unscheduled Maintenance Process Flow Chart

If there is no part available, the 'Failure_Entity' checks depot inventory while starting Non-Mission Capable Supply (NMCS)time for the aircraft. NMCS time is started when the first back order occurs for the broken part of an aircraft and is stopped when the last back ordered part of an aircraft is available in bench stock inventory.

After a spare part in the inventory is assigned to the 'Failure_Entity', the entity goes into the 'Unscheduled Maintenance' process and waits for available maintenance personnel to be repaired. If there are no maintenance personnel available, Non-Mission

Capable Maintenance (NMCM) time starts for the aircraft. NMCM time for an aircraft starts with the first waiting part of the aircraft and stops when the last waiting part seizes a maintenance personnel resource.

Supply Chain Processes

Supply chain activities in our simulation contain three basic processes. The first process is expending, repairing, or condemning spares. There are two types of spares, the first is expendable spares which cannot be used again. The other kind of spares is repairable which are repaired if possible or otherwise condemned. The Simio® model of the process is shown in Figure 8.

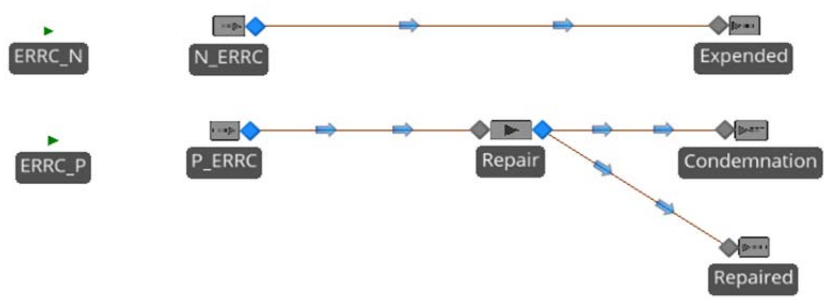


Figure 8. Expending, Repairing or Condemnation Process

The second process is inventory checking. This process checks base inventory first. If there is a spare in the inventory the process decreases the number of spares for this part. Otherwise the process checks the central depot inventory and if a spare is available, the process delays the simulation according to a transportation time. If there is no spare in central depot inventory either, the process creates an order to buy a spare. The Simio® model of the process is shown in Figure 9.

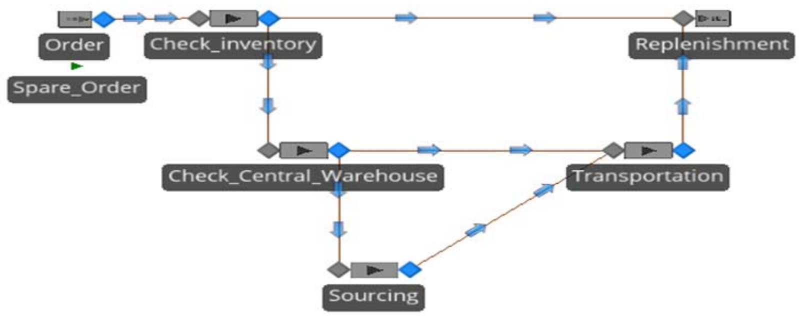


Figure 9. Inventory Checking Process

The third process is material requirement planning (MRP). This process runs once every three months and calculates future usage data according to historical data and creates orders to buy new spares. The simulation is delayed to account for procurement time and transportation time and then increases levels of purchased spare parts. The Simio® model of the process is shown in Figure 10.

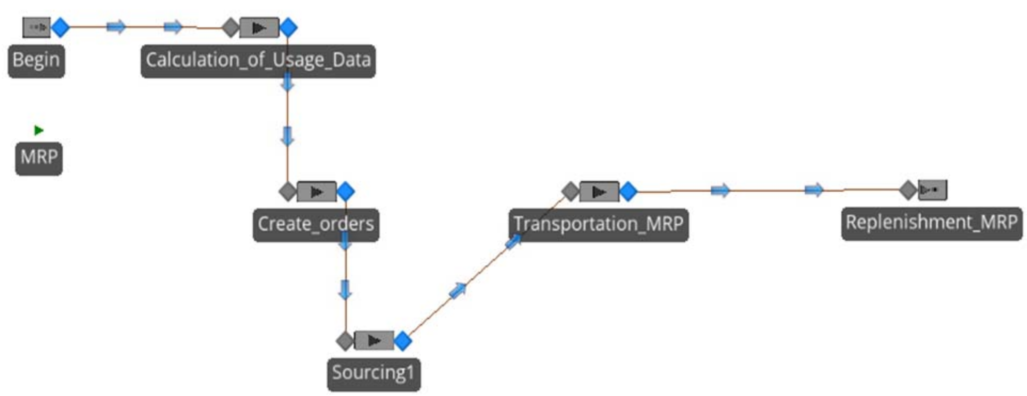


Figure 10. Material Requirement Planning (MRP)

MRP calculates future spare requirements according to past 36 month-usage-data. Since our simulation saves usage data of spare parts in an excel file while it runs, the

MRP process reads these data from the file during the simulation runs. Figure 11 shows how the MRP calculation process works.

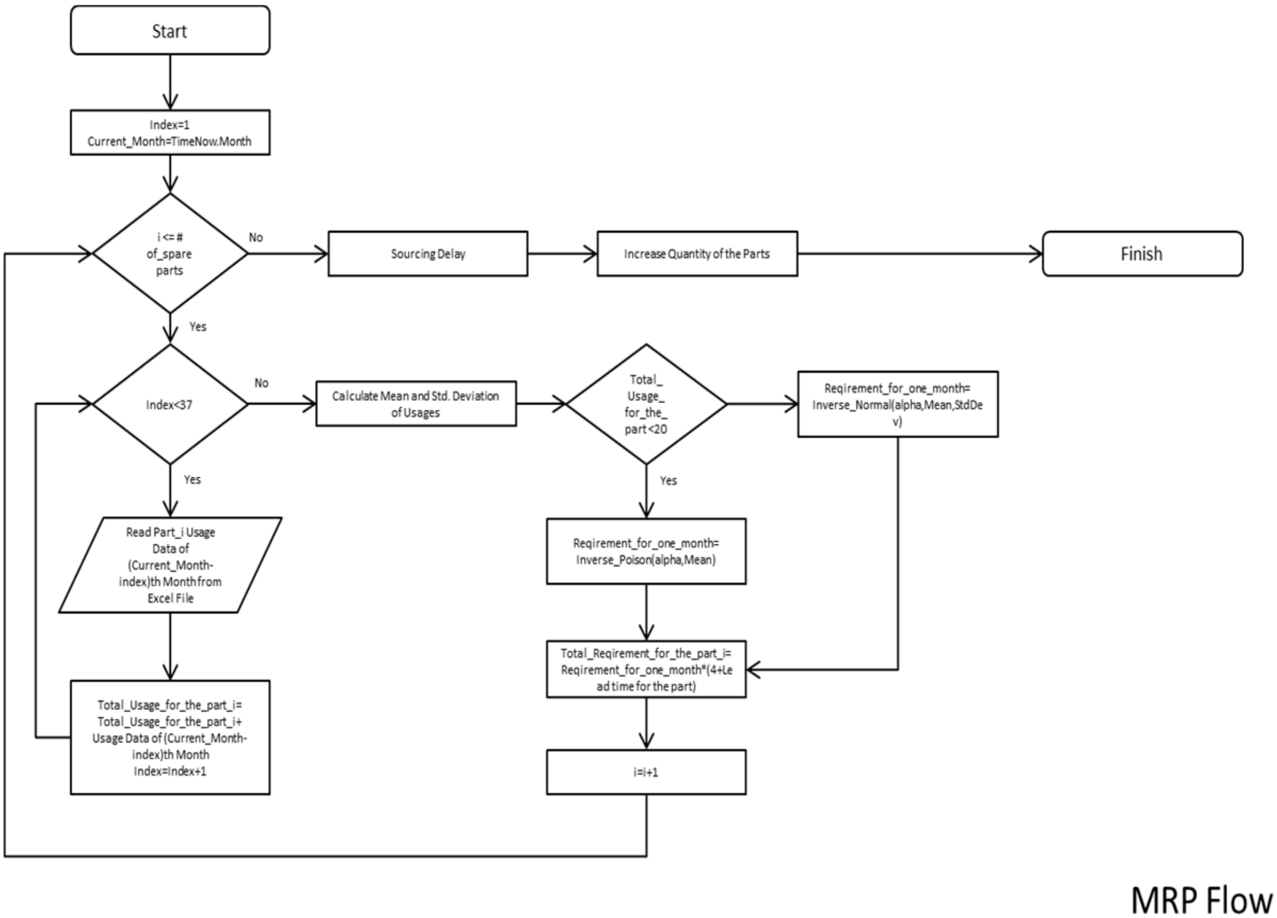


Figure 11. MRP Flow Chart

Model Verification and Validation

It is vital for any simulation study to ensure that the model is built right and the model is accurate enough to adequately represent a system. The verification was done in each step during the model building by the model builder and subject matter experts (SME). Each process was built individually and tested to verify correct procedures. Then a process was checked to ensure that entities flow through in the simulation properly after integration into the simulation model. Outputs of processes in the simulation have been observed with graphs, analyzed and compared with past studies.

It is more desirable to compare real-world data and simulation output for the validation. However, since our simulation model is a simplified version of real sortie generation process, there is no exact system to compare with our simulation result. Therefore the validation was conducted with three SME from TURAF. The different functional areas were gone over by the SMEs. Their suggestions were included in the simulation model.

Simulation Design

The motivation of our simulation study was to analyze the effects of differing levels of maintenance and supply factors on the sortie generation process. For maintenance we varied the number of maintenance teams between two and five and doubled the LRU replacement time. The first supply factor was supply availability varied between 70% and 95%. The second factor was the number of days between MRP orders from 120 to 300. We did not set up a formal design of experiment, but instead looked at 12 different combinations (scenarios) of most interest to our study as shown in

Table 3. Our simulation model was run over three years of simulated time with no warm-up period. Twenty replications are done such that sufficiently accurate estimates of the responses are captured.

Table 3. Scenarios with Supply and Maintenance Factors

Scenarios	Number of Maintenance	Supply Availability Percentage	MRP Frequency	LRU Replacement Time
Scenario1	4	95	120	TRI (60,84,120)
Scenario2	4	90	120	TRI (60,84,120)
Scenario3 (Baseline Model)	4	85	120	TRI (60,84,120)
Scenario4	4	80	120	TRI (60,84,120)
Scenario5	4	70	120	TRI (60,84,120)
Scenario6	5	85	120	TRI (60,84,120)
Scenario7	3	85	120	TRI (60,84,120)
Scenario8	2	85	120	TRI (60,84,120)
Scenario9	4	85	150	TRI (60,84,120)
Scenario10	4	85	180	TRI (60,84,120)
Scenario11	4	85	120	TRI (120,168,240)
Scenario12	4	85	300	TRI (60,84,120)

During the model building, the best key measures of effectiveness (MOE) were identified and model states were defined according to these MOE's. Analyses in the next chapter were conducted based on these MOE's shown in Table 4.

Table 4. MOE Definitions

MOE No	MOE
MOE-1	Number of Sorties generated
MOE-2	Utilization of Maintenance
MOE-3	TNMC
MOE-4	TNMCS
MOE-5	Number of Back Orders
MOE-6	Number of Supply Issues
MOE-7	Average Part Inventory

Conclusion

This chapter has provided the methodology that was undertaken in this research in order to achieve the research objectives. The content analysis was explained and the processes that make up the model were detailed along with a discussion of factors and metrics to use in our analysis. The following chapter presents the results of our simulation model analysis and provides the answers to the investigative questions.

IV. Analysis and Results

Introduction

This chapter presents the results of the experiment. It describes the steps followed in analyzing output data and testing outputs of our simulation to determine differences between scenarios. It describes the steps followed in output data and offers conclusions based on these results.

Results

Our simulation model was run over three years of simulated time with no warm-up period for all scenarios. Twenty replications were collected for each scenario to provide approximately normal data with sufficiently accurate estimates of our responses. Table 5 gives the sample mean results with 95% confidence interval half-width from our simulation model.

When looking in values at our MOEs in **Error! Not a valid bookmark self-reference.**, recall that we are only modeling one aircraft system (radar) and four LRUs, based on F-16 data used by Faas (2003). Therefore we realize some metrics, such as utilization of maintenance teams, are much smaller than would be expected. However, we are not interested in the value of these metrics, but in the difference between these metrics for the selected scenarios.

Table 5. Simulation Results

Scenarios	Number of Sortie	Utilization Of Maintenance	TNMC	TNMCS	Back Orders	Number of Supply Issued	Average Inventory
Scenario1	10005.90±16.02	9.65±1.12	9.93±0.14	9.52±0.11	19.00±11.36	4317.30±499.07	666.32±35.96
Scenario2	10001.55±17.67	9.66±1.12	9.93±0.14	9.52±0.10	19.50±11.60	4320.30±500.17	589.38±30.78
Scenario3	9999.30±16.69	9.67±1.12	9.92±0.15	9.51±0.11	19.95±11.09	4323.85±499.01	537.67±27.29
Scenario4	10001.55±18.28	9.66±1.11	9.92±0.15	9.51±0.11	18.25±11.29	4319.95±497.36	496.84±24.54
Scenario5	10001.10±17.24	9.67±1.12	9.91±0.15	9.50±0.11	19.35±11.37	4325.40±498.65	430.25±20.13
Scenario6	10007.55±19.23	8.06±0.94	9.93±0.19	9.53±0.15	18.70±11.65	4328.05±505.70	537.71±27.65
Scenario7	9993.45±20.58	12.06±1.39	9.96±0.12	9.53±0.08	17.85±10.41	4317.00±498.05	537.91±27.41
Scenario8	9964.00±24.92	15.92±1.80	9.96±0.17	9.48±0.13	16.50±9.66	4276.15±483.21	539.32±26.90
Scenario9	10005.75±13.58	9.63±1.11	9.85±0.12	9.45±0.12	15.40±9.67	4310.90±495.55	628.45±29.84
Scenario10	10002.70±16.85	9.65±1.12	9.91±0.15	9.51±0.13	15.40±10.43	4322.10±498.77	719.63±32.84
Scenario11	9793.35±41.68	18.41±1.99	10.05±0.15	9.33±0.12	13.00±8.44	4103.80±442.96	544.73±25.51
Scenario12	10012.50±15.57	9.66±1.12	9.85±0.14	9.44±0.13	13.15±9.68	4328.85±502.04	1094.68±46.45

Testing for normality of Outputs

In order to correctly perform classic statistical analysis we need to check to see if our simulation output data is approximately normally distributed. The normality test result for Scenario1 is shown in Figure 12 below. The normality test results for other scenarios are located in Appendix A. Since all scenarios passed the normality test, our 20 replications for each scenario were sufficient.

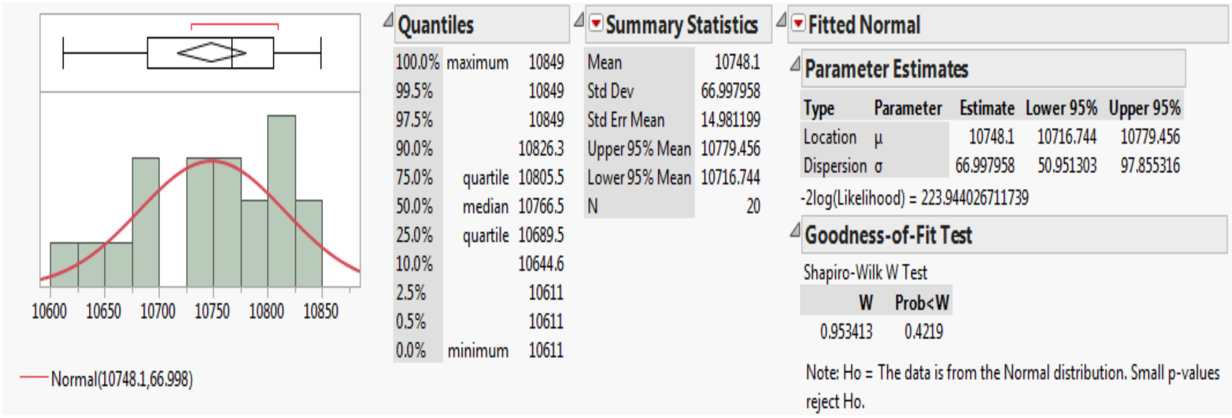


Figure 12. Shapiro-Wilk Test Results for Scenario1

Output Analysis

This section introduces four analyses. The first analysis is conducted to demonstrate how effective supply service level is for different MOE's. Likewise, the purpose of the second analysis is to show the effect of manpower to our MOE's. The third analysis explains whether the MRP frequency changes cause a significant difference or not. Finally, the last analysis aims at demonstrating the effects of repair time to the sortie generation process. We focus our analysis on MOE-1 (Number of Sorties) and MOE-7 (Average Inventory) since these MOE's are the most interesting. Results for other MOE's are contained in Appendices.

