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MILITARY R&D DECISION SUPPORT SYSTEM: PROJECT OVERVIEW

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Introduction

In 1992 DoD revised the process for development and acquisition of defensive equipment. The purpose of this action was to streamline the acquisition process and ensure development of quality systems to accomplish the required mission. One major aspect of this streamlining process was the enforcement of front-end analyses and reporting of candidate developments. R&D Program Managers would now have to prepare documentation of in-depth system analyses including user and technical requirements, as well as emerging and off-the shelf technologies. The documents that relate this information are the Operational Requirements Document and the Cost and Operational Effectiveness Analysis. These, along with other Program Management documentation must be approved at each Program Review (Milestones).

As an integral part of these analyses, to provide access to user and technical community priorities and to relate these priorities to material test data, a Decision Support System (DSS) was developed. The process employs models based on the principles of operations research and decision analyses, specifically the Analytic Hierarchy Process (AHP), to evaluate candidate technologies.

The final results of the DSS model evaluations is a normalized ranking of candidate configurations' Measure of Effectiveness (MOE) in percent. The DSS models are not presumed to make a final selection of the best candidate configuration, rather they provide decision makers with a validated means to thoroughly analyze the full spectrum of decision criteria, and make the most effective decision possible. Specifically the DSS process provides the means to:

a) Evaluate and prepare standardized definitions for Service requirements.

b) Prioritize and weight the performance characteristics IAW with each Service's requirement documents, mission, and use concept.

c) Evaluate and rank the performance of each candidate relative to each performance element using data obtained via standardized/approved test and analysis methods.

d) Integrate the analyses of multivariate performance measures into a single meaningful overall performance measure.

e) Document and validate the priorities assigned, the rationale used to develop those priorities, the decisions made, and the process used to reach those decisions.

