AFIT/GSE/ENY/98M-01

PRELIMINARY DESIGN OF A JOINT SIMULATION, ANALYSIS, AND WARGAMING CENTER FOR THE TURKISH GENERAL STAFF

THESIS

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Abbreviations

ACC/SAS	Air Combat Command Studies and Analyses Squadron
AFIT	Air Force Institute of Technology
AFSAA	Air Force Studies and Analyses Center
C2	Command and Control
C4	Command, Control, Communications, and Computers
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
CAA	US Army Concept Analysis Agency
CAN	Center for Naval Analysis
CENTCOM	US Central Command
DMSO	Defense Modeling and Simulation Office
DoD	Department of Defense
DTIC	Defense Technical Information Center
IDA	Institute for Defense Analysis
J-8	The Force Structure and Assessment Directorate, US Joint Staff.
JCM	Joint Campaign Level Model
JSAWC	Joint Simulation, Analysis, and Wargaming Center
JTASC	Joint Training and Simulation Center
JWARS	Joint Warfighting Systems
JWFC	Joint Warfigting Center
MOOTW	Military Operations Other Than War
MORS	Military Operations Research Society
M&S	Modeling and Simulation
NATO	North Atlantic Treaty Organization
OR	Operations Research
RAND	Research and Development Institution
TAFSC	Turkish Armed Forces Staff College
TGS	Turkish General Staff (Joint Staff)
USACOM	US Atlantic Command
WGSC	Wargaming and Simulation Center, National Defense University

Abstract

This study develops a framework for the design of a Joint Simulation, Analysis, and Wargaming Center (JSAWC). JSAWC is proposed as the primary decision support center for the Turkish General Staff. The complexity of warfare systems and the fog of future wars make military planning, problem solving, and decision making processes difficult to accomplish without using computerized analysis support tools. The proposed JSAWC will use modeling and simulation technology to provide analytical support for Turkish military decision-makers and planners in operations planning, force structuring, and training. An iterative systems engineering process is defined and applied to the primary design of the center. After providing a background on modeling and simulation, basic functions of the Turkish Defense System are analyzed to identify appropriate missions, users, and environment of the JSAWC. General needs, constraints, and alterables of the project are identified. Functional objectives and performance objectives of the center are examined by detailing them to the lowest possible level and connecting them with the related system behaviors. A preliminary requirement analysis is completed for the software and personnel areas based on the design objectives and necessary functions. Finally, future study plans are developed to continue the design of the center.

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1 INTRODUCTION

1.1 WHY WE NEED THIS STUDY

As I learned about modeling and simulation technology at the Air Force Institute of Technology (AFIT), I started to ask myself: Do we have our own warfare simulation models which represent the Turkish Defense System? How do we make our operational plans? How do we test them to make sure that they are the best ones? How do we build our force structure? Before buying a new weapon system, how can we know which of them is more beneficial than the others? How do we compare their effects or contributions in possible future wars? How do we decide what type of and what size of force is necessary to defend the country? How do we assess our adversaries' and our operational capabilities? How do we examine our defense system and find its deficiencies? These are only some of the questions that we need to answer honestly in order to be a strong military force.

Unfortunately, the answers to these questions do not include enough usage of modeling and simulation technology. Currently, we do not have our own warfare simulation models. We do not have a center in which this technology is used to analyze military problems. We do not have sufficient personnel educated in this area. We have a few wargame models which are being used for training purposes at the staff colleges, but they do not have a significant capability and serve in only limited training objectives.

The objective of the Turkish Armed Forces is to enter the 21^{st} century as one of the most powerful military forces in the world to protect Turkey and its allied countries' territories and their interests from possible hostile actions. To accomplish this objective, we have to *use and effectively plan* our current military capabilities and future defense budget. It is the only way to build and sustain an ideal military power which guarantees the peace of the country and its allies.

Since the Turkish Defense is a highly complex system, it has never been an easy job to structure, plan, and operate the armed forces effectively. We need some decision support tools to decrease the complexity of military problems and increase the success of the decision-makers. Modeling and simulation technology is a vital tool which can provide important assistance for analysts and decision makers.

The basic objective of this technology is to decrease the complexity of defense problems by projecting the related military systems and their functions into models which can be used for the given study. After creating the models of the real systems, we can easily explore them by using computer simulation technology and solve related military problems. The insights gained from this experimentation will help the decision makers and commanders to understand the problems and make better decisions.

Providing analytical support for the military decision-makers by using modeling and simulation technology has become a very important issue all over the world. US Department of Defense agencies are especially aware of the usefulness of this technology and have been using it for almost thirty years in many military areas. From joint operational planning to tactical mission planning, weapon system selection to force sizing, engineering to test & evaluation, and personnel educating to training, they are benefiting from its advantages [Office of Secretary of Defense, 1992].

In the last decade, computer technology has improved tremendously and keeps getting better. The improving computer technology is directly affecting the capability of modeling and simulation and making it more powerful and more useful for the military community. You can model highly complex military systems and their interactions in war situations. You can run simulations very fast for analysis purposes or you can connect different models from a variety of areas and execute real time simulations for training objectives. These are only a few of the benefits that make this technology necessary for military analysis and training.

It is true that previously the Turkish Armed Forces did not use this technology much in their business. Fortunately, in recent years all of the services (Turkish Army, Navy, and Air Force) have begun to understand the importance of modeling and simulation technology and have prepared some projects in this area. Their plans include creating simulation centers for training and educating Turkish military personnel. But, currently these plans do not cover any usage of modeling and simulation in analysis and decision support areas.

The objective of this thesis is to fill this gap by initiating the preliminary design of a Joint Simulation, Analysis, and Wargaming Center (JSAWC) for the Turkish General Staff. This center will provide the necessary decision support for commanders and high level DoD decision-makers to increase the success of the Turkish Military Forces. Through modeling and simulation, Joint Force leaders will be able to analyze, up front, operational plans and determine how the decisions they will make affect the outcome of a conflict. They will also visualize the force requirements of possible war scenarios and be able to test the alternative force structures to create the best defense system within a given budget.

Besides analysis support, the JSAWC will also offer limited computer assisted wargaming for Turkish generals and some of the staff officers. These wargames will cover current war scenarios and future expectations. With the assistance of wargaming, the commanders and staff officers will find many opportunities to make decisions and plans on the strategic and operation level of war and will be mentally ready for possible crises.

In addition to these general benefits of the JSAWC, since it will be a joint decision support center, military problems will be seen in all three aspects by thinking jointly. This approach will increase the benefits of the overall Turkish Defense System. Otherwise, without first creating a *joint* simulation and analysis center, if we built a similar type of center in each service, there could be a lack of coordination in terms of modeling and simulation standards and there may be overlap between their studies. There may be also a trend of thinking about the success of their own services without understanding the real benefits of the overall defense system.

US Department of Defense faced these types of problems many years ago, because of insufficient coordination, communication and standards between the modeling, simulation, and analysis agencies. Every service created and used its own models without exactly knowing how others were doing the same job. They encountered many difficulties when they had to study together for the same military problem. They spent a great deal of time and money trying to understand each other. Now, the U.S.

Department of Defense are aware of these problems and trying to think and act as jointly as possible in every area [Allen, 1997], [Kjonnerod, 1997]. Creating a joint center in this area will eliminate these kinds of problems and prepare an environment in which our analytical capabilities can be used effectively.

1.2 OBJECTIVES OF THE THESIS

This study has two different types of objectives. The first group is related to the center itself.

- Proposing a Joint Simulation, Analysis, and Wargaming Center (JSAWC) for the Turkish General Staff.
- Showing the importance of this technology for military analysis and training to the Turkish Armed Forces and providing a background for them.
- Learning the military application of modeling and simulation in the world especially in US Defense System.
- Initiating the preliminary design of JSAWC by providing a systems engineering process outline.

The second group is related to the educational objectives of the Master of Science degree.

- Experiencing system engineering process by applying it to a system design project.
- Improving my knowledge about modeling and simulation technology

1.3 SCOPE OF THIS THESIS

In this thesis, I will propose a decision support center for the Turkish General Staff, which will assist the Turkish commanders by analyzing their military problems with the tools of modeling and simulation technology. Designing this center is a very broad project that should be studied by a group of people. This group, called a design team, must include all the required experts such as systems engineer, project manager, software engineer, simulation experts, and cost analyst. All the necessary aspects of the project, from analyzing the Turkish Defense System to detailed problem definition, procuring necessary software tools to planning all personnel needs, organizing the system to constructing the building, must be studied in a very detailed fashion.

I have started this thesis by assuming that in the future the Turkish General Staff will accept this project and start designing the JSAWC. My studies will form a foundation for the future efforts of the project and can be used as reference material for members of the design team. In this thesis, I will focus on the initial part of the project, instead of briefly studying all of the related areas. In some parts of the thesis, I will use future tense in my sentences instead of past tense to refer to the future activities of the project.

Providing a systems engineering approach to the problem is the first thing I will cover in this thesis. Acquiring detailed information on modeling and simulation technology will form the necessary background to continue the study. This information will also be extremely useful for the readers who are unfamiliar with this technology.

A brief analysis of the Turkish Defense System is included in the thesis, which is necessary to be able to assign the correct mission to the JSAWC. Defining the problem, from the decision-maker (the Turkish General Staff) point of view, is the other critical part of the study, which should be done very carefully. Since this is not yet a planned project by the Turkish General Staff, I will take the responsibility of the decision-maker and prepare the problem definition statements according to my point of view. Identifying the mission, users, the environment, needs, constraints, and alterables of the system will be all covered in the scope of this thesis.

Analysis of the system design objectives and required system functions is also included in this thesis. The initial requirements identification for the center, including software and personnel needs, will be defined at the end of the study. I will not include the detail requirement analyses of the software tools and models, but I will provide a requirement specification study for a warfare model as the reference for future efforts.

Identification of system hardware and infrastructure requirements is excluded from the scope of this thesis, because they need system workload analysis for the given missions before studying them. This analysis should be done in Turkey by surveying the potential amount of JSAWC support which is needed.

1.4 OVERVIEW OF THE THESIS

Chapter 2: The methodology of the study is described in this section. This chapter addresses the importance of the systems engineering approach for the JSAWC project and introduces a systems engineering process as the methodology of the current and future studies of the design team. This design process has an iterative nature and it is adapted from Hall's seven systems engineering steps [Hall, 1969]: 1) Gaining Knowledge, 2) Problem Definition, 3) Requirement Analysis, 4) System Synthesis, 5)

System Analysis, 6) Decision Making, 7) Planning for Action. All of these steps, including the actions that should be taken in each of them, are explained in detail. An initial iteration plan is presented at the end of the chapter to provide a guide for further studies.

Chapter 3: Gaining knowledge which is the first step of the system engineering process, is described in this chapter. The necessary topics which should be studied before continuing the design of the center are identified. There are a total of seven important subjects such as "system, model, and simulation" and "military applications of modeling and simulation" in this chapter. All of them are related to modeling and simulation technology and its applications.

Chapter 4: Problem definition of the design topic is presented in this section. This chapter explains the objectives and the importance of the JSAWC. Before assigning any missions to the center, the general structure and functions of the Turkish Defense System are analyzed. The most important activities, from the Turkish national security strategy to tactical operation planning are discussed, including the factors affecting them. After that, the potential users, missions, and environment of the center are detailed. The decision-maker's requests about some aspects of the center are presented as the need statements of the system. The possible constraint areas of the project including monetary, personnel, technology, and security constraints are explained without giving any quantitative input. At the end of this chapter, system alterables, also called decision variables, are identified.

Chapter 5: Requirements of the system are analyzed in this chapter. First, I have examined the objectives of the JSAWC by using hierarchical decomposition technique [Ostrowski, 1977]. The decomposition process is started by dividing the main system objective into the functional and performance objectives. System functional objectives are divided in three major categories: strategy and operational planning, force structuring, and training. There are five sub-objectives under system performance. They are maximum effectiveness, minimum cost, maximum security, maximum flexibility, and maximum reliability. Then by further decompositions, the lowest possible system performance objectives are defined.

After analyzing the system objective, the required system functions are identified by using the same hierarchical decomposition technique. System functions are organized in three main categories: system administrative functions, major system functions, and operational support functions. Then, all of the sub-functions in these categories are described and analyzed in a great detail. After understanding those necessary system behaviors, I have identified the system physical requirements to accomplish the given objectives and system functions. Software and personnel requirements from those physical requirement areas are also addressed. The types of necessary software tools and profession and proficiencies of the personnel are identified.

Chapter 6: In this final chapter, the overall study is summarized. The thesis is concluded the thesis with recommendations for further research and studies about designing the JSAWC.

2 METHODOLOGY

2.1 SYSTEMS ENGINEERING PROCESS

Designing a new complex system like Joint Simulation Analysis and Wargaming Center (JSAWC) is a very challenging task. It requires a deep knowledge about the system topic, and very good planning and organization to produce a satisfactory system. I do not want to say "perfect", because in real life there are many constraints such as money, time, and personnel, so it is almost impossible to design a perfect system. You may see also a system as a living creature. After it is born, it does not stay the same as time goes. People always change or improve the system as they use it and see the deficiencies of the system or when new technology forces the system to adapt to the new environment. The system that I have studied, the Joint Simulation, Analysis, and Wargaming Center of the Turkish Armed Forces, will also have the same dynamic features.

To design the JSAWC, we have to bring all the related proficiencies together in a design team and apply an appropriate systematic approach. The JSAWC design group basically needs to include the following experts.

- *Systems engineers* are needed to accomplish the overall system design. Problem definition, system requirement analysis, producing alternatives, analyzing alternatives and trade-off studies are some of their responsibilities.
- *Personnel who have strong operations background in the Army, Navy, and Air Force* are needed to analyze the Turkish Defense System, to identify correct missions and

users of the system. They will also contribute to specification and validation of warfare models and personnel planning and selection.

- *Personnel who have strong logistics background in Army, Navy, and Air Force* are needed to analyze the Turkish Defense System, to identify correct missions and users of the system. They will also contribute to specification and validation of warfare models and personnel planning and selection.
- *Personnel who have strong modeling and simulation background* are needed to identify requirements of simulation models and tools, analyze, verify and validate them, and to prepare modeling and simulation standards and policies in the system.
- *Computer engineers in network, software, and hardware areas* are needed to analyze computer systems needs in the center. They will be designing the computer network architecture, identifying the software and hardware requirements, and producing related alternatives and analyzing their effectiveness.
- *Project manager* are needed for project planning, activities scheduling, budgeting, project controlling, and other related topics.
- *Civil engineers* are needed to identify the system infrastructure requirements and design building architecture.
- *Cost analysts* are needed for the life cycle cost analysis of the center.

Some of those people may be directly involved in the design project and some of them may be used as advisers out of the design group.

Designing the JSAWC, like designing any complex, system requires the application of a systematic, rational process. After we gather the required proficiencies in the system design team, we need to choose a systems engineering process to apply to the

JSAWC's design study. In the systems engineering area, there is not a unique design process, which is applicable to all system design studies. Although the essential elements and general structure of systematic design processes look similar to each other, there may be some differences depending on the features and environment of the system. It is true that designing an aircraft is not the same as designing a public transportation system or designing the JSAWC.

Sometimes, you may not find an appropriate systems engineering process applicable to your system, so you may need to create your own process or modify a well know existing design process. For the JSAWC design project, I examined the Hall's classic 7 steps [Hall, 1969] as a candidate design process, which is one of the well known systems engineering process in the world. Since it gives a fundamental systematic approach to a system design study, I used it as the basis of the JSAWC's design process. The following design process is the result of adapting Hall's process for this project.

1) *Gaining Knowledge* (What does the design team need to learn about the system topic?)
2) *Problem definition* (System definition: What is the system? What is the objective, missions, needs, constraints, boundaries (environment), and users of it?)
3) *Requirement analysis* (How can the system achieve the given missions? What are the necessary elements that it needs to have? What are required features of those elements?)
4) *System synthesis* (Produce alternatives for the system, subsystem or components)
5) *System analysis* (Examine the alternatives. How does each alternative satisfy the objectives?)

6) *Decision making* (Select the alternative which gives the most benefit in terms of satisfaction of the desired objectives)

7) *Planning for action* (Implementation; plan and schedule to build or buy the selected system, subsystem and component).

Each step of the systems engineering design process shown above is influenced by the actions taken in the other steps. Even though we need to follow the steps of the design process in sequence, there is no rule that we cannot go back and do the previous step again. In most of the system design study, we may need to do a lot of iterations. Sometimes we may not find a feasible solution, or sometimes we realize that we have included unnecessary constraints. For such reasons, we go back and revise the problem definition or requirements. So the process that we are going to follow will have an iterative nature. Depending on the interrelation level of the subsystem and components of the system, the number of iterations is going to change. In some systems design phase as in the JSAWC study, we can not define some components or subsystems, or set their requirements before finishing the identification or selection of the other subsystem(s). For that reason, the design process is going to be spiral or loop as shown in Figure-1. For instance, at JWASC some of the components such as computer hardware, directly depend on the software that is going to be used. We can not start defining the hardware requirements before knowing what kind of software we are going to use at the JSAWC. Since most of the software has different hardware requirements, we need to wait to study hardware components until the decision-maker selects the required software package.

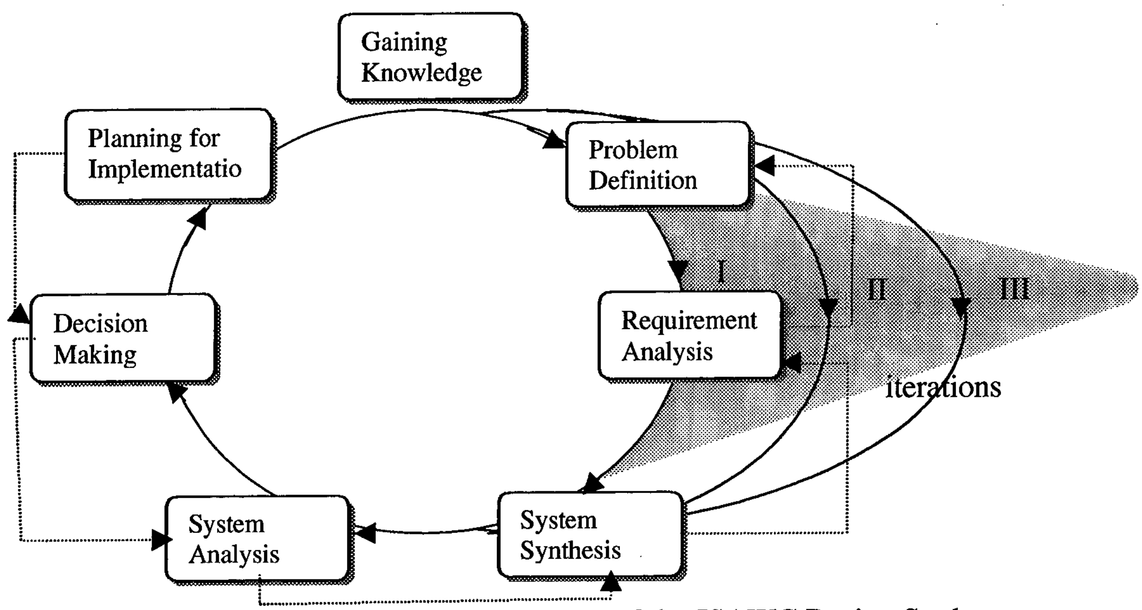


Figure 1: The Systems Engineering Process of the JSAWC Design Study

The methodology described here is offered to the design team to assist in accomplishing the system design in a systematic manner. This methodology is not intended to preclude additional steps or tasks, but is intended to provide a useful, basic working approach to design the JSAWC, a highly complex system. In the following paragraphs, I will explain each step of the systems engineering process selected for use in this study.

2.2 GAINING KNOWLEDGE

We have to accept the fact that we may not have enough knowledge about the system topic that we are going to study. It is for this reason that we need to have different proficiencies in the system design team. Even though you are the expert in one of the system topics, you may not have everything that you need to use on the design study. After you understand what kinds of knowledge you need to have as a team member and identify in what area you are deficient, you may build this knowledge by using some of the following techniques.

- Doing self study
- Taking related courses
- Searching the Internet
- Visiting and examining some places or systems related to your major
- Interviewing other experts or reading studies similar to yours.

In the gaining knowledge step, while we will be learning the newest technology and methodologies about the system topics, we will also examine the past studies to understand the related lessons learned. So, before we start studying the JSAWC design study and during the design study, we need to build up required knowledge about the system topic whenever necessary. This does not mean that every member of the design team has to learn everything about the JSAWC, only that every expert will gain necessary knowledge related to his or her professional area while having a general idea about the whole system.

In this project, there will be an exception. Since I am currently the only member of the design team, I need to build up some more and broad knowledge about the related JSAWC design topics. I listed the following subject areas as important topics which should be known and understood before starting to do the JSAWC design project.

- Modeling and Simulation technology
- Warfare models and their application
- Computer technology
- Simulation, Analysis, and Wargaming Centers in the USA

2.3 PROBLEM DEFINITION

Problem definition is a fundamental step in all system design processes or problem solving techniques. It is a very critical step, because defining the problem or system poorly can cause one to lose much time in unnecessary iteration. Even worse, it may cause one to produce a poor system. As we know, "Finding the correct solution to the wrong problem does not make sense!..". So, in this step, we have to be very careful and define the system very accurately to reduce the risk of losing time and money.

In the problem definition step, there is not a specific rule that we have to follow strictly to define and analyze the problem. The design team, in conjunction with the decision-maker, is expected to somehow clarify questions similar to the following ones [Mosard, 1982], [Hall, 1969].

- What are the system objectives?
- What is the scope of the system?
- In what kind of environment is the system going to work?
- What are the missions or functions of the system going to be?
- What are the possible system design variables/alterables?
- What are the constraints of the system and project?
- Who are the users of the system going to be?
- What are the major assumptions about the system?
- When does the system start performing its mission or objective?

Most of these questions must be answered by the decision maker/customer. The design team in this step should also direct and help the customer by asking necessary questions to come up with a clearer system definition. The design team will then use the answers to those questions in the requirements analysis step of the design process.

2.4 REQUIREMENT ANALYSIS

After completing the problem definition step of the JSAWC, we will go one more step further and analyze the objectives of the JSAWC and its required functions by breaking them down into small parts. Then, we will define the required subsystems and elements of the JSAWC which enable the system to do the desired functions and accomplish the given objectives.

The system objectives defined in the problem definition step are analyzed to define the required functional behavior of the system. This analysis may be through Functional Flow Block Diagrams, Data Flow Diagrams, or other diagramming techniques. The allocation part of the task establishes traceability between requirements, functions and system elements. The feedback loop from Functional to Requirements Analysis indicates the iterative and interrelated nature of these tasks in that as new functions are identified, new derived requirements will need to be defined to quantify the functionality [Hartley, 1988].

The objective is to progressively and systematically work down to the level where resources can be identified with "how" a task or function should be accomplished by a particular system component. Ensure that all functional and performance requirements have been mapped to the system elements. Talk to the decision-makers and possible the system users whenever possible. Identify their wants, needs, and expectations. Organize and categorize these requirements. Quantify these requirements indicating their relative importance to one another [Martin, 1997].

Requirement analysis of the JSAWC can also be thought of as the second phase of the problem definition step as well. The Requirement analysis and problem definition steps are very connected to each other in many ways. The documents written at the problem definition step are going to be the main source documents for the requirement analysis of the JSAWC. Besides those documents, the decision-maker will be another main source for this step.

To perform a good requirement analysis, we need to understand the design objectives of the JSAWC very well. For that reason, the first thing we need to do in this step is to examine objectives of the system in detail. We will use the problem definition documents and interview the decision-maker when necessary to analyze the system objectives. A well-known way to analyze the objectives is creating a system design objective hierarchy and identifying them according to their classes in the hierarchy. We are going to do the same thing for our study. We will create the objective hierarchy of the JSAWC as a first step of the requirement analysis process.

In this step, since we will match the system functions with the system elements, we need to understand how the JSAWC should work, what the relations between the system elements are supposed to be, and what the relations between the system and its environment needs to be. We will also examine the systems required behavioral functions in a hierarchical way, as we will do for the objectives of the JSAWC.

2.5 SYSTEM SYNTHESIS

System synthesis is basically producing potential alternatives for the system that you are trying to design. These alternatives can be totally different architectures that satisfy the system requirements, or they can be alternatives only for the system elements or subsystems. During successive iterations of the process, one or more of the design concepts will be synthesized for each system concept.

In this step, we identify which functions will be performed by which system elements, and we allocate the associated performance of each function to the appropriate system element. Here, we need to ensure that the system elements at each level in the architecture satisfy all requirements and constraints

Synthesis is conducted to define system elements and to refine and integrate them into a physical configuration of the system. At each level in the architecture, design requirements, process requirements, physical configuration, and interfaces must be verified to ensure that functional requirements are satisfied.

The object of producing the alternatives is to design a better or optimum system under the given requirements and constraints. But, because of time constraints or the type of system, we may not be able to produce as many alternative as we want. At this point, a feasible solution may be enough for the decision-maker.

For the JSAWC design study, we can see the following as potential system components or structures for which we can produce alternatives.

- Software
- Hardware
- Personnel/professions

- Infrastructure
- Organization

In addition, since these alterables are dependent on each other, we have to expect that any change on one of them may directly or indirectly affect the others. So we need to understand all the relations of the system components with each other while producing the design alternatives.

2.6 SYSTEM ANALYSIS

System analysis is nothing more than understanding how the system works and how well it performs the desired functions under a given condition. This is a kind of test of the system in which we examine performance of the alternatives. We look at the measures of effectiveness of the system or its components defined by the decision-maker. We then try to figure out how each alternative satisfies the requirements and look at their advantages and disadvantages against other alternatives. We will also try to find what makes an alternative better or worse than other ones.

In this step, one of the useful tools that can help us is modeling and simulation. If the system is very complex and if creating a prototype and doing experimentation on it is very expensive or impossible, we prefer to build a model of the system and analyze it by using simulation techniques. Depending on the resolution of the model of the system, we may be able to examine the whole performance of the system and desired system elements. After that, by looking at the related measure of effectiveness we identify how each alternative contributes to the whole system objectives.

Modeling refers to the development of a descriptive or predictive model representing each alternative set of activities or representing the whole system of interest in such a way as to allow alternative configurations of the systems to be analyzed. Each model should depict system element interrelationships and/or gross resource requirements to the degree necessary in order to help determine the effectiveness and other consequences of each alternative set of activities [Mosard, 1982].

In the JSAWC design study, For example, it is possible to model the computer network of the center including software speeds, hardware capacities and performance, work load, personnel activities, and so on. Using this network model, we may try different computer network structures, hardware types, or software to find how they contribute over all systems objectives in the short and long term.

We can not say that modeling and simulation is applicable to all types of systems. Sometimes, even though we see it as an applicable tool, it may not be very useful because it is very time consuming, requires highly expert people, or is very expensive. If you do not have enough time to create a model of the system and simulate it, you need to search for other tools to analyze the system.

The objective of the system analysis step is not just modeling. Its main objective is to evaluate the alternatives of the system by using any method necessary and applicable to the study. Modeling and simulation is only one of the tools which may be used to analyze the effectiveness of the alternatives.

2.7 DECISION MAKING

Before the decision making step, we passed through the system synthesis and system analysis steps in sequence. In the system synthesis step, we produced the alternatives of the system architecture, subsystem and system elements, which satisfy the related system requirements defined at the requirement analysis step. Then, we examined those alternatives in the system analysis steps, to learn how each alternative affects the system performances. In the decision making step, we select the best system alternative relative to their contribution to the design objectives.

Decision-making step is not a step that can be passed trough only once. Since the systems engineering process is an iterative process, we can visit the decision making step as often as needed. The decision-maker and his preferences are the most important players in this step. He is one of the main authorities who identify the direction of the system design study. Selecting the alternatives of the system is the responsibility of the decision maker rather than design team. For that reason, the decision-maker's interaction with the design team members is critical to help reduce the process iteration and total system design time of the system.

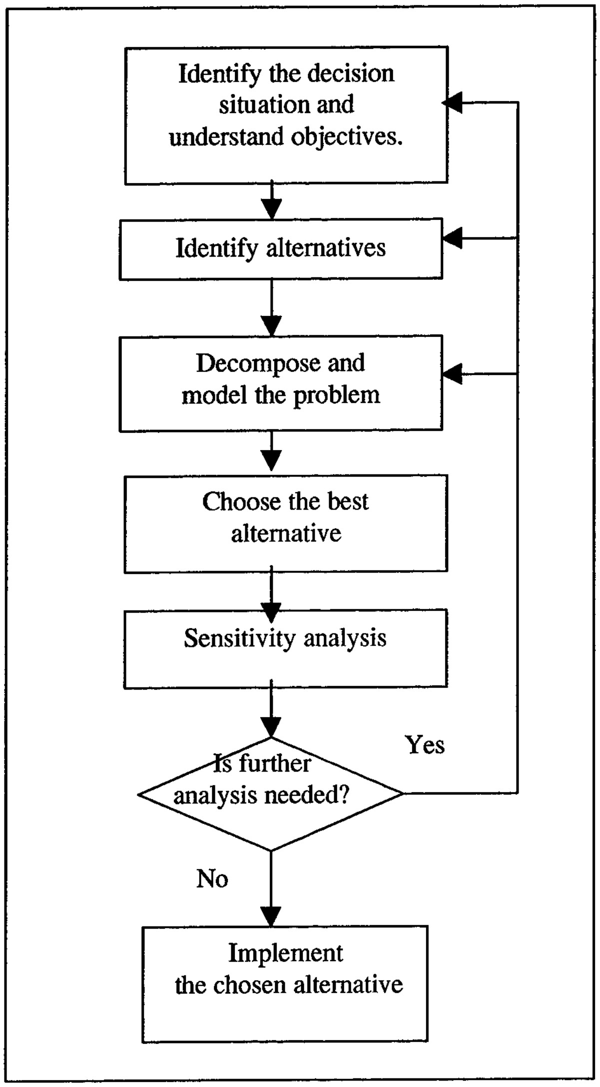
In this step, before we put the alternatives in front of the decision-maker, we perform decision analysis procedures to show how each alternative contributes to the given system objectives. To do that, we need to learn the decision-maker's importance levels in the form of weights on the measures of effectiveness (attributes) of the related alterables (any thing that we are going to make decision on). If there is more than one objective related to an alterable we use multi attribute decision theory to analyze the situation. In decision analysis we try to consider all risks, effectiveness, uncertainties, and costs related to the given alternatives. Decision analysis assists decision-maker to understand all aspects of the problem by providing systematic guidance.

There are many decision analysis techniques being used in a variety of areas. One is Dr. Robert T. Clemen's approach described in the "*Making Hard Decisions, 1995*". Figure-2 shows the flowchart for the decision-analysis process explained in his book.

In the first step, we try to understand the whole aspects of the decision situation. What is important? What are the objectives? Minimize cost and/or maximize profit? How outcomes must be measured and what kind of uncertainties and risks should be considered in the analysis? By answering those questions we try to visualize the decision situation. Second step, identifying the alternatives, has been already done before we came the decision making step.

In the third step, we decompose the problem to understand the structure and different aspects of the problem. After that, we model the decision problem by using tools such as influence diagram and decision trees. For the multiple objective case we assess utility functions in order to model the way in which decision-makers value different outcomes and trade off competing objectives. Here, the advantages of the mathematical representation of a decision can be subjected to analysis, which can indicate a preferred alternative.

Since the objective of the decision analysis to find the best alternative, we try to cover as many scenarios as we can in our analysis. By asking "what if" questions to the decision model, we perform sensitivity analysis to see if the outcome changes in different situations. By doing sensitivity analysis we want to make sure that the alternative we select gives the optimum benefit to us in all possible situations.



We know that the decision analysis process is also an iterative process. We may encounter problems with the decision model as the study goes on or the decision-maker's objectives and preferences may also change over time since he learns the problem much more. For these reasons we ask the decision-maker and ourselves if the analysis that we have done is satisfactory or not. If it is not we refine the decision model and do additional required analysis on it. If it is good enough, we stop the decision making process and implement the chosen alternative.

Figure 2: Decision Analysis Process [Clemen, 1995]

As I mentioned earlier, we are going to perform the decision analysis every time when we need to select certain alternatives during the system design process of the JSAWC.

2.8 IMPLEMENTATION

After an alternative has been selected for the related system elements, it may be appropriate for the design team to assume some of the responsibility for planning the implementation of the alternative. Then, they can proceed with further design iterations.

The following tasks are designed to accomplish this step [Mosard, 1982].

1) Develop plans for initiating or implementing the selected alternative set of activities (show schedule and sequence of tasks, responsibilities and resource requirements for implementation activities).
2) Develop implementation contingency plans with scheduled decision points and decision responsibilities.

2.9 DESIGN PROCESS ITERATIONS

Since the JSAWC's design process has an iterative nature, we cannot complete this project in the initial application of the process. As explained in the section 2.1, there is a close relationship between the system elements, such as software, hardware, and personnel in which specifications and quantities of one of these elements affect the requirements of the others. This relationship between the JSAWC's elements forces us to apply the systems engineering process for each group in sequence. For that reason, we have to make an initial iteration plan for the project. This plan will serve as a guide for my studies and will be refined as the design project goes through.

At least three iterations of the systems engineering process are proposed for the JSAWC project. The reasons for three iterations are explained fully in the requirements analysis section of this thesis. In the first iteration, the software and personnel requirements are developed. In the second (which is not in this thesis scope) organizational structure and hardware will be considered, and in the last one, system infrastructure. In all three iterations, we will pass through all the seven steps in sequence. The actions what need to be done in those steps are shown on the following table.

Table 1: Iterations of the Systems Engineering Process.

Design Process \ Iterations	I	II	III
1. Gaining Knowledge	- System Model and Simulation - Warfare Simulation Models - M&S and Computer Technology - Simulation and Analysis support in the Gulf War. - Military applications of Modeling and Simulation - Simulation, Analysis, and Wargaming centers in the US DoD.	- Computer network - Computer hardware technology - Office Hardware - System organization	- Civil engineering and architecture.
2. Problem Definition	- The System Definition - Turkish Defense System - The Missions of the JSAWC - The Users of the System - The System Environment - Need Statements - Design constraints - The System Alterables	Modify if necessary	Modify if necessary
3. Requirement Analysis	- The System Objectives Decomp. - The System Functional Decomp. - The system Workload Analysis - The system Physical Requirements * Software Requirements * Personnel Requirements	- Hardware; computer and other system hardware requirement. - Organizational Requirements	- Infrastructure Requirements (facility layout; example: required type of, size of , number of rooms, and other physical requirements)
4. System Synthesis	- Produce Alternatives for Required Software and Models. - Produce Alternatives for Personnel Combinations.	- Produce alternatives for the computer hardware systems. - Produce alternatives for the other JSAWC hardware systems - Produce Alternative Organization Structs.	- Produce alternative locations. - Produce architectural structures for the new JSAWC building. - Search for existing buildings as alternatives
5. System Analysis	- Evaluate all the Alternatives (How do they satisfy the system requirements and objectives?)	- Evaluate all the alternatives of the hardware systems and organizational structures	- Evaluate the alternatives of the Locations and infrastructures.
6. Decision Making	- Perform Decision Analysis - Select the required software, proficiencies, and organization structures	- Perform decision analysis and select the required hardware systems	- Perform decision analysis and select the JSAWC's location and infrastructure.
7. Implementation	- Develop a plan for the procurement of the selected software and models - Develop a plan for acquiring selected proficiencies (personnel).	- Develop a plan for the procurement of the selected hardware systems. -Detail all the org. structures, related issues and	-Plan for the procuring the location and constructing the building.

3 GAINING KNOWLEDGE

3.1 INTRODUCTION

In the gaining knowledge step, the JSAWC design team must learn all the necessary information about the system topic. All of the team members should perform research on the topics related to both their expertise and their areas of responsibility for the design project. As the only member of this project, I identified the following areas that I needed to gain knowledge about before starting the JSAWC design project.

Table 2: Research Areas of the Project

TOPICS	QUESTIONS
System, Model, and Simulation	• What are the definitions of system, model, and simulation? • What are the relations between those terms? • Why and when do we need to create models and conduct simulation?
Warfare Simulation Models	• What is a warfare model? • What are the purposes of warfare models? • How are their structures? • What type of warfare model exists?
Military Applications of Modeling and Simulation	• What are the purposes of using modeling and simulation technology in military? • What are their application areas?
Simulation and Analysis in the Gulf War	• How did the US Armed Forces use Simulation and Analysis tool in the Gulf war? • What were the application areas? • How did this support affect the result of battles? • What are the lessons learned?

Computer, Modeling and Simulation Technology	• What are the current computer, M&S trends in terms of hardware, software, network, graphics, ...etc.?
Limitation of Modeling and Simulation	• What are the limits, problem areas of modeling, simulation and their usage?
Simulation, Analysis, and Wargaming Centers	• What are the main simulation, analysis, and wargaming centers in the USA and in TURKEY? • What are their purposes and missions? • What are their organizational structures? • What are their previous products or studies? • What kind of models are they using?

After I defined these topics and related questions, I performed research to fill my knowledge deficiencies in those areas. The first step was to take appropriate academic courses in simulation and combat modeling: *OPER-561 Object Oriented Simulation, OPER-671 Combat Modeling I, OPER-672 Combat Modeling II, and OPER-674 Joint Mobility Modeling* [AFIT Catalog, 1997]. In addition, I surveyed the open literature including DTIC (Defense Technical Information Center), RAND (Research and Development Institution), and MORS (Military Operations Research Society) publications (Bibliography). Information on the Internet, especially Defense Military Simulation Office home page was another important resource for my researches [DMSO, 1997].

Another source of information was visits to US military agencies and centers who are actively using modeling and simulation technology. I visited nine DoD agencies and centers in Washington DC. and West Virginia. They were:

- AFSAA (Air Force, Studies and Analysis Agency),
- CAA (US Army Concept Analysis Agency),
- CNA (Center for Naval Analysis),
- IDA (Institute for Defense Analysis),
- J-8 (The Force Structure and Assessment Directorate),
- JTASC (Joint Training and Simulation Center)
- JWFC (Joint Warfigting Center)
- SAS (Air Combat Command Studies and Analysis Squadron)
- WGSC (National Defense University Wargaming and Simulation Center)

In these visits I interviewed more than forty-five people who were simulation and modeling experts, operations analysts, wargame experts, and computer engineers. These interviews were extremely helpful for me to understand how these US Department of Defense Agencies use modeling and simulation technology. During the interviews we discussed applications, advantages and limitations of the simulation technology, lessons learned and their future plans in military analysis and training areas.

The following parts of this chapter summarize what I have learned and provide a basic introduction for the Turkish DoD for future design team members. The sequences of the topics are as in Table-2.

3.2 SYSTEM, MODEL AND SIMULATION

The basic definition of a system is a group of elements, either human or non-human, that is organized and arranged in such a way that the elements can act as a whole toward achieving some common goals, objectives, or end [Kerzner, 1979]. Some examples of current military systems that are compatible with this definition; MG3 gun, AAM-9 Missile, M-48 Tank, F-16 Aircraft, 192 Fighter Squadron, Air Combat Command, Turkish Air Force, Turkish Joint Force, and NATO. These systems range from engineering level systems to organization level systems or simple systems to more complex systems. The definition of the system depends on the purpose of the study and where you look at the problem. If you are an engineer at Lockheed, the F-16 may be the system you are dealing with. But if you are Chief of Staff, all the armed forces form your system. As a commander of national military forces, your concern is to work towards a system or make a system which is going to give you success in unknown future wars. In this project, the Joint Simulation, Analysis, and Wargaming Center (JSAWC) is the system I will study.

Many times, we find ourselves in a position where we have to deal with many problems about the systems in our responsibility. There are many different ways to examine and solve these problems. One of the most effective approaches is doing experimentation on the system to understand the relationships between its components and its overall behavior. The experimental method is based on a scientific principle, but it has many limitations. It is often inappropriate or difficult to carry out an experiment, because it is:

- too expensive

- too dangerous
- impossible
- very much time consuming
- or the real system does not (yet) exist.

Consider the YF-22 aircraft, for an example. If you want to do experimentation in the design phase, for every change on YF-22 you have to produce a prototype and fly it. We know that it is practically impossible and extremely dangerous. For another example, as a commander or operation planner, assume that you have many tactical ideas in your mind and you would like them to be tested before making your final decision. As you can see it is very expensive, dangerous, and time consuming to use real soldiers and equipment for the experiments. We can produce many more examples like these to show the problems with real time experimentation.

If the experiment on a real system cannot be carried out, we can build a model of the system and use it to find the answers to these questions by experimenting on the model instead. So what is a model? A *Model* is a physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process [Hughes, 1997]. In other words, it is an abstract representation of actual system or subsystems for the purpose of studying the system [Banks, 1995]. Even if a model is a simplification of the system, it should be sufficiently detailed to permit valid conclusions to be drawn about the real system. It is usually not true that a bigger model is a better model- the best model is the simplest one that fulfills its specific purposes.

Models are not reality, and a model, no matter how complex, is only a representation of reality and should never be confused with it. Although it does not represent every aspect of the system, a model would allow the analyst to better understand the complex interrelationships of the system and through the model the analyst can generate specifically tailored information that he can not retrieve directly from the real system.

We can classify models in many different ways. The categories in the classification scheme given below are not the only ones and may not be all mutually exclusive.

Mathematical model: If the relationships between quantities in the system are described as mathematical relations then we call it a mathematical model.

Computer model: It is a computer program that implements a system's model.

Static – Dynamic: A static model represents a system at a particular point in time. A dynamic model represents the system as it changes over time.

Deterministic – Stochastic: Models that work with an exact relationship between measurable and derived variables and express themselves without uncertainty are called deterministic models. They do not contain any random variables inside any relationship. On the other hand, if a model has one or more random variables than it is called a stochastic model.

Discrete – Continuous: If the state variable values change at only a countable number of instants in time, it is called a discrete model. In a continuous model, state variables can change at any time.

For many reasons, the model can be used to calculate or decide how the system would have reacted. This can be done analytically, that is, by mathematically solving the equations that describe the system and studying the answer. But this method sometimes can be impossible or very difficult depending upon the complexity of the system. With effective computer power, a numerical experiment can be performed on the model. This process is called *simulation.* Simulation is a process which allows us to understand the behavior of an existing (or future) system by observing the behavior of its model.

The most critical in the modeling and simulation discipline is to build a correct model to properly represent the system and address the problem to be solved. While modeling deals primarily with relationships between real systems and model, simulation refers primarily to the relationships between computers and models (Figure-3). In other words, modeling is the development of equations, constraints, and logic rules, while simulation is the exercising of the model. Simulation models give opportunities to express the relationships of the components of the system in decision rules in addition to algebraic equations. If the simulation study is properly conducted, with good planning and by posing meaningful questions to be answered, it will lead to increased knowledge of the system.

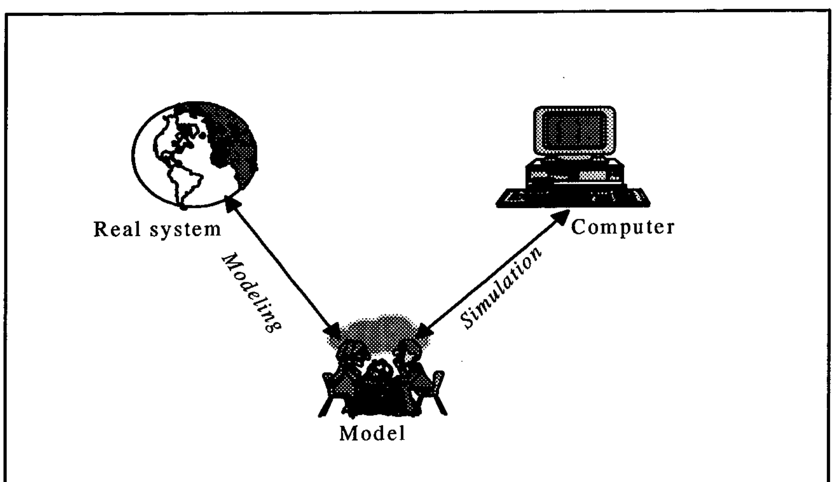


Figure 3: The Basic Elements and Relations of Modeling and Simulation,

[McHaney, 1991]

The continuing advancement in computer technology in terms of reduced size, and increased speed, capacity, and reliability, coupled with cost reduction, makes simulation technology very attractive and encourages people to use as much as possible. The following are some of the activities in which modeling and simulation tools can be used very effectively.

- Increase the understanding of the system itself
- Optimization of the system design
- General analysis
- Performance evaluation
- Sensitivity analysis
- Compression of alternatives
- Forecasting
- Human in the loop training
- Teaching
- Decision making

The advantages of modeling and simulation are numerous: there is no need to experiment with the original system, there is no threat to the system: results can be obtained quickly and investigations can cover a much broader range than would be possible with the real system.

Simulation is an inexpensive and safe way to do analysis without constructing or experimenting with the real system. Safety is of primary importance under circumstances in which the lives or health of people might be in jeopardy or expensive equipment might be in danger. For instance, in many military forces senior officers spend a lot of time on performing war games, i.e., simulation of large-scale military maneuvers, so that they can be exposed to many possible situations before performing live exercises. As a result, they may find optimum tactics or maneuvers which decrease the possibility of personnel injury or death.

