

EVALUATION OF ARMY CORPS ARTILLERY
AMMUNITION SUPPLY SYSTEM VIA SIMULATION

A THESIS
SUBMITTED TO THE DEPARTMENT OF INDUSTRIAL
ENGINEERING
AND THE INSTITUTE OF ENGINEERING AND SCIENCES
OF BUKENT UNIVERSITY
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
MASTER OF SCIENCE

By
Dursun Hakan Utku
July, 2000

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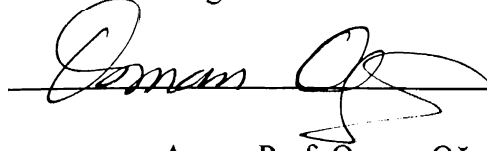
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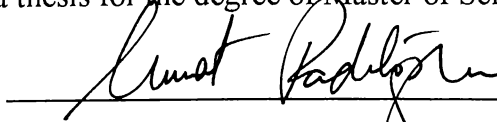
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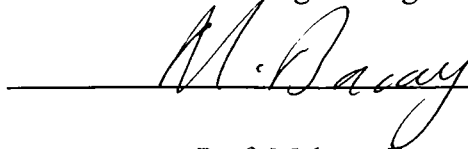
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I certify that I have read this thesis and that in my opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.



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ABSTRACT

EVALUATION OF ARMY CORPS ARTILLERY AMMUNITION SUPPLY SYSTEM VIA SIMULATION

Durdu Hakan Utku
M.S. in Industrial Engineering
Supervisor: Assoc. Prof. Ihsan Sabuncuoğlu
July, 2000

Since the use of enhanced technology by the opposing forces, Turkish Armed Forces must adopt new tactics, employ appropriately upgraded delivery equipment to deliver rations, fuel, ammunition, personnel, repair parts to forces in forward areas to be able to react in time. Within the budget limits, the opportunity to explore new tactics and to test and evaluate new logistics material delivery equipment is correspondingly difficult and sometimes impossible. However, by the use of simulation, which is inexpensive, new supply distribution techniques employing different equipment combinations both currently existing and experimental can be tested.

In this study, we evaluate the performance of the existing and new systems of army corps artillery ammunition supply systems. The objective is to see whether the systems operate properly and to select the system design.

Key Words: Logistics, Ammunition Supply, Military Simulation

ÖZET

KOLORDU TOPÇU MÜHİMMAT İKMAL SİSTEMİNİN SİMULASYON YOLUYLA DEĞERLENDİRİLMESİ

Durdu Hakan Utku
Endüstri Mühendisliği Bölümü Yüksek Lisans
Danışman: Doç. İhsan Sabuncuoğlu
Temmuz, 2000

Karşı kuvvetler tarafından yüksek teknolojinin kullanılması nedeniyle Türk Silahlı Kuvvetleri yeni taktikler edinmeli, yiyecek, akaryakıt, mühimmat, personel ve yedek parçaları dağıtmak için uygun gelişmiş dağıtım teçhizatı kullanmalıdır. Bütçe sınırları dahilinde, yeni taktikler geliştirme ve test etme fırsatı zor ve bazen imkansızdır. Bununla beraber, mevcut ve deneysel olanın her ikisi de pahalı olmayan simulasyon kullanımıyla, değişik teçhizat kombinasyonlarıyla yeni ikmal dağıtım teknikleri test edilebilir.

Bu çalışmada, yeni ve eski kolordu topçu mühimmat ikmal sistemlerinin performansını değerlendiriyoruz. Amaç, sistemlerin uygun şekilde işleyip işlemediğini görmek ve sistem tasarımını seçmektir.

Anahtar sözcükler: Lojistik, Mühimmat İkmali, Askeri Simulasyon

To my wife, and to my son

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Chapter 1

Introduction

1.1. Logistics

Logistics is “The science of planning and carrying out the movement and maintenance of forces”[10]. In a detailed description, logistics is the art and science of creating and maintaining a military capability. Its aim is to create weapons and forces and provide sustained support of those in combat. In comprehensive sense, logistics include the “Design and development, acquisition, storage, movement, distribution, maintenance evacuation, and disposition of material; movement, evacuation, and hospitalization of personnel; acquisition or construction, maintenance, operation, and disposition of facilities; and acquisition or furnishing of services” [10].

The basic mission of the Army Logistics System is to support the soldier in the field with what is needed, when, where, and in the condition and quantity required at minimum expenditure of resources. This mission is the main idea which connects all logistics activity, governs application of principles, and establishes a framework of fundamental logistics principles which helps the army to accomplish its mission.

Since the army logistics is a major system, it consists of a group of functional subsystems. The most effective and efficient system is not the result of only maximizing the effectiveness and efficiency of the performance of each of its subsystems, but is a balanced system capable of adjustment to meet changing priorities and needs. This major system has the following processes as the subsystems:

- Requirement determination: A requirement is a need for the timely allocation of resources to achieve a capability to accomplish an approved military objective, mission, or task. Requirement determination is a statement of need, together with the resource definitions to accomplish the stated need.

- Acquisition: The acquisition process consists of all of those tasks performed to satisfy the quantitative, qualitative, and time specifications of the requirements process.
- Distribution: The distribution process involves all logistical aspects to move, receive, store, handle, and issue materiel in the Army supply system.
- Maintenance: Maintenance is the function of sustaining material (weapons systems, components, spares, support equipment) and facilities in an operational status; restoring them to a serviceable condition; or upgrading their functional utility through modification.
- Disposal: The disposal process involves the purging (under proper authority) of excess, obsolete, or surplus material (weapons systems, components, spares, support equipment), supplies and real property (Government-owned and -leased installations and housing); making such items available to other prospective users; and effecting maximum possible recovery of value of items.

The logistics principles are as follows:

- Logistics intelligence: Commanders must have accurate and timely logistics information in order to provide effective logistics support.
- Objective: Logistics endeavors must be directed toward a clear and attainable objective.
- Generative logistics: The professional application of initiative, knowledge, and ingenuity, and the innovative exploration of technical and scientific advances are fundamental to the generation of logistics systems improvements
- Interdependence: Logistics system efficiency requires effective interrelationships among all functional parts of the system.
- Simplicity : Simplicity is essential at all levels of the logistics system.
- Timeliness. Logistics support must be provided in the right quantity at the proper time and place for accomplishment of the mission.
- Impetus : The impetus of logistics support is forward to support the combat mission.
- Efficient management of logistics resources is essential to cost-effective logistics support.

- Security: Security of every facet of the logistics system must be maintained to preserve resources and insure sustained combat capability.

1.2. Ammunition Supply

The purpose of the ammunition supply is to provide the ammunition to the military units in time wherever it is needed to gain the maximum support to their operation plans. Ammunition is a very important supply material both in peace and in war. That is why it's too essential to have a good working supply system for keeping the units ready in peace and active in war.

1.2.1. Principles of Ammunition Supply System

While obeying the logistics principles, army ammunition has its own principles to be cared. These are [11]:

- Simplicity: By simplicity the mistakes can be diminished and the supply time can be shortened.
- Monotony: If the tools of the system are the same, like the preparation of the reports, filling of the forms, it becomes easier to implement those of the same kind activities.
- Elasticity: Ammunition supply system should be able to react elastically according to the changing tactical situations. The system should be able to deploy and change directions according to the changes of the operational plans.
- Continuity: The flow of ammunition supply should never be delayed or stopped. Even a temporary supply deficiency may end with the failure of the system.
- Security: Ammunition depots, sites should be secured from activities of the enemy and fire.
- Inventory control.
- Economy of supply: The ammunition that is kept in the depots and kept with the units (unit basic loads) should be in good condition by way of suitable maintenance by the responsible personnel.

1.2.2. Phases of Ammunition Supply

Ammunition is supplied within three phases:

- Initial supply phase: That phase contains the calculation, preparation, storing and the maintenance of the necessary ammunition.
- Automatic supply phase: The units go to the battlefield with their Unit Basic Loads (UBL) they already have and they supply the ammunition they consumed automatically from the responsible Ammunition Supply Points (ASP) by evening to the time ordered.
- Normal supply phase: From the beginning of the battle date supply is executed automatically to the time commandant ordered. From that time it's ordered how the supply to be executed. That phase is called the normal supply phase.

1.2.3. Existing Conventional Ammunition Supply System

Conventional Ammunition Supply System (CASS) is done according to the principle of resupplying the controlled consumption of the UBL. Units are responsible for maintaining their UBL available for use every time and go to the battle area with their UBLs and resupply their consumed ammunition within 24-hour periods.

Whenever the ammunition is given to the units from the Ammunition Supply Points it is supplied from The Army and Corps Depots by the army and corps vehicles and Depots of the Command of Logistics by the vehicles of the Command of Logistics (CL). The ammunition which, is supplied from the depots within the Army Supply-Maintenance Zone, is resupplied from ammunition depots of the CL and the ammunition that is supplied from the depots of the CL is resupplied from the production depots and the related ports.

1.2.4. Inventory Control in the Existing Ammunition Supply System

Each battalion has equal and fixed ammunition inventory level which is called as UBL. This amount contains a safety level that is called as UBL. This amount contains a safety level that is not explicitly defined. Yet, the UBL is considered as two or three days ammunition. The used up ammunition is replenished by an order up to level

inventory scheme. That is, the used amount is requested by a form (FORM 581) at the end of the day and the order arrives ready to be used at the beginning of the next day.

1.2.5.Control of the Conventional Ammunition Consumption

Army must control its ammunition consumption within the limits of some measurements to be able to prevent the surplus and aimless use of ammunition. These measurements are implemented by using different methods from the basic battle units to the units that have complicated organization level. The control of the ammunition consumption is done:

- By assigning the Ammunition Credits, the ammunition needed for a tactic task in a determined period, to the armies.
- Restricting or banning the ammunition consumption by using Daily Ammunition Necessity Ratio (DANR) and Daily Ammunition Supply Ratio (DASR).
- Unit Basic Load (UBL): UBL is the quantity of ammunition carried by the unit and its personnel, ordered as “ammunition per barrel” for the ammunition fired by a weapon and as “ number” for the others and calculated for the units by using a table in [12].
- Daily Ammunition Necessity Ratio (DANR): Ratio (DANR) is the quantity of ammunition that a unit needs for the continuation of its tactical operation without any restriction. It’s calculated for every weapon individually for a specific time period and can be changed by time and within the sub units according to the experiences or the table 3.20 in [12] for the units which have tactical tasks then proposed from the sub units to the top.
- Daily Ammunition Supply Ratio (ASR): ASR is the quantity of ammunition which can be supplied by the commandant according to the ammunition in hand and ordered for the critical ammunition individually for a specific time period mentioned day by day. It’s elastic, however, except for the emergency conditions, the units should not exceed the ASR without permission [12].

1.2.6.The Supply Methods of 5th Class Supply Materials In Existing System

Fifth class supply materials include the ammunition the units need during the battle. The methods used for the existing ammunition supply system are “Supply point distribution method” for the units that are sub units of corps and “Distribution to the unit distribution method” for the units that are the sub units of army. In the first method the units send their supply vehicles to the supply point, take the ammunition and come back to their battle area. In the second method the consumed ammunition is directly supplied by the vehicles of the army to the ammunition supply points. Since we study on the part from the corps to the battle units the following explains the details of the artillery ammunition supply system from corps to the battle units of that corps [13] [30]:

- The units go to the battle area with their UBL initially. The main principle behind the idea of war condition supply is the completion of the ammunition consumed from the UBL.
- The battalion supply officer (S4) gathers the lists of the consumed ammunition which are reported by the battery commanders and fills in three copies of FORM 581s including the ammunition necessary to complete the consumed ammunition from the UBLs and gives them to the commander of the convoy who is responsible to take the convoy to the Ammunition Supply Point (ASP).
- On the way to the ASP, the convoy commander takes these forms to the Brigade Ammunition Bureau (BAB) to have approved the forms. The idea of the approval is the comparison of the ammunition request with the ordered ASR. BAB reports the critical ammunition or ammunitions to the brigade.
- The convoy commander leaves one of the forms and takes the two and goes to the ASP supporting the related brigade. After the upload of the ammunition to the vehicles, the convoy commander leaves one of the Form 581 to the ASP and takes the convoy back to the battalion and gives the last Form 581 to the S4. That is the supply point distribution method.

All these activities can be seen in Figure 1.2.5.1.

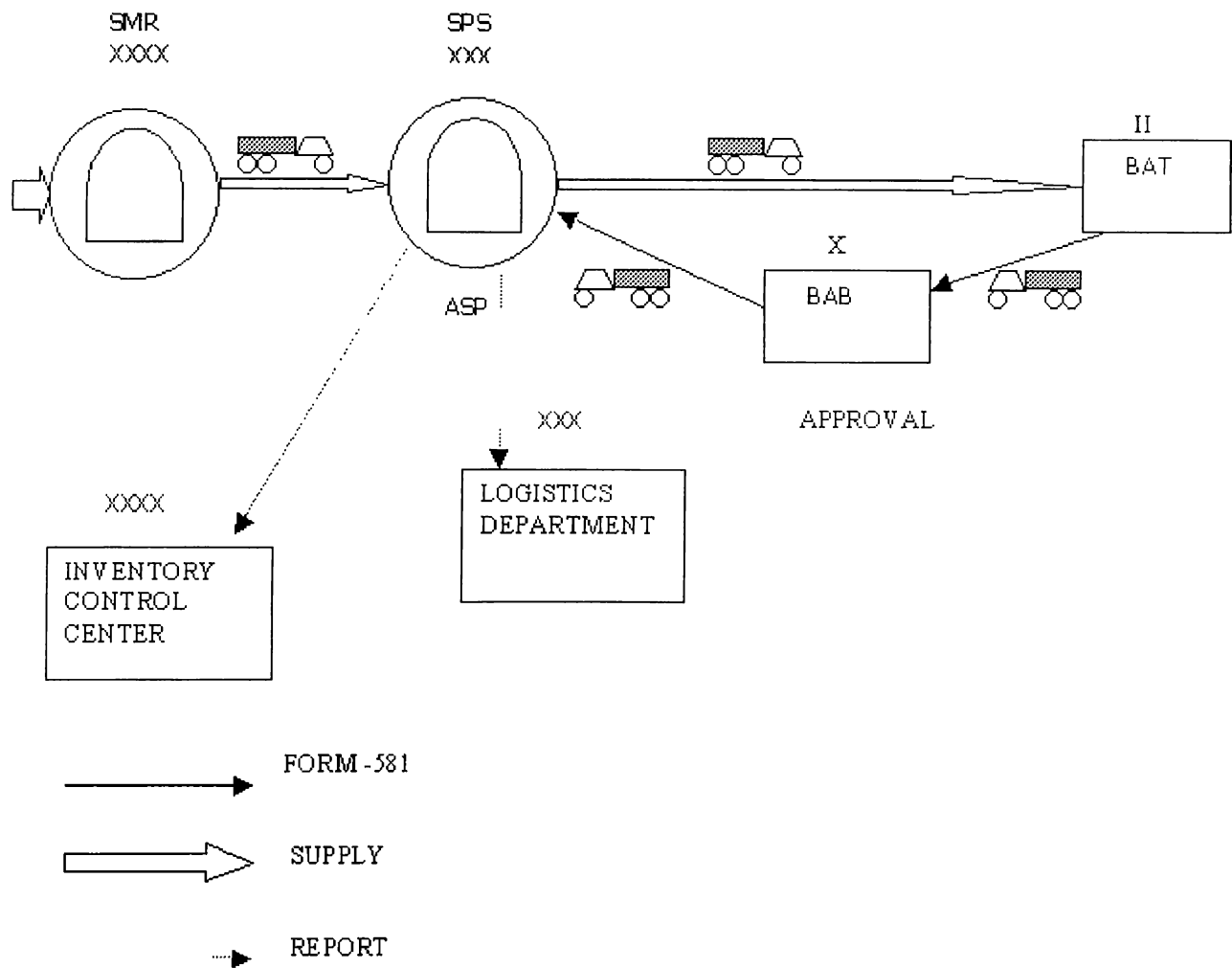


Figure 1.2.6.1. Ammunition supply flow from corps to battalion in war conditions

1.2.7. The Supply Method of 5th Class Supply Materials In New Ammunition Supply System

New ammunition supply system is the system that is proposed and about to be implemented by the army logistics system. The main difference between these systems is the implementation of the system just by using the “Distribution to the unit distribution method”. All of the logistic activities of the army are commanded by the Army Logistics Management Center (ALMC). The transportation issues are planned by the Transportation Center, which is a sub department of ALMC. ALMC is informed by use of an on-line network about the consumed ammunition by the brigades. As the information is gained by the ALMC, it is decided which ASP is

responsible for the supply of the related brigade and which transportation unit is responsible for the transportation of this ammunition.

According to the new system, the ammunition in the ASPs and other depots are kept in the 20-ton containers and these containers are carried by 20 tons capacity vehicles having tools to load and unload these containers. Figure 1.2.6.1 presents these activities.

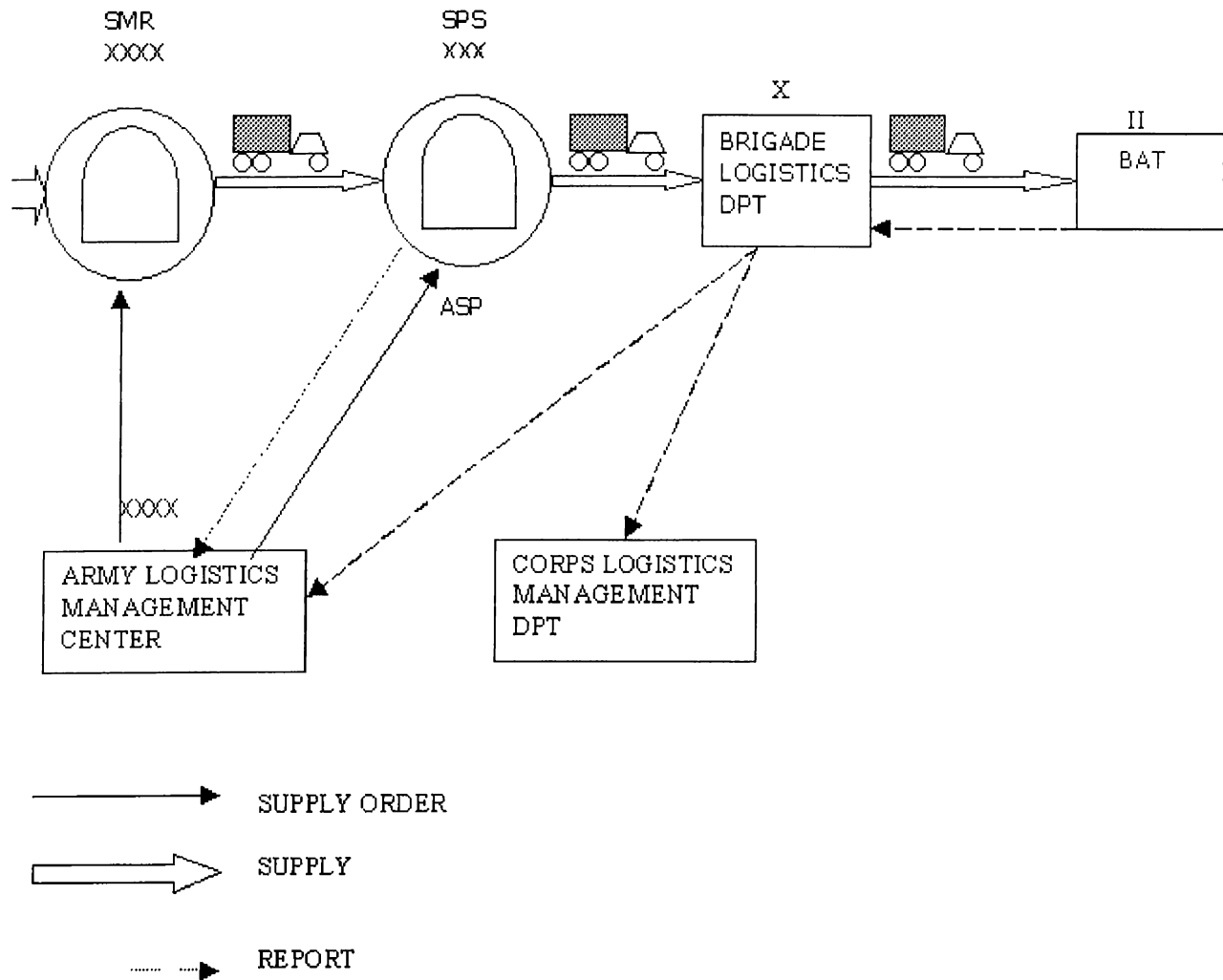


Figure 1.2.7.1: Ammunition supply flow from corps to battalion in war conditions

The rest of the thesis is organized as follows. Chapter 2 presents the related literature with the simulation software and methods; the requirements of military simulation modeling; general logistics applications that are similar to the system we

simulate and military logistics problems in which the simulation is used. Chapter 3 describes implementation of the simulation model of army corps artillery ammunition supply system. Chapter 4 interprets the output results of the simulation model related with the existing ammunition supply system by showing the numerical results. Chapter 5 presents the output data analysis that evaluates and interprets the results of the simulation models related with the army new ammunition supply system. In this chapter, the results are shown numerically and graphically, then the interpretations of these results are given. Chapter 6 includes a sensitivity analysis on the parameters of ASP in modified existing system and provides the interpretation of this analysis. Chapter 7 concludes the research. It discusses the research and gathers the ideas of the study. Finally, ideas and suggestions for future work are listed. Appendices provide the computer codes, outputs and some figures of the supply systems mentioned in the previous chapters.

Chapter 2

Literature Review

2.1. Simulation Software and Methodology

Throughout our study we use the basic principles which stated in Banks [3]. In this study, the author explains the fundamentals of the modeling methodologies, gives brief information about the use of simulation and then recommends a stepwise logic for all phases of simulation.

In our study we use ARENA software for the modeling since it is a flexible and powerful tool that allows us to create an animated simulation model and to analyze the outputs easily. Takus and Profozich [15] explain the software and its capabilities in their tutorial.

Sargent [16] discusses approaches to verification and validation of simulation models and how model verification and validation relate to the model development process. After defining various validation techniques he describes conceptual model validity, model verification, operational validity, data validity and recommends a procedure.

Kleijnen [14] explains which statistical techniques can be used to validate simulation models depending on which real-life data are available. He distinguishes the situations as the cases of having no data, only output data, both input and output data. To explain these three cases he provides some case study summary.

Kelton [21], Centeno and Reyes [20], Alexopoulos and Seila [22] and Sanchez [23] all study on the procedures, techniques about the simulation output analysis. We use the techniques determined for the terminating systems.

2.2. Military Simulation

Smith [2] identifies and explains the essential techniques necessary for modern military training simulations. He provides a brief historical introduction; discussions of system architecture; multiple interactive training simulations; event and time management; distributed simulation; and verification, validation, and accreditation. After all, he discusses the fundamental principles in modeling and specific military modeling domains. While discussing the fundamental principles of modeling he stresses on the importance of modeling the right problem, complete and accurate understanding, credibility and construction of the model subject to some constraints. Under the heading of physical modeling he focuses on the importance and usage of physical objects, which include vehicles, people, and machinery involved in the activities of moving, perceiving other objects, and interacting with them in the military simulations. Behavioral, environmental and multi-resolution modeling are the other discussed subjects in his study.

Garrabrants [9] proposes “an expansion of simulation systems’ role to support all levels of command and control functioning, especially staff planning after receipt of orders and mission rehearsal” in his study. He explains how Marine Tactical Warfare Simulation (MTWS), an advanced simulation system, is used to model all aspects of combat (air, land, sea, and amphibious ship-to-shore activities) and gives detailed information about its usage.

In the panel “The future of military simulation” by the chairman Roland [26], military simulation is categorized as including engineering models, analyses models and training models. The members answer the questions about their background; goals and objectives of their involvement in modeling and simulation; HLA studies; major problems in the current state of modeling and simulation development and use; today’s major modeling and simulation opportunities and challenges.

Kang and Roland [3] discuss the military simulation within the subjects of organizations that deal with and their areas of study, classification of military simulation, simulation as a training tool, and applications. They stress on the subjects of advanced distributed simulation, distributed interactive simulation, and high level architecture.

Sisti and Far [18] study on the topics of interest to researchers in the simulation community and present some of selected Air Force programs. They deal with the wide variety of research issues in simulation science being presented by government, academia and industry, and their application to the military domain; especially, to the problems of intelligence analyst.

Hartley [17] discusses the difficulties, ways and cost of the military simulation model validation and verification. He compares the other simulation models with the military ones in terms of validation, verification and accreditation.

2.3. Logistics

Otto and Jeyabalan [4] study on a simulation model which captures the essentials of the JIT manufacturing system which needs the timely delivery of material from its arrival point at the facility to the point of processing. In this study, they focus on the internal material delivery system, design and the evaluation of the performance of these material delivery systems. Entities of the system are containers, racks, crates and trucks; resources are ducks and unes; transporters are fork trucks and other material handling vehicles. The major performance measure of the material delivery and handling system is whether that system is able to support the demands of the production system they serve.

Diaz and Harris [5] studied on a simulation of a logistic service system describing an application at American Express Southern Regional Operational Center (SROC). Its purpose has the purpose of discussing the evaluation of different alternatives to implement a Centralized Mail Distribution Center That receives, processes and forwards mail correspondence from American Express Cardholders to the different industry-specialized Regional Operational Center (ROCs).

Carr and Way [27] developed a rail simulation to represent the entire rail operation since the complexity of the process and system interaction required a dynamic simulation model. The model describes the loading, staging, travel and unloading of rail cars at a facility and two distribution centers. They try to optimize the rail car availability and crew sizing by using the model output and sensitivity analyses.

Angelides [19] develops a simulation model for the material supply for an offshore pipe laying construction by using an object-oriented environment. The model is applied to the loading of the barge at the coating yard, the transportation of the material to the pipe-laying site, and the pipe-laying activity performed by the pipe-laying vessel.

2.4. Military Logistics

Parker [8] develops a simulation model capable of analyzing the deployment strategies of combat, combat support, and service support units. The model is developed on the deployment of the field artillery ammunition carrying vehicles to an ammunition supply point. The model is written in SLAM II and subroutines are written in Microsoft Fortran 77. The vehicles are the entities and the berths are the resources of the model.

Borrego, Cheng and Janz [6] study on The Comprehensive Operational Support Evaluation Model for Space (COSEMS) which is a discrete event simulation with objective of evaluating alternative logistics support concepts that have been proposed by the Strategic Defense System (SDS). It is written in SIMSCRIPT II.5 and FORTRAN.

Parker and Williams [7] construct a model to develop alternative approach to the existing studies whether the Air Force can maintain logistics to support strategies of force. They try to give a method for the analyst to develop flow diagrams which can be used to analyze logistics requirements to evaluate force sustainment. The model makes it possible to evaluate the steady -state logistics flow of fuel and ammunition through time for the user.

In the panel presented by Carson et al. [28] the use of simulation versus optimization and heuristic models, the features in current generation simulation software relevant to transportation and logistics modeling, the possibility of combining simulation and optimization or mathematical models are discussed.

Parsons and Krause [29] introduce the TloadDS simulation model that is a tool to study the delivery of logistics material to U.S. Marine Expeditionary Forces. This tool tries to provide inexpensive, flexible and frequent evaluation of new logistics delivery tactics and logistics material transport vehicles. It has purpose of encompassing all elements of the previously built models into one model, allowing for easy user

modification increasing execution speed significantly. It allows the user to design and record model responses for variations in input parameters such as force distribution and placement, logistics distribution networks, hostile threats, weather, types and quantities of vehicles, competition for the scarce resources such as transport vehicles and material handling equipment.

CLASSIFICATION	PUBLICATION	SUBJECT
Simulation Software and Methodology	Takus and Profozich [15] Sanchez [23] Kleijnen [14] Kelton [21] Centeno & Reyes [20] Alexopoulos & Seila [22] Sanchez [23]	ARENA software tutorial Verification and validation of simulation models Statistical techniques and data availability Statistical analysis of simulation output Simulation output analysis Advanced methods for simulation output analysis ABC's of output analysis
Military Simulation	Smith [2] Garabrants [9] Rolant et.al [26] Kang & Roland [3] Sisti & Far [18] Hartley [17]	Essential techniques for military modeling and simulation Simulation as a mission planning and rehearsal tool Panel: The future of military simulation Military simulation Modeling and simulation technologies for military applications Verification and validation in military simulations
Logistics	Otto & Jeyebalan [4] Diaz & Harris [5] Carr & Way [27] Angelides [19]	Simulation models of material delivery systems Simulation of a centralized mail distribution center Million dollar logistic decisions using simulation Material supply simulation for offshore pipelaying construction
Military Logistics	Parker [8] Borrego, Cheng & Janz [6] Carson et. al [28] Parsons & Krause [29]	Ammunition upload and deployment V2.0: A simulation analysis A space logistics simulation implementation in ADA Panel on transportation and logistic modeling Tactical Logistics And Distribution Systems (TLOADS) simulation

Table 2. Summary table of related literature

Chapter 3

The Simulation Model

3.1. Formulation of the Problem and Planning the Study

The objectives of this study are to examine the behavior of the existing and new army corps ammunition supply systems, establish the nature of the relationships among one or more significant factors and the systems' responses, see whether these systems operate properly or not considering the performance measures below, compare these systems and improve system performances. In case the system does not work in a proper way, we try to detect the bottleneck factors of the system by analyzing the behaviors of the system in different conditions, then propose the modified system/systems operating properly. The performance measures under consideration are:

- Average time in system of the ammunition convoys
- Average time in queue in the ASPs
- Average number of convoys waiting in ASP loading queues.
- Average number of ammunition in use
- Utilization of the loading units

By using this simulation model we try to answer the following questions of interest:

- Does the system operate properly? (Does the artillery always have ammunition to fire during the battle?)
- If not, what are the critical issues to be examined, changed, added or omitted?
- Which supply system is better considering the stated performance measures?
- Is there a need to change the constructions of the facilities of the system?
- How many vehicles are needed for the system to operate properly?

To construct an eligible model we need enough data. Since our system is considering the war conditions, it's difficult to find exactly fitting data to the real conditions. For the implementation of the simulation model we need:

- The number of ammunition the battalions have as UBL with them,
- The number of ammunition consumed by the battalions
- The inspection and approval times of FORM 581 in BAB
- The inspection and approval times of FORM 581 in ASP
- Velocity of the convoys
- Loading capacity of a vehicle
- Loading time of a vehicle
- Loading capacity of an ASP (How many convoys can be loaded at the same time)
- Loading capacity of an ASP (How many vehicles can be loaded at the same time)

This study helps to see how the system operates, how the behavior of the system changes under certain conditions and helps to evaluate the system as a whole rather than just evaluating within the subsystems. The end user of this study is the Turkish Army Logistics System.

By using the model the user can make decisions and evaluations on the system by way of sensitivity analysis. The model can be easily adapted to model other combat units, combat service support units, as well as combining several modules of this program together to implement for the army. ARENA software has the flexibility of adding and subtracting some of these modules to develop the model.

The model enables the user to see the system behavior physically with the help of animation part. If desired the user can develop the animation the way it's expected. The model developed in this thesis can be used for the civilian market as a model for developing and analyzing the distribution of the product to the demand points by making small changes like particularly for grocery chains, storage facilities and other trucking and distribution applications.

The data used in the model is presented in the input data analysis section. The warfare related data are mostly taken from the publications of the army, which are the statistics gathered from the past experiences.

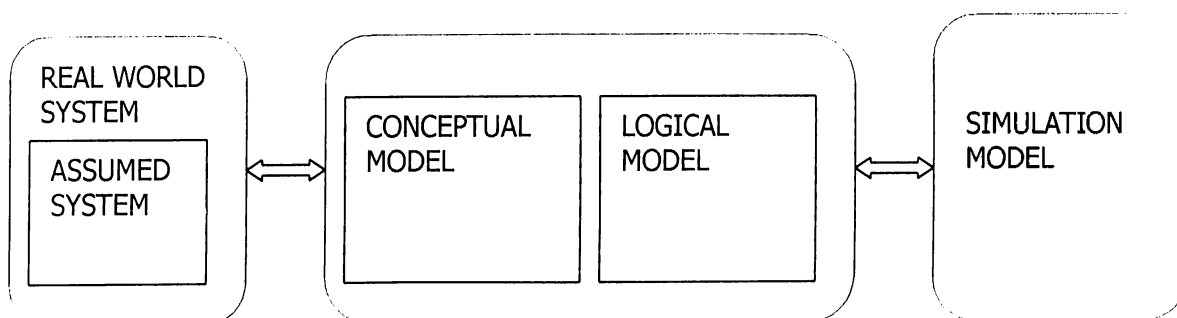
The limitations of the model are mostly comes from the size of the system. Since the difficulty of gathering the data, time limit and for the sake of simplicity we've only modelled the artillery ammunition upload and distribution system. The nature of

war requires many stochastic event and factors. But we've modeled just the flow of the system without including these surprising events and factors since we hope to find the fundamental issues as stated before. Because of the flexibility of the model and the software, if needed these factors can be included in the model. The assumptions of our model are:

- There are enough vehicles
- The basic unit is battalion
- The construction of the corps is as in Appendix F
- The battalions consume ammunition as stated in input data analysis
- The ASR is accepted as the maximum limit of ammunition consumption of the battalions and assumed as the units are not consuming more than that quantity.
- The velocity of the convoys are 25 km per hour and there is no hindrance (if needed it can be included easily)
- The operation under consideration is offence and daily move of one brigade is 15 km per day during the battle time.
- To force the systems' reaction and performance we assume that the operation is always going further although the model includes the probabilities of staying at the same position and withdrawal. The system is analyzed while the brigades move forward with the probability 1 for each day.

3.2. Model Development

To be able to simulate the essence of the system, the conceptual model is first formed after the interviews with the experts of the real ammunition supply system and the users, then the logic model and the computer model are constructed. As a schematic view of model development is:



3.2.1. Conceptual Model

The real-world system under investigation is abstracted by the conceptual model to make it simple to examine the essential components and the structure of the system. Conceptual model contains the elements of the real system that we believe that should be included in the model.

In our study, we evaluate following four systems:

- Existing ammunition supply system
- New ammunition supply system
- Modified existing ammunition supply system
- Modified new ammunition supply system

New ammunition supply system is designed by the Army Logistics Information Systems Department (ALISD) and Army Logistics Command (ALC) to cope with the problems of existing ammunition supply system. It has major differences from the existing supply system from the point of deployments of the supply units, distribution of the ammunition to the tactical units and reporting technologies. We construct the modified existing ammunition supply system by making some modifications on the ASPs and reporting system to obtain an effective and less expensive system. Finally by modifying the new ammunition supply system by just changing the parameters of ASPs we try to obtain a more effective system than the new system.

The interviews with the ammunition supply experts ALISD and the Army Ammunition Department (AAD) help us to make the conceptualization to the point. Now we present the conceptual models of these four systems.

3.2.1.1 The Existing Ammunition Supply System

Events:

The events that occur during the model are the followings:

- Ammunition consumption event: S-4 (supply officer) of battalion gives 3 Form-581s including the number of consumed ammunition to the convoy commander.

- Departure of the convoy from the battalion event: Convoy commander rides to the BAB for the approval of the forms with the convoy that is responsible for transporting the ammunition to be supplied.
- Arrival of the convoy to the BAB event .
- Completion of the approval event: Ammunition officer approves the forms and take one of the forms
- Departure of the convoy from the BAB event: Convoy rides to the ASP which is responsible for the supply of the related units.
- Arrival of the convoy to the ASP event: Convoy commanders take the forms to the ammunition officer of the ASP to get the approval of loading the ammunition, after approval, leave one of the forms therewhile the convoys are waiting at the parks, the personnel approving the forms reports these number of ammunition to corps headquarter.
- Arrival of the convoy to the loading area and the beginning of the loading event
- Completion of the loading event
- Departure of the convoy from the ASP event
- Arrival of the convoy to the battalion event

Entities:

There are two entities of the system. The first one is the major entity of the system but the second one is a control entity.