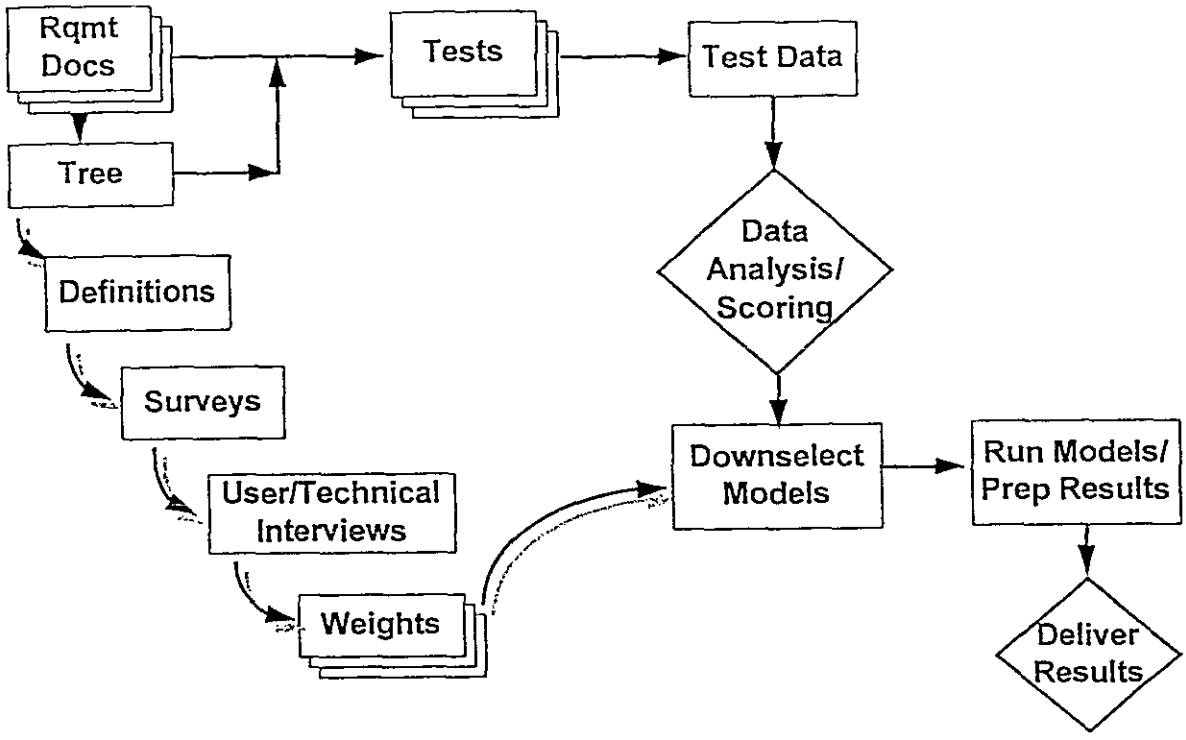


Figure 1. R&D DSS Process Overview

f) Provide a clear, well-defined audit trail for future analyses and documentation of acquisition decisions.

A graphical representation of the DSS process is provided as Figure 1.

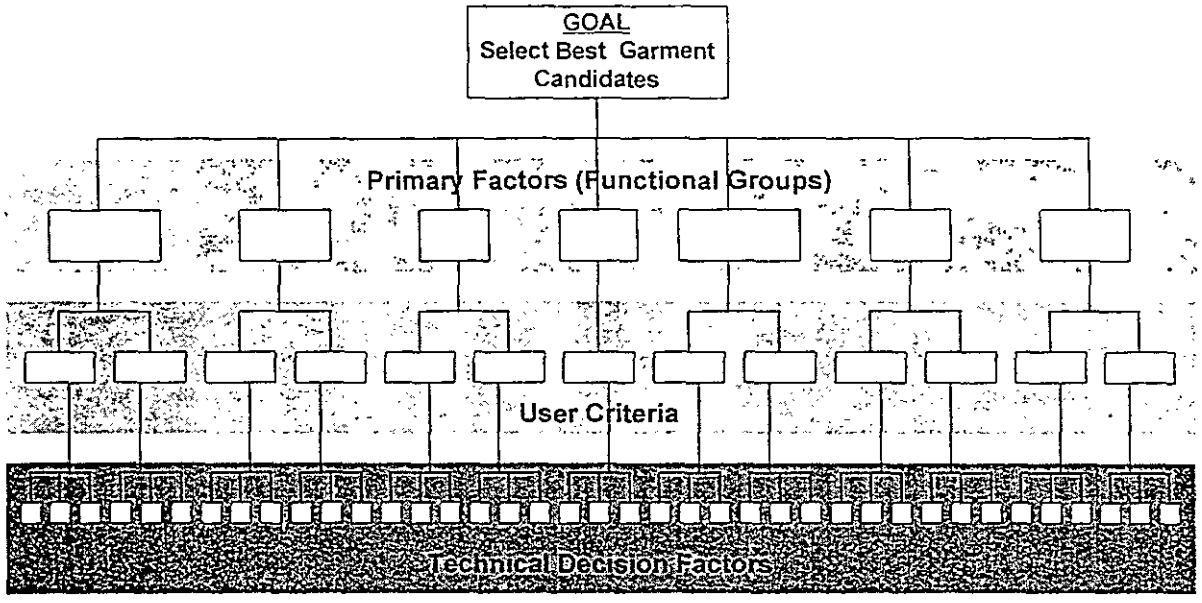
The first step in the development of the DSS was the selection of the Analytic Hierarchy Process (AHP) as the basic analytical modeling tool. An exhaustive literature survey was conducted on available decision support techniques, models and software packages.

DSS Development/Implementation

Hierarchy

In order to apply the AHP to an R&D system analysis, the decision problem must be hierarchically structured with specifically defined decision criteria. To accomplish this an analysis of all pertinent parameters concerning the system requirements must be conducted. Available requirement documents (including all Services if it is a Joint Service development) for the system, as well as previous test and assessment documents must be thoroughly reviewed. A hierarchal decision tree (Figure 2) can then be constructed. This should include all user all parameters found in each of the requirement documents, and should reflect any technical criteria for which the system will be tested. Priorities for criteria (User and technical) are dependant upon Service evaluations of each parameter with respect to the Service specific mission and use concepts. Methodology for Service evaluations is discussed in the following sections.

