# Analytical Support Capabilities of Turkish General Staff Scientific Decision Support Centre (SDSC) to Defence Transformation

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## 1. INTRODUCTION

Future military force structure will be the result of present decisions based ultimately on judgments about the size and character of the threat and on the resources available to develop and maintain forces. The expected size and type of the threat, the desired rate at which forces should be committed, the length of time they should be sustained, the autonomy desired for the forces and the expected performance of weapons compared to those of potential adversaries are major force-structure judgments.

The assessed size and type of threat clearly affects the desired overall size of forces. The desired rate of force commitment determines the readiness of the force, which refers to the level of training, the peacetime operational and maintenance tempo, the required stockpiles of ammunition and spare parts. Autonomy of forces means the degree to which they can operate without foreign forces, weapons, or bases and infrastructure, and the extent to which the Nation will allow itself to use foreign technology.

Quantitative estimates of the combat potential of armed forces have been made since the dawn of history, but they were undertaken with added rigor beginning in the 1960s, using the power of computers and macro modeling. The hopes and optimism of the times were exemplified by the aim of then US Secretary of Defense Robert McNamara to answer the question "How much is enough?" with heavy dependence on analysis. Two problems resulted that endure to the present. The lesser one was that the modeling involved was necessarily macro in scope. Treating this change of scope as the essential difference either battle, wartime or weapon procurement modeling, military operations researchers struggled to add detail to these models. Operations Research (OR) Community built successively more complicated models, traded verisimilitude for opacity, and in the end failed to achieve anything commensurate with the effort. The analytical support capabilities of Turkish Scientific Decision Support Center to Defense Transformation will be determined and some of the current modeling and simulation support will explicitly identified in this paper.

## 2. ORGANIZATION

Turkish Scientific Decision Support Center (SDSC) is directly linked to Deputy Chief of Turkish General Staff. SDSC consists of 40 consultants from various scientific and technology areas. The percentage of people with OR and Modeling and Simulation (M&S) background approximately % 75 percent of the

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total. The current manpower is about 25. One-star general manages the SDSC. There is one technical deputy chief called Projects General Coordinator in the organization. The SDSC has three analyses, one technology monitoring and assessment and one modeling and simulation coordination team. Analysis teams are focused on Force Structure, Logistics and General Areas.

## 3. MISSIONS AND FUNCTIONS

SDCS basically provide consultancy on science and technology not only for Deputy Chief of General Staff but also for all Turkish General Staff Headquarters (TGS HQs). We conduct research and analysis on joint issues demanded by other departments in TGS. The services have similar structure but not as big as TGS in their organization. Because of this reason the analysis on force related issues are covered by Scientific Decision Support Units of services.

One of the team in SDSC monitors and assesses the impact of developments in science and technology and directs research and development projects accordingly. They also give very valuable information to other teams during the analysis. SDSC establishes principles of M&S development activities and coordinates the realization of M&S related projects.

The main functions of SDSC are analysis, modeling and simulation, research and development and science and technology monitoring and assessment. The areas of interest of SDSC are Human Resource Management, Intelligence Management, National Policy Analysis, Force Structure Analysis, Joined and Combat C4SIR, Logistic and Logistic Support Analysis and Cost Effectiveness Analysis. The teams work under the matrix organization. The mixed study groups are formed within the SDSC with respect to the analysis requirement.

## 4. ANALYTICAL CAPABILITIES

The analytical capabilities of SDSC are classified in four different levels. These levels are engineering, engagement, mission/battle and theater campaign. In engineering level, the models are to design, cost and manufacturing supportability of system. Engagement level models drive the effectiveness of the system at system on system level. The engineering models are very detailed models. If you are interested in the effectiveness of force package at force on force level then mission/battle level models are used. The theater level campaign models estimate the outcome of combined forces at highest level of conflict.

Turkish Armed Forces-TAF believes that to decrease military expenditure and use of existing budget more effectively will be possible with the use of synthetic environment, while providing defense requirements so TAF begins to use and develop analytical model and simulation systems at 1970s. By now, with the requirements due to the changes in operational environment and the joint studies executing under the scope of NATO, the usage of modeling and simulation has become widespread and the requirements in this concept has increased.