Supply Service Level Analysis

First analysis shows how effective supply service level is on different MOE's. Supply service level is modeled as availability percentage in our simulation. We vary the level for Scenario1 to Scenario5 respectively as follows: 95%, 90%, 85%, 80% and 70%. Figure 13 shows comparison of means for all five scenarios while Figure 14 shows the results of all pair-wise comparisons for MOE-1 (Number of Sorties). Scenario3 is our baseline model for comparisons.

Test results given in Figure 13 and Figure 14 show that there is very little change in mean and 95% confidence intervals for the scenarios. However, we conclude that range gets larger when the service level percentage decreases.

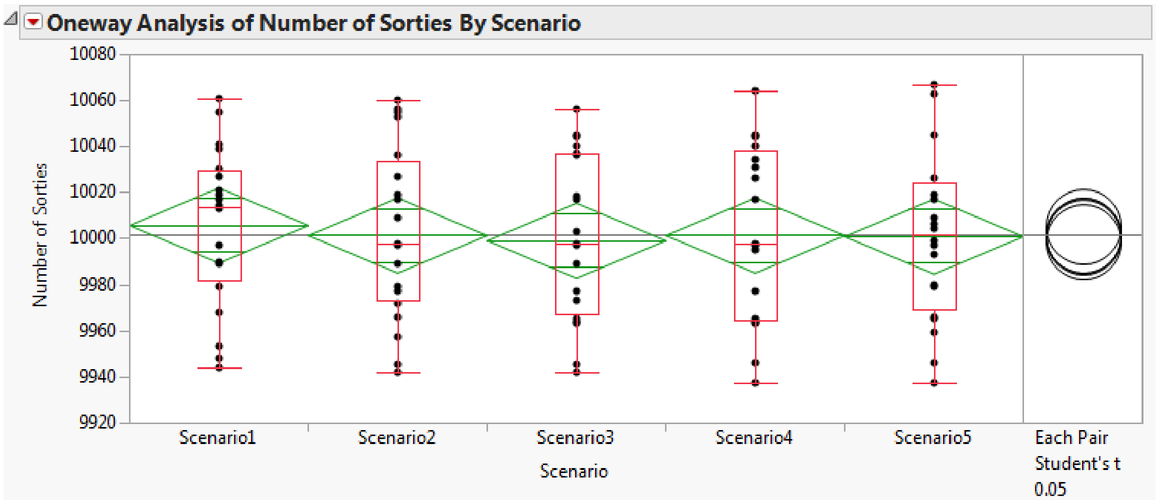


Figure 13. Supply Service Level Analysis for Number of Sorties

Comparisons for each pair using Student's t

Confidence Quantile

t	Alpha
1.98525	0.05

LSD Threshold Matrix

Abs(Dif)-LSD

	Scenario1	Scenario2	Scenario4	Scenario5	Scenario3
Scenario1	-23.070	-18.720	-18.720	-18.270	-16.470
Scenario2	-18.720	-23.070	-23.070	-22.620	-20.820
Scenario4	-18.720	-23.070	-23.070	-22.620	-20.820
Scenario5	-18.270	-22.620	-22.620	-23.070	-21.270
Scenario3	-16.470	-20.820	-20.820	-21.270	-23.070

Positive values show pairs of means that are significantly different.

Figure 14. Comparisons of Scenarios Using Student's t for Number of Sorties

Although we saw no statistically significant differences between our baseline and other scenarios for MOE-1 (Number of Sorties), the differences are statistically significant for MOE-7 (Average Inventory) between our baseline and all other scenarios as shown in Figure 15 and Figure 16. Whereas mean and confidence intervals show statistically significant decreases with a decrease in supply service level, the range of results also gets narrower. The results for other MOE's showed no statistically significant differences and are included in Appendix B.

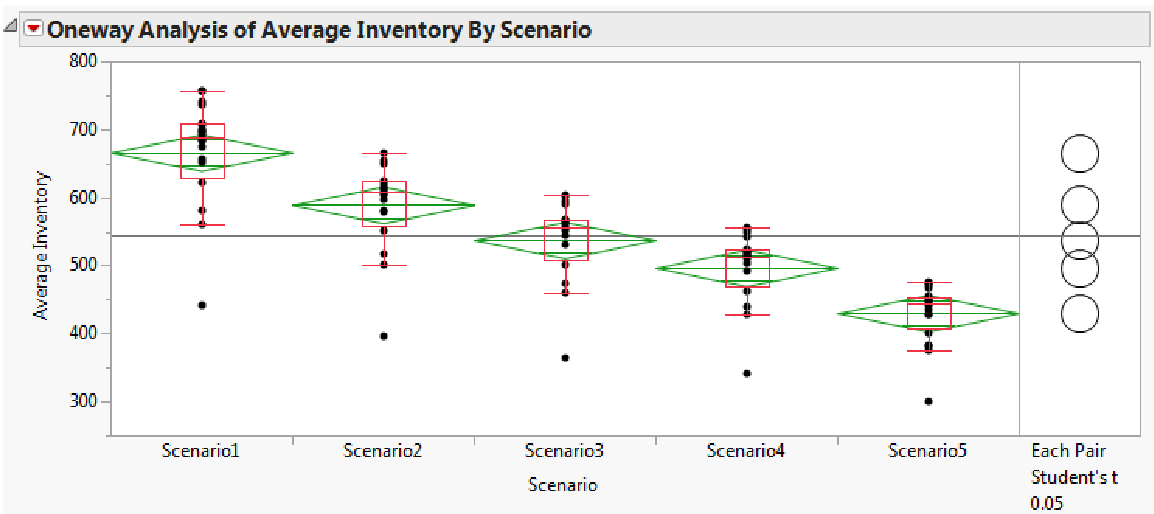


Figure 15. Supply Service Level Analysis for Average Inventory

Comparisons for each pair using Student's t

Confidence Quantile

t	Alpha
1.98525	0.05

LSD Threshold Matrix

Abs(Dif)-LSD

	Scenario1	Scenario2	Scenario3	Scenario4	Scenario5
Scenario1	-37.91	39.03	90.74	131.57	198.16
Scenario2	39.03	-37.91	13.80	54.63	121.22
Scenario3	90.74	13.80	-37.91	2.92	69.51
Scenario4	131.57	54.63	2.92	-37.91	28.68
Scenario5	198.16	121.22	69.51	28.68	-37.91

Positive values show pairs of means that are significantly different.

Figure 16. Comparisons of Supply Service Level Analysis Using Student's t for Average Inventory

Manpower Analysis

Our second analysis aims to demonstrate how manpower affects our outputs. Manpower is modeled as a number of maintenance teams. We start with 4 teams for Scenario3 (baseline) and vary the levels as follows: Scenario6 to 5 teams, Scenario7 to 3 teams, and Scenario8 to 2 teams. The outputs of Scenario3, Scenario6, Scenario7 and Scenario8 were compared for each MOE. Scenarios in Figure 17-19 are ordered from largest to smallest number of maimtenance team. Figure 17 and Figure 18 shows results of MOE-1 (Number of Sorties) comparisons. We see a decrease in the average number of sorties as the number of maintenance teams decreases, along with an increase in the range of responses.

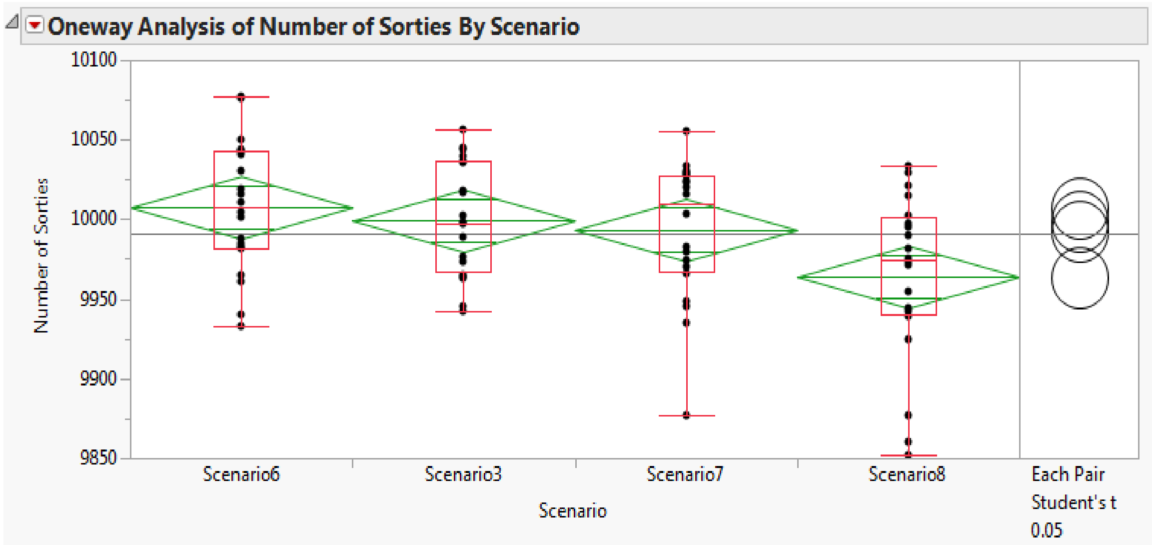


Figure 17. Manpower Analysis Number of Sorties

Comparisons for each pair using Student's t

Confidence Quantile

t	Alpha
1.99167	0.05

LSD Threshold Matrix

Abs(Dif)-LSD

	Scenario6	Scenario3	Scenario7	Scenario8
Scenario6	-27.686	-19.436	-13.586	15.864
Scenario3	-19.436	-27.686	-21.836	7.614
Scenario7	-13.586	-21.836	-27.686	1.764
Scenario8	15.864	7.614	1.764	-27.686

Positive values show pairs of means that are significantly different.

Figure 18. Comparisons of Manpower Analysis Using Student's t for Number of Sorties

Whereas the differences between Scenario3, Scenario6 and Scenario7 are not statistically significant, comparison between Scenario3 and Scenario8 shows that decreasing the number of maintenance teams by two causes a statistically significant effect on MOE-1 (Number of Sorties). Unsurprisingly, changing the number of maintenance team also has a significant effect on the utilization of the maintenance team as shown in Figure 19. Other results of comparisons are shown in Appendix C.

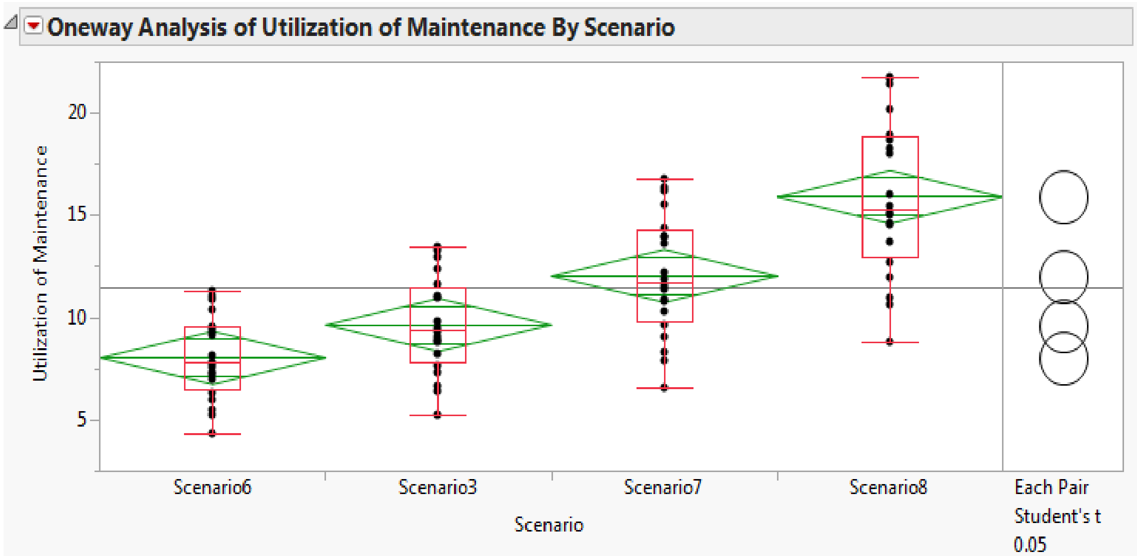
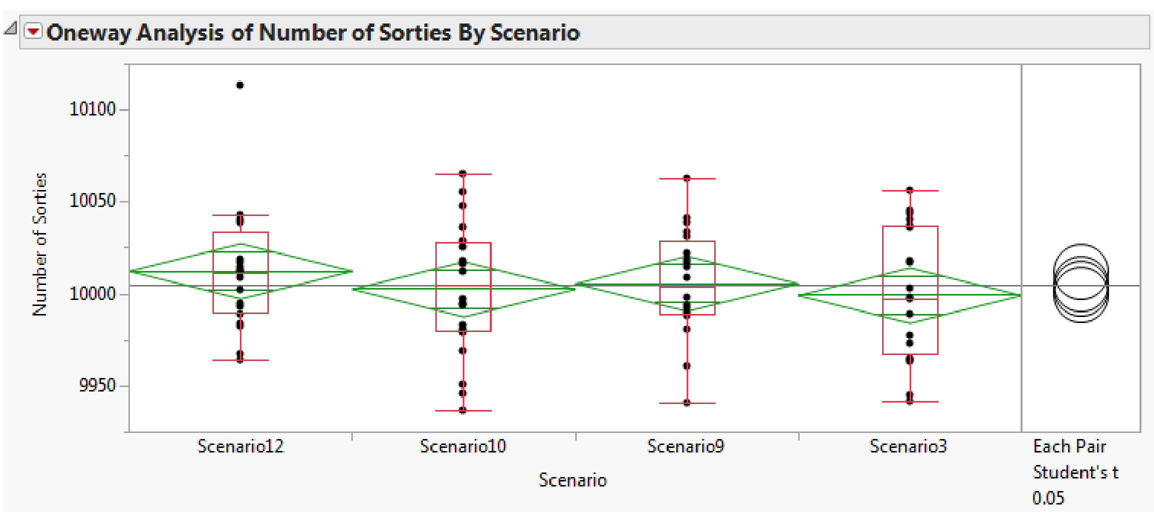


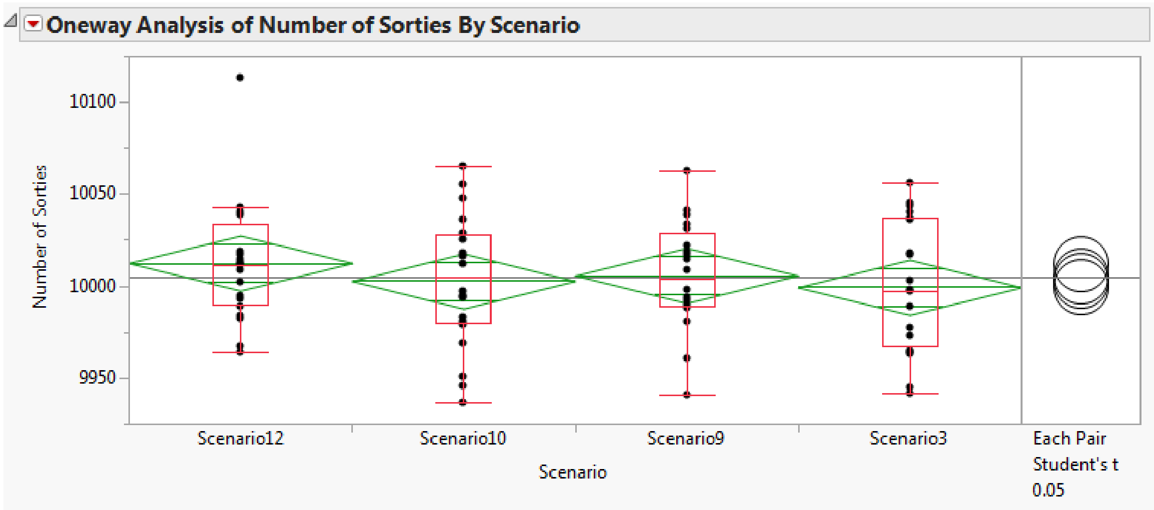
Figure 19. Manpower Analysis for Utilization of Maintenance