Figure 2. Sample DSS hierarchy



Criteria Definitions

An important part of the decision hierarchy development is preparing draft definitions for each of the elements in the decision hierarchy. The purpose for developing criteria definitions is to facilitate user and technical representatives' understanding of the decision criteria during the pairwise comparison process, and ensure consistency among the responses. Throughout the survey process definitions may be refined and revised to reflect program specific user requirements, and technical test methods and procedures.

Surveys

Development

Based on the hierarchal decision tree, sets of user and technical surveys are developed based on the pairwise comparison method. The pairwise comparison method uses one-to-one criteria evaluations to weight and normalize each of the elements in a given level of the hierarchy under the same node. The surveys should be distributed to appropriate designated user and technical representatives prior to interview sessions for completion. Respondents are then grouped per requirement document (depending on the nature, Joint or individual Service development) for face-to-face interviews. Each respondent is asked to select a preference from each pairwise comparison, indicate to what degree that selection was preferred, and provide written rationale for that choice.

Administration

Survey respondents are interviewed within their respective Service groups. Interviews are conducted with focus groups of user or technical representatives to review the responses and weight the elements. Respondents should prepare written responses with rationale prior to the interviews. The focus group method was chosen to facilitate review of each individual respondents' answers/rationale, promote group discussion, and arrive at a group consensus for each survey question.

Expert Choice software loaded on a laptop computer is used to automate administration of the surveys. During the interviews respondents are provided with immediate feedback of results and potential inconsistencies among responses. The use of the laptop and software also provides a means to keep a permanent record of responses and results. As a follow-on action to the interviews, respondents may be provided a package of their responses and results for review, reconsideration if necessary, and final approval.

Data Analysis

As a separate perhaps concurrent action to the DSS development, technical tests on candidate systems are conducted. Upon completion of the tests each data source (laboratories/test agencies) structures the data into a usable format for rating the results of each test. For example a "0" to "3" scoring scale for each technical criterion may be used for input into the DSS model. Each scoring function should be tailored to each specific type of technical data, and designed for ease of use, comprehension, and reduction of bias.

DSS Models

The DSS models consist of a combination of the weighting results obtained through the survey interviews, and the raw scores obtained from the data sources. The models then employ a spreadsheet based rating scale method to score the performance of each configuration with respect to each decision criterion. The DSS spreadsheets represent the product of the raw score and the criteria weight for each candidate in each Service model where the columns represent candidates and the rows represent criteria/weights. The final MOE (in %) is arrived at by normalizing the sum total score for each candidate (column total) and multiplying by 100.

The MOE's may then be compared to a control system or some evaluation standard as defined by the Program Management. The results are then presented to the decision authority in graphic format for a final evaluation and decision. Additional analyses such as benefit cost, risk management or optimization may be integrated as required prior to making a final decision.

Effectiveness Analyses (COEA) as required by DoD 5000.2. The system can be easily adapted to relatively large or small development programs in a joint or individual Service arena due to its user friendliness and ability to capture and prioritize the elements of mulitvariate decision.

Conclusion

The DSS developed for the military R&D evaluations provides a means to evaluate a large number of candidates in a user friendly manner. The system, also facilitates incorporation of specific Service priorities for user and technical requirements. Specific advantages and disadvantages of the DSS are as follows:

Advantages:

- Maximize user and technical community coordination
- Structure complex multivariate decision problem.
- Quantify qualitative criteria, and clarify and prioritize requirements.
- Integrate user friendly/graphical software interfaces.
- Provide real time feedback and analysis during interviews and program reviews.
- Minimize potential error and program risk.
- Identify sensitivities among Service requirements and priorities.
- Focus testing objectives.
- Integrate multiple Service requirements and objectives.
- Integrate multiple technologies and manufacturers.
- Provide concise validated set of results for formulation of final decisions.

Disadvantages:

- Requires cooperation and extensive subject knowledge among Service representatives.
- Involves sometimes lengthy interview process.

Recommendation

The DSS is recommended for further analysis of any variety of military R&D development programs. This style of DSS process is highly valuable for any R&D decision analysis in early development, and provides the foundation for Cost and Operational