- Ammunition supply convoy
- Ammunition report (from ASP to Corps headquarter- used as control entity)

Activities:

There are four activities:

- The move of convoys
- The approval of forms
- Ammunition upload
- Reporting

Attributes:

The attributes of the model are the followings:

- Convoy identification numbers
- ASP identification numbers
- Battalion position identification numbers
- The beginning time of the time that the supply begins
- The beginning time of the entrance of the convoys to the ASP loading queues

Exogeneous Variables (Input Variables):

We have the following decision variables and parameters:

- Decision Variables:

- Number of loading units in ASPs
- Capacity of ASPs (number of convoys to be served at one time)
- Loading capacity of vehicles
- Velocity of vehicles
- The distances

- Parameters:

- Number of consumed ammunition for one day
- Approval time of forms in BAB
- Approval time of forms in ASP
- Loading time of one vehicle
- The time of getting ready to move the convoy after loading
- The ASR

Endogenous Variables (Output Variables):

We determine the endogenous variables as follows:

- State variables:

- Number of ammunition the units have
- Number of vehicles in the convoys
- Number of convoys waiting in the loading queues
- State of the ASP loading units (busy or idle)

- Performance measures:

- Average time in the system
- Average waiting time in the queues
- Average number of convoys waiting in the queues
- Utilizations of the loading units
- Average number of ammunition the units have
- Minimum number of ammunition the units have

Assumptions:

We modeled the system considering the following assumptions:

- There are enough vehicles
- The basic unit is battalion
- The construction of the corps is as in Appendix F
- The battalions consume ammunition as stated in Appendix E
- The ASR is accepted as the maximum limit of ammunition consumption of the battalions and assumed as the units are not consuming more than that quantity.

- The velocity of the convoys are 25 km per hour and there is no hindrance (if needed it can be included easily)
- The operation under consideration is offence and daily move of one brigade is 15 km per day during the battle time.
- To force the systems' reaction and performance we assume that the operation is always going further although the model includes the probabilities of staying at the same position and withdrawal. The system is analyzed while the brigades move forward with the probability 1 for each day.

3.2.1.2 New Ammunition Supply System

Events:

- Ammunition consumption event: S-4 reports the number of consumed ammunition to Brigade Ammunition Bureau (BAB)
- Departure of the loaded convoy from the brigade supply region to the battalion event
- Report event: BAB reports the consumed ammunition to the Matariel Management Center (MMC), MMC orders the suitable ASP and the transportation unit to send the supplied ammunition to the Brigade Supply Region
- Beginning of loading the convoy event
- Completion of the loading event
- Departure of the convoy to the brigade event: The consumed ammunition is send to the battalions by the vehicles that are assigned by Transportation Center from the Brigade Supply Region
- The arrival of the convoy to the brigade supply region event
- Completion of the unloading and the departure of the convoy from the brigade zone to ASP event
- Arrival of the convoy to ASP event

Entities:

- Ammunition supply convoy

Activities:

- The move of convoys
- Ammunition loading and unloading
- Reporting

Attributes:

The attributes of the model are the followings:

- Convoy identification numbers
- ASP identification numbers
- Battalion position identification numbers
- The beginning time of the time that the supply begins
- The beginning time of the entrance of the convoys to the ASP loading queues

Exogeneous Variables (Input Variables):

- Decision Variables:

- Number of loading units in ASPs
- Capacity of ASPs (number of convoys to be served at one time)
- Loading capacity of vehicles
- Velocity of vehicles
- The distances

- Parameters:

- Number of consumed ammunition for one day
- Loading time of one vehicle
- The time of getting ready to move the convoy after loading
- The ASR

Endogenous Variables (Output Variables):

- State Variables:

- Number of ammunition the units have
- Number of vehicles in the convoys
- Number of convoys waiting in the loading queues
- State of the ASP loading units (busy or idle)

- Performance Measures:

- Average time in the system
- Average waiting time in the queues
- Average number of convoys waiting in the queues
- Utilizations of the loading units
- Average number of ammunition the units have
- Minimum number of ammunition with units have

Assumptions:

- There are enough vehicles
- The basic unit is battalion
- The construction of the corps is as in Appendix F

- The battalions consume ammunition as stated in Appendix E
- The ASR is accepted as the maximum limit of ammunition consumption of the battalions and assumed as the units are not consuming more than that quantity.
- The velocity of the convoys are 25 km per hour and there is no hindrance (if needed it can be included easily)
- The operation under consideration is offence and daily move of one brigade is 15 km per day during the battle time.
- To force the systems' reaction and performance we assume that the operation is always going further although the model includes the probabilities of staying at the same position and withdrawal. The system is analyzed while the brigades move forward with the probability 1 for each day.

3.2.1.3 Modified Existing Ammunition Supply System

Events:

- Ammunition consumption event: S-4 (supply officer) of battalion reports the consumed ammunition to the brigade ammunition bureau by an on-line system.
- Departure of the convoy from the battalion event: Convoy commander rides to the ASP which is responsible for the supply of the related
- Arrival of the convoy to the ASP event
- Arrival of the convoy to the loading area and the beginning of the loading event
- Completion of the loading event
- Departure of the convoy from the ASP event
- Arrival of the convoy to the battalion event

Entities:

- Ammunition supply convoy
- Ammunition report (from ASP to Corps headquarter)

Activities:

- The move of convoys
- The approval of forms
- Ammunition upload
- Reporting

Attributes:

The attributes of the model are:

- Convoy identification numbers
- ASP identification numbers
- Battalion position identification numbers
- The beginning time of the time that the supply begins
- The beginning time of the entrance of the convoys to the ASP loading queues

Exogeneous Variables (Input Variables):

- Decision variables:

- Number of loading units in ASPs
- Capacity of ASPs (number of convoys to be served at one time)
- Loading capacity of vehicles
- Velocity of vehicles
- The distances

- Parameters:

- Number of consumed ammunition for one day
- Approval time of forms in BAB

- Approval time of forms in ASP
- Loading time of one vehicle
- The time of getting ready to move the convoy after loading
- The ASR

Endogenous Variables (Output Variables):

- State variables:

- Number of ammunition the units have
- Number of vehicles in the convoys
- Number of convoys waiting in the loading queues
- State of the ASP loading units (busy or idle)

- Performance measures:

- Average time in the system
- Average waiting time in the queues
- Average number of convoys waiting in the queues
- Utilizations of the loading units
- Average number of ammunition the units have
- Minimum number of ammunition the units have

Assumptions:

- There are enough vehicles
- The basic unit is battalion
- The construction of the corps is as in Appendix F
- The battalions consume ammunition as stated in Appendix E

- The ASR is accepted as the maximum limit of ammunition consumption of the battalions and assumed as the units are not consuming more than that quantity.
- The velocity of the convoys are 25 km per hour and there is no hindrance (if needed it can be included easily)
- The operation under consideration is offence and daily move of one brigade is 15 km per day during the battle time.
- To force the systems' reaction and performance we assume that the operation is always going further although the model includes the probabilities of staying at the same position and withdrawal. The system is analyzed while the brigades move forward with the probability 1 for each day.

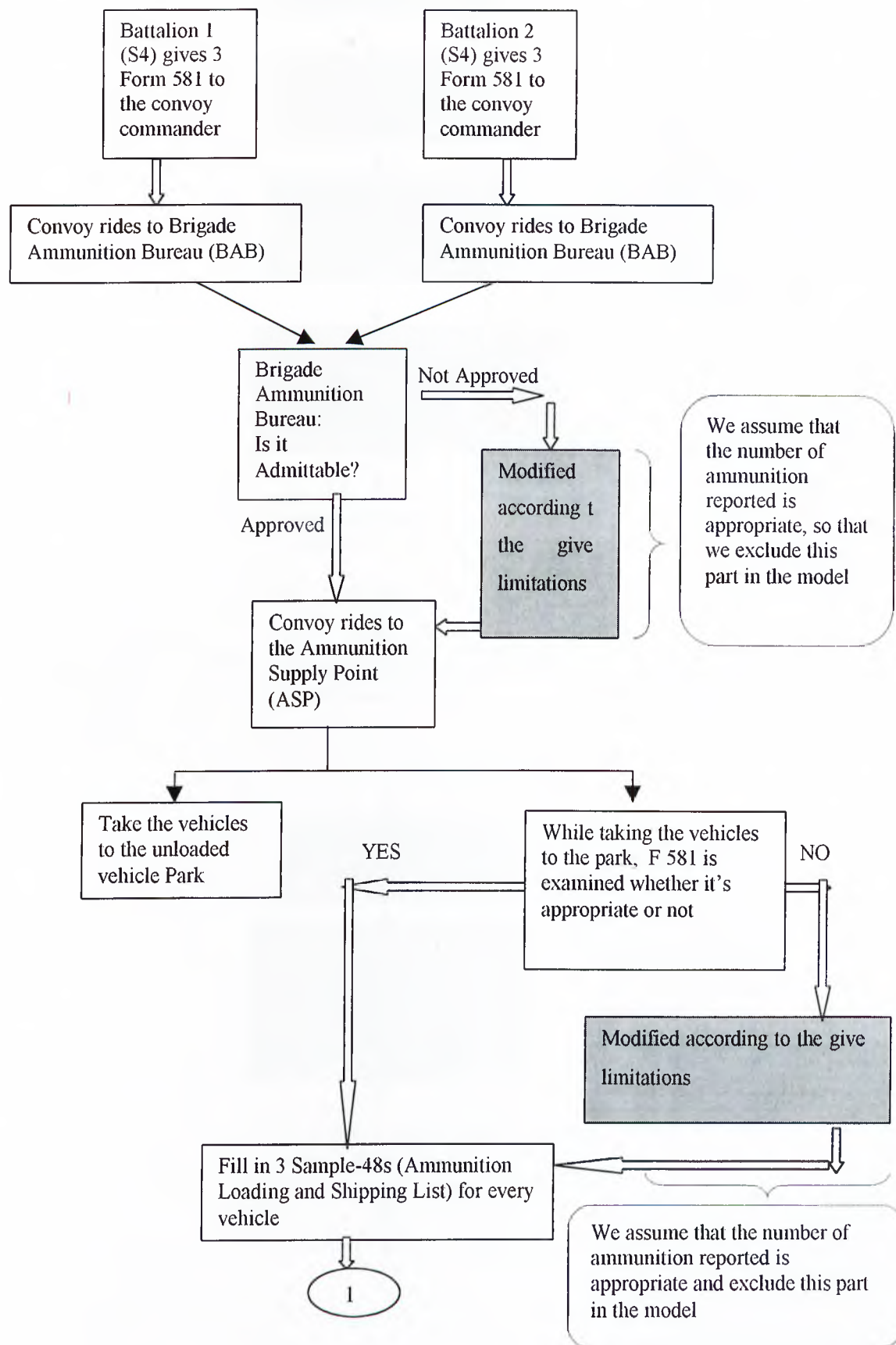
3.2.1.4 Modified New Ammunition Supply System

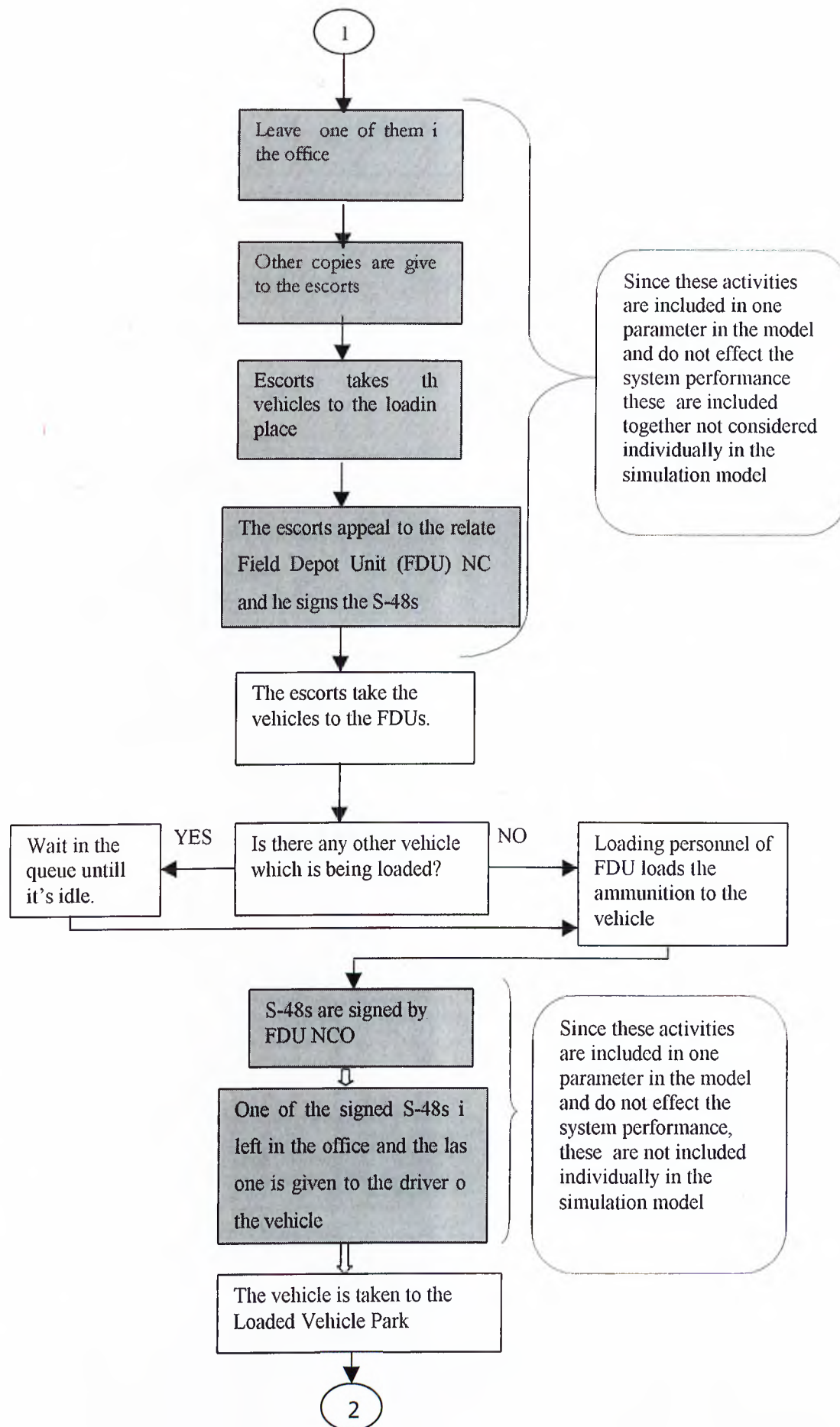
All of the elements of the model are the same as in the army new ammunition supply system except for the changes in the values of some of these values as stated in Appendix 8.

3.2.2 Logical Model

The logical model of each system is given in flow charts. While developing the models we exclude the parts with greyed boxes in the charts. The idea behind excluding some parts is to keep the details appropriate not to cope with unimportant details of the real life system.

3.2.2.3 Existing Ammunition Supply System





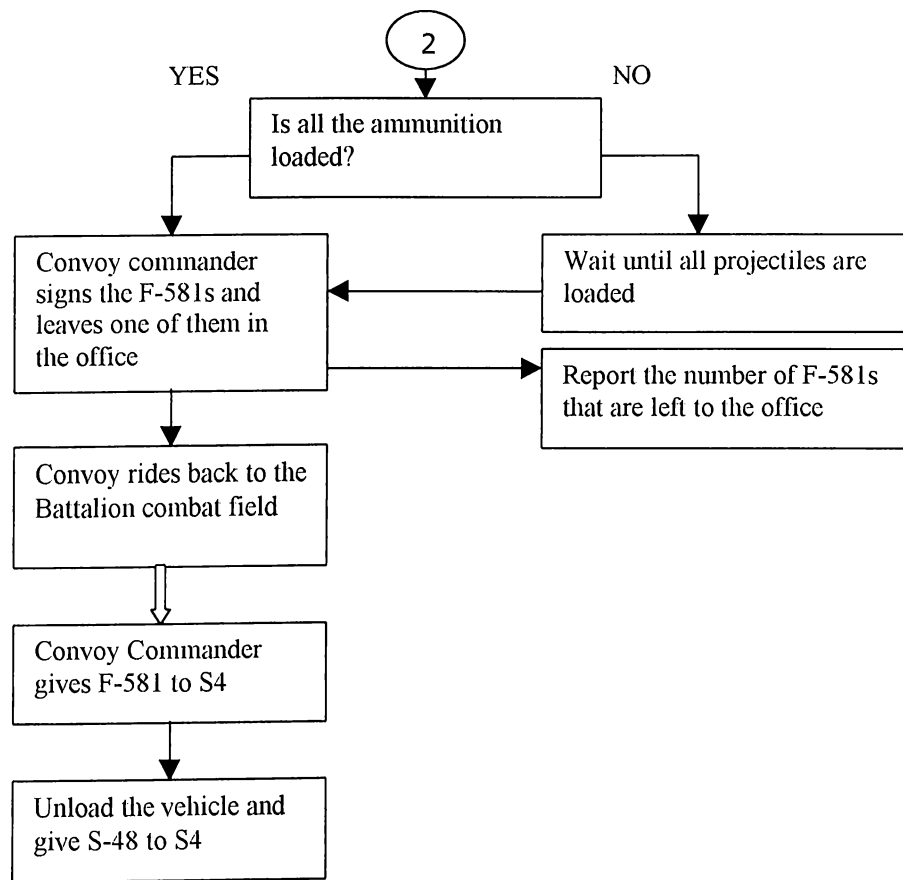


Figure 3.2.2.1: The flowchart of existing artillery ammunition supply system

3.2.2.4 New Ammunition Supply System

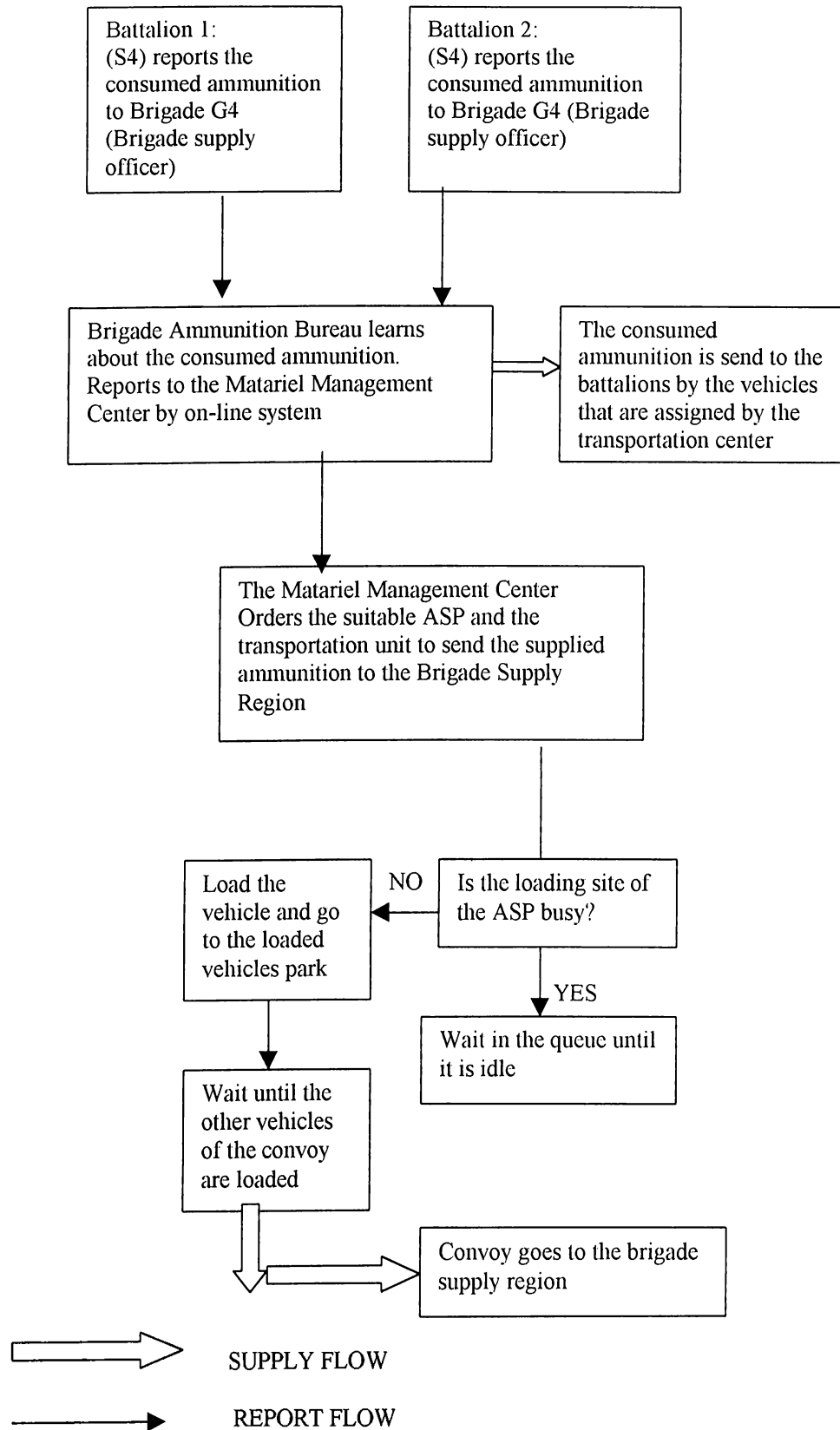
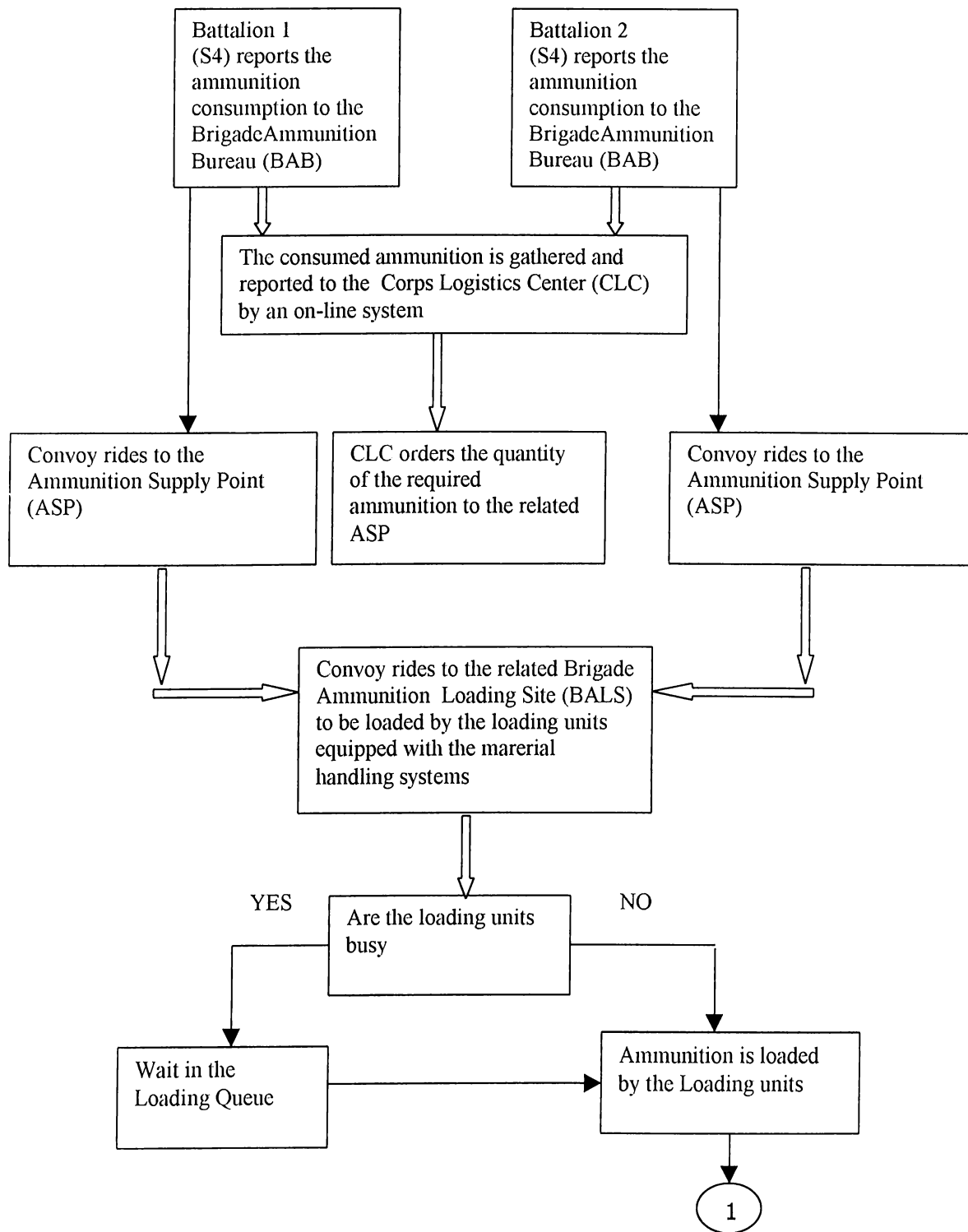


Figure 3.2.2.2: The flowchart of new artillery ammunition supply system

3.2.2.5 Modified Existing Ammunition Supply System



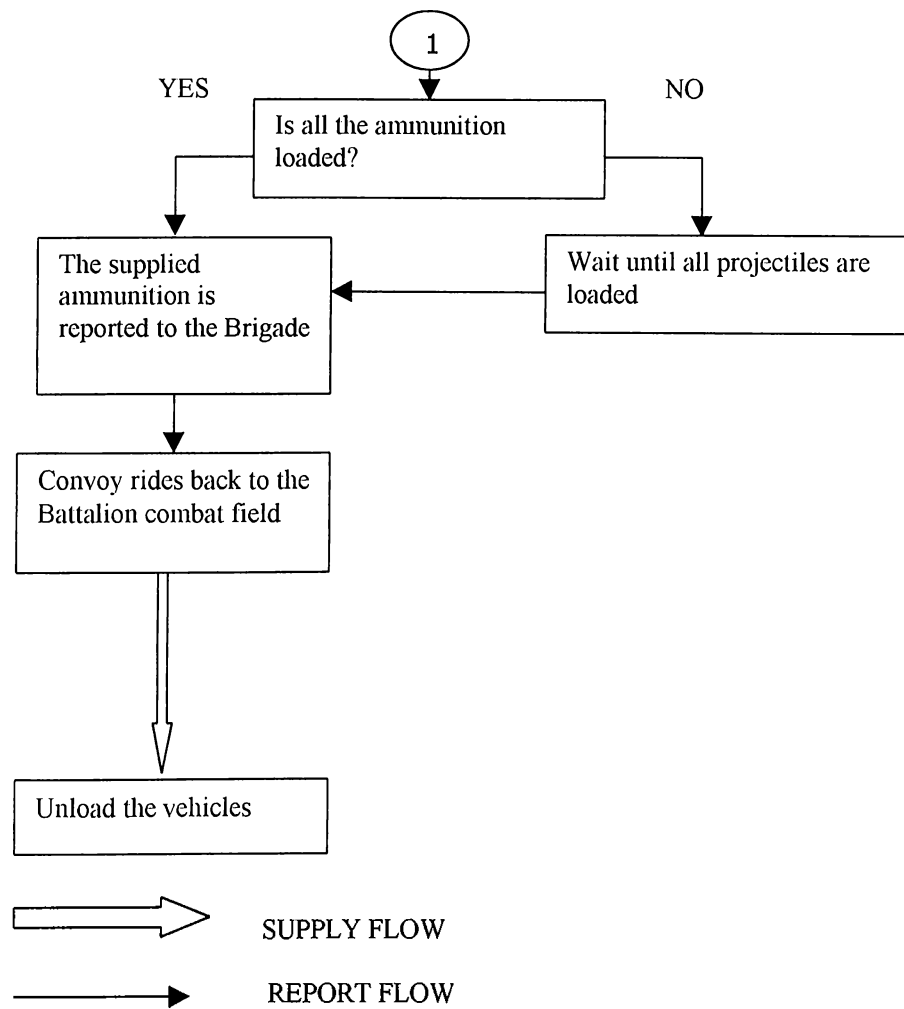


Figure 3.2.2.3: The flowchart of modified existing artillery ammunition supply system

3.2.3 Simulation Model (Computer Code)

We use ARENA software since it is a flexible and powerful tool that allows us to create graphical and animated models easily and offers reasonably good simulation input and output process.

We have two main models including the existing and new ammunition supply systems and two modified models from these two systems. The computer codes for existing, new and modified existing systems occupy 1290 KB, 1699 KB and 1271 KB, and one run takes 2, 5 and 2 seconds correspondingly. For the computer codes of these systems, one can refer to the web site <http://www.ie.bilkent.edu.tr/archive/research/hakan-utku>.

3.3. Input Data Analysis

We consider the war conditions and have no opportunity to experience and collect data in real life. As Vincent [3] recommended we used triangular distributions considering the interviews with the personnel who are ammunition specialists or experienced crisis conditions and included in some supply activities. Some of the data are taken from the army field manuals that are written according to the war experiences. Since the data taken from that manuals are not raw data and certain numbers we used them for the minimum, average and maximum values of the triangular distribution. In the future applications, as we have new data, the input data analysis techniques discussed in Law and Kelton [24] can be used to fit correct distribution functions to the data set.

The source we used for the determination of the ammunition consumption quantities is Kara Kuvvetleri Lojistik Faktorler Yonergesi [12]. It is used for war condition calculations of army logistics. The input data is stated in Appendix 8.

3.4. Model Verification and Validation

Considering the principles Balci [25] stated we performed the Verification and Validation (V&V) techniques for all steps of our study from the beginning. We apply the V&V techniques to all four systems.

3.4.1. Verification

“Computerized model verification ensures that the computer programming and implementation of the conceptual model are correct.” [16]. We applied the techniques that Banks [1] recommended.

- We used ARENA debugger function with the logic flow together to see whether the events occur properly or not. It helped us to monitor the simulation as it progresses.
- We tested our model for the different and extreme conditions to observe whether the model behaves reasonable.
- Since ARENA has the capability of collecting most of the statistics automatically we have the chance to observe the outputs easily. Besides, we used different output statistics that are verifying the other statistics (total time in system and partial time in some activities, queues and utilization etc.)
- Since we used animation in our models, we see the movements of the entities toward the system that ensures the model verification.
- We checked our computer model by other analysts.

3.4.2. Validation

3.4.2.1. Face Validity

From the beginning of the study we include the users of the system into the study to assure the model is behaving as expected in the real conditions. Since we have no opportunity to observe the real conditions we included two of the personnel of The Army Logistics Department (ALD) as the users of the system and an instructor of the Military Operation Tactics course in Army War Academy as a consultant for the military tactics of the model while we are constructing the conceptual model and

showed the computer output results. They find the results reasonable and quite satisfactory [1].

3.4.2.2. Validation of Model Assumptions

The data and the structural assumptions of the model are discussed with the two personnel of the ALD and three personnel of the Army Ammunition Department. Within the bounds of our objectives they find these assumptions reasonable.

3.4.2.3. Statistical Validation

We could not do the statistical validation because of a lack of data from actual war conditions.

Chapter 4

The Evaluation of the Existing System

In this section we try to understand the behavior of the existing system in terms of some performance measures. The analysis can help us to find the bottlenecks in the system operation and ways to cope with them.

4.1. Evaluation of System by using “Time In System” Performance Measure

Table 4.1.1 gives the results of simulation experiments in terms of the time passing through the move between battalion, the place where the ammunition is consumed, and Ammunition Supply Point (ASP), where the ammunition to be supplied. The model stops running when the ammunition level comes to zero. If the units get the ammunition within one day time while they’re going forward to the new positions, the units will have the opportunity to continue the battle. We know that the Unit Basic Load (UBL) that the units have at the beginning of the battle can satisfy the military units’ ammunition needs at most for two days.

In Tables 4.1.1, 4.1.2 and 4.1.3, we see that the existing system doesn’t work in some simulation experiments as indicated by replications. Let’s examine the eighth replication as one of the the worst case. At time zero, some amount of ammunition is consumed and after that the supply convoy goes for the approval. After the approval it goes further to the ASP for the loading of ammunition. Then it waits for the completion of the loading there. At that time the consumption of the ammunition continues. The major mission of an artillery unit is to support the manoeuvre units. How can an artillery unit accomplish its mission without ammunition? Since the consumed ammunition can’t be supplied and the unit doesn’t have ammunition, the artillery battalion can not go on battle and will

eventually loose the battle. Naturally, this affects the manoeuvre units' further actions even if they have ammunition. Since we modeled just the artillery ammunition supply system, the battle ends for the artillery unit as a result of having nothing to do for its mission due to the lack of ammunition. Then the battle ends before the expected war time and the unit can not accomplish its mission for determined conditions. It is also the failure of the ammunition supply system even a battalion can't accomplish its mission due to the lack of ammunition.

BRIGADE A								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	89.33	124.96	161.12	197.06	232.78	268.80	304.67	339.30
2	88.82	125.14	160.59	196.91	—	—	—	—
3	88.81	125.43	161.37	196.88	233.15	268.87	304.84	338.99
4	89.63	125.22	161.05	196.69	232.90	268.69	305.35	338.89
5	88.58	125.24	161.18	196.90	233.02	268.85	303.71	339.04
6	89.04	125.32	160.64	196.36	233.61	268.32	305.27	—
7	89.60	124.78	161.66	197.56	233.09	—	—	—
8	89.21	—	—	—	—	—	—	—
9	89.14	125.13	161.39	197.60	233.05	268.98	—	—
10	89.28	125.04	160.83	196.84	—	—	—	—

Table 4.1.1. Travel time (in minute) between battalion to ASP in existing system for ten replications

BRIGADE B								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	797.77	1,020.08	627.97	764.72	769.70	1,036.68	773.82	89.62
2	957.71	1,375.51	1,284.20	465.41	—	—	—	—
3	910.10	1,192.85	1,214.46	1,407.71	1,356.63	1,185.35	737.31	—
4	865.61	1,275.58	910.70	740.32	1,019.36	1,364.59	1,110.56	—
5	912.43	1,177.30	1,418.31	1,731.66	1,805.22	1,787.84	1,617.34	96.28
6	742.20	848.77	848.64	1,097.46	1,564.75	1,276.77	—	—
7	1,058.1	1,307.04	1,268.18	851.54	706.98	—	—	—
8	—	—	—	—	—	—	—	—
9	919.44	1,325.75	1,167.89	1,429.89	1,146.43	—	—	—
10	208.87	1,492.74	1,426.47	—	—	—	—	—

Table 4.1.2. Time (in minute) in ASP in existing system for ten replications

BRIGADE C								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	96.23	132.31	167.97	203.73	238.54	277.45	313.60	—
2	96.85	132.98	167.75	68.78	—	—	—	—
3	95.81	132.88	168.16	203.90	239.68	276.11	207.94	—
4	97.38	130.23	167.94	205.13	240.90	276.19	104.15	—
5	96.72	134.59	167.83	204.89	240.14	277.08	208.68	—
6	96.98	132.04	169.52	204.00	240.16	230.81	—	—
7	95.63	131.59	167.59	204.76	119.92	—	—	—
8	—	—	—	—	—	—	—	—
9	98.01	131.37	168.14	203.85	199.81	—	—	—
10	96.03	132.17	168.34	—	—	—	—	—

Table 4.1.3. Travel time(in minute) between ASP to battalion in existing system for ten replications

REP#	SIMULATION RUN TIME
1	11000
2	5760
3	11000
4	11000
5	11000
6	10080
7	7200
8	1440
9	8640
10	5760
MEAN	8288
VAR	10401706.67
STD DEV	3225.167696
CI	1998.939956
MIN	6289.060
MAX	10286.940

Table 4.1.4. Simulation end times (in minute) considering the number of ammunition during the battle time

4.2. Evaluation of the System by using “Average Number of Convoys Waiting in ASP Queue” Performance Measure

In this section we try to understand whether the ASP is crowded by the convoys or not. As seen in Table 4.2.1 with 95% confidence level, we have minimum 2 and maximum 3 convoys waiting in ASP loading queue.