At the beginning modeling and simulation systems needed in education, planning/analysis, operation support and engineering/research and development are obtained from NATO, and the lack of systems which meets different national requirements, has made nationally self-containment a must. TASCFORM, SPASM, JTLS, TAMARI, CAPS, EADSIM and ACROSS are the models obtained from NATO. Prioritization models such as LISTSEL, BESTSEL etc. optimization models such as DPM, UHAM etc. and multi criteria models such as ECEAM, TCEAM etc. are examples for the models developed by SDSC. Some of the analysis with these models will be explained in this paper.

# 5. MODELING AND SIMULATION

Especially beginning from 1990's, with the Research and Development studies depending on the organization and academic cooperation, TAF, has established organizations in order to widespread modeling and simulation, and started using M&S systems, especially in educational activities, as part of infrastructure activities. At the moment, by scientific decision support units organized in service command constitutions; the usage of modeling and simulation in analysis, planning, operation support and research-development/engineering fields has been provided and also by war game centers at TAF; the usage of M&S systems in education fields have been become widespread. For the activities reminded above; academic collaboration has been established with research and application centers in two different universities, and besides other public and private enterprises, international collaboration studies has been attended under the scope of NATO and computer aided exercises have been hosted.

TAF determined the vision and the mission about the modeling and simulation studies by announcing TAF Modeling and Simulation Vision and Master Plan Document, which is a product of 5-years work, in December 2003. The Vision is defined as, uses of the M&S systems widely, developed according to 21st Century technologies and standards, own necessary management method and organization and also support TAF for fulfilling tasks effectively, productively and economically.

According to underlying vision, M&S mission is

a) With the help of ready to use, operationally acceptable, integrated with C4ISR systems, aggregated and/or high resolution and joint operation based analytic models, constructive, virtual and real simulations:

   - Analyze the complex military problems that cannot be solved by appreciation of the situation and headquarters studies by national M&S systems.
   - Improve the decision-making ability of the TAF stuff related to training, education and exercise function, economically.
   - Create the synthetic environments and/or virtual prototypes that TAF will need and that will be used during the process of concept development, analysis of technologies, which are related with the weapon systems, equipment and materials technologies at the research-development-engineering process.

b) And also mission defines principles and methods related with M&S organization, management, training, education, development and usage of national models.

Departments, which follow, coordinate and execute the activities to reach the goals determined in "TAF M&S Vision and Master Plan Document", have been organized first at the General Staff Headquarters and at the Service Commands at M&S function areas. Scientific Decision Support Departments are responsible for this issue. They follow and execute development of M&S infrastructure and also provide the wide spreading of getting benefits of M&S ability and skills. The general coordinator of the whole M&S activities is Scientific Decision Support Center (SDSC) Division that is a department of General Staff Headquarter.

TAF has active participation to the activities of NATO Simulation Analysis and Studies Panel and NATO Modeling and Simulation Group in order to follow the developments in M&S area and also to share its knowledge. TAF considers, establishing collaboration with the universities for developing national M&S systems and technologies through basic and applied researches, important. METU-TAF Modeling and Simulation Research and Application Center (MODSIMMER) at The Middle East Technical University (METU), and ITU-TAF Modeling and Simulation Lab (MODSIMLAB) at Istanbul Technical University (ITU) are the examples of collaboration between TAF and universities. By means of this research center and the laboratory, relationship of academic knowledge with the activities of public / private enterprises serving defense industries is provided and so that the theoretical and prototype studies can be transferred to the application area.

In order to meet the requirement of the educated personal in the area of modeling and simulation, TAF, benefits from national and international universities. A master program, just on M&S area, has started its education at METU in 1999. Foreign students are also accepted to this program. More than 50 students who have graduated from this program by now, they have chance to implement their theoretical knowledge at MODSIMMER.

# 6. TECHNOLOGY MONITORING AND ASSESSMENT

The recent developments in science and technology are monitored by SDSC. Technology forecasting is one of the main issues in technology monitoring and assessment. Technology forecasting is very important to capture the developments in science and technology and carry this information to R&D projects and the analysis of modernization projects. The R&D studies related to defense industry must be managed with respect to technology developments.

SDSC is working with very close coordination to Operations and General Plans and Policy Divisions. The results of technology monitoring and assessment studies are gathered with medium and long-term capabilities with a systematic approach. By mapping defense system requirements and technology, SDSC determines technology priorities for the future developments.