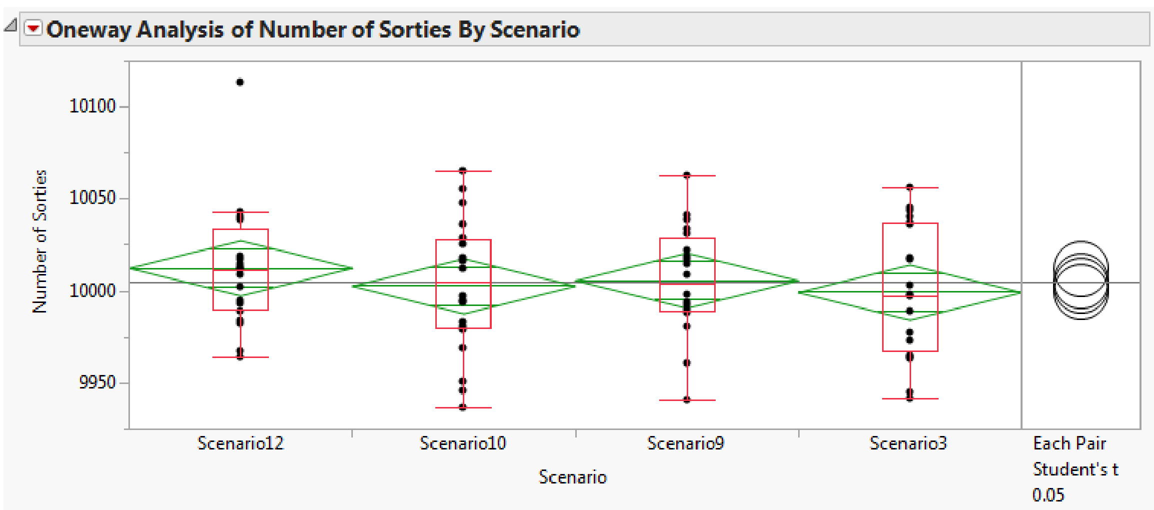
MRP Frequency Analysis

Our third analysis highlights the effects of MRP frequency on our outputs. We vary MRP frequency by changing the number of days between running the MRP process. Scenario3 (baseline) uses 120 days. We vary this level as follows: Scenario9 to 150 days, Scenario10 to 180 days, and Scenario12 to 300 days. The outputs of Scenario3, Scenario9, Scenario10 and Scenario12 were compared for each MOE. Scenarios in



-22 are ordered from largest to shortest time between running the MRP process. The differences between the baseline and alternative scenarios are not statistically significant for MOE-1 (Number of Sorties) as shown in





. However, the test conducted for MOE-7 (Average Inventory) indicates that the difference is statistically significant as shown in Figure 21 and Figure 22. The large difference in

Figure 21 between Scenario12 (300 days) and Scenario10 (150 days) was expected with the doubling of days between running the MRP process with Scenario12. The test results for other MOE's are in Appendix D.

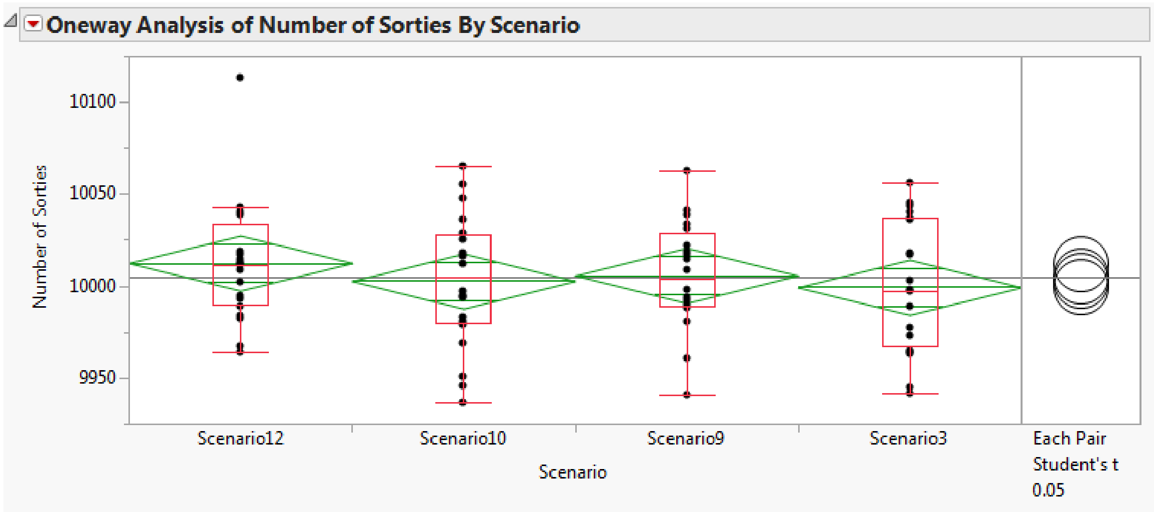


Figure 20. MRP Frequency Analysis for Number of Sorties

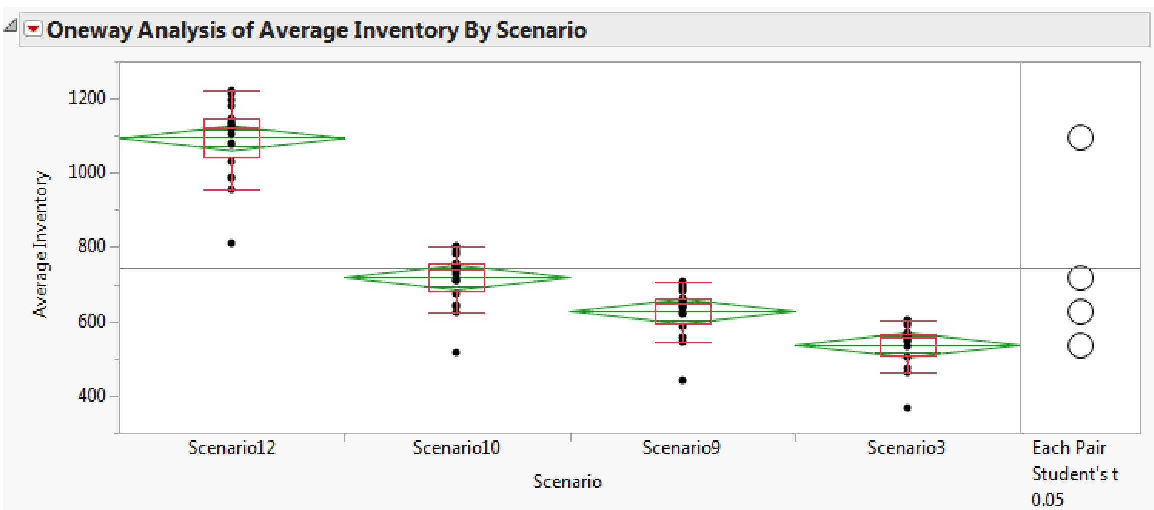


Figure 21. MRP Frequency Analysis for Average Inventory

Comparisons for each pair using Student's t

Confidence Quantile

t	Alpha
1.99167	0.05

LSD Threshold Matrix

Abs(Dif)-LSD

	Scenario12	Scenario10	Scenario9	Scenario3
Scenario12	-46.96	328.09	419.27	510.05
Scenario10	328.09	-46.96	44.22	135.00
Scenario9	419.27	44.22	-46.96	43.82
Scenario3	510.05	135.00	43.82	-46.96

Positive values show pairs of means that are significantly different.

Figure 22. Comparisons of MRP Frequency Analysis Using Student's t for Average Inventory

Repair Time Analysis

Our last analysis highlights the effects of repair time on our outputs. We modeled repair time as a triangular distribution with Scenario3 (baseline) using the following parameters: minimum 60 minutes, mode 84 minutes, and maximum 120 minutes. For Scenario11 we double all three triangular distribution parameters. The outputs of Scenario3 and Scenario11 were compared for each MOE. Results demonstrate that the differences between the baseline and alternative scenario are statistically significant for MOE-1 (Number of Sorties) as shown in Figure 23 and Figure 24. Since repair time and utilization of maintenance are highly correlated, expectedly, there is a statistically significant difference between scenarios for MOE-2 (Maintenance Utilization). The test results for other MOE’s are located in in Appendix E.

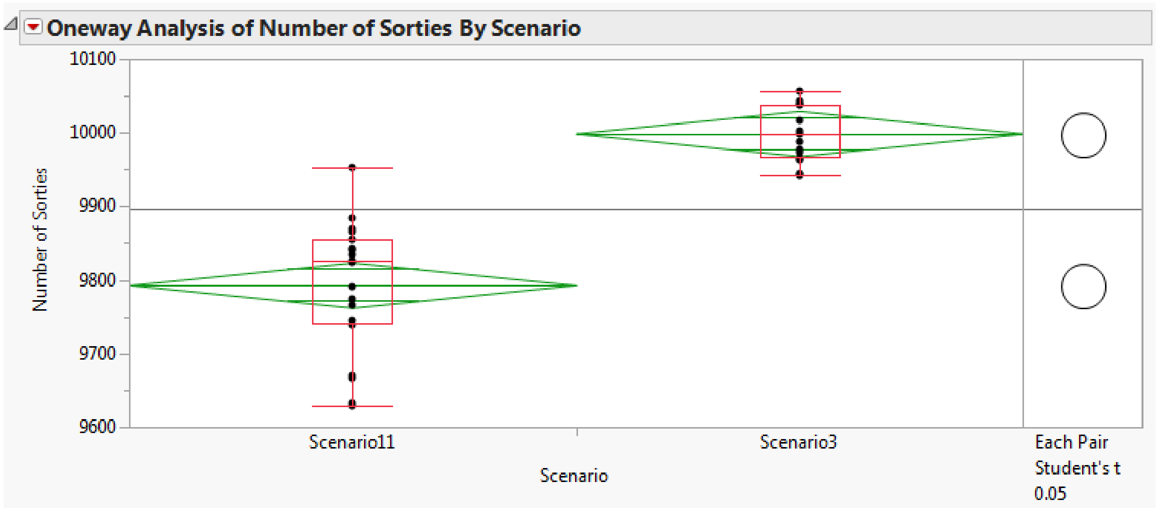


Figure 23. Repair Time Analysis for Number of Sorties

Comparisons for each pair using Student's t

Confidence Quantile

t	Alpha
2.02439	0.05

LSD Threshold Matrix

Abs(Dif)-LSD

	Scenario3	Scenario11
Scenario3	-43.43	162.52
Scenario11	162.52	-43.43

Positive values show pairs of means that are significantly different.

Figure 24. Comparisons of Repair Time Analysis Using Student's t for Number of Sorties

Results of the Investigative Questions

IQ1: What are the effects of manpower on the number of sorties?

The manpower is a very critical factor. However, since only one system with four LRUs was modeled in this research, the effects of manpower were limited on the number of sorties. Since the manpower factor is very serious, decision makers have to analyze the critical level for each maintenance organization section.

IQ2: What are the effects of supply resources on the number of sorties?

Although it didn't provide a statistically significant difference, supply level is another critical factor. Even if it has very small effect on number of sorties, it can have a huge effect on total inventory held in warehouses. Holding more inventories means more money. Even though, broad analyses are required, this factor may provide an opportunity to decision makers to reduce cost with a small loss in operation capabilities.

IQ3: Where are the bottlenecks in the sortie generation process?

According to simulation results and experiences during model building, both supply and maintenance organizations may be the bottleneck in sortie generation process, unless adequate levels of resources are provided. Therefore, decision makers in both organizations have to analyze their processes and define their critical levels of resources they need. Although the simulation results give very small utilization percentage for manpower because of modeling a small piece of real world system, increasing or decreasing manpower creates significant differences in utilization percentage. This shows us that such resources like manpower are very important for our system.

IQ4: How does the number of sorties generated at a base change when current acquisition system parameters change?

Acquisition parameters such as MRP frequency are managed by the Air Logistics Command in TURAF. The simulation results show that there is no statistical significant difference for these parameters. In spite of no statistical difference, there is a impact in average results. For that reason, broader and more complex studies should be conducted to see the effect of changing parameters across the entire inventory.

Conclusion

This chapter began with a summary of the analysis conducted. Next, the results section reported outcomes of the simulation. The tests conducted for outcomes were explained. In the output analysis section, the statistical comparisons of scenarios conducted in commercial software were described. The chapter concluded with answering the investigative questions. The next chapter summarizes our research and gives recommendations for further studies.

V. Conclusion

Introduction

This chapter begins with a summary of the research conducted. Next, the research conclusion section explains its findings. The chapter concludes with recommendations for future research.

Research Summary

This research built a simulation model representing the sortie generation process at a TURAF base. The core activities were selected to model a simplified sortie generation process with an emphasis on maintenance and supply processes. According to findings after our literature review, critical MOE's were defined to measure performances of alternative scenarios designed for this research.

The simulation built for this research provides logistics decision makers a tool to see the potential impact of adjustments made to modeled real world processes through a number of different MOEs. Even though our model only captures a small part of the maintenance and supply activities at a fighter squadron, it still provides useful insight to changes in system performance based on our modeled maintenance and supply factors.

Research Conclusion

Four different analyses were conducted for different MOE's in this research. Since the main motivation of studies on the sortie generation process is the number of sorties generated, analyses focused on MOE-1(Number of Sorties) in the previous chapter. However, other MOEs are also very critical for different situations, positions and environments.

The simulation results showed that all factors have different amounts of influence on sortie numbers, although some of the factors explored did not have any statistical significance. Both maintenance factors we used in our analysis are highly significant for MOE-1 (Number of Sorties), whereas supply factors are more influential for other MOEs, in particular MOE-7(Inventory Level). It is apparent that there are many factors that should be considered for the sortie generation process at a base, many involving different organizations above the base level.

According to results of the current supply and maintenance factors used in this research, even though broader analysis is required, the maintenance factors we examined had a larger impact than the supply factors on operational performance. However, the supply factors we examined did show the expected impact on supply metrics such as inventory level. In terms of cost it is more straight forward to associate a dollar figure to inventory size than to increased maintenance performance through additional manpower or an increase in repair time.

Recommendations for Further Study

Every study has limitations and can be improved. Therefore, there are many possible opportunities to make enhancements to our model. This section explains possible improvements that make the simulation model built for this study more realistic.

First, more aircraft systems should be added to the simulation model for more accurate results. Although our model allows using multiple LRU's, data for other LRU's should be analyzed to use in our simulation. Because including new systems requires more realistic maintenance and supply data, the simulation model should be reviewed.

Second enhancement is expanding the number of squadron. This tool represents a squadron with 20 aircrafts. Multiple squadron features should be added to this tool to represent a realistic fighter air force base. Besides, including auto-scheduling capability represents planning sections in a fighter squadron to the simulation would increase confidence level of simulation results.

Next, since each aircraft type has unique operational and logistics features, this tool should be used for other aircraft types. Studying the sortie generation process for different aircrafts would provide more in-depth information for decision-makers.

Finally, multiple bases and multiple warehouses should be added to the model. This provides broader view on interactions between activities and organizations in the sortie generation process in the Air Force.

Since the complexity of a model is affected by different factors such as number of entities or calculation steps, it should be known that these enhancements increase our model complexity. Therefore scalability and synchronization issues should be handled.