In a design phase of an unexisting system, you can test the alternatives by modeling and simulating the desired system behavior before make any selection. It gives you an opportunity to analyze and understand how each alternative contributes to the objectives of the system. So, you may find optimum system structure, elements and components to design the system. It also provides hints concerning necessary actions to avoid inadmissible or even dangerous developments. Using modeling and simulation we can experiment with systems in early stages of their development.

Computer simulation experiments are completely repeatable and nondestructive. Once developed and validated, a model can be used to investigate a wide variety of "what if" questions about the real-world system and do sensitivity analysis. They can be run over and over switching various operating regimes to determine how best to operate the real system.

3.3 WARFARE SIMULATION MODELS

Warfare simulation models are models that represent any part of the military systems or operations. In the world, there are many different types of warfare simulation models being used including combat models, mobility models and wargames for training, education or analysis purposes.

The Military Operations Research Society (Anderson, Cushman, Gropman, and Roske) developed a very useful decomposition of warfare simulation models in 1989 [Anderson, 1989]. I will summarize their study and include my ideas about taxonomy of warfare simulation models.

There are many ways that we can classify the warfare simulation model. MORS has defined three equally important, relational (as opposed to hierarchical) dimensions; the *purpose*, the *qualities,* and the *construction* of the warfare model. In addition to those dimensions, I will also show the classification of military models in a hierarchical perspective.

3.3.1 CLASSIFICATION BY PURPOSE

There are two main purposes for which we build a warfare simulation model. One of them is analysis and the other is training and education (Figure-4). Most models are mainly built for either analysis needs or training and education purposes, but you can also find some models that can be used for the both purposes. If a model is used to discover relationships, to understand the logic of the systems, or to explore the merits of alternative courses of action, then the purposes is analysis. If a model is used to teach some lessons or relationship that is already known, then the purpose is training and education.

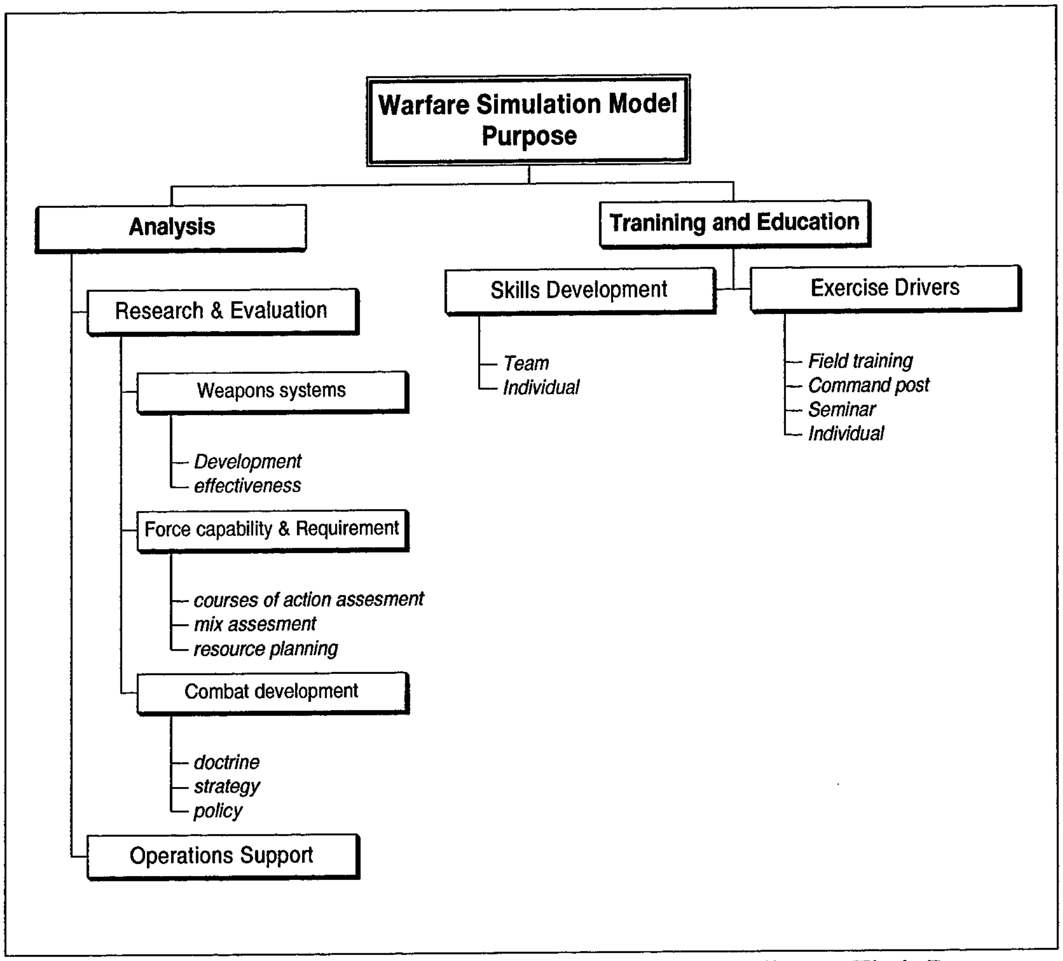


Figure 4: Classification of Warfare Sim. Models According to Their Purposes.

3.3.1.1 Analysis

Warfare simulation models are being used extensively in the defense community of many counties for analysis purposes. They are used at the strategic, operational, and tactical levels of warfare to evaluate combat processes and outcomes to support analysis or ongoing operations. Measuring weapon system's effectiveness, providing forecasts for acquisition, planning, programming and budgeting, testing and evaluating operational plans are examples of objectives of military analysis.

Warfare simulations provide significant insights into planning, movement and employment of forces, logistical and operational coordination, weapon system use in complex environments, and infrastructure requirements. They are also used for specific analysis such as missile defense, air to air, and air to ground type of combat activities.

Analysis can be further subdivided into two branches, *Research and Evaluation*, and *Operations Support*. The Research and Evaluation may be subdivided into three levels: weapons systems, force capability assessment and combat development. Weapon system development and effectiveness analysis fall into "the weapon system" category. Course of action assessment, force mixture assessment, effectiveness, and resource-planning analysis fall into "Force capability and requirements". "Combat Development" examines current doctrine, explores new doctrine, evaluates competing strategies or tactics, and studies various policies.

By operations support we mean supporting the decision making elements of operations, resource management, and operations. Automatic mission planning, inventory reorder, and weight and balance models for loading aircraft are some examples for this category.

3.3.1.2 Training and Education

Another broad purpose of using warfare simulation models is training and education. In a training perspective, we generally use simulation models to improve the personnel's skill of operating weapon/combat systems that include aircraft, tanks, and guns, depending on the proficiency and position of the personnel. Training simulations recreate situations that people will face on the job and stimulate the subject to react to the situation until the correct responses are learned. These devices produce better-prepared personnel without the expense of making mistakes on the job. Training technology, when properly designed and implemented, can dramatically improve student performance when compared to traditional classroom training methods.

In the education perspective, warfare simulation models are commonly used to improve staff officers' level of awareness and understanding of military problems in strategic and tactical planning. By using war games, commanders can explore critical military issues, and improve their decision-making capability under current crisis scenarios.

3.3.2 CLASSIFICATION BY QUALITIES

MORS has also classified the warfare models according to real entities and processes which the models represent. They examine the qualities of the model in seven categories: domain, span, environment, force composition, scope of conflict, mission area, and level of detail of processes and entities (resolution).

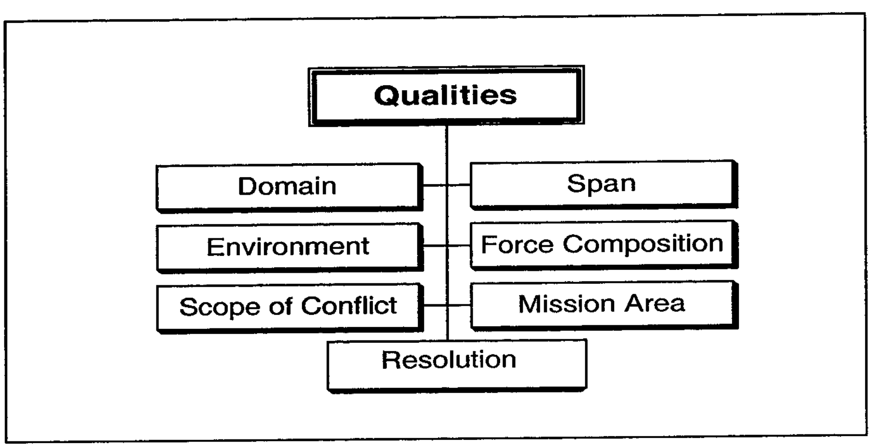


Figure 5: Classification of Warfare Sim. Models According to Their Qualities.

3.3.2.1 Domain

By domain we mean the physical or abstract area/space in which the entities and processes operate. The physical domain can be land, sea, air, space, undersea or any combination of the above. The abstract domain can be an n-dimensional mathematical space, or economic or psychological domains.

3.3.2.2 Span

Span is the scale of the domain that can be global, theater, regional, local, or individual.

3.3.2.3 Environment

The environment is the physical makeup or detail of the domain that is terrain structure, weather, day, night, etc.

3.3.2.4 Force Composition

The mix of forces that can be represented by the model such as combined forces, joint forces, components, or elements. Processes such logistics, communications, and intelligence as well as the composition of force entities work together to determine the force composition abilities of the model.

3.3.2.5 Scope of Conflict

This dimension describes the category of weapons which can be either conventional, chemical, biological, or nuclear.

3.3.2.6 Mission Area

The mission area can be air to air, air space control, airlift, sea control, undersea operations, indirect artillery or other combinations of military missions.

3.3.2.7 Resolution (Level of Detail)

We can examine resolution in two sub categories: a) level of detail of entities and b) processes. By level of detail of entities we mean the lowest discrete entity that can be represented in the system model. It can be air division, wing, squadron, aircraft, or components of the aircraft. This level changes according to the design purpose of the model.

The resolution of processes shows how much detail interactions of individual combatants or weapon systems should be represented in the model. For example, for an air to air mission you may model all the maneuvers of the aircraft in a engagement or you may model their relation just as a probability of kill (Pk).

There is always a trade off between resolution and size of the force that you can model. You can build a high-resolution model, which is a reasonably accurate representation of the system but focused on one small area (small forces). On the other hand, if you prefer to model more complex and larger forces you could lose detailed information about the individuals and the engagements, so your model is going to be an aggregated (low-resolution) model.

3.3.3 CLASSIFICATION BY CONSTRUCTION

We can organize the model structure into four major categories. They are human participation, time processing, treatment of randomness, and sidedness.

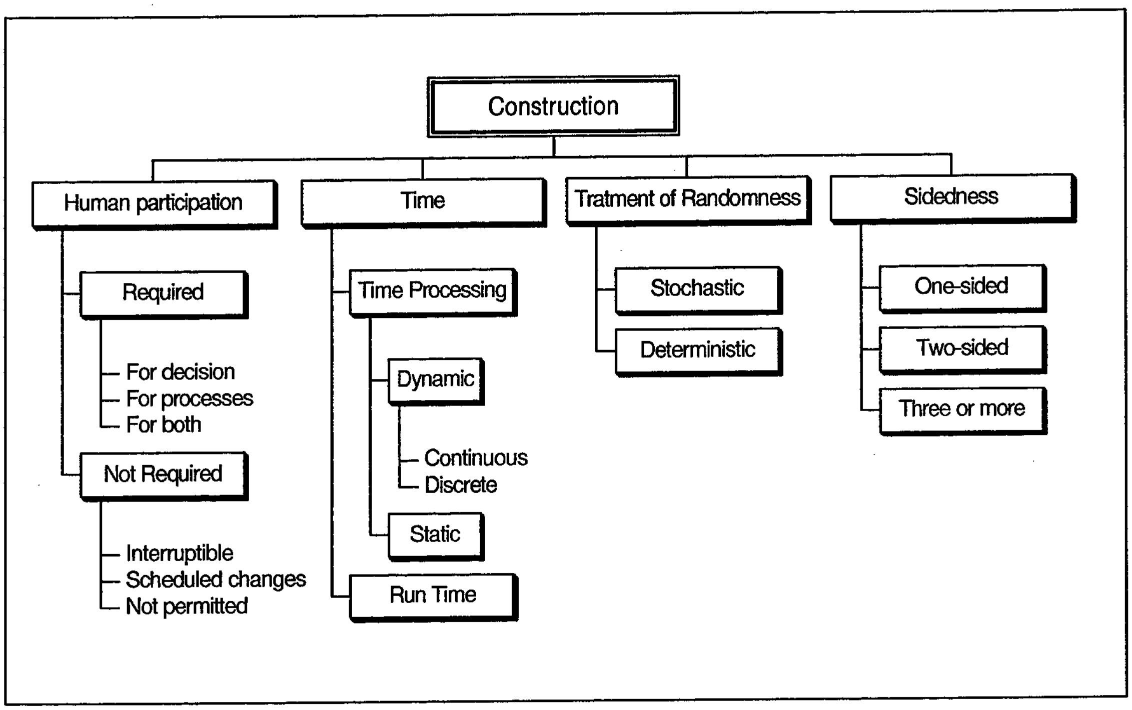


Figure 6: Classification of Warfare Sim. Models According to Their Constructions.

3.3.3.1 Human Participation

In this category, we first look at the model to determine if human participation is required during the simulation or not. A model that requires human participation is sometimes called *interactive* or *human-in-the-loop model.* If it does not require human participation, sometimes we call it a *fully automated model.*

Human participation required. This type of model may require decisions that humans would have to make in combat situations or some physical process and/or outcomes for specific combat interactions that have to be selected by human participants during the simulation. At the time the model needs human participation it may keep running (simulating) events as if no decisions were being made or it may wait for human input.

In the human interactive models, the hard decisions are handed off to the individual players. The commanders and other decision-makers view status and intelligence reports prepared by the computer model and provide the decision input to the model by giving orders to the simulation just as they would give orders to subordinates in actual combat. Although having decision-makers interaction during the simulation makes the combat model simpler, it may make analysis of model output more difficult.

Human participation not required. In warfare models which do not require human participation, the entire management of the battle scenario such as force movement, engagement initiation, engagement outcomes, and the representation of time, are simulated by computer. These computer simulations can also automate all of the required decisions which are an important part of combat models. Such models are called batch run models. Since they simulate the entire battle scenario without human interaction during program execution, you have to input all the decision logic for any required decisions prior to running the model.

Even though these types of models do not necessarily require human participation, it is possible to interrupt some of them during the simulation. Some models allow you to pause the simulation and change decisions/data at any time. Some others allow interruption only through scheduled changes or at certain time periods.

There are also some models which cannot be interrupted at all during the simulation period.

3.3.3.2 Time

The way a simulation model handles time is one of the most important factors affecting the structure of the model. There are two aspects of time in a model, "Time Processing" and "Run Time".

3.3.3.2.1 Time Processing

There are two options for the time processing of the model: dynamic or static. Static models do not depend on time, and they represent the system as if time change does not affect the behavior of the system. On the other hand, dynamic models explicitly represent the passage of time. They show how the time changes impact the system resources and function.

If the model is a dynamic model, it may represent time continuously or discretely (incremented in steps). A model is called a discrete model if the state variable value changes at only a countable number of instants in time.

3.3.3.2.2 Run Time

Basically, we could examine the run time of the simulation model in four categories. Simulation time of a model may equal real time, be faster or slower than real time, or a combination of the three. Real time simulation models are generally used for training and education purposes in distributed simulation environment. On the other hand, faster than real time simulation models are preferred for military analysis studies, since results can be collected more rapidly and many alternative scenarios can be explored in a short time.

3.3.3.3 Treatment of Randomness

There are two different types of models depending on how they treat randomness. These are deterministic models and stochastic models. If the model contains no probabilities or random effects then it is called a deterministic model. It can be deterministic model of either stochastic processes or deterministic processes. On the other hand, if a model uses random numbers for any process that the model represents, it is called a stochastic model. Stochastic models may produce different outcomes of the same event each time they are run.

3.3.3.4 Sidedness

This refers to the number of collections or alliances of resources working in or through the model toward a common goal. Models are classified a being one, two, or three or more sided.

3.3.4 WARFARE SIMULATION MODEL HIERARCHY

Warfare models are generally classified in a hierarchical perspective as shown in the figure below.

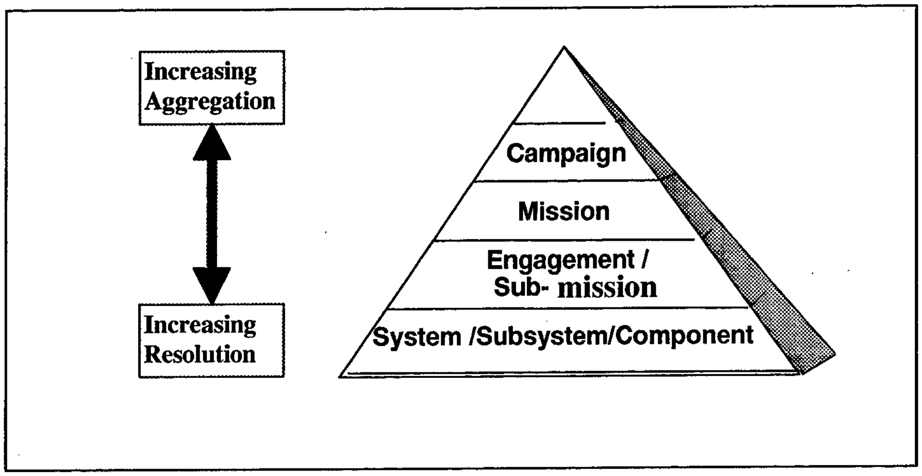


Figure 7: Warfare Simulation Model Hierarchy

The levels within the above hierarchy are described as follows:

- System/Sub-system/Component (Engineering) - Design, cost, manufacturing, and supportability. Provides measures of performance.
- Engagement/Sub-mission - Evaluation of system effectiveness against enemy systems. Provides measures of effectiveness at the system level.
- Mission (Battle) - Effectiveness of a force package or multiple platforms performing specific missions.
- Campaign (Theater) - Outcomes of joint/combined forces in campaign/theater level conflict. Provides high level measures of merit.

For analysis, the System/Sub-system/Component level models have been used to support engineering level tradeoffs and design decisions. The Engagement/Sub-mission level of models has been used to represent systems in one-on-one or few-on-few simulations to provide lethality, survivability, and vulnerability assessments. Mission/Battle tools support higher levels research and analysis such as requirement development. The Campaign and Theater level of models support at higher level of acquisition and force structure decisions. On the training side, most simulator applications have been supported by the Engagement/Sub-mission to Mission level while battlestaff training and educational wargaming have been conducted at the Campaign level.

The models within the three upper level of the pyramid can be used in many different areas such as resource allocation, Mission Area Assessment, Mission Needs Analysis, and Mission Area plans or functional Area Plans. At the System/Sub-system/Component level, simulation models supports design tradeoffs in research and development and aids in test design, test conduct, and pre-test and post-test analyses during Test and Evaluation (T&E). At the Engagement/Sub-mission level, simulation models support more complicated, integrated studies such as Combat Operations Effectiveness Analyses (COEAs), capability analyses as well as T&E plans for system performance.

3.4 MILITARY APPLICATION OF MODELING & SIMULATION

The USA's military forces and Department of Defense (DoD) are using computer models extensively. Before making important military decisions, most decision makers are analyzing the critical and complex issues by using warfare simulation models. Since they have experience in modeling and simulation (M&S) use, I did a search to learn in which military areas they are using this technology. Basically, they divide M&S applications into two main groups, **analysis** and **training**, which are integrated throughout all echelons of the Joint Force.

In the modeling and simulation master plan (1995), the US Air Force defines the analysis and training areas as shown in the figure below.

Analysis ⇨ ***Better Decisions***	***Training*** ⇨ ***Better Skills***
• Threat Assessment	• Joint Task Force
• Systems Engineering	• Full Mission Simulator
• Force Structure Decisions	• Mission Planning & Rehearsal
• Acquisition	• Part Task Simulator
• Logistic	• Education
• Test & Evaluation	
• Weapon Employment	
• Mission Planning & Rehearsal	
• Basic Research	

Figure 8: M&S Applications in the USAF.

DoD's approach is a little bit different than the Air Force's. In Defense Modeling and Simulation Initiatives (1992) they define M&S application as follows:

Education, Training, and Military Operations:

- Re-creation of historical battles
- Doctrine and tactics development
- Command and unit training
- Operational planning and rehearsal
- Wartime situation assessment

Analysis:

- Campaign analysis
- Force structure assessment
- System configuration determination
- Cost analysis

Test and Evaluation:

- Early operational assessment
- Operational test design
- Excursion and sensitivity analyses

Production and Logistics:

- System producibility assessment
- Logistics requirements determination
- Industrial base appraisal

Research and Development:

- Requirements definition
- Engineering design support
- System performance assessment

Figure 9: M&S Applications in the USA DoD.

Modeling and Simulation is a powerful technology used by the Department of Defense (DoD) of many countries as an enhancement to their training, education, engineering, testing, and analysis of battle scenarios and troop logistics. DoD uses modeling and simulation technology in computer representations of command and control systems, military platforms, and weapon systems. Military planners, operators, and commanders use M&S to increase defense capabilities and reduce costs in many of DoD's activities.

The Air Force senior leadership uses M&S to help create and explain force structure positions to DoD and Congress, and operational battle staffs and aircrews use M&S to make critical warfighting decisions. The Air Force continually educates and trains its personnel to improve warfighting skills. M&S is used in many Air Force training programs to improve pilot and crew performance, teach and highlight air campaign planning, exercise theater battle staffs, and -- at the tip of the spear -- accomplish mission planning and rehearsal. [Department of the Air Force, 1996].

The development of strategy, tactics, and doctrine can address any or all phases of deploying, employing, or sustaining military forces. Models at all levels when used together could cover the scope from one-on-one to global conflict. The effort need not be limited strictly to battlefield situations. Under this broad umbrella one might imagine experiments, for example, to assess the effects of organizational structures. These experiments might include evaluation of the effects on Tactical Air Command of a new aircraft maintenance concept or the implications of various options for Air Training command in a mobilization. [Fox, 1985].

Warfare simulations provide a forum from which to demonstrate the worth of a proposed weapon system, the necessity of a given force level, or the advantage of a particular force structure alternative, with the aid of a war game it is possible to demonstrate, in tangible terms, the effects of specific policy and budget decisions to show

how they translate into specific military systems and further to demonstrate how the capability of these systems stacks up against enemy capabilities. [Fox, 1985].

Warfare simulations are also used at the strategic and operation levels of warfare to evaluate combat processes and outcomes to support ongoing operations or future planning. Those kinds of studies are generally done by the assist of campaign level combat models. However, engagement and lower level models generally are used for specific analyses, focusing on a particular engagement type or weapon system.

Computer wargaming may be the most widespread application of military modeling and simulation. A computer war game is a simulation program of military operations used for research, analysis, training, or education, that is designed to produce a better understanding of warfare. The main differences between war games and combat models are amounts of human interface during the simulation and simulation time. War games requires much more decision maker inputs than typical combat models do and they generally run close to real time while combat models are not tied to real time, often running faster.

The education of military personnel in strategic planning, war fighting and budgeting is a common application of war gaming. Seminar and path games are often used by the war colleges and military commands in USA to improve officer-level awareness and understanding. War games tend to focus on the higher levels of warfare and allow insights into planning, movement, and employment of forces, especially within joint military operations. [Kjonnerod, 1997].

War games can cover a wide range of activities including research and development of strategy, tactics, and doctrine and development and evaluation of battlefield support tools. In addition, they can do best in an educational environment is provide a laboratory where players can practice wartime decision-making skills. War games help players examine the vast gulf between peacetime and wartime performance expectations. This will help the armed forces to train the way it intends to fight. Additionally, during peacetime, war gaming is a practical war experience most of the military can get at reasonable cost. [Fox, 1985].

Another constructive application of warfare simulation and war gaming in particular is as a form of brainstorming to uncover aspects of a situation not initially apparent. By role playing in a realistic war game, participants involved in a complex scenario can explore alternative policies, discover unexpected alternatives, and sometimes, anticipate outcomes that differ from those originally envisioned. One worthwhile outcome is that a game can serve as a forum for formally considering how participants in the real-world counterpart may react. Used in this way games can facilitate research to generate and test hypotheses concerning, for example, the process of international relations and the nature of crises. [Fox, 1985].

Another useful application of warfare modeling and simulation is in testing plans. A real world situation requires planning a complex sequence of actions and if a realistic warfare simulation is available, it is an obvious candidate for testing a proposed plan. If a warfare simulation can be used to evaluate a plan, the next logical step is to integrate simulation into the planning process. If the evaluation reveals deficiencies in the plan, these can be addressed in a second iteration. When the testing function is closely tied to the planning process and the planning, testing, and replanning cycle is used iteratively to produce a final plan, then the warfare simulation has become not just a testing tool but a planning tools as well.

3.5 SIMULATION AND ANALYSIS IN THE GULF WAR

The Gulf War was one of the biggest live examples where simulation and analysis were used to assist the combat decision-makers. Although most of the documents telling us about how U.S. Armed Forces used simulation models in the Gulf War and the lessons learned are still classified, it is possible to find some unclassified articles in open literature. One of the excellent unclassified articles is " The Wizard Warriors of Desert Storm" written by Col. Thomas A. Cardwell III Ph.D., USAF. [Cardwell, 1992].

According to Col. Cardwell, Air Force Studies and Analysis Agency (AFSAA) played a very important role as a decision support team for the Campaign Planners. Immediately after Iraqi forces invaded Kuwait, the team started working on an analysis of the Iraqi air defense system. They were first asked to find an estimate of US attrition in an air campaign against Iraq. They initially looked at the problem quickly by using previous study efforts and produced a very rough attrition estimate of the entire war within a week. Then they used TAC THUNDER which is a theater level campaign model to estimate the probable attrition during the first 30 days of air war. After that, The AFSAA team examined the first few hours of the air campaign. For this detailed study they used The Extended Air Defense Simulation (EADSIM) computer model.

During The Gulf War, they directly supported the Air Force two-star general chief of the Riyadh-based CENTAF director of campaign plans. Most of the time they used TAC THUNDER and EADSIM for evaluating air operations. The models' sophisticated graphics, which could display a detailed map of the whole Iraq/Kuwait theater of operations, enabled the analysts to peek into the future and watch the war's initial missions unfold, gauging the changes in outcome with each adjustment to the battle plan. [Cardwell, 1992].

The primary concern in operation plans was possible allied losses. After getting the analysis results they modified the plans or tactics to minimize the attrition rate. Simulation thus had a direct influence on tactics. For example, The results of one analysis persuaded CENTAF's chief war planner to keep F-111s and F-15s away from heavily fortified Baghdad and use the F-117 stealth fighter instead. They estimated this change saved a lot of lives.

Col. Cardwell lists the general studies that they accomplished through the use of simulation models at that time:

- Designing a SEAD (suppression of enemy air defenses) campaign
- Identifying attrition 'hot spots' or finding Iraqi air defense vulnerabilities.
- Analyzing the dangers of traffic congestion in the crowded air corridors of a combat theater.
- Examining the impact of changes in the composition of strike forces (what kind of aircraft mix was needed, how should they be armed, etc.).
- Analyzing individual aircraft losses to determine the reason for downed aircraft.
- Concept analyses consisted of modeling several proposed missions to assess effectiveness and risk. The missions included:
    - ◊ An F-111 attack on Shayka Mazhir airfield in which the aircraft penetrates at varying altitudes and time intervals.

◊ An F-15E attack on Tallil airfield.

◊ A B-52 attack against Republican Guard units in northern Kuwait comparing results with and without EF-111 and F-4G support.

◊ Attacks by F-117s and RAF Tornados in the Baghdad area.

◊ B-52 attacks in and around Baghdad to determine which threat systems should be suppressed.

Some leaders of strike forces, besides requesting those kind of analysis, wanted to see a mission flown on the computer before committing themselves to a contemplated attack profile. It helped them to visualize the complete mission action as a whole, at times becoming aware of some critical point that was not considered previously.

The AFSAA team faced a lot of challenges at that time. One of the challenges, maybe the most important one, was getting enough correct data at the right time. Radar frequencies, antenna capabilities and transmission power levels, missile and bomb kill probabilities against various types of targets, and reaction times for fighters were just a few of the models' data requirements. In addition, hourly changing mission plans and current capabilities of the Iraqi Forces were not easy to get and change in the models' dynamic scenario. Because of these problems, after the air war began, they could not possibly use the simulation models as a means to estimate overall daily attrition. Instead the team used the simulation models for activities that were regional in scope such as shootdown analyses and concept analyses.

The AFSAA team reached several conclusions based on their experience in the Gulf War. 1) Combat simulation models do have potential for effective use in an operational environment; however, they must be equipped to perform in that environment. Attributes such as high resolution graphic output and user-friendly windowed inputs are a must. Furthermore, automatic feeds from both aircrew planning aids (e.g., MSSII, TAMPS) as well as intelligence fusion feeds which include position as well as connectivity data must be developed.

2) An analysis team at the operational level of employment can provide mission-essential feedback to multiple levels of command, from the theater planning level to the unit employment level. Off-the shelf tools exist today to support such a team; however, they must be modified to accommodate the environment in which the team will be employed. The analysts must be trained to produce real-time, interactive analysis before hostilities begin. This training cannot be accomplished in an academic environment. Although schools can teach fundamentals of analysis, analysts can only get this training in the field exercises.

TACtical WARfare (TACWAR), a division level campaign simulation model, was another one which was used by USA Central Command's combat analysis group in the Gulf War. The model was able to deal with air, ground, logistics, and chemical warfare operations. By combining it with other PC based graphics packages, the analysis group interpreted its results for the CENTCOM staff and commanders, and made it very useful decision support tool. Another group simultaneously ran the same simulation model in Florida (original headquarters of the CENTCOM). Then they simultaneously transferred the data and outputs through a satellite link between Florida and the Gulf. [Dunnigan, 1992].

The analysis group used this model most often to find expected casualties under certain offensive and defensive courses of action, and to answer tough force structure and logistics questions. Col. Gary Ware listed other areas in which they had used TACWAR during Desert Storm and Desert Shield [Hillestad, 1992]:

- The mix and positioning of the defensive forces
- Mission objectives of the Arab Corps
- Interdiction delay and force requirements
- Allocation of air
- Deployment and employment of VII Corps
- Composition of the main attack force
- Timing and sequencing of the attack forces
- Commitment of the reserve
- Attacks on Iraqi SCUD positions.
- Locations of supply nodes and ports
- Logistics sustainability for offense and defense
- Transportation aspects
- Residual force options

Since this was the first time simulation was used so heavily in a war, the team was having problems updating the TACWAR scenarios and database. Security was another issue as most of the data was classified. Since the some computer programmers did not have security clearance at the time the team needed those programmers help to modify or to fix the TACWAR, the analysis team had to replace the top secret data with unclassified ones. This kind of actions caused them losing time which is another important thing to remember during wartime.

US Army Concepts Analysis Agency (CAA) was another agency that played a very important role as a decision support group. The main model used by CAA in the Gulf War was the Concepts Evaluation Model (CEM) which is a two-sided deterministic campaign model. The CAA tried to use CEM and Thunder interactively together. CEM was good at representing land battle while not as accurate at modeling air war. Similarly, THUNDER, the preferred air model at theater level, did not contain a credible ground war sub model.

CAA did a lot of analysis on concept of operations with CEM to minimize both the causalities and the duration of combat. In addition to that, CEM's simulation results were used to identify and solve logistics problems such as ammunition supply, permanent losses of class VII combat equipment and personnel losses. Generally, they also did analysis about strategic deployment, operational assessment, risk assessment and supportability issues of the force development [Appleget 1995].

J. Appleget summarized lesson learned from the Gulf War experience:

- Simulation capabilities must be able to accurately model joint campaigns, reflecting the contributions of all services.
- Simulation models must cover accurate weapon systems interactions. Almost every simulation prior to Desert Storm pitted U.S and NATO equipment against those of the Soviet/Warsaw Pact's. A compendium of the equipment used by coalition forces in Desert Storm shows a curious mix of U.S., non-U.S., NATO, Warsaw Pact, and other countries' weapon systems.
- Analytical agencies that simulate theater-level conflicts must have analysts familiar with the possible enemies and allies. The decision making process must accurately

reflect that of the forces involved. The resolution must be appropriate for the tactics of the combatants. In addition the model must be able to reflect the current doctrine.

- Theater-level simulation models must accurately reflect the contributions of light infantry and special operations forces.
- Current measures of effectiveness may have to be augmented or replaced when assessing the outcome of theater simulations.
- Stochastic theater-level simulations can provide more insight and must be considered by the analytical community.

In addition to the military simulation models, some commercial wargames were also used in 1991. In the first days of Iraq's conquest of Kuwait, they needed quick wargaming tools. The only kind of wargame that could get results quickly was a manual game called Gulf Strike that could be bought in a game store. Gulf Strike, designed by Mark Herman, produced results which assisted much of the decision making during August 1990 at the Pentagon [Dunnigan 1992].

After the Gulf War, when they compared the actual results, especially attrition rates, with the simulation models' results, they saw that the models (EADSIM is one of them) had over estimated the attrition rate. Some experts agree that it was not because the simulation model was wrong, but it was because they did not have accurate data and made some false assumptions. The modelers had assumed a rational and skillful opponent, instead of what the coalition forces would actually face in the war [Cardwell,1992]. Maybe another lesson must be taken from the Gulf War; Soft factors, such as leadership, morale, and training must be also considered by the analysts and modelers [Appleget, 1995].

Generally, we can say that powerful computer models, statistical techniques and well-qualified analysts helped the Coalition Forces to plan in advance the appropriate strategies and tactics and predict the outcome of their applications. In doing so, they thereby improved the quality of Coalition Force decision making.

3.6 COMPUTER, MODELING AND SIMULATION TECHNOLOGY

The enormous changes in computer technology directly affect the military modeling and simulation technology. Computer hardware technology has improved several orders of magnitude in the past decade; microprocessor speed alone has increased about 100 fold (Figure-10). The overwhelming trend is faster, smaller, and cheaper. This reduction in cost and size coupled with the increase in speed and capacity has resulted in a massive increase in simulation capability. Computational power continues to increase as prices decrease. As the decade moves on, a multiprocessor on the desktop will be commonplace for simulation and analysis. It will be accompanied by the continued decentralization away from the central site to distributed computing -- personal processors close to the user mixed with computationally intensive servers on a heterogeneous network. [McQuay,1996].

The fact that computers can process quickly and precisely any mathematical or logical formulation in arbitrary combinations widens the applicability of modeling and simulation to anything - in any form - that can be formalized and made computable. This development leads to new possibilities in almost all domains of human experience: for representing as yet hardly accessible complex systems, for simulating their dynamics, and for understanding systems and dealing with them better than before.

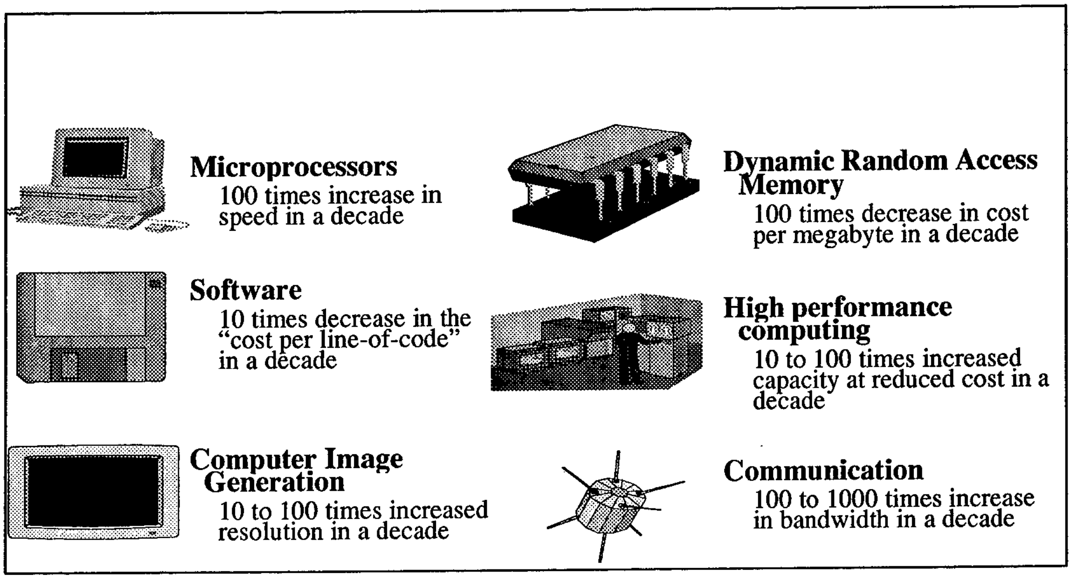


Figure 10: Computer and Simulation Technology Trends [McQuay,1996]

These advances in computerization have resulted in a dramatic expansion in the use of simulation. The computer revolution has made advanced computing and communications technologies so inexpensive that it is now possible to integrate a wide number of M&S tasks which had previously been operating independently. These trends are expected to continue in the future, providing the modeling and simulation community the ability to perform a variety of tasks across a broad set of applications

Simulations, leverage technologies from other areas of science. The need and the information to create very complex simulation models have often preceded the ability of computer hardware and software to represent it. However, simulation applications are growing larger and more useful as a result of developments in the computer field that provide tools powerful enough to represent the problems. A few of the most useful technologies are described in the following paragraphs [ECS, 1998].

3.6.1 NETWORKS

The ability to distribute a simulation across a network of computers leads to more detailed, scaleable, complex, and accessible models. Distributed message passing and event synchronization allow a single problem to be addressed with a large number of traditional computers on a network. The proliferation of standardized networks between computerized machinery, communications systems, decision aids, and other tools has created an environment in which simulations can drive "real world" computers directly and extract data from them in real time. This has blurred the boundary where real and simulated worlds meet.

Networks allow the interaction of many of the distributed simulations. Networks link simulators to other simulators (e.g., aircraft vs. aircraft), simulations to other simulations, and also simulators with operational equipment (e.g. weapon or command and control systems).

3.6.2 PARALLEL COMPUTING

Parallel computing provides many of the advantages of distributed networked simulations, but adds the characteristic of close coupling. Some problems can be divided into many thousands of separate processes, but the interactions between these are so frequent that a general purpose network for delivering messages introduces delays that greatly extend the execution time of the simulation. In these cases, parallel computers can provide the close coupling between processors and memory that allows the simulation to execute much more efficiently and thus handle much larger models.

3.6.3 ARTIFICIAL INTELLIGENCE

As mentioned earlier, the representation of human and group behavior has become essential in some parts of the simulation community. The use of techniques developed under the umbrella of artificial intelligence and cognitive modeling can solve some of these problems. Simulations are including more finite state machines, expert systems, neural networks, case based reasoning, and genetic algorithms in an attempt to represent these behaviors with more fidelity and realism.

3.6.4 COMPUTER GRAPHICS

Simulation data lends itself very well to graphic displays. Factories and battlefields can be represented in full 3D animation using virtual reality techniques and hardware devices. Graphical user interfaces can provide easy model construction, operation, data analysis, and data presentation. These tools place a new and more attractive face on simulations that previously relied on the mind's eye for pictorial representation. This often leads to greater acceptance of the models and their results by the engineering and business communities.

3.6.5 DATABASES

Simulations can generate a large amount of data to be analyzed and may require as much input data to drive the models. The availability of relational and object oriented databases has made the task of organizing and accessing this information much more efficient and accessible. Previously, model developers were required to build their own storage constructs and query languages, a distraction from the real focus of the simulation study.

3.6.6 SIMULATION LANGUAGES AND TOOLS

A number of simulation languages and packages have been developed specifically to assist developers in constructing models of their systems. These languages are intended to serve a specific problem domain, rather than support general purpose programming as do FORTRAN, C, Pascal, and Ada. However, general purpose languages are still widely used to construct simulations in domains for which simulation specific languages or packages do not yet exist or where the problem is so unique that simulation tools can not be created economically.

Some of the more popular languages and packages are listed below.

Discrete Event Simulation Languages: SIMULA, GPSS/H, SIMSCRIPT II.5, SIMAN/Cinema, SLAM II, and MODSIM.

Discrete Event Simulation Packages: EXTEND, WORKBENCH, TAYLOR II, COMNET III, BONeS Designer, CSIM18, SimPack, and CPSim.

Continuous Simulation Languages: The Advanced Continuous Simulation Language (ACSL) and The Continuous System Modeling Program (CSMP)

Interactive Simulation: VRLink, FLAMES, ITEMS, and MultiGenII,

3.6.7 SYSTEMS ARCHITECTURE

There is a recognition that simulations fall into families, or domains, that can use the same architectures to represent entire classes of problems. These architectures are made up of components with defined capabilities and specified interfaces that allow the reuse of the components in a variety of problems. This recognition in transaction-based simulation has lead to the creation of a host of simulation products that encapsulate functionality used to model everything from factory operations to aircraft routing schedules.

3.6.8 WORLD WIDE WEB

The expansion of the Internet and the World Wide Web has led to experiments with simulations that are either distributed through the Internet or accessible from it. These simulations make use of standard protocols and allow the distribution of a simulation across multiple computers that are not directly controlled on a dedicated network. Simulation users do not necessarily need to own the computers that run the simulation. Instead, the user may access a simulation-specific machine connected to the Web, provide input values, control model execution, and receive the results without ever having their own copy of the simulation software or the computers necessary to run it.

3.6.9 USER INTERFACE

The interface through which operators interact with simulations is being improved to allow intuitive analysis and realistic training and education. Graphic user interface, interacting through the use of icons, pull-down menus, and other symbology makes running simulations and analyzing results more straightforward.

3.6.10 VIRTUAL REALITY

Virtual reality is another current interest. It is an environment in which users can enter an alternate, machine-based reality, and can interact in real time with data structures or programs. Virtual environments have been defined as possessing 3-D real time interactive graphic, multiple senses beyond graphics (sound, touch), direct manipulation of objects(e.g., by using a glove), free motion of the eyepoint within the space, and multiple interacting players who are mutually visible. The military's interest in synthetic environments stems form its ability to immerse a person in a realistic combat setting for training, the possibility of integrating individual participants within a large network of simulated weapon systems, and its potential to allow generic control panels to represent deferent configurations for system assessment.

3.6.11 ADVANCED DISTRIBUTED SIMULATION (ADS)

ADS is a mix of human-in-the-loop and computer simulations which interact within the same synthetic environment across distributed computer networks. The implication is that models and simulations, whether they are live flights supporting training or test and evaluation or force/deployment studies, all have the potential to be linked in real-time.

There are two main components which make using ADS feasible. One component of ADS is a standard for operability called Distributed Interactive Simulation (DIS) which is an industry standard communications protocol for the real time linking among participants. The second component is the Defense Simulation Internet (DSI) which is the communications backbone of ADS. It is able to concurrently link a large number of geographically separated participants performing many different types of M&S activities.

3.7 LIMITATIONS OF MODELING AND SIMULATION

A model is not reality, but represents the reality. We should always remember this fact while using models for our studies. It is only a tool which helps us to understand the problem, explore the situations, and find the most accurate solution. Like every decision and analysis support tool, it has also some limitations and disadvantages. It is important to be aware of the problems with modeling and simulation. In the following some critical aspects of modeling, simulation, and their usage are discussed.

- There is no often adequate way to validate the accuracy of the model result. For instance, there are innumerable ways to combine counts of warhead, equipment reliability, and evaluations of enemy intentions. The question is what is the appropriate way to combine them in order to calculate the probability of enemy attack? [Fox, 1985].
- It is hard to find an analyst with an operational background who can use warfare models effectively. [Allen, 1997].
- There is a trend towards using output of models without the complete understanding of the logic behind it. [Clover, 1997].
- It is hard to provide or sometimes impossible to find enough accurate data for simulation models. So, it is necessary to make many assumptions in the model which may affect the results of simulation. [Bennett, 1997].
- It can be time consuming, expensive, and requires special training to create a model that accurately represents the system to be simulated. [Banks, 1996].
- Using stochastic simulation models in an analysis sometimes requires too much time to produce credible results.

- Simulation results may be difficult to interpret [Banks,1996]
- One of the dangers of war gaming in an educational environment is that players may carry away the wrong lesson. A war game is certainly an effective way to reinforce existing doctrine; however, the game may discourage players from trying new methods or tactics [Donuhue, 1997].
- The use of models may not enhance creativity in the analytic process. Because models provide a limited view of the real world and represent only one set of hypotheses about the relationship of things, they do not lend themselves to the development of new hypotheses or the examination of effects outside their scope. [Hillestad, 1996]
- Another problem with the model can be lack of documentation. If there is not enough information describing the logic of the model, assumptions, or purposes, you can not understand the results of the simulation easily or you may not use it for the correct problem.

Even though modeling and simulation have many problems as shown above, it is the only tool that can be used to explore the complex warfare situation without loss of life or millions of dollars. There is no quicker and more convenient way to obtain analytical results other than simulation. The importing thing here is to use the modeling and simulation tool effectively within its limits. Improving the user's education is one of the best ways to minimize some of its problems and to get the most advantages from it.