# 7. CAPABILITY BASED PLANNING

SDSC is playing a very important role in Turkey's Defense Planning. Our defense planning is focusing on capability based planning. SDSC is giving scientific and analytical support to the HQs to define capability deficiencies during the strategy planning. Qualitative and quantitative techniques are used in the analysis. Taking account Joint Operation Concept and Combat Readiness Assessment design concept development and experimentation studies. SDSC also supports these studies by providing virtual modeling and simulation environment and scenario design to concept developers.

SDSC has an important role to provide inputs from Strategy Planning to Planning cycle of the Defense Planning. These inputs are scenarios, strategic and operational required capabilities, newly developed concepts, scenario mission functional capabilities. The members of SDSC participate in Capability Working Groups (CWG) and conduct qualitative and quantitative capability system analysis. Capability Working Groups produce documents named Capability Definition Document (CDD). SDSC conducts capability pre-screening analysis by taking Capability Definition Documents into account. These analyses provide analytical support to develop Capability Requirement Plan (CRP). The members of SDSC also work as member of Capability Requirement Committee (CRC).

SDSC conducts system analysis in terms of capabilities after Capability Requirement Plan is developed. These analyses help to the owner of requirement to develop the first version of Project Definition Document (PDD). Analyses of system alternatives are conducted after all PDDs are developed. The results from these analyses provide more information on the proposed project and then the second version of PDDs is developed. The second version basically covers the result of cost effectiveness analysis of each alternative. Planning Investigation Committee reviews the second version of PTDs and develops Strategic Goal Plan (SGP).

SDSC close coordination with National Defense Ministry conduct analysis on industrialization, budget and acquisition management. These analysis develop the third version of PDDs. This version includes estimated budget of the project and details related to acquisition management. Programming Investigation Committee (PRIC) reviews these final versions. PRIC develops Ten Years Acquisition Program (TAP) by taking constraints with budget and acquisition management.

# 8. ANALYTICAL SUPPORT TO CAPABILITY BASED PLANNING

SDSC uses three different types of modeling and simulation tools. Some of them are NATO models. SDSC generally develops models itself and some time makes the university and industry develop model by means of the modeling and simulation in its organizations. In this paper the brief information on some of the models developed by SDSC and some of the models developed by universities and industry will be discussed in detail.

*Weapon and Ammunition Planning Decision Support Tool for Tactical Level Land Combat (WAPMOS)* is one of the modeling and simulation tool developed by Modeling and Simulation Center (MSC) of Turkish Armed Forces established in Middle East Technical University's Campus. The main objective of WAPMOS is to develop a decision support system for weapon and ammunition planning at tactical level land combat.

WAPMOS is a semi-dynamic approach to land combat modeling and ammunition planning at tactical level. WAPMOS decomposes a battle between heterogeneous forces into stages and mini battles. For each mini battle in a stage, we use three modules: mathematical programming models for optimizing force allocations and ammunition planning; a simulation module including deterministic Lanchester, discrete time stochastic and Monte Carlo tools for predicting whether or not the stage targets are reached under the allocations and for calculating ammunition expenditures; and a module for weapon cost/effectiveness update from one stage to the next.

These modules interact with each other within the framework of a decision support system to help the user with allocation decisions as well as prediction of force/ammunition requirements to win the battle. The system permits the decision maker to create and analyze various scenarios. By modeling such scenarios, it would be possible for the decision maker to see allocation possibilities, to predict force, weapon system and ammunition requirements, and to conduct sensitivity analyses for parameters such as weapon cost/effectiveness indices and attrition coefficients. The developed decision support system could as well be used as a training tool besides an analysis tool, for planning tactical level land combat and ammunition planning. The system runs on PC in Windows environment. However, the C programs and the database are transportable to other platforms.

*Sensor Simulation Model (SENSIM)* is a sensor simulation and optimization model to find out cost-effective sensor coverage by taking different sensor systems (day camera, thermal camera, radar etc.) in to account. SENSIM is developed to analyze surveillance of large terrains using limited sensor capabilities in a cost-effective manner. There are three types of optimization in SENSIM. They are location optimization, cost optimization and effectiveness optimization. The location optimization is trying to optimize the number of location for surveillance for a given number of sensors and area. The cost optimization is trying to minimize cost of sensors to be used in surveillance for a given level of effectiveness and for a given area. The effectiveness optimization is trying to maximize effectiveness of sensors to be used in surveillance for a given budget and for a given area. The real word is represented as virtual environment in SENSIM. The threat, platform and sensor parameters are input to the model as scenarios.