Beside the time consumption, the existence of convoys more than one makes it more susceptible for being a good target for the enemy air forces and the long distance weapons. It is unacceptable and risky to have a lot of vehicles waiting for loading due to the high possibility of being destroyed and losing the transportation capability at least within the scarce operation time limit.

CORPS	
REP#	AVG NO OF CONVOYS
1	2
2	2
3	3
4	2
5	3
6	2
7	2
8	2
9	3
10	2
MEAN	2
VAR	0.219722997
STD DEV	0.468746196
CI	0.290526134
MIN	2
MAX	3

Table 4.2.1. Average number of convoys waiting in ASP loading queues in existing system for ten replications

4.3. Evaluation of the System by using “Average Waiting Time of Convoys in ASP Queue” Performance Measure

In Table 4.3.1 we see the convoys wait in queue for loading with 95% confidence level. 27.6 min for the minimum and 29.6 min for the maximum. *This practically means that without adding the loading time of the vehicles in this convoys, in sophisticated war conditions, it is a very suitable time for the target acquisition and reacting the high mobile deep operation units, weapons and other war instruments even if by using the most primitive method of these.* Target acquisition can be done by using reconnaissance helicopters, warplanes, radars, satellites and reconnaissance units. After that by using warplanes, artillery, missiles, helicopters and assault units these targets can be destroyed or hampered during the battle time.

CORPS	
REP#	AVG TIME IN Q
1	27.858
2	29.2965
3	28.2385
4	27.7625
5	27.8
6	28.1375
7	28.4475
8	32.986
9	27.6215
10	27.92
MEAN	28.607
VAR	2.600147011
STD DEV	1.612497135
CI	0.999416234
MIN	27.607
MAX	29.606

Table 4.3.1. Average number of convoys waiting in ASP loading queues in existing system for ten replications

4.4. Evaluation of the System by using “Utilization of ASP Loading Unit” Performance Measure

From Table 4.4.1, it is clear that the utilization of the loading unit is very high. This performance metric ensures us the necessity of increasing the capacity of the loading unit to accomplish the duty.

Then, what can we do to cope with this problem? To decrease the time spend in ASP we have the alternatives of increasing the number of loading unit resources, increasing the capacity of the loading units in terms of vehicles loaded at the same time and decreasing the loading time of one vehicle. By establishing these measures individually or together the time passing in ASP can be diminished. Chapter 6 evaluates improving the system by implementing all these measurements together.

Since the existing system fails to accomplish its mission we don't need to compare it with any of the other systems with it.

CORPS	
REP #	UTILIZATION OF LOADING UNIT
1	0.87794
2	0.98166
3	0.982705
4	0.94176
5	0.990495
6	0.93112
7	0.97816
8	0.92673
9	0.98363
10	0.780725
MEAN	0.9374925
VAR	0.004320435
STD DEV	0.065730019
CI	0.040739079
MIN	0.896753421
MAX	0.978231579

Table 4.4.1: The average utilization of an ASP in existing system for ten replications

Chapter 5

Comparison of the Alternative Systems

To compare the systems, we use paired-t test. We synchronize the ammunition consumptions of the systems, use the same run length and we replicate the systems 10 times of each.

If the the mean performance measure for system i is denoted by θ_i , our goal is to obtain the point and the interval estimates of the difference in mean performance, namely $\theta_i - \theta_2$. From replication r of system i , we obtain an estimate Y_{ri} of the mean performance measure, θ_i .

We compute a confidence interval for the difference between the two mean performance measures θ_1 and θ_2 . The confidence interval is used to answer how large the mean difference is, how precise the estimator of the mean difference is and to learn whether there exists a significant difference between those or not. The last question leads us to one of the following three conclusions[1]:

- If the confidence interval for the difference between the mean performance measures is totally to the left of zero, then there is a strong evidence for the hypothesis that $\theta_i - \theta_2 < 0$.
- If the confidence interval for the difference between the mean performance measures is totally to the right of zero, then there is a strong evidence for the hypothesis that $\theta_i - \theta_2 > 0$.
- If the confidence interval for the difference between the mean performance measures contains zero, then there is no strong evidence that one system design is better than the other.

- A two sided $100(1-\alpha)\%$ C.I. for $\theta_1 - \theta_2$ will always be of the form

$$\left(\bar{Y}_{.1} - \bar{Y}_{.2} \right) \pm t_{\alpha/2, v} s.e. \left(\bar{Y}_{.1} - \bar{Y}_{.2} \right)$$

where $\bar{Y}_{.i}$ is the sample mean performance measure, for system i over all replications:

$$\bar{Y}_{.i} = \frac{1}{R_i} \sum_{r=1}^{R_i} Y_{ri}$$

where v is the degrees of freedom associated with the variance estimator, $t_{\alpha/2, v}$ is the $100(1 - \alpha/2)$ percent of a t distribution with v degrees of freedom, and s.e. (.) represents the standard error of the specified point estimator. To obtain the standard error and the degrees of freedom, we assume that the basic data, Y_{ri} are approximately normally distributed. This assumption is reasonable provided that each Y_{ri} is itself a sample mean of observations from replication r.

This chapter is organized as follows: In section 5.1 we present the comparison of the modified existing system and the new system considering the performance measures of “time –in-system”, “average number of ammunition during the battle time”, “waiting time in ASP for loadingqueue”, “utilization of ASPloading unit”, “average number of convoys waiting in ASP for loading” and “number of vehicles in a convoy” from sections 5.1.1 to 5.1.6 correspondingly. In section 5.2 we compare the new and the modified new systems by considering the performance measures of “time-in-system”, “average number of ammunition with units during the battle time” since the others are the same in sections 5.2.1 to 5.2.3 correspondingly. Finally in section 5.3, we compare the modified existing system with the modified new system.

The simulation outputs for the existing, new, modified existing and the modified new systems are given in Appendices A,B,C and D.

5.1. Comparison of the Modified Existing System and the New System

In this section, we try to see whether there exists a difference between the modified existing system and the new system against several performance measures. To do that first we look at the “time in system” performance measure which we think as the main one then consider a number of other measures such as, “number of ammunition during the battle time”, “time in ASP loading queue”, “number of convoys waiting in ASP loading queue”, “number of vehicles in convoys in the ASP. By comparing the two system we will try to understand the core behaviors of these two systems which make them good or bad.

5.1.1. Comparison of the Systems by “Time in System” Performance Measure

In the battle field, units can go on the battle by using their war instruments. One of these is the weapons that the units have. Weapons provide the necessary fire power to destroy the enemy. It's impossible to move even for one meter without this power. From the beginning of the battle the units spend their ammunition to achieve their mission, which can be defending a domain terrain feature or attacking to the enemy forces and destroying them. In that case, the capability of supplying the ammunition in time is an important factor from the point of being an effective supply system.

Since we consider the offence of the corps, the brigades move during the battle. In our model we have the flexibility of determining the probabilities of the unit's being in the forward position, staying at the same position or withdrawing for the next day in simulation time. For example we can say that 0.80, 0.15, 0.05, correspondingly. This means that the unit will move to the forward position with probability 0.80, stay in the same position with probability 0.15 and withdraw with probability 0.05 for the next day. To test the most forcing condition we take this probability as 1 for moving forward for

the units and for the other alternatives as 0. That results with the increase of the supply distance due to the ASPs are in stable position. We modified the existing system by eliminating the approval times in brigade and in ASP and diminishing the time spend in loading action. Table 5.1.1.1 presents total time passed between the commence of the travel of convoy from the battalion to ASP, time spend in ASP during the loading of the ammunition and time spend between ASP to a battalion position for the modified existing system. Table 5.1.1.2 displays us the total time passed in ASP for loading and between ASP and Battaliom positions. Horizontal numbers represent the time-in-system values to the position where the unit get its ammunition while the vertical ones represent the simulation runs (or replications).

The results indicate that for the last position, which is 135 km far away the ASP, the system supplies the unit with minimum 776 min (12.9 hours) and maximum 800 min (13.3 hours) with 95% confidence level. Considering the existing system's reaction with even more than 1 or 2 day time, this is a significant improvement as the modified system performs the job within half a day. What about the new system? It does it with min in 432 min (7.2 hours) and maximum 456 min (7.6 hours) with 95% confidence level. Table 5.1.1.2 presents the difference between the system more clearly. Note that the confidence intervals given in the Table 5.1.1.3 do not include zero. Thus, we conclude that there is a significant difference between the modified system and the new system. According to the results, the new system (proposed by army) is better than the modified existing system (modified by us). Figure 5.1.1.1 assures this difference apparently.

Statistically speaking, the new system is best ;but, considering the achievement of the mission according to the pre-determined standards by military, which seeks the system to supply within the night time, the modified system achieve the same mission as well.

But as we know, in the improved system there is a move of convoys from the battle field to the ASP as a difference between the new system and the modified old system. Now let's examine whether this significant difference is due to that reason. Since the velocity of the convoys of the both systems are taken the same in the model due to the rules in army and the stated documents, we do not need to include the ASP- battle area

BRIGADE									
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8	
1	260.98	349.69	384.62	483.67	565.46	637.44	705.55	804.13	
2	268.72	385.17	415.04	505.04	586.37	652.06	726.75	810.49	
3	298.76	338.86	428.76	490.25	592.41	615.45	713.19	777.71	
4	274.45	372.31	385.65	502.22	559.01	633.07	765.23	798.89	
5	281.63	372.64	426.41	499.29	583.95	633.94	710.57	735.17	
6	257.73	361.5	400.4	524	576.73	659.15	711.82	793.7	
7	291.06	384.26	423.17	477.63	584.65	694.72	737.89	777.62	
8	298.79	378.8	422.22	497.61	569.32	643.08	684.81	800.42	
9	284.39	350.54	424.64	487.03	588.3	680.1	709.86	799.02	
10	197.47	391.65	418.91	579.33	564.63	629.5	695.98	791.27	
MEAN	271.4	365.9742	412.3212	496.3041	578.4663	649.8907	718.4057	788.5725	
VAR	232.9479	276.3446	308.0431	190.0003	132.072	617.2024	517.6098	524.3054	
STDDEV	15.26263	16.62362	17.55116	13.78406	11.49226	24.84356	22.75104	22.89772	
CI	8.058228	8.776789	9.266504	7.277586	6.06758	13.11668	12.01189	12.08933	
MIN	263.338	357.1974	403.0547	489.0265	572.3987	636.774	706.3938	776.4831	
MAX	279.45	374.75	421.59	503.58	584.53	663.01	730.42	800.66	

Table 5.1.1.1. Average time in system (in minute) in the modified existing system for ten replications.

BRIGADE									
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8	
1	170.25	261.41	226.49	290.17	325.42	377.04	383.12	424.46	
2	213.72	252.38	232.61	318.56	372.18	366.42	445.68	422.46	
3	212.85	244.44	308.48	336.74	311.59	375.88	401.61	443.14	
4	186.88	268.29	206.66	296.3	342.16	353.42	407.2	459.63	
5	207.51	255.23	245.6	363.85	333.17	379.96	372.79	408.5	
6	178.52	236.1	261.41	365.06	338.92	432.76	428.27	437.46	
7	212.61	243.57	236.6	303.14	339.89	454.09	404.05	456.19	
8	227.67	220.08	252.46	319.68	328.75	368.45	384.25	469.26	
9	174.11	248.93	236.47	313.46	372.81	444.23	404.12	477.53	
10	125.7	291.21	254.26	310.41	313.91	377.82	431.42	466.71	
MEAN	198.2365	247.8251	245.1982	322.9943	340.5427	394.6952	403.4541	444.2902	
VAR	436.9169	202.1466	807.9991	741.6352	413.4344	1438.075	517.4772	537.9472	
STDDEV	20.90256	14.21783	28.42533	27.23298	20.33309	37.92195	22.74813	23.19369	
CI	11.03595	7.506602	15.00775	14.37823	10.73528	20.0217	12.01035	12.2456	
MIN	187.2005	240.3185	230.1904	308.616	329.8074	374.6735	391.4437	432.0446	
MAX	209.2724	255.3317	260.2059	337.3725	351.2779	414.7169	415.4645	456.5358	

Table 5.1.1.2. Average time in system in the new system for ten replications.

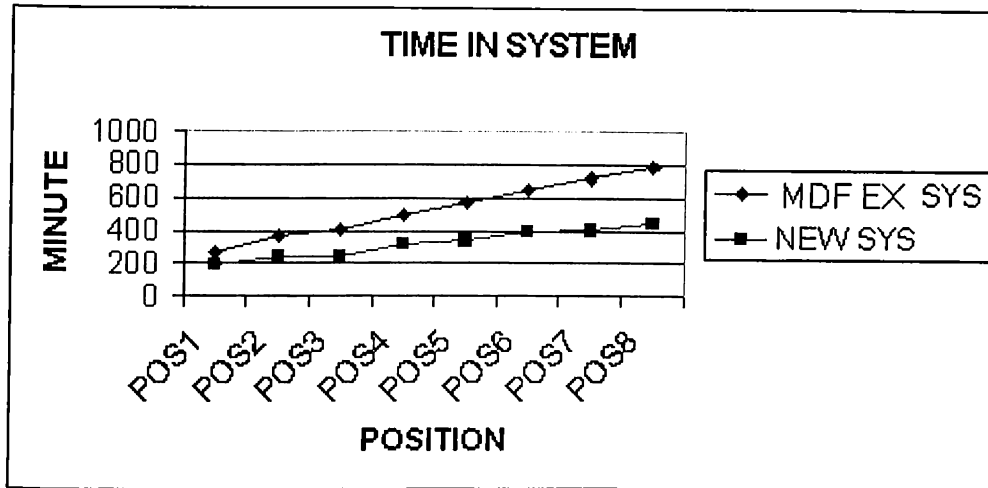


FIGURE 5.1.1.1. Averages of ten replications for time in system performance measure values of the modified existing system and the new system

BRIGADE								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	90.73	88.28	158.13	193.5	240.04	260.4	322.43	379.67
2	55	132.79	182.43	186.48	214.19	285.64	281.07	388.03
3	85.91	94.42	120.28	153.51	280.82	239.57	311.58	334.57
4	87.57	104.02	178.99	205.92	216.85	279.65	358.03	339.26
5	74.12	117.41	180.81	135.44	250.78	253.98	337.78	326.67
6	79.21	125.4	138.99	158.94	237.81	226.39	283.55	356.24
7	78.45	140.69	186.57	174.49	244.76	240.63	333.84	321.43
8	71.12	158.72	169.76	177.93	240.57	274.63	300.56	331.16
9	110.28	101.61	188.17	173.57	215.49	235.87	305.74	321.49
10	71.77	100.44	164.65	268.92	250.72	251.68	264.56	324.56
MEAN	81.37667	118.1489	167.1256	173.3089	237.9233	255.1956	314.9533	344.28
VAR	231.0803	543.7468	557.1483	462.4969	446.7834	448.837	653.3681	619.0992
STDDEV	15.20133	23.31838	23.60399	21.50574	21.13725	21.18577	25.56107	24.8817
CI	8.025862	12.31143	12.46222	11.35441	11.15986	11.18548	13.49551	13.13682
MIN	73.3508	105.8375	154.6633	161.9545	226.7635	244.0101	301.4578	331.1432
MAX	89.40253	130.4603	179.5878	184.6633	249.0832	266.381	328.4488	357.4168

Table 5.1.1.3. Statistics of the difference between the Table 5.1.1.1 and Table 5.1.1.2.

BRIGADE								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	82.53	132.49	63.54	91.93	95	110.57	115.38	85.29
2	124.88	125.99	68.69	123.32	129.03	88.82	141.06	81.4
3	124.44	117.54	148.17	137.82	78.88	99.7	135	100.53
4	97.56	145.6	46.18	101.87	100.69	85.97	103.18	120.25
5	118.73	127.75	78.95	163.92	91.96	112.04	71.03	69.43
6	91.55	107.56	101.88	165.53	93.69	156.79	124.63	98.66
7	123.93	120.29	77.87	106.85	97.55	183.24	101.8	116.46
8	138.01	92.03	89.74	124.96	97.09	88.6	81.25	131.1
9	85.42	119.59	72.86	119.7	142.47	178.82	101.24	135.23
10	35.96	168.74	90.96	111.61	82.27	111.44	128.71	128.25
MEAN	109.6721	120.9839	83.09746	126.2114	102.9297	122.7276	108.2846	104.2606
VAR	417.2206	230.192	841.7599	662.2231	394.9547	1553.257	542.7352	528.1861
STDDEV	20.42598	15.17208	29.0131	25.7337	19.87347	39.41138	23.29668	22.9823
CI	10.78433	8.010419	15.31808	13.58665	10.49262	20.80807	12.29997	12.13399

Table 5.1.1.4. Summary statistics of the time passed in ASP (in minute) in modified existing system for ten replications.

BRIGADE								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	89.02	103.85	66.52	93.72	105.32	105	100.45	127.65
2	94.76	140.04	97.66	115.17	124.95	120.06	121.12	136.03
3	123.83	94.22	112.08	99.98	131.84	83.78	109.04	101.77
4	101.24	125.36	68.46	112.52	98.26	100.46	160.74	124.26
5	108.14	127.66	109.05	110.74	124.02	101.2	105.55	60.63
6	84.8	117.7	84.25	134.8	115.76	126.43	107.92	119.83
7	117.41	138.19	105.77	88.04	124.8	161.95	132.67	103.16
8	125.16	132.69	105.07	110.09	109.1	109.75	79.55	125.72
9	111.2	105.05	106.65	97.29	127.14	147.95	103.55	124.52
10	23.76	146.45	102.45	190.92	104.17	97.35	92.23	116.71
MEAN	106.1736	120.5295	95.05633	106.9297	117.9087	117.3974	113.3983	113.7306
VAR	216.6551	266.5755	310.0023	196.6398	130.0522	612.3596	524.1331	521.7433
STDDEV	14.71921	16.32714	17.60688	14.02283	11.40404	24.7459	22.89395	22.8417
CI	7.771317	8.620259	9.295925	7.403649	6.021004	13.06512	12.08735	12.05976

Table Table 5.1.1.5. Summary statistics of the time passed in ASP (in minute) in new system for ten replications.

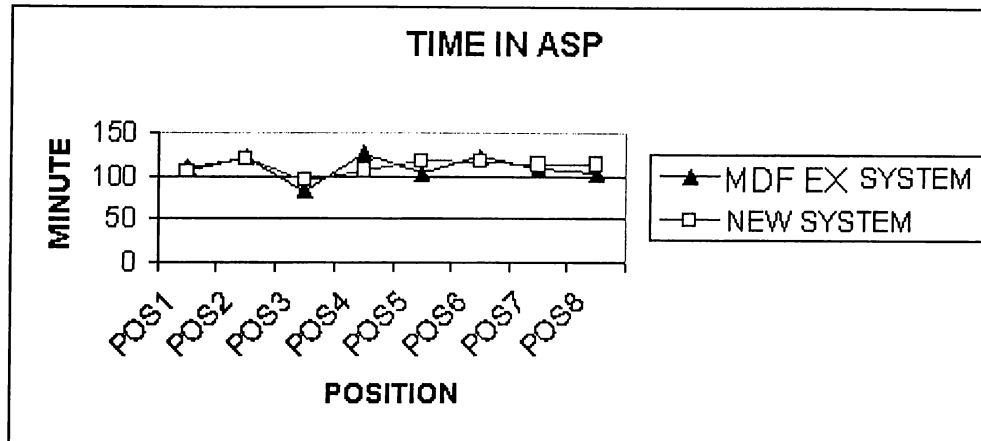


FIGURE 5.1.1.2. Averages of ten replications for time in ASP performance measure values of the modified existing system and the new system

BRIGADE								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	6.49	-28.64	2.98	1.79	10.32	-5.57	-14.93	42.36
2	-30.12	14.05	28.97	-8.15	-4.08	31.24	-19.94	54.63
3	-0.61	-23.32	-36.09	-37.84	52.96	-15.92	-25.96	1.24
4	3.68	-20.24	22.28	10.65	-2.43	14.49	57.56	4.01
5	-10.59	-0.09	30.1	-53.18	32.06	-10.84	34.52	-8.8
6	-6.75	10.14	-17.63	-30.73	22.07	-30.36	-16.71	21.17
7	-6.52	17.9	27.9	-18.81	27.25	-21.29	30.87	-13.3
8	-12.85	40.66	15.33	-14.87	12.01	21.15	-1.7	-5.38
9	25.78	-14.54	33.79	-22.41	-15.33	-30.87	2.31	-10.71
10	-12.2	-22.29	11.49	79.31	21.9	-14.09	-36.48	-11.54
MEAN	-3.498889	-0.453333	11.95889	-19.28333	14.98111	-5.33	5.113333	9.468889
VAR	235.3776	532.1459	591.4878	389.7348	443.8315	513.4335	850.5382	604.4541
STDDEV	15.34202	23.06829	24.32052	19.7417	21.06731	22.65907	29.16399	24.58565
CI	8.100144	12.17939	12.84053	10.42305	11.12293	11.96333	15.39774	12.98051
MIN	-11.59903	-12.63272	-0.881644	-29.70638	3.85818	-17.29333	-10.28441	-3.511623
MAX	4.601255	11.72606	24.79942	-8.860285	26.10404	6.633334	20.51108	22.4494

Table 5.1.1.6. Statistics of the difference between the Table 5.1.1.4 and Table 5.1.1.5.

distance. Now we compare the time consumed in ASP for both systems in Table 5.1.1.4 and Table 5.1.1.5.

We see from the results (Table 5.1.1.6) that except for the position 5, all the confidence intervals include zero. This means that the “time passing in ASP” performances of the modified existing system and the proposed new system are statistically the same. This is apparent in Figure 5.1.1.2. We conclude this section that the major bottleneck in the existing system is mainly the time passing in ASPs during the loading activities. This issue has been discussed in Chapter 4.

5.1.2. Comparison of the Systems by “Average Number of Ammunition During the Battle Time” Performance Measure

The number of ammunition during the battle time performance measure is an indicator of the systems’ efficiency to give the battle units the availability of being ready to the changing battle conditions. Since having sufficient ammunition during the battle time gives the commanders the deciding flexibility, it is advantageous to have UBL completed after consumption.

We apply paired-t test for the outputs of the modified existing system and new system to see whether there exists a significant difference between them or not.

BATTALION			
REP#	NEW SYS AVG NO AMMO	MDF EXIST SYS AVG NO AMMO	DIFFERENCE
1	5570	4980	590
2	5568	4854	714
3	5569	4954	615
4	5569	4899	670
5	5569	4977	592
6	5569	4897	672
7	5568	4856	712
8	5569	4922	647
9	5568	4861	707
10	5568	4885	683
MEAN	5569	4909	660.2
VAR	0.372163574	2303.796361	2257.733333
STD DEV	0.610052108	47.99787871	47.51561147
CI	0.378106706	29.74880274	29.44989634
MIN	5568	4879	630.7501037
MAX	5569	4938	689.6498963

Table 5.1.2.1. The summary statistics of the ammunition during the battle time (in minute) in the new and modified existing systems for ten replications

As can be seen in Table 5.1.2.1, there is a significant difference in favor of the new system between the modified existing system and the new system.

5.1.3. Comparison by “Waiting time in ASP Loading Queue” Performance Measure

As discussed in Chapter 4, the waiting time of convoys in the ammunition loading queue makes them susceptible for the enemy target acquisition units and as the results of their reconnaissance for the attack of enemy long distance weapons, warplanes and units. The shorter time the units wait there the better from the point of the damage to be exposed.

As can be seen in Table 5.1.3, there is even no need to apply paired-t test to detect the difference between these systems since it is apparent that the improved existing system is better than the new system. There is no any time passing in the queue in the improved existing system while the new system has some. This deficiency of the new

system comes from the insufficient loading capacity of the ASPs. New system has only one convoy loading capacity and 1 vehicle loading capacity atone time while the modified existing system has 4 for the both at one time.

CORPS REP#	NEW SYS AVG TIME IN ASPQ	MDF EXISTING SYS AVG TIME IN ASPQ
1	83.33	0
2	98.06	0
3	92.89	0
4	95.37	0
5	90.53	0
6	93.24	0
7	97.09	0
8	88	0
9	98.17	0
10	99.92	0
MEAN	93.66	0
VAR	26.99737651	0
STD DEV	5.195899971	0
95%CI	3.220388222	
MIN	90.44	
MAX	96.88	

Table 5.1.3. Summary statistics of waiting time in ASP loading queue (in minute) for ten replicatins

5.1.4. Comparison of the Systems by “Utilization of ASP Loading Unit” Performance Measure

Battle conditions include surprising events due to its stochastic nature. For example one of these is the destruction of one of the ASPs by the enemy forces and the necessity of using the other ASP for the supply of the units needed at least during the time to construct the new ASP. ASP should be ready to cope with these surprising worst case conditions. To be able to do that it should always have extra capacity. That means the utilization of ASP should not be too high.

When we look at the utilization statistics, we observe that both of the systems have lower utilizations. But while doing that the resources should be used effectively. From

that point of view, the modified existing system is not so much effective as the new system is. By using paired-t test we can say that with 95%CI, there is a strong evidence that both systems are different from each other since the confidence intervals don't include zero.

In conclusion, the new system (proposed by Army) has higher utilization as seen in Table 5.1.4.1. That means that the new and modified existing systems have enough capacity for the outstanding conditions; but, the new system is more effective than the modified existing system from the point of using the resources effective.

CORPS REP#	NEW SYS UTILIZATION OF ASP1	MDF EXISTING SYS UTILIZATION OF ASP1	DIFFERENCE
1	0.165255	0.04131375	0.12394125
2	0.18492	0.04623	0.13869
3	0.183635	0.04590875	0.13772625
4	0.180435	0.04510875	0.13532625
5	0.177305	0.04432625	0.13297875
6	0.178065	0.04451625	0.13354875
7	0.1862	0.04655	0.13965
8	0.173715	0.04342875	0.13028625
9	0.190135	0.04753375	0.14260125
10	0.185065	0.04626625	0.13879875
MEAN	0.180473	0.04511825	0.13535475
VAR	5.22E-05	3.26E-06	2.94E-05
STD DEV	0.007227321	0.00180683	0.005420491
95%CI	0.004479451	0.001119863	0.003359588
MIN	0.175993549	0.043998387	0.131995162
MAX	0.184952451	0.046238113	0.138714338

Table 5.1.4.1. Statistics of the Utilization of ASP for ten replications

5.1.5. Comparison of the Systems by “Average Number of Convoys Waiting in ASP For Loading” Performance Measure

This statistic supports the results of the time in queue performance of both systems as we stated in section 5.1.3. Although the system has a good response in terms of time in system performance, the existence of convoys waiting in queue is disadvantageous.

Because, existence of even one convoy makes the ASP sensitive regarding that we're just simulating the artillery ammunition supply system.

As seen in Table 5.1.5.1, the results indicate that modified existing system is better than the new system since it has no convoys waiting in queue. Despite the new system has good responses to most of the activities, having convoys waiting in queue is an important drawback for the new system.

CORPS REP#	NEW SYS AVG NO OF CONV	MDF EXISTING SYS AVG NO OF CONV
1	0.25622	0
2	0.29267	0
3	0.27995	0
4	0.30172	0
5	0.28823	0
6	0.26042	0
7	0.2676	0
8	0.23866	0
9	0.26227	0
10	0.29024	0
MEAN	0.273798	0
VAR	0,000394	0
STD DEV	0.019850009	0
95%CI	0.012302918	
MIN	0.261495082	
MAX	0.286100918	

Table 5.1.5.1. Average number of convoys waiting in the ASP for loading for ten replications

5.1.6. Comparison of the Systems by “Number of Vehicles in a Convoy” Performance Measure

The number of vehicles in a convoy is important from the point of being a target while travelling loaded or unloaded and waiting in ASPs for the loading activity. We see that in Table 5.1.6.1 it is apparent that modified existing system is more susceptible that the new system by using of paired-t test.

BRIGADE1/BAT1				
REP#	MDF EXST SYS AVG NO OF VHC	NEW SYS AVG NO OF VHC	DIFFERENCE	
1	27	8	19	
2	32	9	23	
3	29	9	20	
4	30	9	21	
5	29	9	20	
6	30	9	21	
7	31	9	22	
8	30	9	21	
9	32	9	23	
10	30	9	21	
MEAN	29.875	8.820833333	21.1	
VAR	2.381944444	0.142380401	1.655555556	
STD DEV	1.543354931	0.377333276	1.286683938	
CI	0.956562303	0.233868944	0.797479132	
MIN	28.9184377	8.58696439	20.30252087	
MAX	30.8315623	9.054702277	21.89747913	

Table 5.1.6.1. Summary statistics for average number of vehicles in a convoy for ten replications

5.2. Comparison of The New and The Modified New Systems

To be able to improve the deficiencies of the new system we propose the changes in the values of the parameters. While doing that we don't change the main structure and process of this system. Since we detect that there exists a queue in ASP we try to prevent its occurrence. Instead of the having only one convoy loaded in a loading site and having one vehicle loading capacity at one time site we propose four for the both for the new system.

5.2.1. Comparison of the Systems by “Time In System” Performance Measure

The simulation results are summarized in Tables 5.2.1.1 – 5.2.1.3. In Table 5.2.1.1 and Table 5.2.1.2, columns are the time in system values for the positions that the units are

located at that time. Positions are ordered from near to far as explained before. To test the most forcing case, we again take the probability of going forward as 1. That means that the units will be at the next forward position on the day after and the supply distance will increase.

To measure the difference between the two systems we form Table 5.2.1.3 and apply the paired-t test. The results indicate that non of the confidence intervals in the Table 5.2.1.3 include zero. This means that the difference is significant. According to the test result, we conclude that the modified new system is significantly better than the new system in terms of the time in system performance it yields the shorter the time spend in ASP.

BRIGADE								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	170.25	261.41	226.49	290.17	325.42	377.04	383.12	424.46
2	213.72	252.38	232.61	318.56	372.18	366.42	445.68	422.46
3	212.85	244.44	308.48	336.74	311.59	375.88	401.61	443.14
4	186.88	268.29	206.66	296.3	342.16	353.42	407.2	459.63
5	207.51	255.23	245.6	363.85	333.17	379.96	372.79	408.5
6	178.52	236.1	261.41	365.06	338.92	432.76	428.27	437.46
7	212.61	243.57	236.6	303.14	339.89	454.09	404.05	456.19
8	227.67	220.08	252.46	319.68	328.75	368.45	384.25	469.26
9	174.11	248.93	236.47	313.46	372.81	444.23	404.12	477.53
10	125.7	291.21	254.26	310.41	313.91	377.82	431.42	466.71
MEAN	190.982	252.164	246.104	321.737	337.88	393.007	406.251	446.534
VAR	914.5031	367.8872	726.442	675.1085	438.5058	1306.825	538.168	528.4776
STDDEV	30.24075	19.18038	26.95259	25.98285	20.94053	36.15003	23.19845	22.98864
CI	18.74304	11.88789	16.70506	16.10402	12.97882	22.40558	14.37826	14.24822
MAX	209.725	264.0519	262.8091	337.841	350.8588	415.4126	420.6293	460.7822
MIN	172.239	240.2761	229.3989	305.633	324.9012	370.6014	391.8727	432.2858

Table 5.2.1.1. Summary results of the mean time (in minutes) the convoys spend in the ASP in the new system for ten replications.

BRIGADE								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	99.2	137.01	170.41	207.48	243.65	284.29	315.26	355.13
2	101.48	143.98	177.08	212.01	248.94	284.35	319.65	357.28
3	103.27	136.76	176.38	208.91	244.78	281.42	316.96	352.57
4	100.03	138.63	169.39	210.47	244.44	282.59	322.36	355.28
5	102.42	143	173.8	209.34	248.22	280.42	317.22	349.56
6	99.91	140.23	173.97	212.98	246.48	283.83	320.06	358.11
7	103.03	139.82	172.9	206.39	243.98	287.65	318.66	353.64
8	105.12	136.95	175.55	209.41	243.62	282	314.79	355.31
9	105.67	135.79	177.2	206.75	246.88	286.2	317.36	355.5
10	93.99	144.98	173.08	214.88	247.36	280.83	318.2	354.46
MEAN	101.412	139.715	173.976	209.862	245.835	283.358	318.052	354.684
VAR	11.45728	10.80612	7.113893	7.631351	3.92705	5.531796	5.148396	5.77256
STDDEV	3.384861	3.287266	2.667188	2.76249	1.981679	2.351977	2.269008	2.402615
CI	2.097917	2.037428	1.653108	1.712175	1.228233	1.457741	1.406318	1.489127
MAX	103.5099	141.7524	175.6291	211.5742	247.0632	284.8157	319.4583	356.1731
MIN	99.31408	137.6776	172.3229	208.1498	244.6068	281.9003	316.6457	353.1949

Table 5.2.1.2. Summary results of the mean time (in minutes) the convoys spend in the ASP in the modified new system for ten replications.

BRIGADE								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	71.05	124.4	56.08	82.69	81.77	92.75	67.86	69.33
2	112.24	108.4	55.53	106.55	123.24	82.07	126.03	65.18
3	109.58	107.68	132.1	127.83	66.81	94.46	84.65	90.57
4	86.85	129.66	37.27	85.83	97.72	70.83	84.84	104.35
5	105.09	112.23	71.8	154.51	84.95	99.54	55.57	58.94
6	78.61	95.87	87.44	152.08	92.44	148.93	108.21	79.35
7	109.58	103.75	63.7	96.75	95.91	166.44	85.39	102.55
8	122.55	83.13	76.91	110.27	85.13	86.45	69.46	113.95
9	68.44	113.14	59.27	106.71	125.93	158.03	86.76	122.03
10	31.71	146.23	81.18	95.53	66.55	96.99	113.22	112.25
MEAN	89.57	112.449	72.128	111.875	92.045	109.649	88.199	91.85
VAR	767.5608	314.4449	657.8315	641.3763	406.5726	1188.152	480.1101	505.0598
STDDEV	27.70489	17.73259	25.64823	25.32541	20.16365	34.46958	21.91142	22.47354
CI	17.17133	10.99056	15.89662	15.69654	12.49731	21.36404	13.58057	13.92897
MAX	106.7413	123.4396	88.02462	127.5715	104.5423	131.013	101.7796	105.779
MIN	72.39867	101.4584	56.23138	96.17846	79.54769	88.28496	74.61843	77.92103

Table 5.2.1.3. The difference between the values of Table 5.2.1.1 and Table 5.2.1.2

5.2.2. Comparison of the Systems by “Average Ammunition with the Units During the Battle Time Performance Measure

During the battle time the ammunition consumed from UBL, which is the ammunition that the unit bear as approximately two-day ammunition, should be completed before the next day began due to the supply rule of Army . The more the system completes the ammunition consumed earlier the better the system to be chosen. That means the system with the more average ammunition during the battle time is better. Since each system is run by using the same random number seed and the same random variable for determination of the consumption we use the paired-t test to determine the significance of the difference between the two systems.

In Table 5.2.2, we see the average number of the ammunition during the battle for these two systems. The results of tests indicate that the new system is better than the modified new system. That is reasonable since new system also is effective in terms of time in system.