Appendix A: Normality Test Results for MOE-1

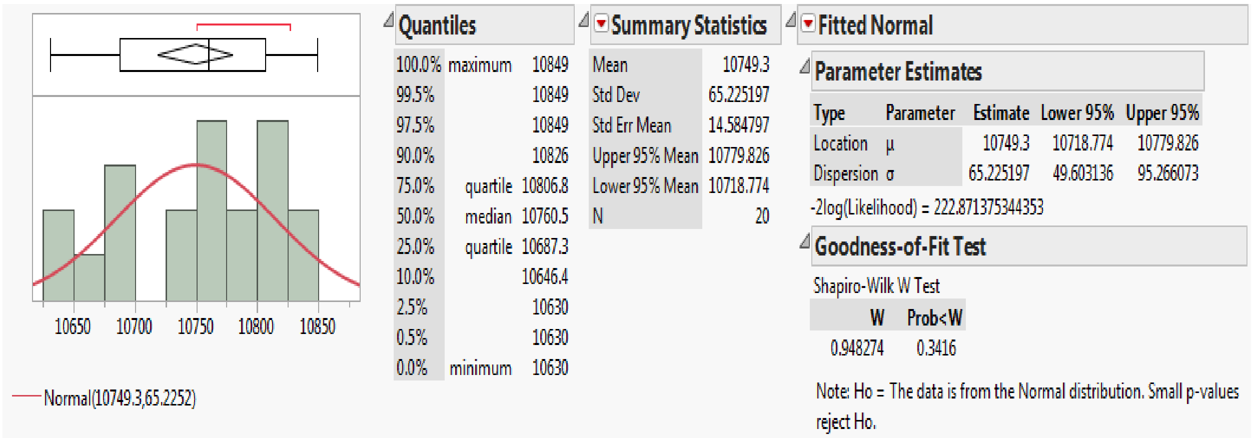


Figure 25. Shapiro-Wilk Test Results for Scenario2

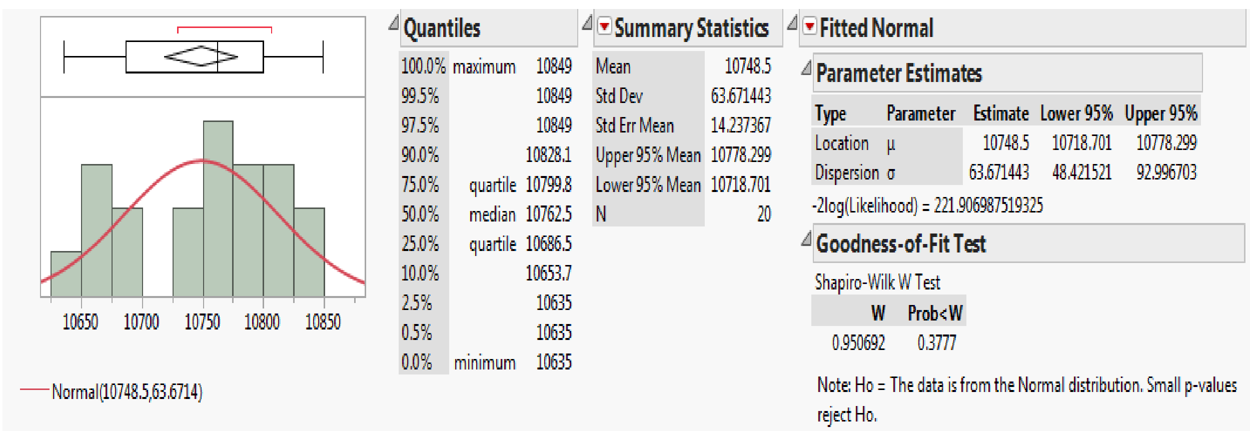


Figure 26. Shapiro-Wilk Test Results for Scenario3

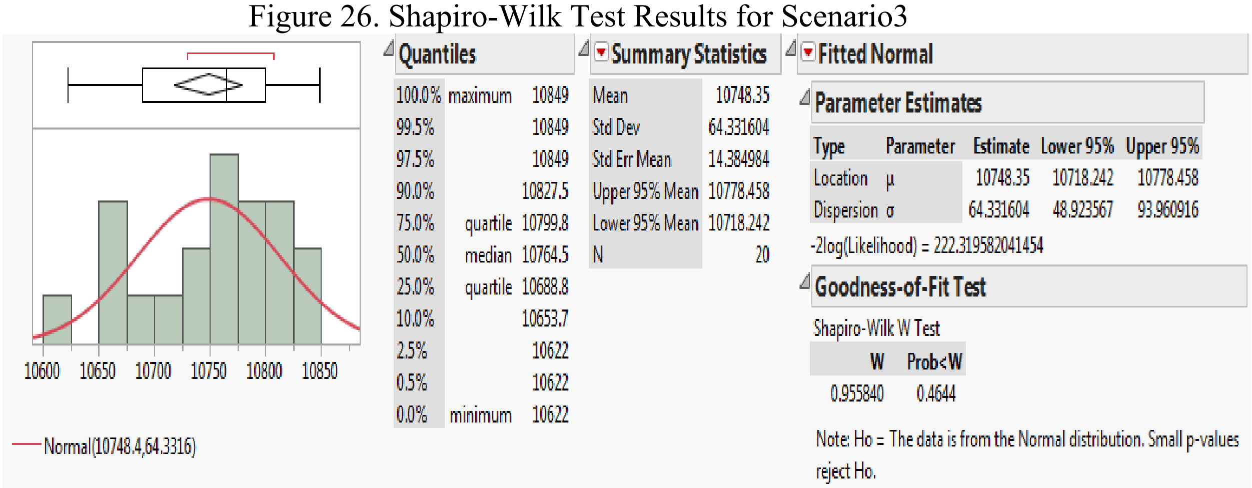


Figure 27. Shapiro-Wilk Test Results for Scenario4

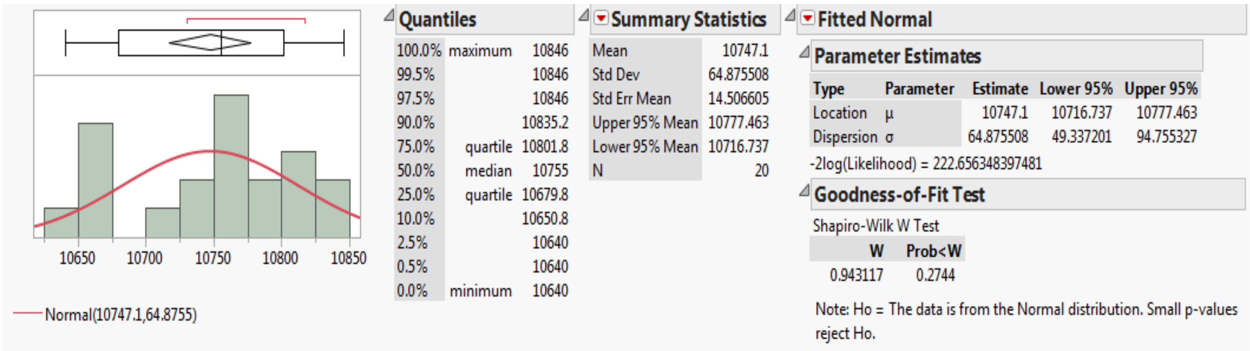


Figure 28. Shapiro-Wilk Test Results for Scenario5

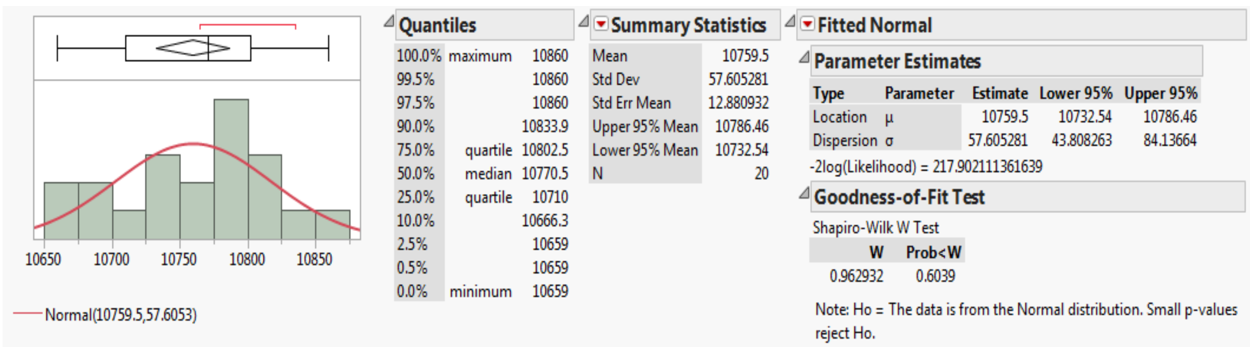


Figure 29. Shapiro-Wilk Test Results for Scenario6

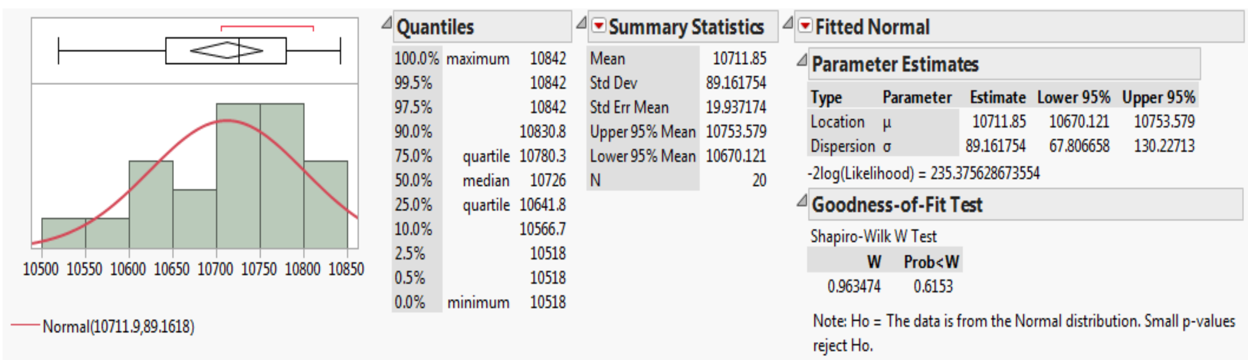
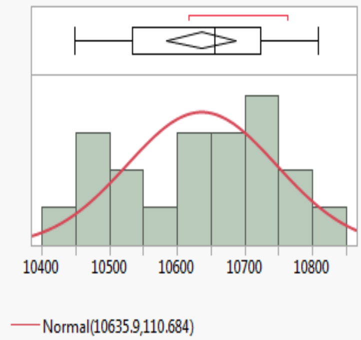


Figure 30. Shapiro-Wilk Test Results for Scenario7



Quantiles

100.0%	maximum	10809
99.5%		10809
97.5%		10809
90.0%		10782
75.0%	quartile	10724
50.0%	median	10656
25.0%	quartile	10534.3
10.0%		10468.5
2.5%		10448
0.5%		10448
0.0%	minimum	10448

Summary Statistics

Mean	10635.9
Std Dev	110.68395
Std Err Mean	24.749684
Upper 95% Mean	10687.702
Lower 95% Mean	10584.098
N	20

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	10635.9	10584.098	10687.702
Dispersion	σ	110.68395	84.174081	161.66184

-2log(Likelihood) = 244.024695127291

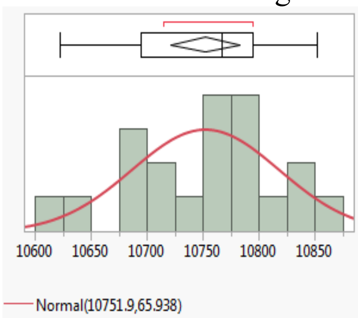
Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.950053	0.3679

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

Figure 31. Shapiro-Wilk Test Results for Scenario8



Quantiles

100.0%	maximum	10852
99.5%		10852
97.5%		10852
90.0%		10841
75.0%	quartile	10794.8
50.0%	median	10767
25.0%	quartile	10694
10.0%		10646.4
2.5%		10622
0.5%		10622
0.0%	minimum	10622

Summary Statistics

Mean	10751.85
Std Dev	65.937989
Std Err Mean	14.744183
Upper 95% Mean	10782.71
Lower 95% Mean	10720.99
N	20

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	10751.85	10720.99	10782.71
Dispersion	σ	65.937989	50.145207	96.307157

-2log(Likelihood) = 223.30613104582

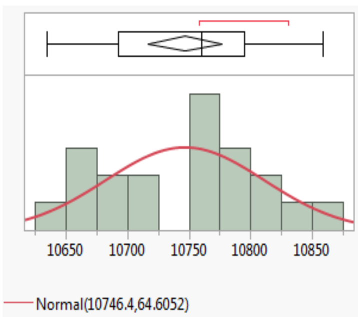
Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.962331	0.5914

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

Figure 32. Shapiro-Wilk Test Results for Scenario9



Quantiles

100.0%	maximum	10859
99.5%		10859
97.5%		10859
90.0%		10829.2
75.0%	quartile	10795
50.0%	median	10760.5
25.0%	quartile	10692
10.0%		10652.4
2.5%		10634
0.5%		10634
0.0%	minimum	10634

Summary Statistics

Mean	10746.4
Std Dev	64.605198
Std Err Mean	14.446161
Upper 95% Mean	10776.636
Lower 95% Mean	10716.164
N	20

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	10746.4	10716.164	10776.636
Dispersion	σ	64.605198	49.131632	94.360519

-2log(Likelihood) = 222.489336063917

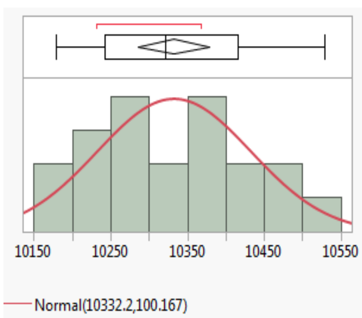
Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.956825	0.4825

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

Figure 33. Shapiro-Wilk Test Results for Scenario10



Quantiles

100.0%	maximum	10529
99.5%		10529
97.5%		10529
90.0%		10476.4
75.0%	quartile	10416.5
50.0%	median	10321.5
25.0%	quartile	10242.5
10.0%		10194.2
2.5%		10179
0.5%		10179
0.0%	minimum	10179

Summary Statistics

Mean	10332.15
Std Dev	100.16737
Std Err Mean	22.398106
Upper 95% Mean	10379.03
Lower 95% Mean	10285.27
N	20

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	10332.15	10285.27	10379.03
Dispersion	σ	100.16737	76.176325	146.30162

-2log(Likelihood) = 240.031242038303

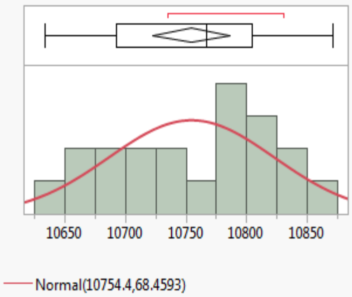
Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.968624	0.7256

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

Figure 34. Shapiro-Wilk Test Results for Scenario11



Quantiles

100.0%	maximum	10872
99.5%		10872
97.5%		10872
90.0%		10840.9
75.0%	quartile	10805
50.0%	median	10766.5
25.0%	quartile	10692.5
10.0%		10654.7
2.5%		10633
0.5%		10633
0.0%	minimum	10633

Summary Statistics

Mean	10754.4
Std Dev	68.459285
Std Err Mean	15.307961
Upper 95% Mean	10786.44
Lower 95% Mean	10722.36
N	20

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	10754.4	10722.36	10786.44
Dispersion	σ	68.459285	52.062629	99.98969