3.8 SIMULATION, ANALYSIS, AND WARGAMING CENTERS

In this part of the thesis, I wanted to introduce some of the US DoD agencies and military centers which are currently using modeling and simulation technology in their studies. They are excellent examples for the JSAWC project. We can examine their objectives, missions, structures, and models and take them as a reference for future studies. I visited all of the centers which are introduced below and interviewed their personnel about the functions, structures, models, and previous studies of these centers. The knowledge that gained from these researches formed the major source of this study

3.8.1 AFSAA, AIR FORCE STUDIES AND ANALYSIS AGENCY

The AFSAA is the main analytical organization in the US Air Force and is located at the Pentagon, Washington DC. Its objective is to support senior leaders and the Air force by providing them with appropriate analyses, insights, models, and simulation. It is organized into three divisions, a theater battle arena, and a senior analysis review group with consolidated executive services [Allen, 1997]:

Force Application Division (SAG) is made up of nine branches: Campaign Analysis, Battle Management Command and Control, Information Superiority, Global Attack/Precision Engagement, Global Mobility, Space Superiority, Air Superiority, and Wargaming Branches. *Capabilities Assessment Division (SAQ* consists of Joint Issues, and Assessment Analysis Branches. *Resource Management Division (SAM)* is made up of Computer Resources & Information Management, Financial & Contract Management, Graphics, and Personnel Manager Branches.

3.8.1.1 Types of Major Products and Services

- Provide senior Air Force leadership quality analyses and foster excellence in modeling and simulation.
- Conduct studies and analysis, explore new concepts and provide expertise and advice to meet short and long term requirements of our customers.
- Provide analyses focusing on operational reality to support programmatic and doctrinal decisions.
- Studies range from long-range strategic and operational level through campaign and tactical level to those with very narrow focus.
- Acquire and manage models, simulations, data and computer architectures to support the analysis effort.
- Coordinate and recommend action on matters affecting modeling, simulation and analysis within the Air Force and Department of Defense.

3.8.1.2 Examples of Previous Studies and Analyses

Airborne Laser Analysis of Alternatives, BMDO Cruise Missile Defense, J-8 Land Attack Cruise Missile Defense Study, U-2 Defensive System Requirements Study, Determined the 2MRC wartime requirement for AF, Air Refueling Tanker Requirements, U-2 Survivability Requirements Study - Fighter Aircraft Threats, F-22 Comprehensive Analyses, Theater Air and Missile Defense Family of Systems Effectiveness, and ISR / Weapons Mix Study.

3.8.1.3 Models currently in use

ALM, BRAWLER, CFAM, EADSIM, ESAMS, ISRSIM, NRMO, RADGUNS, STRATC2AM, SPAM, SWEG, and THUNDER (Appendix-A)

3.8.2 CAA, UNITED STATES ARMY CONCEPTS ANALYSIS AGENCY

Concepts Analysis Agency is a field operating agency of the Chief of Staff, Army, located in Bethesda, Maryland. The mission of the CAA is to conduct analyses of Army force level systems in the context of joint and combined forces. Its major types of functions are:

- Analyze strategic concepts and military options
- Estimate requirements to support Army inputs to PPBES (planning, programming, budgeting, and evaluating systems)
- Evaluate Army force capabilities
- Design Army forces and evaluate force alternatives
- Develop theater force level scenarios
- Resource analysis

The CAA is organized into the Office of the Directory and 13 divisions: Operations Support, Force Strategy, Operations Capability Assessment, EAD/NBC, Management Support, Technology Support, Resource Analysis, Operations Capability Assessment, Tactical Analysis, Data Management, Conflict Analysis, Value Added Analysis, and Mobilization and Deployment [CAA Memo, 1995].

3.8.2.1 Examples of Previous Studies and Analyses

Near term ammunition requirements for Korea, required Army forces under new Defense Planning Guidance, analysis support of Desert Shield/Storm, Analysis support to development of new Korean OPLAN. Optimization Army acquisition programs, policy issues regarding potential biological threats, and issues of peacekeeping operations. [Whitley, 1997].

3.8.2.2 Models currently in use

CEM, COSAGE, FASTALS, GDAS, and MOBCEM (Appendix-A)

3.8.3 J-8, FORCE STRUCTURE, RESOURCES, AND ASSESSMENT DIRECTORATE

The Force Structure and Assessment Directorate is located at the Pentagon, Washington, DC. The Director, J-8, is charged with providing support to CJCS (Chairman of the Joint Chiefs of Staff) for developing force structure requirements, conducting studies, analyses, assessments, and for evaluating military forces, plans programs, and strategies. J-8 conducts joint, bilateral, and multilateral war games and interagency politico-military seminars and simulations. J-8 develops, maintains, and improves the models, techniques, and capabilities used by the Joint Staff and the conduct studies and analyses for CJCS. [McCloud, 1997].

J-8 consists of a Director, a Vice Director, three Deputy Directors and three subordinate divisions (Warfighting Analysis Division, Requirements Assessment and Integration Division, and CINC Liaison Office):

Deputy Director of Force Structure and Resources: Force Division, Program and Budget Analysis Division, Acquisition and Technology Division.

Deputy Director for Joint Warfighting Capability Assessments: Sea-Air-Space Superiority Assessment Division, Strike Warfare Assessment Division, Land and Littoral Warfare Assessment Division.

Deputy Director for Wargaming, Simulation and Operations: Studies, Analysis and Gaming Division, Simulations and Analysis Management Division, Resources and Acquisition Management Office.

3.8.3.1 Models Currently in Use

TACWAR, MIDAS, FDE, Spreadsheet, and Linear Models (Appendix-A)

3.8.4 JWFC, JOINT WARFIGHTING CENTER

The JWFC is a JCS (Joint Chief of Staff) organization designed to enhance joint operations and training. The JWFC assists the Chairman of the Joint Chiefs of Staff, Combatant Commanders, and the Chiefs of the Services in their preparation for joint and multi-national operations, in the conceptualization, development, and assessment of current and future joint doctrine, and in the accomplishment of joint and multi-national training and exercises. It is located at Fort Monroe in Hampton, Virginia. [Hornburg, 1997]

JWFC products and services are CINC (commander of a combatant command) exercises, Joint Training Assessment, Joint Doctrine/Joint Tactics, Techniques, and Procedures, and Joint Concept Development.

3.8.4.1 Models Currently in Use

JTLS, JTS, ALSP, CBS, AWSIM, RESA, and MTWS (Appendix-A)

3.8.5 ACC/SAS, AIR COMBAT COMMAND STUDIES AND ANALYSIS SQ.

ACC/Studies and Analysis Squadron is located at the Langley AFB in West Virginia. The SAS conducts operations research and systems analysis on the application of air power for the ACC commander and the ACC staff. The SAS serves as Combat Air Force (CAF) focal point for detailed assessments of combat capabilities of current and projected systems. Tools used include theater warfare modeling, aircraft attrition modeling, mission-level modeling, and other operations research techniques. [Hickman, 1997].

SAS is administratively organized into four analytical branches: Force Analysis, Logistics Analysis, Mission Analysis and Systems Analysis. Squadron personnel in the four branches are functionally organized into analysis teams.

3.8.5.1 Examples of Previous Studies and Analyses

Combat search and rescue analysis, Active/Air National Guard fighter force mix study, Cruise missile defense study, Theater missile defense attack operations study, Evaluating the operational capabilities of each aircraft Airborne laser employment study, Two major regional conflict study, JSF/F-22 Force structure alternatives, F-15A/D contribution to campaign, and C-130 Airdrop survivability.

3.8.5.2 Models Currently in Use

EADSIM, ISAAC, SPAM, THUNDER, CFAM, BRAWLER, and LCOM (Appendix-A)

3.8.6 WGSC, NATIONAL DEFENSE UNIVERSITY WARGAMING AND SIMULATION CENTER

The War Gaming and Simulation Center (WGSC) is located at Fort McNair in Washington DC. It works under the Institute for National Strategic Studies of the National Defense University (NDU). The WGSC supports the entire spectrum of the NDU mission, spanning joint professional military education, out-reach and policy and analysis programs. The Center, through the medium of war games and simulations, provides enhanced educational and decision-making experiences for the US and foreign national students attending the various NDU Colleges. The out-reach arena the WGSC provides gaming and simulation opportunities for a wide range of government organizations, US institutions of higher education, NDU's counterparts overseas, and the International Military Education and Training Programs. For the interagency community the WGSC develops, executes and assesses games and simulations relating to national policy and security issues. [Kjonnerod, 1997].

3.8.7 CNA, CENTER FOR NAVAL ANALYSIS

CNA is a federally funded research and development center (FFRDC) sponsored by the Department of the Navy. It is located in Alexandria, West Virginia. The CNA conducts research and analysis for Navy, Marine and other Department of Defense and non-Defense clients whose needs fall within CNA's. The Center for Naval Analyses helps its clients:

- Make current operations more effective and efficient
- Assess future needs and decide how to apply new technology to meet those needs

- Manage work force and infrastructure
- Develop strategies and long-range plans
- Improve business and decision processes

The Center for Naval Analyses is divided into five operating divisions, each of which has several research teams: [Gibson, 1997]

Support Planning and Management Division: Infrastructure and Readiness Team, Manpower, Personnel and Training Team, Medical Team, and Resource Team.

Federal Programs Division: Information Management and Systems, and Resource Planning and Management Analysis.

Operating Forces Division: FLOAT Team, Operational Training Team, Systems and Tactics Team, and Theater Operations Team.

Requirements and Advanced Systems Division: Air and Strike Weapons and Systems Team, Aircraft Programs Team, Electronic Systems Team, Mine Warfare Systems Team, Modeling and Simulation Team, Science and Technology Requirements Team, Subsurface, ASW, Deterrent and Surveillance Systems Team, Surface Combat Systems Team, and USMC and Expeditionary Systems Team.

Policy, Strategy, and Forces Division: Concepts and Assessment Team, Information Operations and Warfare Team, Operational Policy Team, Regional Issues Team, Roles, Missions, and Forces Team.

3.8.7.1 Examples of Previous Studies and Analyses

Shaping the next-generation Joint Strike Fighter, improving the Tomahawk missile, reducing errors in air traffic operations, fighting the war against drugs, improving humanitarian operations, and improving medical care on the battlefield.

3.8.7.2 Models currently in use

ITEM, ALM, PC ARROWS, ESAMS, THUNDER, EADSIM, DYNA-METRIC, and SOMFOR. (Appendix-A).

3.8.8 JTASC, JOINT TRAINING, ANALYSIS, AND SIMULATION CENTER

The JTASC is the primary center for training Joint Task Force staffs and the components in the US Atlantic Command (USACOM). It is located in Suffolk, West Virginia. The JTASC supports JTF training in the areas of joint doctrine, tactics, techniques, and procedures, training in the planning of joint operations, and using simulation based exercises in the conduct of such training. Computer simulations and associated models emulate the full range of "real life" variables (forces, terrain, communications, logistics, weapons systems, etc.) that JTF Commanders and staffs face on the battlefield.[JTASC, 1997].

3.8.8.1 Types of Major Products and Services

- Develop, execute and assess a program of distributed joint and simulation support exercises in joint, mission essential task conditions, and standards.
- Integrate in coordination with other CINCs, rehearse assigned forces for worldwide employment in actual crisis.
- Provide planning facilities and a command post for use by commanders of the joint task and their staffs in exercises and crisis rehearsals.
- Assesses the joint operations readiness of assigned forces.

- Provide a laboratory for the operational demonstration and assessment of technologies, systems, joint doctrine, tactics, techniques, and procedures within the joint training, exercise rehearsal program.

3.8.8.2 Example of the Previous Exercises:

Coherent Defense 97, Joint Warrior Interoperability Demonstration, The Synthetic Theater of War 97,Theater Missile Defense Initiative 98, and Roving Stands 98

3.8.8.3 Models Currently in Use:

ALSP, AWSIM, CBS, CSSTSS, JECEWSI, MTWS, PMS, RESA, and TACSIM (Appendix-A)

3.8.9 TAFSC, TURKISH ARMED FORCES STAFF COLLEGE

Turkish Armed Forces Staff College (TAFSC) is currently the only place where warfare simulation models are being used in Turkey. The TAFSC provides computer-assisted wargaming exercises for staff officers. The staff officers improve their operational planning and decision making capabilities during these games. The Staff Collage is located in Istanbul, Turkey.

The TAFSC previously used IDAHEX for Land, BIMHOM for air, and BARBAROS for naval warfare simulations. These models are not very sophisticated wargames and have many limitations. For that reason, the TAFSC prepared a master plan to improve the simulation and wargaming capabilities and activities in the Staff Collage. This plan covers acquiring many new warfare models and computer simulation systems such as JTLS and BBS which are being used by the US Department of Defense agencies.

4 PROBLEM DEFINITION

4.1 INTRODUCTION

The Turkish Armed Forces would like to enter the 21st century as one of the most powerful military forces in the world. This objective can be accomplished, if we plan and manage our resources very well, while professionally educating and training our military personnel. These functions/tasks are not easy to achieve. Since the Turkish Armed Forces is a very complex system, the commanders' (decision-makers) jobs of planning and commanding all the related activities are very difficult. To increase the success of the commanders' and other high level officials' decision making and planning process, we need to provide decision support systems which include the latest technological improvements. Currently, in the headquarters of the Turkish General Staff and of all three services, there are analysis and research divisions acting as decision support centers. The problem is that these analysis and research divisions do not use modeling and simulation tools sufficiently. We know that in the last ten years modeling and simulation have improved quite drastically in parallel with computer technology. They have become very useful tools enabling us to analyze and solve the problems very effectively in many areas. Military planning, problem solving, and training may be the leading areas in which we can use this powerful tool. Currently, people are able to model very complex systems and use simulation for detailed analysis and other studies easily. The new amazing software tools and powerful computers make this process much more accurate and much easier.

If we look at the United States Armed Forces, we see that they have been using modeling and simulation technology to analyze military problems and train military personnel for more than thirty years. The following paragraphs show how they think about the modeling and simulation technology.

> Decision-making takes place everywhere in the Air Force and is often supported by M&S. Acquisition programs rely heavily on M&S to develop and justify program decisions. The Air Force senior leadership uses M&S to help create and explain force structure positions to DoD and Congress, and operational battle staffs and aircrews use M&S to make critical warfighting decisions. The Air Force continually educates and trains its personnel to improve warfighting skills. M&S is used in many Air Force training programs to improve pilot and crew performance, teach and highlight air campaign planning, exercise theater battle staffs, and -- at the tip of the spear -- accomplish mission planning and rehearsal. **[Department of the Air Force, 1996]**.

> The acquisition of any major weapon system, such as an aircraft, tank, satellite, or ship, is a very expensive process. This acquisition involves years of time, billions of dollars in research, development, and acquisition cost, and considerable risk that the system will actually counter the threat when delivered. Any means that will shorten the lead-time, decrease the cost, or lessen the risk is greatly needed. Simulation and modeling offer help in all three of these areas and, therefore, the DoD is looking much harder at these techniques, especially, in the era of declining budgets **[Schuppe, 1991]**.

> The operational community is greatly expanding its reliance on automated decision aids to improve operations planning, training and exercising, and real-time decision making. Simulation of joint combat operations is becoming a primary tool for exploring alternative courses of action in planning military operations. The continued reduction in operating funds coupled with a concern for protecting the environment and the quality of life of civil populations around military installations is steadily constraining the ability to exercise and train troops in the fields. In response, simulation is an increasingly effective method for providing realistic decision making experiences to weapon systems operators and to the staffs. The Force Design and Cost Analysis communities are using modeling and simulation as an aid to assessing force capability and cost alternatives in complex combinations of conflict scenarios and potential future defense budget levels **[Hillestad, 1992]**.

I believe that if we have a center occupied with a variety of useful decision support tools including modeling and simulation, and if we also have enough well educated personnel, we may be able to make better decisions and take the Turkish Armed

Forces to a higher level. We can use our limited resources to plan the short and long term activities very efficiently by having this analysis support.

4.2 THE SYSTEM DEFINITION

The system under study is the Joint Simulation, Analysis, and Wargaming Center (JSAWC) for the Turkish General Staff. It will be the major decision support and analysis center for operational planning and force structuring in the Turkish Armed Forces. Beside this function, the JSAWC will provide limited training to decision-makers and staff officers by using wargames.

After we define the general objectives of the JSAWC, we need to develop the detailed mission specifications of the system. But even before that, we have to understand the Turkish defense system in which the JSAWC is going to be positioned. Here, my objective is to be able to determine appropriate missions for the JSAWC and identify its potential users in the Turkish Department of Defense.

4.3 THE TURKISH DEFENSE SYSTEM

In this step, I will examine the general structure and the basic functions of the Turkish defense system. The general understanding of the system environment as a result of this study will help me assign basic missions to the JSAWC to initiate the design study. When the JSAWC project becomes a real project in the future we have to come this step again and analyze the Turkish defense system in greater detail.

One way to understand the Turkish defense system is to interview many professionals from the Turkish Armed Forces and the Department of Defense. I found an opportunity to interview two Turkish senior officers who have strong operational and logistics backgrounds. [Elibol, 1997], [Kilic, 1997]. This analysis is based on those interviews, my personal knowledge and the information posted on the Internet web page of the Turkish Armed Force [Turkish Armed Forces, 1997]. I also assume that the functions and methods that will be attributed to the Turkish defense system are generally accurate.

I will try to describe the Turkish defense process from top to bottom; from defining the national security objectives to planning the operational tasks. First, I will describe the environment as the combination of important factors affecting the basic function of the Turkish defense system and then I will define the activities in those functions. In conclusion, after defining the activities of the Turkish defense system, I will identify appropriate missions in which the JSAWC can help the military decision-makers and planners.

4.3.1 TURKISH DEFENSE STRUCTURE

There are three official authorities that play executive role in the Turkish defense system. They are the Turkish Council of Ministers, the Turkish General Staff, and the Turkish Department of Defense. We can describe their positions according to the responsibilities in the Turkish Defense System.

The Council of Ministers is responsible to the Turkish Grand National for national security and preparation of the armed forces for defense of the county. The chief of the Turkish General Staff is responsible to the Prime Minister and is charged with the overall command and control of the Turkish Armed Forces. He is also responsible for the effective conduct of military operations and the readiness of the Turkish Armed Forces. The Ministry of Defense is responsible for budgeting, procurement, defense industry, technological research, administration of military justice, social services, construction, conscription, and mobilization.

The figure-11 shows the position of the each defense organization of the Turkish defense system in hierarchical way. The next three figures show the general force structure of the Turkish Land, Air, and Naval Forces. I will not expand on the lower level of the Turkish defense structure, since it is not necessary for the beginning of the study.

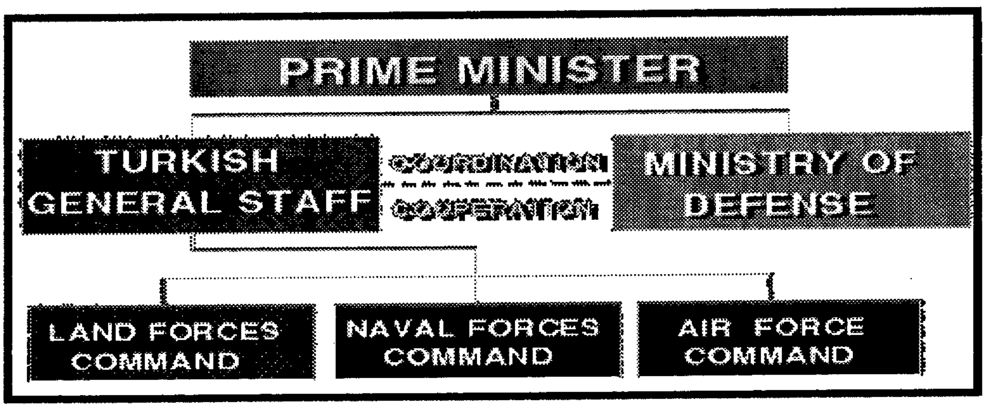


Figure 11: Turkish Defense System Structure

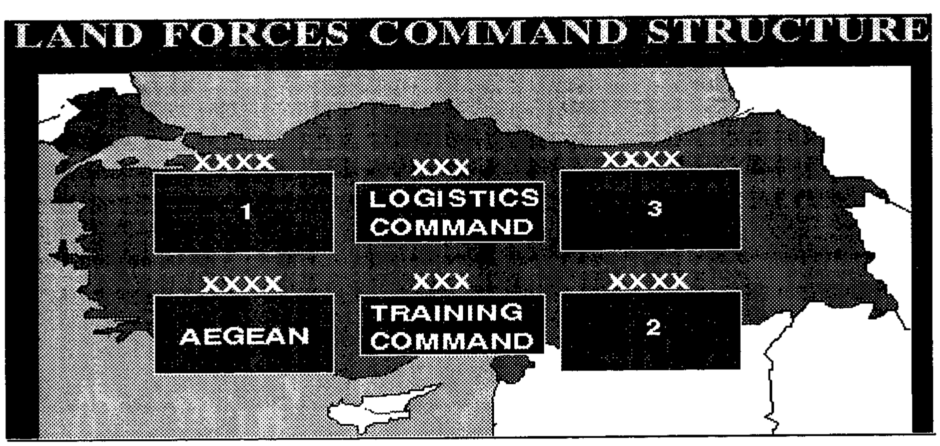


Figure 12: Turkish Land Force Command Structure

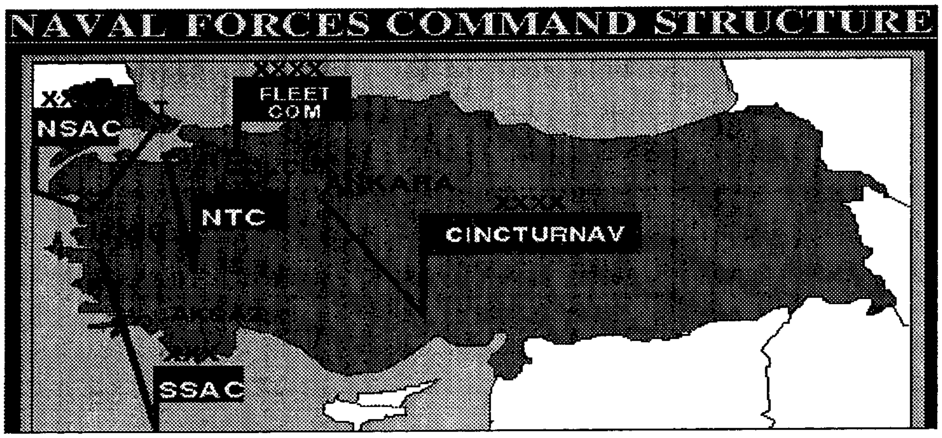


Figure 13: Turkish Naval Force Command Structure

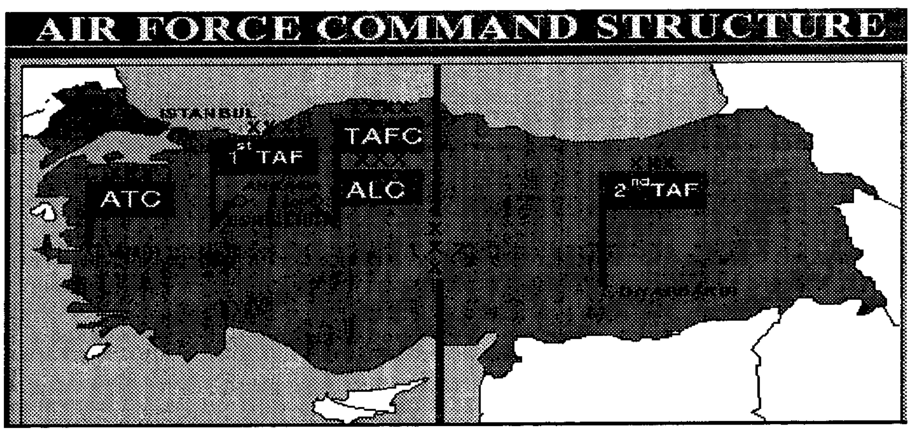


Figure 14: Turkish Air Force Command Structure

4.3.2 THE GENERAL FUNCTIONS OF TURKISH DEFENSE SYSTEM

The major types of Turkish defense system functions are defining the Turkish National Security Objectives and Strategy, defining the Turkish National Military Objectives and Strategy, Force Structuring, Operational Planning, and Execution [Figure-15]. In this study, first I examined the environments of these five main functions to understand what factors affect them. Then I defined the basic activities and products of these functions, which can be considered in the JSAWC' mission areas.

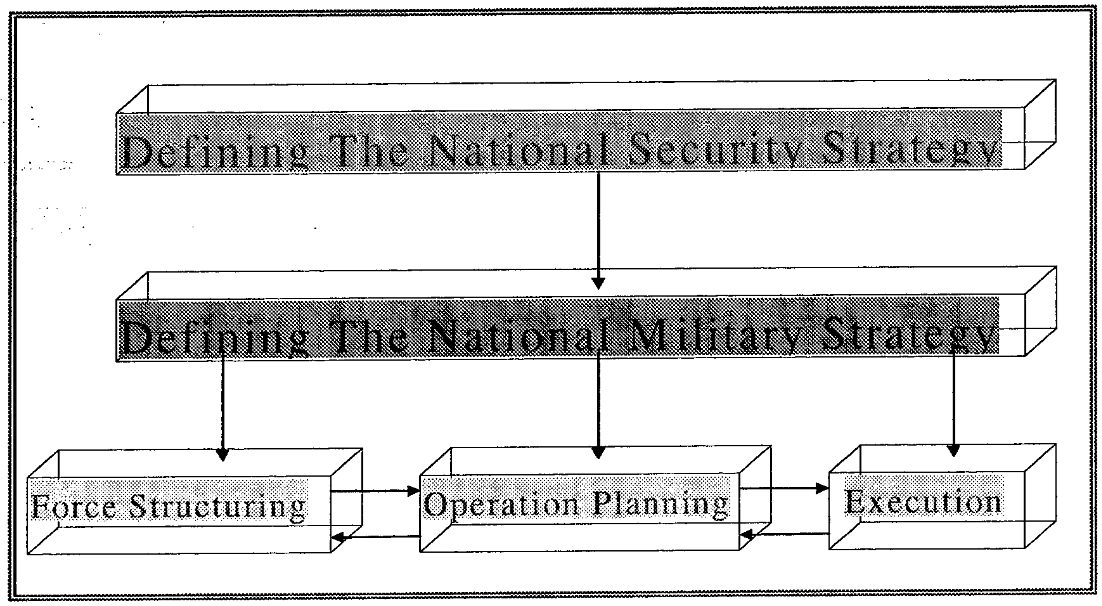


Figure 15: Major Functions of the Turkish Defense System.

4.3.2.1 Defining Turkish National Security Objectives and Strategy

Defining the Turkish National Security objectives is the first function at the top of the Turkish defense systems. Our national security objectives tell us what must be done to preserve and protect the fundamental principles, goals, and interests of Turkey in the face of threats and challenges. To define a realistic national objective we have to understand the national goals and interests [Figure-16].

The President of the Turkish Republic and the Council of Ministers in collaboration with the Turkish Grand National Assembly define the Turkish national security objectives and strategy. Once they define the threats to our nation and alliances, and examine the Turkish national power, they declare the Turkish National Security Objectives. The national security objectives then become the main source of the entire defense plans and activities. Enhancing the national security and promoting our prosperity are two examples of Turkish national security objectives.

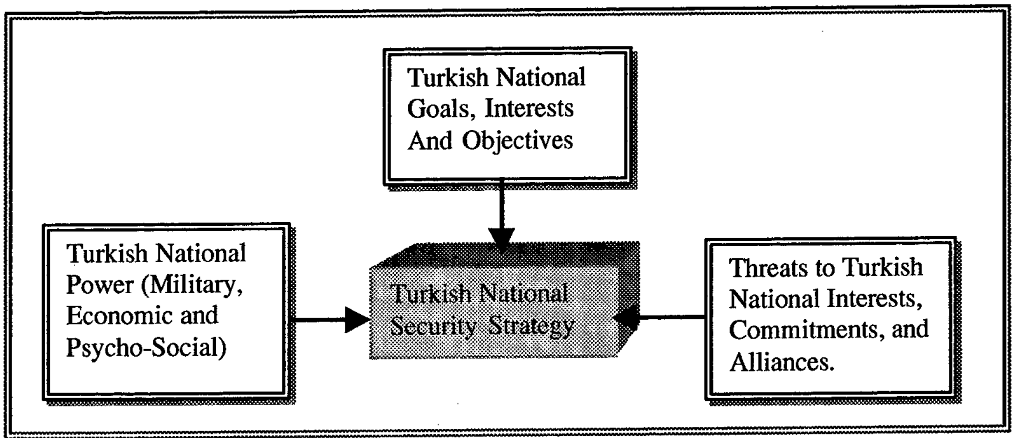


Figure 16: Environment of the Turkish National Security Strategy.

Identifying the national security strategy is the second step. The national security strategy is basically a way of employing the nation's military, political and economical power to achieve our stated national security objectives in peace and war. It generally includes statements as shown in the figure below.

Defining the Turkish National Security Strategy

- Analyze and understand the Turkish National Goals, Interests, and Objectives.
- Describe the threats to our interests, commitments, and alliances
- Describe the Turkish National Security Objectives.
- Describe the Turkish National Security Strategy: How to employ our total national power to protect our interests in presence of those threats. (Near, Mid, and Long Term)
    1. International Policy
        - ◊ Relationships with other countries (Economical, Military, and Political)
        - ◊ Relationships with international unions and organizations.
    2. Military Missions and Responsibilities at
        - ◊ Major Theater of War
        - ◊ Offensive actions to our security
        - ◊ Crises (domestic and international)
        - ◊ Other areas.
    3. Desired, Projected, Military Capabilities
- Describe the level of risk that the nation would be taking in underwriting the stated strategy because of insufficient operational capabilities due to fiscal constraints.

Figure 17: Process of defining the Turkish National Military Strategy

4.3.2.2 Defining Turkish National Military Strategy

After having the Turkish national security strategy, The Chief of the Turkish General Staff defines the Turkish National Military Objectives by analyzing the national goals, interests, security objectives, and the national security strategy of the country. Turkish National Military Objectives generally tell us what the Turkish Armed Forces must do to accomplish the national security objectives and protect its interests.

Some of the military objectives of Turkey include:

- Promoting Peace and Stability in and around Turkey.
- Ensuring the protection of Turkey's interests.
- Defeating the threats of organized violence against Turkey and its interests, when diplomatic attempts fail.

Turkish national military strategy basically represents the art and science of employing its military forces to ensure the given goals and missions in the national security strategy of the country. Under Turkish National Military Strategy, the Chief of the Turkish General staff states how we are going to achieve our military objectives, in other words, how we are going to structure, be equipped and act to accomplish the nation's military objectives. He takes the factors shown in Figure-18 into consideration before defining the national military strategy.

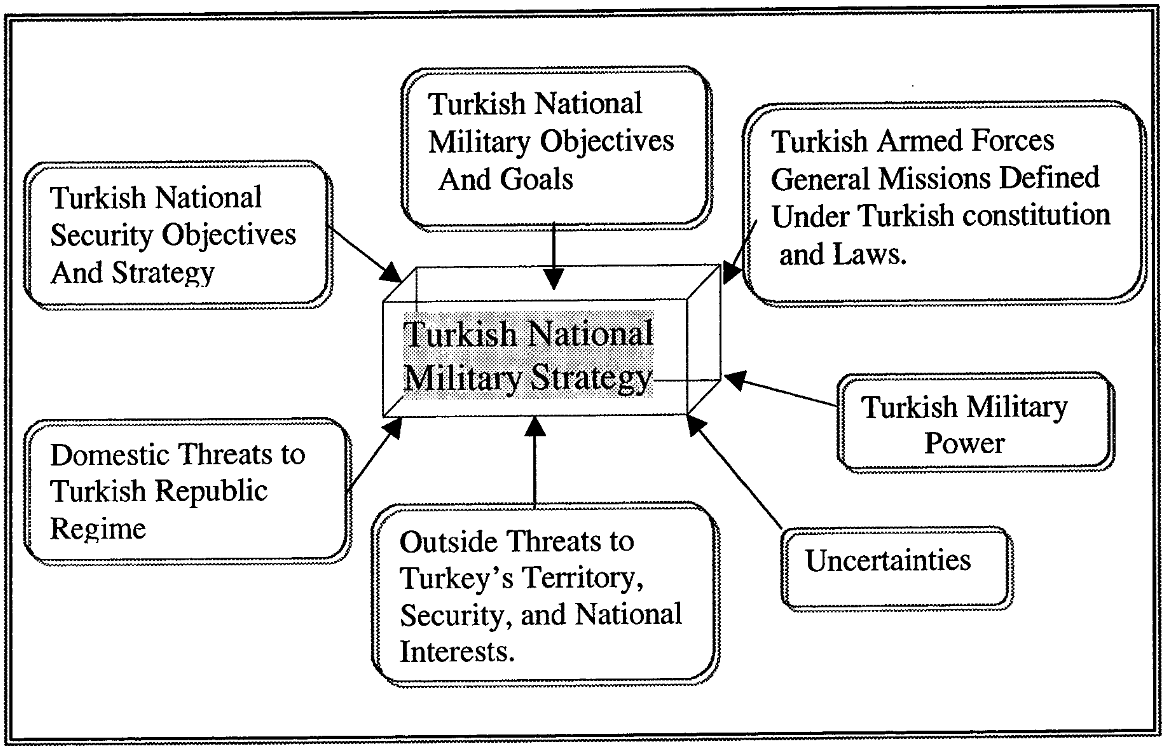


Figure 18: Turkish Military Strategy Environment

The Chief of the Turkish General Staff in coordination with the chief of each service prepares the Turkish National Military Strategy under influence of the factors shown above. They go through many iterations to find the near, mid, and long term optimum strategy. Because of Turkey's critical geopolitical position, there are many potential conflict areas. Adding global uncertainties to this situation, we can produce a lot of possible crisis scenarios. To be ready for future uncertainties we have to define our national military strategy very carefully. The general process of preparing Turkish Military Strategy is shown in the Figure-19.

Defining the Turkish National Military Strategy

- Analyze and understand the Turkish national goals, interests, objectives, and security strategy.
- Describe in detail the external threats to our security; identify where and in what way our national interest are threatened; describe the aspirations, goals, and intentions of adversaries.
- Assess the adversaries' military capabilities.
- Describe the internal threats to the Turkish Republic regime.
- Forecast the future environments.
- Describe the Turkish National Military Objectives. What should we do as Turkish Armed Forces under those conditions?
- Assess Turkish military capability as a joint force.
- Produce alternative military strategies.
- Assess the alternative strategies.
- Choose the best strategy under certain monetary and political constraints.
- Describe the Turkish National Military Strategy: How to design the defense system, how to employ our military power and how to act to protect our interests in presence of those threats. (Near, Mid, and Long Term)
  1. International Security Relationships
     - ◊ Engagement activities with our allies and friends.
     - ◊ Relationships with international defense organizations.
  2. Military Capabilities
     - ◊ Near, Mid, and Long term plans to have powerful warfighting capabilities which can response to the full spectrum of crises and which has high ability to deter.
     - ◊ How should Turkish armed forces be organized and equipped to carry out assigned missions. (Operational, Personnel, Logistic, Intelligence, and C4 systems)
     - ◊ Education and Training system.
  3. Threat Assessments
     - ◊ Assessment of exterior and interior threats
     - ◊ Prioritization of the threats according to their possible effects on Turkish national vital, important, and low level interests.
  4. Operational Concepts.
     - ◊ Describe objectives of various military operations (Major Theater of War, counter terrorism,...,humanitarian operations)
     - ◊ Explanation of how the various force elements would operate jointly to achieve operational objectives.
     - ◊ Definition of the Air Force, Naval Force, and Army employment concepts to carry out define operations and other missions.
- Describe the level of risk under this strategy.

Figure 19: General Process of Defining the Turkish National Military Strategy

Under the national military strategy, there are three basic functions that support the national military strategy directly. They are, as shown before in Figure-15, Force Structuring, Operation Planning, and Execution. Operational Planning

I divided operational planning into the following categories: national vs. international, deliberate vs. crisis, and major joint operations vs. military operations other than war (MOOTW) (Figure-20). I will not examine the Multinational operational planning part so as to not spread out the initial focus. I will explain the deliberate major joint operational and MOOTW planning phase. In addition, I assume that in crisis situations, joint operational planning and MOOTW planning follow the same steps as in deliberate planning, differing only in level of detail.

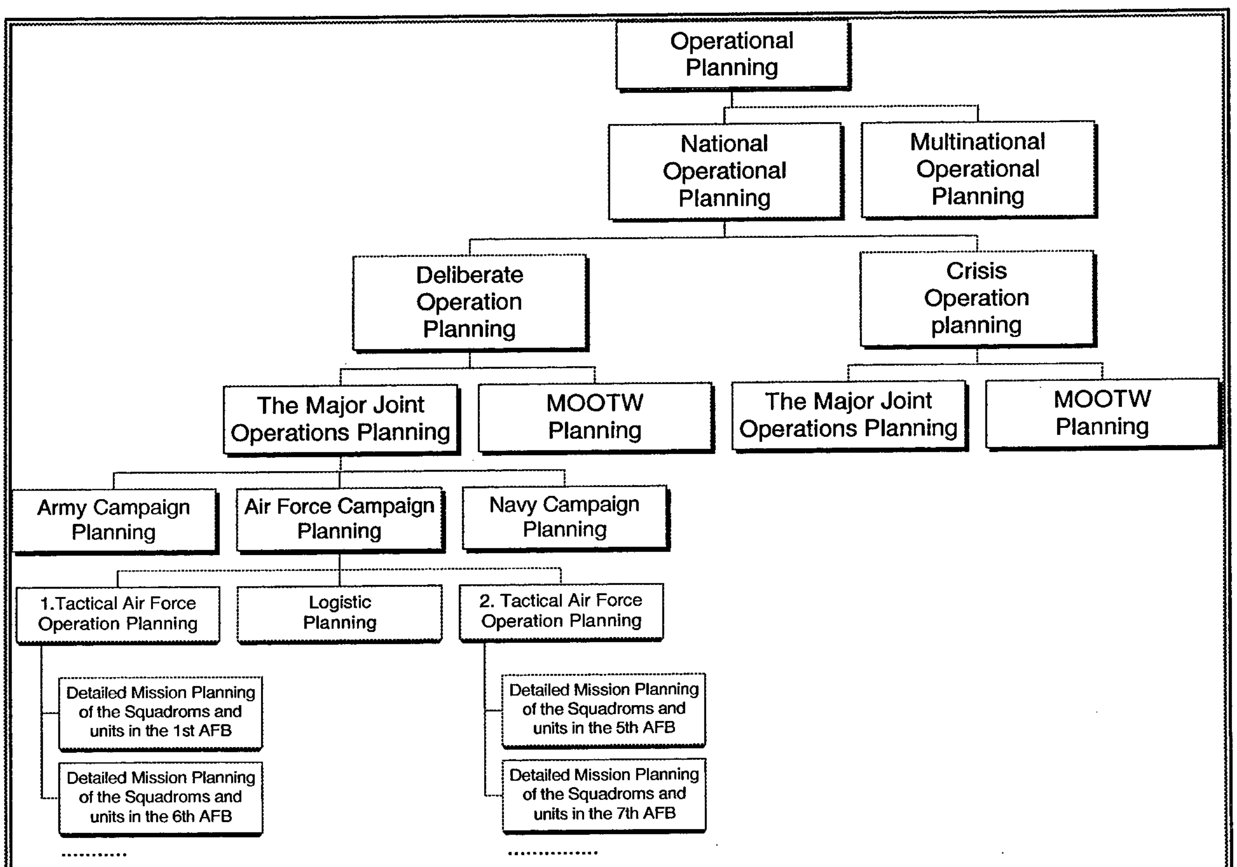


Figure 20: Operational Planning Hierarchy

4.3.2.2.1 National Deliberate Major Joint Operational Planning

After the Chief of the General Staff states the national military strategy, he and the chiefs of the three major services prepare the joint operational plans for the prioritized war/threat scenarios. At the beginning of this joint planning step, creating realistic scenarios plays a very important part in this process. They have to understand the adversaries' intentions, goals and force capabilities. Other important factors affecting a joint operation plan are shown in the figure below.

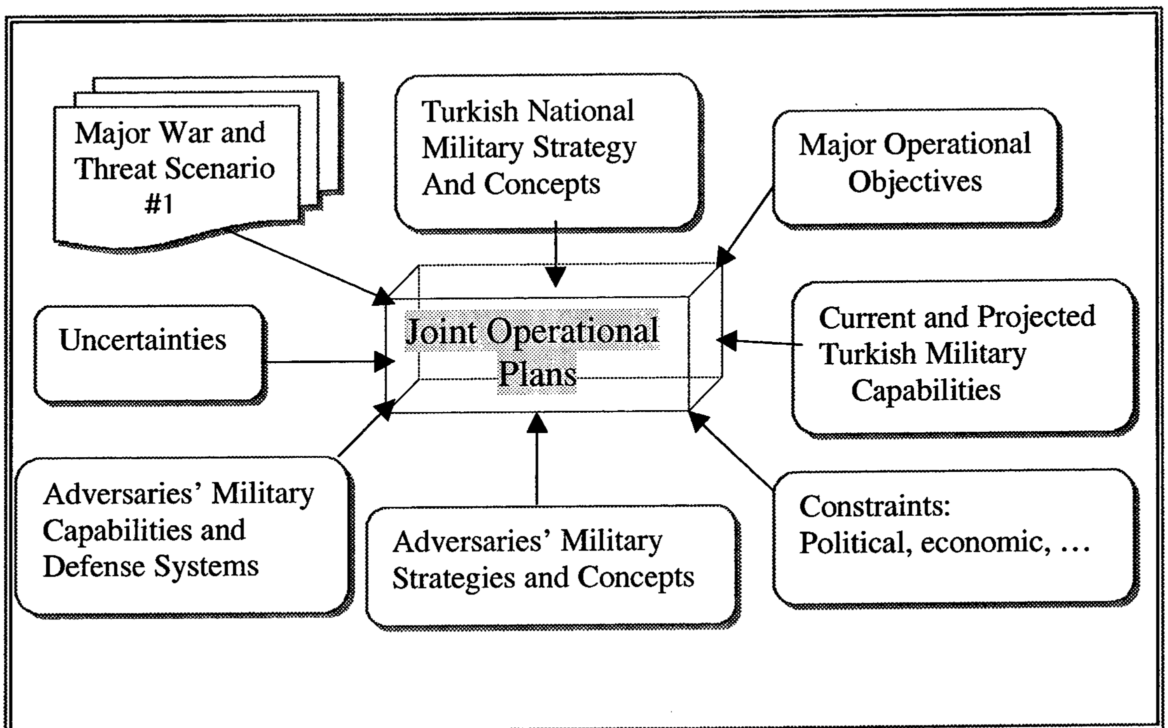


Figure 21: Major Joint Operational Planning Environment

Planning for employment of joint teams begins with articulating and understanding the purpose of the operation and the commander's intent (the commander's vision of how the operation will be conducted). Chief of Turkish General Staff and Chiefs of Services Commanders receive the direction and guidance from the Turkish National Security and Military Objectives and strategies. The basic elements of a joint operational planning phase are shown in Figure-22.

Major Joint Operational Planning

- Define the Joint operational Objectives.
- Analyze and understand the related threat scenario.
- Assess adversaries' current and projected military capabilities and defense system.
- Analyze and understand adversaries' military strategies and concepts
- Consider uncertainties
- Assess our operational capabilities.
- Define all constraints.
- Produce alternative joint operational plans by using related joint doctrine and concepts.
- Assess the alternative operational plans.
- Choose the best plan under the defined objectives meeting monetary, political and other constraints.
- Describe the Joint operational plan for the given scenario
    - ◊ Planning Assumptions.
    - ◊ Operational Areas.
    - ◊ Target Selection.
    - ◊ Resource Allocation.
    - ◊ The course of actions
    - ◊ Missions assigned to each service.
    - ◊ Organization and employment of command and forces including arrangement of their efforts in time
    - ◊ Coordination and communication procedures.
    - ◊ Operational concepts.
    - ◊ Logistic planning
- Requirements for the planned major joint operation plan.
- Describe the cost and risks of this operation plan.

Figure 22: General Process of the Major Joint Operational Planning.

In this planning process, the Chief of the Air Force, Army and Navy prepare their service's campaign plans in order to accomplish their missions in the major joint operation for the given scenario. Due to the missions of each, the type of procedures used to create their own campaign plan may be different from each other. But in general we may assume that most of the planning procedures are the same. For that reason, I am going to tell only how Turkish Air Force prepares its own campaign plan.

4.3.2.2.1.1 Air Campaign Planning

The Chief of the Turkish Air Force, after the missions of his service are defined in the joint operation plan, starts preparing the air campaign plan. He considers Turkish and adversaries' air power while preparing the air campaign plan. The other important factors which affect the over all plan are shown in Figure-23.

In the air campaign plan, The Chief of the Turkish Air Force sets the main objective of the plan and defines regional and operational force employment concepts. He is also responsible for all coordination between other services. According to this strategy, he allocates the forces, logistics, personnel and resources under his control, to accomplish the objective of the air campaign. Then, he declares the operational tasks of the Tactical Air Forces and defines the expected operational success for each in the given scenario. The general functions in preparation of an air campaign plan are listed in Figure-24.