BRIGADE1/BAT1			
REP#	NEW SYS AVG NO OF AMMO	MDF NEW SYS AVG NO OF AMMO	DIFFERENCE
1	4980	4896	84
2	4854	4729	125
3	4954	4939	15
4	4899	4858	41
5	4977	4984	-7
6	4897	4923	-26
7	4856	4830	26
8	4922	4873	49
9	4861	4945	-84
10	4885	4901	-16
MEAN	4909	4888	20.7
VAR	2303.796361	5155.004444	3490.677778
STD DEV	47.99787871	71.79835962	59.08195814
CI	29.74880274	44.50020073	36.61864993
MIN	4879	4843	-15.9186499
MAX	4938	4932	57.31864993

Table 5.2.2.1. Summary statistics for the average number of ammunition during the battle time for ten replications

5.2.3. Comparison of the Systems by “Waiting time in ASP Loading Queue” Performance Measure

Table 5.2.3.1 summarizes the results of the simulation experiment with ten replications of the modified new system. It's evident that modified new system is better than the new system since there is no waiting time in ASP loading queue.

CORPS REP#	NEW SYS AVG TIME IN ASPQ	MDF NEW SYS AVG TIME IN ASPQ
1	83.33	0
2	98.06	0
3	92.89	0
4	95.37	0
5	90.53	0
6	93.24	0
7	97.09	0
8	88	0
9	98.17	0
10	99.92	0
MEAN	93.66	0
VAR	26.99737651	0
STD DEV	5.195899971	0
95%CI	3.220388222	
MIN	90.44	
MAX	96.88	

Table 5.2.3.1. The average time in queue in ASP (in minutes) for 10 replications

5.3. Comparison of the Modified Existing System and the modified New System

By only changing the convoy loading capacity at one time as 4 instead of 1 and vehicle loading capacity as 4 instead of 1, we obtained the modified new system considering the feedbacks of Section 5.2. In this section, we will see whether there exists a difference between the modified existing system and the modified new system against several performance measures. To do that first we look at the “time in system” performance measure which we think as the main one then consider a number of other measures such as, “number of ammunition during the battle time”, “time in ASP loading queue”, “number of convoys waiting in ASP loading queue”, “number of vehicles in convoys in the ASP. By comparing the two system we try to understand the behaviors of these two systems.

5.3.1. Comparison by “Time in System” Performance Measure

The simulation results are summarized in Tables 5.3.1.1 – 5.3.1.3. In these tables, columns are the time in system values for the positions that the units are located at that time. Positions are ordered from near to far as explained before. As in the sections before, to test the most forcing case, we again take the probability of going forward as 1. That means that the units will be at the next forward position on the day after and the supply distance will increase.

To measure the difference between the two systems we made Table 5.3.1.3 and applied the paired-t test. The results indicate that non of the confidence intervals in the Table 5.3.1.3 include zero. This means the modified new system is significantly better than the modified existing system in terms of the time in system performance.

When we only consider the time passing in ASP, we get the results in Tables 5.3.1.4 – 5.3.1.6. According to the paired-t test results, the modified new system is better than the modified existing system (Table 5.3.1.6). Figure 5.3.1.2 shows that graphically.

BRIGADE								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	260.98	349.69	384.62	483.67	565.46	637.44	705.55	804.13
2	268.72	385.17	415.04	505.04	586.37	652.06	726.75	810.49
3	298.76	338.86	428.76	490.25	592.41	615.45	713.19	777.71
4	274.45	372.31	385.65	502.22	559.01	633.07	765.23	798.89
5	281.63	372.64	426.41	499.29	583.95	633.94	710.57	735.17
6	257.73	361.5	400.4	524	576.73	659.15	711.82	793.7
7	291.06	384.26	423.17	477.63	584.65	694.72	737.89	777.62
8	298.79	378.8	422.22	497.61	569.32	643.08	684.81	800.42
9	284.39	350.54	424.64	487.03	588.3	680.1	709.86	799.02
10	197.47	391.65	418.91	579.33	564.63	629.5	695.98	791.27
MEAN	271.4	365.9742	412.3212	496.3041	578.4663	649.8907	718.4057	788.5725
VAR	232.9479	276.3446	308.0431	190.0003	132.072	617.2024	517.6098	524.3054
STDDEV	15.26263	16.62362	17.55116	13.78406	11.49226	24.84356	22.75104	22.89772
CI	8.058228	8.776789	9.266504	7.277586	6.06758	13.11668	12.01189	12.08933
MIN	263.338	357.1974	403.0547	489.0265	572.3987	636.774	706.3938	776.4831
MAX	279.45	374.75	421.59	503.58	584.53	663.01	730.42	800.66

Table 5.3.1.1. Average time in system (in minutes) in the modified existing system for ten replications.

BRIGADE								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	99.2	137.01	170.41	207.48	243.65	284.29	315.26	355.13
2	101.48	143.98	177.08	212.01	248.94	284.35	319.65	357.28
3	103.27	136.76	176.38	208.91	244.78	281.42	316.96	352.57
4	100.03	138.63	169.39	210.47	244.44	282.59	322.36	355.28
5	102.42	143	173.8	209.34	248.22	280.42	317.22	349.56
6	99.91	140.23	173.97	212.98	246.48	283.83	320.06	358.11
7	103.03	139.82	172.9	206.39	243.98	287.65	318.66	353.64
8	105.12	136.95	175.55	209.41	243.62	282	314.79	355.31
9	105.67	135.79	177.2	206.75	246.88	286.2	317.36	355.5
10	93.99	144.98	173.08	214.88	247.36	280.83	318.2	354.46
MEAN	102.2358	139.1299	174.0758	209.3038	245.6644	283.6396	318.0368	354.7095
VAR	5.23367	8.300246	7.897671	5.086165	4.088123	5.329779	5.791568	6.487108
STDDEV	2.287722	2.881015	2.81028	2.255253	2.021911	2.308631	2.406568	2.54698
CI	1.207851	1.521093	1.483746	1.190708	1.06751	1.218891	1.270598	1.344732

Table 5.3.1.2. Average time in system (in minutes) in the modified new system for ten replications.

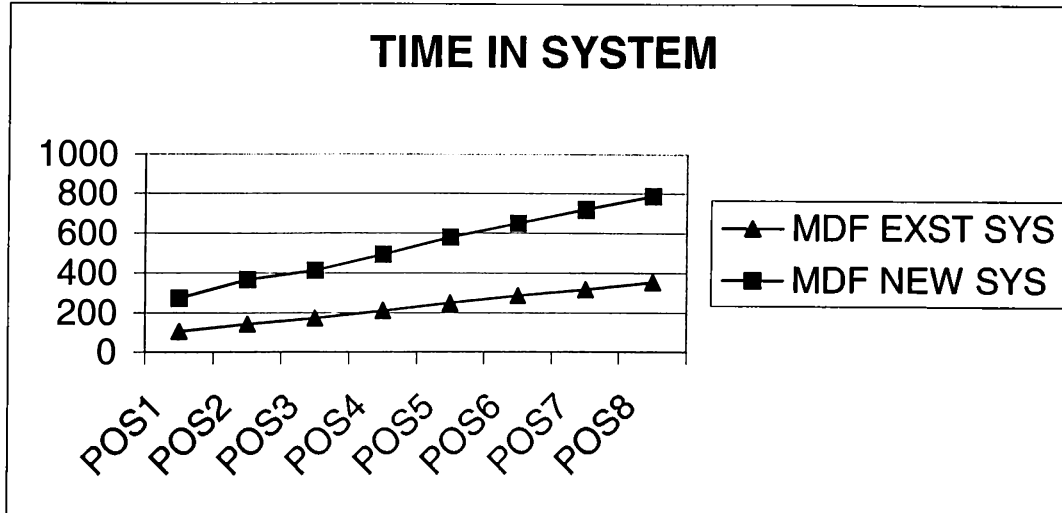


FIGURE 5.3.1.1. Averages of ten replications for time in system performance measure values of the modified existing system and the modified new system

BRIGADE								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	161.78	212.68	214.21	276.19	321.81	353.15	390.29	449
2	167.24	241.19	237.96	293.03	337.43	367.71	407.1	453.21
3	195.49	202.1	252.38	281.34	347.63	334.03	396.23	425.14
4	174.42	233.68	216.26	291.75	314.57	350.48	442.87	443.61
5	179.21	229.64	252.61	289.95	335.73	353.52	393.35	385.61
6	157.82	221.27	226.43	311.02	330.25	375.32	391.76	435.59
7	188.03	244.44	250.27	271.24	340.67	407.07	419.23	423.98
8	193.67	241.85	246.67	288.2	325.7	361.08	370.02	445.11
9	178.72	214.75	247.44	280.28	341.42	393.9	392.5	443.52
10	103.48	246.67	245.83	364.45	317.27	348.67	377.78	436.81
MEAN	169.986	228.827	239.006	294.745	331.248	364.493	398.113	434.158
VAR	707.104	237.6802	217.6354	720.7896	123.7013	493.3989	432.4253	381.2339
STDDEV	26.59143	15.41688	14.75247	26.84752	11.12211	22.21259	20.79484	19.52521
CI	16.48121	9.555291	9.143495	16.63994	6.893416	13.76723	12.88852	12.10161
MIN	153.5048	219.2717	229.8625	278.1051	324.3546	350.7258	385.2245	422.0564
MAX	186.4672	238.3823	248.1495	311.3849	338.1414	378.2602	411.0015	446.2596

Table 5.3.1.3. Statistics of the difference between the Table 5.3.1.1 and Table 5.3.1.2.

BRIGADE								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	82.53	132.49	63.54	91.93	95	110.57	115.38	85.29
2	124.88	125.99	68.69	123.32	129.03	88.82	141.06	81.4
3	124.44	117.54	148.17	137.82	78.88	99.7	135	100.53
4	97.56	145.6	46.18	101.87	100.69	85.97	103.18	120.25
5	118.73	127.75	78.95	163.92	91.96	112.04	71.03	69.43
6	91.55	107.56	101.88	165.53	93.69	156.79	124.63	98.66
7	123.93	120.29	77.87	106.85	97.55	183.24	101.8	116.46
8	138.01	92.03	89.74	124.96	97.09	88.6	81.25	131.1
9	85.42	119.59	72.86	119.7	142.47	178.82	101.24	135.23
10	35.96	168.74	90.96	111.61	82.27	111.44	128.71	128.25
MEAN	109.6721	120.9839	83.09746	126.2114	102.9297	122.7276	108.2846	104.2606
VAR	417.2206	230.192	841.7599	662.2231	394.9547	1553.257	542.7352	528.1861
STDDEV	20.42598	15.17208	29.0131	25.7337	19.87347	39.41138	23.29668	22.9823
CI	10.78433	8.010419	15.31808	13.58665	10.49262	20.80807	12.29997	12.13399

Table 5.3.1.4. Summary statistics of the time passed in ASP (in minutes) in modified existing system for ten replications.

BRIGADE								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	13.13	14.43	11.2	13.75	12.94	15.96	15.08	17.15
2	15.39	20.55	16.5	17.14	17.5	16.09	18.56	17.79
3	15.89	15.32	17.09	14.95	15.28	14.51	14.26	14.36
4	13.46	15.61	11.09	14.77	14.77	15.86	20.33	16.78
5	15.67	19.77	15.49	14.63	17.51	13.89	14.75	9.5
6	12.52	17.03	12.81	16.99	16.35	16.17	16.44	18.48
7	14.85	17.51	14.26	11.22	14.43	20.63	16.22	14.74
8	17.01	15.13	16.61	14.59	15.18	15.71	12.27	16.14
9	16.37	14.22	16.25	13.69	16.43	19.42	15.22	16.63
10	7.48	21.57	14.69	20.5	16.96	13.85	15.39	15.38
MEAN	14.92053	16.6182	14.58913	14.63632	15.59811	16.4719	15.90221	15.72865
VAR	2.417272	5.225132	5.569452	3.161434	2.237451	4.752905	5.676373	7.191522
STDDEV	1.554758	2.285855	2.359969	1.778042	1.495811	2.180116	2.382514	2.681701
CI	0.820867	1.206865	1.245995	0.938755	0.789745	1.151038	1.257899	1.415861

Table 5.3.1.5. Summary statistics of the time passed in ASP (in minutes) in modified new system for ten replications.

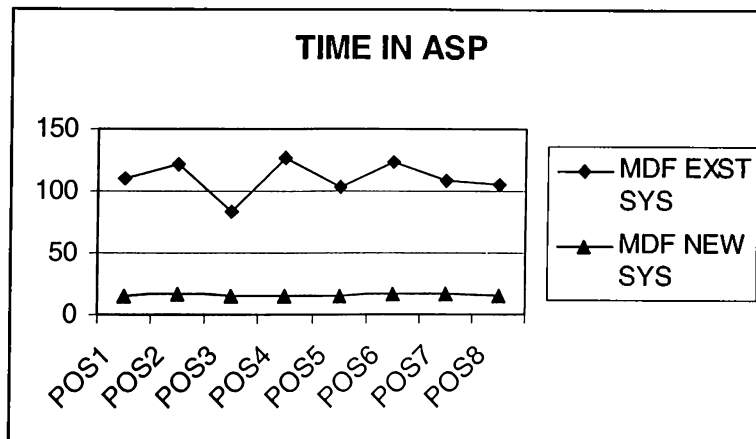


FIGURE 5.3.1.2. Averages of ten replications for time in ASP performance measure values of the modified existing system and the new system

BRIGADE								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	69.4	118.06	52.34	78.18	82.06	94.61	100.3	68.14
2	109.49	105.44	52.19	106.18	111.53	72.73	122.5	63.61
3	108.55	102.22	131.08	122.87	63.6	85.19	120.74	86.17
4	84.1	129.99	35.09	87.1	85.92	70.11	82.85	103.47
5	103.06	107.98	63.46	149.29	74.45	98.15	56.28	59.93
6	79.03	90.53	89.07	148.54	77.34	140.62	108.19	80.18
7	109.08	102.78	63.61	95.63	83.12	162.61	85.58	101.72
8	121	76.9	73.13	110.37	81.91	72.89	68.98	114.96
9	69.05	105.37	56.61	106.01	126.04	159.4	86.02	118.6
10	28.48	147.17	76.27	91.11	65.31	97.59	113.32	112.87
MEAN	88.124	108.644	69.285	109.528	85.128	105.39	94.476	90.965
VAR	776.3892	384.6049	694.3449	591.4828	380.685	1270.83	494.1132	495.8982
STDDEV	27.86376	19.61135	26.35043	24.32042	19.51115	35.6487	22.22866	22.26877
CI	17.2698	12.155	16.33184	15.07365	12.0929	22.09486	13.77719	13.80205
MIN	70.8542	96.489	52.95316	94.45435	73.0351	83.29514	80.69881	77.16295
MAX	105.3938	120.799	85.61684	124.6017	97.2209	127.4849	108.2532	104.7671

Table 5.3.1.6. Statistics of the difference between the Table 5.3.1.4 and Table 5.3.1.5.

5.3.2. Comparison of the Systems by “Average Number of Ammunition During the Battle Time” Performance Measure

The number of ammunition during the battle time performance measure ensures the systems' efficiency from the point of giving the battle units the availability of the being ready to the changing battle conditions. It is advantageous to have UBL completed after consumption to provide the commander planning the operations without the doubt of having lack ammunition .

We apply paired-t test for the outputs of the modified existing system and modified new system to see whether there is a significant difference between them or not. As can be seen in Table 5.3.2.1, there is no difference between two systems in terms of the number of ammunition during the battle time.

BATTALION			
REP#	NEW SYS AVG NO AMMO	MDF EXIST SYS AVG NO AMMO	DIFFERENCE
1	4896	4980	-84
2	4729	4854	-125
3	4939	4954	-15
4	4858	4899	-41
5	4984	4977	7
6	4923	4897	26
7	4830	4856	-26
8	4873	4922	-49
9	4945	4861	84
10	4901	4885	16
MEAN	4888	4909	-21
VAR	5143.733333	2312.722222	3490.677778
STD DEV	71.71982525	48.09077066	59.08195814
CI	44.45152558	29.80637662	36.61864993
MIN	4843.348474	4878.693623	-57.31864993
MAX	4932.251526	4938.306377	15.91864993

Table 5.3.2.1. The summary statistics of the ammunition during the battle time in the new and modified existing systems for ten replications

5.3.3. Comparison of the Systems by “Number of Vehicles in a Convoy” Performance Measure

The number of vehicles in a convoy is important from the point of being a target while travelling loaded or unloaded and waiting in ASPs for the loading activity. We see that in Table 5.3.3.1 the modified new system is more advantageous than the modified existing system since it has less vehicles in the convoys and less susceptible to the enemy attacks.

BRIGADE1/BAT1			
REP#	MDF EXST SYS AVG NO OF VHC	MDF NEW SYS AVG NO OF VHC	DIFFERENCE
1	27	8	19
2	32	9	23
3	29	9	20
4	30	9	21
5	29	9	20
6	30	9	21
7	31	9	22
8	30	9	21
9	32	9	23
10	30	9	21
MEAN	29.875	8.820833333	21.1
VAR	2.381944444	0.142380401	1.655555556
STD DEV	1.543354931	0.377333276	1.286683938
CI	0.956562303	0.233868944	0.797479132
MIN	28.9184377	8.58696439	20.30252087
MAX	30.8315623	9.054702277	21.89747913

Table 5.3.3.1. Summary statistics for average number of vehicles in a convoy for ten replications

5.4 Conclusions

As a summary of the results that have obtained from the sections above:

- The existing system can not accomplish its mission since it can not supply the military units in all phases of the battle. The system collapses for all performance measures.
- Modified existing system has good reaction from the point of “time in ASP” and reasonable results for other performance measures. The modified existing system can accomplish its supply mission. The only drawback of the system is the crowded numbers of vehicles in the convoys that makes the system susceptible to the enemy assaults.
- New system has better results than the modified existing system except for the “waiting time in ASP loading queue”. Although the system has better results for all other performance measures this deficiency makes it susceptible to the long distance enemy assaults.
- Since the modified new system is constructed by renewal of the parameters of the new system to get better results considering the “waiting time in ASP loading queue” performance measure, it has the best results of all systems for all performance measures.

Chapter 6

Sensitivity Analysis on ASP Loading Times for Modified Existing System at Different Loading Times

In this section we try to see the behavior of the system at different loading time of a vehicle, loading capacity in terms of vehicles loaded at one time and loading capacity in terms of convoys loaded at one time for a loading site. We use the “time in ASP” performance measure.

The main question we try to answer in this section is “which factor is more effective on the time passing in ASP?”. We consider two alternatives of vehicle loading time, four alternatives of number of convoys loaded and four alternatives of number of vehicles loaded.

In this study, we don’t try to obtain the optimum. Our aim is just to see the effects of the factors mentioned above and get the user of the system focus on the effective factor or factors first to deal with the current time problems. We test the system while keeping the loading time fixed with the triangular distribution having maximum 20 min, average 15 min and the minimum 10 min. We replicate the system ten times for each alternative and evaluate them.

In the following sections we first analyze the effects of these two factors for the two positions individually, then conclude by summarizing for all positions. We test the differences by applying the paired-t to obtain a general idea about the effects of them to the performance of the system.

6.1 For Position 1

In Table 6.1.1 we see the experiments of the model with the capacities changing. We run the simulation model of the modified existing system with the convoy loading capacity changing from 1 to 4 while the vehicle loading capacity is changing from 1 to 4 for Position 1. We only evaluate the system by “time in ASP” performance measure. For example, for 1 convoy loading capacity and 2 vehicles loading capacity the system has a time in ASP value of 359.63 minutes; however, the system has a time in ASP value of 297.65 minutes for 1 convoy loading capacity and 14 vehicle loading capacity. It is clear that as the values of these factors increase the time in ASP will decrease; but, that requires some cost that the army can bear.

Now let’s examine which factor is more effective on this performance measure. To do that we consider one factor is constant and evaluate the change on the other factor and later test the difference between them. Table 6.1.2 shows the reaction of the system in case 4 convoys capacity is constant and 4 vehicles capacity is constant. Since the confidence interval of the differences do not include zero, we conclude that changing the convoy loading capacity has more effect than changing the vehicle capacity with 95% confidence level for Position 1

	1 CONVOY	2 CONVOYS	3 CONVOYS	4 CONVOYS
1 VEHICLE	1,200.33	689.23	346.72	369.99
2 VEHICLES	623.49	359.63	182.09	192.76
3 VEHICLES	400.21	229.34	112.55	124.50
4 VEHICLES	297.65	171.48	88.09	92.44

Table 6.1.1. The behavior of the system with the changes in convoy loading capacity and vehicle loading capacity for position 1

4 CONVOYS CONSTANT		4 VEHICLES CONSTANT		Difference
1 VEHICLE	369.99	1 CONVOY	297.65	72.34
2 VEHICLES	192.76	2 CONVOYS	171.48	21.28
3 VEHICLES	124.5	3 CONVOYS	88.09	36.41
4 VEHICLES	92.44	4 CONVOYS	92.44	0
MEAN	194.9225	MEAN	162.415	32.5075
VAR	15371.77	VAR	9597.129	928.2173
STD DEV	123.9829	STD DEV	97.96494	30.46666
CI	121.5009	CI	96.00373	29.85673
MIN	73.42165	MIN	66.41127	2.650767
MAX	316.4234	MAX	258.4187	62.36423

Table 6.1.1. Comparison between the effects of changing the capacity in terms of “convoys loaded at one time” and changing the capacity in terms of” vehicles loaded at one time” for Position 1 considering the time (in minute) in ASP

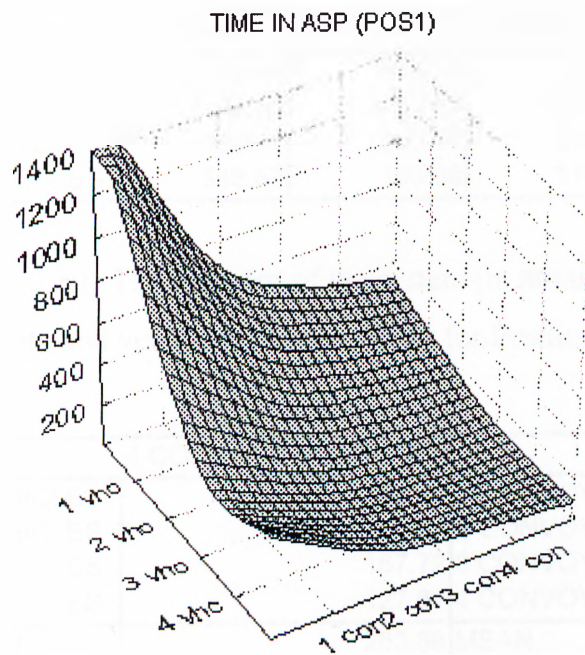


Figure 6.1.1. The behavior of the system with the changes in convoy loading capacity and vehicle loading capacity for position 1

6.2 For Position 2

We apply the same procedure to detect the reaction of the system for Position 2. The confidence interval of the differences contains zero. Hence, there is no any evidence that there exists a significant difference between them (Table 6.2.2). We see that while the capacity changes in both factor have different effect on the system for Position 1 there seems no difference for the Position 2. That means we can decrease the time in ASP by either increasing the convoy loading capacity or vehicle capacity according to the results in Position 2 and the effects of the both factors are the same on the “time in ASP” performance.

	1 CONVOY	2 CONVOYS	3 CONVOYS	4 CONVOYS
1 VEHICLE	1,625.84	875.18	742.2	501.49
2 VEHICLES	798.65	463.42	425.98	258.7
3 VEHICLES	454.44	292.17	212.58	167.72
4 VEHICLES	348.87	193.88	178.05	127.61

Table 6.2.1. The behavior of the system (in minute) with the changes in convoy loading capacity and vehicle loading capacity for Position 2

4 CONVOYS CONSTANT		4 VEHICLES CONSTANT		Difference
1 VEHICLE	501.49	1 CONVOY	348.87	152.62
2 VEHICLES	258.7	2 CONVOYS	193.88	64.82
3 VEHICLES	167.72	3 CONVOYS	178.05	-10.33
4 VEHICLES	127.61	4 CONVOYS	127.61	0
MEAN	263.88	MEAN	212.1025	51.7775
VAR	28100.53	VAR	9111.988	5625.856
STD DEV	167.6321	STD DEV	95.45673	75.00571
CI	164.2762	CI	93.54574	73.50413
MIN	99.60376	MIN	118.5568	-21.7266
MAX	428.1562	MAX	305.6482	125.2816

Table 6.2.2. Comparison between the effects of changing the capacity in terms of “convoys loaded at one time” and changing the capacity in terms of “vehicles loaded at one time” for Position 2 considering the time (in minute) in ASP

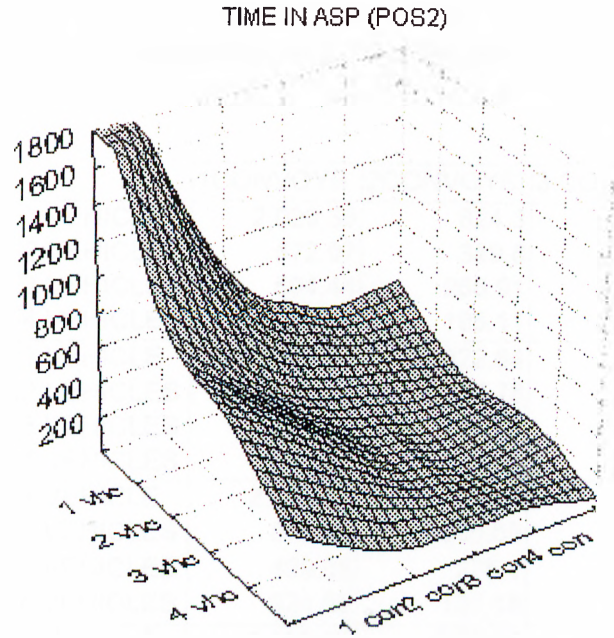


Figure 6.2.1. The behavior of the system in terms of “time in ASP” performance measure with the changes in convoy loading capacity and vehicle loading capacity for position 2

6.3 Other Positions and Discussion

In Table 6.3.1, we see the average time in ASP based on ten simulation for six of the positions with the stated numbers of convoy loading capacities and vehicle loading capacities. Two of the experiment sets for each position conclude that increasing the number of convoys loaded at one time has more effect than increasing the number of vehicles loaded at one time since the difference in terms of time (in minute) passing in ASP is significant due to the confidence intervals of the differences does not contain with 95% confidence level (Table 6.3.2). On the other hand, for the other positions there exists no difference between these factors because the confidence intervals include zero (Table 6.3.2). Recalling the results of the Chapter 5, we must consider the numbers of convoys waiting in the loading queue in the ASPs while having few numbers of loading capacity in terms of convoys loaded at the same time. Even in the new ammunition supply system there are convoys waiting for the loading activity which is a deficiency. Then, we can conclude that it is better to increase both the convoy loading capacity and

the vehicle loading capacity at one time to gain the efficiency on a secure loading activity. The decision maker should decide on the cost he can bear to get the best profit.

		1CONVOYS	2CONVOYS	3 CONVOYS	4 CONVOYS
POS3	1 VEHICLE	2,020.35	824.3	458.56	557.46
	2 VEHICLES	572.07	359.8	223.04	286.82
	3 VEHICLES	504.44	268.91	148.22	185.19
	4 VEHICLES	327.9	195.11	103.66	138.89
POS4	1 VEHICLE	1,696.76	622.84	587.21	417.4
	2 VEHICLES	649.54	376.78	308.9	215.94
	3 VEHICLES	421.14	211.74	213.03	141.64
	4 VEHICLES	241.87	157.82	130.89	102.06
POS5	1 VEHICLE	2,182.31	732.23	591.37	437.19
	2 VEHICLES	878.95	385.65	285.87	226.19
	3 VEHICLES	429.05	275.1	195.32	145.77
	4 VEHICLES	324.62	137.18	148.67	108.15
POS6	1 VEHICLE	2,399.59	483.84	619.6	431.86
	2 VEHICLES	477.6	294.65	251.48	223.26
	3 VEHICLES	390.89	224.11	206.73	141.93
	4 VEHICLES	280.68	140.43	143.4	109.3

Table 6.3.1. The behavior of the system in terms of “time in ASP” (in minute) with the changes in convoy loading capacity and vehicle loading capacity for six positions

	4 CONVOYS		4 VEHICLES		DIFFERENCE
POS3	1 VEHICLE	557.46	1 CONVOY	327.9	229.56
	2 VEHICLES	286.82	2 CONVOYS	195.11	91.71
	3 VEHICLES	185.19	3 CONVOYS	103.66	81.53
	4 VEHICLES	138.89	4 CONVOYS	138.89	0
	MEAN	292.09	MEAN	191.39	100.7
	VAR	35115.6	VAR	9700.54	9064.6
	STD DEV	187.392	STD DEV	98.49132	95.208
	CI	183.64	CI	96.51958	93.302
	MIN	108.45	MIN	94.87042	7.398
	MAX	475.73	MAX	287.9096	194
POS4	1 VEHICLE	417.4	1 CONVOY	241.87	175.53
	2 VEHICLES	215.94	2 CONVOYS	157.82	58.12
	3 VEHICLES	141.64	3 CONVOYS	130.89	10.75
	4 VEHICLES	102.06	4 CONVOYS	102.06	0
	MEAN	219.26	MEAN	158.16	61.1
	VAR	19677.1	VAR	3632.8	6457.1
	STD DEV	140.275	STD DEV	60.273	80.356
	CI	137.467	CI	59.066	78.748
	MIN	81.7933	MIN	99.094	-17.65
	MAX	356.727	MAX	217.23	139.85
POS5	1 VEHICLE	437.19	1 CONVOY	324.62	112.57
	2 VEHICLES	226.19	2 CONVOYS	137.18	89.01
	3 VEHICLES	145.77	3 CONVOYS	148.67	-2.9
	4 VEHICLES	108.15	4 CONVOYS	108.15	0
	MEAN	229.325	MEAN	179.66	49.67
	VAR	21627.5	VAR	9630.7	3578.3
	STD DEV	147.063	STD DEV	98.136	59.819
	CI	144.119	CI	96.171	58.621
	MIN	85.2062	MIN	83.484	-8.951
	MAX	373.444	MAX	275.83	108.29
POS6	1 VEHICLE	431.86	1 CONVOY	280.68	151.18
	2 VEHICLES	223.26	2 CONVOYS	140.43	82.83
	3 VEHICLES	141.93	3 CONVOYS	143.4	-1.47
	4 VEHICLES	109.3	4 CONVOYS	109.3	0
	MEAN	226.588	MEAN	168.45	58.135
	VAR	21023.7	VAR	5835.6	5399.9
	STD DEV	144.996	STD DEV	76.391	73.484
	CI	142.093	CI	74.862	72.013
	MIN	84.4947	MIN	93.59	-13.88
	MAX	368.68	MAX	243.31	130.15

Table 6.3.2. Comparison between the effects of changing the capacity in terms of convoy loaded at the same time and changing the capacity in terms of vehicles loaded at the same time for other four positions (in minute)

Chapter 7

Conclusion

7.1 General

In this study, we developed a simulation model capable of analyzing the behavior of the existing and new ammunition supply systems of Turkish Army. Due to the size of the system, the model is constructed for only corps artillery ammunition supply system. The model can be adapted to represent other types of ammunition supply systems and represent higher level of units.

The objectives of this study are:

- To understand the behaviors of the existing and new systems,
- To detect the bottlenecks or problem areas and to develop alternative system designs to cope with these bottlenecks.

The simulation model enables the user to test the system with different factors such as the velocity of convoys, capacity of vehicles, capacity of ASPs, number of ammunition consumed and the probability of advance of the tactical units.

In this study, we evaluate the existing and new system, compare them by using the performance measures: time-in-system, number of ammunition during the battle time, time in ASP, waiting time in ASP queue, number of convoys waiting in ASP loading queue, utilization of loading units in ASP and number of vehicles in convoys.

7.2 Existing Ammunition Supply System

We obtain the following results:

- Considering an 8-day battle time, the units cannot be supplied in all phases of the battle, which means that the existing system cannot accomplish its mission in actual war conditions.
- Existing ammunition system can supply the units for 4 days minimum and 7 days maximum with 95% confidence level, after that it collapses.
- During the battle time there are minimum 2 and maximum 3 convoys waiting in ASP loading queue with minimum 27.8 minutes and maximum 29.6 minutes waiting times in queue with 95% confidence level which is an important drawback in terms of being susceptible to the enemy long distance vehicles and assault units.
- Considering the worst case conditions, having a utilization of minimum 0.89 and maximum 0.97 is very disadvantageous for the existing system as well.

7.3 Comparison of Modified Existing System and the New System

We modify the existing system by increasing the loading capacity of ASPs in terms of convoys and vehicles and the report system to get a working system. The idea is to obtain a less expensive and more effective improvement in the system. We get the following results when we compare the modified existing system with the new supply system proposed by army:

- Although the new system has statistically better results, both of the systems accomplish the mission of supplying the military units in time considering the standards maintained by military.
- There exists a significant difference between the new and the modified existing system in favor of new system considering the number of ammunition during the wartime.

- The modified existing system has no any convoy waiting in ASP loading queue while the new system has.
- Although the modified existing system has better utilization values, both of the systems have reasonable utilization values.

7.4 Comparison of Modified New System and the New System

We modify the parameters of the new system to obtain the modified new system for getting better results by evaluating the drawbacks of the new system. We observe the followings:

- We achieve approximately 50% improvement compared to the new system in terms of time-in-system performance measure.
- There is no difference between these two systems in terms of the average ammunition with the units during the battle time with 95% confidence level.
- The modified new system has no convoys waiting in the loading queue which means that it is better than the new ammunition supply system.

7.5 Comparison of Modified Existing System and the Modified New System

Since we modified the new system according to the feedback of the comparison of the modified existing system and the new system, we check the improvements done in the new system by this comparison. We get the following results:

- We obtain an 85% improvement compared to the modified existing modified system from the point of time in ASP performance measure.
- Both of the systems have the same amount of ammunition during the battle time with 95% confidence level.
- There is no any convoy waiting in ASP loading queue in both systems

- The modified new system is better than the modified existing system with minimum 8 and maximum 9 vehicles in convoys while the modified existing system has minimum 28 and maximum 30 vehicles in the convoys.

7.6 Factor Efficiency in ASP Loading Units

In Chapter 6, we see that convoy loading capacity at one time is the most effective factor while keeping the loading time of a vehicle constant. Considering the cost, the decision-maker may decide on a mixture of these two factors still having an effective result.

7.7 Concluding Remarks

We have the following conclusions from our study:

- 1 Existing system does not accomplish its mission since it can not supply the ammunition during all phases of the battle.
- 2 Modified existing system accomplishes its mission within the bounds of the determined conditions mentioned before. Because the modifications are made on the reporting system by making it by way of an on-line system and the material handling systems, such that forklifts and conveyors, it has less cost than the new and the modified new systems. However, it has the drawback of having a crowded number of vehicles in the convoys which makes it susceptible to the enemy long distance and air assaults.
- 3 In general, new system has better results than the modified existing system except for the existence of convoy loading queue, which makes it susceptible to the enemy assaults. It costs more than the modified existing system considering the changes to be made on the system, storage equipment and special vehicles containing material handling equipment.
- 4 Modified new system is the best system of all from the point of the performance it yields; but it costs more compared to the other systems.

- 5 For the modification of the ASP, both of the factors, convoy loading capacity and vehicle loading capacity, have the same effect on the efficiency of the system. The decision-maker decide on the a mixture of both systems considering the cost.

The designed systems are evaluated within the logic as presented in Figure 7.7.1.