-2log(Likelihood) = 224.80710880894

Goodness-of-Fit Test

Shapiro-Wilk W Test

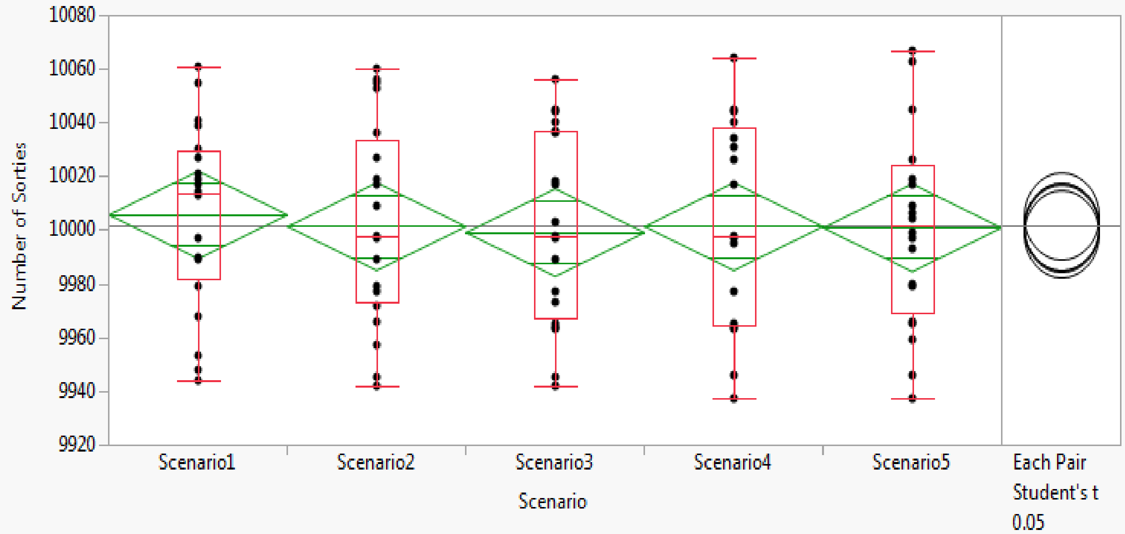
W	Prob<W
0.964159	0.6298

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

Figure 35. Shapiro-Wilk Test Results for Scenario12

Appendix B: Test Results for Supply Service Level Analysis

Oneway Analysis of Number of Sorties By Scenario



Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Scenario1	9944	9948.5	9981.5	10013.5	10029.25	10053.6	10061
Scenario2	9942	9946.2	9973.25	9997.5	10033.75	10055.9	10060
Scenario3	9942	9946.8	9967	9997.5	10036.75	10044.9	10056
Scenario4	9937	9946	9964.25	9997.5	10038.5	10045	10064
Scenario5	9937	9947.3	9969.25	10001.5	10024.25	10061.2	10067

Oneway Anova

Means Comparisons

Comparisons for each pair using Student's t

Confidence Quantile

t	Alpha
1.98525	0.05

LSD Threshold Matrix

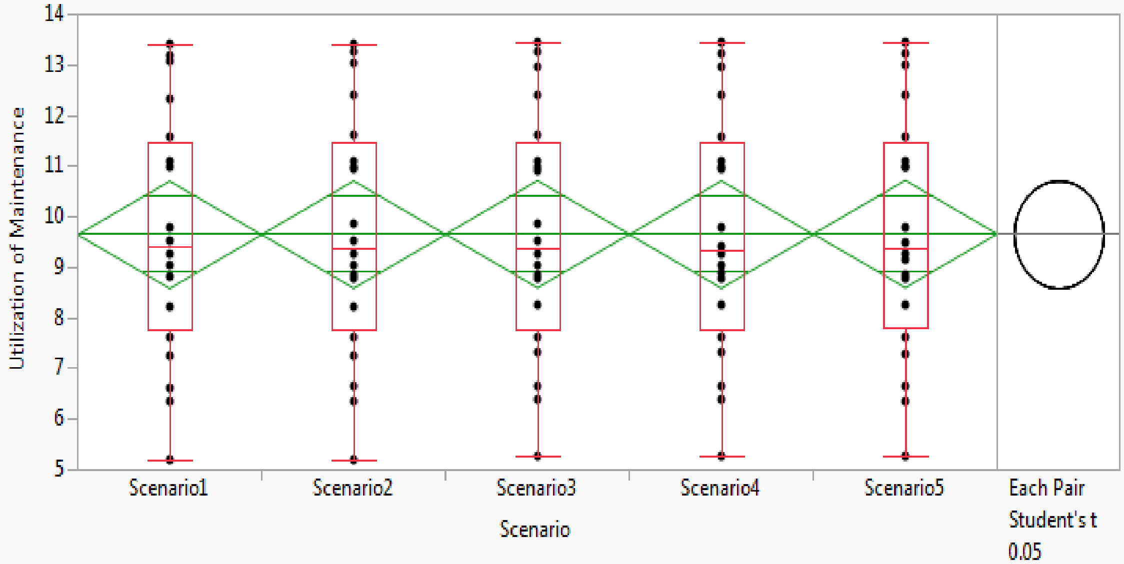
Abs(Dif)-LSD

	Scenario1	Scenario2	Scenario4	Scenario5	Scenario3
Scenario1	-23.070	-18.720	-18.720	-18.270	-16.470
Scenario2	-18.720	-23.070	-23.070	-22.620	-20.820
Scenario4	-18.720	-23.070	-23.070	-22.620	-20.820
Scenario5	-18.270	-22.620	-22.620	-23.070	-21.270
Scenario3	-16.470	-20.820	-20.820	-21.270	-23.070

Positive values show pairs of means that are significantly different.

Figure 36. Supply Service Level Results for MOE-1 (Number of Sorties)

Oneway Analysis of Utilization of Maintenance By Scenario



Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Scenario1	5.197869	6.356444	7.763827	9.390978	11.44297	13.17948	13.3948
Scenario2	5.197869	6.376422	7.76774	9.380221	11.46619	13.21997	13.42059
Scenario3	5.246216	6.39769	7.777654	9.387832	11.47019	13.23757	13.44376
Scenario4	5.246216	6.39769	7.771026	9.341574	11.45017	13.20007	13.44376
Scenario5	5.260434	6.358119	7.784487	9.378653	11.4521	13.20423	13.45053

Oneway Anova

Means Comparisons

Comparisons for each pair using Student's t

Confidence Quantile

t	Alpha
1.98525	0.05

LSD Threshold Matrix

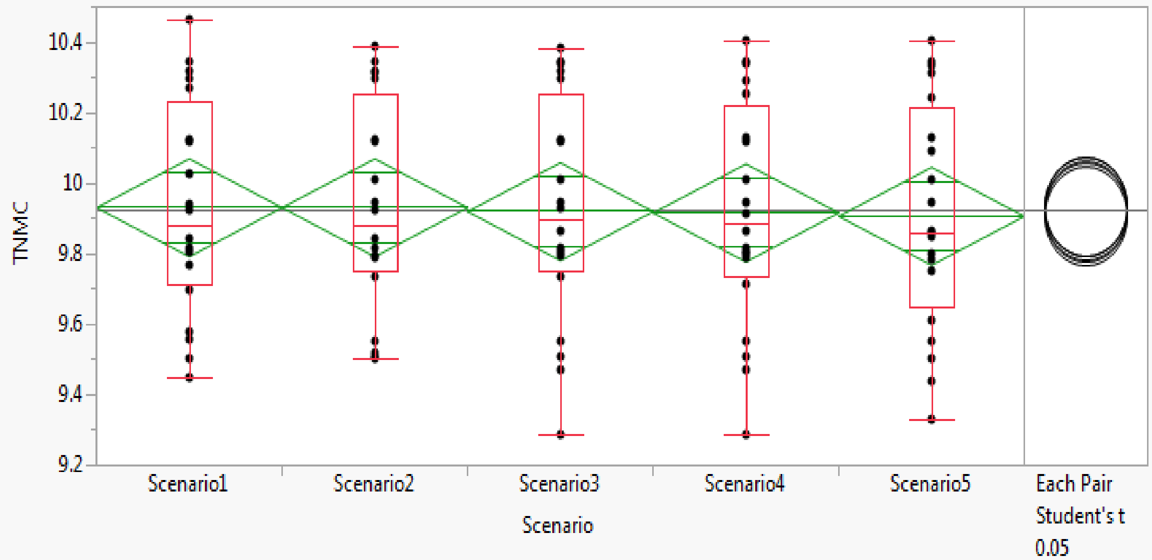
Abs(Dif)-LSD

	Scenario5	Scenario3	Scenario2	Scenario4	Scenario1
Scenario5	-1.4984	-1.4942	-1.4856	-1.4854	-1.4804
Scenario3	-1.4942	-1.4984	-1.4898	-1.4896	-1.4846
Scenario2	-1.4856	-1.4898	-1.4984	-1.4982	-1.4932
Scenario4	-1.4854	-1.4896	-1.4982	-1.4984	-1.4934
Scenario1	-1.4804	-1.4846	-1.4932	-1.4934	-1.4984

Positive values show pairs of means that are significantly different.

Figure 37. Supply Service Level Results for MOE-2 (Utilization of Maintenance)

Oneway Analysis of TNMC By Scenario



Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Scenario1	9.45027	9.506172	9.714081	9.882282	10.2292	10.34229	10.46381
Scenario2	9.500526	9.509571	9.748205	9.882282	10.25386	10.34229	10.38584
Scenario3	9.287826	9.474872	9.748205	9.89462	10.25242	10.34439	10.38183
Scenario4	9.287826	9.474872	9.731807	9.88707	10.2195	10.34439	10.40447
Scenario5	9.331177	9.445582	9.645639	9.860066	10.21449	10.34391	10.40447

Oneway Anova

Means Comparisons

Comparisons for each pair using Student's t

Confidence Quantile

t	Alpha
1.98525	0.05

LSD Threshold Matrix

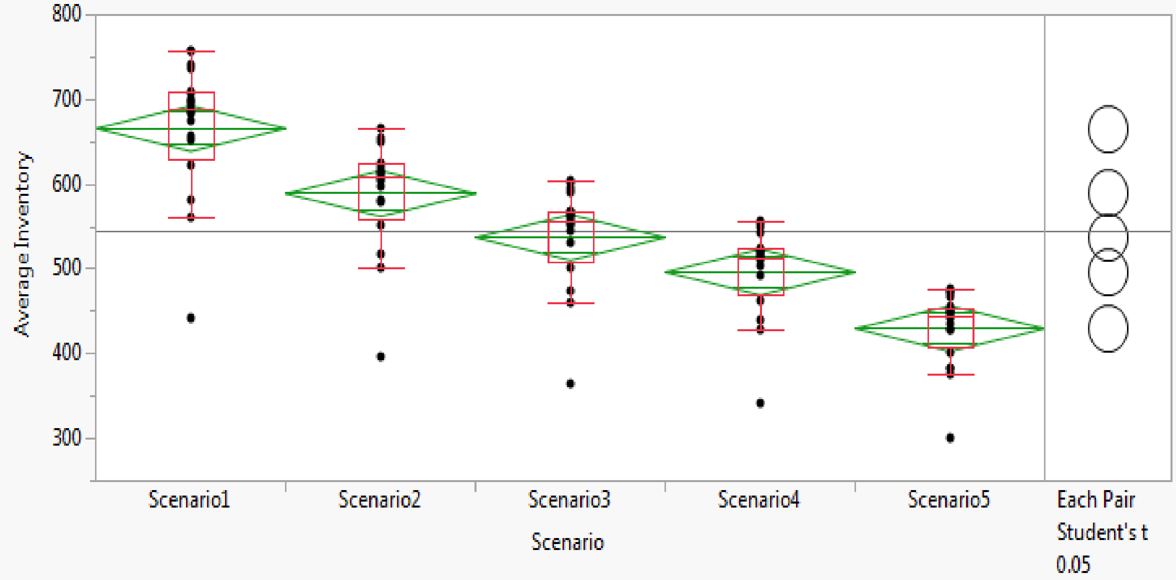
Abs(Dif)-LSD

	Scenario2	Scenario1	Scenario3	Scenario4	Scenario5
Scenario2	-0.19622	-0.19621	-0.18498	-0.18135	-0.17170
Scenario1	-0.19621	-0.19622	-0.18499	-0.18136	-0.17171
Scenario3	-0.18498	-0.18499	-0.19622	-0.19259	-0.18294
Scenario4	-0.18135	-0.18136	-0.19259	-0.19622	-0.18657
Scenario5	-0.17170	-0.17171	-0.18294	-0.18657	-0.19622

Positive values show pairs of means that are significantly different.

Figure 38. Supply Service Level Results for MOE-3(TNMC)

Oneway Analysis of Average Inventory By Scenario



Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Scenario1	442.3373	563.3447	629.8937	687.4097	707.5973	754.6945	757.5532
Scenario2	395.5267	502.787	557.4699	608.6518	623.7071	663.8306	665.3931
Scenario3	364.5197	462.1102	508.6938	555.5004	567.6249	601.107	604.7757
Scenario4	340.2292	429.7243	470.1964	513.5641	524.0251	552.584	556.5256
Scenario5	300.2149	376.7161	406.9428	444.2672	454.008	473.633	476.8652

Oneway Anova

Means Comparisons

Comparisons for each pair using Student's t

Confidence Quantile

t	Alpha
1.98525	0.05

LSD Threshold Matrix

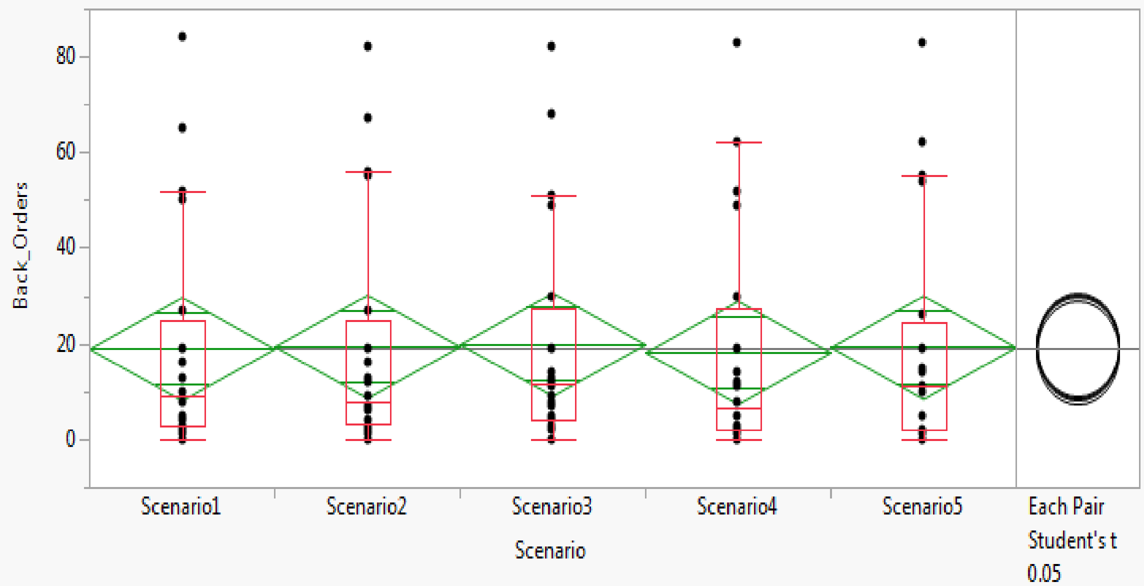
Abs(Dif)-LSD

	Scenario1	Scenario2	Scenario3	Scenario4	Scenario5
Scenario1	-37.91	39.03	90.74	131.57	198.16
Scenario2	39.03	-37.91	13.80	54.63	121.22
Scenario3	90.74	13.80	-37.91	2.92	69.51
Scenario4	131.57	54.63	2.92	-37.91	28.68
Scenario5	198.16	121.22	69.51	28.68	-37.91

Positive values show pairs of means that are significantly different.