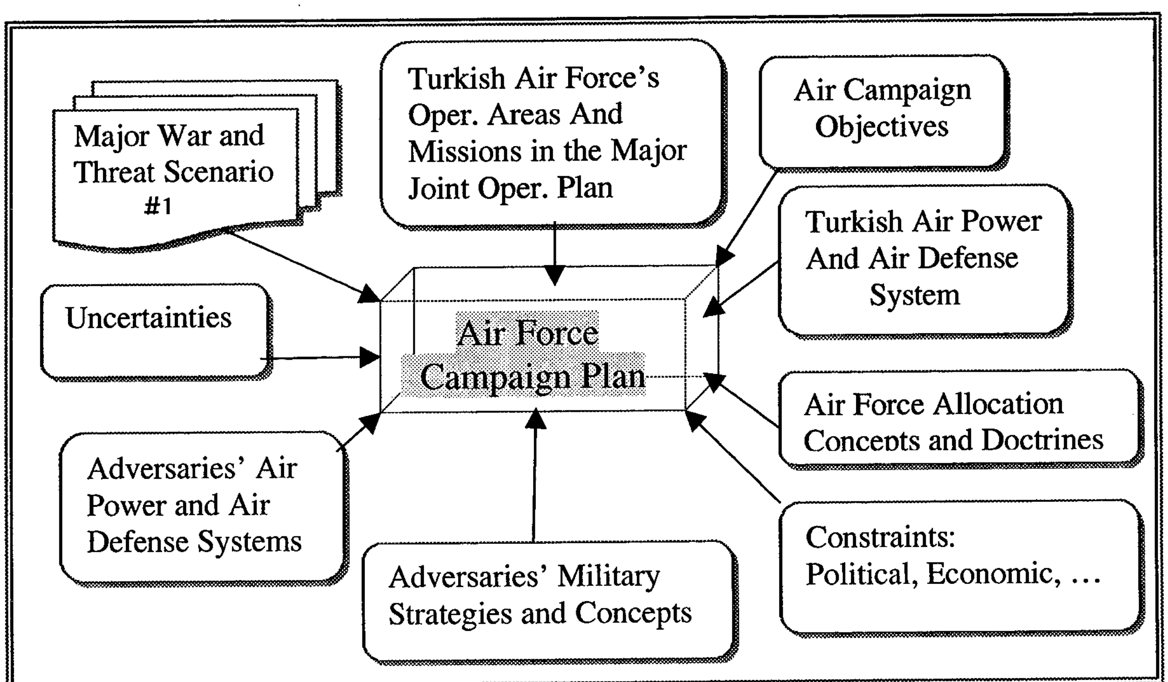


Figure 23: Air Force Campaign Planning Environment

Air Campaign Planning

- Define the air campaign objectives.
- Analyze and understand the related threat scenario.
- Understand the given missions in Major Joint Operation Plan.
- Assess adversaries' current and projected air power and air defense system.
- Analyze and understand adversaries' air operation and air defense strategies and concepts.
- Consider uncertainties
- Assess our air operational and air defense capabilities.
- Define all constraints.
- Produce alternative air campaign plans by using related air force doctrines and concepts.
- Assess the alternative air campaign plans.
- Choose the best plan under the defined objectives and monetary, logistics, and other constraints.
- Describe the air campaign plan for the given scenario
    - ◊ Planning Assumptions.
    - ◊ Explanation of missions
    - ◊ Resource Allocation.
    - ◊ The course of actions
    - ◊ Missions assigned to each Tactical Air Force Command.
    - ◊ Organization and employment of command and forces including arrangement of their efforts in time
    - ◊ Coordination and communication procedures.
    - ◊ Air operational concepts.
    - ◊ Logistic planning
- Requirements Analysis for the selected air campaign plan
- Describe the cost and risks of this campaign plan.

Figure 24: Processes of Air Campaign Planning.

4.3.2.2.1.2 Tactical Operations Planning

The Commanders of the Tactical Air Forces prepare their own operational planning after their operational tasks are given to them by the Chief of the Turkish Air Force. According to those given tasks the commanders define the objectives of the tactical air operations. Before they start preparing their plans they perform a situation analysis with the experts of operation, logistical, personnel, intelligence and communication. In this analysis, they basically examine the adversaries' force capability, expected strategy and tactics, critical targets and the defense system. At the same time, they also examine our operational, logistic, personnel and other military capabilities (Figure-25). Thereafter, they create alternative tactical plans including risk assessments and detailed requirement analysis for each tactical scenario. They then propose these alternative tactical plans to the Chief of the Air Force for final decision.

When a general tactical plan is selected, the missions of each squadron and other units in the main Air Force bases are defined according to the tactical plan. Then the related commanders of each unit prepare their detailed mission plans to accomplish the given task objectives (Figure-26)

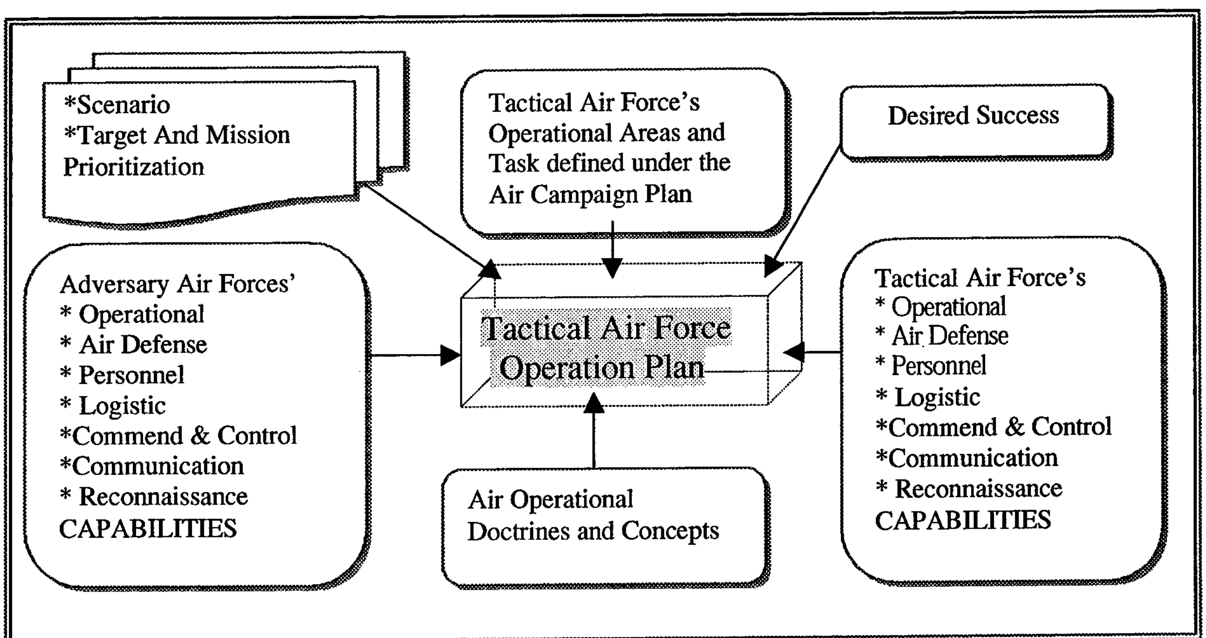


Figure 25: Air: Tactical Air Force Operational Planning Environment.

Tactical Air Force Operational Planning

- Define the objectives of the tactical air operations.
- Analyze and understand the related threat scenario.
- Understand the given missions in the air campaign plan.
- Assess adversaries' current and projected air operational, air defense, logistics, personnel and C4ISR capabilities
- Analyze and understand adversaries' possible air operation and air defense tactics.
- Consider uncertainties
- Assess our air operational and air defense capabilities.
- Define all constraints.
- Produce alternative tactical air operation plans by using related air force doctrines and concepts.
- Assess the alternative tactical air operation plans.
- Choose the best plan under the defined objectives and operational, logistics, and other constraints.
- Describe the tactical air operational plan for the given scenario.
    - ◊ Planning Assumptions.
    - ◊ Target and Mission Prioritization
    - ◊ Resource Allocation.
    - ◊ The course of actions
    - ◊ Missions assigned to each squadron and units in the Air Force Bases.
    - ◊ Organization and allocation of the total unit forces including arrangement of their efforts in time
    - ◊ Coordination and communication procedures.
    - ◊ Air operational concepts.
    - ◊ Logistic planning
- Requirements Analysis for the selected tactical air operations
- Describe the cost and risks of this operation plan.

Figure 26: Processes of Tactical Air Operation planning.

4.3.2.2.1.3 Air Campaign Logistic Planning

Besides the Tactical Air Forces, The Turkish Air Force Logistic Command prepares its own deployment and operational support plan in coordination with the Tactical Air Forces and headquarters of the Turkish Air Force. Military operations require the ability to provide logistics packages to meet operational and tactical requirements. How to organize and manage logistics efforts to meet those requirements is a very tough problem. The logistics command tries to find the optimum way of moving and sustaining operating forces in the execution of a military strategy and operations. The Logistics plan generally includes supply, maintenance, transportation, engineering and medical sub-plans in and out of operational areas. Figure-27 and Figure-28 show the general factors and procedures of an air campaign logistic planning.

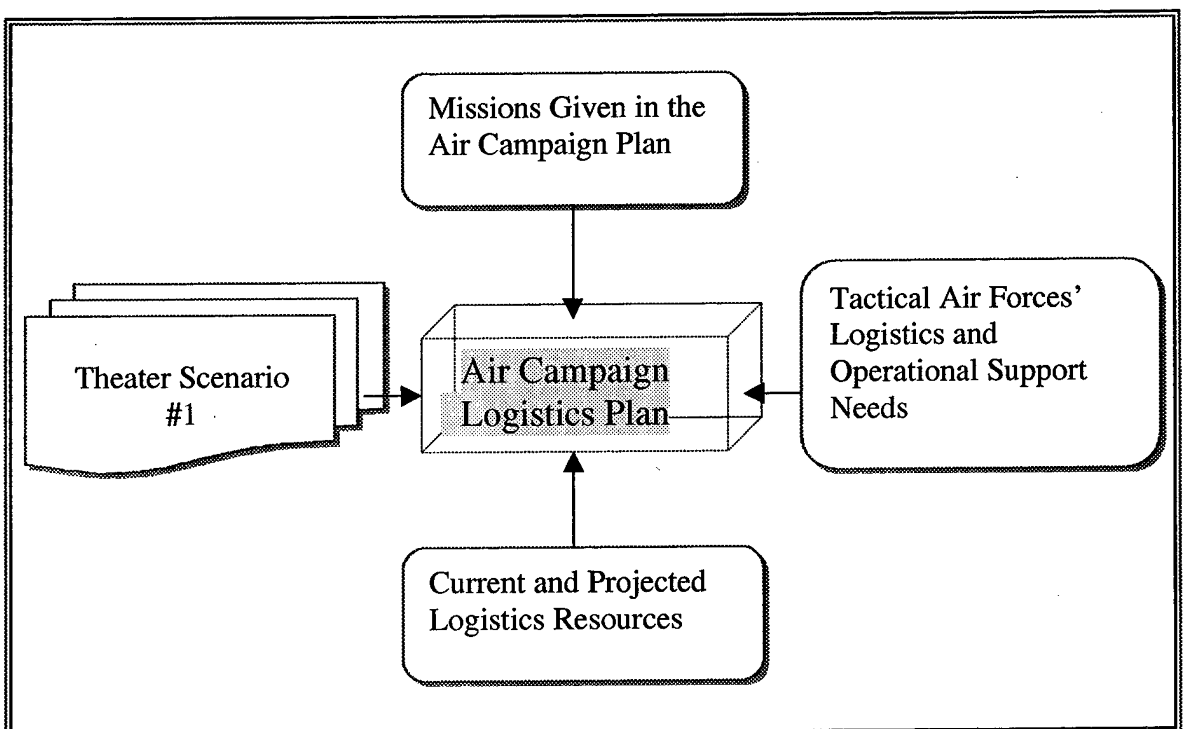


Figure 27: Processes of Tactical Air Operation planning.

Air Campaign Logistics Planning

- Analyze and understand the campaign plan.
- Analyze and understand the Tactical Air Forces' logistic needs and operational support requirements.
- Assess Turkish Air Force's current and projected logistics capabilities.
- Define all constraints.
- Produce feasible alternative logistics plans.
- Assess the alternative logistics plans
- Choose the best plan under the defined objectives and constraints.
- Describe the air campaign logistics plan for the given scenario
  - ◊ Planning Assumptions.
  - ◊ Explanation of missions
  - ◊ Resource Allocation.
  - ◊ Deployment plan
  - ◊ Transportation plans
  - ◊ Operational support plans
  - ◊ Organization and employment of supply materials
  - ◊ Coordination issues in and out of the Air Force.
- Requirement Analysis for the selected logistics plan.

Figure 28: Processes of the Air Campaign Logistic Planning

4.3.2.2.2 Planning for Military Operations Other Than War

Military operations other than war (MOOTW) generally include smaller operations such as combating terrorism, humanitarian assistance, military support to civil authorities, and peace operations. We may categorize it as Domestic and International MOOTW. Depending on the type of the MOOTW, it may require expertise from many different areas. The general environment that affects the MOOTW plan is shown in the figure below.

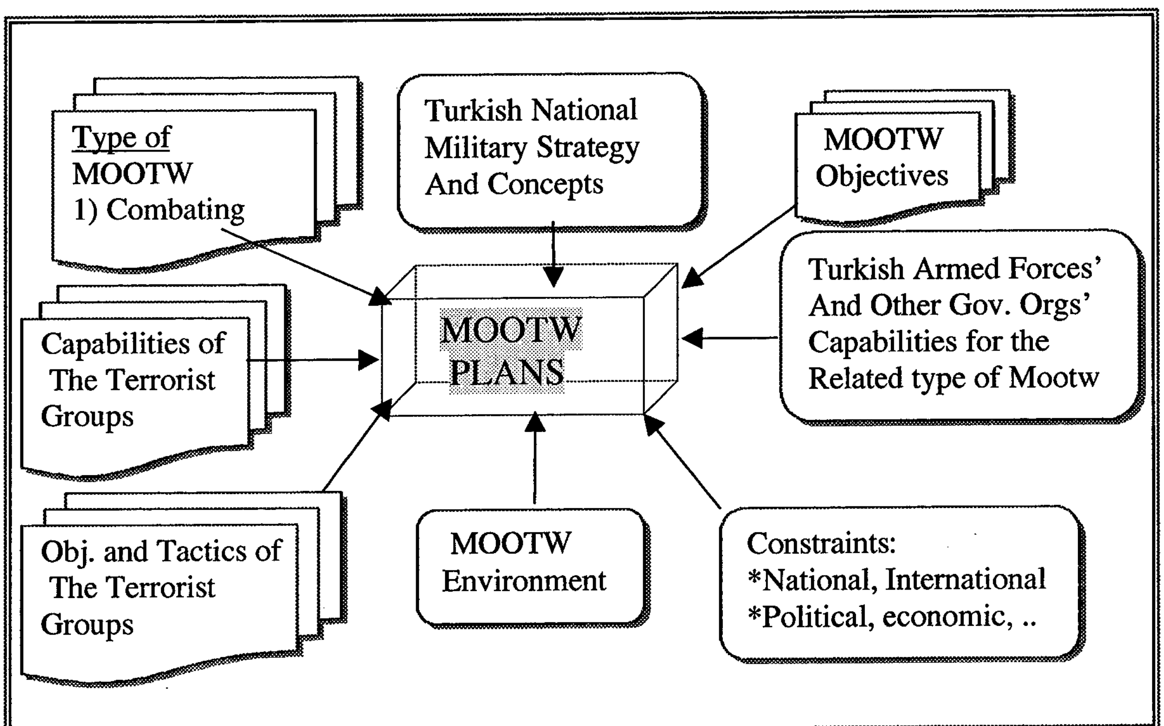


Figure 29: MOOTW Planning Environment.

The Chief of the Turkish General Staff is also responsible for planning and executing MOOTW in conjunction with the other defense authorities. MOOTW plans generally include the subjects shown in Figure-30. Although, the planning process of the MOOTW strictly depends on the type of the operation, the following procedures give us at least a basic idea of the sequence should proceed.

Planning Military Operations Other Than War

- Analyze and understand the Turkish Military Objectives and Strategy
- Analyze and define the problem carefully.
- Define the objectives of the operation other than war.
- Assess the capabilities of Turkish Armed Forces and related civilian organizations for the defined operation.
- Assess the capabilities of the opposed forces if there is. (Terrorists,..)
- Define all constraints; national and international political constraints, psycho-social, economical, etc.
- Produce feasible alternative operation plans.
- Assess the alternative force plan in terms of effectiveness, risks and cost.
- Choose the best operation plan under the defined objectives and constraints.
- Describe the operation other than war plan for a given problem.
    - ◊ Planning Assumptions.
    - ◊ Course of actions.
    - ◊ Organization and allocation of military and civilian resources.
    - ◊ Command and coordination procedures.
    - ◊ Logistic plan
    - ◊ Intelligence procedures
    - ◊ Pre-operation preparation and training plan.
- Detailed requirement analysis for the selected operational plan.
- Define the risks under this plan.

Figure 30: Process of MOOTW Planning

4.3.2.3 Force Structuring

Basically, force structuring is a process that creates a linkage between the Turkish Military Objectives and military capabilities expected under fiscal constraints. The main idea is to be able to employ the right mix of forces and capabilities to provide decisive advantage in any operation. Force structuring is an optimization process which tries to maximize the military capabilities in order to achieve the operational objectives by organizing and modifying military systems and resources. Since the future is full of uncertainties, planning the armed forces for those stochastic environments is a very tough but important mission which is primarily the responsibility of the Turkish General Staff, the Turkish Army, Air Force, and Navy in conjunction with the Department of Defense. The basic environment and general functions of the force structuring in Turkish defense system are shown in Figure-31 and described in Figure-32.

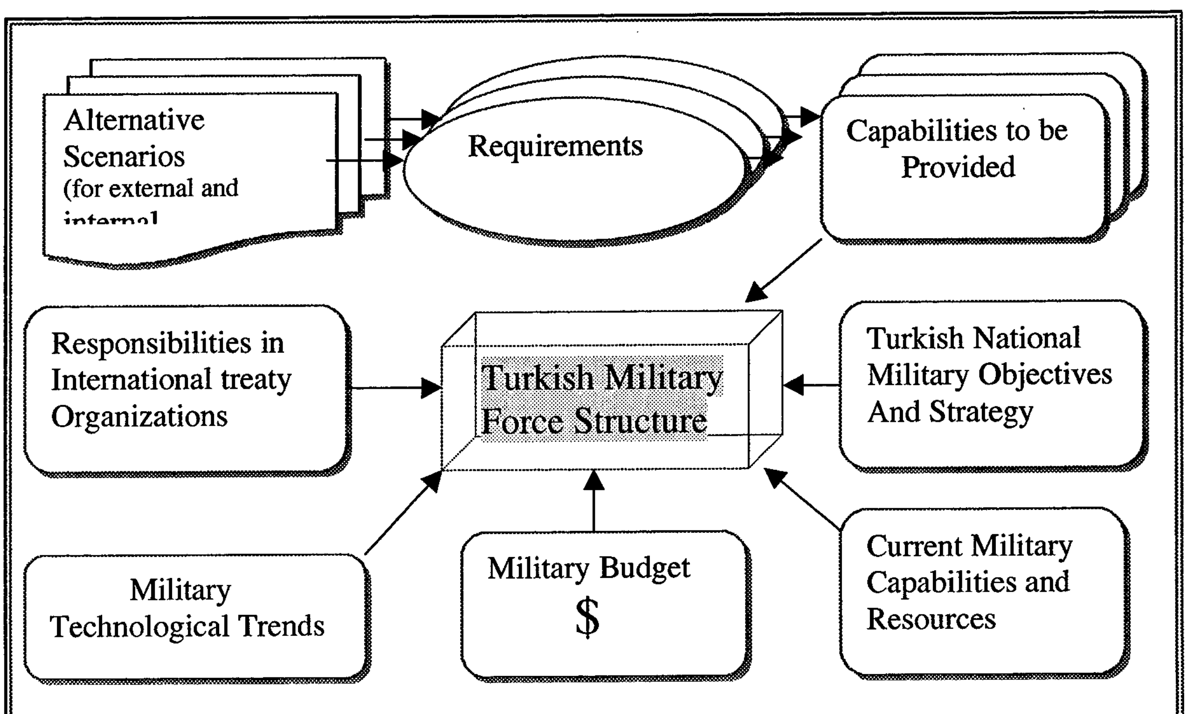


Figure 31: Turkish Military Force Structuring Environment.

Force Structuring Process

- Analyze and understand the Turkish Military Objectives and Strategy
- Analyze and understand the required current and future operational capabilities under the defined scenarios.
- Understand the responsibilities in International treaty organizations
- Assess Turkish military capabilities as a Joint; identify the critical problem areas where the capabilities of our forces are found deficient in achieving operational objectives.
- Explore the current and future military technological trends.
- Define all the constraints including current and expected long range Military Budget.
- Produce feasible alternative force structures.
- Assess the alternative force structures; effectiveness versus cost; cost versus risk, etc.
- Choose the best force structure under the defined objectives and constraints.
- Describe the Turkish force structure (near, mid and long term).
  - ◊ Planning Assumptions.
  - ◊ Architecture of the defense system
  - ◊ Organization of the force elements (Air, Naval, Land)
    - ♦ Operational
    - ♦ Logistics
    - ♦ C4ISR
    - ♦ Training
  - ◊ Force Sizing: How many weapon system, logistics, etc. are we going to employ and modernize from which type?
  - ◊ Human Resource plans.
- Detailed requirement analysis for the selected force structure.
- Define the risks and cost under this force structure.

Figure 32: Processes of the Force Structuring.

4.3.2.4 Execution

Execution is another phase of the defense system. We categorize this function into peacetime and wartime executions. We define wartime execution as taking the operational plans and orders into action in a war time situation. It is an ongoing process until the war or operation ends. On the other hand, peacetime execution is a combination of managing activities of the training process to prepare the military forces for a wartime situation.

We may also group the execution as national or international. The execution of international military operations differs from the national operations in many ways. They require different organization, command, control and communication procedures, and operational planning. For instance, NATO, one of the military organizations of which we are apart in, has special requirements, standards, and procedures for its exercises that we may not have for national ones.

Wartime execution assistance is not in the scope of this study. The JSAWC is going to provide decision support for only planning the operations in wartime. Execution missions may be considered in the future study. The hierarchical view of the execution function of the Turkish Military system is shown in the figure below.

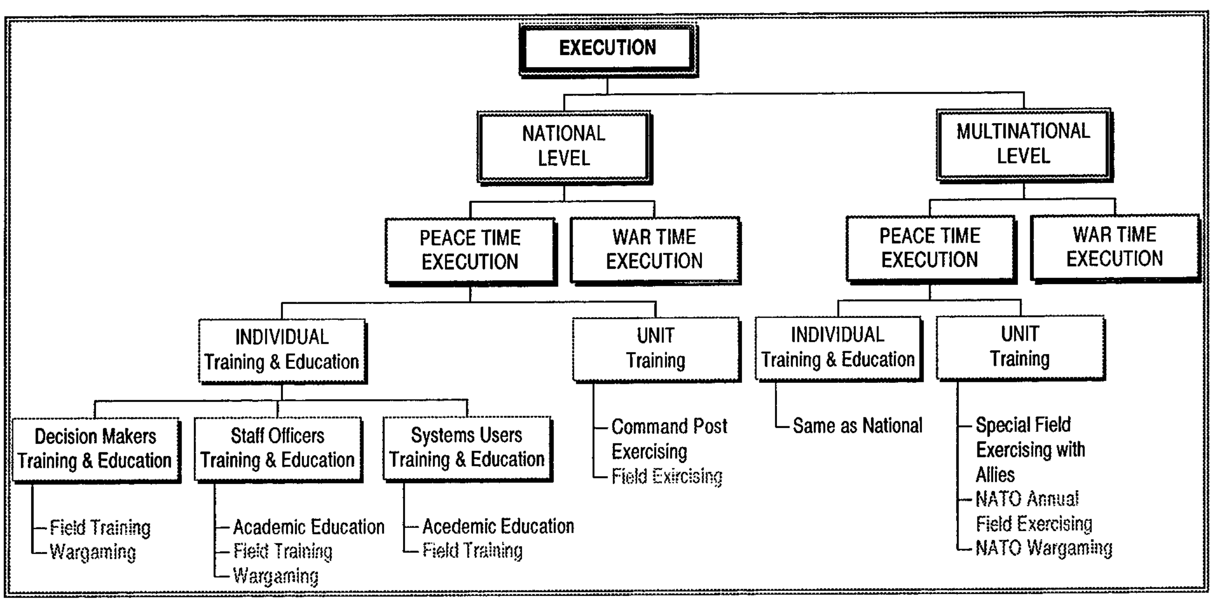


Figure 33: The General Execution Hierarchy

As shown in the Figure-33, I have divided peacetime execution into *unit training* and *individual training & education.* The objective of the unit training is to prepare military personnel for possible future wars by providing them a simulated war environment. Two known exercise types are command post exercises and field exercises. While we test some tactics and operational procedures in these exercises, we also try to find deficiencies and problem areas of our defense system.

Individual training & education can be categorized into three levels; 1) decision-makers training, 2) staff officers training, and 3) system users training. Academic education, field training, simulation and wargaming are the environments in which individuals get their training & education.

Objectives for the decision-makers training are to:

- Understand the Turkish and adversaries' Defense system; military capabilities and deficiencies.

- Be aware of the current threat scenarios.

- Be prepared to make critical decisions in a war situation.

- Learn how to use decision support tools

- Improve the understanding of the command, control, and communication procedures.

Objectives for the staff officer training are:

- Understand the Turkish and adversaries' Defense system; military capabilities and deficiencies.

- Be aware of the current threat scenarios.

- Be able to produce alternative courses of actions and analyze them.

- Be able to make detailed mission plans.

- Be able to do requirement analysis for a given operational task.

Objectives for the system users training are to:

- Learn how to use their system (weapon, radar, vehicle, etc.) effectively.

- Understand the status and importance of their roles in a war.

- Prepare themselves as if they are going to fight tomorrow.

4.4 GENERAL MISSIONS OF THE JSAWC

After examining the functions of the Turkish defense system, I selected the specific missions shown below that can be accomplished by the JSAWC. The mission areas are very important and critical in which military decision-makers and planners need highly analytical decision support to increase the power and success of the Turkish Armed Forces. I categorize the JSAWC's mission according to the types of military functions as in the Turkish Defense System, part 4.3.2. In peacetime, the JSAWC has to accomplish all of the missions listed below. However, in wartime, the JSAWC will focus on only the missions under the joint operation-planning phase and ignore the other missions about the force structuring, and training.

Here, I defined the JSAWC's missions related to the service campaign, tactical, and logistics planning, only for the Turkish Air Force. I assume that the JSAWC's missions in the Army and Navy will be similar to the ones defined for the Air Force. When the JSAWC becomes a project, all the missions will have to be specified in detail.

Defining the Turkish National Military Strategy

- Assessments of Turkish and the adversaries' military capabilities.
- General threat assessment and prioritization.

- Analysis of the alternative military strategies.
- Risk assessment of the selected military strategy.

Major Joint Operations Planning

- Assessment of Turkish joint operational capability in a given scenario.
- Assessments of the adversaries' joint operational capability in the same scenario.
- Analysis of the alternative operational strategies.
- General requirement analysis for a given major joint operational plan.
  - ♦ What type of weapon system and how many do we need?
  - ♦ Command, control and communication system needs.
  - ♦ Personnel needs.
  - ♦ General Logistic and transportation analysis
  - ♦ Deployment and redeployment analysis.
- Cost and risk assessment of the selected major joint operational plan under the given scenario.

Air Campaign Planning

- Assessments of the Turkish air operation and air defense capabilities in a given scenario.
- Assessments of the adversaries' air operation and air defense capabilities in a given scenario.
- Analysis of Alternative Air campaign plans
- Requirement analysis for the selected air campaign plan.
  - ♦ Weapon system needs (aircraft, radar, missiles, ...etc.)
  - ♦ Ammunition needs

- ♦ Personnel needs
- ♦ Transportation needs
- ♦ Command, control and communication system needs.
- ♦ Other logistic needs
- ♦ Air deployment and redeployment analysis

- Cost and Risk assessment of the selected major joint operational plan under the given scenario.

Tactical Air Operations Planning

- Assessment of the Turkish and adversaries' tactical air operations in a given scenario.

Air to Air, Air to Ground, Ground to Air, Air to Sea, Sea to Air,

- Analysis of alternative air tactical plans.
  - ♦ Target selection
  - ♦ Target - Aircraft combination
  - ♦ Task - Squadron/Unit force
  - ♦ Weapon system mix
  - ♦ The course of actions
- Detailed Requirement analysis of the planned tactical air operation
  - ♦ Weapon (X type Fighter, Bomber, ... etc. aircraft) needs
  - ♦ Personnel (pilot, maintenance personnel, ... etc.) needs
  - ♦ Ammunition (AIM9, MK-84, ... etc.) needs
  - ♦ Transportation needs
  - ♦ Other logistics needs.

- Cost and Risk assessment of the selected tactical air operation plan under the given scenario.

Air Campaign Logistics Planning

- Assessment of the Turkish Air Force logistics capabilities in an air campaign.
- Analysis of the alternative logistics plan in a given scenario
  - ♦ Deployment and Redeployment,
  - ♦ Propositioning,
  - ♦ Support forces,
  - ♦ Resource allocation,
  - ♦ Maintenance,
- Requirement analysis of the selected logistics plan in a given air campaign.

Planning Military Operations Other Than War

Currently I am not going to give any specific mission to the JSAWC for the MOOTW planning. It does not mean that those missions are less important or not appropriate for the JSAWC. My aim here is not to spread out the functions of the JSAWC at the initial phase. In the future, we can add those missions and modify its structure after the JSAWC has been in use for a couple of years.

Force Structuring Process

- Analysis of alternative force structures; effectiveness vs. cost; cost vs. risk, ... etc.
- Force sizing study; how many weapon system, personnel, logistics equipment, ... etc. we need to employ.
- Weapon systems' effectiveness analysis for procurement projects.
  - ♦ New aircraft selection

- ♦ New tactical Missile selection
- ♦ New radar selection
- ♦ ... etc.

- Risk assessment of the given force structure.
- Cost Analysis of the given force structure.

Training

- Give short courses to decisions makers about M&S and Wargaming.
- Prepare computer assisted wargaming in operational level for decision makers and staff officers.

4.5 THE POTENTIAL USERS OF THE JSAWC

The system users are the people or groups who have the right to request a study or analysis as defined under the JSAWC's mission statement and who can request training from the JSAWC. According to the mission statement of the JSAWC, I identified the following groups as the system users. These are the authorities in the Turkish Defense System, who are responsible for the execution of the missions in which the JSAWC's analytical support is needed.

Analysis:

- The Chief of theTurkish General Staff.
- The Chiefs of Army, Navy, and Air Force
- Operational planning divisions of the each service.
- Logistics planning division of the each service
- Force structuring division of the each service

- Research division of the each service
- Turkish Department of Defense

Training:

- All general officers of the Turkish Armed Forces
- The high level decision makers of the Department of Defense.
- Staff officers working at the operational planning, Logistics Planning and Force structuring division of the Army, Navy, and Air Force headquarters.

4.6 THE SYSTEM ENVIRONMENT

The environment of the JSAWC refers to the combination of all people and organizations that have relations with the JSAWC and affect its functions (Figure-34). The main organizations in the JSAWC's environment are the Turkish General Staff and headquarters of Air Force, Navy, and Army. The main objective of the JSAWC is to provide decision support for the Turkish general officers, related to force structuring, operational planning and logistics problems of the Turkish Armed Forces and Department of Defense. In addition to this analysis support, the JSAWC will also provide training for the Turkish general officers and some staff officers by using wargaming techniques.

I assume that in the future there will be centers similar to JSAWC in the Air Force, Army, and Navy headquarters that provide M&S supported analyses to their headquarters for the lower level military problems and situations. When they are built, there will be a close relationship between the JSAWC and those centers. The objective is to use our analysis capacity efficiently, and not allow undue overlaps. Therefore, we need to incorporate them into the future environment of the JSAWC.

In the JSAWC environment, we can also include symposium, conferences, and other activities related to its missions and interests. The JSAWC will closely follow technological improvements in the world. So, its members will need to attend national or international symposiums, conferences and other activities related to military modeling, simulation, optimization, analysis, wargaming, decision making, and operations research.

Another element in the JSAWC's environment will be academia. It will build close relationships with the Universities in Turkey. The center will sponsor theses and dissertations related to military problems. For some problems, personnel will work together with academics to produce better analysis or research. Being in touch with academia is very important for JSAWC members to built up their knowledge and keep it fresh. New members of the center will go to national or foreign universities to take some courses if they need to do their job successfully.

Civilian companies related to the JSAWC's missions will be also in that environment. The JSAWC will need to work with the national and international companies that have technical expertise not available in the center. Software and model development is one of the areas that will also require a high level of expert support from the outside. Technology transfer from civil companies is another dimension of the relationship that must be considered.

Another mission for the JSAWC is to represent Turkey in other simulation, analyses, and wargames activities in NATO or other multinational exercises. If they share the information and techniques for the solution of the same military problem, and if they work together on common problems, all of the allied countries will get benefits such as less cost and less time for solving problems. For these reasons, we have to put the allied military forces or DoD into the JSAWC's working environment.

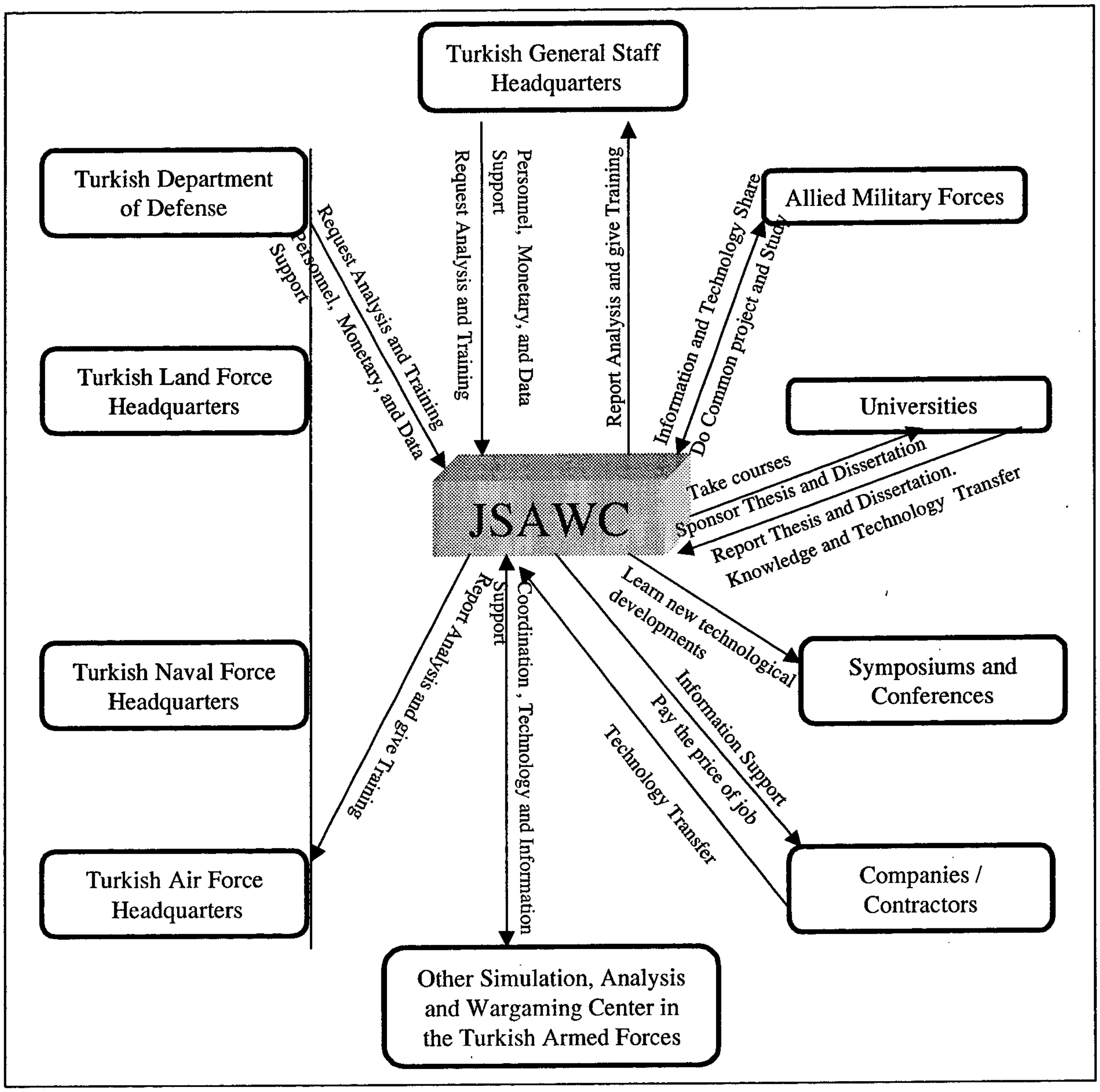


Figure 34: The Environment of the JSAWC

4.7 NEEDS

In this part of the problem definition step, we will identify the needs of the system from the decision-maker's viewpoint. The decision-maker's needs statements generally shows ideas about how the system should accomplish the missions defined in the mission statement. In addition, he also specifies the desired features of the system, system components, and the way the system works. The decision-maker's need statements combined with the mission will be used at the requirement analysis step of the design process as the main source documents. Since the system engineering process is an iterative process, according to further results of the design study those needs statements and mission statements are going to be modified by the decision-maker.

As you see below, I have proposed the following as a part of the decision maker's need statements under the categories of model, data, personnel, location, infrastructure, computer system and management.

4.7.1 MODEL

- Produce combat simulation models, mobility models and wargames at the JSAWC to accomplish the given analysis and training missions.
- If the JSAWC cannot produce all models, acquire them from civilian computer and simulation companies in Turkey, from outside companies, or the Department of Defense of the allied foreign countries.
- Always use updated simulation models in the JSAWC in terms of current data, scenarios and new technologies.
- Ensure that Air, Army and Naval Force roles and missions are properly represented in JSAWC's simulation combat models and wargames.

- Ensure that Joint Command, Control, Communications Intelligence, Surveillance and Reconnaissance (C4ISR) systems capabilities and architectures are properly represented in the JSAWC.
- Models should be interoperable with other modeling systems in the Turkish Defense System.
- There must be a formal standard for representing roles and missions of the functional areas supporting combat systems.
- There must be a standard architecture for all the models used at the JSAWC.
- All the models must be flexible enough for future improvements.
- There must be a formal verification, validation, and accreditation process of the models.

4.7.2 DATA

- Create a fast data link with the data sources (intelligence agency, allied countries, ... etc.).
- Create a central data base system for the required data of the models.
- There must be a formal validation process of the data before using it in studies and models.

4.7.3 PERSONNEL

- Prepare a short term and long term personnel program to meet the personnel needs of the JSAWC. Specify all the required features for the personnel in each position, and plan future personnel according to those specifications by sending them to appropriate universities, programs, or courses.

- Prepare an education program for the JSAWC personnel and send them to universities and other institutes to take courses related to their proficiencies to improve their knowledge every year.
- Maintain a continuing education program for JSAWC personnel.
- Participate in the national or international symposiums, conferences, and other activities related to JSAWC's missions, functions, and other areas of concern.

4.7.4 LOCATION

- The JSAWC should be located at the Turkish General Staff Headquarters or very close to it in Ankara (the capital city of Turkey).
- The JSAWC should have deployable capability for wartime close operational planning support if needed.

4.7.5 INFRASTRUCTURE

- There should be at least one cubicle or room for a person in the JSAWC.
- There should be enough computer labs, study rooms, and briefing rooms, which satisfy the system workload.
- The structure of the building and area of the JSAWC should be big enough to be able to expand the system capacity in terms of new missions and workload as needed. (Minimum 50% expandability)

- The infrastructure of the JSAWC should be suitable to add distributed simulation systems if needed in the future.

4.7.6 COMPUTER SYSTEM

- The capacity of the computer network should not be a constraint for the JSAWC's studies.
- Each hardware requirement of the simulation models and other software should be satisfied.
- The types of and number of computers should not be a constraint for JSAWC's studies.
- There should be global connectivity (Internet system).
- The computer system must satisfy security requirements.

4.7.7 MANAGEMENT

- There should be minimal overlap and duplication of efforts.
- All the studies and analyses must be recorded and archived.
- Every military study and analysis done over the last 50 years related to the JWASC missions should be gathered in the Library of the JSAWC.
- All the security issues should be considered in the JSAWC.

4.8 CONSTRAINTS

I can see six types of constraints for the JSAWC's design study: monetary, personnel, technological, location & space, security, and socio-psychological constraints.

Only types of constraints will be defined for this study without giving any quantitative input. All the constraints of the JSAWC will be defined exactly when the Turkish DoD accepts this project.

4.8.1 MONETARY CONSTRAINTS

One major factor that must be considered is the issue of funding. Since the Turkish General Staff can not give an unlimited amount of money to the JSAWC project, we have to consider the total cost of the project as a constraint. Cost implies not only the construction cost of the JSAWC, but also the research, design, and operating cost of the system. The question here is, how much can the Turkish Department of Defense spend on this project? This will have to be answered before the project can begin. I will not estimate the availability of funds as the monetary constraint of the project, because, first, I do not know the future budget plan of the Turkish Defense and second, I will not get into the detail that the system cost analysis study is performed, in my thesis.

4.8.2 PERSONNEL CONSTRAINTS

We have to think of personnel constraints in three time phases. The first time phase is the research and design phase of the JSAWC. The situation that we must analyze is how many people from the required proficiencies we need to have in the system design team versus how many people the Turkish General Staff can provide. If there are not enough people, the time of the project is going to increase and the quality of the job is probably going to decrease.

The second time phase is the first two or three years of the JSAWC. We need to figure out the minimum number of personnel required for each position at the JSAWC to initiate the operation. The number of personnel currently available in the Turkish Defense System for those positions is the constraint at this time.

The third time phase is the time that the JSAWC plans to be functioning at its full capacity. I assume that the Turkish DoD is going to plan and send some personnel to universities for graduate education, send others for special courses, or hire new personnel to fill the required positions at the JSAWC. If the Turkish DoD can not allocate enough personnel, we need to change the schedule or the capacity of the JSAWC. So, the DoD's capability of providing personnel for the JSAWC is another constraint will need to be considered.

4.8.3 TECHNOLOGICAL CONSTRAINTS

Technology is another important constraint that we have to consider. We may not always be able to find the technology that we desire. We need to set the requirements of the system according to existing technology. The limiting technology can be software, hardware, or civil engineering technology for our system. What are the maximum performances of the different types of computer hardware? What are the capabilities and limits of the simulation languages and existing simulation technology? The answers to questions similar to these identify the limits of technology that we can use in our system.

4.8.4 SPACE CONSTRAINTS

Does the Turkish General Staff have enough buildings or space in or near the headquarters for the JSAWC? If there is available space, what is the exact size of it? The size of the space is going to affect the architecture of the building. If there is no available space in or around the headquarters of the Turkish General Staff, what are other appropriate places that we can be used for the JSAWC? Questions like these recognize there may be space and location constraints to consider in planning.

4.8.5 SECURITY CONSTRAINTS

Since most of the data that will be used in the analyses and combat models is going to be classified as secret or top-secret, we have to consider the security of the center as a top priority. This constraint will limit our study from the beginning of the project to the end of the JSAWC's life. We are not going to be able to work with every person on our project, studies, and researches. We can not share information or discuss problems easily with anyone outside of the JSAWC. In its design phase, we have to consider the security issue and take appropriate actions.

4.8.6 SOCIO-PSYCHOLOGICAL CONSTRAINTS

In this study, socio-psychological constraints refer to possible contradictory reactions. It is basically the response of the people in the DoD to the project of the JSAWC and the system after it is built. If you convince people around you to believe the benefit and advantage of the JSAWC, they will try to help your study in the design phase of the system. Also, after you design the JSAWC, if the users believe in the advantages the system has to offer, they will try to use the JSAWC as much as they can and they will contribute to the studies positively. But, on the other hand, if some people do not believe the usefulness of the JSAWC or if they believe that it is going to take their job from their hand by centralizing most of the analysis job, they may contradict the JSAWC project and cause problems. This is a very sensitive subject to be considered carefully from the beginning to the end of the project.

4.9 ALTERABLES

Alterables are variables of the system and its environment that can be controlled by the design team or the decision-maker. Software, hardware, personnel, and location are the ones that we consider as the main types of alterables in the JSAWC project. I proposed the following as the system alterables in these four groups.

4.9.1 SOFTWARE

Each type of software required in the JSAWC is an alterable of the system. We are going to make decisions on what type, which brand, and how many of the software we will use in the JSAWC. We might categorize some of them as;

- Warfare models
- Modeling and Simulation Software
- Statistical Analysis Software
- Optimization Software
- Office Software

4.9.2 HARDWARE

Any equipment in the JSAWC required to accomplish the given functions. We need to decide what type, which brand, and how many we need to have for the JSAWC.

- Computer Hardware
  - Network File Server
  - Work Station, Personal Computer
  - Backup Server
  - Printer, …etc.
- Office Hardware
  - Standard office equipment (Desk, chair, copier, …)
  - Presentation equipment (Projector, TV, VCR, ...)
  - Library and Archive Equipment, …etc.

4.9.3 PERSONNEL

We will decide how many people and from which service, professions and proficiency we need to hire.

4.9.4 ORGANIZATIONAL STRUCTURE

We need to identify the organizational structure of the center.

4.9.5 LOCATION

We have to decide where we are going to locate the JSAWC.

4.9.6 INFRASTRUCTURE

The decision should be made on architecture of the JSAWC building such as number of and size of study rooms, briefing rooms, and computer labs, type of materials, and other facility related issues).