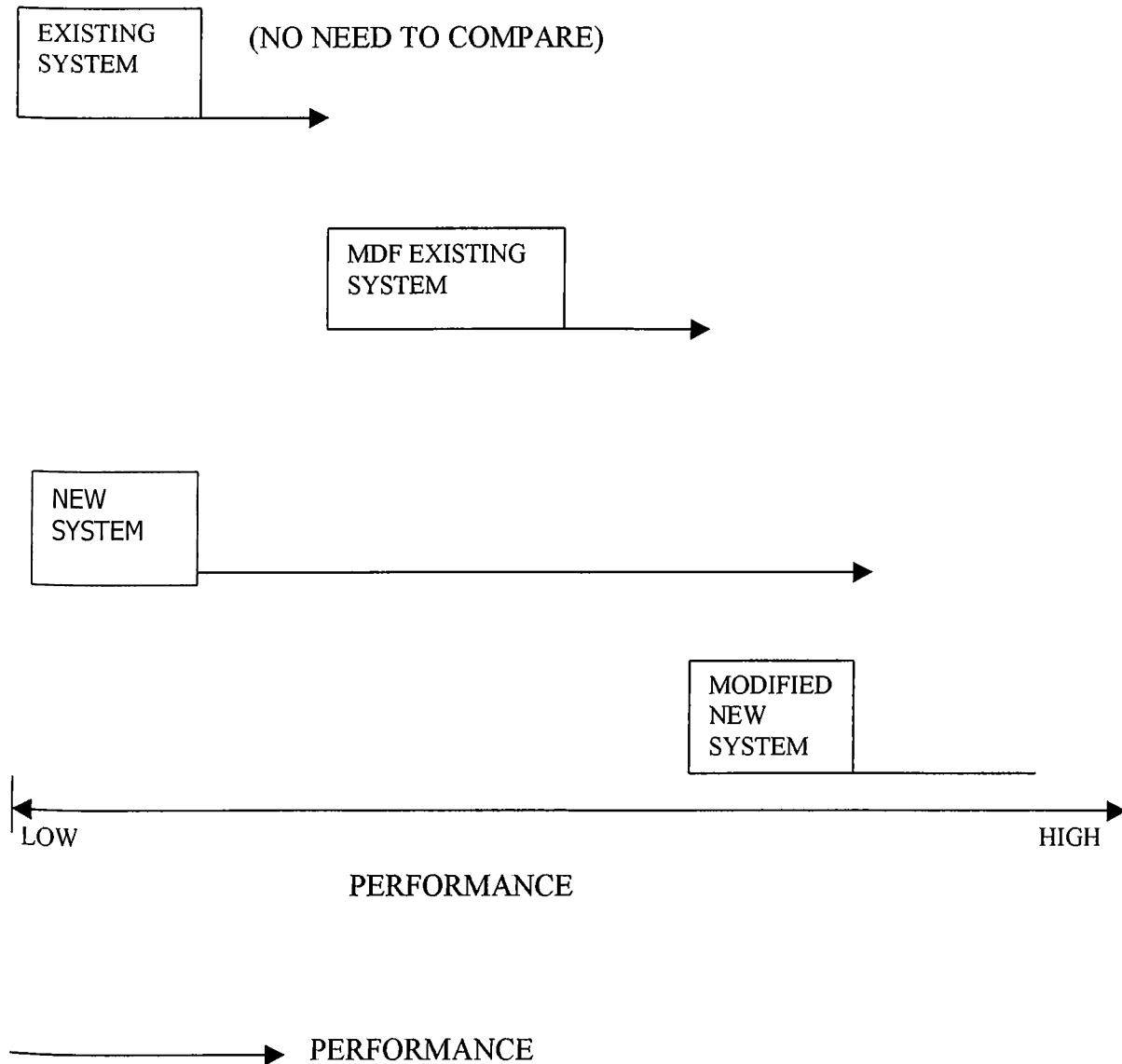


Figure 7.7.1. Logic of evaluation of ammunition supply systems

7.8 Future Research Topics

Logistics is one of the main issues in military that never loses its importance. As the technology and the needs of the war conditions change logistics also gain different problems with them. This topic still has many aspects to be developed from the point of simulation. Even the terrain factors where the military operation goes on and the structure changes in the units can be the only issue to deal with the simulation to cope with the problems.

During this study, the hazards of the war conditions were not simulated due to the time and data limitations. This can be undertaken in the future studies.

The success of the ammunition supply system depends on the inventory control system of the army as well. This study can be extended with the studies on the inventory control of the ammunition.

The capacities and the traffic factors for the roads can be seen to be a drawback. The proposed models can be extended to include these factors in future studies.

Cost is one of the major effect for the determination of the system design. The cost factor should be included in the future studies. The cost factor can be expanded to the inventory control.

A forecasting mechanism for the ammunition consumption can be developed and be included in the models to be able to react the supply systems that are responsible for supplying the depots in the Supply Point Series (SPS) and army depots.

All these systems do not include an aviation supply mechanism. These systems can be modified by adding an aviation supply system especially for the outstanding conditions.

Appendix A

Output Data for Existing Ammunition Supply System

BRIGADE 1 /BAT1 A								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	89.16	126.25	162.44	196.94	232.45	268.63	304.59	328.96
2	88.72	126.57	162.24	197.10				
3	88.42	124.77	162.25	195.04	233.70	267.04	304.55	330.39
4	90.30	124.71	161.02	196.43	232.82	266.86	305.23	328.85
5	88.26	123.51	159.70	198.65	233.11	266.78	303.67	329.62
6	88.22	125.69	160.03	196.61	233.72	268.14	306.18	
7	89.08	125.26	161.22	196.49	234.23			
8	89.48							
9	87.84	126.68	161.10	198.76	233.92	269.31		
10	89.21	125.65	161.47	194.58				
MEAN	88.83107	125.4309	161.2478	197.0012	233.4219	267.7909	304.8434	329.4548
VAR	0.578693	1.183653	1.050487	1.487274	0.412497	1.117648	0.865702	0.50772
STDDEV	0.760718	1.087958	1.024932	1.219538	0.642259	1.057189	0.930431	0.712545
CI	0.401637	0.57441	0.541135	0.643881	0.339094	0.558165	0.491241	0.376203

Table 4.1. Travel time (in minute) between battalion to ASP in existing system for the 1st Battalion of 1st Brigade for ten replications

BRIGADE 1 /BAT1 B								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	454.00	1,150.00	487.00	595.00	826.00	750.00	1,330.00	578.00
2	443.00	2,170.00	1,310.00	887.00				
3	616.00	1,140.00	1,640.00	1,630.00	2,090.00	1,860.00		
4	791.00	722.00	766.00	971.00	565.00	665.00	1,390.00	
5	334.00	763.00	865.00	1,660.00	1,610.00	1,200.00	1,600.00	
6	518.00	1,050.00	251.00	1,020.00	1,030.00	1,090.00		
7	1,010.00	1,390.00	1,220.00	820.00	1,070.00			
8								
9	557.00	1,700.00	478.00	1,300.00	1,260.00			
10	165.00	2,100.00	1,420.00					
MEAN	590.7604	1262.31	877.5029	1109.492	1206.526	1113.841	1437.742	577.6789
VAR	47573.32	236508.1	229679.3	147652.1	258551.2	224959.2	21054.3	
STDDEV	218.1131	486.321	479.2487	384.2552	508.4793	474.2986	145.101	
CI	115.1574	256.7635	253.0295	202.8756	268.4624	250.416	76.60914	

Table 4.2. Time (in minute) in ASP in existing system for the 1st Battalion of 1st Brigade for ten replications

BRIGADE 1 /BAT1 C								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	93.78	132.09	172.49	202.76	237.99	274.52	311.31	
2	92.80	136.50	168.57	206.31				
3	94.46	133.75	167.22	202.21	243.12	275.91		
4	98.14	129.72	165.60	204.32	240.86	277.85	310.36	
5	96.34	134.05	168.91	202.99	240.18	279.25	314.66	
6	97.62	135.01	169.33	204.15	237.94	273.78		
7	97.96	128.92	168.13	206.35				
8								
9	98.46	133.17	167.21	207.39	236.99			
10	96.56	129.86	170.57					
MEAN	96.1942	132.9015	168.4325	204.5589	239.5116	276.2638	312.1106	
VAR	4.924392	6.591308	4.084108	3.669451	5.288856	5.196373	5.103405	
STDDEV	2.219097	2.567354	2.020918	1.915581	2.299751	2.279555	2.259072	
CI	1.171619	1.355489	1.066986	1.011372	1.214202	1.203539	1.192725	

Table 4.3. Travel time (in minute) between ASP to battalion in existing system for the 1st Battalion of 1st Brigade for ten replications

BRIGADE 1 /BAT2 A								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	90.30	124.00	161.00	196.00	231.00	269.00	303.00	342.00
2	89.00	126.00	161.00	198.00	-	-	-	-
3	88.80	125.00	161.00	197.00	234.00	268.00	304.00	340.00
4	90.10	126.00	160.00	196.00	233.00	269.00	305.00	342.00
5	88.50	126.00	161.00	197.00	233.00	270.00	303.00	341.00
6	88.80	123.00	161.00	196.00	234.00	269.00	306.00	-
7	90.40	127.00	162.00	199.00	233.00	-	-	-
8	87.50	-	-	-	-	-	-	-
9	88.50	124.00	162.00	197.00	232.00	268.00	-	-
10	89.40	126.00	160.00	198.00	-	-	-	-
MEAN	89.10394	111.343	143.2863	175.1107	181.1317	179.2105	169.1849	151.7089
VAR	0.947355	1744.475	2887.576	4312.83	10546.21	18065.8	25762.05	32366.24
STDDEV	0.973322	41.76691	53.73617	65.67214	102.6947	134.4091	160.5056	179.9062
CI	0.513886	22.05172	28.37115	34.67299	54.21985	70.96412	84.74233	94.98528

Table 4.4. Travel time (in minute) between battalion to ASP in existing system for the 2nd Battalion of 1st Brigade for ten replications

BRIGADE 1 /BAT2 B								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	953.00	580.00	284.00	95.80	427.00	1,030.00	909.00	
2	949.00	1,370.00	835.00					
3	1,330.00	1,760.00	1,310.00	2,050.00	1,750.00	2,250.00		
4	533.00	1,810.00	577.00	410.00	716.00	1,050.00	1,830.00	
5	886.00	1,890.00	1,210.00	1,210.00	1,950.00	1,560.00	1,460.00	
6	1,400.00	323.00	440.00	576.00	1,250.00	1,560.00		
7	1,860.00	2,110.00	1,420.00	888.00	595.00			
8	504.00							
9	743.00	1,440.00	1,140.00	900.00	687.00			
10	242.00	1,710.00	1,080.00					
MEAN	1016.888	1409.476	900.3203	875.065	1053.169	1487.507	1400.615	
VAR	193696.1	409268.9	183183	399943.9	362306.6	247923.7	215078.1	
STDDEV	440.1091	639.7413	427.9988	632.4111	601.9191	497.9194	463.7651	
CI	232.3649	337.7649	225.971	333.8948	317.7959	262.8871	244.8546	

Table 4.5. Time (in minute) in ASP in existing system for the 2nd Battalion of 1st Brigade for ten replications

BRIGADE 1 /BAT2 C								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	95.20	134.00	170.00	202.00	240.00	274.00	312.00	
2	99.60	131.00	166.00					
3	96.10	135.00	171.00	202.00	242.00	275.00		
4	99.40	129.00	167.00	208.00	243.00	277.00		
5	93.10	134.00	168.00	208.00	242.00	277.00	313.00	
6	94.30	132.00	169.00	203.00	239.00	277.00		
7	99.00	131.00	168.00	207.00	241.00			
8	95.10							
9	97.20	134.00	170.00	205.00	240.00			
10	94.80	132.00	165.00					
MEAN	96.55625	132.4435	168.6037	204.8971	240.9766	276.0475	312.7637	
VAR	5.542468	4.643679	2.746588	8.191619	2.28674	1.7474	1.037074	
STDDEV	2.354245	2.15492	1.657283	2.862101	1.512197	1.321892	1.018368	
CI	1.242973	1.137735	0.874998	1.511106	0.798396	0.697921	0.537669	

Table 4.6. Travel time (in minute) between ASP to battalion in existing system for the 2nd Battalion of 1st Brigade for ten replications

BRIGADE 2 /BAT1 A								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	89.15	125.64	160.52	196.31	234.04	268.75	305.72	340.45
2	89.38	124.63	159.85	197.66				
3	88.22	124.45	161.24	197.88	231.63	268.29	305.47	342.69
4	89.20	124.80	162.37	196.26	234.05	267.89	305.29	340.54
5	88.98	126.43	161.42	197.03	231.20	270.19	303.15	340.05
6	89.62	126.65	160.54	195.66	232.83	266.69	306.87	
7	88.07	124.34	161.91	197.39	231.91			
8	89.19							
9	89.38	125.92	161.31	198.28	232.10	269.56		
10	88.71	125.47	161.29	198.69				
MEAN	89.02062	125.3572	161.146	197.0607	232.536	268.5614	305.3012	340.9331
VAR	0.281836	0.845443	0.659644	0.829869	1.306366	1.543751	1.816036	1.424126
STDDEV	0.530883	0.91948	0.812185	0.910971	1.142964	1.242478	1.347604	1.193368
CI	0.280291	0.485459	0.42881	0.480967	0.603452	0.655992	0.711496	0.630064

Table 4.7. Travel time (in minute) between battalion to ASP in existing system for the 1st Battalion of 2nd Brigade for ten replications

BRIGADE 2 /BAT1 B								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	980.84	1,623.63	837.07	785.30	1,317.37	1,421.67	732.46	537.74
2	1,294.78	1,269.77	1,147.76					
3	553.95	458.43	930.60	1,232.47	434.60	251.35	938.19	
4	769.35	595.77	1,426.61	143.74	1,910.31	1,004.98	1,930.95	
5	1,070.40	1,678.87	1,911.46	2,010.92	1,235.97	2,441.86	1,250.00	
6	565.59	1,789.12	926.31	1,044.24	961.15	1,301.34		
7	176.90	1,239.45	1,115.74	952.52	590.76			
8	876.16							
9	914.68	1,712.04	1,557.26	2,280.57	1,180.24			
10	84.82	2,071.94	1,734.70					
MEAN	800.2936	1295.885	1231.602	1207.11	1090.056	1284.242	1212.899	537.7437
VAR	109282.5	266557.9	138028.7	533181.7	241575	626029.4	274418.3	
STDDEV	330.579	516.2925	371.5221	730.1929	491.5028	791.2202	523.8495	
CI	174.5362	272.5875	196.1529	385.5208	259.4993	417.7414	276.5774	

Table 4.8. Time (in minute) in ASP in existing system for the 1st Battalion of 2nd Brigade for ten replications

BRIGADE 2 /BAT1 C								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	98.04	132.25	166.23	206.89	238.13	278.14	316.32	
2	96.01	132.83	170.53					
3	99.10	132.66	167.76	202.05	237.92	272.78	312.72	
4	98.20	130.41	168.77	206.78	237.71	277.64		
5	97.59	132.23	168.02	203.67	239.41	274.30	312.07	
6	98.06	129.80	168.72	200.20	238.71	279.29		
7	94.74	130.59	168.16	201.74	238.62			
8	98.67							
9	96.21	131.08	168.82	203.36	240.07			
10	95.76	133.53	170.38					
MEAN	97.40401	131.4828	168.3766	203.5259	238.6526	276.4313	313.7008	
VAR	2.052005	1.326155	1.468684	6.405441	0.711406	7.600352	5.248694	
STDDEV	1.432482	1.151588	1.211893	2.530897	0.843449	2.756874	2.291003	
CI	0.756309	0.608005	0.639844	1.336241	0.445317	1.45555	1.209583	

Table 4.9. Travel time (in minute) between ASP to battalion in existing system for the 1st Battalion of 2nd Brigade for ten replications

BRIGADE 2 /BAT2 A								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	88.32	125.13	160.14	195.71	232.75	267.29	307.02	340.52
2	87.79	124.24	160.00	195.29				
3	89.55	125.40	160.07	194.93	233.90	270.42	306.20	341.93
4	89.70	125.09	159.77	196.60	232.91	269.60	305.47	339.47
5	88.23	125.95	162.45	195.59	232.13	266.91	304.70	340.42
6	87.80	125.39	160.58	195.55	233.76	270.29	303.78	
7	91.05	123.99	162.16	197.19	233.68			
8	88.96							
9	89.95	124.66	163.19	197.72	234.71	268.19		
10	89.15	124.32	160.82	196.60				
MEAN	89.03818	124.9822	161.046	196.0718	233.4061	268.785	305.4346	340.5841
VAR	1.230725	0.420768	1.788439	0.971522	0.740367	2.346674	1.596884	1.033369
STDDEV	1.10938	0.648666	1.337325	0.985658	0.860446	1.531886	1.263679	1.016548
CI	0.585721	0.342477	0.706069	0.520399	0.454291	0.808791	0.667186	0.536708

Table 4.10. Travel time (in minute) between battalion to ASP in existing system for the 2nd Battalion of 2nd Brigade for ten replications

BRIGADE 2 /BAT2 B								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	356.33	1,211.91	380.79	463.08	190.14	573.62	1,068.80	
2	647.52	1,003.21	1,583.16	719.04				
3	1,120.09	1,046.07	464.43	777.99	1,373.62	915.33	1,724.88	
4	1,091.44	1,494.61	611.91	606.31	1,358.20	1,828.46		
5	987.32	1,362.39	2,353.02	1,775.63	1,602.58	1,388.94	2,042.84	
6	139.23	582.95	1,230.96	604.26	2,123.24			
7	1,585.64	716.07	1,600.36	569.15				
8	555.94							
9	1,140.10	1,095.65	2,099.03	1,301.24				
10	166.18	1,068.16	1,257.35					
MEAN	847.0673	1064.107	1290.457	852.0874	1329.558	1176.587	1612.174	
VAR	206466.4	93403.77	562616.8	204438.7	501377.2	300617.8	246714	
STDDEV	454.3858	305.6203	750.0779	452.149	708.0799	548.2863	496.7031	
CI	239.9026	161.3587	396.0194	238.7216	373.8457	289.4793	262.2449	

Table 4.11. Time (in minute) in ASP in existing system for the 2nd Battalion of 2nd Brigade for ten replications

BRIGADE 2 /BAT2 C								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	95.13	129.30	164.73	204.36	237.23	279.81	314.29	
2	99.17	130.11	169.82	206.38				
3	93.41	131.84	165.67	206.38	237.94	273.52	311.09	
4	94.57	130.08	170.32	204.24	242.34	275.69		
5	96.69	137.21	165.37	206.56	239.66	279.56		
6	96.07	129.72	172.14	207.13	243.76			
7	92.67	131.68	166.02	205.63				
8	98.97							
9	99.93	131.33	171.41	201.60				
10	96.98	130.91	168.29					
MEAN	96.28844	131.4094	168.1856	205.2844	240.1869	277.1438	312.6862	
VAR	6.82881	6.378867	9.167599	3.294564	7.865736	9.38327	5.115636	
STDDEV	2.613199	2.525642	3.027804	1.815094	2.804592	3.063212	2.261777	
CI	1.379694	1.333466	1.598593	0.958317	1.480743	1.617288	1.194153	

Table 4.12. Travel time (in minute) between ASP to battalion in existing system for the 2nd Battalion of 2nd Brigade for ten replications

BRIGADE 3 /BAT1 A								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	88.90	123.64	160.49	198.99	232.77	268.70	303.98	342.28
2	88.59	126.70	159.05	198.04				
3	88.13	125.71	162.75	198.65	231.75	270.68	305.65	340.26
4	88.71	124.87	161.00	197.69	232.66	269.87	305.97	340.67
5	88.04	123.82	161.37	195.53	234.11	269.92	303.97	341.91
6	90.18	126.29	162.62	195.87	234.19	267.88	305.11	
7	89.26	124.80	160.78	197.02	232.85			
8	90.25							
9	90.60	124.71	161.28	197.73	232.99	268.71		
10	89.44	125.10	159.54	197.75				
MEAN	89.18468	125.0667	161.1685	197.4403	233.0459	269.2932	304.9358	341.2798
VAR	0.903381	1.202787	1.395216	1.524257	0.728778	1.069426	0.865025	0.938824
STDDEV	0.950463	1.096716	1.181193	1.234608	0.853685	1.034131	0.930067	0.968929
CI	0.501817	0.579035	0.623636	0.651837	0.450721	0.545991	0.491049	0.511567

Table 4.13. Travel time (in minute) between battalion to ASP in existing system for the 1st Battalion of 3rd Brigade for ten replications

BRIGADE 3 /BAT1 B								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	669.42	612.25	615.44	1,584.40	732.57	947.34	507.97	
2	928.65	1,826.84	816.54					
3	185.50	1,282.45	1,695.48	1,692.10	832.28	1,334.56	1,375.66	
4	434.81	1,178.10	888.97	1,311.44	941.65	2,373.51		
5	637.88	429.82	1,415.97	1,248.84	2,010.44	2,169.66	1,799.56	
6	1,164.98	1,176.70	1,546.31	1,446.79	2,514.90	2,095.48		
7	676.04	2,086.00	724.21	502.15	793.91			
8								
9	1,702.52	1,275.84	1,144.92	1,911.29	2,177.29			
10	255.48	1,508.45	733.88					
MEAN	799.9741	1233.498	1105.979	1385.286	1429.005	1784.11	1227.729	
VAR	219141	303021.4	165180.6	203042	593189.1	373816.5	433464	
STDDEV	468.125	550.4738	406.4241	450.6018	770.1877	611.4053	658.3798	
CI	247.1565	290.6343	214.5802	237.9047	406.6368	322.8043	347.6055	

Table 4.14. Time (in minute) in ASP in existing system for the 1st Battalion of 3rd Brigade for ten replications

BRIGADE 3 /BAT1 C								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	98.49	134.92	166.21	204.01	240.02	277.73	313.13	
2	99.55	133.53	166.26					
3	94.65	136.17	169.10	202.49	236.74	279.64	314.46	
4	95.99	133.12	167.49	202.55	238.48	276.65		
5	95.99	135.09	167.27	202.14	237.70	275.06		
6	96.73	132.29	170.21	205.31	242.90	275.25		
7	92.40	130.57	167.11	202.78	239.65			
8								
9	97.82	128.09	166.79	201.05	239.37			
10	95.78	135.13	166.13					
MEAN	96.45482	132.9725	167.5543	202.9042	239.2647	276.8668	313.7971	
VAR	5.115859	6.989061	1.973941	1.891729	3.89507	3.588477	0.88638	
STDDEV	2.261827	2.643683	1.40497	1.375401	1.973593	1.894328	0.941477	
CI	1.194179	1.395788	0.741784	0.726172	1.042	1.00015	0.497073	

Table 4.15. Travel time (in minute) between ASP to battalion in existing system for the 1st Battalion of 3rd Brigade for ten replications

BRIGADE 3 /BAT2 A								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	90.13	124.67	162.03	198.11	233.21	270.44	303.27	341.47
2	89.40	122.86	161.04	195.82				
3	89.74	126.90	161.24	197.34	234.33	268.80	302.86	339.13
4	89.75	125.85	162.35	197.14	231.67	268.90	304.64	341.60
5	89.54	125.70	160.75	197.59	234.15	269.66	303.61	340.73
6	89.62	124.63	158.59	198.36	233.43	267.57	303.42	
7	89.77	123.52	162.13	198.50	233.10			
8	89.90							
9	88.55	124.39	159.48	196.31	232.62	270.19		
10	89.83	124.05	161.75	195.12				
MEAN	89.60068	124.8146	160.9506	197.3985	233.2155	269.2591	303.5585	340.7334
VAR	0.197768	1.70729	1.769799	0.918139	0.820263	1.122798	0.445481	1.283736
STDDEV	0.444711	1.306633	1.330338	0.958196	0.905684	1.059622	0.667444	1.133021
CI	0.234794	0.689864	0.70238	0.5059	0.478175	0.55945	0.352391	0.598202

Table 4.16. Travel time (in minute) between battalion to ASP in existing system for the 2nd Battalion of 3rd Brigade for ten replications

BRIGADE 3 /BAT2 B								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	1,372.82	940.11	1,163.94	1,064.27	1,125.50	1,501.26	99.37	
2	1,484.08	607.77	2,016.75	1,186.15				
3	1,656.12	1,471.68	1,247.43	1,069.24	1,657.83	504.09	385.13	
4	1,573.94	1,853.57	1,193.53	999.27	624.74	1,267.46	1,515.37	
5	1,559.39	940.19	758.34	2,484.90	2,428.03	1,962.98	1,547.92	
6	670.24	171.88	697.56	1,897.90	1,512.98	1,616.79		
7	1,036.55	302.00	1,529.00	1,376.97	1,191.53			
8								
9	459.65	727.88	588.63	888.72	1,574.68			
10	339.86	500.40	2,333.62					
MEAN	1226.601	876.8844	1149.397	1370.929	1445.042	1370.515	886.9489	
VAR	205344.9	319694.1	225674	301217.2	312042.2	297520	567962.9	
STDDEV	453.1499	565.415	475.0516	548.8326	558.6073	545.4539	753.6331	
CI	239.2501	298.5228	250.8135	289.7677	294.9285	287.9839	397.8965	

Table 4.17. Time (in minute) in ASP in existing system for the 2nd Battalion of 3rd Brigade for ten replications

BRIGADE 3 /BAT2 C								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	96.69	131.08	168.38	202.78	238.35	280.45	314.50	
2	94.00	134.06	165.51					
3	97.14	128.30	168.39	208.64	239.94	279.50	309.40	
4	98.01	129.33	168.16	204.70	242.90	272.13	314.57	
5	100.59	134.79	169.53	206.10	242.37	277.41	311.90	
6	99.10	133.43	167.47	204.14	238.29	279.73		
7	97.03	136.94	168.14	205.00				
8								
9	98.48	130.44	164.55	204.84	242.87			
10	96.27	131.56	169.36					
MEAN	97.63084	132.2952	167.5173	205.1725	240.7861	277.8454	312.5906	
VAR	3.775038	8.838318	2.745445	3.34853	4.843598	11.47858	6.065596	
STDDEV	1.942946	2.972931	1.656939	1.829899	2.200818	3.388005	2.462843	
CI	1.025819	1.569622	0.874816	0.966134	1.161968	1.788769	1.30031	

Table 4.18. Travel time (in minute) between ASP to battalion in existing system for the 2nd Battalion of 3rd Brigade for ten replications

REGIMENT/BAT1								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	90.11	125.40	172.48	236.45	308.42	340.39	340.36	384.33
2	89.04	124.78	200.48	228.45				
3	88.57	124.07	244.48	268.45	296.42	340.39	352.36	408.33
4	90.52	124.00	172.48	260.45	304.42	328.39	396.36	424.33
5	88.78	125.42	236.48	276.45	296.42	288.39	384.36	352.33
6	88.43	125.32	176.48	252.45	292.42	332.39	380.36	
7	88.35	125.97	204.48	252.45	264.42			
8	88.53							
9	89.97	123.46	228.48	268.45	272.42	364.39		
10	88.75	123.56	192.48	296.45				
MEAN	89.14211	124.8033	204.4772	255.4484	290.7054	332.3909	370.7621	392.3333
VAR	0.685055	0.764467	864	273.1429	265.9048	620.8	548.8	981.3333
STDDEV	0.82768	0.874338	29.39388	16.52703	16.30659	24.91586	23.42648	31.32624
CI	0.436991	0.461625	15.51912	8.725797	8.609407	13.15485	12.36851	16.53935

Table 4.19. Travel time (in minute) between battalion to ASP in existing system for the 1st Battalion of Corps Artillery Regiment for ten replications

REGIMENT/BAT1								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	680.12	937.67	754.53	963.17	1,776.67	1,374.35	1,658.88	
2	1,553.99	752.03	1,597.72					
3	1,035.13	747.24	1,944.53	2,818.89	3,052.27	2,911.13		
4	1,046.69	468.05	931.09	1,178.61	1,017.55	2,107.60		
5	1,385.41	1,110.07	1,673.14	1,944.15	2,143.21	2,690.43		
6	857.53	551.12	766.52	1,540.11	1,954.19	1,906.79		
7	524.48	1,865.40	1,450.14	1,557.54				
8	1,166.98							
9	1,408.20	803.17	1,974.58	1,653.80	1,732.74			
10	84.81	542.36	2,129.83					
MEAN	1073.17	904.3443	1386.53	1665.181	1946.103	2198.061	1658.878	
VAR	119240	191471.1	254173.7	360966.2	439791.8	380606.1		
STDDEV	345.3115	437.5741	504.1565	600.8046	663.168	616.9328		
CI	182.3145	231.0265	266.1801	317.2075	350.1335	325.7227		

Table 4.20. Time (in minute) in ASP in existing system for the 1st Battalion of Corps Artillery Regiment for ten replications

REGIMENT/BAT1								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	93.91	111.98	168.47	203.60	239.63	279.35	315.36	
2	95.75	109.28	171.50					
3	96.33	105.67	168.21	208.47	238.46	280.16		
4	96.74	110.02	166.83	204.21	241.18	273.81		
5	98.97	111.64	166.68	204.68	241.38	275.44		
6	97.85	109.49	169.52	208.78	240.85			
7	98.86	107.34	170.71	203.52				
8								
9	94.44	110.43	170.25	203.66	236.05			
10	95.56	110.21						
MEAN	96.60715	109.5915	168.021	205.4179	239.5915	277.1884	315.3605	
VAR	3.570603	3.879144	3.139504	5.004905	4.230098	9.328458		
STDDEV	1.889604	1.969554	1.771865	2.237164	2.05672	3.054252		
CI	0.997656	1.039868	0.935493	1.181158	1.085889	1.612557		

Table 4.21. Travel time (in minute) between ASP to battalion in existing system for the 1st Battalion of Corps Artillery Regiment for ten replications

REGIMENT/BAT1								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	89.07	126.45	172.48	236.45	308.42	340.39	340.36	384.33
2	89.42	126.48	200.48	228.45				
3	88.99	126.28	244.48	268.45	296.42	340.39	352.36	408.33
4	88.85	125.07	172.48	260.45	304.42	328.39	396.36	424.33
5	89.61	125.87	236.48	276.45	296.42	288.39	384.36	352.33
6	87.62	125.79	176.48	252.45	292.42	332.39	380.36	
7	89.75	124.51	204.48	252.45	264.42			
8	89.86							
9	88.56	123.45	228.48	268.45	272.42	364.39		
10	91.24	124.16	192.48	296.45				
MEAN	89.08141	125.4871	204.4772	255.4484	290.7054	332.3909	370.7621	392.3333
VAR	0.486287	1.156266	864	273.1429	265.9048	620.8	548.8	981.3333
STDDEV	0.697342	1.075298	29.39388	16.52703	16.30659	24.91586	23.42648	31.32624
CI	0.368177	0.567726	15.51912	8.725797	8.609407	13.15485	12.36851	16.53935

Table 4.22. Travel time (in minute) between battalion to ASP in existing system for the 1st Battalion of Corps Artillery Regiment for ten replications

REGIMENT/BAT2								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	179.70	1,587.12	596.65	1,265.69	1,346.15	1,687.82	1,642.44	
2	1,842.13	1,679.66	1,852.56					
3	1,672.42	2,313.84	2,542.53	2,506.39	2,573.83	2,489.74		
4	177.88	1,170.36	1,074.30	1,696.99	1,593.20	1,470.49		
5	1,901.61	1,570.14	2,152.63	2,431.32	2,333.78	2,183.95	1,786.52	
6	431.93	1,438.22	577.46	2,069.30	1,638.50	2,498.91		
7	1,541.52	833.53	1,837.67	1,201.88				
8								
9	1,276.68	459.81	1,489.07	1,955.30	2,362.25			
10	315.70	1,102.58						
MEAN	1127.984	1381.585	1515.359	1875.267	1974.62	2066.183	1714.48	
VAR	554925.6	319086.9	513957	268063.9	258348.3	219635	10379.02	
STDDEV	744.9333	564.8778	716.9079	517.7489	508.2797	468.6523	101.8775	
CI	393.3032	298.2391	378.5067	273.3565	268.357	247.4349	53.78837	

Table 4.23. Time (in minute) in ASP in existing system for the 2nd Battalion of Corps Artillery Regiment for ten replications

REGIMENT/BAT2								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	93.91	110.98	168.47	204.60	239.63	279.35	315.36	
2	95.75	109.28	171.50					
3	96.33	105.67	168.21	208.47	238.46	280.16		
4	96.74	110.02	166.83	204.21	241.18	273.81		
5	98.97	111.64	166.68	204.68	241.38	275.44		
6	97.85	109.49	169.52	208.78	240.85			
7	98.86	107.34	170.71	203.52				
8								
9	94.44	110.43	170.25	203.66	236.05			
10	95.56	110.21						
MEAN	96.60715	109.3575	169.021	205.4179	239.5915	277.1884	315.3605	
VAR	3.570603	3.879144	3.139504	5.004905	4.230098	9.328458		
STDDEV	1.889604	1.969554	1.771865	2.237164	2.05672	3.054252		
CI	0.997656	1.039868	0.935493	1.181158	1.085889	1.612557		

Table 4.24. Travel time (in minute) between ASP to battalion in existing system for the 2nd Battalion of Corps Artillery Regiment for ten replications

REP#	BRI1/BT1	BRI1/BT2	BRI2/B1	BRI2/BT2	BRI3/BT1	BRI3/BT2	REG/BT1	REG/BT2
1	4263.2	4710.1	3580.1	4567	4070.1	3799.3	1822.7	1491.7
2	3376.4	2662.4	4130.8	4002.4	3986.1	5558.3	1413.1	1721.2
3	3091.3	3593.7	4665.1	3433.4	4256.9	3201.5	1224.5	1236.7
4	4045.9	2962.4	3417.2	3476.7	3978.4	3597.6	1968.6	1703
5	3649.6	2304.1	2972.1	3246.4	3068.3	3488.4	1130.3	1243.8
6	4128.5	3561.7	3142.3	4731	3345.4	4001	1612.5	1307.5
7	3445.4	3762.2	3549.5	2307.3	2699.6	3974.3	2102.1	1648.3
8	4038	4434.4	4668.9	4461.6	4773	2535	1588.4	1894
9	4020.5	3043.1	3164.8	3614.5	2859.1	4154.4	2199.6	1593.7
10	3173.3	3297.2	3140.2	3805.8	3333.6	4013.8	1954.5	1827.5
MEAN	3723	3433	3643	3765	3637	3832	1702	1567
VAR	183560	560523.8	397898	525466	453902.4	602191.8	135145.6	56772.38
STD DEV	428.439	748.6814	630.792	724.89	673.7228	776.0102	367.6215	238.2696
CI	265.544	464.0283	390.961	449.283	417.5694	480.9666	227.8497	147.6781
MIN	3458	2969	3252	3315	3219	3351	1474	1419
MAX	3989	3897	4034	4214	4055	4313	1929	1714

Table 4.25. Average number of ammunition during the battle in existing system for ten replications

REP#	BRI1/BT1	BRI1/BT2	BRI2/B1	BRI2/BT2	BRI3/BT1	BRI3/BT2	REG/BT1	REG/BT2
1	1044	2184	1039	1683	1218	1867	895	388
2	1263	-1491	1855	2707	1441	1688	665	1328
3	1130	1914	1806	1268	2349	1365	130	60
4	924	13	398	1045	1145	1828	921	558
5	1166	581	932	1595	1391	381	265	330
6	1317	1970	478	1344	605	1725	517	-106
7	862	1971	1310	-2093	635	1413	1048	595
8	1876	2946	4347	3415	2868	-324	1519	1385
9	1245	-735	947	645	762	1550	1225	587
10	196	-107	447	555	-190	1494	754	171
MEAN	1102	925	1356	1216	1222	1299	794	530
VAR	178893	2160171	1373575	2131242	776945.8	503388	179771	243391.8
STD DEV	422.957	1469.752	1172	1459.88	881.4453	709.4984	423.9941	493.3476
CI	262.146	910.9437	726.396	904.824	546.3146	439.7429	262.789	305.7739
MIN	840	14	630	312	676	859	531	224
MAX	1364	1836	2082	2121	1769	1738	1057	835