Figure 39. Supply Service Level Results for MOE-4(Average Inventory)

Oneway Analysis of Back_Orders By Scenario



Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Scenario1	0	1	3	9	25	63.7	84
Scenario2	0	1.1	3.25	8	25	65.9	82
Scenario3	0	0.2	4.25	11.5	27.25	66.3	82
Scenario4	0	1.1	2	6.5	27.25	61	83
Scenario5	0	0.1	2	11	24.25	61.3	83

Oneway Anova

Means Comparisons

Comparisons for each pair using Student's t

Confidence Quantile

t	Alpha
1.98525	0.05

LSD Threshold Matrix

Abs(Dif)-LSD

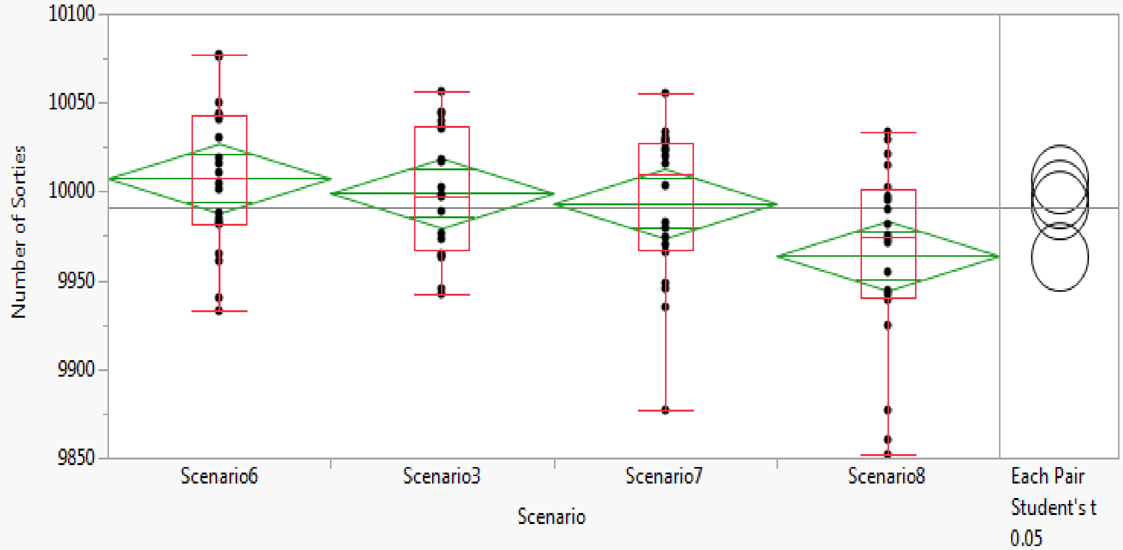
	Scenario3	Scenario2	Scenario5	Scenario1	Scenario4
Scenario3	-15.215	-14.765	-14.615	-14.265	-13.515
Scenario2	-14.765	-15.215	-15.065	-14.715	-13.965
Scenario5	-14.615	-15.065	-15.215	-14.865	-14.115
Scenario1	-14.265	-14.715	-14.865	-15.215	-14.465
Scenario4	-13.515	-13.965	-14.115	-14.465	-15.215

Positive values show pairs of means that are significantly different.

Figure 40. Supply Service Level Results for MOE-5(Number of Back Orders)

Appendix C: Test Results for Manpower Analysis

Oneway Analysis of Number of Sorties By Scenario



Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Scenario6	9933	9942.1	9982.25	10008	10042.5	10073.4	10077
Scenario3	9942	9946.8	9967	9997.5	10036.75	10044.9	10056
Scenario7	9877	9936	9967	10010	10027.75	10033.6	10055
Scenario8	9852	9861.7	9939.75	9974.5	10001.5	10028.2	10034

Oneway Anova

Means Comparisons

Comparisons for each pair using Student's t

Confidence Quantile

t	Alpha
1.99167	0.05

LSD Threshold Matrix

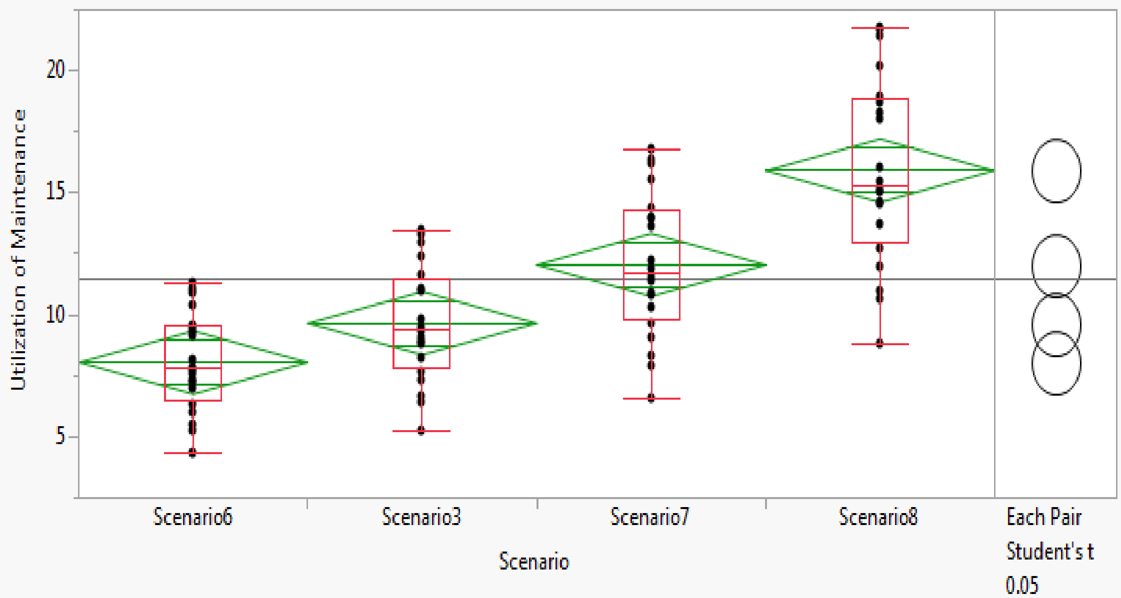
Abs(Dif)-LSD

	Scenario6	Scenario3	Scenario7	Scenario8
Scenario6	-27.686	-19.436	-13.586	15.864
Scenario3	-19.436	-27.686	-21.836	7.614
Scenario7	-13.586	-21.836	-27.686	1.764
Scenario8	15.864	7.614	1.764	-27.686

Positive values show pairs of means that are significantly different.

Figure 41. Manpower Analysis Results for MOE-1 (Number of Sorties)

Oneway Analysis of Utilization of Maintenance By Scenario



Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Scenario6	4.361905	5.265869	6.500741	7.791707	9.517383	10.99621	11.25602
Scenario3	5.246216	6.39769	7.777654	9.387832	11.47019	13.23757	13.44376
Scenario7	6.537988	7.928591	9.780157	11.69697	14.24614	16.36083	16.80147
Scenario8	8.773349	10.63549	12.9624	15.30827	18.85799	21.62402	21.78613

Oneway Anova

Means Comparisons

Comparisons for each pair using Student's t

Confidence Quantile

t	Alpha
1.99167	0.05

LSD Threshold Matrix

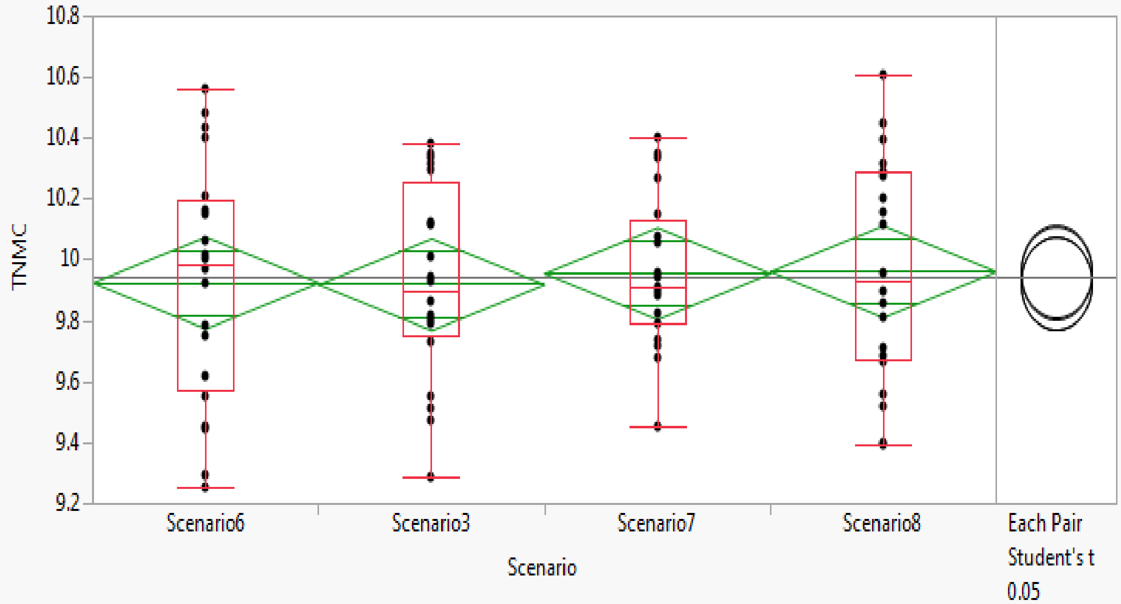
Abs(Dif)-LSD

	Scenario8	Scenario7	Scenario3	Scenario6
Scenario8	-1.8226	2.0414	4.4337	6.0393
Scenario7	2.0414	-1.8226	0.5698	2.1753
Scenario3	4.4337	0.5698	-1.8226	-0.2171
Scenario6	6.0393	2.1753	-0.2171	-1.8226

Positive values show pairs of means that are significantly different.

Figure 42. Manpower Analysis Results for MOE-2 (Utilization of Maintenance)

Oneway Analysis of TNMC By Scenario



Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Scenario6	9.252364	9.307697	9.570157	9.984681	10.19637	10.47831	10.56155
Scenario3	9.287826	9.474872	9.748205	9.89462	10.25242	10.34439	10.38183
Scenario7	9.455082	9.682411	9.789905	9.907198	10.13272	10.34853	10.4011
Scenario8	9.393698	9.411265	9.670004	9.928809	10.28757	10.44213	10.60811

Oneway Anova

Means Comparisons

Comparisons for each pair using Student's t

Confidence Quantile

t	Alpha
1.99167	0.05

LSD Threshold Matrix

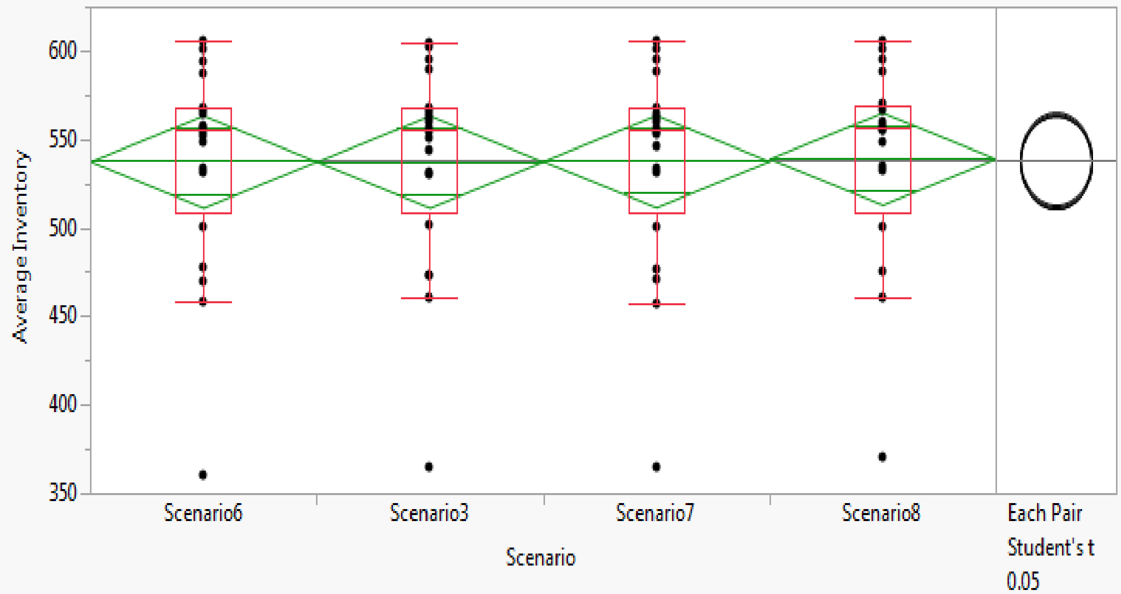
Abs(Dif)-LSD

	Scenario8	Scenario7	Scenario6	Scenario3
Scenario8	-0.21311	-0.20662	-0.17628	-0.17057
Scenario7	-0.20662	-0.21311	-0.18277	-0.17706
Scenario6	-0.17628	-0.18277	-0.21311	-0.20740
Scenario3	-0.17057	-0.17706	-0.20740	-0.21311

Positive values show pairs of means that are significantly different.

Figure 43. Manpower Analysis Results for MOE-3(TNMC)

Oneway Analysis of Average Inventory By Scenario



Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Scenario6	360.4648	459.2866	508.6466	555.7888	568.1198	600.5665	605.2617
Scenario3	364.5197	462.1102	508.6938	555.5004	567.6249	601.107	604.7757
Scenario7	364.6138	458.9591	508.0519	555.4899	567.8545	600.7915	605.1203
Scenario8	371.0299	461.9917	508.1409	556.887	569.0684	600.7322	605.4599

Oneway Anova

Means Comparisons

Comparisons for each pair using Student's t

Confidence Quantile

t	Alpha
1.99167	0.05

LSD Threshold Matrix

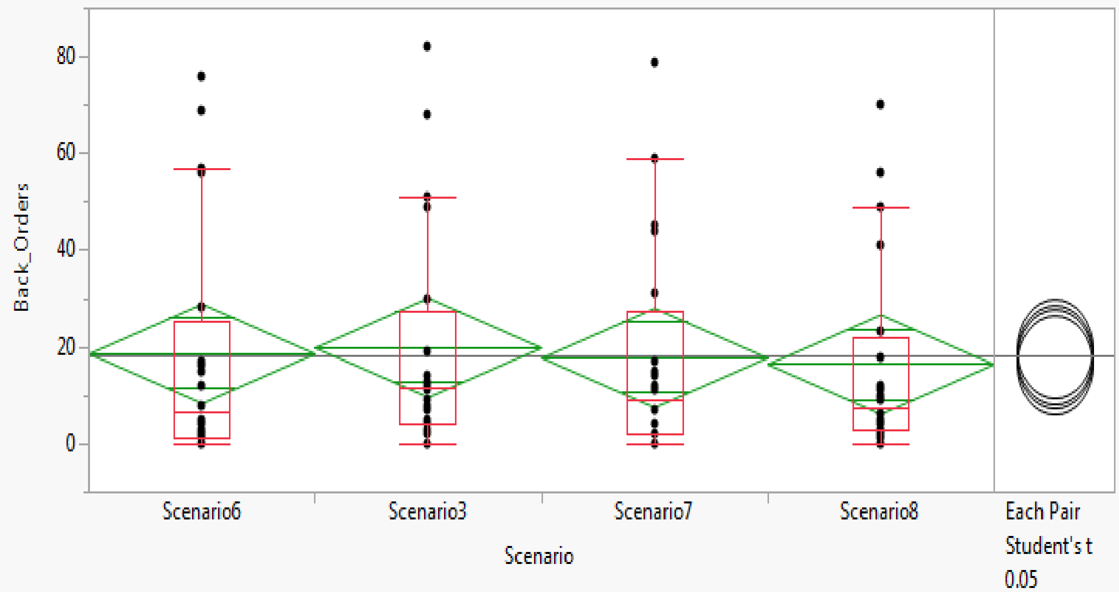
Abs(Dif)-LSD

	Scenario8	Scenario7	Scenario6	Scenario3
Scenario8	-36.754	-35.343	-35.138	-35.099
Scenario7	-35.343	-36.754	-36.550	-36.510
Scenario6	-35.138	-36.550	-36.754	-36.715
Scenario3	-35.099	-36.510	-36.715	-36.754

Positive values show pairs of means that are significantly different.