5 REQUIREMENT ANALYSIS

5.1 INTRODUCTION

Requirement analysis of the JSAWC can also be thought of as the second phase of the problem definition step. The requirement analysis and problem definition steps are connected to each other in many ways. The documents written in the problem definition step are going to be the main source documents for the requirement analysis of the JSAWC. Besides those documents, the decision-maker will be another main source for this step. The decision-maker will play an active role in the requirement analysis step by being ready to answer the design team's questions.

In the requirement analysis step, we are going to identify the necessary types of system elements and the general system structure to accomplish the missions and the objectives defined by the decision-maker. Then we will identify the required specifications of the system elements according to the required functions, the need statements, and the decision-maker's values.

To produce a good requirement analysis, it is necessary to have an intense understanding of the JSAWC's design objectives. For that reason, the first thing we need to do in this step is to examine the objectives of the system in detail. We are going to use the problem definition documents and interview with the decision-maker when necessary to analyze the system objectives. A way to analyze the objectives is by creating a system design objective hierarchy and identifying them according to their classes in the hierarchy. We are going to do the same thing for our study. We will create the objective hierarchy of the JSAWC as a first step of the requirement analysis process.

In this step, since we will match the system functions with the system elements, we need to understand how the JSAWC should work, what the relationship between the system elements are supposed to be, and what the relationship between the system and its environment needs to be. We will also examine the systems required behavioral functions in a hierarchical way, as we will do for the objectives of the JSAWC.

Since the system design process is a highly iterative process, the requirement analysis step should be visited more than once until the end of the project. The question here is from which point we need to start defining the requirements of the system elements. After we understand all the relationships between the system elements, we will identify the sequence of the requirement analysis steps.

5.2 THE SYSTEM OBJECTIVE HIERARCHY

We are going to analyze the JSAWC design objectives in this step. The hierarchical way of breaking down the objectives will provide a good picture to understand the importance points of the system. After we see the relationships between all of the objectives from top to bottom, we will define how we can accomplish those objectives.

The overall objective: The primary objective of the design study is *to design the best joint simulation analysis and wargaming center for the Turkish General Staff.* Since it is a very generic objective, we need to specify it by breaking it into two main classes. One of them is *the system functional objective* and the other is *the system performance objective.* In this project, the best means a center which satisfies all the design objectives the most, such as maximum effectiveness, maximum security, and minimum cost which are defined under the system functional and performance objectives.

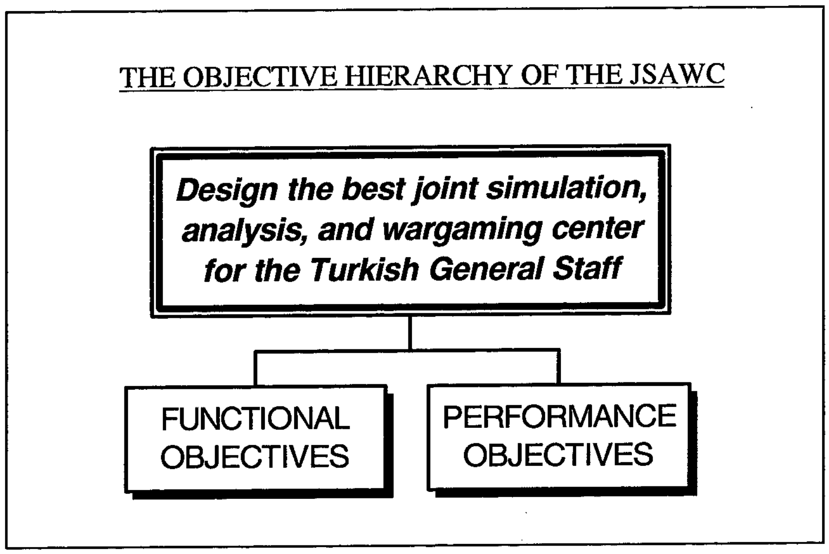


Figure 35: The Top-Level Objective of the JSAWC.

5.2.1 THE SYSTEM FUNCTIONAL OBJECTIVES

These are all the missions and functions that are expected to be accomplished by the JSAWC. These objectives basically come from the mission statements defined in the problem definition step. In the Figure-36, I showed the types of missions that we want to accomplish at the JSAWC. The exact missions can be found in the mission statement documents defined in the problem definition step (Section 4.4)

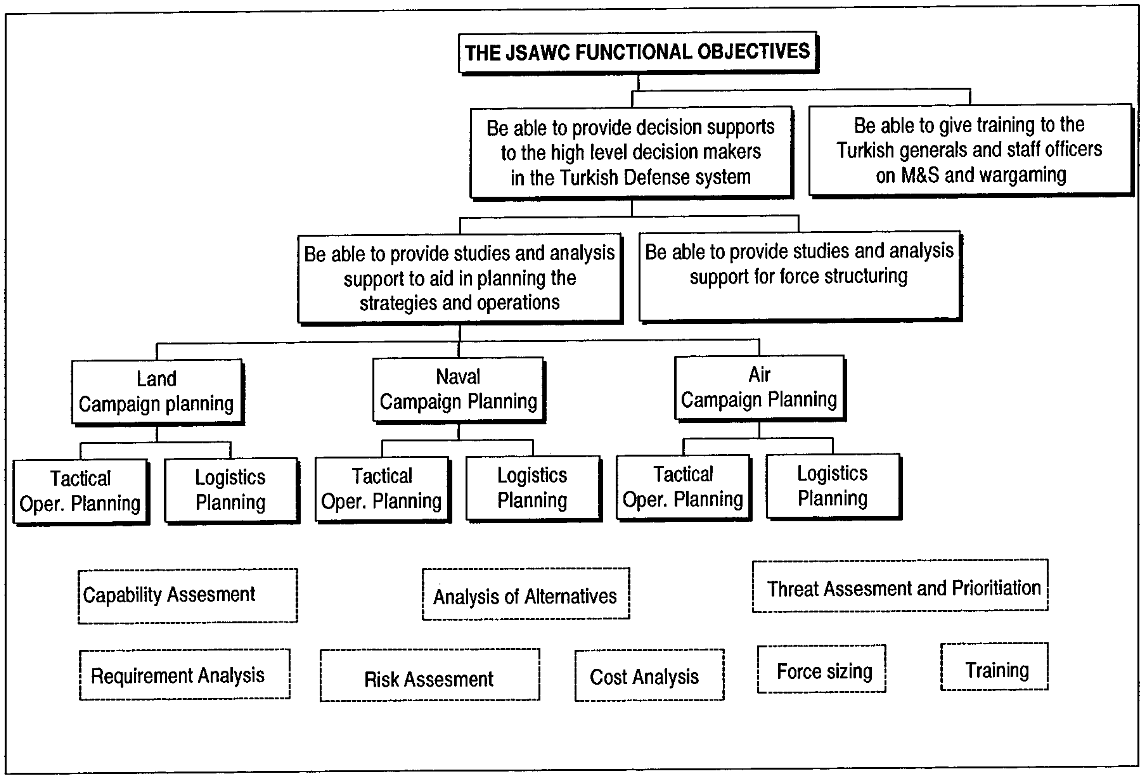


Figure 36: The JSAWC Functional Objectives

In addition to this hierarchy, to understand the functional objectives of the JSAWC better, we can classify the desired functions of the center according to their type, area, and level within the defense system. Besides these three classes we also need to add one more, top-level mission class. Basically we can see three main mission area in this class:

- Strategy and Operation planning
- Force Structuring
- Training

5.2.1.1 Strategy and Operational Planning

In this mission area, our objective is to be able to perform the given studies and analyses as shown in the Figure-37 at the JSAWC. The same types of studies and analysis should be done in three levels (Joint level, Service level, and Service Tactical level) for three areas (Operational, Logistics, and C4ISR).

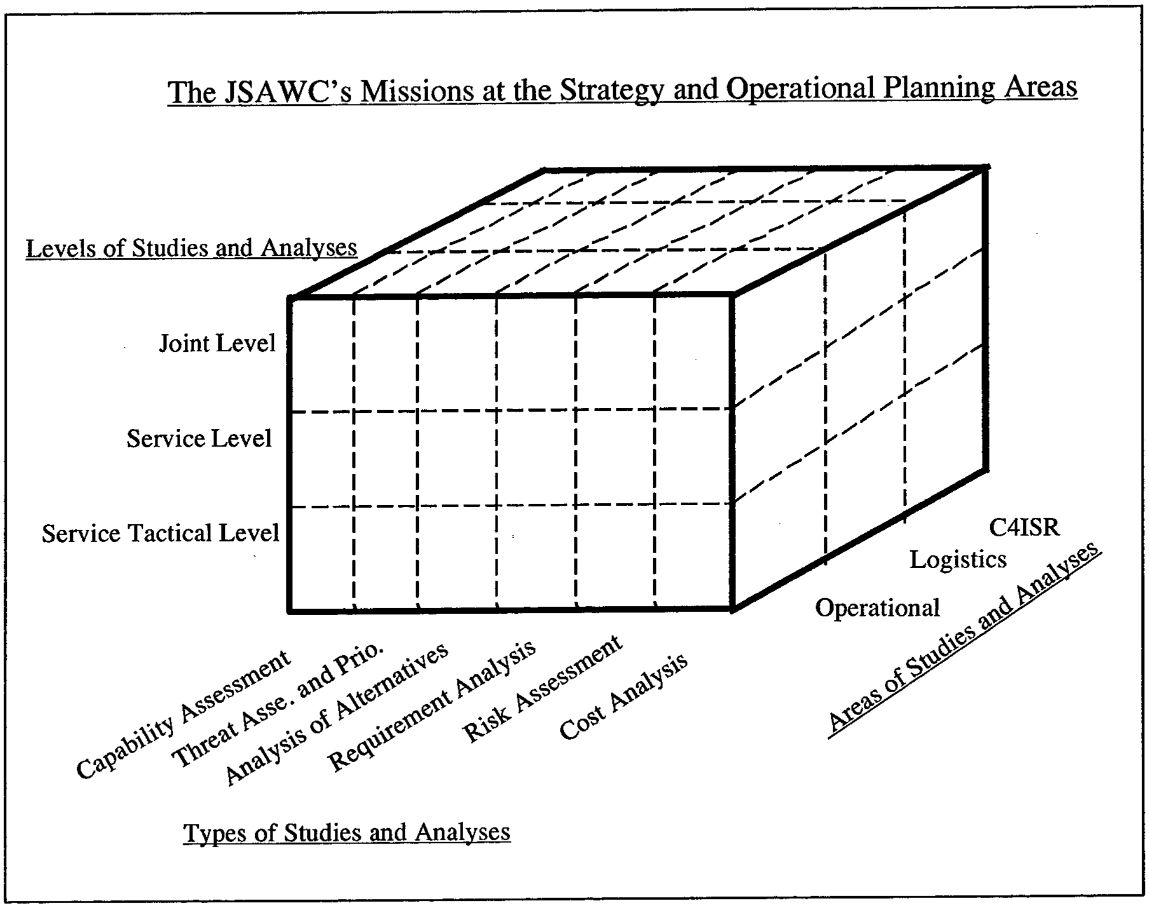


Figure 37: Functional Objectives at Strategy and Operational Planning Areas

5.2.1.2 Force Structuring

Force structuring and strategy and operational planning are very close to each other. While operational planning deals with a certain scenario, force structuring has to deal with all the possible scenarios, all the operational plans, and all the desired military capabilities. The requirements of the operational plans become inputs to the force structuring studies. For that reason the missions at the strategy, operational planning area and force structuring are very close to each other.

The objective of the JSAWC in the force structuring area is to be able to accomplish the following missions shown in the figure below.

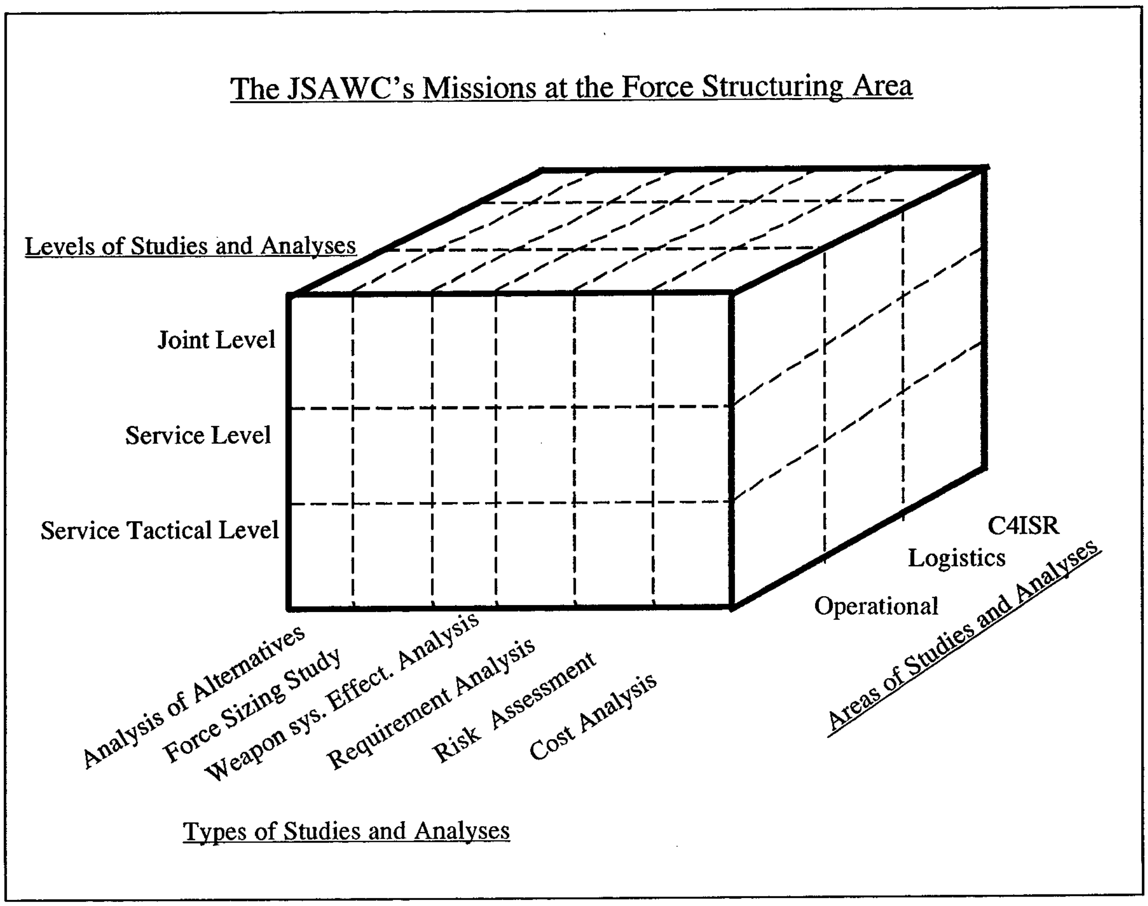


Figure 38: Functional Objectives at Force Structuring Area

5.2.1.3 Training

The objective in training is very limited. We want JSAWC first to provide short courses to the decision-makers and staff officers on M&S and their military applications. Second, we want the JSAWC to be able to provide an opportunity for the decision makers and staff officers to make decisions as if they are in a war situation by using computer assisted wargaming techniques. When we prepare wargames which represent the current or possible crises scenarios, the decision makers and staff officers will understand our and the potential adversaries' military capabilities better and they will be mentally ready for the possible short term and long term crises.

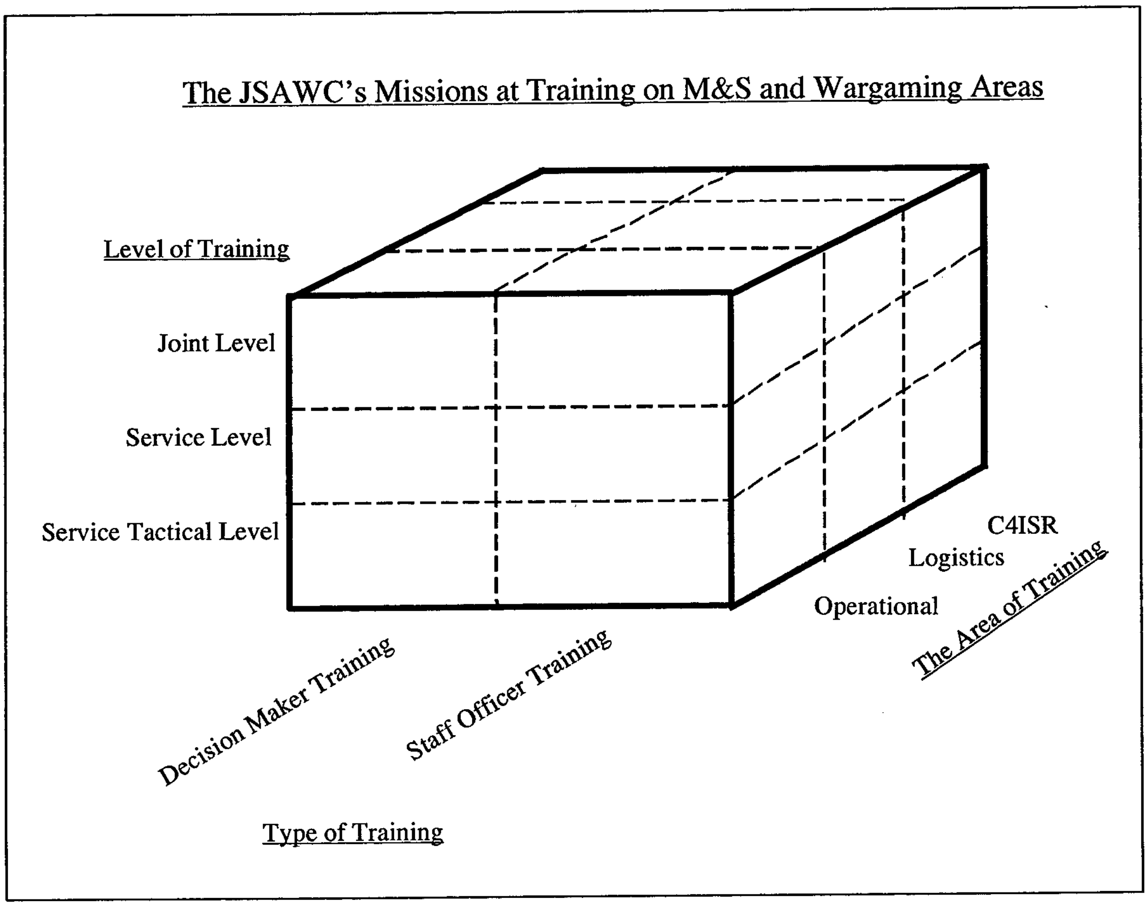


Figure 39: Functional Objectives at Training on M&S and Wargaming Areas.

5.2.2 THE SYSTEM PERFORMANCE OBJECTIVES

What kind of performance are we expecting from the center? How should the JSAWC perform the given missions? The answer to those questions and the general features that we want to see on the JSAWC, form the system performance objectives.

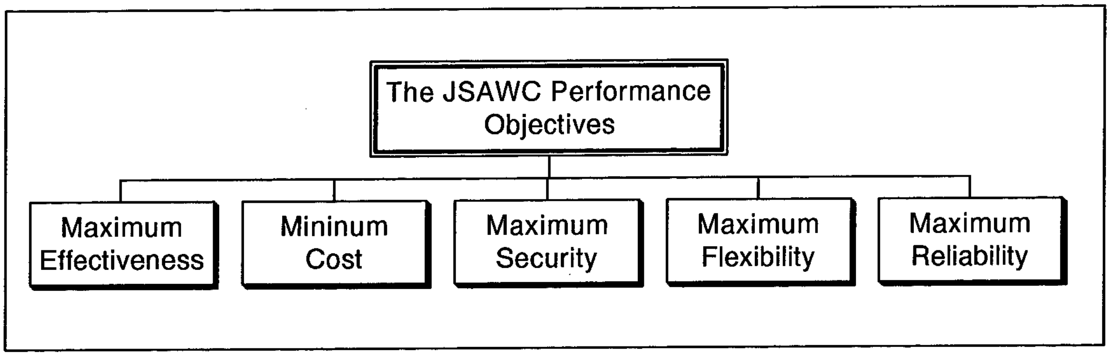


Figure 40: The System Performance Objectives

5.2.2.1 Maximum Effectiveness

Effectiveness is the main performance objective of the JSAWC. We would like to design a system which works with maximum effectiveness. Since the word effectiveness is a very generic term, we need to explain what we mean by the maximum effectiveness of the system. For the JSAWC we can think three measures of the effectiveness. They are the accuracy of the studies, analysis, and training, the time spent on studies and analyses, and the number of products (studies, analyses, and training) that the JSAWC produces.

By maximum effectiveness we mean producing the most accurate studies, analysis, and training; accomplishing the studies and analysis in a minimum amount of time; and producing maximum number of products in a year.

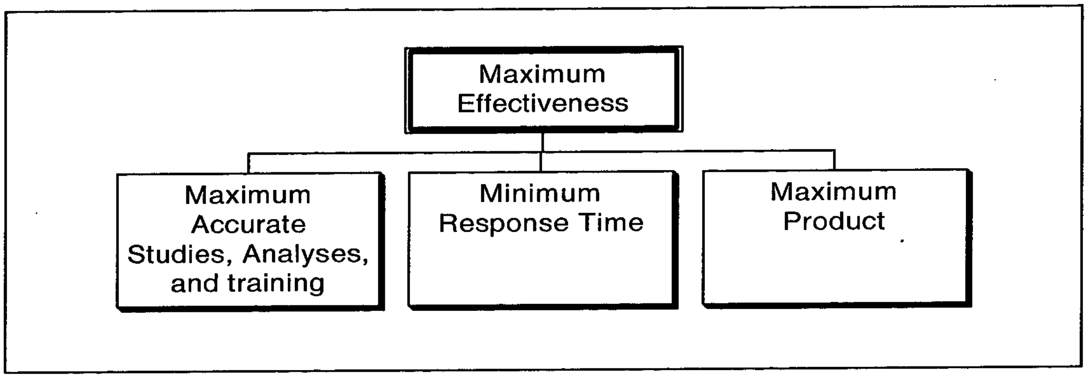


Figure 41: Effectiveness Objectives

5.2.2.1.1 Maximum Accurate Studies, Analysis, and Training

This objective can be accomplished by having well educated personnel, optimum mix of proficiencies in the system, and by using accurate models and data for the studies.

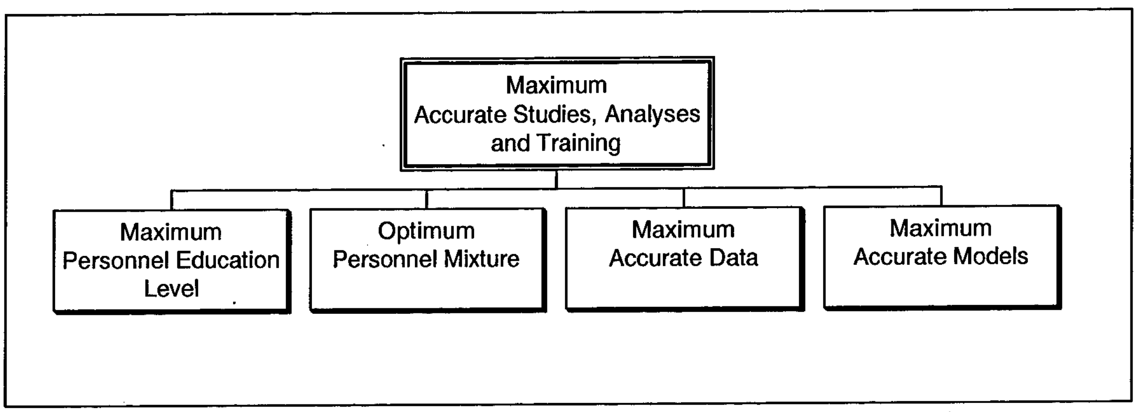


Figure 42: Maximum Accurate Studies, Analyses, and Training

5.2.2.1.2 Minimum Response Time

To be able to minimize the time required to accomplish the given mission we need to understand the factors affect the study performance. They can be number of personnel, capacity of computer machines or network, performance of the models or other software tools, data access time, or customers' contribution to the study.

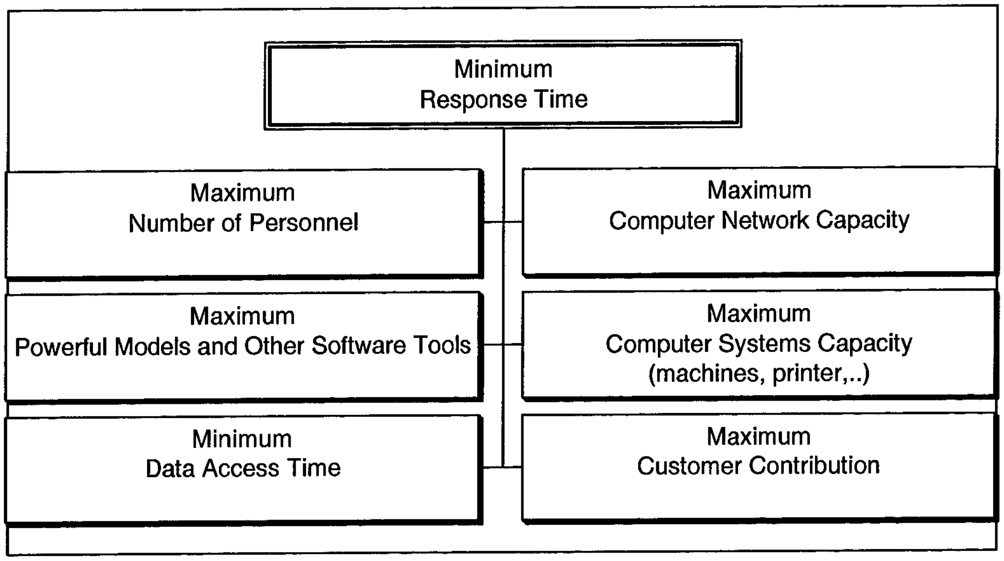


Figure 43: Minimum Response Time

5.2.2.1.3 Maximum Product

Product of the JSAWC refers to 1) Studies and Analyses and 2) Training. We want the center first to accomplish as many studies and analyses as possible. Second we also want it to offer wargaming and introductory modeling and simulation courses to as many trainees as possible. We can accomplish both objectives by minimizing the system response time defined above and increasing the number of customers.

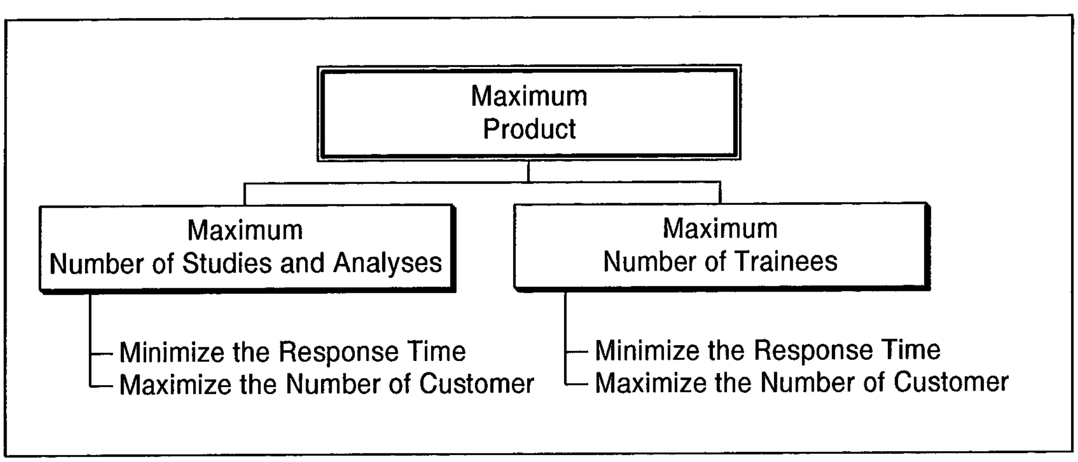


Figure 44: Maximum Product

5.2.2.2 Minimum Cost

In every design study the overall cost of the system should be as low as possible. We also want to design a JSAWC which should cost the Turkish Department of Defense a minimum amount of money. By cost, here we mean the system acquisition and the system operations cost.

Since *cost* and *effectiveness* objectives are generally contradictory, there must be a trade off between the two objectives that produces the optimum benefit. This trade off strictly depends on the values of the decision-maker. What is enough, how effective should the system be, and how much money can the Turkish Department of Defense afford for this project are the questions that must be answered in future trade off studies.

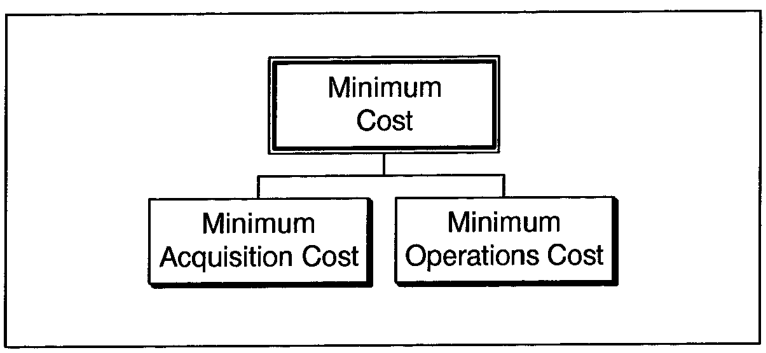


Figure 45: Cost Objectives

5.2.2.2.1 Minimum Acquisition Cost

Acquisition cost includes all the expenditures from the beginning of the JSAWC project to the end of the construction of the system or to the time that the system is ready for operation.

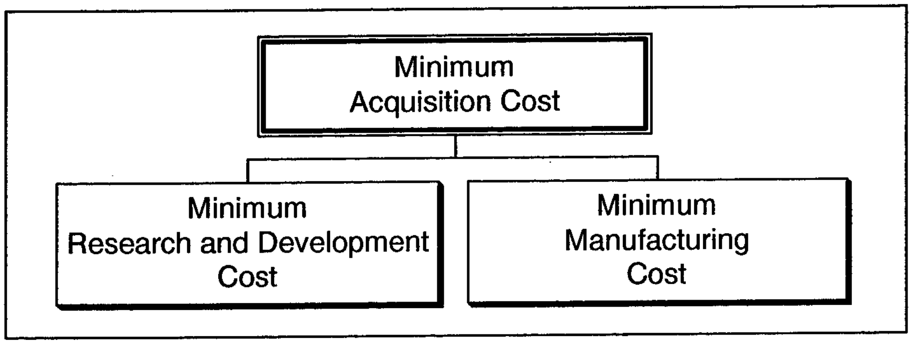


Figure 46: Acquisition Cost Objectives

5.2.2.2.1.1 Minimum Research and Development Cost

This is the expenditure that the system design team incurs to design the JSAWC. It covers the cost of every effort to design the best system. Some of the well-known expenditures are research cost, studies and analysis costs, salary, and required tools' costs

5.2.2.2.1.2 Minimum Manufacturing Cost

This refers to the total cost of building the JSAWC. This covers prices of all the hardware, software, and personnel education and training costs until the JSAWC starts operating.

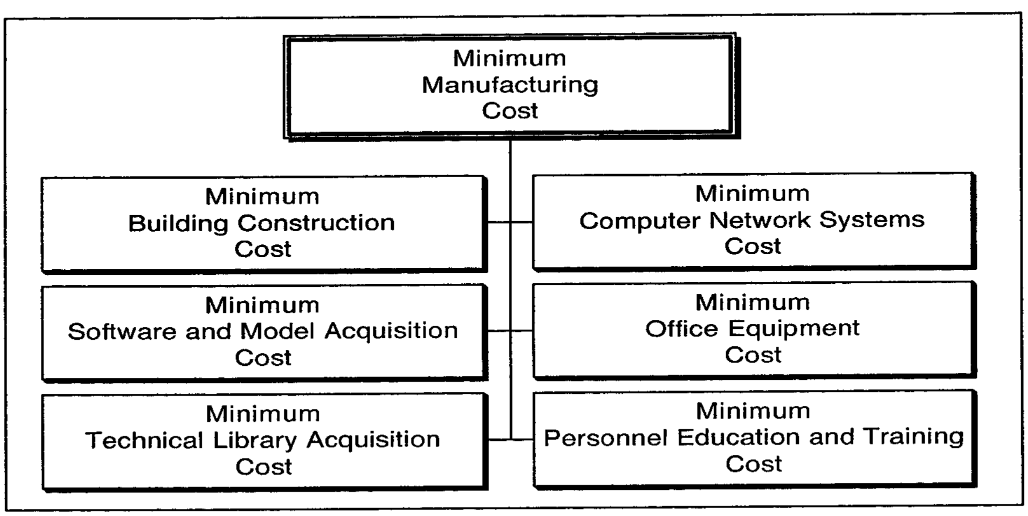


Figure 47: Manufacturing Cost Objectives

5.2.2.2.2 Minimum Operations Cost

The system operations cost is as important as the manufacturing cost. We would like to design a system which requires the minimum amount of money to operate. We can put personnel expenditures, cost of office supplies, utilities, system support, research, studies and analysis, new software acquisition, development, and support costs in this category. The structures, organizational procedures, workload, and the capacity of the JSAWC are other factors to consider in the cost of the system operations

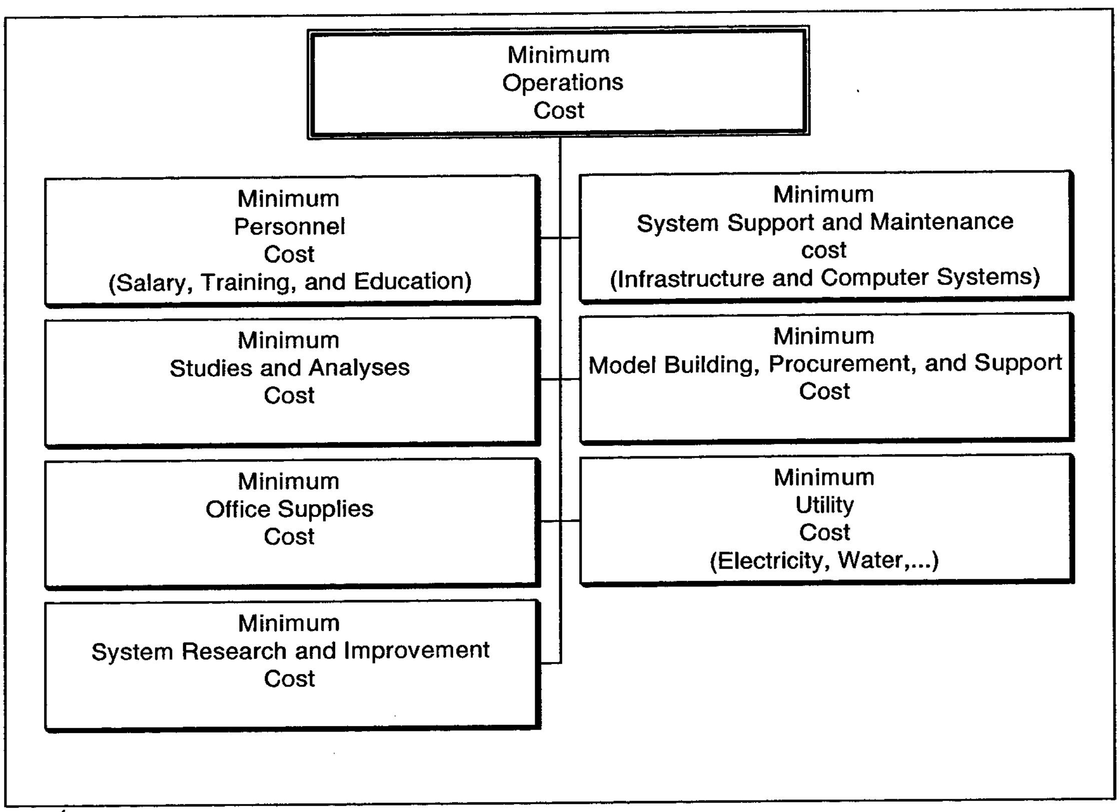


Figure 48: Operations Cost Objectives

5.2.2.3 Maximum Security

System security is another important issue that we need to consider in the design phase of the JSAWC. Since most of the studies and analyses of the JSAWC will be classified, the center must be very secure to protect the classified information and data. We would like to build a center which has maximum system security against physical attacks and maximum information security to deter spy activities.

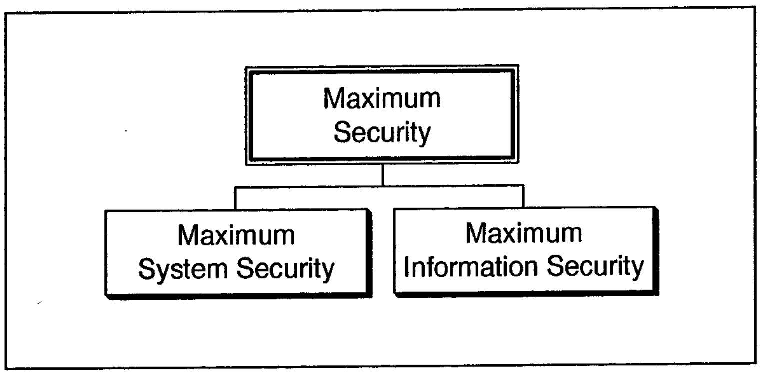


Figure 49: Security Objectives

5.2.2.3.1 Maximum System Security

Security of the center can be guaranteed by controlling entrances to the system, providing and applying robust security policies, and continually educating the personnel on this issue.

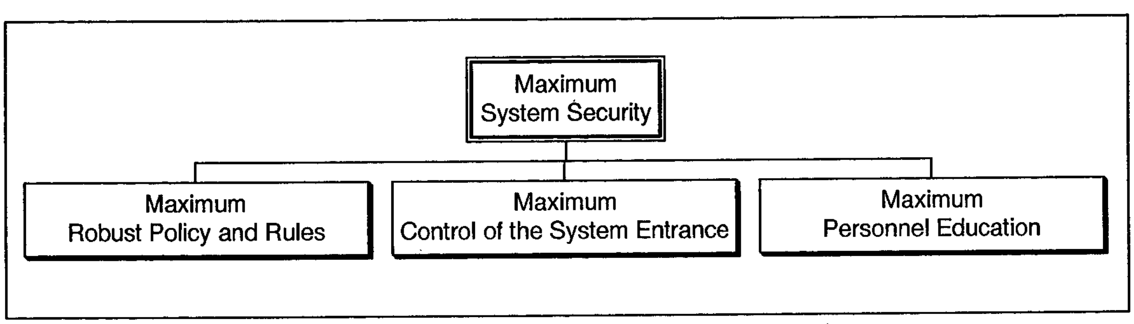


Figure 50: System Security Objectives

5.2.2.3.2 Maximum Information Security

Information security requires to control all the sensitive areas in which classified data and information may be acquired. Those areas can be computer network, personal computers, archives and databases, copier or printer rooms, and communication systems. We need to take all the necessary actions to control those areas.

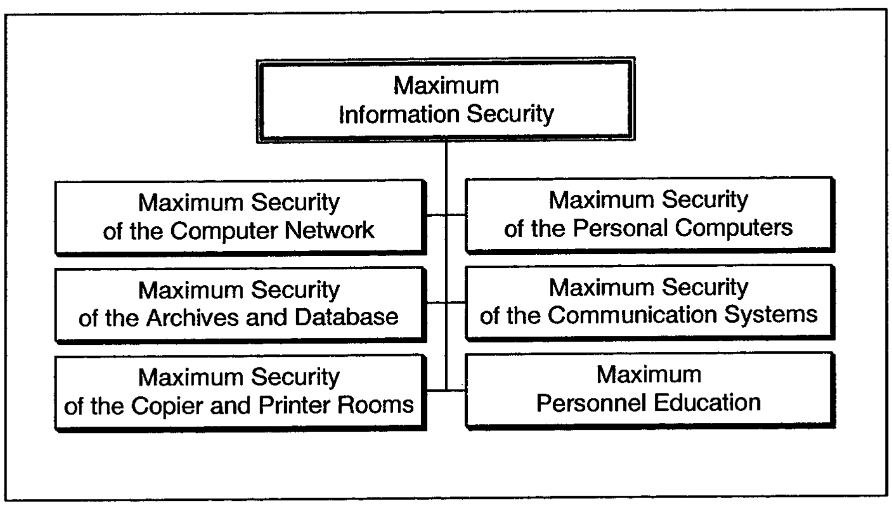


Figure 51: Information Security

5.2.2.4 Maximum Flexibility

By flexibility, we mean easily adding or changing something in the system. If a system is flexible enough, you can improve the system easily and you may be able to use the system for other purposes that were not defined at the beginning. Being flexible is very important for the JSAWC and needs to be considered in the design study as well.

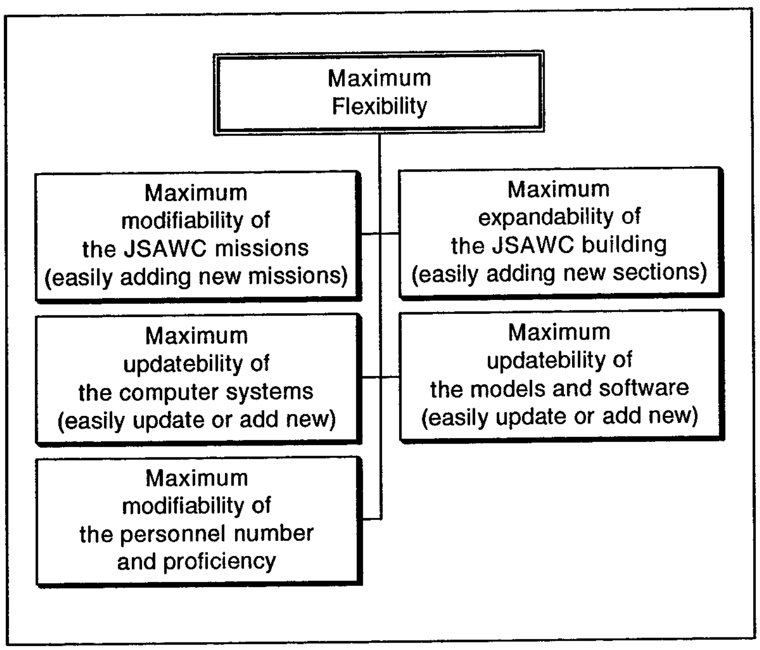


Figure 52: Flexibility Objectives

5.2.2.5 Maximum Reliability

Reliability of the system shows how much we can depend on the system availability. Does it crash easily? How often does it require unplanned maintenance? Our objective here is to minimize the probability of failure for the overall system over the mission life, under normal operating conditions.

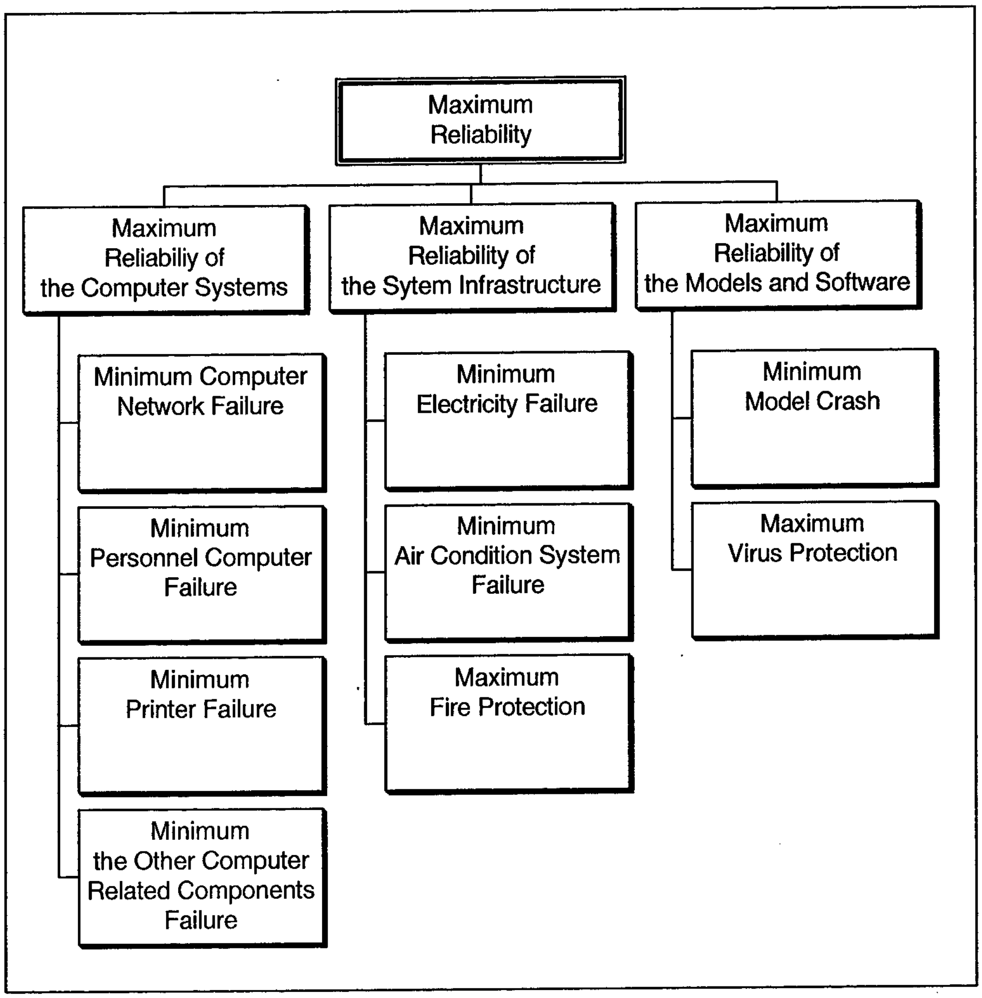


Figure 53: Reliability Objectives

5.3 THE SYSTEM FUNCTIONAL HIERARCHY

The objective of drawing the system function hierarchy is to be able to examine the required JSAWC's functions by decomposing them in a logical way. The problem definition of the JSAWC is the basic resource for this portion of the study. Some of AFIT's professors such as Maj. Raymond R. Hill, Dr. Thomas C. Hartrum, and Dr. Mike Garrambone contributed to this study by clarifying some of the system functions related to their professional areas. In addition to that, my own experiences from the visits of military studies, analyses and wargaming centers in the USA [Section 3.8], such as AFSAA (Air Force Studies and Analysis Agency), CAA (Concept Analysis Agency), JTASC (Joint Training Analysis and Simulation Center), and J-8 (Force Structure, Resources and Assessment Directorate), formed the other required knowledge resource to produce the functional decomposition of the JSAWC.