Table 4.26. Minimum number of ammunition during the battle in existing system for ten replications

CORPS		
REP#	UTILIZATION OF ASP1	UTILIZATION OF ASP2
1	0.85847	0.89741
2	0.98203	0.98129
3	0.99049	0.97492
4	0.91415	0.96937
5	0.99052	0.99047
6	0.9052	0.95704
7	0.98579	0.97053
8	0.92803	0.92543
9	0.97914	0.98812
10	0.77819	0.78326
MEAN	0.931201	0.943784
VAR	0.004952737	0.004035833
STD DEV	0.070375684	0.063528208
CI (0.95)	0.043618434	0.03937441
MIN	0.887582566	0.90440959
MAX	0.974819434	0.98315841

Table 4.27. Utilization of ASPs in existing ammunition supply system for ten replications

REP#	BRI1/BT1	BRI1/BT2	BRI2/BT1	BRI2/BT2	BRI3/BT1	BRI3/BT2	REG/BT1	REG/BT2
1	28	25	27	26	32	25	27	26
2	35	37	26	29	31	30	33	23
3	31	31	25	35	26	27	35	35
4	30	29	30	30	29	30	28	33
5	28	32	24	27	29	33	30	31
6	29	30	29	31	37	26	26	30
7	36	25	33	34	31	29	27	33
8	33	45	19	33	25	52	37	26
9	29	31	31	30	37	32	30	37
10	31	34	32	35	25	27	34	31
MEAN	30.8797	31.8468	27.5885	30.8957	30.1583	30.9421	30.7228	30.4114
VAR	8.74494	35.78199	18.47254	10.46752	18.91264	61.60611	14.1832	17.67448
STD DEV	2.957185	5.981805	4.29797	3.235354	4.348867	7.848956	3.766059	4.204102
CI (0.95)	1.832846	3.707487	2.663856	2.005254	2.695402	4.864737	2.334181	2.605678
MIN	29.04685	28.13931	24.92464	28.89045	27.4629	26.07736	28.38862	27.80572
MAX	32.71255	35.55429	30.25236	32.90095	32.8537	35.80684	33.05698	33.01708

Table 4.28. Average numbers of vehicles in convoys in existing ammunition supply system for ten replications

Appendix B

Output Data for New Ammunition Supply System

BRIGADE 1 /BAT1 A								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-
MEAN	0	0	0	0	0	0	0	0
VAR	0	0	0	0	0	0	0	0
STDDEV	0	0	0	0	0	0	0	0
CI								

Table 5.1. Travel time (in minute) between battalion to ASP in new ammunition supply system for the 1st Battalion of 1st Brigade for ten replications

BRIGADE 1 /BAT1 B								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	115.28	39.26	121.77	212.19	66.21	65.81	78.59	181.34
2	233.05	64.03	153.65	77.61	72.38	78.10	242.80	157.34
3	207.84	77.38	294.23	65.69	162.08	52.44	224.34	47.01
4	138.04	279.24	26.96	73.00	279.10	187.68	198.74	93.04
5	199.69	46.86	64.54	82.41	204.91	51.93	117.78	104.83
6	147.00	59.47	141.20	63.22	58.66	212.44	71.56	61.05
7	208.88	164.10	84.94	64.24	199.17	268.68	57.28	212.33
8	232.19	57.54	191.04	257.50	100.25	34.83	148.23	129.24
9	115.19	233.34	101.99	205.32	208.94	73.09	29.44	106.28
10	58.63	301.15	51.97	205.09	199.16	194.85	56.55	46.85
MEAN	177.4617	113.4674	131.1475	122.3532	150.189	113.8922	129.8615	121.385
VAR	2339.627	8018.495	6144.638	6167.473	6198.129	7279.961	6036.134	2962.169
STDDEV	48.36969	89.54605	78.38774	78.53326	78.7282	85.32269	77.69256	54.42581
CI	25.5378	47.27773	41.38646	41.46329	41.56621	45.04791	41.01943	28.73526

Table 5.2. Time (in minute) in ASP in new ammunition supply system for the 1st Battalion of 1st Brigade for ten replications

BRIGADE 1 /BAT1 C								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	86.16	133.34	160.59	193.59	230.13	264.10	311.39	335.45
2	89.81	136.24	157.79	193.71	280.85	314.31	303.56	338.41
3	89.17	135.66	157.47	196.79	229.27	264.72	300.08	352.27
4	86.23	124.15	159.36	197.69	229.58	267.80	303.94	339.09
5	86.69	133.56	171.87	202.30	228.28	263.04	301.70	340.34
6	85.41	132.63	157.71	205.90	233.28	266.52	301.86	334.33
7	84.37	121.93	159.32	193.51	227.25	267.03	303.82	337.64
8	89.85	136.06	159.22	197.05	233.39	266.93	299.70	339.60
9	84.54	124.28	156.05	192.58	229.32	266.81	302.98	338.39
10	88.62	123.26	167.29	194.51	227.20	268.30	299.32	339.79
MEAN	86.91476	130.8715	159.9299	197.013	235.7068	271.2522	303.226	339.5014
VAR	4.689627	32.96591	21.84194	20.25232	290.8774	263.183	11.77232	26.60668
STDDEV	2.165555	5.741594	4.673536	4.500258	17.05513	16.22292	3.431082	5.158166
CI	1.14335	3.031396	2.467492	2.376006	9.004615	8.565231	1.811512	2.723363

Table 5.3. Travel time (in minute) between ASP to battalion in new ammunition supply system for the 1st Battalion of 1st Brigade for ten replications

BRIGADE 1 /BAT2 A								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-
MEAN	0	0	0	0	0	0	0	0
VAR	0	0	0	0	0	0	0	0
STDDEV	0	0	0	0	0	0	0	0
CI								

Table 5.4. Travel time (in minute) between battalion to ASP in new ammunition supply system for the 2nd Battalion of 1st Brigade for ten replications

BRIGADE 1 /BAT2 B								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	50.20	231.77	32.03	20.50	270.58	274.24	143.61	41.45
2	74.42	279.85	21.67	272.27	157.90	169.02	104.17	46.65
3	46.94	321.70	66.47	189.28	61.46	53.72	50.60	258.31
4	58.45	247.29	61.43	223.92	30.83	101.74	103.73	242.29
5	74.58	299.80	67.57	309.66	61.74	161.68	60.85	34.75
6	72.73	156.14	103.70	359.56	35.24	58.22	193.98	232.79
7	41.71	204.96	131.30	164.40	70.45	176.13	104.83	162.23
8	72.97	176.48	48.17	144.04	28.20	70.18	115.77	35.55
9	27.96	98.97	74.81	246.34	238.73	355.64	271.66	172.92
10	19.88	387.84	111.96	84.73	81.71	245.27	253.44	169.93
MEAN	57.77318	224.105	67.46126	214.4395	106.1252	157.8413	127.6882	136.3262
VAR	292.0481	5233.927	1150.48	10035.28	8664.332	10593.06	4697.254	9367.358
STDDEV	17.08941	72.34589	33.91873	100.1762	93.08239	102.9226	68.53652	96.78511
CI	9.022717	38.19654	17.90811	52.89015	49.14481	54.34015	36.1853	51.09974

Table 5.5. Time (in minute) in ASP in new ammunition supply system for the 2nd Battalion of 1st Brigade for ten replications

BRIGADE 1 /BAT2 C								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	89.16	125.76	154.64	193.61	232.15	267.01	301.10	340.14
2	90.19	121.99	173.27	196.40	229.59	267.08	305.70	348.20
3	88.49	121.93	159.89	194.94	230.31	315.74	302.49	340.99
4	89.02	122.64	158.07	192.81	274.97	264.89	305.17	338.53
5	90.29	123.42	159.85	192.76	281.27	263.92	301.34	340.36
6	85.05	123.54	162.94	193.26	279.14	319.26	303.47	335.57
7	87.93	127.62	158.27	191.98	280.96	268.61	302.05	337.89
8	87.39	123.81	156.89	193.32	231.91	318.35	303.97	338.42
9	88.50	136.53	174.93	190.40	232.06	265.46	302.00	339.72
10	87.49	121.73	160.39	206.23	229.93	262.62	301.86	337.31
MEAN	88.44535	125.2496	162.0835	193.2737	252.4843	283.3672	303.0322	339.9792
VAR	2.529935	21.24065	51.69803	2.883038	640.6062	668.8579	2.711812	12.14487
STDDEV	1.590577	4.608758	7.190134	1.697951	25.3102	25.86229	1.646758	3.484949
CI	0.839779	2.433291	3.796183	0.896469	13.36305	13.65454	0.869441	1.839952

Table 5.6. Travel time (in minute) between ASP to battalion in new ammunition supply system for the 2nd Battalion of 1st Brigade for ten replications

BRIGADE 2 /BAT1 A								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-
MEAN	0	0	0	0	0	0	0	0
VAR	0	0	0	0	0	0	0	0
STDDEV	0	0	0	0	0	0	0	0
CI								

Table 5.7. Travel time (in minute) between battalion to ASP in new ammunition supply system for the 1st Battalion of 2nd Brigade for ten replications

BRIGADE 2 /BAT1 B								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	43.45	102.93	32.90	53.35	68.69	147.30	157.89	54.98
2	46.56	142.73	46.08	237.77	205.48	87.87	52.88	63.22
3	70.36	86.88	165.88	194.89	32.82	119.98	243.90	155.77
4	49.15	127.11	40.84	143.69	86.08	64.39	72.35	223.72
5	16.75	147.58	88.69	250.34	41.20	219.28	86.33	140.61
6	61.67	85.23	210.35	150.50	72.01	238.97	109.78	69.65
7	40.21	143.71	62.64	155.83	130.76	161.78	248.30	124.12
8	59.28	102.41	62.95	173.31	254.05	51.21	51.59	301.87
9	78.08	147.03	64.96	80.43	196.80	370.58	120.94	167.77
10	19.45	83.90	131.15	101.77	40.47	52.87	252.95	182.38
MEAN	51.72289	120.6242	86.1423	160.0123	120.8772	162.3729	127.1075	144.6336
VAR	331.8759	690.4197	3728.092	4210.222	6397.761	10248.51	5686.225	6545.344
STDDEV	18.21746	26.27584	61.0581	64.88622	79.986	101.2349	75.40706	80.9033
CI	9.618293	13.87288	32.23692	34.25805	42.2303	53.44912	39.81275	42.71461

Table 5.8. Time (in minute) in ASP in new ammunition supply system for the 1st Battalion of 2nd Brigade for ten replications

BRIGADE 2 /BAT1 C								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	86.27	120.71	158.93	197.41	231.31	265.21	305.41	343.19
2	85.07	126.33	169.93	195.96	231.12	267.00	302.91	339.58
3	85.31	120.69	158.24	193.04	243.80	265.50	302.57	341.66
4	85.73	123.03	162.62	196.22	226.79	276.83	301.76	340.22
5	86.37	125.16	160.82	196.07	229.70	270.67	300.62	337.66
6	85.86	126.77	161.44	195.61	244.21	264.44	304.09	342.46
7	87.17	123.22	159.94	195.70	228.52	266.02	298.81	340.42
8	90.11	121.72	160.01	192.92	231.33	266.91	304.78	337.65
9	89.52	123.05	172.81	194.02	230.43	263.19	303.12	335.77
10	85.61	122.98	159.97	205.90	241.59	264.35	301.43	337.62
MEAN	86.82318	123.409	162.7484	195.2169	233.0243	267.3068	302.6736	339.8462
VAR	3.270824	5.092998	26.07787	2.360674	40.94707	17.07834	4.268526	6.015018
STDDEV	1.808542	2.256767	5.106649	1.536449	6.39899	4.132595	2.066041	2.452553
CI	0.954858	1.191508	2.696163	0.8112	3.378482	2.181891	1.09081	1.294877

Table 5.9. Travel time (in minute) between ASP to battalion in new ammunition supply system for the 1st Battalion of 1st Brigade for ten replications

BRIGADE 2 /BAT2 A								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-
MEAN	0	0	0	0	0	0	0	0
VAR	0	0	0	0	0	0	0	0
STDDEV	0	0	0	0	0	0	0	0
CI								

Table 5.10. Travel time (in minute) between battalion to ASP in new ammunition supply system for the 2nd Battalion of 2nd Brigade for ten replications

BRIGADE 2 /BAT2 B								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	168.40	44.62	53.00	47.55	20.39	69.93	46.49	91.78
2	306.01	107.44	74.86	38.43	60.30	53.88	299.36	105.11
3	306.89	141.98	224.62	73.83	68.52	274.59	46.60	48.35
4	200.33	59.13	42.28	55.54	75.28	77.68	83.52	54.21
5	258.10	151.04	36.01	54.80	82.88	115.27	45.11	33.76
6	169.61	61.52	53.10	86.16	53.21	296.85	255.75	77.49
7	311.74	62.91	92.44	141.90	92.37	73.88	72.76	74.92
8	313.85	95.23	87.11	64.34	65.50	45.29	48.70	166.73
9	146.22	58.25	49.30	73.87	64.56	100.57	50.16	80.19
10	80.09	91.70	185.48	80.56	74.26	20.76	87.00	226.49
MEAN	242.3507	86.9015	79.1913	70.7123	64.7778	123.1058	105.3827	81.39367
VAR	5019.88	1529.789	3361.876	928.6534	417.2064	8983.053	9824.988	1513.898
STDDEV	70.85111	39.11252	57.98169	30.47382	20.42563	94.77897	99.12108	38.90884
CI	37.40734	20.65028	30.61266	16.08929	10.78414	50.04056	52.33306	20.54274

Table 5.11. Time (in minute) in ASP in new ammunition supply system for the 2nd Battalion of 2nd Brigade for ten replications

BRIGADE 2 /BAT2 C								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	95.90	122.44	159.44	193.30	227.93	266.34	301.08	340.42
2	98.25	134.61	163.13	197.16	230.12	281.19	313.80	337.72
3	99.21	137.50	170.96	195.16	229.55	280.60	305.04	342.51
4	97.73	119.88	161.68	193.32	230.23	263.67	307.05	338.25
5	95.57	135.39	160.49	192.98	244.95	277.61	302.69	339.40
6	95.49	123.18	159.68	195.52	227.90	274.06	310.32	340.79
7	99.82	120.89	159.29	204.77	230.74	265.34	301.15	338.47
8	99.63	137.58	160.16	195.57	232.85	267.36	301.67	339.48
9	95.94	124.88	159.61	193.62	230.54	265.71	302.19	337.06
10	102.27	122.85	172.42	198.42	230.49	266.91	305.14	338.42
MEAN	97.50376	128.4849	161.6046	195.7109	231.6453	271.3203	304.9992	339.3442
VAR	3.274967	57.3173	13.87586	13.4682	27.12612	49.62047	20.56036	2.887774
STDDEV	1.809687	7.570819	3.725031	3.669905	5.208274	7.04418	4.534353	1.699345
CI	0.955462	3.997174	1.966709	1.937604	2.749818	3.719123	2.394007	0.897205

Table 5.12. Travel time (minute) between ASP to battalion in new ammunition supply system for the 2nd Battalion of 2nd Brigade for ten replications

BRIGADE 3 /BAT1 A								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-
MEAN	0	0	0	0	0	0	0	0
VAR	0	0	0	0	0	0	0	0
STDDEV	0	0	0	0	0	0	0	0
CI								

Table 5.13. Travel time (in minute) between battalion to ASP in new ammunition supply system for the 1st Battalion of 3rd Brigade for ten replications

BRIGADE 3 /BAT1 B								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	52.38	108.49	47.92	87.52	94.65	64.88	245.19	53.58
2	51.87	58.58	65.76	48.11	79.32	58.30	90.27	39.18
3	38.97	41.56	79.42	67.17	70.83	52.95	56.43	30.17
4	67.47	98.49	48.14	48.90	38.16	27.78	78.23	54.24
5	86.79	46.15	148.34	241.51	75.19	60.68	34.37	53.98
6	77.57	88.84	51.13	257.34	83.42	59.11	73.40	96.01
7	87.72	107.38	25.94	48.67	35.99	347.60	80.17	42.90
8	41.90	54.84	34.07	40.57	65.75	86.48	45.57	73.80
9	72.38	39.31	92.31	56.48	73.88	97.98	77.62	245.24
10	20.47	60.01	20.12	97.12	52.90	82.45	62.35	78.80
MEAN	64.11714	71.51477	65.89315	99.58455	68.57672	95.0849	86.806	76.56513
VAR	343.2349	838.1398	1392.958	7422.219	385.9752	9361.892	3856.611	4382.056
STDDEV	18.5266	28.95064	37.32235	86.1523	19.64625	96.75687	62.10162	66.1971
CI	9.781509	15.2851	19.70512	45.48593	10.37265	51.08483	32.78786	34.95016

Table 5.14. Time (in minute) in ASP in new ammunition supply system for the 1st Battalion of 3rd Brigade for ten replications

BRIGADE 3 /BAT1 C								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	83.35	127.25	158.91	194.62	230.56	268.89	83.10	339.34
2	86.17	120.61	160.21	192.24	230.57	267.62	301.68	343.08
3	83.85	122.59	159.74	196.72	231.38	266.87	304.72	340.09
4	86.85	123.23	158.93	192.89	231.42	265.68	303.78	342.51
5	86.74	123.40	185.67	219.54	230.44	268.64	302.29	338.42
6	85.55	118.76	159.19	216.25	230.89	262.58	300.91	340.39
7	86.64	122.72	158.72	194.40	255.40	291.55	305.08	342.56
8	83.02	122.29	159.89	194.08	228.12	267.12	301.61	336.04
9	82.90	123.30	159.75	195.33	230.31	266.92	306.83	362.84
10	87.49	123.64	158.89	194.54	230.05	268.07	305.19	338.84
MEAN	85.00966	122.6837	162.3334	199.5637	233.231	269.5419	278.89	342.8069
VAR	2.903641	5.236825	76.855	110.3576	70.02639	71.56119	5394.653	61.47146
STDDEV	1.704007	2.288411	8.766699	10.50512	8.368177	8.459385	73.4483	7.840374
CI	0.899667	1.208215	4.628564	5.546401	4.418156	4.466311	38.77858	4.139491

Table 5.15. Travel time (in minute) between ASP to battalion in new ammunition supply system for the 1st Battalion of 3rd Brigade for ten replications

BRIGADE 3 /BAT2 A								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-
MEAN	0	0	0	0	0	0	0	0
VAR	0	0	0	0	0	0	0	0
STDDEV	0	0	0	0	0	0	0	0
CI								

Table 5.16. Travel time (in minute) between battalion to ASP in new ammunition supply system for the 2nd Battalion of 3rd Brigade for ten replications

BRIGADE 3 /BAT2 B								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	65.47	267.85	93.60	130.47	49.51	41.28	20.52	88.63
2	37.37	103.32	50.12	65.77	198.79	85.74	56.87	76.90
3	75.62	35.77	58.41	236.06	77.58	44.51	188.13	63.55
4	71.92	62.35	57.46	66.18	94.71	56.55	82.50	54.03
5	76.44	75.09	68.52	44.81	85.84	63.41	81.74	48.63
6	20.71	194.18	51.79	76.43	259.61	75.12	43.30	54.95
7	53.31	38.68	69.94	66.04	56.54	71.38	47.45	82.24
8	107.89	65.71	115.11	70.01	68.81	243.59	77.63	79.42
9	72.71	140.67	53.81	55.73	71.91	75.04	57.63	39.01
10	17.21	87.82	45.06	100.41	45.11	72.40	60.00	65.06
MEAN	64.60685	109.2904	68.74929	90.16649	107.0324	84.06828	72.8619	65.26015
VAR	631.3674	6128.919	482.5686	3562.508	5215.104	3794.073	2278.444	296.4322
STDDEV	25.12702	78.28741	21.96744	59.68675	72.21568	61.59605	47.73305	17.21721
CI	13.26634	41.33349	11.59818	31.51288	38.12779	32.52093	25.20167	9.090188

Table 5.17. Time (in minute) in ASP in new ammunition supply system for the 2nd Battalion of 3rd Brigade for ten replications

BRIGADE 3 /BAT2 C								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	85.50	144.06	185.19	216.88	230.41	267.22	304.36	336.45
2	83.58	118.54	159.20	195.96	256.64	268.41	300.11	339.35
3	84.45	123.00	155.53	216.87	231.98	263.67	84.77	338.16
4	90.33	123.21	162.24	193.64	255.78	265.87	302.43	337.63
5	87.02	123.92	161.25	195.92	232.66	263.62	301.92	338.29
6	84.48	146.33	156.25	190.60	255.94	269.00	301.17	339.31
7	86.14	123.31	156.87	197.38	231.16	266.51	302.59	341.38
8	87.96	126.80	180.12	195.39	232.35	292.46	306.29	337.75
9	90.74	143.97	158.50	196.64	229.35	264.39	300.11	339.98
10	86.97	120.37	160.86	193.19	230.54	268.08	303.32	338.75
MEAN	86.68981	130.3484	163.9045	199.9189	239.5857	269.0174	278.1958	338.6993
VAR	6.572403	122.1246	119.4274	96.31407	154.8298	81.08374	5265.033	2.146625
STDDEV	2.56367	11.051	10.92828	9.813973	12.44306	9.004651	72.56055	1.465137
CI	1.353544	5.834608	5.769818	5.181494	6.569577	4.754196	38.30987	0.77355

Table 5.18. Travel time (in minute) between ASP to battalion in new ammunition supply system for the 2nd Battalion of 3rd Brigade for ten replications

REGIMENT/BAT1								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-
MEAN	0	0	0	0	0	0	0	0
VAR	0	0	0	0	0	0	0	0
STDDEV	0	0	0	0	0	0	0	0
CI								

Table 5.19. Travel time (in minute) between battalion to ASP in new system for the 1st Battalion of Corps Artillery Regiment for ten replications

REGIMENT/BAT1								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	84.80	151.30	28.60	80.77	225.86	143.08	77.39	270.64
2	164.58	173.19	222.94	154.85	63.17	224.69	178.17	81.83
3	137.36	221.45	151.62	85.98	46.69	201.79	133.45	120.85
4	90.67	144.13	93.58	265.93	161.22	57.72	268.42	169.57
5	159.76	205.64	283.86	173.97	131.73	48.66	295.96	69.33
6	123.72	105.44	27.54	183.24	99.49	132.20	72.93	110.07
7	136.56	90.84	203.60	23.28	142.91	86.54	196.21	143.67
8	158.98	246.05	251.47	190.73	159.83	183.61	33.99	69.83
9	48.67	188.36	168.46	64.97	114.37	265.83	102.52	45.70
10	37.52	84.00	235.05	116.00	80.18	71.86	135.96	66.86
MEAN	122.7879	169.5994	159.0742	135.9697	127.2525	149.3483	151.0035	120.1657
VAR	1599.443	2687.415	8616.083	5901.261	2967.098	5747.601	8180.697	4733.642
STDDEV	39.99303	51.84028	92.82286	76.81966	54.47108	75.81294	90.44721	68.80146
CI	21.11517	27.37017	49.00779	40.55856	28.75915	40.02704	47.75351	36.32519

Table 5.20. Time (in minute) in ASP in new ammunition supply system for the 1st Battalion of Corps Artillery Regiment for ten replications

REGIMENT/BAT1								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	89.78	123.55	169.95	191.40	228.56	269.96	305.21	337.08
2	86.91	121.04	160.74	193.31	233.08	265.43	301.70	337.94
3	88.68	124.97	155.41	205.69	244.31	266.17	304.83	338.39
4	84.08	124.75	158.75	194.75	234.11	274.67	306.02	336.62
5	87.40	123.97	158.03	192.61	228.18	277.80	300.09	338.12
6	90.21	119.17	156.79	193.49	230.10	262.25	314.63	339.77
7	87.92	124.81	161.08	204.26	231.30	268.91	304.14	337.44
8	91.28	124.02	162.02	194.69	231.03	264.85	303.20	341.55
9	86.62	123.51	155.25	195.96	230.56	269.70	302.07	352.00
10	85.33	126.03	160.37	193.48	246.29	265.17	302.69	351.32
MEAN	88.09764	123.3088	159.78	196.2396	232.3571	268.8604	304.6532	339.8783
VAR	4.749579	3.800938	20.45851	26.38553	23.69184	24.29141	17.54012	22.91989
STDDEV	2.179353	1.949599	4.523108	5.136685	4.867426	4.928632	4.188092	4.787473
CI	1.150635	1.029332	2.38807	2.712021	2.56986	2.602175	2.211192	2.527647

Table 5.21. Travel time (in minute) between ASP to battalion in new ammunition supply system for the 1st Battalion of Corps Artillery Regiment for ten replications

REGIMENT/BAT2								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-
MEAN	0	0	0	0	0	0	0	0
VAR	0	0	0	0	0	0	0	0
STDDEV	0	0	0	0	0	0	0	0
CI								

Table 5.22. Travel time (in minute) between battalion to ASP in new system for the 2nd Battalion of Corps Artillery Regiment for ten replications

REGIMENT/BAT2								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	82.06	89.57	142.67	244.91	148.90	228.91	197.39	276.17
2	115.24	42.58	85.69	202.70	244.52	93.94	190.69	202.56
3	110.98	60.48	111.85	148.22	236.82	118.37	112.35	185.65
4	81.35	95.22	111.58	156.65	234.38	54.09	370.11	334.04
5	83.33	81.46	221.79	91.58	293.00	200.73	217.65	129.56
6	126.22	62.53	62.28	66.91	52.77	73.74	142.04	169.30
7	105.07	59.30	250.89	122.90	91.44	251.60	150.04	73.64
8	130.14	43.16	237.33	78.48	215.87	113.03	74.57	220.29
9	137.28	78.75	256.57	133.15	45.36	192.23	192.23	43.35
10	40.05	187.10	43.65	286.44	142.83	136.94	200.20	118.89
MEAN	107.9629	68.11493	164.5158	138.3885	173.6744	147.4045	183.0073	181.6184
VAR	467.6507	365.9916	5904.122	3383.634	8395.841	5171.368	7009.382	8470.533
STDDEV	21.62523	19.13091	76.83828	58.16901	91.62882	71.91222	83.72205	92.0355
CI	11.4175	10.10057	40.56839	30.71156	48.37737	37.96758	44.20283	48.59209

Table 5.23. Time (in minute) in ASP in new ammunition supply system for the 2nd Battalion of Corps Artillery Regiment for ten replications

REGIMENT/BAT2								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	98.56	124.42	161.30	208.60	230.77	268.54	303.22	350.30
2	99.00	122.15	160.22	194.88	230.81	265.55	316.95	336.04
3	99.47	123.51	170.71	190.49	232.02	266.36	315.24	338.78
4	96.13	119.10	161.07	192.62	233.66	266.44	301.71	337.91
5	99.79	125.64	160.30	197.60	228.68	264.27	305.36	338.98
6	97.53	120.85	158.65	195.11	239.43	267.47	304.54	339.66
7	100.48	120.14	159.42	193.13	230.75	280.44	301.43	338.67
8	96.55	123.33	172.93	192.17	233.34	264.56	300.23	349.79
9	96.15	124.92	161.11	191.08	235.27	264.50	301.62	339.79
10	98.93	121.80	162.10	198.70	234.15	268.95	301.38	338.33
MEAN	98.18391	122.6747	162.8567	195.0765	232.7485	267.5713	305.5879	341.1006
VAR	2.721958	5.097109	26.8418	30.57268	10.11091	25.36007	38.23109	26.93948
STDDEV	1.649836	2.257678	5.180907	5.529257	3.179766	5.035878	6.18313	5.190326
CI	0.871066	1.191989	2.735369	2.919288	1.678825	2.658798	3.264514	2.740342

Table 5.24. Travel time (in minute) between ASP to battalion in new ammunition supply system for the 1st Battalion of Corps Artillery Regiment for ten replications

REP#	BRI1/BT1	BRI1/BT2	BRI2/BT1	BRI2/BT2	BRI3/BT1	BRI3/BT2	REG/BT1	REG/BT2
1	5570.1	5571.6	5569.9	5570	5567.5	5570.6	2626.6	2626.9
2	5567.1	5567.7	5570.4	5568.2	5568.1	5567.4	2627.1	2629.6
3	5570.3	5569	5570.4	5566.3	5570	5569.8	2622.4	2620.2
4	5569.6	5570	5568.1	5568.2	5568.7	5568.3	2625.2	2621.2
5	5570.1	5569.4	5570.9	5569.6	5568.8	5567.1	2623.7	2621.8
6	5569.2	5570.5	5568.9	5567.9	5565.5	5570.2	2627.4	2624.3
7	5568.4	5572	5566.7	5566.6	5567.3	5568.5	2628.1	2622.7
8	5569	5571	5570.6	5568.3	5568.6	5565.6	2627.8	2626.6
9	5570.6	5568.3	5567.7	5568.1	5565.2	5568.4	2623.2	2620.2
10	5568.6	5567.8	5568.5	5567.8	5568.3	5569	2623.8	2620.6
MEAN	5569	5570	5569	5568	5568	5568	2626	2623
VAR	1.144444	2.384556	2.056556	1.282222	2.224444	2.318778	4.504556	10.88322
STD DEV	1.069787	1.544201	1.43407	1.132353	1.491457	1.522753	2.122394	3.298973
CI	0.663048	0.957086	0.888828	0.701825	0.924396	0.943794	1.315447	2.044684
MIN	5569	5569	5568	5567	5567	5568	2624	2621
MAX	5570	5571	5570	5569	5569	5569	2627	2625

Table 5.25. Average numbers of ammunition during the battle in new ammunition supply system for ten replications

REP#	BRI1/BT1	BRI1/BT2	BRI2/BT1	BRI2/BT2	BRI3/BT1	BRI3/BT2	REG/BT1	REG/BT2
1	3027	3191	2988	3126	3034	3201	1759	1631
2	3039	2816	3263	3142	3417	2476	1484	1883
3	3250	3111	3298	3125	3610	3350	1568	1534
4	3026	3063	3095	3124	2741	3199	1427	1395
5	3231	2516	3289	3413	3078	3335	1608	1551
6	3196	2918	3069	2947	2687	3413	1370	1650
7	3078	3123	3035	2964	2602	3289	1450	1412
8	3254	2946	3534	3415	3095	2535	1519	1735
9	2993	2848	3053	3078	2832	3142	1412	1385
10	2847	2856	2864	2871	2877	2889	1346	1338
MEAN	3094	2939	3149	3121	2997	3083	1494	1551
VAR	18079.21	39115.29	37966.18	32384.72	103220.9	113708.8	15538.9	30794.49
STD DEV	134.459	197.7759	194.8491	179.9576	321.2801	337.2073	124.6551	175.4836
CI	83.33687	122.5803	120.7663	111.5366	199.1275	208.9991	77.26051	108.7637
MIN	3011	2816	3028	3009	2798	2874	1417	1443
MAX	3177	3061	3270	3232	3196	3292	1572	1660

Table 5.26. Minimum numbers of ammunition during the battle in new ammunition supply system for ten replications

CORPS		
REP#	UTILIZATION OF ASP1	UTILIZATION OF ASP2
1	0.04131375	0.165255
2	0.04623	0.18492
3	0.04590875	0.183635
4	0.04510875	0.180435
5	0.04432625	0.177305
6	0.04451625	0.178065
7	0.04655	0.1862
8	0.04342875	0.173715
9	0.04753375	0.190135
10	0.04626625	0.185065
MEAN	0.04511825	0.180473
VAR	3.26E-06	5.22E-05
STD DEV	0.00180683	0.007227321
CI (0.95)	0.001119863	0.004479451
MIN	0.043998387	0.175993549
MAX	0.046238113	0.184952451

Table 5.27. Utilization of ASPs in new ammunition supply system for ten replications

REP#	BRI1/BT1	BRI1/BT2	BRI2/BT1	BRI2/BT2	BRI3/BT1	BRI3/BT2	REG/BT1	REG/BT2
1	9	7	8	8	9	8	9	8
2	11	11	7	9	9	9	10	7
3	9	9	7	10	8	8	11	10
4	9	9	9	9	9	9	8	10
5	8	9	7	8	9	10	9	10
6	8	9	9	9	11	8	8	9
7	10	7	10	10	9	9	8	9
8	9	9	8	8.75	9	11	8	8
9	9	9	9	9	11	9	9	10
10	9	9	9	9	9	8	11	10
MEAN	9.025	8.775	8.25	8.975	9.15	8.75	8.95	9.05
VAR	0.575694	0.9368056	0.972222	0.450694	0.669444	1	0.941667	0.983333
STD DEV	0.758745	0.9678872	0.986013	0.671338	0.818196	1	0.970395	0.991632
CI	0.470266	0.5998908	0.611125	0.416091	0.507113	0.619794	0.601445	0.614607
MIN	8.554734	8.1751092	7.638875	8.558909	8.642887	8.130206	8.348555	8.435393
MAX	9.495266	9.3748908	8.861125	9.391091	9.657113	9.369794	9.551445	9.664607

Table 5.28. Average numbers of vehicles in convoys in new ammunition supply system for ten replications

Appendix C

Output Data for Modified New Ammunition Supply System

BRIGADE 1 /BAT1 A								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-
MEAN	0	0	0	0	0	0	0	0
VAR	0	0	0	0	0	0	0	0
STDDEV	0	0	0	0	0	0	0	0
CI								

Table 5.29. Travel time (in minute) between battalion to ASP in modified new ammunition supply system for the 1st Battalion of 1st Brigade for ten replications

BRIGADE 1 /BAT1 B								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	7.75	7.78	7.06	16.86	14.39	17.17	25.05	18.08
2	14.82	23.65	23.06	13.75	23.20	19.50	22.32	17.76
3	21.33	15.64	24.63	13.67	17.32	12.84	6.86	16.13
4	13.61	5.39	8.02	23.48	12.02	22.52	18.07	23.23
5	13.89	12.76	15.01	20.53	19.59	12.29	14.53	6.57
6	5.41	20.84	7.86	16.02	14.59	19.89	15.32	13.36
7	13.92	21.80	16.22	14.04	14.62	23.34	11.16	16.30
8	12.54	20.87	21.83	23.53	23.42	7.45	5.23	15.23
9	17.94	16.47	7.17	11.32	24.36	19.88	6.46	13.95
10	7.08	25.62	15.79	20.76	16.34	14.20	11.94	12.96
MEAN	13.46632	16.13436	14.54163	17.02002	18.16562	17.21022	13.88744	15.62276
VAR	22.81764	41.25162	53.47349	20.08733	21.43126	27.98594	50.33953	19.90556
STDDEV	4.776781	6.422742	7.312557	4.481889	4.62939	5.290174	7.095036	4.461565
CI	2.522003	3.391022	3.860819	2.366308	2.444184	2.793059	3.745974	2.355577

Table 5.30. Time (in minute) in ASP in modified new ammunition supply system for the 1st Battalion of 1st Brigade for ten replications