Figure 44. Manpower Analysis Results for MOE-4(Average Inventory)

Oneway Analysis of Back_Orders By Scenario



Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Scenario6	0	0	1.25	6.5	25.25	67.8	76
Scenario3	0	0.2	4.25	11.5	27.25	66.3	82
Scenario7	0	0.2	2	9	27.5	57.6	79
Scenario8	0	1.1	3	7.5	21.75	55.3	70

Oneway Anova

Means Comparisons

Comparisons for each pair using Student's t

Confidence Quantile

t	Alpha
1.99167	0.05

LSD Threshold Matrix

Abs(Dif)-LSD

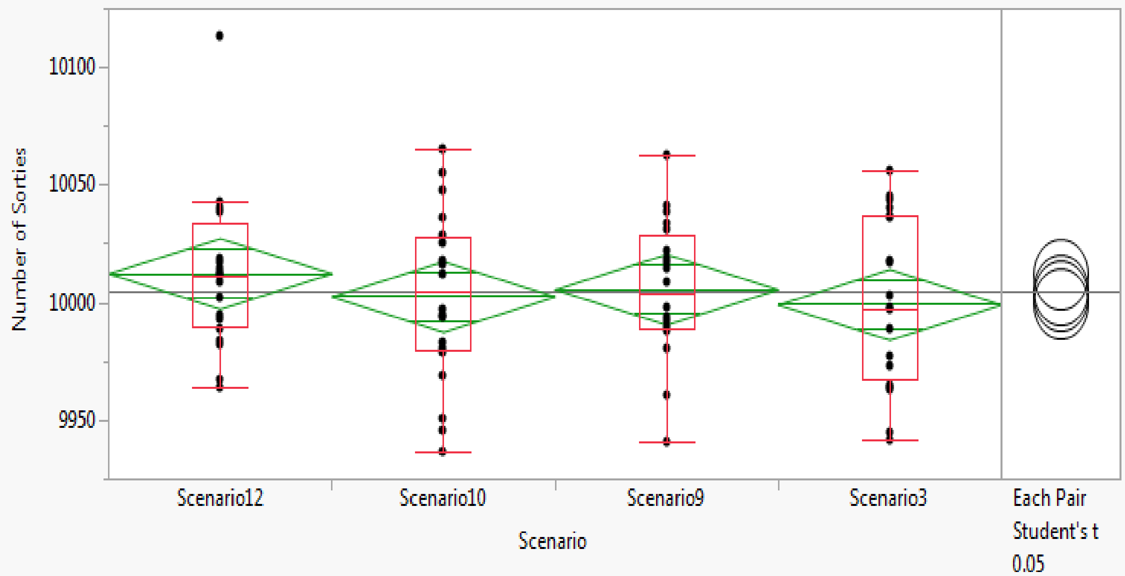
	Scenario3	Scenario6	Scenario7	Scenario8
Scenario3	-14.438	-13.188	-12.338	-10.988
Scenario6	-13.188	-14.438	-13.588	-12.238
Scenario7	-12.338	-13.588	-14.438	-13.088
Scenario8	-10.988	-12.238	-13.088	-14.438

Positive values show pairs of means that are significantly different.

Figure 45. Manpower Analysis Results for MOE-5(Number of Back Orders)

Appendix D: Test Results for MRP Frequency Analysis

Oneway Analysis of Number of Sorties By Scenario



Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Scenario12	9964	9968.5	9990	10011.5	10034	10043	10113
Scenario10	9937	9946.5	9979.5	10004.5	10028	10054.3	10065
Scenario9	9941	9963	9988.5	10003.5	10028.75	10040.8	10063
Scenario3	9942	9946.8	9967	9997.5	10036.75	10044.9	10056

Oneway Anova

Means Comparisons

Comparisons for each pair using Student's t

Confidence Quantile

t	Alpha
1.99167	0.05

LSD Threshold Matrix

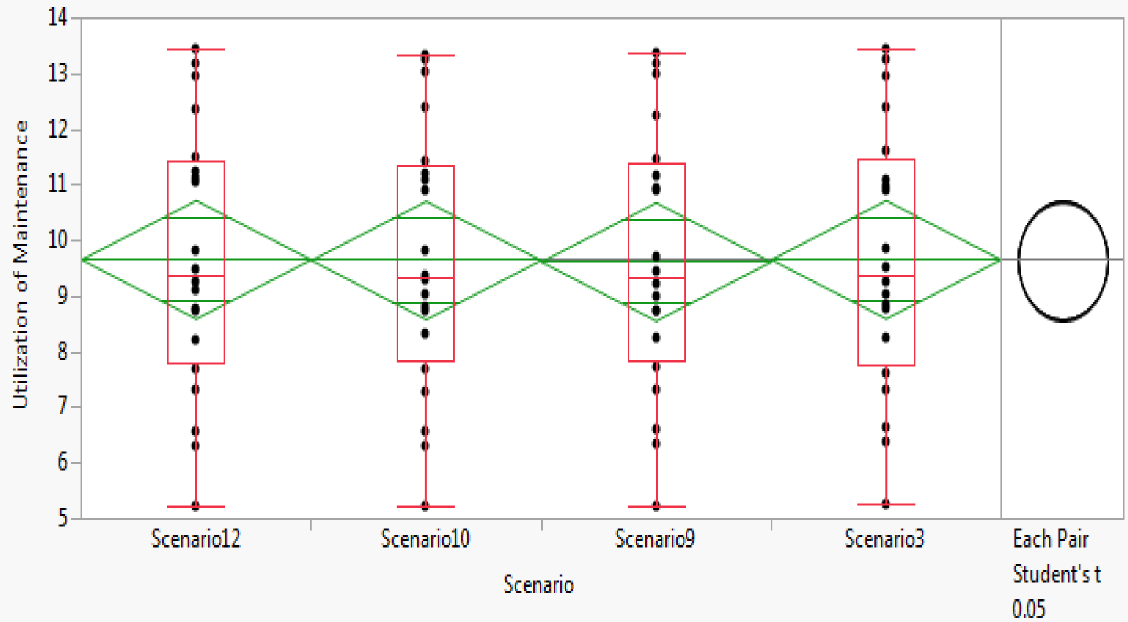
Abs(Dif)-LSD

	Scenario12	Scenario9	Scenario10	Scenario3
Scenario12	-21.162	-14.412	-11.362	-7.962
Scenario9	-14.412	-21.162	-18.112	-14.712
Scenario10	-11.362	-18.112	-21.162	-17.762
Scenario3	-7.962	-14.712	-17.762	-21.162

Positive values show pairs of means that are significantly different.

Figure 46. MRP Frequency Analysis Results for MOE-1 (Number of Sorties)

Oneway Analysis of Utilization of Maintenance By Scenario



Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Scenario12	5.241257	6.319469	7.813287	9.365628	11.42213	13.14015	13.45355
Scenario10	5.216607	6.351414	7.838359	9.32334	11.3621	13.21875	13.34359
Scenario9	5.212022	6.354244	7.848759	9.321831	11.38591	13.16339	13.3697
Scenario3	5.246216	6.39769	7.777654	9.387832	11.47019	13.23757	13.44376

Oneway Anova

Means Comparisons

Comparisons for each pair using Student's t

Confidence Quantile

t	Alpha
1.99167	0.05

LSD Threshold Matrix

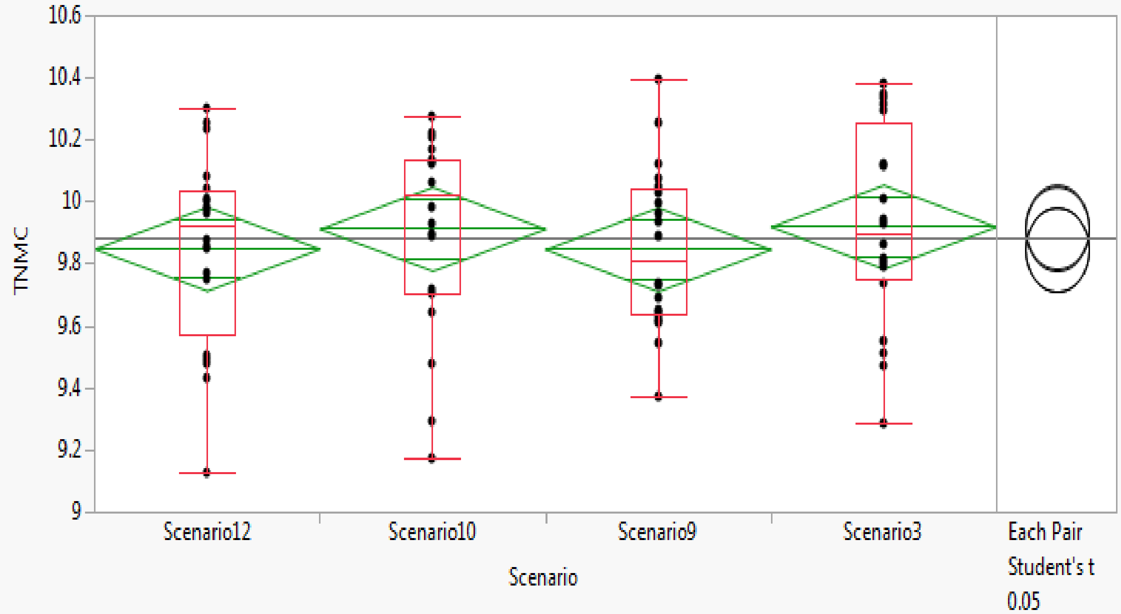
Abs(Dif)-LSD

	Scenario3	Scenario12	Scenario10	Scenario9
Scenario3	-1.5008	-1.5000	-1.4872	-1.4610
Scenario12	-1.5000	-1.5008	-1.4880	-1.4618
Scenario10	-1.4872	-1.4880	-1.5008	-1.4746
Scenario9	-1.4610	-1.4618	-1.4746	-1.5008

Positive values show pairs of means that are significantly different.

Figure 47. MRP Frequency Analysis Results for MOE-2 (Utilization of Maintenance)

Oneway Analysis of TNMC By Scenario



Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Scenario12	9.123454	9.434732	9.567769	9.922105	10.03336	10.25486	10.30261
Scenario10	9.175179	9.307834	9.706089	10.02316	10.13485	10.21737	10.27518
Scenario9	9.373011	9.553353	9.634293	9.811799	10.04266	10.24198	10.3974
Scenario3	9.287826	9.474872	9.748205	9.89462	10.25242	10.34439	10.38183

Oneway Anova

Means Comparisons

Comparisons for each pair using Student's t

Confidence Quantile

t	Alpha
1.99167	0.05

LSD Threshold Matrix

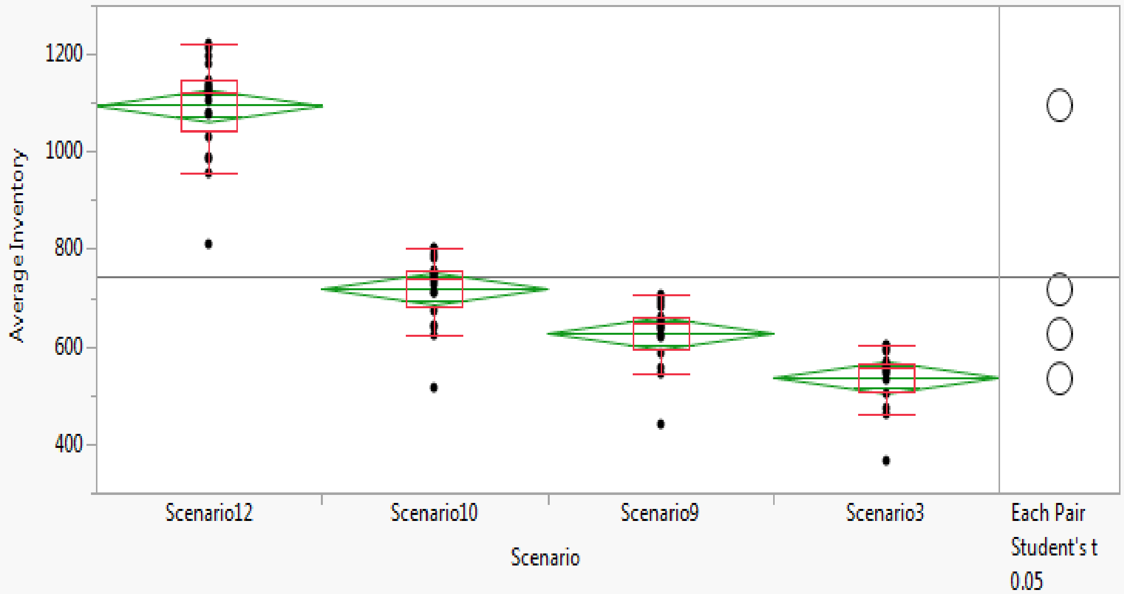
Abs(Dif)-LSD

	Scenario3	Scenario10	Scenario12	Scenario9
Scenario3	-0.19104	-0.18406	-0.11984	-0.11793
Scenario10	-0.18406	-0.19104	-0.12682	-0.12491
Scenario12	-0.11984	-0.12682	-0.19104	-0.18913
Scenario9	-0.11793	-0.12491	-0.18913	-0.19104

Positive values show pairs of means that are significantly different.

Figure 48. MRP Frequency Analysis Results for MOE-3(TNMC)

Oneway Analysis of Average Inventory By Scenario



Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Scenario12	810.9221	960.0248	1041.064	1122.54	1145.73	1211.234	1219.871
Scenario10	515.7551	625.9317	683.1863	740.3659	755.798	800.0921	803.1297
Scenario9	440.2199	544.8668	595.5766	647.059	660.183	699.1251	704.7847
Scenario3	364.5197	462.1102	508.6938	555.5004	567.6249	601.107	604.7757

Oneway Anova

Means Comparisons

Comparisons for each pair using Student's t

Confidence Quantile

t	Alpha
1.99167	0.05

LSD Threshold Matrix

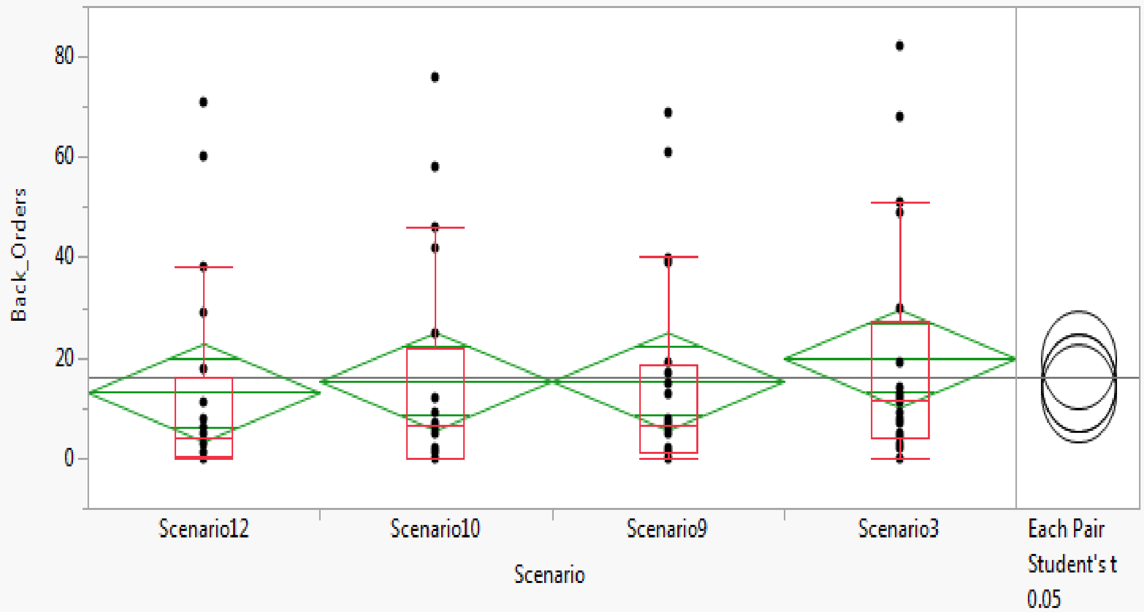
Abs(Dif)-LSD

	Scenario12	Scenario10	Scenario9	Scenario3
Scenario12	-46.96	328.09	419.27	510.05
Scenario10	328.09	-46.96	44.22	135.00
Scenario9	419.27	44.22	-46.96	43.82
Scenario3	510.05	135.00	43.82	-46.96

Positive values show pairs of means that are significantly different.