The functions defined here are the required system behaviors that should be considered *the functional requirements* of the JSAWC. We will later use those functional requirements to determine the necessary system components and required system structure. Thereafter, to develop the JSAWC's *physical requirements*, the design team will identify the necessary features of the system components by using the objectives of the JSAWC, expert advice, and the decision-maker's values.

There are three different categories at the top of the functional hierarchy in Figure-54. These are the JSAWC's administrative functions, major functions, and system support functions. As we discussed in the problem definition step and analyzed in section 3.2, the JSAWC has a given major mission set to be accomplished. To be able to accomplish those decision support and training missions, the JSAWC has to have some support activities inside it. In addition to those operational support functions, JSAWC also has to perform some basic administrative functions to plan, control, and coordinate the system functions as every organizational system does.

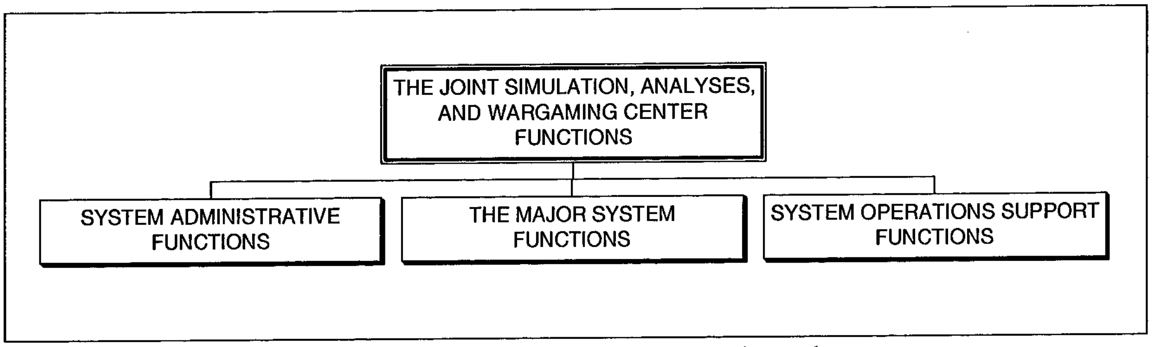


Figure 54: Top Level Functional Hierarchy

5.3.1 SYSTEM ADMINISTRATIVE FUNCTIONS

Administrative functions of the JSAWC include all necessary activities to manage the system. The Figure-55 shows the basic administration functions of the system: *planning, coordinating, and controlling*. These functions must be performed very carefully to accomplish the objectives of the JSAWC. Any problem with one of the administrative functions may cause it to produce poor products. To be able to use the system resources effectively and to guarantee producing quality products from the JSAWC, we have to plan, coordinate, and control all the system functions very carefully.

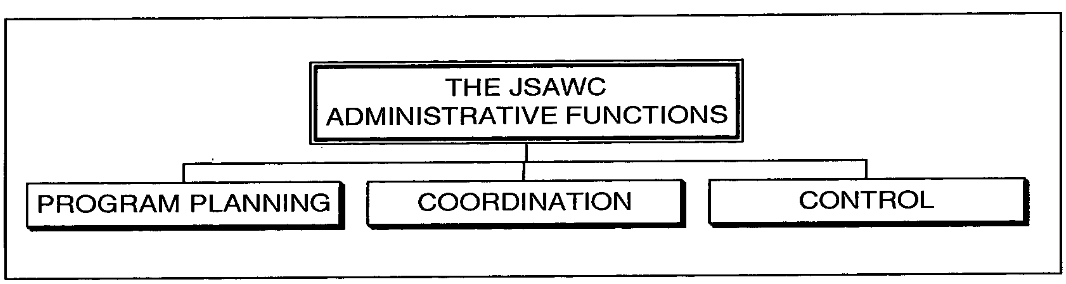


Figure 55: The JSAWC's Administrative Functions

5.3.1.1 Program Planning

The program planning activity is one of the administrative functions, which identifies and organizes the JSAWC's work program. This function also includes other necessary activities such as personnel planning, acquisition, and budgeting.

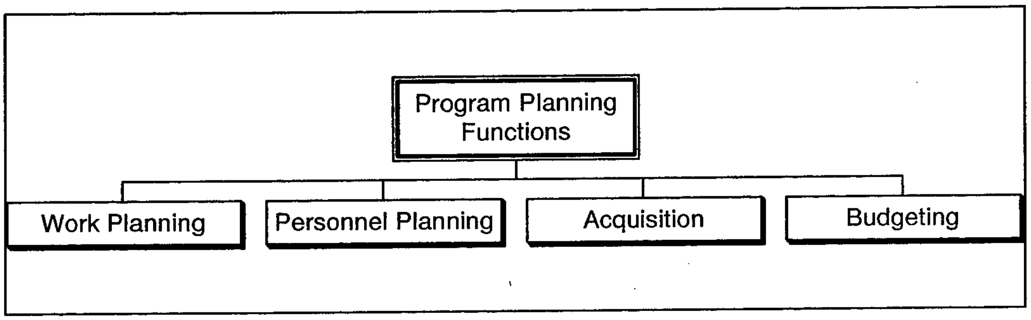


Figure 56: Program Planning Functions

5.3.1.1.1 Work Planning

We can examine this function in two categories; long-term work planning and short-term work planning. Long-term work plans include studies and projects that take several months of work time to be accomplished. Short-term work plans include quick time (called also quick-turn) analysis, and unscheduled training requests. Short-term plans can be for daily, weekly, or monthly tasks.

There must be an excellent balance between the long term and short-term plans. The work planning of the JSAWC should be done according to the importance and time sensitivity of the request, and according to the available system resources and personnel. Figure-57 shows the activities in the JSAWC work planning function.

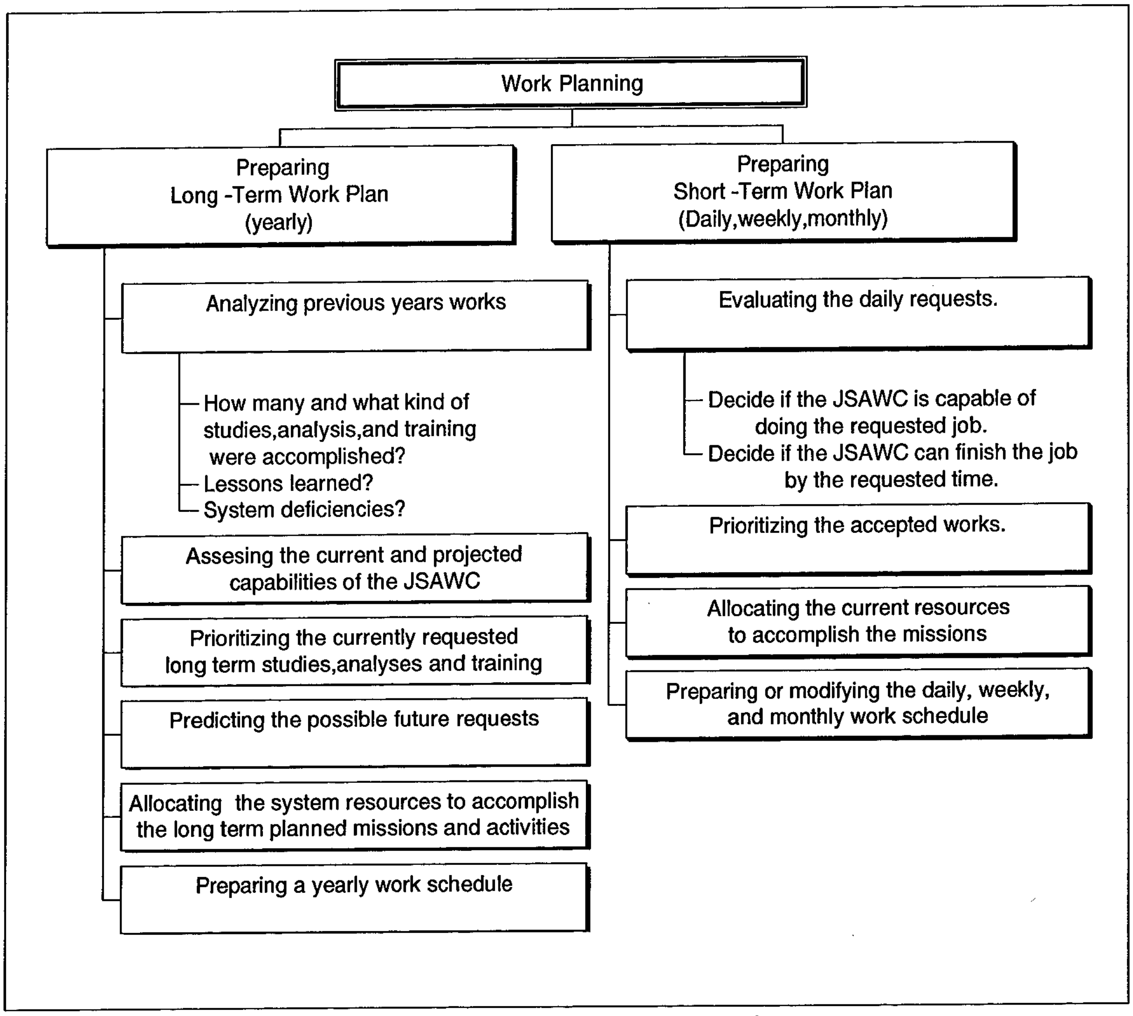


Figure 57: Work Planning Functions

5.3.1.1.2 Personnel Planning

Personnel planning is another very important activity that we must consider in the planning functions of the JSAWC. We can place every function related to the JSAWC's personnel under this category. Personnel planning directly depends on the type of studies and workload of the system. As shown in Figure-58, employing, assigning, training, and awarding personnel are functions of personnel planning.

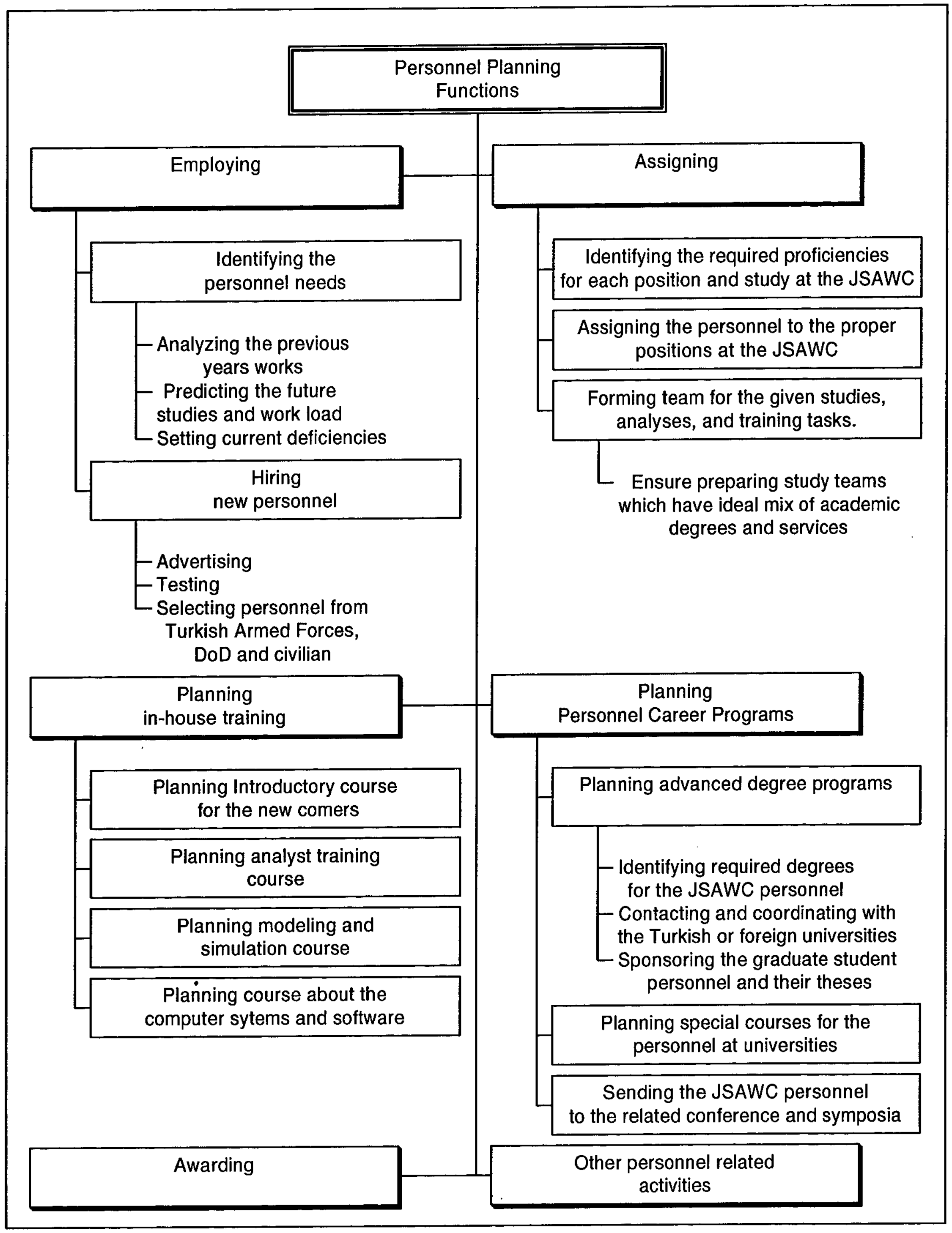


Figure 58: Personnel Planning Functions

5.3.1.1.3 Acquisition

Planning and managing the JSAWC acquisition program is another administrative function. Procuring what the system needs including computer hardware, software, and office supplies is one of the activities under the JSAWC acquisition functions. Another issue in this category is contracting with national or international civilian companies. From computer system support to complex warfare models development, the JSAWC has to work with companies/contractors where it can not accomplish those jobs internally.

Since the JSAWC will be a government agency under the Turkish Department of Defense, it cannot act independently due to government acquisition regulations. The JSAWC has to coordinate acquisition activities with the related Turkish DoD divisions. The important thing is having an effective acquisition management system, which allows the JSAWC to purchase the necessary systems and get the latest technology and support as quickly as possible.

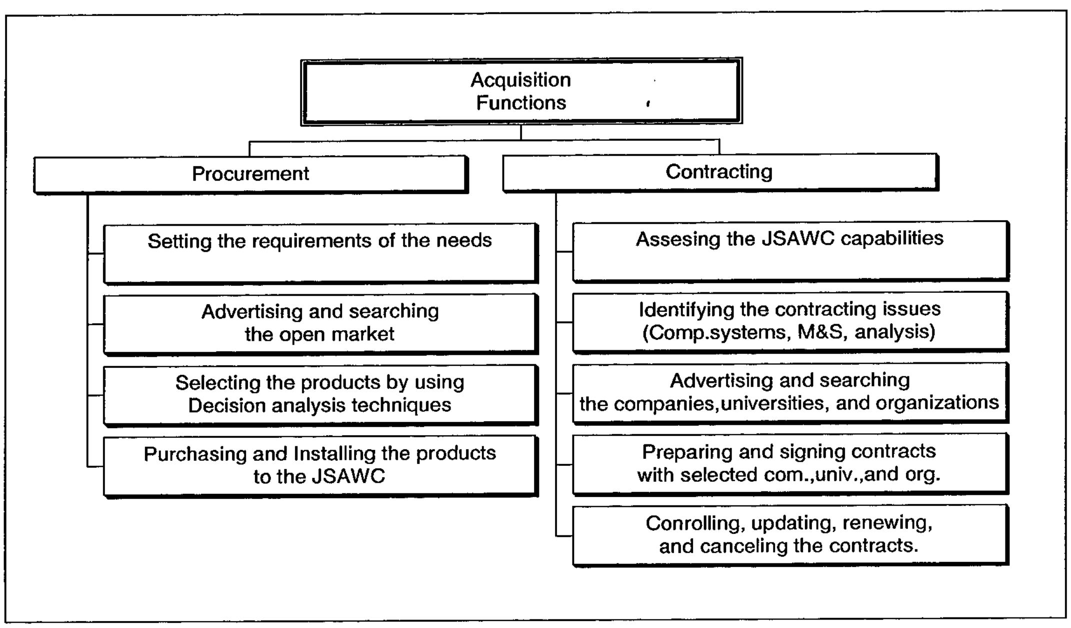


Figure 59: Acquisition Functions

5.3.1.1.4 Budgeting

The budgeting function covers all monetary activities of the JSAWC. Basically, budgeting is the process of managing and controlling the incomes and expenditures of the system. We can think of budgeting as an optimization process which produces maximum benefits for the system by planning where to use its limited funds. The budgeting function of the JSAWC is related to all of the other planning functions.

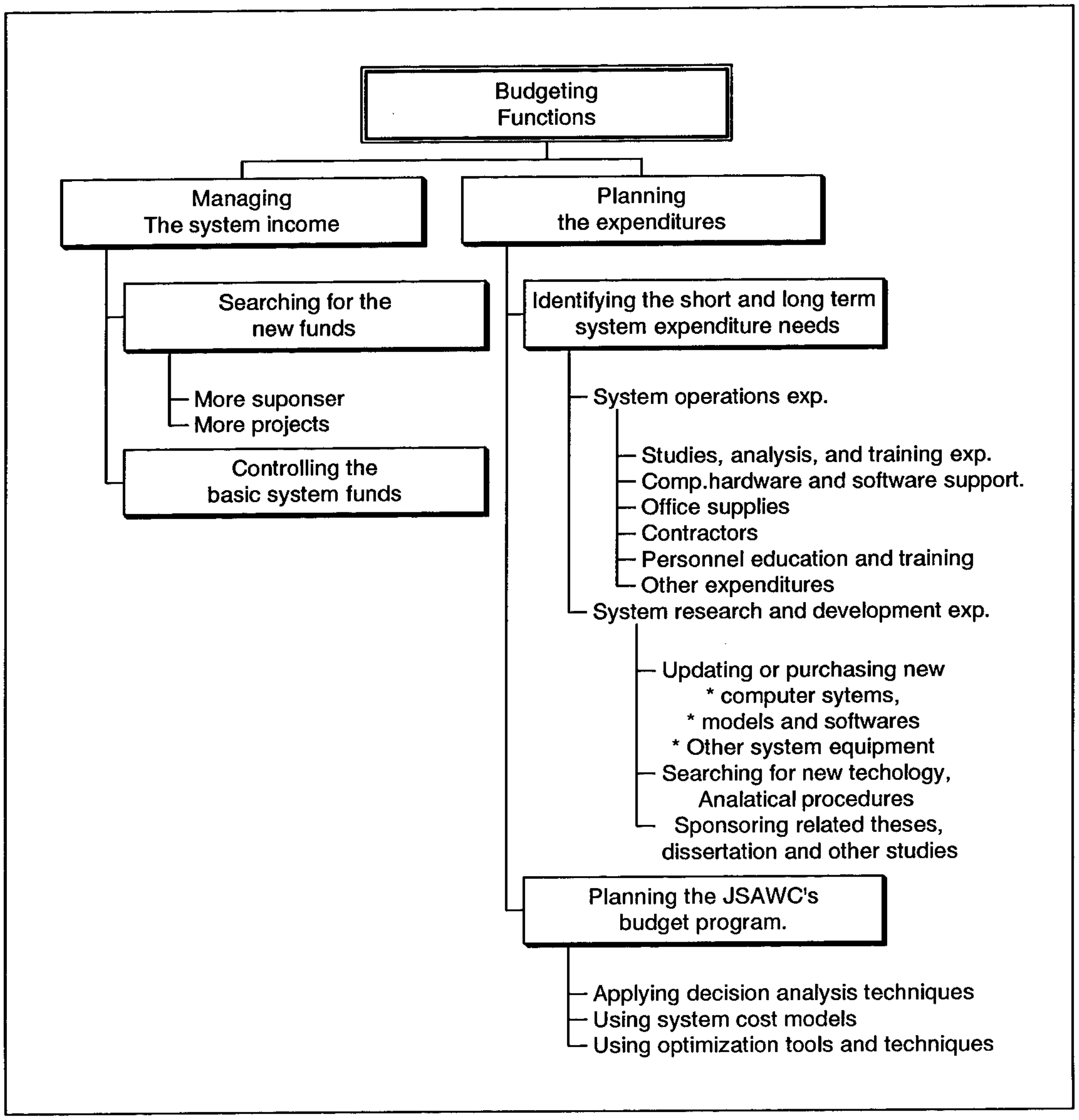


Figure 60: Budgeting Functions

5.3.1.2 Coordination

Coordination is the other administrative function of the JSAWC which is necessary to make the system work harmoniously. Since coordination activities are strictly connected with the planning activities of the system, both planning and coordination functions should be performed at the same time.

We can examine the coordination function of the JSAWC in two categories. One of them is coordination activity between the system elements and system functions. Good coordination between the JSAWC's personnel and divisions produces excellent information flow inside the system, and correct understanding of all the objectives and activities in the JSAWC. Good coordination also decreases the time required to finish the given missions of the JSAWC. In a well-coordinated environment where everybody knows his tasks, knows whom he needs to contact, and where he can obtain the required information, necessary tools, and support, the JSAWC will work very efficiently and produce more valuable studies, analysis, and training as a result.

The second coordination category is the one between the JSAWC and its environment. First, there must be communication between the JSAWC and its users/customers to accomplish their studies, analysis and training requests. Second, we need to provide agency level interfacing with other military, government, academic, private, international, and foreign research and analyses organizations to facilitate exchanges of information on methodology, technology, and analyses related to the JSAWC's missions and interests.

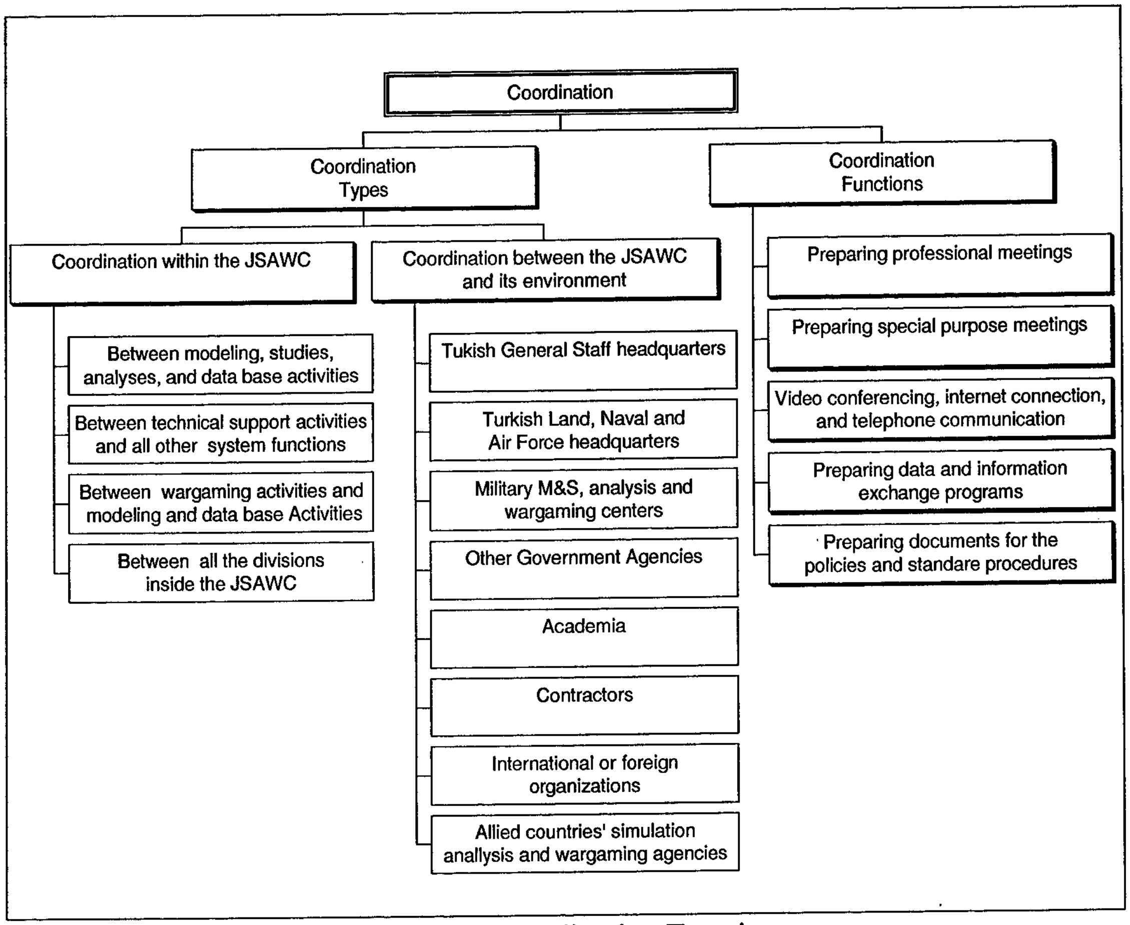


Figure 61: Coordination Functions

5.3.1.3 Control

The control functions of the JSAWC are divided into two parts. As shown in the Figure-62, they are the system quality control and the system security control functions.

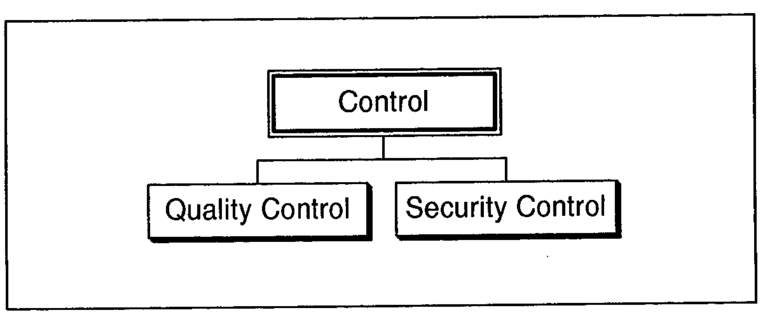


Figure 62: Control Functions

5.3.1.3.1 Quality Control

By the quality control of the JSAWC, I mean all the related activities to ensure producing credible studies, analysis, training and military models. We have to control products of the JSAWC not only just before distribution but also at the planning and performing phases of the studies, analysis, training, and model development.

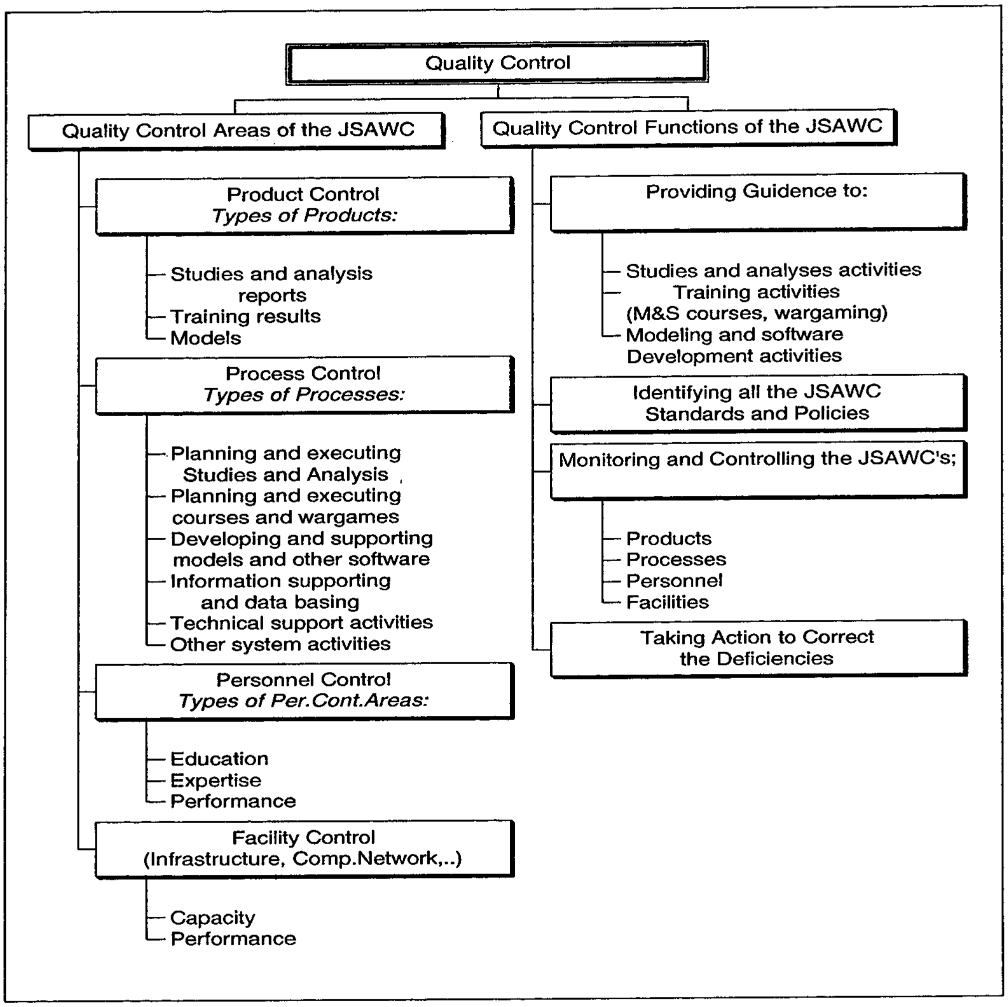


Figure 63: Quality Control Functions

5.3.1.3.2 Security Control

Security control means first protecting all classified information: data, studies, analysis, technology, models, and other related functions and materials from being obtained or distributed illegally. Second, it means taking the necessary actions to protect the JSAWC from physical attacks and other offensive actions that are intended to delay the system functions or damage the system.

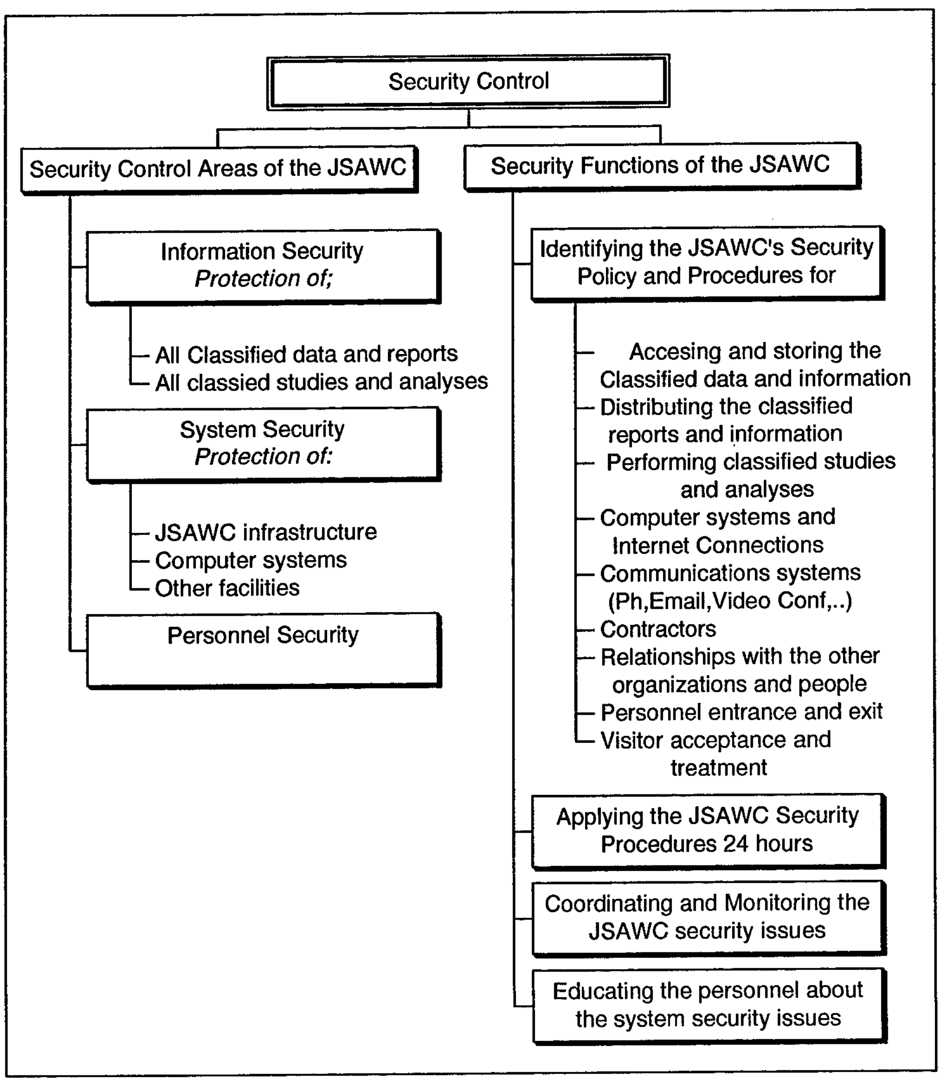


Figure 64: Security Functions

5.3.2 MAJOR SYSTEM FUNCTIONS

The major system functions are basically derived from the main objectives of the JSAWC. When we look at the mission statements of the JSAWC and the objective hierarchy of the system, we can see two different types of major system functions. The first one is conducting studies and analyses, and the other one is offering training. These two major functions of the JSAWC do not have the same importance and priority. Performing studies and analyses is the number one mission that may account for 70-80 percent of the JSAWC's major workload.

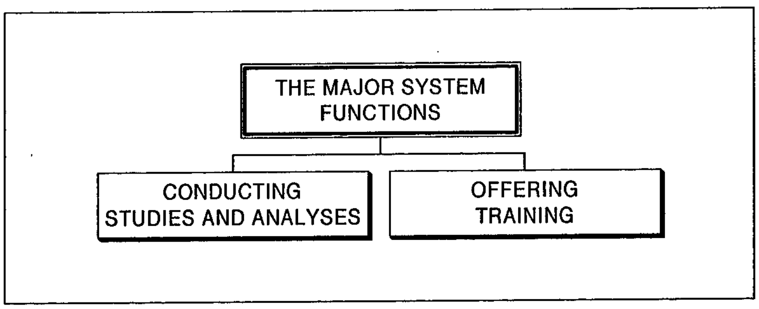


Figure 65: Major System Functions

These functions will be examined in detail by breaking them down into sub functions. Besides identifying the bottom level functions in this category, I will also describe the general methodologies that we need to follow while conducting studies, analyses, and training at the JSAWC. In addition, it is also important to know user-JSAWC relationships during execution of major system functions. In this part of the study, possible sequential user-JSAWC relationships will also be generally explained.

5.3.2.1 Conducting Studies and Analyses

Studies and analyses refer to all the works and investigations needed to understand military problems and situations better and to find solutions and improvements for them. A study is broader then analysis and may include analysis activities within its efforts. On the other hand, an analysis examines a set of assumptions and inputs in a model and reports results and findings [Hughes, 1997]. As I described before, the general types of studies and analyses that the JSAWC will perform are capability assessment, threat assessment and prioritization, analysis of alternatives, requirement analysis, risk assessment, force sizing, and cost analysis. The level of military problems can be joint strategic and operational, service campaign, and service tactical. The areas of the studies will be operations, logistics, and C4ISR.The main objective of the studies and analyses is to provide decision support to the military decision-makers for a better Turkish Armed Force.

Before examining the general studies and analysis methodologies and functions, it is important to understand the positions of the JSAWC in the Turkish Defense System. The following figure shows the possible sequences of the type of studies and analyses that will be requested from the JSAWC. From this figure we can understand how the JSAWC will be valuable to the Turkish military decision-makers and planners

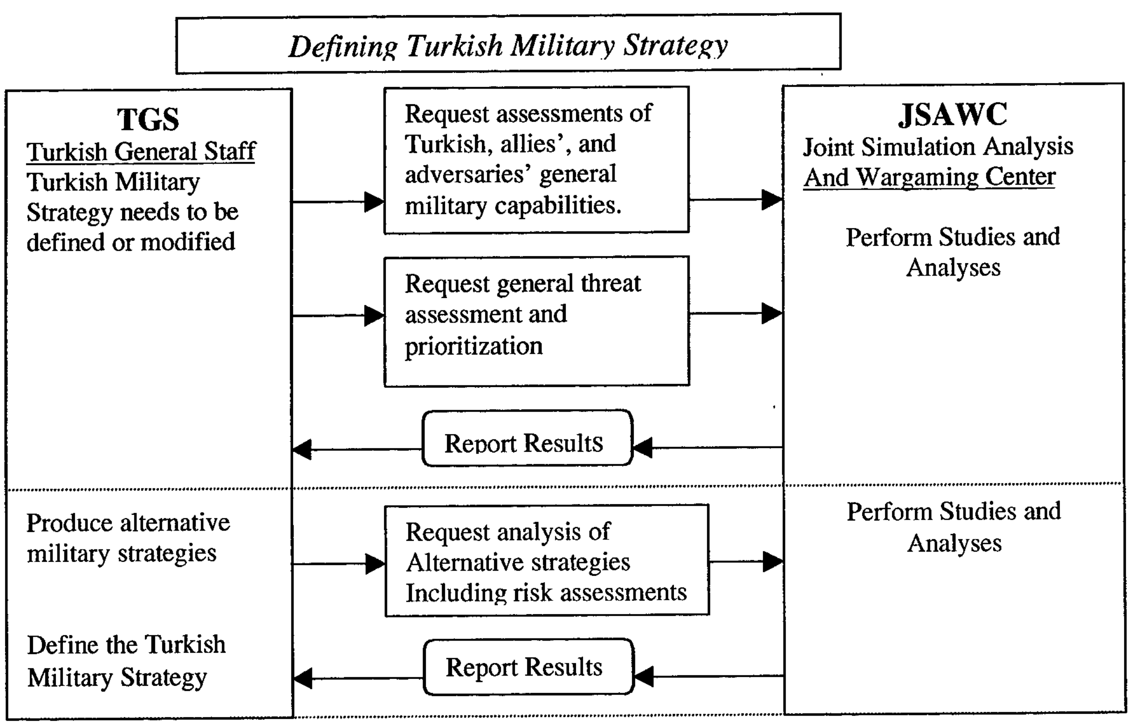


Figure 65 Relation between the JSAWC and Turkish Military Strategy

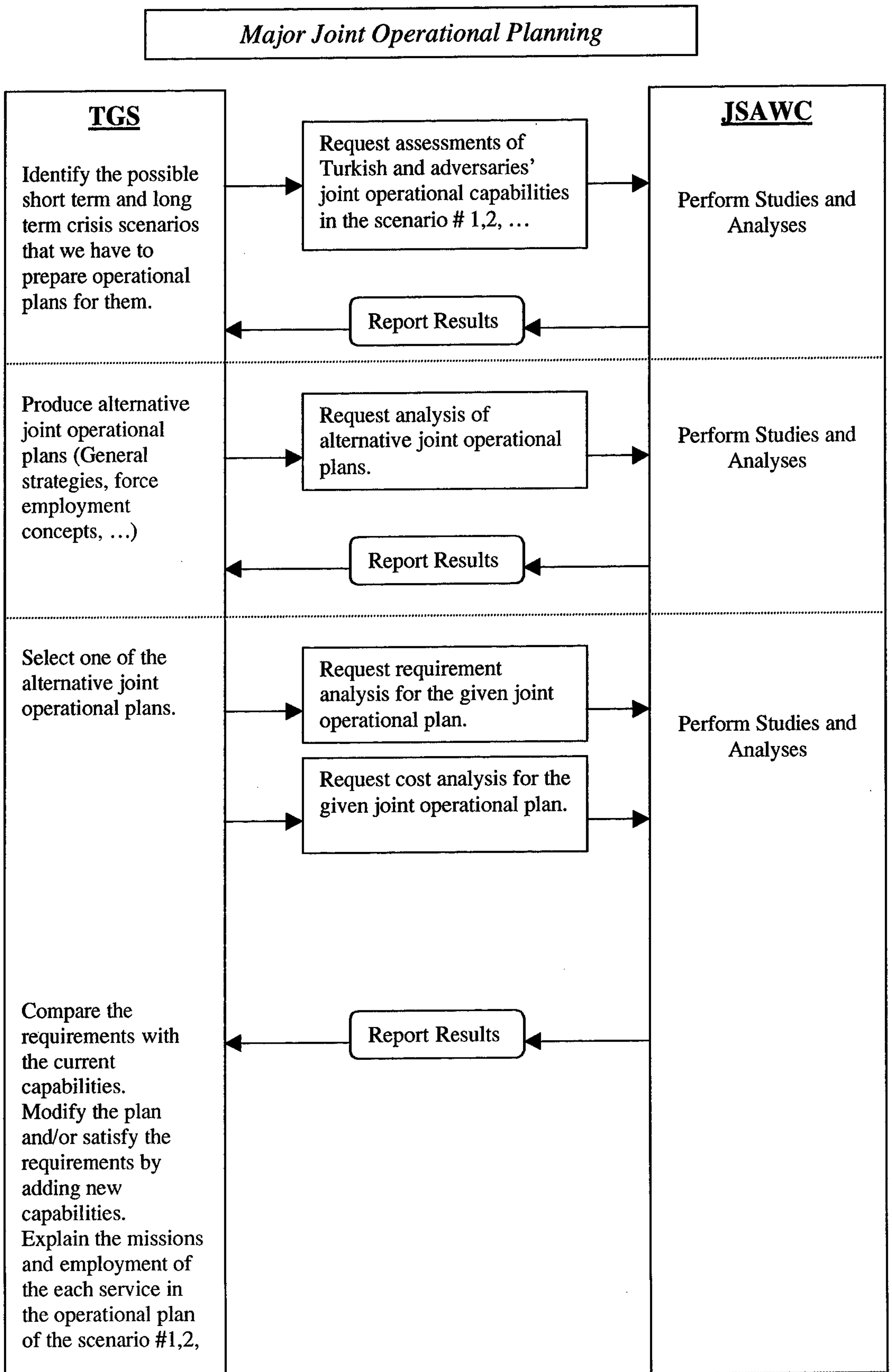


Figure 66: Relation between the JSAWC and Maj. Joint Oper. Planning

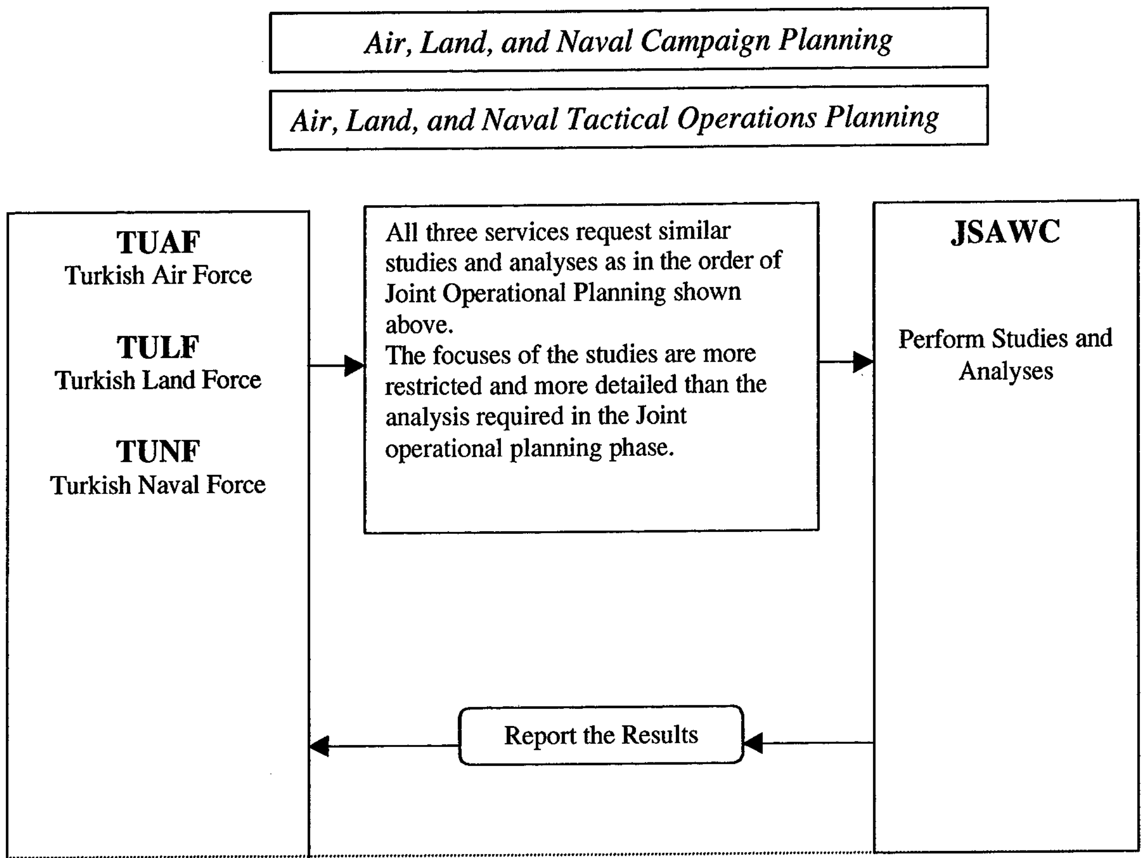
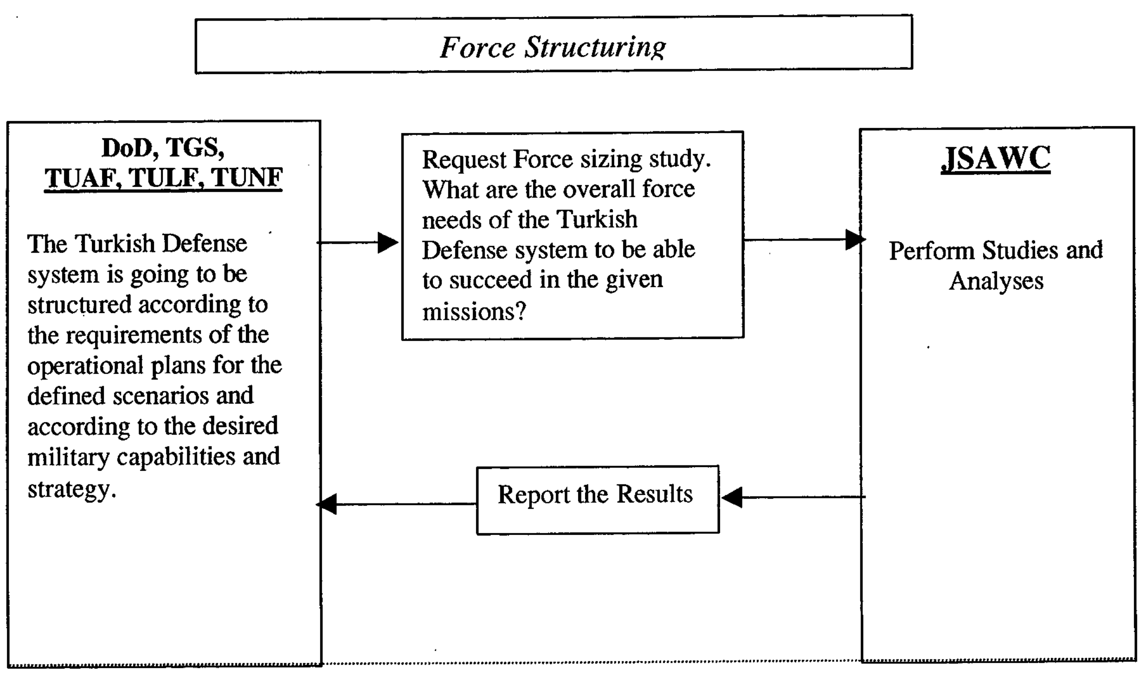


Figure 67 Relation between the JSAWC and Service Camp. And Tac.Planning



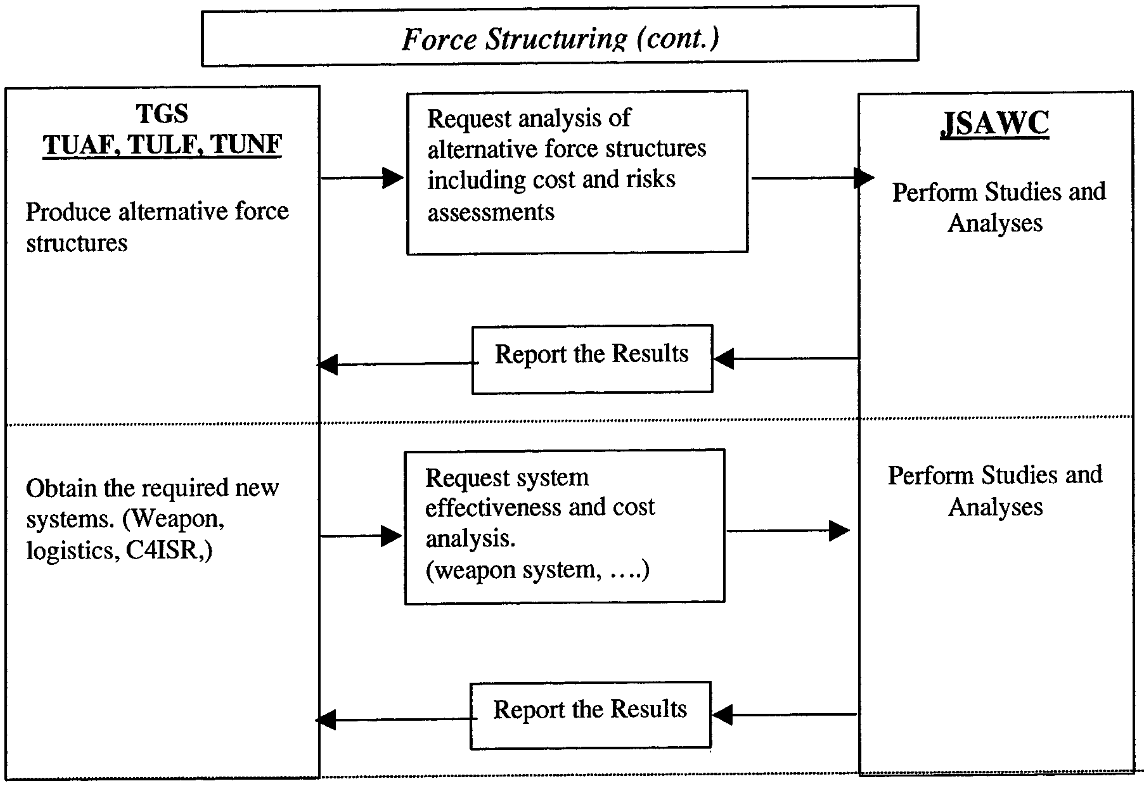


Figure 68: Relation between the JSAWC and Force Structuring

The basic relationships between the JSAWC and its users are shown above. These figures clarify the position of the JSAWC in the overall Turkish Defense System. Next we will examine studies and analyses functions of the JSAWC shown above by breaking it down into detailed sub-functions (Figure-69). This functional break down will help us to identify required system elements and allow us to match elements or subsystems of the JSAWC with its required functions.