BRIGADE 1 /BAT1 C								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	88.42	123.70	155.22	195.75	230.73	266.96	299.70	339.60
2	86.66	122.99	161.18	193.84	227.63	266.94	300.93	339.78
3	87.70	123.92	157.73	192.93	227.70	267.56	306.54	335.94
4	88.77	120.51	156.92	193.61	233.94	265.74	302.28	338.49
5	88.00	123.34	160.38	192.43	229.63	264.55	302.40	339.18
6	87.94	121.18	162.08	195.53	229.92	270.52	303.86	336.43
7	87.37	123.89	159.77	193.58	229.48	267.99	303.21	334.32
8	86.70	125.11	155.65	194.35	231.38	267.54	299.98	340.37
9	89.35	121.61	155.44	191.40	228.62	271.31	301.95	337.33
10	84.61	122.02	160.16	195.41	233.25	264.99	299.90	338.45
MEAN	87.87821	122.917	158.2647	193.7132	229.893	267.6795	302.318	337.9374
VAR	0.803605	2.259892	6.990601	1.935255	3.883273	4.501082	4.417831	4.211328
STDDEV	0.89644	1.503294	2.643974	1.391134	1.970602	2.121575	2.101864	2.052152
CI	0.473295	0.793696	1.395942	0.734479	1.040421	1.12013	1.109723	1.083477

Table 5.31. Travel time (in minute) between ASP to battalion in modified new ammunition supply system for the 1st Battalion of 1st Brigade for ten replications

BRIGADE 1 /BAT2 A								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-
MEAN	0	0	0	0	0	0	0	0
VAR	0	0	0	0	0	0	0	0
STDDEV	0	0	0	0	0	0	0	0
CI								

Table 5.32: Travel time (in minute) between battalion to ASP in modified new ammunition supply system for the 2nd Battalion of 1st Brigade for ten replications

BRIGADE 1 /BAT2 B								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	14.34	20.58	7.55	6.20	13.99	15.61	22.01	13.41
2	18.08	24.29	8.62	25.73	21.35	19.36	23.01	14.67
3	16.44	19.82	22.61	12.42	11.33	14.66	13.66	21.70
4	13.54	23.32	6.64	14.78	6.81	12.85	18.92	20.34
5	16.96	31.64	14.98	12.28	17.09	11.86	13.89	7.54
6	19.73	15.65	11.93	22.75	7.15	12.37	15.70	13.76
7	12.62	15.93	14.16	6.36	14.84	18.39	16.11	5.29
8	23.19	15.61	16.01	13.30	6.49	24.37	13.16	10.60
9	6.49	20.00	25.79	15.07	8.63	16.72	25.00	13.34
10	7.42	25.27	15.11	23.67	22.82	15.08	14.65	15.21
MEAN	15.70986	20.75919	14.25478	14.32217	11.96463	16.24265	17.93987	13.40455
VAR	22.6211	26.83781	43.33766	42.51408	27.24491	16.16462	19.88867	28.35717
STDDEV	4.756165	5.180522	6.583135	6.520282	5.219666	4.020525	4.459671	5.325145
CI	2.511118	2.735166	3.475705	3.44252	2.755833	2.122721	2.354578	2.811523

Table 5.33. Time (in minute) in ASP in modified new ammunition supply system for the 2nd Battalion of 1st Brigade for ten replications

BRIGADE 1 /BAT2 C								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	83.91	121.86	160.44	193.59	231.35	270.80	304.91	338.31
2	84.65	122.26	159.01	197.11	233.22	269.43	301.97	339.07
3	86.69	119.44	156.05	195.41	228.31	267.28	300.35	339.98
4	90.56	125.10	158.85	192.77	229.71	262.70	300.65	338.61
5	85.14	124.22	157.59	194.97	230.23	266.67	301.80	338.61
6	85.46	124.77	160.91	197.06	230.29	267.75	306.54	341.01
7	88.63	124.81	158.81	194.08	229.82	270.11	306.22	342.63
8	87.28	122.14	159.39	196.54	227.76	267.04	306.56	337.31
9	87.67	119.11	161.44	194.81	230.77	265.01	302.80	338.98
10	88.66	124.31	156.18	197.13	229.39	267.95	302.80	337.23
MEAN	86.66419	122.6359	159.1653	195.15	230.1613	267.4211	303.5342	339.3898
VAR	4.478151	5.184501	2.794967	2.359874	2.588081	6.453119	6.472727	2.558694
STDDEV	2.116164	2.27695	1.671815	1.536188	1.608751	2.540299	2.544155	1.599592
CI	1.117274	1.202164	0.88267	0.811063	0.849374	1.341205	1.343241	0.844538

Table 5.34. Travel time (in minute) between ASP to battalion in modified new ammunition supply system for the 2nd Battalion of 1st Brigade for ten replications

BRIGADE 2 /BAT1 A								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-
MEAN	0	0	0	0	0	0	0	0
VAR	0	0	0	0	0	0	0	0
STDDEV	0	0	0	0	0	0	0	0
CI								

Table 5.35: Travel time (in minute) between battalion to ASP in modified new ammunition supply system for the 1st Battalion of 2nd Brigade for ten replications

BRIGADE 2 /BAT1 B								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	12.41	15.70	6.63	12.43	12.18	19.02	6.02	16.24
2	12.34	6.08	15.49	25.75	13.99	6.99	11.75	13.37
3	11.61	14.97	13.71	8.48	6.49	6.62	22.49	12.33
4	13.84	17.36	7.60	5.39	18.26	21.34	23.15	15.68
5	6.83	22.93	13.45	13.67	15.48	14.86	14.20	7.16
6	15.71	20.14	13.44	14.90	20.02	14.84	5.96	17.92
7	6.66	17.36	13.63	13.31	19.09	21.41	17.87	22.27
8	14.89	6.48	12.38	6.66	12.16	10.71	16.93	25.65
9	22.47	16.34	12.81	5.77	14.07	20.57	11.48	19.66
10	7.59	20.27	18.99	20.88	17.06	12.16	7.49	19.41
MEAN	12.97362	15.26251	12.12748	11.81828	14.63809	15.15017	14.42795	16.69678
VAR	22.80065	31.78391	8.846668	40.65818	17.72493	35.13501	39.70177	30.47407
STDDEV	4.775002	5.637722	2.974335	6.376377	4.210098	5.927479	6.300934	5.520332
CI	2.521063	2.976554	1.570363	3.366543	2.22281	3.129538	3.326711	2.914576

Table 5.36. Time (in minute) in ASP in modified new ammunition supply system for the 1st Battalion of 2nd Brigade for ten replications

BRIGADE 2 /BAT1 C								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	83.35	120.08	159.44	196.61	228.58	267.98	298.55	335.55
2	86.15	120.36	161.84	195.57	229.19	270.49	298.42	336.34
3	85.81	121.44	160.75	194.34	228.75	269.07	302.42	340.96
4	89.28	122.60	160.07	198.14	229.90	266.46	302.91	335.50
5	84.61	123.03	156.10	195.22	230.25	265.75	303.10	341.22
6	88.86	120.83	159.00	198.39	228.97	267.20	304.31	333.98
7	86.67	120.33	158.25	196.51	226.87	265.95	298.85	339.89
8	88.22	122.09	160.67	195.18	229.67	265.86	301.45	338.99
9	85.23	121.84	161.24	192.08	229.11	262.67	301.12	341.51
10	85.88	125.80	160.12	191.53	230.41	268.04	304.09	337.31
MEAN	86.46458	121.4007	159.7069	195.7812	229.0314	266.8239	301.2366	338.2181
VAR	3.994657	1.131613	3.092197	3.765178	0.95563	5.031014	4.757371	8.340217
STDDEV	1.998664	1.063773	1.758464	1.940407	0.977563	2.242992	2.18114	2.887943
CI	1.055237	0.561642	0.928418	1.024479	0.516125	1.184235	1.151579	1.524751

Table 5.37: Travel time (in minute) between ASP to battalion in modified new ammunition supply system for the 1st Battalion of 1st Brigade for ten replications

BRIGADE 2 /BAT2 A								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-
MEAN	0	0	0	0	0	0	0	0
VAR	0	0	0	0	0	0	0	0
STDDEV	0	0	0	0	0	0	0	0
CI								

Table 5.38. Travel time (in minute) between battalion to ASP in modified new ammunition supply system for the 2nd Battalion of 2nd Brigade for ten replications

BRIGADE 2 /BAT2 B								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	14.97	12.87	17.59	12.99	5.84	19.43	14.14	19.60
2	24.44	14.41	14.32	7.44	14.13	14.22	16.45	22.86
3	19.78	18.34	16.27	23.47	18.73	25.38	16.93	16.06
4	10.71	15.07	14.65	13.63	15.35	14.62	19.67	14.84
5	13.39	14.75	6.40	13.96	17.55	12.89	16.49	6.24
6	5.34	14.61	14.05	19.64	12.94	20.77	25.38	25.87
7	18.28	11.66	21.59	6.89	18.50	17.74	17.73	14.88
8	20.44	11.70	19.51	17.07	13.91	14.02	13.81	12.46
9	8.01	10.98	16.79	21.14	17.34	19.45	12.71	19.58
10	7.49	17.09	20.66	15.98	20.87	7.23	21.12	11.11
MEAN	15.03888	13.82173	15.68553	15.13615	14.92293	17.61231	17.03364	16.93152
VAR	39.43813	5.243659	18.31514	33.11275	16.03351	16.57905	14.4134	34.10088
STDDEV	6.279978	2.289904	4.279619	5.754368	4.004186	4.071738	3.796498	5.839596
CI	3.315647	1.209003	2.259515	3.03814	2.114095	2.14976	2.004441	3.083138

Table 5.39. Time (in minute) in ASP in modified new ammunition supply system for the 2nd Battalion of 2nd Brigade for ten replications

BRIGADE 2 /BAT2 C								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	85.50	118.30	157.01	193.53	229.30	265.90	300.07	338.72
2	86.51	123.92	159.40	193.42	229.85	263.06	301.92	337.19
3	87.03	120.42	160.93	193.58	231.45	264.49	302.51	337.35
4	83.03	125.71	156.39	194.26	226.71	267.81	301.80	339.20
5	85.92	124.33	156.79	194.64	230.85	265.52	298.18	338.50
6	88.55	124.42	161.34	198.24	228.57	266.91	300.01	341.44
7	90.45	121.71	156.58	196.67	232.20	268.48	305.61	341.42
8	88.44	120.98	158.80	195.78	229.82	265.70	303.53	340.10
9	91.00	121.28	160.48	194.38	232.21	265.24	304.34	339.87
10	87.92	121.64	161.03	191.41	227.50	267.21	305.03	338.75
MEAN	87.38118	122.3404	158.6349	194.945	230.1049	265.902	301.9968	339.3107
VAR	6.308286	5.685398	3.993932	2.698356	3.234144	2.748912	5.423281	2.412129
STDDEV	2.51163	2.384407	1.998482	1.642667	1.798373	1.657984	2.328794	1.553103
CI	1.326068	1.258898	1.055141	0.867281	0.949489	0.875368	1.229536	0.819994

Table 5.40. Travel time (in minute) between ASP to battalion in modified new ammunition supply system for the 2nd Battalion of 2nd Brigade for ten replications

BRIGADE 3 /BAT1 A								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-
MEAN	0	0	0	0	0	0	0	0
VAR	0	0	0	0	0	0	0	0
STDDEV	0	0	0	0	0	0	0	0
CI								

Table 5.41. Travel time (in minute) between battalion to ASP in modified new ammunition supply system for the 1st Battalion of 3rd Brigade for ten replications

BRIGADE 3 /BAT1 B								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	15.44	17.86	14.66	19.13	20.17	11.79	16.11	16.11
2	15.22	21.13	23.10	14.66	19.74	16.03	24.26	17.47
3	7.15	17.20	11.63	20.49	15.37	14.25	12.15	6.72
4	12.48	19.17	13.61	15.25	15.63	7.98	25.38	14.79
5	19.77	14.41	22.46	15.47	12.51	16.07	6.57	16.61
6	22.83	23.80	12.72	15.20	19.52	12.29	22.16	25.27
7	23.16	31.08	6.61	10.98	6.50	22.15	18.70	14.56
8	6.69	14.27	7.61	14.22	20.74	21.26	12.09	16.91
9	22.16	6.35	23.00	12.93	19.62	17.44	21.66	18.71
10	7.59	20.56	5.55	21.61	11.24	21.01	23.77	17.29
MEAN	16.09914	18.36236	15.0444	15.36987	16.64493	15.47303	17.67381	16.35009
VAR	41.02989	47.25266	41.09473	8.432854	22.31825	20.49172	40.89235	23.16067
STDDEV	6.405458	6.874057	6.410517	2.903938	4.72422	4.526778	6.394713	4.812554
CI	3.381897	3.629303	3.384568	1.533195	2.494251	2.390008	3.376224	2.540889

Table 5.42. Time (in minute) in ASP in modified new ammunition supply system for the 1st Battalion of 3rd Brigade for ten replications

BRIGADE 3 /BAT1 C								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	87.63	125.76	161.57	191.45	232.15	269.18	298.92	337.87
2	86.26	125.53	161.02	194.63	234.37	269.81	301.64	342.29
3	88.53	121.71	160.14	193.77	230.39	266.52	302.19	337.53
4	83.91	122.10	158.77	197.69	228.86	268.85	302.28	339.60
5	88.40	122.22	159.50	195.49	231.64	268.35	304.69	341.43
6	86.77	124.00	161.80	193.36	231.52	266.81	303.52	342.47
7	87.99	121.57	159.22	195.09	229.47	264.77	300.39	337.55
8	89.00	120.32	159.58	193.53	226.03	265.80	301.80	339.13
9	91.28	122.79	163.55	192.86	231.00	268.22	301.31	337.77
10	85.98	123.32	156.44	195.40	230.93	266.84	302.53	341.39
MEAN	87.75161	122.888	160.5742	194.2076	230.6036	267.5899	301.861	339.5144
VAR	4.131806	3.414886	2.37109	3.194279	5.494352	2.874545	2.774408	4.219301
STDDEV	2.032685	1.847941	1.539834	1.787255	2.344003	1.695448	1.665655	2.054094
CI	1.073199	0.975659	0.812988	0.943619	1.237566	0.895148	0.879418	1.084502

Table 5.43: Travel time (in minute) between ASP to battalion in modified new ammunition supply system for the 1st Battalion of 3rd Brigade for ten replications

BRIGADE 3 /BAT2 A								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-
MEAN	0	0	0	0	0	0	0	0
VAR	0	0	0	0	0	0	0	0
STDDEV	0	0	0	0	0	0	0	0
CI								

Table 5.44. Travel time (in minute) between battalion to ASP in modified new ammunition supply system for the 2nd Battalion of 3rd Brigade for ten replications

BRIGADE 3 /BAT2 B								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	13.84	11.79	13.69	14.89	11.08	12.72	7.14	19.44
2	7.47	33.71	14.44	15.54	12.57	20.46	13.58	20.60
3	19.02	5.94	13.67	11.15	22.43	13.31	13.47	13.21
4	16.58	13.33	16.02	16.12	20.57	15.85	16.78	11.78
5	23.19	22.16	20.66	11.88	22.83	15.37	22.81	12.89
6	6.09	7.12	16.87	13.41	23.85	16.85	14.11	14.68
7	14.45	7.21	13.36	15.74	13.01	20.79	15.75	15.16
8	24.34	21.85	22.30	12.76	14.34	16.47	12.41	15.99
9	21.13	15.20	11.91	15.89	14.58	22.48	14.00	14.54
10	7.72	20.63	12.03	20.10	13.42	13.43	13.37	16.32
MEAN	16.2354	15.36903	15.88097	14.15143	17.25244	17.14303	14.45056	15.36623
VAR	41.8088	83.1386	12.36999	3.559922	25.76826	11.55482	17.06119	8.661603
STDDEV	6.465972	9.118037	3.5171	1.886776	5.076244	3.399239	4.130519	2.94306
CI	3.413847	4.81406	1.856927	0.996163	2.68011	1.7947	2.180795	1.553851

Table 5.45. Time (in minute) in ASP in modified new ammunition supply system for the 2nd Battalion of 3rd Brigade for ten replications

BRIGADE 3 /BAT2 A								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-
MEAN	0	0	0	0	0	0	0	0
VAR	0	0	0	0	0	0	0	0
STDDEV	0	0	0	0	0	0	0	0
CI								

Table 5.44. Travel time (in minute) between battalion to ASP in modified new ammunition supply system for the 2nd Battalion of 3rd Brigade for ten replications

BRIGADE 3 /BAT2 B								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	13.84	11.79	13.69	14.89	11.08	12.72	7.14	19.44
2	7.47	33.71	14.44	15.54	12.57	20.46	13.58	20.60
3	19.02	5.94	13.67	11.15	22.43	13.31	13.47	13.21
4	16.58	13.33	16.02	16.12	20.57	15.85	16.78	11.78
5	23.19	22.16	20.66	11.88	22.83	15.37	22.81	12.89
6	6.09	7.12	16.87	13.41	23.85	16.85	14.11	14.68
7	14.45	7.21	13.36	15.74	13.01	20.79	15.75	15.16
8	24.34	21.85	22.30	12.76	14.34	16.47	12.41	15.99
9	21.13	15.20	11.91	15.89	14.58	22.48	14.00	14.54
10	7.72	20.63	12.03	20.10	13.42	13.43	13.37	16.32
MEAN	16.2354	15.36903	15.88097	14.15143	17.25244	17.14303	14.45056	15.36623
VAR	41.8088	83.1386	12.36999	3.559922	25.76826	11.55482	17.06119	8.661603
STDDEV	6.465972	9.118037	3.5171	1.886776	5.076244	3.399239	4.130519	2.94306
CI	3.413847	4.81406	1.856927	0.996163	2.68011	1.7947	2.180795	1.553851

Table 5.45. Time (in minute) in ASP in modified new ammunition supply system for the 2nd Battalion of 3rd Brigade for ten replications

BRIGADE 3 /BAT2 C								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	87.63	125.76	161.57	191.45	232.15	269.18	298.92	337.87
2	86.26	125.53	161.02	194.63	234.37	269.81	301.64	342.29
3	88.53	121.71	160.14	193.77	230.39	266.52	302.19	337.53
4	83.91	122.10	158.77	197.69	228.86	268.85	302.28	339.60
5	88.40	122.22	159.50	195.49	231.64	268.35	304.69	341.43
6	86.77	124.00	161.80	193.36	231.52	266.81	303.52	342.47
7	87.99	121.57	159.22	195.09	229.47	264.77	300.39	337.55
8	89.00	120.32	159.58	193.53	226.03	265.80	301.80	339.13
9	91.28	122.79	163.55	192.86	231.00	268.22	301.31	337.77
10	85.98	123.32	156.44	195.40	230.93	266.84	302.53	341.39
MEAN	87.75161	122.888	160.5742	194.2076	230.6036	267.5899	301.861	339.5144
VAR	4.131806	3.414886	2.37109	3.194279	5.494352	2.874545	2.774408	4.219301
STDDEV	2.032685	1.847941	1.539834	1.787255	2.344003	1.695448	1.665655	2.054094
CI	1.073199	0.975659	0.812988	0.943619	1.237566	0.895148	0.879418	1.084502

Table 5.46. Travel time (in minute) between ASP to battalion in modified new ammunition supply system for the 2nd Battalion of 3rd Brigade for ten replications

REGIMENT/BAT1								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-
MEAN	0	0	0	0	0	0	0	0
VAR	0	0	0	0	0	0	0	0
STDDEV	0	0	0	0	0	0	0	0
CI								

Table 5.47. Travel time (in minute) between battalion to ASP in modified new system for the 1st Battalion of Corps Artillery Regiment for ten replications

REGIMENT/BAT1								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	7.20	13.07	7.68	13.81	18.22	12.62	13.13	21.71
2	18.84	16.73	15.07	13.67	15.37	13.85	16.25	19.99
3	23.09	18.13	25.03	20.05	13.59	17.65	24.17	15.80
4	6.52	14.25	6.51	10.38	15.45	15.09	21.42	24.65
5	22.22	15.55	22.77	17.94	13.21	12.85	22.94	6.44
6	12.35	8.62	6.46	24.07	6.65	13.57	23.97	15.95
7	19.81	6.76	12.34	6.42	15.37	22.56	17.31	14.88
8	24.19	14.30	15.13	14.76	11.77	13.21	6.05	6.46
9	7.90	13.01	15.47	20.72	13.54	22.18	15.34	16.67
10	7.60	19.55	13.02	24.36	26.16	19.36	17.05	22.74
MEAN	15.79034	13.37893	14.05114	15.75846	13.68437	15.95321	17.84121	15.83952
VAR	53.04606	13.35645	44.86274	30.286	10.35022	15.56123	35.83072	38.42549
STDDEV	7.283272	3.654648	6.697965	5.503272	3.217176	3.944772	5.985877	6.198829
CI	3.845357	1.929549	3.536332	2.905569	1.698576	2.082726	3.16037	3.272803

Table 5.48. Time (in minute) in ASP in modified new ammunition supply system for the 1st Battalion of Corps Artillery Regiment for ten replications

REGIMENT/BAT1								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	7.20	13.07	7.68	13.81	18.22	12.62	13.13	21.71
2	18.84	16.73	15.07	13.67	15.37	13.85	16.25	19.99
3	23.09	18.13	25.03	20.05	13.59	17.65	24.17	15.80
4	6.52	14.25	6.51	10.38	15.45	15.09	21.42	24.65
5	22.22	15.55	22.77	17.94	13.21	12.85	22.94	6.44
6	12.35	8.62	6.46	24.07	6.65	13.57	23.97	15.95
7	19.81	6.76	12.34	6.42	15.37	22.56	17.31	14.88
8	24.19	14.30	15.13	14.76	11.77	13.21	6.05	6.46
9	7.90	13.01	15.47	20.72	13.54	22.18	15.34	16.67
10	7.60	19.55	13.02	24.36	26.16	19.36	17.05	22.74
MEAN	15.79034	13.37893	14.05114	15.75846	13.68437	15.95321	17.84121	15.83952
VAR	53.04606	13.35645	44.86274	30.286	10.35022	15.56123	35.83072	38.42549
STDDEV	7.283272	3.654648	6.697965	5.503272	3.217176	3.944772	5.985877	6.198829
CI	3.845357	1.929549	3.536332	2.905569	1.698576	2.082726	3.16037	3.272803

Table 5.49. Travel time (in minute) between ASP to battalion in modified new ammunition supply system for the 1st Battalion of Corps Artillery Regiment for ten replications

REGIMENT/BAT1								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-
MEAN	0	0	0	0	0	0	0	0
VAR	0	0	0	0	0	0	0	0
STDDEV	0	0	0	0	0	0	0	0
CI								

Table 5.50. Travel time (in minute) between battalion to ASP in modified new system for the 2nd Battalion of Corps Artillery Regiment for ten replications

REGIMENT/BAT2								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	6.39	25.04	5.72	13.39	20.50	23.24	15.28	12.12
2	16.60	16.41	11.32	11.32	16.40	11.83	11.87	14.16
3	15.78	15.59	21.11	25.42	24.08	23.68	14.49	15.95
4	7.22	20.68	7.35	21.71	17.25	14.75	20.17	16.75
5	11.98	20.03	17.54	23.41	21.11	6.26	23.80	6.82
6	16.51	14.64	7.15	13.66	12.11	15.67	24.13	13.35
7	20.97	13.77	12.56	17.70	15.85	20.08	13.27	22.46
8	11.98	15.58	16.05	22.39	11.97	22.58	5.75	15.60
9	15.55	17.58	25.01	21.01	16.31	27.97	19.02	7.29
10	7.00	20.65	14.94	34.28	12.56	18.87	23.92	15.42
MEAN	13.66285	17.70248	13.7572	18.89072	17.28588	18.4528	16.41769	13.83314
VAR	22.28067	12.94442	44.61406	25.50323	16.24582	46.82701	35.50753	23.23096
STDDEV	4.720241	3.597836	6.679375	5.050072	4.030611	6.843027	5.95882	4.81985
CI	2.492151	1.899553	3.526517	2.666292	2.128046	3.61292	3.146085	2.544742

Table 5.51: Time (in minute) in ASP in modified new ammunition supply system for the 2nd Battalion of Corps Artillery Regiment for ten replications

REGIMENT/BAT2								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	89.78	125.11	161.30	194.35	235.00	268.26	302.96	337.08
2	86.80	124.34	159.05	193.72	231.55	267.42	305.96	340.99
3	83.10	123.70	154.52	194.03	232.29	268.86	304.12	340.82
4	83.13	120.42	156.65	193.33	227.96	268.05	304.25	338.54
5	85.60	122.06	160.22	197.34	231.44	264.88	302.15	337.63
6	86.70	124.17	158.13	192.90	231.37	262.38	303.00	337.63
7	86.00	125.44	161.19	195.29	235.00	265.49	301.81	336.48
8	84.20	120.59	155.67	195.45	229.60	264.30	301.72	340.90
9	86.64	120.48	162.77	193.71	233.36	265.66	301.81	342.27
10	88.78	126.38	157.25	191.96	233.34	270.22	304.75	337.85
MEAN	85.77168	122.9231	158.8339	194.4578	231.9517	266.145	303.0858	339.148
VAR	4.419098	4.213984	7.879118	1.871877	5.361189	4.608734	2.09027	4.421615
STDDEV	2.102165	2.052799	2.806977	1.368166	2.315424	2.146796	1.445777	2.102764
CI	1.109882	1.083819	1.482003	0.722352	1.222477	1.133446	0.763328	1.110198

Table 5.52. Travel time (in minute) between ASP to battalion in modified new ammunition supply system for the 1st Battalion of Corps Artillery Regiment for ten replications

REP#	BRI1/BT1	BRI1/BT2	BRI2/BT1	BRI2/BT2	BRI3/BT1	BRI3/BT2	REG/BT1	REG/BT2
1	4896	5051	5008	4979	4882	5067	2363	2390
2	4729	4731	5051	4910	4893	4809	2329	2432
3	4939	4885	5056	4825	5018	5000	2294	2292
4	4858	4929	4869	4888	4947	4906	2348	2290
5	4984	4914	5083	5031	4988	4860	2371	2348
6	4923	4943	4963	4837	4728	4990	2382	2354
7	4830	5066	4759	4768	4820	4896	2366	2334
8	4873	4987	5037	4979	4893	4762	2402	2388
9	4945	4865	4867	4876	4665	4949	2345	2304
10	4901	4859	4884	4874	4853	4942	2260	2290
MEAN	4888	4923	4958	4897	4869	4918	2346	2342
VAR	5155.004	9696.274	11527.79	6445.711	11975.69	8401.911	1775.332	2453.714
STD DEV	71.79836	98.46966	107.3675	80.28519	109.4335	91.66194	42.13469	49.53498
CI	44.5002	61.03092	66.54577	49.76029	67.82624	56.81153	26.11483	30.70149
MIN	4843	4862	4891	4847	4801	4861	2320	2311
MAX	4932	4984	5024	4946	4936	4975	2372	2373

Table 5.53. Average numbers of ammunition during the battle in modified new ammunition supply system for ten replications

REP#	BRI1/BT1	BRI1/BT2	BRI2/BT1	BRI2/BT2	BRI3/BT1	BRI3/BT2	REG/BT1	REG/BT2
1	3027	3191	2988	3126	3034	3201	1759	1631
2	3039	2816	3263	3142	3417	2476	1484	1883
3	2832	3111	3298	3125	3610	3350	1568	1534
4	3026	3063	3095	3124	2741	3199	1427	1395
5	3231	2516	3289	3413	3078	3335	1608	1551
6	3196	2918	3069	2947	2687	3413	1370	1650
7	3078	3123	3035	2964	2602	3289	1450	1412
8	3254	2946	3534	3415	3095	2535	1519	1735
9	2993	2848	3053	3078	2832	3142	1412	1385
10	2847	2856	2864	2871	2877	2889	1346	1338
MEAN	3052	2939	3149	3121	2997	3083	1494	1551
VAR	21070.23	39115.29	37966.18	32384.72	103220.9	113708.8	15538.9	30794.49
STD DEV	145.1559	197.7759	194.8491	179.9576	321.2801	337.2073	124.6551	175.4836
CI	89.96677	122.5803	120.7663	111.5366	199.1275	208.9991	77.26051	108.7637
MIN	2962	2816	3028	3009	2798	2874	1417	1443
MAX	3142	3061	3270	3232	3196	3292	1572	1660

Table 5.54. Minimum numbers of ammunition during the battle in modified new ammunition supply system for ten replications

CORPS		
REP#	UTILIZATION OF ASP1	UTILIZATION OF ASP2
1	0.07041	0.07171
2	0.08525	0.08213
3	0.09041	0.07456
4	0.08071	0.08071
5	0.07954	0.07566
6	0.07926	0.08278
7	0.07995	0.09228
8	0.08111	0.07801
9	0.08086	0.08687
10	0.08877	0.07764
MEAN	0.081627	0.080235
VAR	3.12864E-05	3.74328E-05
STD DEV	0.005593427	0.006118237
CI (0.95)	0.003466773	0.003792047
MIN	0.078160227	0.076442953
MAX	0.085093773	0.084027047

Table 5.55. Utilization of ASPs in modified new ammunition supply system for ten replications

REP#	BRI1/BT1	BRI1/BT2	BRI2/BT1	BRI2/BT2	BRI3/BT1	BRI3/BT2	REG/BT1	REG/BT2
1	9	7	8	8	9	8	9	8
2	11	11	7	9	9	9	10	7
3	9	9	7	10	8	8	11	10
4	9	9	9	9	9	9	8	10
5	8	9	7	8	9	10	9	10
6	8	9	9	9	11	8	8	9
7	10	7	10	10	9	9	8	9
8	9	9	8	8.75	9	11	8	8
9	9	9	9	9	11	9	9	10
10	9	9	9	9	9	8	11	10
MEAN	9.025	8.775	8.25	8.975	9.15	8.75	8.95	9.05
VAR	0.575694	0.9368056	0.972222	0.450694	0.669444	1	0.941667	0.983333
STD DEV	0.758745	0.9678872	0.986013	0.671338	0.818196	1	0.970395	0.991632
CI	0.470266	0.5998908	0.611125	0.416091	0.507113	0.619794	0.601445	0.614607
MIN	8.554734	8.1751092	7.638875	8.558909	8.642887	8.130206	8.348555	8.435393
MAX	9.495266	9.3748908	8.861125	9.391091	9.657113	9.369794	9.551445	9.664607

Table 5.56. Average numbers of vehicles in convoys in modified new ammunition supply system for ten replications

Appendix D

Output Data for Modified Existing Ammunition Supply System

BRIGADE 1 /BAT1 A								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	81.53	117.51	153.48	189.45	225.42	261.39	297.36	321.34
2	81.53	117.51	153.48	189.45	225.42	261.39	297.36	321.34
3	81.53	117.51	153.48	189.45	225.42	261.39	297.36	321.34
4	81.53	117.51	153.48	189.45	225.42	261.39	297.36	321.34
5	81.53	117.51	153.48	189.45	225.42	261.39	297.36	321.34
6	81.53	117.51	153.48	189.45	225.42	261.39	297.36	321.34
7	81.53	117.51	153.48	189.45	225.42	261.39	297.36	321.34
8	81.53	117.51	153.48	189.45	225.42	261.39	297.36	321.34
9	81.53	117.51	153.48	189.45	225.42	261.39	297.36	321.34
10	81.53	117.51	153.48	189.45	225.42	261.39	297.36	321.34
MEAN	81.53477	117.506	153.4772	189.4484	225.4197	261.3909	297.3621	321.3429
VAR	2.73E-12	0	0	0	7.28E-12	0	1.46E-11	2.91E-11
STDDEV	1.65E-06	0	0	0	2.7E-06	0	3.81E-06	5.39E-06
CI	8.72E-07				1.42E-06		2.01E-06	2.85E-06

Table 5.57. Travel time (minute) between battalion to ASP in modified existing system for the 1st Battalion of 1st Brigade for ten replications

BRIGADE 1 /BAT1 B								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	68.87	66.03	60.11	157.99	132.22	93.45	142.58	188.52
2	77.41	185.71	107.99	124.12	142.47	118.96	168.24	135.72
3	182.35	89.51	145.90	102.50	166.80	96.15	63.29	84.77
4	79.41	59.28	53.90	171.85	97.11	116.25	199.25	173.52
5	98.86	88.81	113.89	127.73	127.50	74.74	120.74	43.57
6	29.09	135.93	75.83	118.95	113.34	156.95	129.76	91.71
7	149.79	159.83	153.92	148.07	116.81	167.14	101.03	74.81
8	115.98	191.35	161.03	176.56	153.37	46.39	59.67	150.17
9	139.94	74.19	63.06	106.76	193.34	115.95	76.51	125.29
10	12.00	172.82	105.17	209.51	99.47	148.48	128.23	66.85
MEAN	104.6333	116.7371	103.9586	137.1699	138.1065	109.5522	117.8974	118.6758
VAR	2231.325	2719.353	1815.125	753.0636	877.6334	1422.181	2284.933	2331.686
STDDEV	47.2369	52.14741	42.60429	27.442	29.62488	37.71181	47.80098	48.28753
CI	24.93972	27.53233	22.49383	14.48859	15.64108	19.91075	25.23753	25.49442

Table 5.58. Time (minute) in ASP in modified existing system for the 1st Battalion of 1st Brigade for ten replications

BRIGADE 1 /BAT1 C								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	90.75	130.87	162.55	198.12	235.15	269.81	310.00	345.98
2	94.78	130.92	164.81	200.55	237.48	268.67	310.42	342.49
3	94.59	123.66	164.26	196.48	234.33	268.14	307.85	343.20
4	91.93	128.06	162.22	198.96	238.07	270.92	304.87	339.82
5	90.61	127.58	164.94	199.56	233.62	269.24	305.72	344.41
6	91.77	127.27	163.06	200.25	232.83	272.53	306.48	342.41
7	92.10	129.05	160.57	197.43	233.76	271.31	307.09	344.46
8	91.46	125.13	161.60	200.45	232.54	272.80	308.52	345.84
9	94.35	129.04	162.60	201.69	236.52	268.96	312.03	339.88
10	91.48	130.07	162.51	196.19	233.49	269.31	304.90	344.60
MEAN	92.48141	127.9531	162.9582	199.2774	234.9232	270.2651	308.1077	343.1639
VAR	2.710588	5.839749	2.182408	2.811389	4.062218	2.885866	5.554736	5.161545
STDDEV	1.646386	2.416557	1.477297	1.67672	2.015495	1.698784	2.356849	2.271903
CI	0.869244	1.275872	0.77997	0.88526	1.064123	0.896909	1.244348	1.199499

Table 5.59. Travel time (minute) between ASP to battalion in modified existing system for the 1st Battalion of 1st Brigade for ten replications

BRIGADE 1 /BAT2 A								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
2	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
3	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
4	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
5	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
6	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
7	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
8	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
9	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
10	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
MEAN	81.53477	117.506	153.4772	189.4484	225.4197	261.3909	297.3621	333.3333
VAR	2.73E-12	0	0	0	7.28E-12	0	1.46E-11	0
STDDEV	1.65E-06	0	0	0	2.7E-06	0	3.81E-06	0
CI	8.72E-07				1.42E-06		2.01E-06	

Table 5.60. Travel time (minute) between battalion to ASP in modified existing system for the 2nd Battalion of 1st Brigade for ten replications

BRIGADE 1 /BAT2 B								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	84.02	152.15	43.04	13.45	100.13	66.38	149.11	75.90
2	142.20	152.48	32.49	114.63	167.84	151.68	162.92	100.05
3	102.27	137.59	113.47	87.50	137.40	59.65	137.89	151.53
4	103.49	162.82	58.90	102.84	36.53	84.76	143.40	153.50
5	126.24	184.48	112.40	143.92	129.80	87.90	119.03	53.25
6	152.50	83.52	72.95	177.24	54.56	143.33	62.71	108.15
7	90.04	112.65	61.13	14.73	132.44	140.29	121.51	27.51
8	177.34	171.12	89.38	102.94	31.52	166.14	79.74	77.79
9	38.50	167.97	130.73	67.82	36.79	147.04	115.57	118.16
10	14.23	125.75	113.44	149.49	152.04	119.50	78.89	132.05
MEAN	112.9558	147.197	79.38695	91.67265	91.88921	116.3538	121.3204	96.20448
VAR	1731.242	1003.946	1162.752	2931.904	2766.012	1686.207	1058.412	1787.469
STDDEV	41.60819	31.6851	34.09915	54.14706	52.59289	41.06346	32.53325	42.27846
CI	21.96792	16.72882	18.00337	28.58808	27.76753	21.68032	17.17662	22.32181