*Utility Helicopter Analysis Model (UHAM)* is a discrete optimization model to define the number of helicopters needed for the accomplishment of a given task. The model also provides opportunity to analyze different types of objectives. The model may minimize the number of helicopters for a given scenario or time to accomplish the task with a given number of helicopters. UHAM considers unit size, completion time, size of wave, time between waves, helicopter fleet, capacity for carrying, flight time, capacity of landing and loading point, time of embarkation and debarkation. UHAM provides the type and number of helicopters; time scheduling for operation planning and the quantity of load and personnel carried per wave. The user may have a chance to conduct trade-off analysis between the execution time to accomplish the mission and the number of helicopters used.

*Helicopter Mission Planning Model (HELOMIP)* is a Mixed Integer Programming (MIP) model is developed to determine the optimum routes for helicopters, load/unload quantities, refueling activities and load configurations while carrying out material and human transfer between locations. This model is one of the studies that Turkey leads in Studies Analysis and Simulation (SAS) Panel of Research Technology Organization. When HELOMIP developed it was considered to cover both NATO and national requirements.

The principal inputs of HELOMIP are requirement information of demand locations, supply information of operation bases, availability, and capacities of helicopters. In detail, the demand amount for each type of material and human evacuation requirement for each demand location is declared by demand locations, while the supply amount for each type of material, human, medical service availability, and refueling availability are also known. The other group of inputs is related to the parameters of the helicopter. Human and material cargo capacities and human evacuation capabilities for each type of helicopter must be provided. In order to organize the routing, the distances between locations, initial locations of the helicopters, and fuel tank capacities of the helicopters are needed. In order to take into account time-related constraints, speed, load, and unload times of cargo, fuel consumption and maximum flight duration of helicopters must be provided. Since the assignments of pilots to helicopters are considered in the problem, the initial locations of pilots and maximum flight duration for each pilot should be given. NARAT is a standardized format to be used by national military airlift authorities to request airlift assistance from other NATO countries when national airlift resources are not available or sufficient. For these purposes HELOMIP receives some of input data directly from NARAT.

The model is developed to provide the optimum solutions for routes of helicopters, material – human load and unload quantities, refueling locations and amounts, bin packing of helicopters at each flight leg. The HELOMIP optimization model takes routes of helicopters, helicopter capacities, material and human force transformation, human evacuation, fueling and flight durations into account as constraints.

*Search and Rescue Helicopter Acquisition Analysis Model (SARHAAM)* is developed to determine the quantity of air vehicles for search and rescue operations both peace and battle time. It is an optimization model to estimate the number of SAR helicopter needed for SAR operations in a given SAR area. The information such as helicopter type, helicopter quantity and specifications etc. is needed as input. The locations of helicopters are known. The SARHAAM is trying to optimize air vehicles by taking operational requirement for minimum average reaction time into account as constraint.

SARHAAM provides possible deployment points, number of helicopters in each point, coverage percentage, average reaction times from the first and second closest point, helicopters in pool to satisfy requested criteria information after the scenario analysis.

*Smaller Scale Contingencies Modeling and Simulation System (S2CMO*S) has been developed to simulate small size contingency operations on 3D terrain at Modeling and Simulation Center of Middle East Technical University supported by Turkish Armed Forces. A soldier or a group of soldiers is modeled as a semi-automated agent who is able to perceive the environment partially through its sensors (eye, electro-optic devices, etc) and make decision to do what next considering its mission and observed situation, and perform its action (dash, open fire, communicate, etc).

There are two sides in the simulation, a troop to attack a facility defended by an opponent troop. Activities of agents are simulated in real 3D terrain data (elevation and raster data) enhanced with whether conditions. For both sides, multi-agent plans are entered using a user-friendly interface with 2D/3D visualization support. In the plan, the user specifies tasks, groups assigned to these task and conditions (situations) to signal a transition from a task to another. Agents are treated as semi-autonomous as they have to follow, in appropriate order, their own tasks dictated by the multi-agent plan. Agents are autonomous in performing a single task. Agents' decision making is modeled by using Behavior Transition Diagrams (BTN). BTNs can be nested to produce a layered decision making which is highly modular and open to development.

The simulation system is to be used in two modes: analysis and training. In the first mode, it helps a commander to prepare, test, and analyze a tactic letting him develop new tactical concepts. In the second mode, leader at different command levels can interact through an intelligent interface (with 2D/3D visualization abilities) to issue orders and react to emerging situations due to the injection of unexpected events by the simulation manager, who are expected to be trainer.