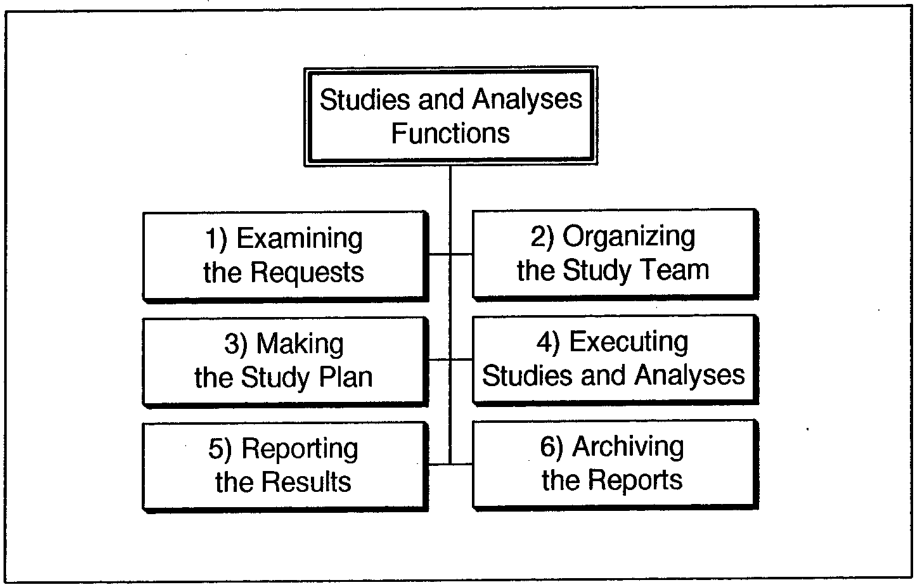


Figure 69: Studies and Analyses Functions

5.3.2.1.1 Examining the requests

When a study is requested by the system users, the first thing that we have to do is make a decision on whether or not the center can accomplish the requested study based on a realistic assessments of the JSAWC's ability. If the decision is positive, then we need to examine the JSAWC's work schedule and decide if the requested study and analysis can be accomplished by the given deadline. For this decision, we should consider the importance of the requested study and analysis by giving proper prioritization.

If the requested study and analysis is accepted, the JSAWC will identify the classification level of the study and put it on the work plan by modifying the current schedule.

5.3.2.1.2 Organizing the study team

When a study begins the first task is to decide who is going to conduct the related studies and analyses for the given topic. According to the type of the study and analysis we will identify the personnel needs in terms of proficiency and service background (Air Force, Army, and Navy) to accomplish the given study. We have to assemble an interdisciplinary team of individuals with appropriate skills and diversity of both knowledge and viewpoint. The first resource of the study team is of course going to be the JSAWC's personnel. If we can not find enough people to form the ideal study team, we will look at outside sources such as other related military agencies, government organizations, or universities.

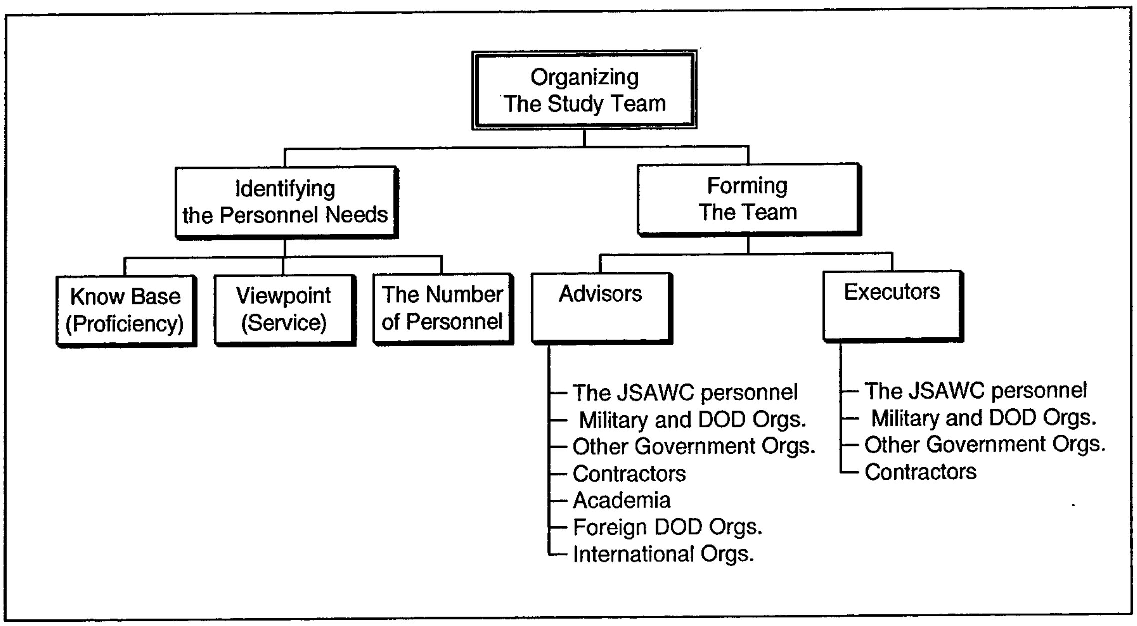


Figure 70: Organizing the Study Team

5.3.2.1.3 Making the study plan

After a study team is formed and assigned for the scheduled study and analysis, the team takes the responsibility and starts doing the required work immediately. At first the team members prepare a work plan to accomplish the given study and analysis systematically. Making the plan for the study starts with defining the problem correctly. It means the team has to understand the objectives of the study and scope the problem. After that, the team identifies all the necessary decision-maker's (sponsor's) inputs, and required knowledge, information, and data to conduct the study. The team also decides what kind of simulation models, software, database, and related hardware are needed for the given study.

The study team sets the methodology and procedures that will be used while conducting the study and analysis. The team also identifies the responsibilities of each team member and schedules the related work of the given study and analysis.

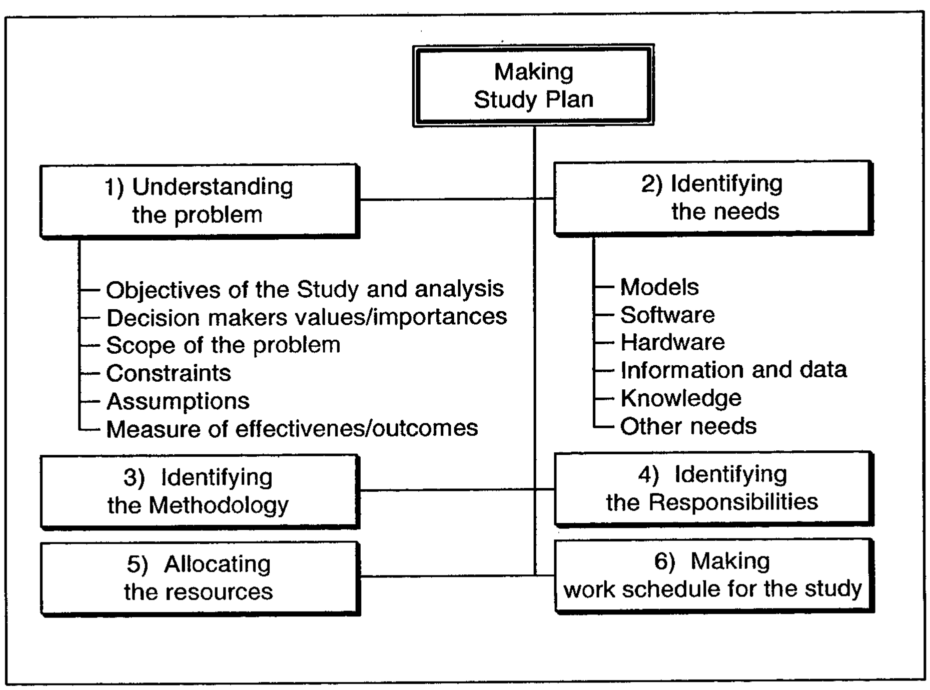


Figure 71: Making Study Plan

5.3.2.1.4 Executing studies and analyses

All studies and analyses problems/topics naturally have some unique features depending on the type, level, and purpose of the study, so necessary procedures and efforts required to accomplish a study may differ from one another. For that reason, we cannot examine the functions of the studies and analyses in detail. But as shown in Figure-72, we can identify the general procedures that we need to follow while conducting a study and analysis.

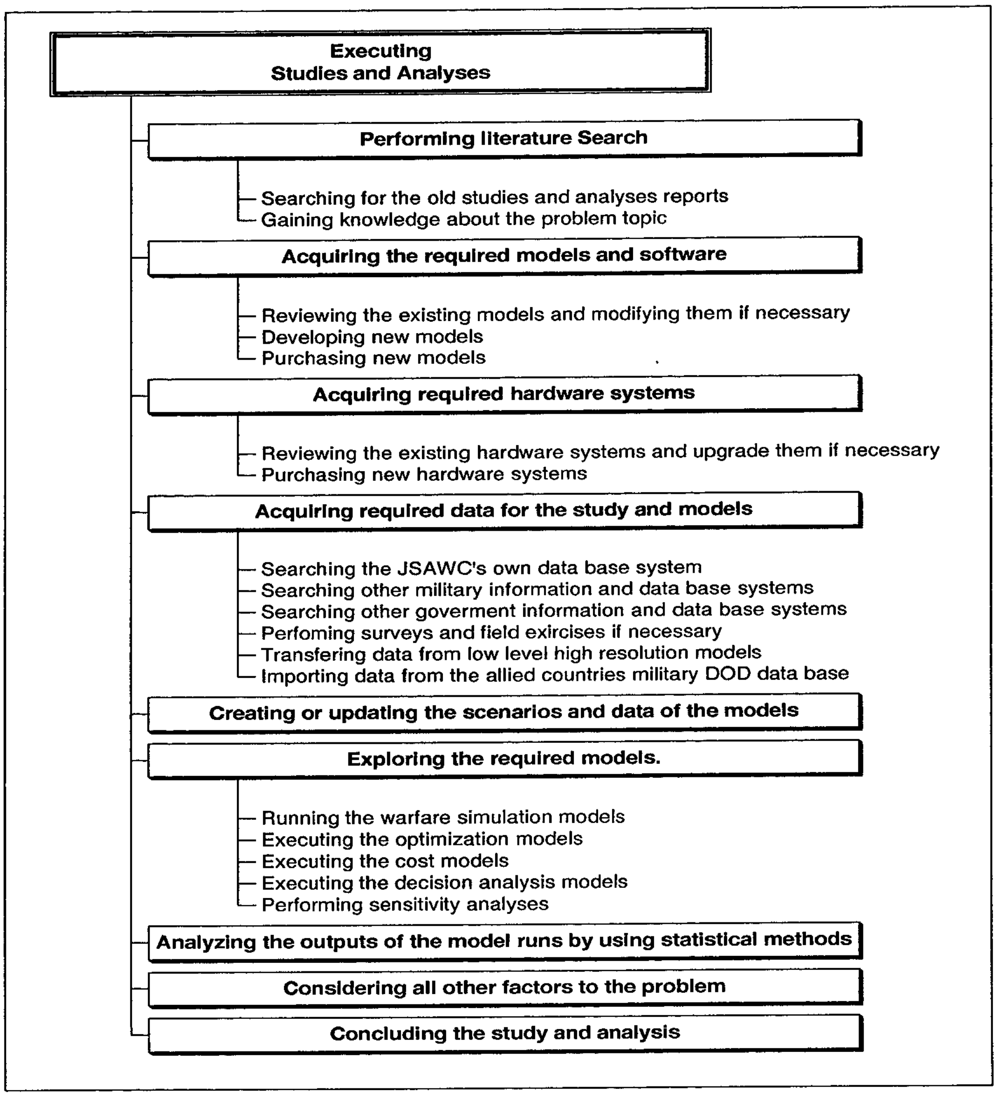


Figure 72: Executing Studies and Analyses

5.3.2.1.5 Reporting the studies and analyses

Reporting the results of the study is another important task that the study team needs to do. There are basically three different functions in the reporting process of a study. These are documenting the critical efforts of the study, presenting the results, and writing the final report.

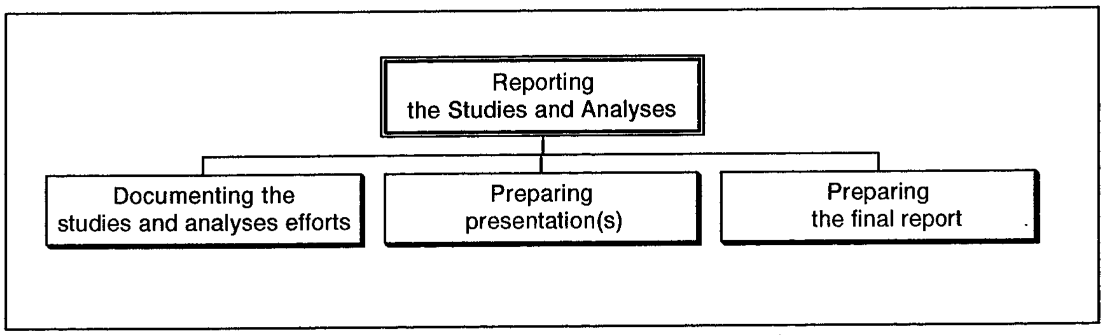


Figure 73: Reporting the Studies and Analyses

Documenting the efforts during the study such as problem definition, methodology, and execution, helps people who may be asked to do similar studies in the future. In addition, when the team members do a critique after completing the study, these documents will help them identify lessons learned.

The study team should present the study efforts and results during the study and/or before turning in the final report. It gives them opportunity to clarify some of the problems and assumptions with the decision-maker(s). It also brings up additional questions, and issues which should be examined and answered during the study.

The last process in this step is preparing the final document. This final report will include the executive summary of the study, critical assumptions made by the study team, important findings, conclusions, and recommendations. The report will be published and distributed to the sponsors and other related military agencies.

5.3.2.1.6 Archiving the studies and analyses

After a study is completed, its reports and associated materials will be archived at the JSAWC as a reference for future studies and analyses. The documents of the study will be decomposed according to their classification levels and archived as such. Here, the objective is not to allow applying unnecessary classified storage rules to a study report just because one of its parts is classified.

5.3.2.2 Training

The training function of the JSAWC consists of introductory modeling and simulation courses and related wargaming activities. The objective of the training at the JSAWC is not to perform complex wargames like that of the JTASC (Joint Training and Simulation Center of the USACOM) which prepares training for 200-400 people at the same time. Instead, the JSAWC will offer computer-assisted wargaming of current and critical crises scenarios to small groups of Turkish Generals and staff officers. In addition to wargaming, the JSAWC will also provide introductory modeling and simulation courses on military applications to help users understand the current simulation technology better and improve their performance in the wargame realistically.

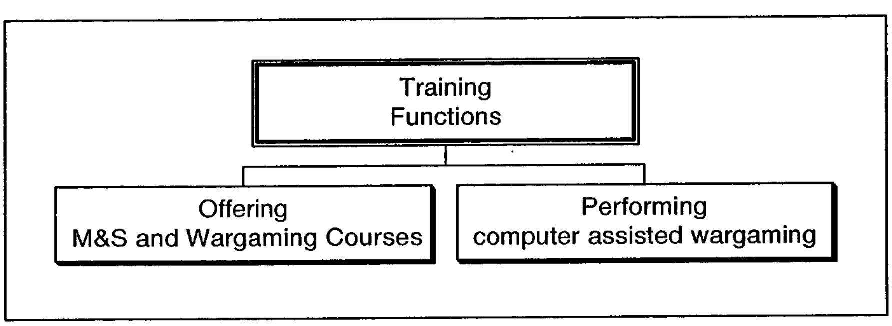


Figure 74: Training Functions

The JSAWC's external relations while performing the training functions may be described as shown in the figure below.

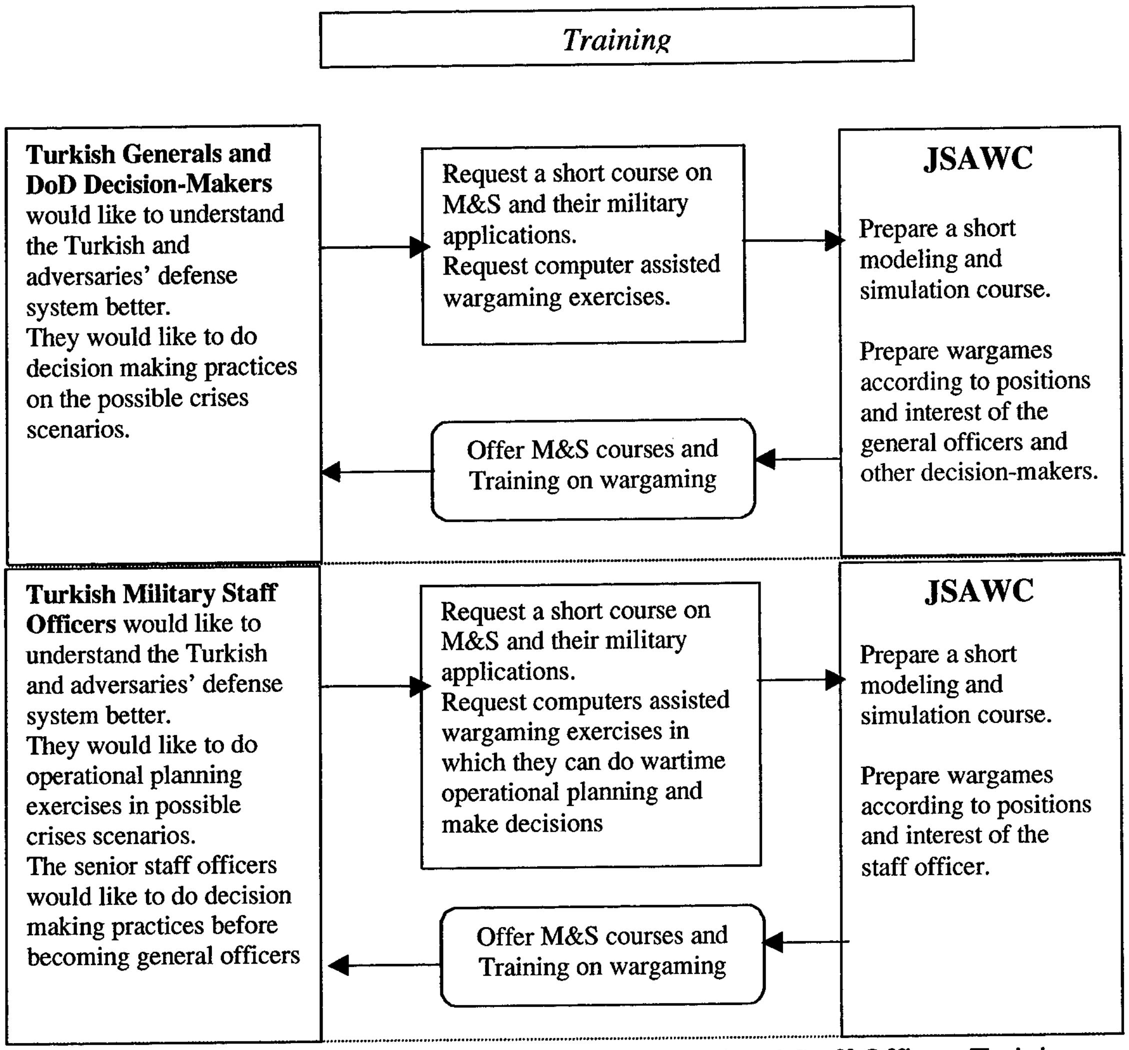


Figure 75: Relation between the JSAWC and General and Staff Officers Training

5.3.2.2.1 Offering M&S and Wargaming Courses

One of the objectives of providing M&S and wargaming courses to the Turkish generals and staff officers is to improve their knowledge about current modeling and simulation technology and show their worldwide military applications. As future users of this technology, they need to understand the logic, strengths, and limitations of M&S to use it effectively for the right purposes. Another objective of this course is to prepare decision-makers and planners for computer assisted wargaming exercises.

The content of the M&S and wargaming courses should be identified based on a survey and analysis of the needs of the potential course attendees. A front-end analysis would start with the following M&S and wargaming course topics.

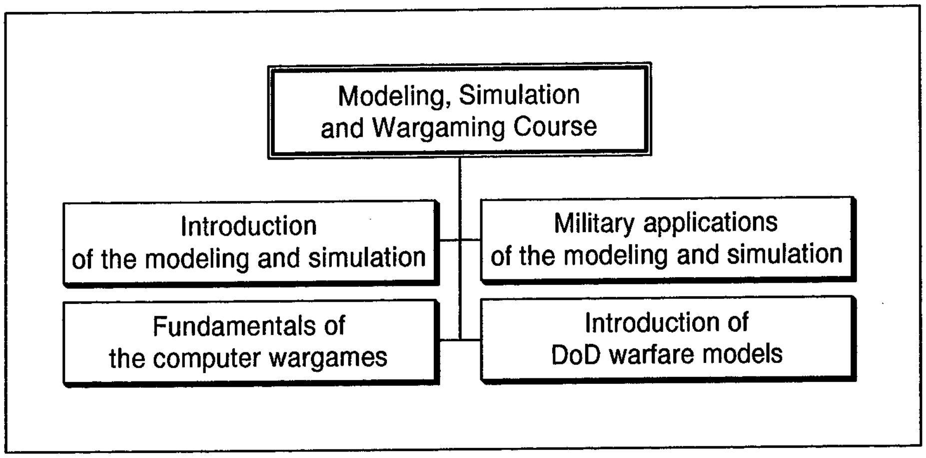


Figure 76: M&S and Wargaming Courses

5.3.2.2.2 Performing computer assisted wargaming

A computer wargame is a warfare simulation game in which participants seek to achieve a specified military objective given pre-established resources and constraints; for example, a simulation in which participants make battlefield decisions and a computer determines the results of those decisions [DMSO, 1998]. Peter Perla, a senior wargaming expert, defines a wargame as "a warfare model or simulation, not involving actual military forces, and in which the flow of events is affected by and in turn affects decisions made during the course of those events by players representing the opposing sides" [Perla, 1991]. The key words in Perla's definition are *players* and *decisions*.

Wargaming is an experiment in human interaction. Without human interactions we can only imagine analysis purposes warfare simulations.

The functions of wargames may differ according to the level and objective of the wargame, the decision-makers' or players' position, and the scenario. The activities in playing wargame can be divided into four categories as shown in the figure below.

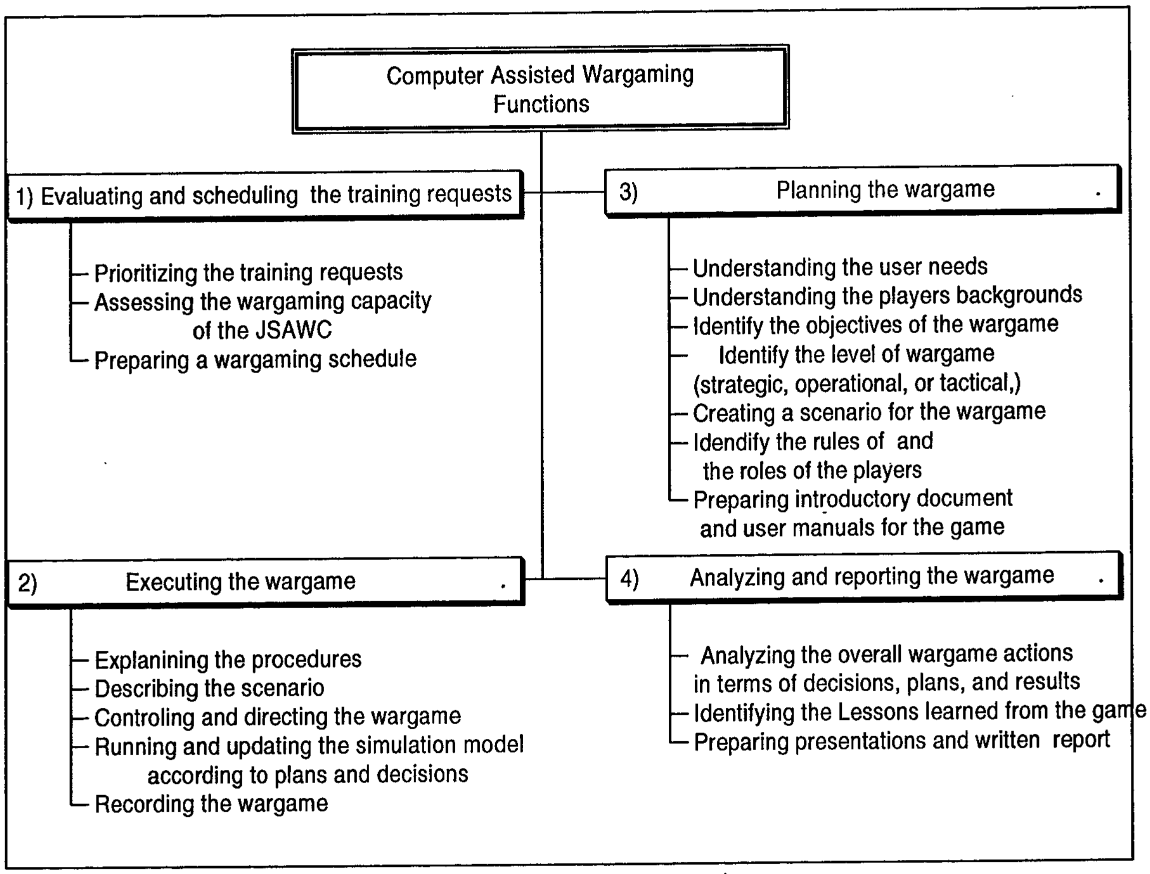


Figure 77: Computer Assisted Wargaming Functions

5.4 SYSTEM OPERATIONS SUPPORT FUNCTIONS

In this category, we will consider all the other system activities necessary to accomplish the JSAWC major missions as the system operations support functions. If we see all the system functions as connected to each other like a chain, we can understand the importance of every activity in the JSAWC. Whether it is a major, administrative, or support function, we need to plan and perform it carefully to achieve the JSAWC's overall objectives. The following activities are the support functions of the system that should be provided based on the major functions described above.

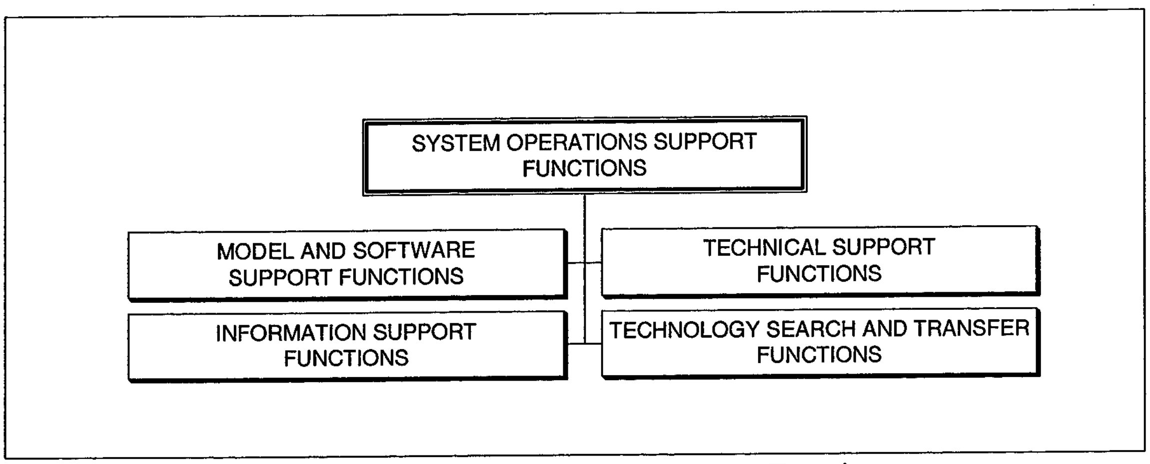


Figure 78: System Operations Support Functions

5.4.1.1 Model and Software Support Functions

The JSAWC must be capable of developing, providing, and supporting the required computer models in the system. The models are vital for the studies, analysis and wargaming activities and directly affect the results and quality of the studies. They may also affect the total time of a study because developing and upgrading simulation models are very time consuming jobs.

We can divide the model acquiring and supporting functions into six categories. Basically, they are model and software development and providing, model and software support, scenario generation, providing user help service, coordination of modeling activities within the DoD organizations, and research for the new modeling technology.

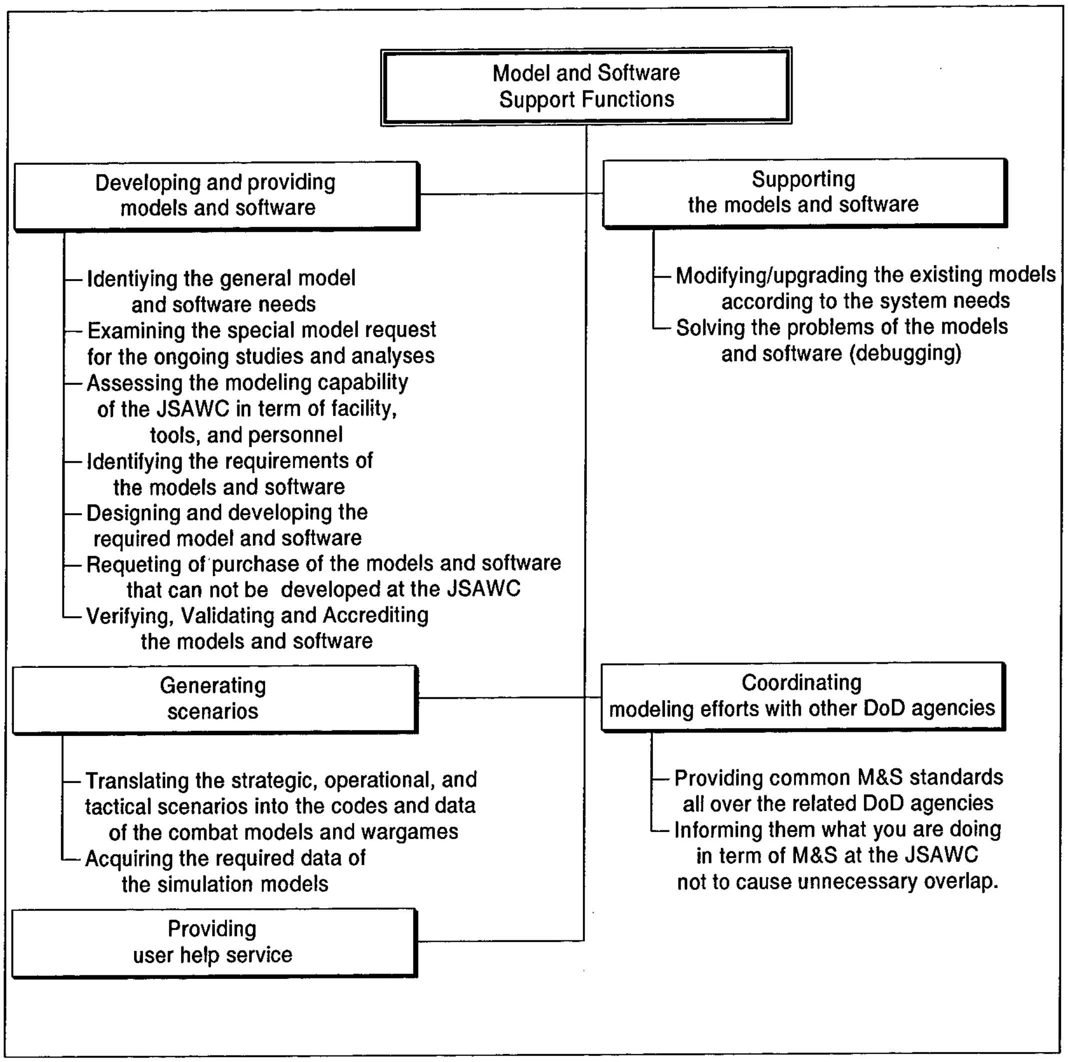


Figure 79: Model and Software Acquisition and Support Functions

5.4.1.2 Technical Support Functions

Technical support is another necessary functions that should be considered at the JSAWC. Technical support covers all the activities such as installing and maintaining system hardware elements. This support function can be provided directly by the JSAWC or by another organization inside the Turkish General Staff.

Technical support includes four types of support activities. These are computer system support, communication system support, system infrastructure support, and other technical support (Figure-80).

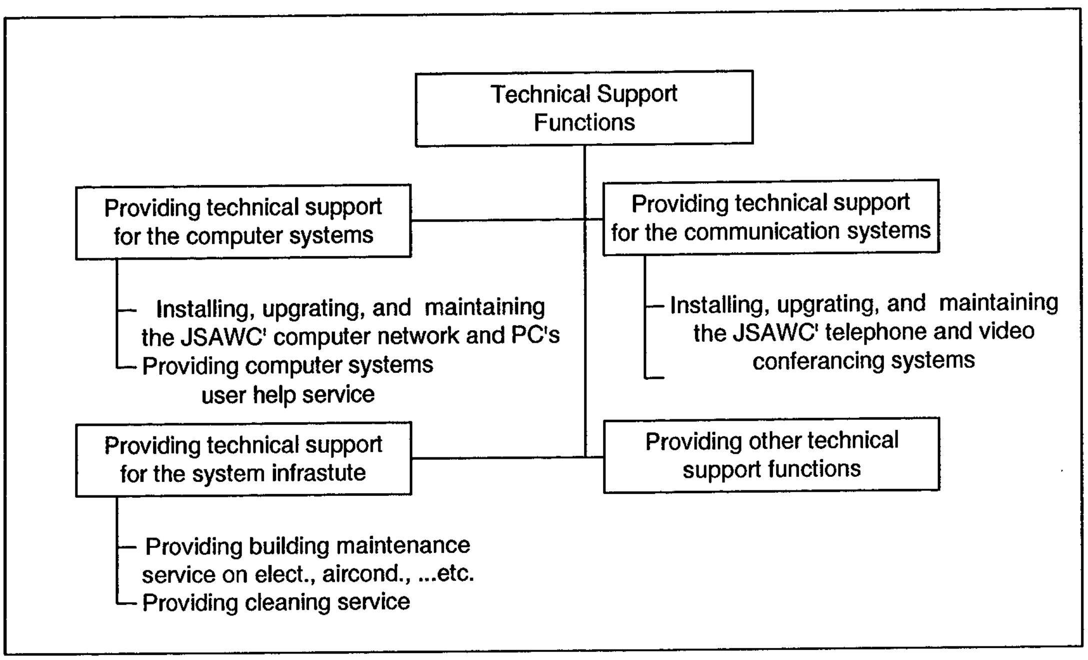


Figure 80: Technical Support Functions

5.4.1.3 Information Support Functions

Information support is yet another important function of the JSAWC that directly affects the quality of the system product. To be able to produce accurate and credible studies and analyses, we have to provide accurate data and information for the models and for the analysts in the JSAWC.

Information support consists of providing an accurate database and complete technical library to the JSAWC. The database should be updated continuously with current, accurate data and information. The data in the models and software should be traceable to the JSAWC's database system and should be updated immediately when data changes or new data comes to the system.

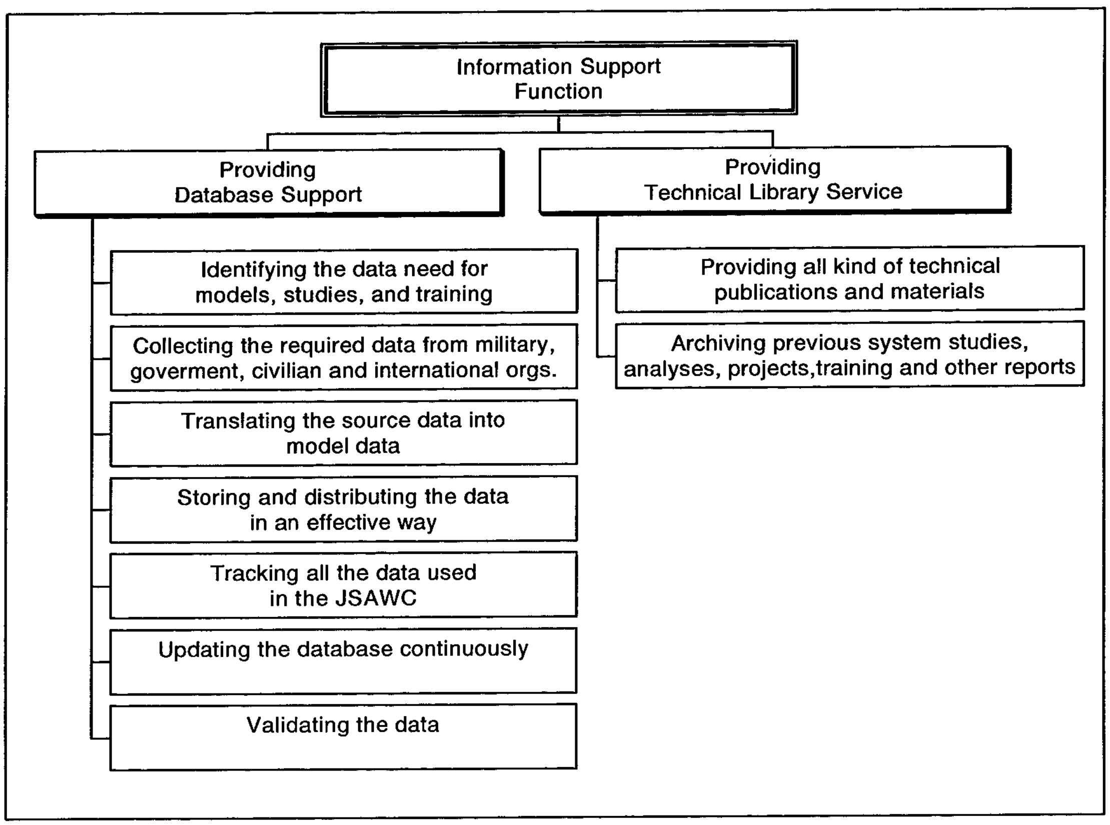


Figure 81: Information Support Functions

5.4.1.4 Technology Search and Transfer Function

The Joint Simulation, Analysis and Wargaming Center will be a dynamic system, which always searches for and uses the best technology in the world. The technology search and transfer functions will be performed for all areas that the JSAWC works in directly or has interests in. The objective of technology transfer is to make the JSAWC a powerful decision support center which always tries to produce better studies, analyses and training for the Turkish Armed Force.

The following are possible areas in which the JSAWC will do technology search and transfer.

- Military operations research; military problem analysis and solution techniques
- Warfare modeling techniques; combat simulation modeling, wargame simulation modeling, and mobility modeling
- Wargaming techniques
- Cost analysis and modeling techniques
- Decision analysis techniques
- Computer engineering, networking, database technology
- Software technology
- System and information security technology
- Management techniques
- Systems engineering techniques

5.5 SYSTEM PHYSICAL REQUIREMENTS

In previous sections, we analyzed the objectives and the functional requirements of the JSAWC in detail. Now we need to identify the system elements necessary to accomplish those objectives and functions. In the JSAWC design study, there are five different areas in which we have to define the physical requirements of the system. We can list those areas as:

- Personnel
- Software
- Hardware
- Organization
- Infrastructure (physical structure or facility layout)

Before we begin identifying the physical requirements of the system elements, we must first decide from which requirement area we need to start. To be able to identify the starting point, we need to understand the relationships between all the requirement areas shown above. Since the features of some system elements may affect the requirements of the others, we should trace the cause-effect relations and find the order of the requirement areas of the JSAWC (Figure-82).