Figure 49. MRP Frequency Analysis Results for MOE-4(Average Inventory)

Oneway Analysis of Back_Orders By Scenario



Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Scenario12	0	0	0.25	4	16.25	57.8	71
Scenario10	0	0	0	6.5	21.75	56.8	76
Scenario9	0	0	1	6.5	18.5	58.9	69
Scenario3	0	0.2	4.25	11.5	27.25	66.3	82

Oneway Anova

Means Comparisons

Comparisons for each pair using Student's t

Confidence Quantile

t	Alpha
1.99167	0.05

LSD Threshold Matrix

Abs(Dif)-LSD

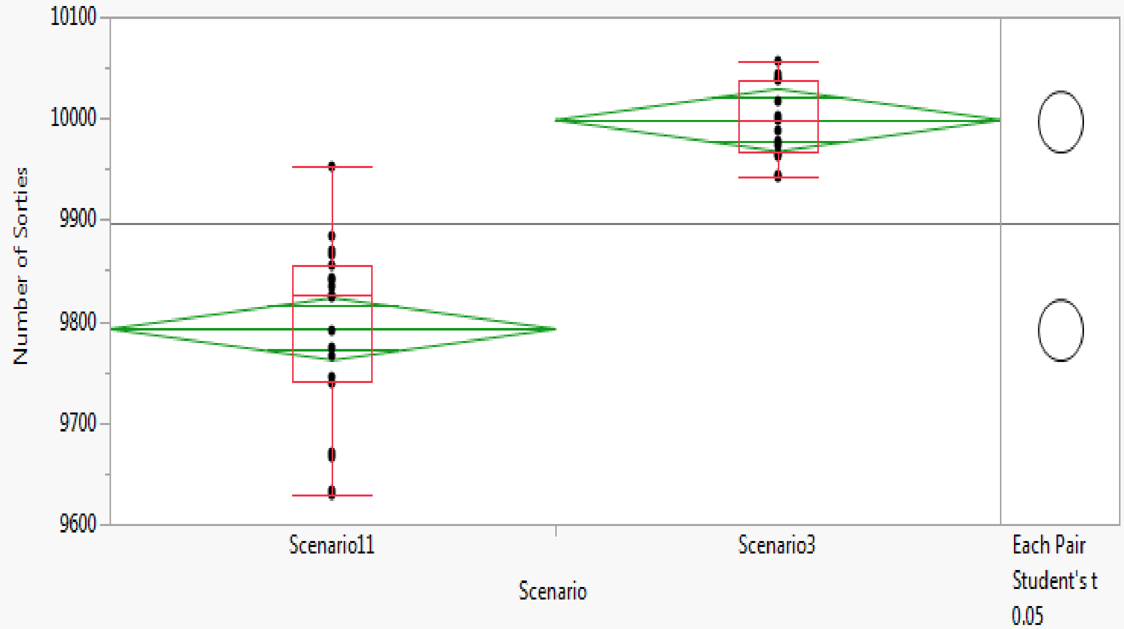
	Scenario3	Scenario10	Scenario9	Scenario12
Scenario3	-13.772	-9.222	-9.222	-6.972
Scenario10	-9.222	-13.772	-13.772	-11.522
Scenario9	-9.222	-13.772	-13.772	-11.522
Scenario12	-6.972	-11.522	-11.522	-13.772

Positive values show pairs of means that are significantly different.

Figure 50. MRP Frequency Analysis Results for MOE-5(Number of Back Orders)

Appendix E: Test Results for Repair Time Analysis

Oneway Analysis of Number of Sorties By Scenario



Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Scenario11	9630	9636.3	9741.25	9825.5	9855.75	9882.6	9952
Scenario3	9942	9946.8	9967	9997.5	10036.75	10044.9	10056

Oneway Anova

Means Comparisons

Comparisons for each pair using Student's t

Confidence Quantile

t	Alpha
2.02439	0.05

LSD Threshold Matrix

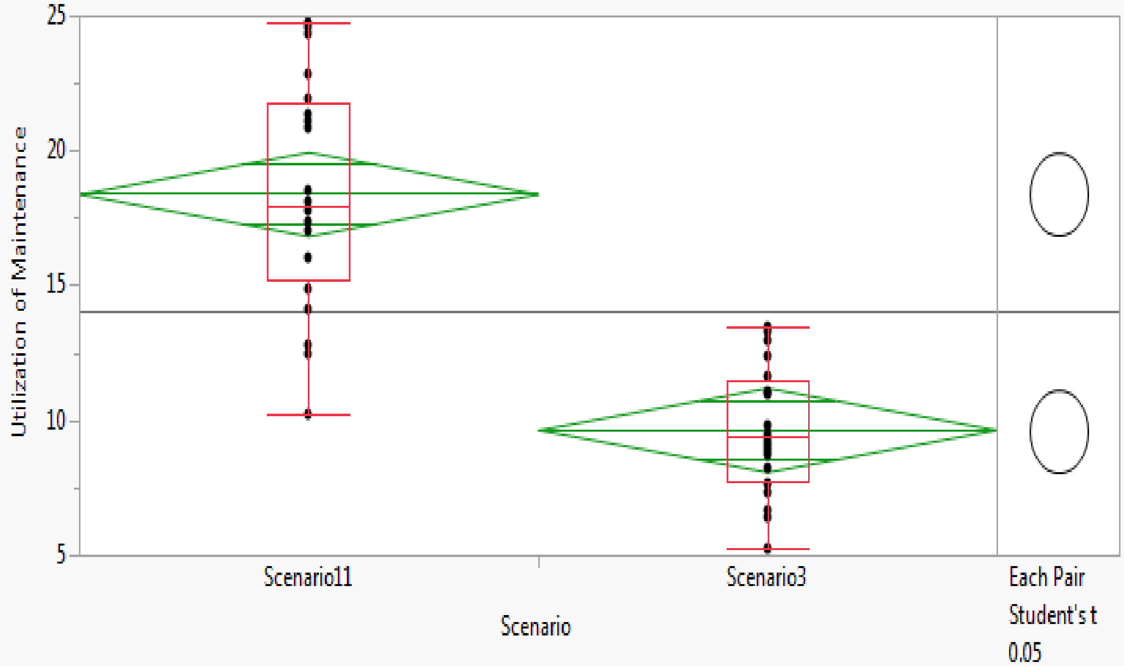
Abs(Dif)-LSD

	Scenario3	Scenario11
Scenario3	-43.43	162.52
Scenario11	162.52	-43.43

Positive values show pairs of means that are significantly different.

Figure 51. Repair Time Analysis Results for MOE-1 (Number of Sorties)

Oneway Analysis of Utilization of Maintenance By Scenario



Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Scenario11	10.26241	12.53761	15.17472	17.9429	21.76886	24.55392	24.77673
Scenario3	5.246216	6.39769	7.777654	9.387832	11.47019	13.23757	13.44376

Oneway Anova

Means Comparisons

Comparisons for each pair using Student's t

Confidence Quantile

t	Alpha
2.02439	0.05

LSD Threshold Matrix

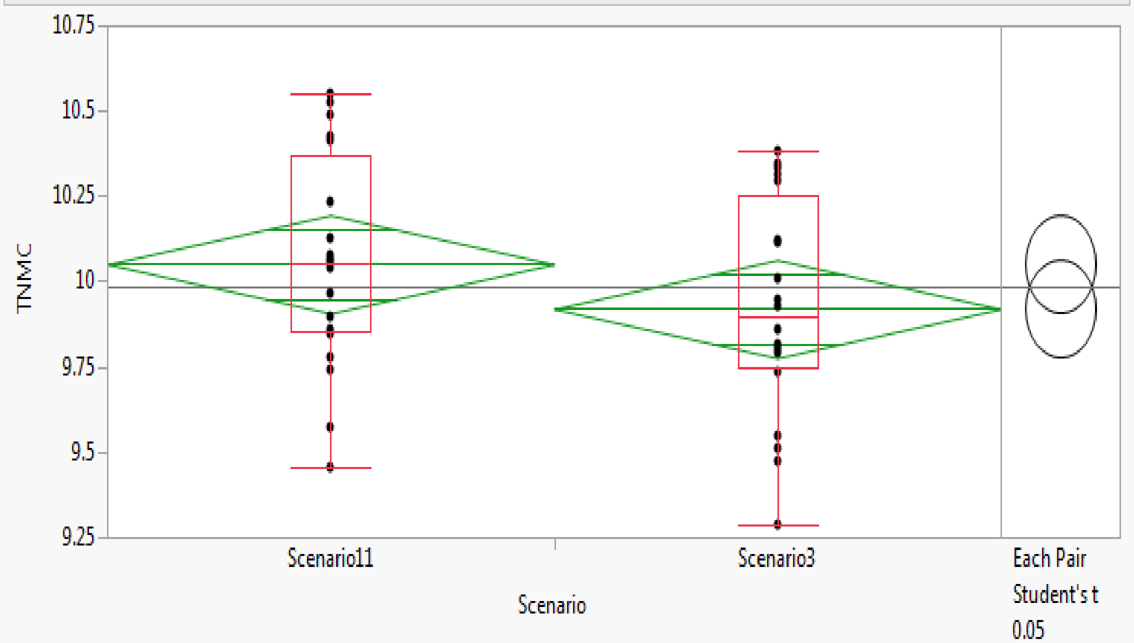
Abs(Dif)-LSD

	Scenario11	Scenario3
Scenario11	-2.2027	6.5412
Scenario3	6.5412	-2.2027

Positive values show pairs of means that are significantly different.

Figure 52. Repair Time Analysis Results for MOE-2 (Utilization of Maintenance)

Oneway Analysis of TNMC By Scenario



Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Scenario11	9.455695	9.587795	9.852603	10.05001	10.37164	10.52416	10.5503
Scenario3	9.287826	9.474872	9.748205	9.89462	10.25242	10.34439	10.38183

Oneway Anova

Means Comparisons

Comparisons for each pair using Student's t

Confidence Quantile

t	Alpha
2.02439	0.05

LSD Threshold Matrix

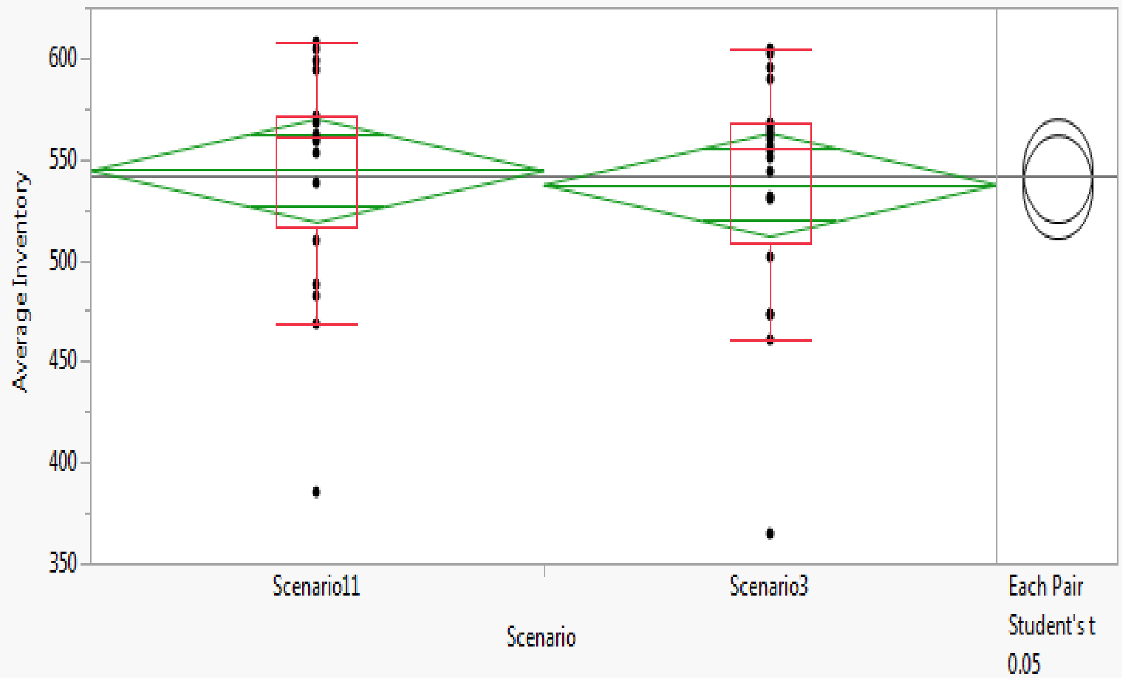
Abs(Dif)-LSD

	Scenario11	Scenario3
Scenario11	-0.20317	-0.07208
Scenario3	-0.07208	-0.20317

Positive values show pairs of means that are significantly different.

Figure 53. Repair Time Analysis Results for MOE-3(TNMC)

Oneway Analysis of Average Inventory By Scenario



Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Scenario11	385.1357	470.2669	516.553	561.1958	571.1573	604.3008	608.1064
Scenario3	364.5197	462.1102	508.6938	555.5004	567.6249	601.107	604.7757

Oneway Anova

Means Comparisons

Comparisons for each pair using Student's t

Confidence Quantile

t	Alpha
2.02439	0.05

LSD Threshold Matrix

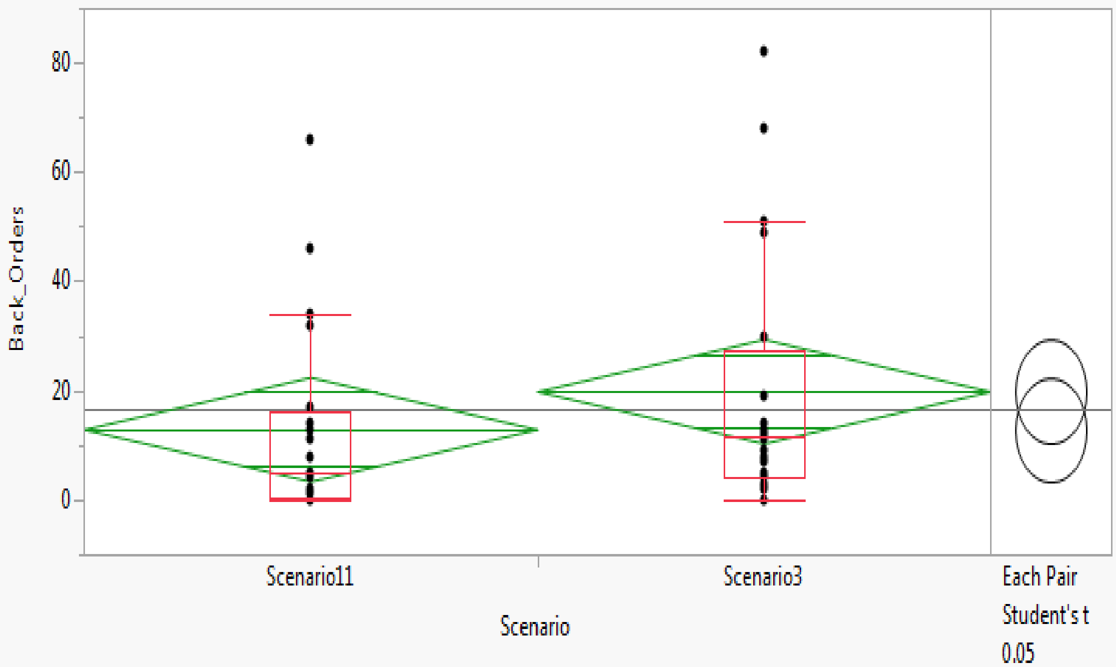
Abs(Dif)-LSD

	Scenario11	Scenario3
Scenario11	-36.131	-29.067
Scenario3	-29.067	-36.131

Positive values show pairs of means that are significantly different.

Figure 54. Repair Time Analysis Results for MOE-4(Average Inventory)

Oneway Analysis of Back_Orders By Scenario



Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Scenario11	0	0	0.25	5	16.25	44.8	66
Scenario3	0	0.2	4.25	11.5	27.25	66.3	82

Oneway Anova

Means Comparisons

Comparisons for each pair using Student's t

Confidence Quantile

t	Alpha
2.02439	0.05

LSD Threshold Matrix

Abs(Dif)-LSD

	Scenario3	Scenario11
Scenario3	-13.484	-6.534
Scenario11	-6.534	-13.484

Positive values show pairs of means that are significantly different.

Figure 55. Repair Time Analysis Results for MOE-5(Number of Back Orders)

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14. ABSTRACT
This thesis builds a discrete event simulation of the sortıe generatıon process, to help decision makers in performing analyses regarding quantity of manpower, bottlenecks in supply and maintenance activities; as well as utilization of maintenance manpower, cost and number of sorties produced in a specific time. We only model one aircraft system with four Line Replacement Units (LRU), but any system and its LRUs can be included in our simulation. Our analysis focuses on seven Measures of Effectiveness (MOE) from our simulation. The final simulation provides a reasonable representation of many, but not all, characteristics of the sortie generation process. It is a preliminary simulation tool for further research on the sortie generation process in the Turkish Air Force, and provides decision-makers with the ability to analyze the sortie generation process in support of future decisions.

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