*Training and Exercises Cost Effectiveness Analysis Models (TECAM&ECEAM)* are developed mainly for planning purposes. Armed Forces need better-trained personnel but almost there is limited budget for every organization. TECAM & EMAM are evaluating and estimating effectiveness and cost of training and exercises. The results form the models provide users to conduct cost effectiveness analysis to have cost-effective training and exercises in Training and Exercises Program. One of the other purposes for these models is to analyze cost and budget structure of the military education and training system.

The activity based costing is used as costing methodology in these models. This methodology tries to estimate cost of activities and resources need for a specific product. It is very useful methodology for planning purposes. It is different from classical approach. This methodology helps user to find savings in budgets. Activity Based Costing is highly dependent on data. It is not easy to find appropriate data for costing and also to decompose activities, resources and products in training and exercises.

Multi-criteria Decision Making approach is used to estimate effectiveness. The initial criteria set is developed and inherited to the models. The basic criteria characteristics are modeled. The user may define his or her criteria set from the scratch, weight them and score each training and exercises. The Shapley methodology is used to define criteria weights and to estimate final effectiveness score.

The final model in this paper is *Human Resources Framework Model (HRFRAM).* This is also one of the studies that Turkey is leading in SAS Panel of RTO. HRFRAM describes processes throughout the organization and the roles, the HRM systems and the resources are not considered in this model. HRFRAM is a framework that describes the processes and the relations between processes of an ideal HRM organization.

HRFRAM consists of 6 processes, and the main objective of the model is at the bottom right corner of the slide as "Right People, in Right Posts, at the Right Time". Among the 6 processes, "Manage Personnel Life-cycle" and "Administer Personnel" processes are Operational Level processes, and "Review and Plan HR Requirements" and "Maintain HR Policies" processes are Strategic Level processes. Although "Managing HRM Processes" and "Develop HRM Strategies and Processes" have both Operational and Strategic Level processes, due to the closeness to each level, "Managing HRM Processes" is considered as an Operational Level, and "Develop HRM Strategies and Processes" is considered as a Strategic Level process. The inner and outer circles in the HRM Framework do not mean that the inner circle is a sub-process of the outer circle, but shows that the outer circle affects (is related to) all inner circle processes.

"Planning Manpower" is one of the basic functions of the whole HR System. Planning manpower consists of "Plan Manpower Structure", "Plan Medium and Long Term Financial Requirements", "Plan HRM Enablers" and "Plan Manpower Requirements". "Plan Manpower Structure" consists of planning the billet and hierarchical structure of the required Total Force of the future. "Planning Medium and Long Term

Financial Requirements" covers estimating the manpower costs of the future and planning budgets due to cost estimates. "Plan HRM Enablers" consists of planning the infrastructure requirements of HRM, such as buildings, computer systems etc. "Plan Manpower Requirements` takes the peacetime / wartime manpower requirements of the future into account and plans the manpower requirements for each occupational group, in other words determines the "spaces".

"Developing Personnel" is the main process in managing personnel life cycle. "Developing Personnel" process covers "Promote Personnel", "Motivate Personnel", "Plan Individuals' Careers", "Plan Duty and Training Assignments", "Educate Train Personnel", "Utilize Personnel", "Appraise Personnel" and "Promote Personnel".

"Motivating Personnel" is another process of the Managing Personnel Life-Cycle. An HRM model should encourage self-development of the personnel, manage the expectations of both personnel and organization, reward and recognize personnel, improve the working conditions, increase personal satisfaction and maintain motivation throughout the service, and counsel personnel by using all means of HRM functions. Personnel motivation should be assessed continuously by using different tools and necessary precautions should be taken if a problem is detected. The core factors for motivating personnel are fairness, transparency and equal opportunity.

## 9. CONCLUSIONS

SDSC is providing unbiased, trusted and innovative decision support to Deputy Chief of TGS and TGS HQs. There is an increasing trend for SDSC in TAF. SDSC is growing in number of scientists. SDSC is planning to be transformed to "Research Analysis & Simulation Center".

SDSC is going on M&S activities based on the Master Plan. The national M&S products as well as known of the shelf are used in support of training and exercise, analysis and planning and simulation based acquisition.

SDSC is making use of capabilities and know-how of Academia and Defense industry. SDSC is ready for international collaboration and to provide its analytical modeling and simulation skills to NATO Defense Transformation.