Table 5.61. Time (minute) in ASP in modified existing system for the 2nd Battalion of 1st Brigade for ten replications

BRIGADE 1 /BAT2 C								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	93.01	131.84	165.80	201.84	239.43	273.40	306.96	344.73
2	92.56	128.27	162.54	203.41	234.19	271.60	310.30	342.21
3	93.20	127.59	161.51	202.47	235.00	272.72	307.54	346.99
4	94.11	128.58	159.46	200.33	237.48	275.47	309.81	343.89
5	94.41	129.88	163.99	200.75	232.63	271.50	311.23	345.93
6	91.17	124.06	161.21	198.74	238.50	268.46	306.04	343.20
7	93.66	130.09	165.37	198.50	233.34	273.70	307.13	339.28
8	90.23	126.55	163.90	198.67	237.26	273.95	307.63	340.55
9	91.56	127.26	162.12	200.74	233.80	272.09	308.96	346.67
10	92.16	125.95	162.20	197.54	233.09	271.10	307.03	347.26
MEAN	92.6548	128.2376	162.8766	200.6056	235.737	272.543	308.4001	343.7163
VAR	1.988928	5.116927	4.260032	3.077119	6.094876	3.937638	3.06242	7.210251
STDDEV	1.410294	2.262062	2.063984	1.754172	2.46878	1.984348	1.749977	2.685191
CI	0.744594	1.194304	1.089724	0.926152	1.303445	1.047679	0.923937	1.417703

Table 5.62. Travel time (minute) between ASP to battalion in modified existing system for the 2nd Battalion of 1st Brigade for ten replications

BRIGADE 2 /BAT1 A								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
2	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
3	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
4	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
5	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
6	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
7	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
8	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
9	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
10	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
MEAN	81.53477	117.506	153.4772	189.4484	225.4197	261.3909	297.3621	333.3333
VAR	2.73E-12	0	0	0	7.28E-12	0	1.46E-11	0
STDDEV	1.65E-06	0	0	0	2.7E-06	0	3.81E-06	0
CI	8.72E-07				1.42E-06		2.01E-06	

Table 5.63. Travel time (minute) between battalion to ASP in modified existing system for the 1st Battalion of 2nd Brigade for ten replications

BRIGADE 2 /BAT1 B								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	87.76	115.84	60.64	91.50	81.47	135.92	53.23	123.34
2	79.22	56.85	86.10	171.35	81.41	74.17	78.11	92.85
3	100.83	80.09	89.86	49.03	72.86	16.72	140.45	110.83
4	77.49	128.58	65.07	30.08	130.37	149.86	152.69	87.21
5	15.15	158.56	92.89	104.27	67.51	86.46	98.54	55.72
6	116.20	185.85	78.04	98.34	152.00	85.11	47.21	139.88
7	48.08	176.94	131.07	123.49	182.16	163.37	101.05	123.89
8	74.41	45.85	129.71	48.37	84.28	122.71	70.36	143.33
9	162.73	103.31	100.67	30.77	133.38	157.21	129.87	145.37
10	15.94	179.00	139.95	233.19	79.90	68.97	42.68	135.20
MEAN	84.65113	116.8737	92.67247	83.02177	109.495	110.1697	96.83377	113.5986
VAR	1714.652	2553.203	620.4816	2260.879	1676.07	2332.147	1443.77	908.6859
STDDEV	41.40835	50.52923	24.90947	47.5487	40.93983	48.29231	37.99697	30.14442
CI	21.86241	26.67797	13.15148	25.10434	21.61505	25.49695	20.0613	15.91538

Table 5.64. Time (minute) in ASP in modified existing system for the 1st Battalion of 2nd Brigade for ten replications

BRIGADE 2 /BAT1 C								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	87.95	130.36	164.91	199.22	235.00	268.63	304.91	347.79
2	91.37	126.75	160.13	196.83	235.19	271.33	303.63	346.53
3	92.57	126.38	165.47	200.68	239.12	268.05	305.91	343.06
4	87.33	129.21	164.81	198.54	234.38	269.10	308.72	342.99
5	93.35	128.52	163.96	198.59	236.63	272.03	306.48	343.63
6	92.19	126.40	159.33	200.70	233.82	270.26	303.14	344.04
7	93.58	124.94	163.87	201.64	236.27	270.76	306.58	345.64
8	92.49	130.37	166.16	195.73	235.31	270.27	310.44	343.76
9	90.54	129.70	163.62	200.68	237.21	272.20	311.25	343.29
10	91.71	128.00	166.53	200.58	232.87	268.13	306.14	345.67
MEAN	91.26291	128.0688	163.5835	199.1789	235.8805	270.2915	306.7849	344.5245
VAR	5.106181	3.987575	5.467883	3.885435	2.626249	2.141274	8.090381	2.941813
STDDEV	2.259686	1.996891	2.33835	1.971151	1.620571	1.463309	2.844359	1.715171
CI	1.193049	1.054301	1.234581	1.040711	0.855614	0.772585	1.50174	0.905561

Table 5.65. Travel time (minute) between ASP to battalion in modified existing system for the 1st Battalion of 2nd Brigade for ten replications

BRIGADE 2 /BAT2 A								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
2	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
3	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
4	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
5	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
6	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
7	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
8	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
9	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
10	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
MEAN	81.53477	117.506	153.4772	189.4484	225.4197	261.3909	297.3621	333.3333
VAR	2.73E-12	0	0	0	7.28E-12	0	1.46E-11	0
STDDEV	1.65E-06	0	0	0	2.7E-06	0	3.81E-06	0
CI	8.72E-07				1.42E-06		2.01E-06	

Table 5.66. Travel time (minute) between battalion to ASP in modified existing system for the 2nd Battalion of 2nd Brigade for ten replications

BRIGADE 2 /BAT2 B								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	88.79	51.20	75.25	109.99	30.97	170.69	110.26	157.27
2	148.23	81.65	114.13	57.17	110.92	100.46	100.98	194.84
3	158.31	137.45	113.48	157.46	126.46	161.50	90.44	102.01
4	128.63	87.39	81.19	133.74	100.03	142.69	119.67	122.23
5	118.34	104.11	67.31	91.51	162.61	98.93	69.13	83.53
6	33.01	85.20	55.08	183.65	76.25	153.47	139.19	127.40
7	166.23	85.68	159.30	16.69	151.73	174.72	196.27	152.00
8	122.82	68.68	95.55	112.27	113.13	96.25	70.62	93.55
9	75.51	111.99	64.93	135.59	132.25	163.61	61.96	151.13
10	31.45	126.59	127.16	198.76	119.35	28.78	119.54	113.66
MEAN	115.5411	90.37263	91.80148	110.8959	111.5937	140.2579	106.5023	131.5518
VAR	1853.555	626.4288	1074.423	2591.564	1593.42	1064.864	1783.838	1274.467
STDDEV	43.05293	25.02856	32.77839	50.90741	39.91767	32.63225	42.23551	35.69968
CI	22.7307	13.21436	17.30604	26.87764	21.07537	17.22889	22.29913	18.8484

Table 5.67. Time (minute) in ASP in modified existing system for the 2nd Battalion of 2nd Brigade for ten replications

BRIGADE 2 /BAT2 C								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	92.22	125.94	163.39	201.20	231.67	270.08	305.69	345.01
2	93.05	128.02	161.42	202.40	234.37	268.20	309.99	340.35
3	93.08	129.10	162.27	200.71	234.64	269.32	306.50	343.10
4	94.20	128.40	165.17	201.06	239.44	269.73	307.30	346.98
5	88.00	127.07	161.67	196.06	236.76	271.75	306.37	343.21
6	90.92	126.11	162.91	198.52	235.48	272.52	309.05	341.30
7	88.36	128.48	168.18	202.03	236.67	269.08	307.66	342.37
8	93.49	130.67	164.57	197.45	236.81	273.05	307.50	340.82
9	91.11	125.14	167.35	198.85	231.54	268.89	307.47	344.48
10	95.46	132.02	163.51	198.48	236.65	270.45	306.33	343.44
MEAN	91.60244	127.6596	164.1032	199.8082	235.2639	270.2905	307.5038	343.069
VAR	4.895896	3.069431	5.864947	4.778853	6.509548	2.979558	1.777472	4.637319
STDDEV	2.212667	1.751979	2.421765	2.186059	2.551382	1.72614	1.333219	2.153443
CI	1.168224	0.924994	1.278622	1.154176	1.347056	0.911352	0.703901	1.136956

Table 5.68. Travel time (minute) between ASP to battalion in modified existing system for the 2nd Battalion of 2nd Brigade for ten replications

BRIGADE 3 /BAT1 A								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
2	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
3	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
4	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
5	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
6	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
7	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
8	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
9	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
10	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
MEAN	81.53477	117.506	153.4772	189.4484	225.4197	261.3909	297.3621	333.3333
VAR	2.73E-12	0	0	0	7.28E-12	0	1.46E-11	0
STDDEV	1.65E-06	0	0	0	2.7E-06	0	3.81E-06	0
CI	8.72E-07				1.42E-06		2.01E-06	

Table 5.69. Travel time (minute) between battalion to ASP in modified existing system for the 1st Battalion of 3rd Brigade for ten replications

BRIGADE 3 /BAT1 B								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	101.20	150.68	72.39	103.92	147.49	98.44	121.41	101.52
2	62.83	131.12	139.56	90.77	158.80	106.88	157.79	107.38
3	57.05	78.76	133.07	114.88	119.40	96.54	104.45	44.39
4	98.09	209.73	59.84	108.13	76.59	40.42	154.75	112.07
5	159.65	92.73	153.79	108.00	115.35	147.09	57.42	59.66
6	148.67	170.34	91.60	98.94	141.74	115.21	165.44	157.73
7	153.98	247.73	25.37	101.87	70.10	141.97	185.88	83.28
8	59.04	116.49	38.49	89.92	153.69	142.67	94.18	141.63
9	125.95	35.65	184.76	139.89	174.05	133.63	136.33	150.23
10	30.83	151.15	36.67	188.73	99.26	129.91	102.36	122.28
MEAN	107.384	137.0271	99.87423	106.259	128.5775	113.6498	130.8485	106.4316
VAR	1741.599	4366.021	3066.897	224.6592	1315.472	1136.902	1634.317	1552.174
STDDEV	41.73247	66.07587	55.37958	14.98864	36.26944	33.71797	40.42669	39.39764
CI	22.03354	34.88615	29.23882	7.913566	19.14921	17.80211	21.34412	20.80082

Table 5.70. Time (minute) in ASP in existing system for the 1st Battalion of 3rd Brigade for ten replications

BRIGADE 3 /BAT1 C								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	88.51	122.89	165.18	202.12	233.89	269.79	309.07	343.93
2	93.11	127.21	167.72	200.22	237.13	272.22	310.38	344.60
3	91.86	128.24	162.01	201.51	231.86	273.96	305.22	345.97
4	88.47	130.73	164.10	200.61	231.74	268.92	303.78	343.78
5	90.29	124.14	163.98	198.76	233.32	272.44	309.38	340.65
6	91.86	127.95	165.09	198.27	234.47	272.79	302.64	339.87
7	92.50	129.79	161.75	199.85	232.83	271.73	309.18	344.38
8	95.36	127.95	161.49	198.99	232.74	268.83	307.47	343.12
9	91.17	126.33	166.16	200.65	238.50	267.59	309.92	341.33
10	92.91	123.37	161.82	198.04	237.23	273.08	308.75	339.15
MEAN	91.45889	127.2488	164.1641	200.1094	234.0545	270.9171	307.4486	343.0713
VAR	4.804861	6.25441	4.521555	1.640515	5.423819	4.761765	8.207431	4.100123
STDDEV	2.191999	2.500882	2.126395	1.280826	2.328909	2.182147	2.864861	2.024876
CI	1.157312	1.320393	1.122675	0.676239	1.229597	1.152111	1.512564	1.069076

Table 5.71. Travel time (minute) between ASP to battalion in modified existing system for the 1st Battalion of 3rd Brigade for ten replications

BRIGADE 3 /BAT2 A								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
2	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
3	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
4	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
5	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
6	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
7	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
8	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
9	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
10	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
MEAN	81.53477	117.506	153.4772	189.4484	225.4197	261.3909	297.3621	333.3333
VAR	2.73E-12	0	0	0	7.28E-12	0	1.46E-11	0
STDDEV	1.65E-06	0	0	0	2.7E-06	0	3.81E-06	0
CI	8.72E-07				1.42E-06		2.01E-06	

Table 5.72. Travel time (minute) between battalion to ASP in modified existing system for the 2nd Battalion of 3rd Brigade for ten replications

BRIGADE 3 /BAT2 B								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	103.48	87.17	87.70	85.45	139.65	65.15	26.11	119.33
2	58.67	232.45	105.70	132.99	88.24	168.22	58.66	185.36
3	142.16	41.95	76.71	88.54	168.13	72.10	117.71	117.11
4	120.35	104.37	91.88	128.48	148.90	68.78	194.67	97.05
5	130.57	137.25	114.00	89.03	141.33	112.06	168.44	68.05
6	29.35	45.39	132.00	131.70	156.67	104.47	103.23	94.13
7	96.35	46.30	103.83	123.41	95.57	184.24	90.29	157.45
8	201.39	202.66	116.22	130.50	118.63	84.35	102.74	147.85
9	124.56	137.20	95.75	102.92	93.01	170.24	101.05	56.96
10	38.13	123.41	92.29	165.82	75.00	88.47	81.67	130.23
MEAN	111.8761	114.9698	102.6442	112.5587	127.7905	114.4008	106.9875	115.9211
VAR	2433.166	4782.119	280.687	429.445	890.9032	2274.377	2600.387	1772.363
STDDEV	49.32713	69.15287	16.75372	20.72305	29.848	47.69043	50.99399	42.09944
CI	26.0433	36.51072	8.845478	10.94117	15.75888	25.17917	26.92335	22.22729

Table 5.73. Time (minute) in ASP in modified existing system for the 2nd Battalion of 3rd Brigade for ten replications

BRIGADE 3 /BAT2 C								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	90.09	128.14	165.89	200.52	233.15	274.56	309.80	343.48
2	89.66	124.56	166.77	199.13	237.68	271.64	304.90	342.53
3	95.08	127.78	163.69	203.01	235.97	269.50	307.67	345.31
4	93.99	131.65	166.48	202.01	230.89	273.20	308.30	342.27
5	95.10	127.66	164.75	200.86	234.12	271.18	306.79	341.41
6	90.45	125.98	164.47	202.00	238.18	271.45	311.86	344.38
7	92.45	129.05	163.78	201.38	233.69	271.65	309.47	342.62
8	89.50	130.96	164.32	197.16	234.12	272.71	305.81	346.12
9	91.21	130.40	165.21	199.12	236.91	274.88	304.03	343.34
10	89.33	126.75	161.32	202.98	236.91	272.46	305.21	339.21
MEAN	91.94958	128.4638	165.0405	200.5766	234.9685	272.3072	307.6265	343.4968
VAR	5.205999	5.388406	1.268367	3.327133	5.677213	2.918022	6.362041	2.317624
STDDEV	2.281666	2.321294	1.126218	1.824043	2.38269	1.708222	2.522309	1.522375
CI	1.204654	1.225576	0.594611	0.963042	1.257992	0.901892	1.331706	0.80377

Table 5.74. Travel time (minute) between ASP to battalion in modified existing system for the 2nd Battalion of 3rd Brigade for ten replications

REGIMENT/BAT1								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
2	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
3	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
4	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
5	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
6	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
7	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
8	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
9	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
10	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
MEAN	81.53477	117.506	153.4772	189.4484	225.4197	261.3909	297.3621	333.3333
VAR	2.73E-12	0	0	0	7.28E-12	0	1.46E-11	0
STDDEV	1.65E-06	0	0	0	2.7E-06	0	3.81E-06	0
CI	8.72E-07				1.42E-06		2.01E-06	

Table 5.75. Travel time (minute) between battalion to ASP in modified existing system for the 1st Battalion of Corps Artillery Regiment for ten replications

REGIMENT/BAT1								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	64.83	102.54	49.12	104.05	102.13	136.77	107.53	135.90
2	144.40	105.77	142.26	106.13	90.37	91.06	119.73	144.88
3	155.21	169.22	167.77	160.58	91.79	150.17	104.00	109.25
4	60.21	128.71	52.02	70.91	103.65	55.91	191.98	182.49
5	141.65	94.10	155.24	173.61	62.72	73.04	109.11	40.70
6	126.75	46.66	51.74	247.69	56.19	104.74	138.95	86.75
7	167.88	60.91	138.18	16.05	88.19	187.06	85.75	103.34
8	168.72	86.74	112.38	86.89	145.11	96.30	55.49	57.97
9	33.76	87.53	98.18	123.59	129.98	167.14	94.63	90.75
10	19.17	178.61	81.92	184.23	156.92	131.87	129.39	171.50
MEAN	118.1563	98.02035	107.4318	121.0567	96.68212	118.0213	111.9071	105.7803
VAR	2630.141	1294.836	2221.048	4448.44	807.6077	1977.456	1432.522	1930.93
STDDEV	51.2849	35.98383	47.128	66.69663	28.41844	44.4686	37.84868	43.94235
CI	27.07694	18.99842	24.88222	35.21389	15.00412	23.47814	19.98301	23.20029

Table 5.76. Time (minute) in ASP in modified existing system for the 1st Battalion of Corps Artillery Regiment for ten replications

REGIMENT/BAT1								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	89.28	128.29	160.07	198.19	235.36	273.14	306.27	342.16
2	91.50	129.71	163.88	198.30	236.14	273.79	307.50	341.50
3	89.98	128.26	165.33	201.31	235.09	271.66	311.01	342.67
4	91.04	125.60	162.65	196.65	234.95	271.72	306.02	345.13
5	88.76	128.52	163.68	198.48	236.85	273.87	304.83	342.49
6	93.34	128.85	165.00	201.52	231.16	272.89	307.08	345.10
7	93.18	129.94	162.49	198.84	236.39	271.86	309.84	339.04
8	94.85	129.69	167.36	197.62	235.96	272.48	309.65	342.49
9	92.50	123.07	160.07	201.98	238.81	269.26	309.72	340.56
10	94.07	126.37	162.02	199.69	237.14	270.76	306.19	341.54
MEAN	91.60192	127.9931	163.3905	199.2092	235.6339	272.2965	307.9916	342.3481
VAR	4.161438	5.092962	5.740221	3.624628	4.169826	1.989491	4.524063	3.793002
STDDEV	2.03996	2.256759	2.395876	1.903846	2.042015	1.410493	2.126984	1.947563
CI	1.07704	1.191504	1.264953	1.005175	1.078125	0.7447	1.122986	1.028257

Table 5.77. Travel time (minute) between ASP to battalion in modified existing system for the 1st Battalion of Corps Artillery Regiment for ten replications

REGIMENT/BAT2								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
2	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
3	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
4	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
5	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
6	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
7	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
8	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
9	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
10	81.53	117.51	153.48	189.45	225.42	261.39	297.36	333.33
MEAN	81.53477	117.506	153.4772	189.4484	225.4197	261.3909	297.3621	333.3333
VAR	2.73E-12	0	0	0	7.28E-12	0	1.46E-11	0
STDDEV	1.65E-06	0	0	0	2.7E-06	0	3.81E-06	0
CI	8.72E-07				1.42E-06		2.01E-06	

Table 5.78. Travel time (minute) between battalion to ASP in modified existing system for the 2nd Battalion of Corps Artillery Regiment for ten replications

REGIMENT/BAT2								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	42.98	154.17	38.97	64.25	121.07	133.63	60.80	85.56
2	130.43	91.05	90.45	68.02	93.17	65.85	98.31	84.26
3	99.31	100.10	154.17	116.46	163.24	161.96	100.58	115.47
4	49.60	124.18	32.88	112.54	149.64	115.20	145.60	178.75
5	90.13	132.72	136.59	186.27	144.54	50.50	130.07	25.71
6	129.37	146.14	33.77	126.09	122.99	136.06	156.71	70.46
7	105.86	127.12	61.45	144.60	60.40	168.29	63.75	167.12
8	130.42	61.38	76.92	133.60	99.38	130.79	35.37	140.81
9	81.58	150.87	169.14	166.28	75.12	178.11	121.46	72.32
10	14.42	178.08	59.23	199.56	128.68	188.47	147.17	108.54
MEAN	95.52128	120.8584	88.2602	124.2354	114.3931	126.7088	101.4075	104.4963
VAR	1099.57	962.2711	2817.491	1634.567	1223.639	1926.132	1709.323	2505.601
STDDEV	33.15976	31.02049	53.08004	40.42978	34.98056	43.88772	41.34396	50.05598
CI	17.5074	16.37792	28.02473	21.34576	18.46872	23.17145	21.82842	26.42811

Table 5.79. Time (minute) in ASP in modified existing system for the 2nd Battalion of Corps Artillery Regiment for ten replications

REGIMENT/BAT2								
REP#	POS1	POS2	POS3	POS4	POS5	POS6	POS7	POS8
1	94.37	100.69	160.28	197.49	235.41	270.93	303.99	341.10
2	91.60	99.15	164.80	201.75	235.16	272.11	304.25	338.99
3	94.83	103.27	164.49	201.38	234.90	268.87	308.35	344.58
4	92.12	103.04	166.39	196.88	234.79	269.58	307.03	343.49
5	90.98	100.50	164.96	201.01	236.92	273.91	307.05	343.25
6	90.56	101.07	164.10	201.35	237.58	273.91	305.01	344.65
7	91.67	103.23	162.63	198.84	237.32	272.27	305.91	341.98
8	93.22	101.61	159.20	200.57	235.11	272.92	303.79	341.04
9	92.85	105.08	165.45	201.38	238.16	275.84	306.84	343.75
10	89.82	104.95	165.05	200.54	237.25	271.09	309.59	343.14
MEAN	92.4683	101.9595	163.589	200.0722	236.1496	272.2613	305.7997	342.536
VAR	2.155779	3.350178	5.864983	3.425094	1.756873	4.887633	2.627751	3.590884
STDDEV	1.468257	1.830349	2.421773	1.850701	1.325471	2.210799	1.621034	1.894963
CI	0.775197	0.966371	1.278626	0.977117	0.69981	1.167238	0.855859	1.000486

Table 5.80. Travel time (minute) between ASP to battalion in modified existing system for the 2nd Battalion of Corps Artillery Regiment for ten replications

REP#	BRI1/BT1	BRI1/BT2	BRI2/BT1	BRI2/BT2	BRI3/BT1	BRI3/BT2	REG/BT1	REG/BT2
1	4896.1	5051	5007.5	4979.2	4881.8	5066.6	2362.6	2389.7
2	4729.1	4730.7	5051.1	4909.5	4893.1	4808.9	2329.4	2432
3	4938.8	4885.4	5056.4	4824.9	5018	4999.5	2294.4	2291.9
4	4857.5	4928.8	4869.4	4887.7	4946.6	4905.9	2347.7	2290.4
5	4984.4	4914.1	5082.8	5030.6	4987.7	4860.3	2370.8	2348.3
6	4922.6	4943	4962.8	4837	4727.9	4989.5	2381.6	2353.6
7	4829.7	5065.9	4759.2	4768	4819.5	4896	2365.5	2334
8	4872.7	4987.3	5037.1	4979.1	4893	4761.8	2401.7	2388.2
9	4945.3	4865	4867.1	4876.2	4665.2	4948.8	2345.4	2303.8
10	4900.8	4859.3	4884.1	4873.5	4853	4941.9	2260	2290
MEAN	4888	4923	4958	4897	4869	4918	2346	2342
VAR	5155.004	9696.274	11527.79	6445.711	11975.69	8401.911	1775.332	2453.714
STD DEV	71.79836	98.46966	107.3675	80.28519	109.4335	91.66194	42.13469	49.53498
CI	44.5002	61.03092	66.54577	49.76029	67.82624	56.81153	26.11483	30.70149
MIN	4843	4862	4891	4847	4801	4861	2320	2311
MAX	4932	4984	5024	4946	4936	4975	2372	2373

Table 5.81. Average number of ammunition during the battle in modified existing ammunition supply system for ten replications

REP#	BRI1/BT1	BRI1/BT2	BRI2/BT1	BRI2/BT2	BRI3/BT1	BRI3/BT2	REG/BT1	REG/BT2
1	3027	3191	2988	3126	3034	3201	1759	1631
2	3039	2816	3263	3142	3417	2476	1484	1883
3	2832	3111	3298	3125	3610	3350	1568	1534
4	3026	3063	3095	3124	2741	3199	1427	1395
5	3231	2516	3289	3413	3078	3335	1608	1551
6	3196	2918	3069	2947	2687	3413	1370	1650
7	3078	3123	3035	2964	2602	3289	1450	1412
8	3254	2946	3534	3415	3095	2535	1519	1735
9	2993	2848	3053	3078	2832	3142	1412	1385
10	2847	2856	2864	2871	2877	2889	1346	1338
MEAN	3052	2939	3149	3121	2997	3083	1494	1551
VAR	21070.23	39115.29	37966.18	32384.72	103220.9	113708.8	15538.9	30794.49
STD DEV	145.1559	197.7759	194.8491	179.9576	321.2801	337.2073	124.6551	175.4836
CI	89.96677	122.5803	120.7663	111.5366	199.1275	208.9991	77.26051	108.7637
MIN	2962	2816	3028	3009	2798	2874	1417	1443
MAX	3142	3061	3270	3232	3196	3292	1572	1660

Table 5.82. Minimum numbers of ammunition during the battle in modified existing ammunition supply system for ten replications

CORPS		
REP#	UTILIZATION OF ASP1	UTILIZATION OF ASP2
1	0.07041	0.07171
2	0.08525	0.08213
3	0.09041	0.07456
4	0.08071	0.08071
5	0.07954	0.07566
6	0.07926	0.08278
7	0.07995	0.09228
8	0.08111	0.07801
9	0.08086	0.08687
10	0.08877	0.07764
MEAN	0.081627	0.080235
VAR	3.12864E-05	3.74328E-05
STD DEV	0.005593427	0.006118237
CI (0.95)	0.003466773	0.003792047
MIN	0.078160227	0.076442953
MAX	0.085093773	0.084027047

Table 5.83. Utilization of ASPs in modified existing ammunition supply system for ten replications

Appendix E

Input Data

We classify our data in four classes since we used four models to evaluate the army corps artillery ammunition supply system.

Existing System

- Battalion ammunition consumption per day :

While determining the maximum we used a table function of the ARENA software since the consumption may change day by day according to the orders about the ASR. We use one different “first day value” and use the same other days values according to the manual, since there is no any distinction of the consumption related with the days of battle. The user of the model can change easily if required:

- For the 155mm self propelled howitzer battalions:

Triangular distribution with parameters (47, 2088, 3456) for the first day.

Triangular distribution with parameters (47, 2088, 2790) for the other days.

- For the 203mm self propelled howitzer battalions:

Triangular distribution with parameters (29, 864, 1428) for the first day.

Triangular distribution with parameters (29, 864, 1320) for the other days.

- Brigade Ammunition Bureau Form 581 approval time:

By asking three specialists separately we decide the parameters of the triangular distribution as (5,8,10) minutes for minimum, average and maximum values correspondingly.

- Ammunition Supply Point Form 581 approval time:

By asking three specialists separately we decide the parameters of the triangular distribution as (10,15,20) minutes for minimum, average and maximum values correspondingly.

- Loading time of a vehicle in Ammunition Supply Point by the loading units:

By asking three specialists separately we decide the parameters of the triangular distribution as (30,40,50) minutes for minimum, average and maximum values correspondingly

- Loading time of a vehicle in Army Ammunition Depot by the loading units:

By asking three specialists separately we decide the parameters of the triangular distribution as (30,40,50) minutes for minimum, average and maximum values correspondingly

- Velocity of a convoy:

It is taken as 25km per hour according to the army traffic rules

Number of convoys loaded at one time: 1

Number of vehicle loaded at one time: 3

New System

- Battalion ammunition consumption per day :

We use the same values stated as in the old system

- For the 155mm self propelled howitzer battalions:

Triangular distribution with parameters (47, 2088, 3456) for the first day.

Triangular distribution with parameters (47, 2088, 2790) for the other days.

- For the 203mm self propelled howitzer battalions:

Triangular distribution with parameters (29, 864, 1428) for the first day.

Triangular distribution with parameters (29, 864, 1320) for the other days.

- Loading time of a vehicle in Ammunition Supply Point by the loading units:

The ammunition is loaded with the containers by the system the vehicles have.

By asking two specialists studying on this system we decide the parameters of the triangular distribution as (5,7,9) minutes for minimum, average and maximum values correspondingly.

- Loading time of a vehicle in Army Ammunition Depot by the loading units:

The parameters of the triangular distribution as (5,7,9) minutes for minimum, average and maximum values correspondingly

- Velocity of a convoy:

It is taken as 25km per hour according to the army traffic

- Number of convoys loaded at one time: 1
- Number of vehicle loaded at one time: 1
- Capacity of one vehicle:

One vehicle can carry one container that has the capacity of loading 20 tons for the maximum. One container can carry 487 rounds of 155mm-howitzer ammunition or 208 rounds of 203mm-howitzer ammunition.

Modified Existing System

- Battalion ammunition consumption per day :

While determining the maximum we used a table function of the ARENA software since the consumption may change day by day according to the orders about the ASR. We use one different “first day value” and use the same other days values according to the manual, since there is no any distinction of the consumption related with the days of battle:

- For the 155mm self propelled howitzer battalions:

Triangular distribution with parameters (47, 2088, 3456) for the first day.

Triangular distribution with parameters (47, 2088, 2790) for the other days.

- For the 203mm self propelled howitzer battalions:

Triangular distribution with parameters (29, 864, 1428) for the first day.

Triangular distribution with parameters (29, 864, 1320) for the other days.

- Loading time of a vehicle in Ammunition Supply Point by the loading units:

By asking three specialists separately we decide the parameters of the triangular distribution as (10,15,20) minutes for minimum, average and maximum values correspondingly

- Loading time of a vehicle in Army Ammunition Depot by the loading units:

By asking three specialists separately we decide the parameters of the triangular distribution as (10,15,20) minutes for minimum, average and maximum values correspondingly

- Velocity of a convoy:

It is taken as 25km per hour according to the army traffic rules

- Number of convoys loaded at one time: 4
- Number of vehicle loaded at one time: 4

Modified New System

- Battalion ammunition consumption per day:

We use the same values stated as in the old system.

- For the 155mm self propelled howitzer battalions:

Triangular distribution with parameters (47, 2088, 3456) for the first day.

Triangular distribution with parameters (47, 2088, 2790) for the other days.

- For the 203mm self propelled howitzer battalions:

Triangular distribution with parameters (29, 864, 1428) for the first day.

Triangular distribution with parameters (29, 864, 1320) for the other days.

- Loading time of a vehicle in Ammunition Supply Point by the loading units:

The ammunition is loaded with the containers by the system the vehicles have.

We decide the parameters of the triangular distribution as (5,7,9) minutes for minimum, average and maximum values correspondingly as in the new system.

- Loading time of a vehicle in Army Ammunition Depot by the loading units:

The parameters of the triangular distribution as (5,7,9) minutes for minimum, average and maximum values correspondingly

- Velocity of a convoy:

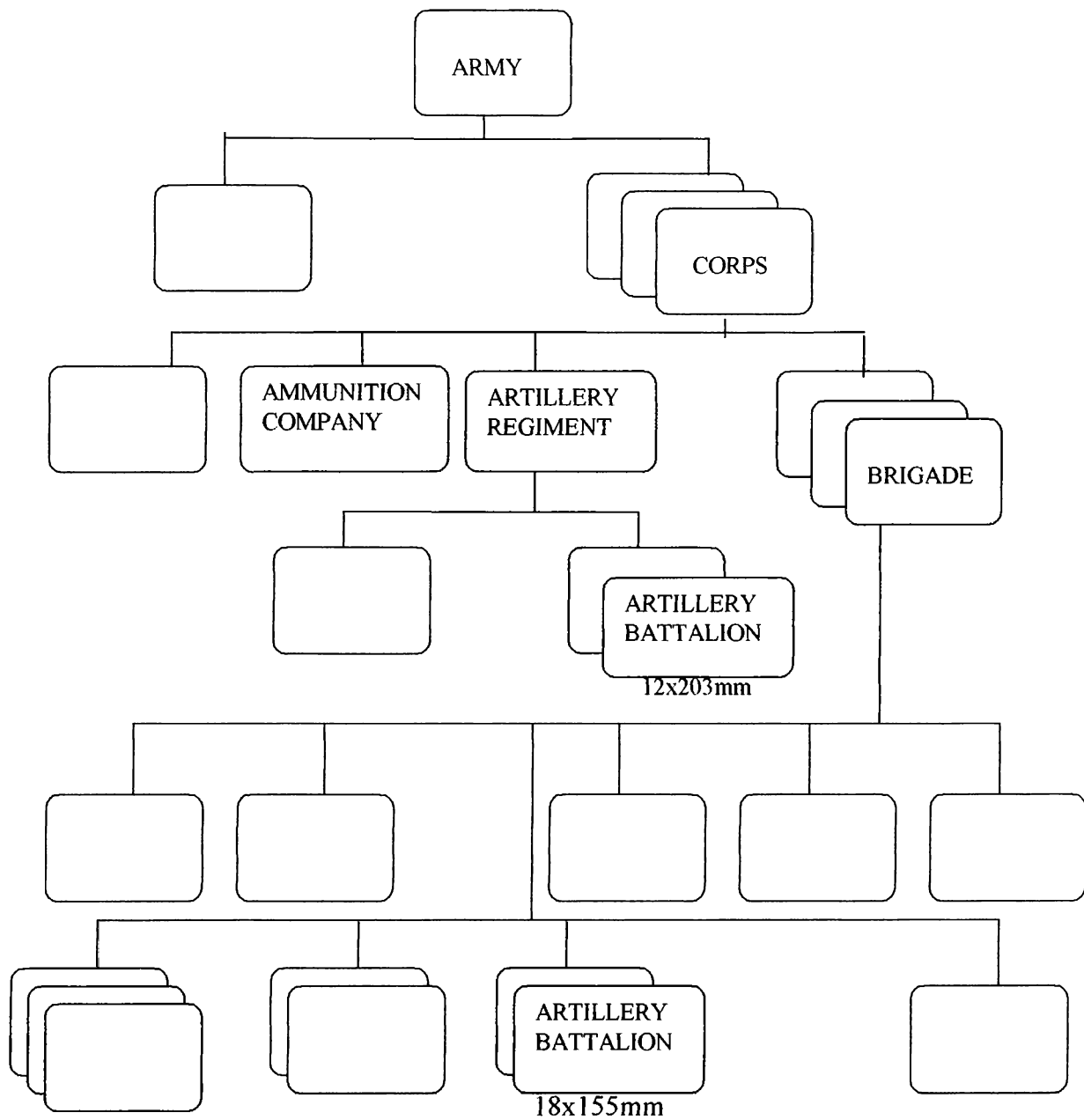
It is taken as 25km per hour according to the army traffic rules

- Number of convoys loaded at one time:4
- Number of vehicle loaded at one time: 4
- Capacity of one vehicle:

One vehicle can carry one container that has the capacity of loading 20 tons for the maximum. One container can carry 487 rounds of 155mm-howitzer ammunition or 208 rounds of 203mm-howitzer ammunition.

Appendix F

Structure of an Army for the Developed Simulation Models



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