After we figure out the sequence in which we are going to define the system requirements, we will make an iteration plan of the design study. In this plan, we will decide how much iteration we need to complete the preliminary design of the center and what we are going to do in each step.

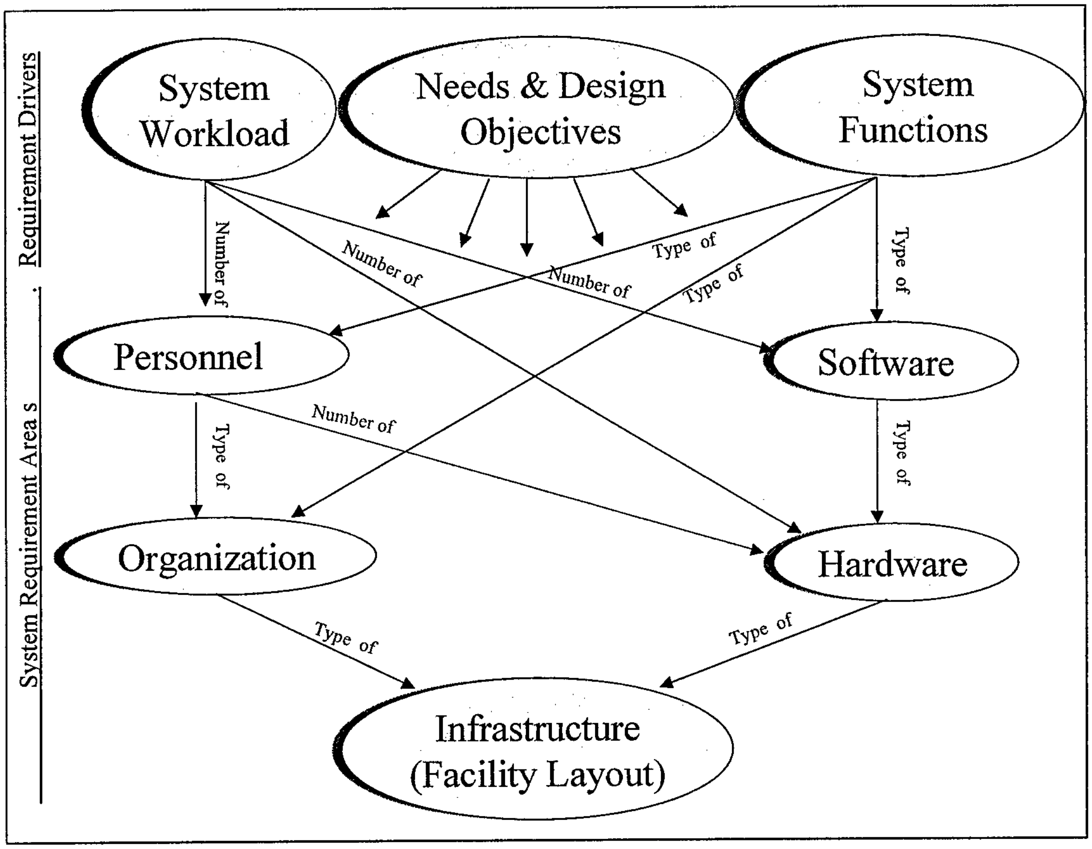


Figure 82: The Relationships between the Requirement Areas

The figure above shows how the requirement drivers (the JSAWC's design objectives, decision maker's need statements, required system functions, and system workload) affect the system requirement areas in terms of type or number of system elements. For example, by looking at the graph, we can see that the *missions and functions* of the JSAWC drive what <u>type of</u> *personnel* (professions) we need in the system. We can see also the similar cause-effect relations between requirement areas. For instance, as shown in the figure above, the number of *personnel* is a factor that affects the <u>number of</u> *hardware* of the JSAWC.

At the top of the figure we see the system design objectives, needs statements, system functions, and system workload as the requirement drivers of the JSAWC. I have already examined the design objectives, need statements, and functional requirements in the previous parts, but I have not identified the JSAWC's workload as of yet. Here, workload refers to the number of missions and functions that the JSAWC has to accomplish in a year. Basically it drives the system capacity in terms of personnel, hardware, and software. We can generally identify the type of the JSAWC's objectives, missions, and functions as we did in previous parts, but we cannot identify the system workload (required capacity) without examining the users of the center and its environment closely. To be able to identify the JSAWC workload, we have to perform a thorough survey of the Turkish General Staff, and the Turkish Air Force, Army, and Navy, which is beyond the scope of this study. Therefore, the number of personnel, hardware, and software will not be identified in this thesis. When the JSAWC project is accepted by the Turkish DoD, this information will be needed to continue the design study.

Based on the relationship between the requirement areas shown above, we can specify the order in which we should consider the physical requirements of the JSAWC. First we have to identify the software and personnel requirements, and then we need to define the system hardware and organizational specification. The required system infrastructure will be specified as the last part of the requirement analysis step.

Software: Define the required types of software only. The number of software must be defined after identifying the system workload.

Personnel: Define the required types of professions only. The number of personnel must be defined after identifying the system workload.

Organization: Define the required organizational structure after knowing the personnel requirements.

Hardware: Define the type of computer and other system hardware after selecting the required software. Define the number of and capacity of the system hardware elements after knowing the system workload and number of personnel.

Infrastructure: Define the JSAWC's physical structure (facility layout) at the end.

The next section presents the software, and personnel, requirements of the JSAWC. In the second systems engineering iteration the organization and hardware requirements will be addressed and in the third iteration the system infrastructure will be defined in sequence.

5.5.1 THE SYSTEM SOFTWARE REQUIREMENTS

In this section, the types of warfare simulation models and other software which are needed to accomplish the given missions and functions of the JSAWC (Joint Simulation Analysis and Wargaming Center) are identified and correlated with the system functions. My personal interviews with the personnel of the DoD Studies, Analyses, and Wargaming Centers, comments of the professors from the OR and Computer Science Departments of the AFIT, and my own ideas were the sources of this software identification study.

After we know what kind of software packages we need at the JSAWC, we will have to specify their required and desired features according to the functions, system objectives, and needs of the system. We should also consider decision-maker's values and expert opinions while defining the specifications of the required software and models.

• Planing Studies	Project management and scheduling tools
• Executing Studies	Related warfare models shown above, Statistical analysis packages, decision and risk analysis tools, cost models, optimization tools, spreadsheets, and graphical software
• Reporting Studies	Presentation software
• Archiving Studies	Publisher tools, Scanner, and database software
2.2 Training	
2.2.1 *Teaching Introductory Modeling and Simulation Course*	Word processing, presentation, and database software
2.2.2 *Wargaming*	Operational level computer wargame
• Planning Wargames	Word processing, and database software
• Execution Wargames	Presentation software
• Analyzing and Reporting	Word processing, spreadsheet, statistical package, presentation, and database software
3 SYSTEM OPERATIONS SUPPORT FUNC.	
3.1 Model and Software Support	
• Model and Software Development	Computer operating system, main simulation language, modeling and simulation packages, graphical tools, database, word processor, and spreadsheet
• Scenario Generation	Scenario generation tools, database, and word processor.
• User help	Email and internet page designer, and surfer.
3.2 Technical Support	Email software, web Server, and network management server.
3.3 Information Support	
• Database Support	Sophisticated database software (Obj.-Orient.)
• Technical Library Service	Database software, search engines, internet

	designer and explorer, email, word processor, and spreadsheet.
3.4 Technology Search and Transfer	Email and internet surfer.

As shown on the table above, we simply identified the required type of software to accomplish the related missions. This table will help us to track the system functions and software relations until the end of the project. All the required software is summarized in the table below.

Table 4: The JSAWC's Software Requirements

THE REQUIRED TYPES OF SOFTWARE
1. Warfare Models
1.1. Combat Models;
1.1.1. **Joint Campaign Model**
1.1.2. Mission and Engagement Level Combat Models
1.1.2.1. **Air to Air**
1.1.2.2. **Air to Ground and Sea**
1.1.2.3. **Sea and Ground to Air**
1.1.2.4. **Ground to Ground**
1.1.2.5. **Sea to Sea**
1.2. **Operational Level Computer Wargame**
1.3. Mobility Models
1.3.1. **Joint Mobility Model**
1.3.2. **Air Mobility Model**

1.3.3. **Sea Mobility Model**
1.3.4. **Land Mobility Model**
2. Computer Operating Systems
2.1. **Workstation Operating Software (Unix)**
2.2. **PC Operating Software**
3. Modeling and Simulation Software
3.1. **The Main Simulation Language**
3.2. **The Modeling and Simulation Tool Set**
3.3. **Graphic Tools**
3.4. **Scenario Generation Tools**
4. Statistical Analysis Software
4.1. **PC Statistical Analysis Package**
4.2. **Workstation Statistical Analysis Package (Unix)**
5. Optimization Software
5.1. **Linear Optimization Tools**
5.2. **Non linear Optimization Tools**
5.3. **Network Optimization Tools**
6. **Decision and Risk Analysis Software**
7. **Cost Models**
8. Project Management Software
8.1. **Project Management Tools**
8.2. **Scheduling Software**
9. Internet Software

9.1. **Web Server**
9.2. **Intranet Server**
9.3. **Internet Surfer**
9.4 **Email Software**
10. Network and Security Software
10.1 **Network Management Server**
10.2 **Proxy**
10.3 **Firewall**
11. Database Software
11.1. **Database for Model Data and Scenarios**
11.2. **Database for Technical Library**
11.3. **Database for Administrative Data.**
12. Office Software
12.1. **Word Processor**
12.2. **Spread Sheet**
12.3. **Presentation**
12.4. **Scanner Software package**

5.5.1.2 Preliminary Software Requirement Specifications

The next step is to identify the required features of the software that will be used at the JSAWC. There are a total of 40 software packages and models which need requirements specifications. Some of them, especially the warfare models, are very critical software which require careful, detailed analysis to specify their essential features. On the other hand, some others like Office and Internet software packages, do not require much detailed analysis to identify their general requirements.

Due to time constraints and the current level of detail in the analysis, it is not possible to consider all the software types. Instead, preliminary requirements for two, joint campaign model and operational level computer wargame will be developed. These will act as guidelines of further development in later iterations.

5.5.1.2.1 The Joint Campaign Model

The joint campaign model (JCM) will be the major warfare model of the JSAWC and will represent future joint theater warfare. The JSAWC will use the JCM for analyzing possible future warfare scenarios to produce the best operational plans and force structures. In addition to analysis the JCM will also be used as a operational computer wargame in the center. The overall purposes of the JCM are listed in the following paragraphs. The JSAWC will need purchase or develop a Joint Campaign Model that serves the following purposes and satisfies all of the requirements defined below.

5.5.1.2.1.1 Purposes of the JCM

5.5.1.2.1.1.1 Analysis Purposes

The joint campaign model will be used for the following analytical purposes at the Joint and service (Air Force, Army, and Navy) level in the area of operations, C4ISR, and Logistics.

- Capability assessment
- Threat assessment and prioritization
- Analysis of alternatives

- Requirement analysis
- Risk assessment
- Force sizing study

5.5.1.2.1.1.2 Wargaming Purposes

The JCM also has to have wargaming features, so it can be used to train the Turkish generals and staff officers with current strategic and operational scenarios.

5.5.1.2.1.2 Functional Requirements

The joint campaign model must cover strategic and operational levels of war, but should focus on the operational level of war. It should be sufficiently flexible to deal with current, near-term, and future warfare concepts, doctrines, systems, and organizations of Turkey, its allies, and potential adversaries.

5.5.1.2.1.2.1 Military missions required to be covered

The Joint Campaign Model must represent all Air, Army, and Naval Forces' roles and functions properly. To identify the military missions that should be modeled by the JCM, we have to examine all the military activities in a possible joint theater warfare. As a reference for those military activities, we can look at the Unified Joint Task List which is developed by the US Joint Staff. [Joint Staff, 1996]. JWARS's (The US Armed Force's model of joint warfare systems under development) design team has been examined the UJTL and ranked the appropriate missions which should be represented in a joint level campaign model.[JWARS, 1997]. This ranked unified task list needs to be modified according to Turkey's, its allies, potential adversaries' operational capabilities and span of military activities.

Here, I will only identify the general type of missions and operations which must be modeled in the joint campaign model. We can list them in these categories: Joint theater operations, C4ISR, Logistics, Information Warfare, Weapons of Mass Destruction, Special Operations, Mobility, and Environment.

Joint Theater Operations: Air defense, air superiority, airborne operation, amphibious operation, close air support, fire support, ground defense, interdiction, maneuver (attack, defend, and move), search and rescue, sea control, suppression of enemy air defense, and strategic attack.

C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance): Dissemination, feedback, intelligence planning and collection, targeting, communications (availability, timeliness, reliability, and security), computer (transform and analyze data), command and control assessment, command decision making, coordination, integration of combat information, mission tasking, and the monitoring of mission execution.

Logistics: Port operation, casualties/attrition, distribution, engineering and construction, intra-theater movement, inventory, maintenance and repair, medical evacuation, medical treatment, pipelines, and refugee control.

Information Warfare: Deception, destruction of C2 and information nodes, electronic attack, electronic protect, and psychological operations.

Weapon Mass Distraction: Decontamination, detection, effects, and protection.

Special Operation: Combating terrorism, direct action, peacetime operations, and special reconnaissance.

Mobility: Deployment, sustainment, and pre-positioning.

Environment: Light condition, littoral characteristics, man-made obstacles, sea state, space, terrain characteristics, weapons effects, and weather.

5.5.1.2.1.2.2 Algorithms

The algorithms, rules, and mathematical formulations used to represent the military activities, states, and interactions in the Joint Campaign Model, should produce credible output results similar to those in real life. For that reason, it is necessary to understand how Turkey, its allies, and potential adversaries doctrinally conduct their missions in order to produce correct algorithms and representations in the JCM. Historical war and exercises information, recorded actions in previous crises, and intelligence information are other resources besides doctrines that can be used to understand how they fight.

Since, the Joint Campaign Model will be used to examine future wars, the algorithms and methods needed to represent the joint operations must be flexible enough to answer critical "what if" questions. The algorithms and construction of the model must be adaptable and flexible, so that we can explore new tactics, new weapons usage, and new doctrines in future wars.

5.5.1.2.1.3 Structural Requirements

Structure of models basically shows the quality of the model. So, this requirement should be defined very carefully. I examined the documentation of some existing campaign level models such as THUNDER and some on going projects such as JWARS.

Their current and projected features were the main source of this study.[JWARS, 1997], [Thunder, 1998].

Currently, the following specifications of the required structures the JCM may be seen impossible to be satisfied. But we should realize that to accomplish this project may take 3-4 years and in this period computer and simulation technology will probably be better than it is today. In addition, the objective of writing this requirement specification is currently to produce a reference guide. If it is seen that because of technological and monetary constraint we can not satisfy all the requirements, we will refine them in later iterations.

5.5.1.2.1.3.1 Model Language

The Language of the Joint Campaign Model should be an object-oriented, modern, supportable programming language.

5.5.1.2.1.3.2 Model Architecture

A standard architecture must be used in the JCM. This modeling architecture should be the same that will be used in the other models of the JSAWC. It must be open, robust, extensible, and flexible architecture which provide for the development of a JCM that can be maintained and evolve as the model operational needs and applications change.

5.5.1.2.1.3.3 Resolution

The JCM should have multiple levels of resolution features. The analyst must be able to select the resolution of the model according to various time constraints, and level of the study topic. The low-resolution mode will be used for the time-constrained analysis across all warfare functions. On the other hand, the high-level resolution mode will be used to provide detailed analysis of selected areas of warfare whenever necessary.

5.5.1.2.1.3.4 Sidedness

The JCM must represent multiple nations in numerous coalitions as well as neutral and opposing forces.

5.5.1.2.1.3.5 Randomness

The JCM should have both deterministic and stochastic features for the representation of the variable aspects of warfare being modeled. A deterministic methodology will be used for the quick time analysis and planning applications. A stochastic methodology will be needed for all other type of detailed studies and analyses. Users should be able to choose from a single value, common probability distributions, or a user-provided distribution for input data.

5.5.1.2.1.3.6 Run time

The JCM has to have adjustable simulation run speed. For analysis purposes, we want to run the simulation as fast as possible to allow users to run more repetitions for better analysis and to produce results in a short time when time is critical. On the other hand, for wargaming purposes we want to run the simulation close to or at the time speed.

5.5.1.2.1.3.7 Run Control.

The user should be able to interrupt JCM, modify data, and start excursions from the same point. In addition, the user should be able to dictate a rolling checkpoint that allows a periodic capture of "the state of the system" at user-defined intervals or at key events and permit restarts with modifications of data, at any of these points. This JCM feature will be especially necessary for wargaming activities.

5.5.1.2.1.3.8 Data handling

All the data in the model should be current and accurate. The JSAWC's database system should be capable of tracking the data in the model. When new data arrives at the database center or when it is internally updated, it should be known which part of the JCM will be affected, and the old data should be changed automatically. The JCM's data handling features should be capable of accomplishing this objective. In addition, classification levels of data must be also appropriately considered in the model.

5.5.1.2.1.3.9 User Interface

The JCM must have user friendly interface features at every stage of the model in which user interaction or monitoring is required. Scenario development, pre-processing and post-processing of data, and execution of the model are the most important areas which need excellent user interface features. The JCM should provide a menu-driven interface that minimizes keyboard entries. It should also allow the users to graphically examine and create entire battle scenarios up to unit objects. In addition, the JCM should have animation features (visualizing movements and actions in a battle) that can be turned on and off whenever needed. It is especially in wargaming, a desired feature which helps players to learn as much as possible from the results of their plans and decisions.

5.5.1.2.1.3.10 Post-processing

The JCM has to have sophisticated post-processing features such as automatic graphical, text, and spreadsheet displays, options to filter output variables, full statistical analysis by itself or connection to other statistical software, automatic producing reports and briefing slides, and rapid-replay capability using map displays.

5.5.1.2.1.4 Performance Requirements

Performance requirements here refers to traceability, ease of use, repeatability , maintainability, and reliability of the Joint Campaign Model. These requirements may not be independent from each other and they have close relations with the structural requirements especially with the model language and architecture.

5.5.1.2.1.4.1 Traceability

This is the ability to identify why a certain output was obtained from the model. The JCM should allow an analyst to identify the cause-and-effect relationships needed to explain analysis. In addition, all the data in the model should also be traceable. If user changes are made for a particular application, the JCM should track the changes from baseline version to analytical excursions and earmark output accordingly.

5.5.1.2.1.4.2 Reliability

Reliability is the ability of the JCM to perform a simulation under stated conditions for a specified period of time. The models should provide a high (~99%) probability of completing a simulation run after initiation when there are no operator input errors.

5.5.1.2.1.4.3 Maintainability

The software should provide assistance to the operator for correction of input data and runtime errors. It should identify the source of and facilitate the correction of errors.

5.5.1.2.1.4.4 Repeatability

Using the same initial conditions (to include random number generator seeds for stochastic replications) should provide the same output on the same hardware platform.

5.5.1.2.1.4.5 Ease of Use.

It should be easy to learn and operate the JCM. For instance, understanding the logic of the model, loading input data, executing model runs, and extracting output data for analysis, and modifying the scenario should be easily learned and performed by the model users after a reasonable period of study.

5.5.1.2.1.5 Other Requirements

5.5.1.2.1.5.1 Verification and Validation

Before selecting and using JCM, the objects and algorithms in it that represent doctrine, system and unit performance, and the environment should be officially verified and validated by subject matter experts.

5.5.1.2.1.5.2 Mobility Requirements

The JCM should be capable of being moved from the JSAWC site to one or more alternate sites with minimal logistical support and without any degradation in capability.

5.5.1.2.1.5.3 Documentation

There must be the following documentation of the JCM in hard copy and electronic copy; executive overview: users' guide; tutorials; analyst manual; programmer's manual; verification, validation, and accreditation manuals; configuration management and the maintenance documentation plan.

5.5.1.2.1.5.4 Affordability

The acquisition, maintaining, and upgrading costs of the JCM must be affordable. It should not require many personnel, or special expensive hardware and extraordinary facilities.

5.5.1.2.2 Operational Computer Wargame

For the purpose of computer assisted wargaming, the JSAWC will use the same Joint Campaign Model described above. As defined in the requirement statements, it will have adjustable run time and interruptible features during the simulation, so it will be used as a wargame. In addition, the multiple resolution feature of the JCM will make it capable of being used in both operational and tactical wargaming purposes.

The main objectives of using the same model for the analysis and training purposes are to have the minimum number of models and to use the same current scenarios for both analyzing the operational plans and training the decision makers at the same time.

5.5.2 PERSONNEL REQUIREMENTS

Defining the personnel requirements of the JSAWC is another critical part of the study. We have to carefully identify the personnel needs of the system. For this section of the study, I examined some of the US studies and analysis agencies' personnel situations. Even though, their objectives, scopes, and service areas are different than JSAWC's, it helped me to understand the general personnel needs of the system. For example, the US Army Concept Analysis Agency's personnel are distributed as follows:

US Army Concepts Analysis Agency:

Total Personnel	:	178
Military	:	54
Civilian	:	124
Oper. Research	:	15%
Math	:	24%
Engineers	:	11%
MBA/Business	:	06%
Computer Sci.	:	20%
Others	:	24%
Doctorate	:	10%
Masters	:	55%
Bachelors	:	35%

Besides knowing what type of specialists are being employed in those simulation and analysis center in the USA, I have also interviewed some of AFIT's professors for their expert advice in this study. In the Table-5, the required types of professions are identified and correlated with the system functions. This table will be used a reference for future studies of the JSAWC design project.

In this table, instead of defining titles of people, I identified only the required areas of expertise, because I wanted to emphasize that a person may have a title but can serve for more than one area. In the system synthesis step, we will produce alternatives for the JSAWC staff to fill the required areas of expertise, not now. At that time we can propose, for instance, two operational research analysts, two software engineer, and so on for the staff, or as an another alternative we can offer two software engineer who have OR background, one pure software engineer and so on.

5.5.2.1 Required Expertise

Table 5: The JSAWC's Functions vs. Required Expertise

THE JSAWC'S FUNCTIONS	REQUIRED EXPERTISE
1 **ADMINISTRATIVE FUNCTIONS**	**Management +**
1.1 Program Planning	
• Work Planning	Program Management, Operations Research
• Personnel Planning and training	Human Resources Expertise
• Acquisition (Procurement and Contr.)	Acquisition, Management, and Decision Analysis
• Budgeting	Finance and Decision Analysis
1.2 Coordination	
• Inside the JSAWC	
• Outside the JSAWC	Public (Customer)Relation and Information Security
1.3 Control	
• Quality Control	Quality Control,
• Security Control - Information Security Control - System Security Control	Intelligence Network, and Software Engineering, System Security Expertise

2 MAJOR SYSTEM FUNCTIONS	
2.1 Studies and Analyses	
2.1.1 Strategy and Operational Planning (Joint, Air Force, Army, and Navy) (Operations, Logistics, and C4ISR)	**Operations Research, Operations Analysis, Simulation Expertise, and Statistics Science** +
• Capability assessment	Operations and Logistics Expertise
• Threat Assessment and Priori.	Intelligence Expertise
• Analysis of alternatives	Field expertise on the topics of studies
• Requirement analysis	Operations, Logistics, and C4ISR Expertise
• Risk assessment	Operations Expertise
2.1.2 Force Structuring (Joint, Air Force, Army, and Navy) (Operations, Logistics, and C4ISR)	**Operations Research, Operations Analysis, Decision Analysis, Optimization, and Statistics Science** +
• Analysis of alternatives	Field expertise on the topics of studies
• Force Sizing	Operations and Logistics Expertise
• Weapon/system Effectiveness. Anal.	Related Weapon/System Expertise
• Requirement Analysis	Operations and Logistics Expertise
• Risk Assessment	Operations Expertise
• Cost Analysis	Cost Analysis Expertise
2.2 Training	
• Offering Modeling and Sim. Course	Modeling and Simulation Expertise
• Wargaming	Wargaming Expertise
3 SYSTEM OPERATIONS SUPPORT FUNC.	
3.1 Model and Software Support	
• Software and Model Development	Software Engineering, Simulation Expertise, Operations, Logistics, and C4ISR Expertise.
• Scenario Generation	Software Engineering,
• User help	Simulation Expertise

3.2 Technical Support	
• Computer System Support	Computer Engineering and Tech. Network Expertise
• Communication Support	Communication Systems Tech.
• Other Technical Supports	Building maintenance
3.3 Information Support	
• Database Support	Software Engineering
• Technical Library Service	Library Science
3.4 Technology Search and Transfer	

5.5.2.2 Required Proficiencies

We need to have well educated, highly qualified personnel in the JSAWC. Since the proficiency of a person directly depends on his education level and amount of time spent in the job, we want every member of the JSAWC to have a higher level academic degree and as much field experience as possible. But practically, in the short term, it may be difficult to find personnel who have MS and Ph.D. degrees from those required areas. In the long term, it is possible to increase the proficiencies of the personnel. Exact target levels of proficiencies can be evaluated after the center workload is defined.

5.5.2.3 Required Personnel Mix

Personnel mix refers to the source of the personnel such as Military vs. Civilian and Army, Air Force vs. Navy. Since the JSAWC will be a joint center, we have to keep even personnel mix from each service. In addition to the service combination, we need to also have an ideal military-civilian employee mix in the center. Since military personnel change their station in every 4-6 years, keeping civilian personnel in the system is critical not to decrease the quality of the studies during the assignment times.

To be able to identify the optimum personnel mix in the JSAWC, we have to learn the potential studies, analyses, and training needs of Turkish Army, Air Force, and Navy. In terms of military-civilian mix, we may consider hiring majority of civilian employee for the operation support position of the center. Because this functions requires deep experience about the system and special proficiencies. Since civilian personnel such as software engineer, computer engineer, and simulation experts can be stationed more than military personnel do, they will be more beneficial. On the other hand, military personnel especially who are analyst and have field experience, are preferable in other areas. Because, they can combine their operational experience with their academic knowledge and produce more credible studies and analysis results.

6 SUMMARY AND RECOMMENDATIONS

6.1 SUMMARY

In this thesis, first, I explained the necessity of using modeling and simulation technology in analyses of military problems and in training of military personnel. Then, I provided background about modeling and simulation for the readers who are not familiar with this technology. This general background is vital for Turkish military decision makers to understand why the center should be built. It also contains essential information that can be utilized by future members of the JSAWC design team to understand the strengths and weaknesses of modeling and simulation and identify the correct direction of the center.

In this study, I prepared a framework for the development of the Joint Simulation, Analysis, and Wargaming Center by using a systems engineering approach. Necessary procedures and actions that should be taken in each design step are explained according to an iteration sequence of the system engineering process. I then completed the problem definition step by identifying the objectives, missions, users, needs, and possible constraints of the center. In this step, the missions and environment of the JSAWC are derived from general functions of the Turkish Defense system. Most of the critical military planning activities are included in the center's mission set.

I transformed the system objectives to the design objectives and analyzed them in detail by using hierarchical decomposition techniques. I also clarified the system's functionality and interaction with its environment. General activities of the system functional areas are defined according to their category. I then identified the requirement areas of the system (software, personnel, organization, hardware, and infrastructure) and started specifying the software and personnel requirements. By using defined functions of the JSAWC, I addressed the types of software and professions that are necessary to accomplish the system objectives and functions. As a reference for the future study I have also presented a model specification study.

6.2 RECOMMENDATIONS

At this point the question is, what is next? What should we do to continue the study? First of all, this thesis should be introduced to the Turkish General Staff and be comprehensively discussed. If they accept this project, they should gather all necessary experts into the system design team as already defined in chapter 2. Then, by taking my efforts as a reference, they can follow the systems engineering process and continue designing the JSAWC from the point I stopped, but in more detail.

Their first action should be validating my analysis of the Turkish Defense System that is presented in chapter 4 and modifying it if necessary. Then, according to those changes, the problem definition step should be studied again. At that time, constraints of the project must be numerically defined according to their types as I defined in section 4.8. Design objectives and system functional requirements should also be reviewed and modified if necessary. If they change system functions or if they assign new ones to the center, they must also modify software and personnel requirements of the JSAWC. The specification of all software types (section 5.4.1) should be identified in detail by the design team. While taking an action in the requirement analysis step, they should always consider the requirement drivers (design objectives, need statements, system functions, and system workload).

In my thesis, I did not identify the system workload since it requires a detailed analysis of the system users who are going to request studies and analysis from the center. The design team must perform a thorough survey of the Turkish General Staff and Turkish Army, Air Force, and Navy to be able to identify the potential number of studies and analysis, and mission categories that can be requested in a year. Knowing the system workload is essential to be able to define capacity of the JSAWC. The system capacity will directly affect the required number of personnel, hardware, and software in the center.

After completing the requirement specification of the system, the design team must produce alternatives for the software and personnel. One way of developing software alternatives is searching the open market and identifying each software brand which can satisfy the requirements. Another way is to identify which models the allied countries' Department of Defense are using for similar applications. The other option is to request civilian companies to develop the required types of software and warfare models.

The design team members has to develop the same type of alternatives for the personnel needs. First, they need to look at the military personnel availability for the JSAWC's expertise requirements. Then, they should think of hiring civilian personnel in the center. While producing alternative staff options for the system, they need to consider the optimum military-civilian and Army-AirForce-Navy mix. Proficiency of the personnel is another important thing that should be considered in that step.

After producing alternative packages for each software type and staff, the design team members should analyze the possible contributions of those alternatives to the objectives of the system. According to the benefits that can be gained from each alternative, they must determine the best alternative of the software packages and personnel groups by using decision analysis techniques. After the Turkish General Staff (the sponsor of the project) makes decision on the system software and personnel, the design team has to plan and take the necessary actions to acquire them.

In the next iterations, the system design team has to follow the same design steps for the system organization, hardware, and infrastructure. In the Table-1 (section 2.9) I briefly summarized all of the necessary actions that should be taken in each system design step. We have to remember that designing the JSAWC is an iterative process. We may not always be able complete each design step in their sequence. For example, definition of the problem may not be completed until all aspects of the problem are understood. It may be necessary for the JSAWC project to modify some of the steps over and over until the end of the project. The important point is to be able to trace all the cause-effect relationships in the system. Before we modify anything we have to know how that change will affect the requirements of other system elements, general system behavior, and the design trade-off.

6.3 CONCLUSION

Technology is improving rapidly in all areas of the world and continues to offer new and amazing tools for the benefits of humanity. Modeling and simulation is one of those growing technologies and can serve the military community in many areas. It is an integral part of the way many armed forces conduct their business. The potential benefits of using modeling and simulation technology are also substantial for the Turkish military. It will increase the decision-makers' understanding of military problems and their complex environments. This will enable the Turkish military to effectively plan and use its limited resources and create a better Turkish Defense System.

In this thesis, I have proposed designing a Joint Simulation, Analysis, and Wargaming Center as the primary decision support center of the Turkish General Staff. Even though this technology has not been utilized very much in the Turkish Defense System, it is never too late to start using and taking advantage of it. What I have done in this thesis can be used as a starting point by the Turkish General Staff to develop this powerful center.

It will provide better analyses,
better decisions
better strategy,
better operational plans,
better force structure,
and consequently better Turkish Armed Forces.

Why not create it ?

Appendix A: Warfare Models Currently in Use

ALM, Airlift Loading Model is a research and evaluation tool for analysis of loadability of military combat and support units on airlift aircraft. The model is used to evaluate capabilities and requirements of current and future airlift fleets. It is a basic building block for analysis of airlift capabilities and requirements relating to military campaigns.

ALSP, Aggregate Level Simulation Protocol acts a postman for messages between the simulations that are members of the JTC. These messages contain formatted data on specific information on objects or actions occurring in one simulation that another simulation must react to. For example, air missions flown in the air simulation can bomb ground units in the Army's ground simulation while the ground model can engage the aircraft with air defenses. Another example is carrier based aircraft bombing air bases in the air simulation or ground units in the marine simulation. ALSP manages these messages and ensures the simulations remain in time synchronization.

AWSIM, The Air Warfare Simulation is the USAF's official air combat simulation model. AWSIM is used to train senior commanders and their battle staffs in the execution of joint/combined operations and in air component commander-level battle staff training for Air Force conducted exercises. ASWIM is a real-time interactive simulation that supports a two-sided scenario. It simulates day and night operations and limited weather operations. Modeled features include air bases, surface-to-air missiles (SAMs), Short Range Air Defense Systems (SHORAD), radar sites, surface-to-surface missile (SSM) sites, and cruise missiles.

BRAWLER is the preferred Air-to-Air analysis tool. It is a comprehensive computer simulation providing a detailed representation of air-to-air combat involving multiple flights of aircraft in both the visual and beyond-visual-range arenas. Because cooperative tactics and human factors such as surprise, confusion, and limited situation awareness play critical roles in such engagements, special emphasis has been placed on carefully modeling these aspects of the simulation. Further, a high level of detail is achieved in the hardware models, including those of aircraft aerodynamics, missiles, guns, expendables, radars, missile launch warning devices, radar warning receivers, IRST, IFF, and NCID. Electronic countermeasures versus radars, missiles, and communications are also handled.

CBS, The Corps Battle Simulation models ground combat, combat support, and combat service support aspects of ground forces in battle. This includes terrain/environment, movement, ground combat, attrition, artillery, chemical, engineer, maintenance, medical, resupply, tactical air, army aviation, air defense, and personnel requirements. CBS supports the joint and service training of commanders and staff officers at the JTF, corps, division, and brigade levels.

CEM, Concepts Evaluation Model is a deterministic theater/campaign combat simulation written in FORTRAN. It represents all air and ground systems that would interact across the theater. The maneuver control logic for determining commitment/reinforcement/ withdrawal/reserves decisions is driven by thresholds specified for each side. The attrition/consumption logic, referred to as ATCAL for Attrition Calibration, is driven by combat samples selectable by force ratio of the opposing systems at the engagement level.

CFAM is an Air Force developed and AFSAA managed linear programming model. It was designed to provide decision makers with an analytical tool for use in determining the impacts of budget, attrition, force structure, targeting decisions, and munitions inventories on war fighting capabilities in a theater scenarios. CFAM resulted from an effort to combine the best qualities of several disparate models in use by AFSAA, XOFW, and ACC/XP-SAS into a single tool used by all three agencies. It consists of two submodels, QUICK STRIKE and TIME STRIKE. CFAM will become the defacto standard for all future Air Force weapons allocation analyses.

COSAGE, COmbat SAmple GEnerator is a stochastic tactical level combat simulation written in SIMSCRIPT. CAA uses it primarily to develop killer-victim scoreboards and consumption tables which are used to calibrate the combat attrition/ammunition consumption computations in the theater level model, CEM. COSAGE is occasionally used to examine the performance of weapon mixes at the division level. COSAGE represents the complete range of air and ground combat systems expected to interact in a tactical level engagement. Unit orders determine maneuver/allocation process.

CSSTSS, The Combat Service Support Training Simulation System provides detailed logistic information for exercising supply, maintenance, transportation, and medical personnel in order to train commanders and their staffs from echelons above corps (EAC) down to battalion level.

Dyna-METRIC, This is a readiness assessment model to support logistics planning

EADSIM, the Extended Air Defense Simulation is a mission level model designed to provide insight into engagement outcomes dependent on Integrated Air Defenses and their associated communication networks.

ESAMS simulates a Surface-to-Air Missile (SAM) engagement against an ingressing aircraft from an enemy SAM system. ESAMS is the most commonly used surface to air missile simulation used in Air Force research and development and acquisition programs. Developed by AFSAA in the late 1970's as TAC Zinger and renamed ESAMS in the early 1980's. ECM functionality was added during in the late 1980's. SA-8 models were verified and validated 1991-1995 by the Naval Air Warfare Center in China Lake.

FASTALS, for Force Analysis Simulation of Theater Administrative and Logistic Support, takes combat workloads (ammunition consumption, system losses, personnel attrition, FEBA movement, etc.) from a campaign level simulation model and determines the support forces required to conduct military operations. Coded in FORTRAN, FASTALS can best be described as a time phased, integerized adaptation of a Leontief input/output formulation (from economics theory).

GDAS, for Global Deployment Analysis System examines intertheater movements of forces, from mobilization station or other initial stationing, across a multimodel network, with intermediate staging, to a theater of operations and tactical assembly areas. Written in C, GDAS, can determine feasible arrival schedules given a force and available strategic lift, or it can be used to determine strategic lift requirements for a force and required arrival schedule.

ISRSIM, the Intelligence, Surveillance and Reconnaissance SIMulator analyzes the performance of Intelligence, Surveillance and Reconnaissance (ISR) systems and the availability, timeliness, and quality of information to the warfighter.

ITEM, Integrated Theater Engagement Model is campaign level simulation model. Support Joint Warfare Analysis, Joint Mission Area (JMA) Assessments, Support Area (SA) Assessments, Major Regional Contingency Scenario applications in Joint Wargames, Cost and Operational Effectiveness Analyses, Studies,Doctrinal Assessments, Strategic Evaluations, Force Mix Comparisons, Resource Allocation Assessment

JECEWSI, Joint Electronic Combat Electronic Warfare Simulation provides automated electronic warfare capability in support of constructive war games and simulations for Service, Multi-Service and Joint Forces training. JECEWSI affects AWSIM aircraft and ground based air defense assets, RESA fixed wing aircraft, and CBS ground-based air defense assets. JECEWSI is an exercise driver designed to focus on the electronic combat environment in support of tactical air and air defense operations.

JTLS, Joint Theater Level Simulation can be used to analyze theater-level operations plans. Designed as operations support and force capability tool for evaluating different mixes of forces or resources; also provides high-resolution play for exercises and seminar wargames. It models land, air and limited naval operations with full intelligence and logistics capabilities.

LCOM, Logistics Composite Model. The LCOM model simulates airbase logistics support operations. The model measures sortie generation capability, aircraft maintenance manpower requirements, and aircraft supportability. LCOM considers the interactions of all support resources (i.e., manpower, spares, support equipment, facilities) and is useful for trade studies and sensitivities of aircraft logistics performance. LCOM provides information on which to base comparisons of sortie generation capability of alternative weapon systems. The model is also useful for manpower determination planning and tradeoffs concerning supportability.

MOBCEM, for Mobilization Capabilities Evaluation Model, examines forces undergoing mobilization at existing facilities to determine shortfalls in capabilities to meet deployment schedules or to determine what schedules are feasible, given mobilization system capabilities. Being written in C++, the model will initially examine Army force mobilization. As planned to be incorporated in the larger OSD system, MOBCEM will eventually include mobilization operations of the sister services.

MTWS, The Marine Air-Ground Task Force (MAGTF) Tactical Warfare Simulation is the approved USMC senior level training simulation. MTWS is capable of air-to-air, air-to-ground, and air-to-ship operations and limited intelligence (air reconnaissance) coordination. MTWS modeling domain includes air, land, limited surface, amphibious, and combat support operations. It covers Marine Expeditionary Force (MEF), Division, Wing, and Force Service Support Group (FSSG) down to company level. MTWS is multi-sided and considers civilian populace and terrorist forces, as well as opposing forces.

NRMO, NPS/RAND Mobility Optimization is the research and evaluation tool for analysis of the airlift system. The model is used to evaluate capabilities and requirements of current and future airlift fleets, infrastructure, and concepts of operations. NRMO uses parameters for aircraft, infrastructure, and routing to determine the optimal number of sorties, aircraft, or routes required to move military units.

PC ARROWS, Personal Computer Aviation Retail Requirements Oriented to Weapon Replaceable Assemblies model provides readiness-based sparing techniques and supply oriented sparing techniques as a means of computing Aviation Consolidated Allowance Lists (AVCALs)

PSM, The Portable Space Model provides a capability to support live and simulated exercises by injecting message sets into operational communications and simulation networks. PSM is a sub-set of the Advanced Real-time Gaming Universal System (ARGUS) used extensively by U.S. Space Command for theater missile defense (TMD) training. PSM is truly portable has it has a stand-alone capability to support exercises without the reliance on the larger ARGUS._PSM includes satellite sensors and ground stations, such as the Joint Tactical Air-to-Ground System (JTAGS). PSM uses parametric and probabilistic models based on real operational capabilities. As PSM receives the information of a TMD threat it injects messages in the proper format to operational C4I systems such as the Tactical Information Broadcast Service (TIBS).

RADGUNS is a complete one-on-one Antiaircraft Artillery (AAA) simulation, including weapon system, operators, target model (radar cross section and vulnerable areas), flight paths, environment (clutter and multipath), electronic countermeasures, and end-game.

RESA, Research, Evaluation, and Systems Analysis provides a computer-based simulation of the naval warfare environment and is capable of supporting a wide variety of research and development efforts, as well as training for senior officers. RESA simulates two-sided (Blue Vs Orange) scenarios in which players may control forces ranging in size from one or more battle groups and associated aircraft, down to a single air, sub-surface, or surface unit.

SOMFOR, Weapon Systems Mix Model is used for to determine the optimal mix of weapons to be acquired by Department of Navy

SPAM, Sensor Platform Allocation Model is a force structure analysis tool that operates at a highly aggregated level of modeling. It is a mathematical programming model (mixed integer program [MIP]). One of several objectives determine "optimality": maximum coverage, maximum value of information, and minimum cost.

STRATC2AM is used to analyze the effectiveness of military C4I systems. It is data base driven, event-scheduled, stochastic computer simulation of C4I network performance. The scenarios can range from ambient to jammed to (optionally) nuclear stressed cases.

SUPPRESSOR is a player-oriented, event-stepped simulation system for modeling multiple-sided conflicts involving air, ground, naval, and/or space-bases forces. It simulates players interacting with other players. Extensive use and configuration control have allowed it to mature into a reliable model.

SWEG, Simulated Warfare Environment Generator is a distributed interactive system (DIS) capable, event-stepped, object-oriented, general purpose conflict simulation. SWEG can participate in a network with other simulations, simulators, hardware, and man-in-the loop systems, or run in a stand-alone constructive manner.

TACSIM, The Tactical Simulation provides an interactive computer-based simulation to support intelligence training from military intelligence brigade through Echelons Above Corps (EAC). It uses the TACSIM ALSP Translator (TAT) to allow a functional interface for coordinated air reconnaissance from RESA, AWSIM, and MTWS; and ghosting of Naval and marine ships and boats. TACSIM models the tasking, collection, and reporting function of selected U.S. reconnaissance assets. It contains Army and Air Force validated models of selected collection assets. TACSIM only supports friendly collection on opposing forces units.

TACWAR is a theater level combat model that examines the interaction of strategic and tactical forcesin a conventional, nuclear, and/or chemical environment. It is intended to model the forces involved in a conflict at the brigade/regimental level or higher. Lower level units can be modeled but should not be mixed in with the standard level units in order to maintain the theater level perspective. The application of the model in scenarios with the standard force at lower levels (battalion or company) has not yet been determined. The model allows an analytical group to examine alternative courses of action considered in the development of operational warplans, and support an operational command group in the conduct of exercises or prosecution of real world contingencies.

THUNDER is a force on force level model which determines the effects of changes in force effectiveness, force structure and force deployment on a military campaign. THUNDER is a two-sided, theater level simulation with a comprehensive blue/red air, land and naval system representation and joint interaction of those systems with one another and their environment. The Campaign Analysis Branch of Air Force Studies and Analyses Agency developed the model . It provides insight into the full range of potential outcomes of a military campaign. THUNDER's ground war combat results were derived from deterministic play of US Army Concepts and Analysis Agency. THUNDER is a data driven model. Scenarios, force structure, terrain, and weapon systems are described in input data. Emphasis is placed on traceability of data back to intelligence/service documents or lower level model outcomes. THUNDER is a stochastic model which supports Monte Carlo simulation and statistical inference.

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Upon his graduation from the Academy, he was assigned to the 2nd Main Jet Base, Izmir Turkey where he began pilot training. In 1995, he earned his jet pilot license and was recognized as the outstanding graduate in his class. His second assignment was to the 3rd Main Jet Base in Konya to complete F-5A/B Combat Readiness Training. His subsequent assignment was to the 4th Main Jet Base in Ankara, Turkey to take F-16 Basic training course. In April 1996, he entered the School of Engineering, Air Force Institute of Technology.

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13. ABSTRACT *(Maximum 200 words)*

This study develops a framework for the design of a Joint Simulation, Analysis, and Wargaming Center (JSAWC). JSAWC is proposed as the primary decision support center for the Turkish General Staff. The complexity of warfare systems and the fog of future wars make military planning, problem solving, and decision making processes difficult to accomplish without using computerized analysis support tools. The proposed JSAWC will use modeling and simulation technology to provide analytical support for Turkish military decision-makers and planners in operations planning, force structuring, and training. An iterative systems engineering process is defined and applied to the primary design of the center. After providing a background on modeling and simulation, basic functions of the Turkish Defense System are analyzed to identify appropriate missions, users, and environment of the JSAWC. General needs, constraints, and alterables of the project are identified. Functional objectives and performance objectives of the center are examined by detailing them to the lowest possible level and connecting them with the related system behaviors. A preliminary requirement analysis is completed for the software and personnel areas based on the design objectives and necessary functions. Finally, future study plans are developed to continue the design of the center.

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