ANALYSIS BASED MODELING AND SIMULATION IN THE ACQUISITION PROCESS

LCDR Dylan Schmorrow, Office of Naval Research, Arlington, Virginia
Dr. Linda J., Kelsey, *MTS Technologies, Inc.,* Virginia Beach, Virginia

ABSTRACT

Simulation Based Acquisition [SBA] offers increased long-term effectiveness, improves acquisition cycle time, and reduces the total ownership costs [TOC] of new weapons systems.˚ Technological advances allow procurement professionals, using operations analysis linked to modeling and simulation [M&S], to leverage mechanisms successfully deployed in training exercise environments.˚

Office of Naval Research [ONR] has sponsored development of an SBA process, called WARCON (Warfighting Concepts to Future Weapon System Designs), which integrates Operations Analysis, Systems Engineering and Integration and Alternative Engineering Design processes to support the acquisition decision maker.˚ M&S tools are employed to determine operational performance measures and TOC for future systems, and provide trade-off analyses among future design options and concepts for the military acquisition decision maker.˚ WARCON guiding principles ensure that models realistically represent valid doctrine and operations and address the customer s acquisition issues.˚

More than two years of WARCON development has resulted in a mature process that provides the flexibility to be tailored for a particular warfighting application while providing enough structure to be applied across a broad spectrum of platforms, systems, and scenarios.˚ Employing many of the same M&S federates that the Navy Warfare Development Command [NWDC] uses for Fleet Battle Experiments [FBEs] and Joint Forces Command [JFCOM] uses for Joint Experimentation, WARCON has demonstrated that analysis linked to M&S can provide quantifiable Measures of Effectiveness [MOEs] and Measures of Performance [MOPs] to support acquisition decision-making.

ABOUT THE AUTHORS

LCDR Schmorrow is serving in the Information Processing Technology Office at DARPA as a Program Manager. Additionally, he coordinates science and technology programs and actions with the Office of Naval Research and the Defense Modeling and Simulation Office. Responsibilities include the management of supporting technologies for future naval capabilities and the development of M&S policy, initiatives, and guidance that will promote cooperation among DoD components and maximize efficiency and effectiveness. Additional areas of expertise include human-factors, training, decision support, biomedicine, and virtual reality.˚ LCDR Schmorrow received a commission in the U.S. Navy in 1993 and completed naval flight training in April of 1994. Academic training includes study at Western Michigan University and the Naval Postgraduate School. He holds a Ph.D. and four masters degrees.

Dr. Kelsey has almost 30 years experience in performing Research, Operations Research and Operations Analysis.˚ After ten years of college and university teaching and research, she became a U.S. Navy Intelligence Analyst.˚ Dr. Kelsey s talents quickly shifted her focus to military operations and support.˚ After serving as Project Director and Field Representative for the Center for Naval Analyses, where she performed operations analysis for numerous Navy and Joint projects, Dr. Kelsey established and directed business in Norfolk, VA for a Washington-based analysis and war gaming firm.˚ She has spent more than three years performing analysis at-sea in Navy combatants, including a six-month deployment onboard an aircraft carrier in the Mediterranean and Red Seas, while attached to the Battle Group staff.˚ In November 2000, Dr. Kelsey became MTS Technologies, Inc. s Lead Analyst for the Navy s Warfighting Concepts to Future Weapon System Designs [WARCON] Program, where she is responsible for all analysis-related aspects of the Program.˚ Linda Kelsey earned a Ph.D. in Science Education (Physics, Cognitive Psychology, Research Design and Statistics), an M.S. in Astronomy, and a BA in Physics and Astronomy from the University of Iowa.˚

ANALYSIS BASED MODELING AND SIMULATION IN THE ACQUISITION PROCESS

LCDR Dylan Schmorrow, Office of Naval Research, Arlington, Virginia
Dr. Linda J., Kelsey, *MTS Technologies, Inc.,* Virginia Beach, Virginia

SIMULATION-BASED ACQUISITION (SBA)

The end of the Cold War brought decreased military budgets at a time when existing platforms and weapons were reaching the end of their programmed service life. New military missions were defined and new technologies became available to support them, leading to the need for a revolution in military acquisition strategy. The Department of Defense (DoD) searched for new ways to improve the systems acquisition process to meet the emerging need. Research showed that what the nation s military needed most were systems that could be fielded *better, faster,* and *cheaper*.

This philosophy, simplistic in its approach, is rather complex in execution. In its zeal to research, develop, test, and field systems, a program office must establish a balance among better, faster, and cheaper. This balance is often measured in the degree of risk that exists in meeting the established objectives that a proposed system is designed to achieve. These objectives include performance, schedule, and cost. DoD research conducted in the early 1990 s concluded that practices and processes using a Simulation Based Acquisition (SBA) approach increased the likelihood of procuring and producing systems that have better performance, a faster schedule for delivery and fielding, and at a significant cost savings compared to acquisition procedures and practices used during the Cold War.

SBA allows a design team to perform what if analyses on hundreds of designs and provides rapid feedback to the design engineers in charge of system development. In addition, SBA applies Modeling and Simulation (M&S) techniques to the entire product life cycle. As result of Joint Vision 2010, DoD directed that acquisition program managers use a SBA process in all future systems procurement programs. The Defense Modeling and Simulation Office (DMSO) was charged with the responsibility of providing assistance to Program Managers (PMs) in developing models and simulations that support the acquisition process.

In 2000, the Office of Naval Research (ONR) sponsored the development of a process that not only used M&S tools, but also for the first time, linked both the warfighter *and* operations analysis to the acquisition process. The process is known as Warfighting Concepts to Future Weapon System Designs (WARCON). It is one of the first Navy efforts in process development for SBA.

WHAT IS WARCON?

Conceptually, the WARCON process links requirements and capabilities desired by the warfighter with the establishment of Measures of Performance and Effectiveness (MOPs/MOEs) defined by operations analysts for a future system. Models and simulations are then developed based on current system capabilities to support these performance measures, and combined with system cost data, to obtain the rapid feedback required by all SBA approaches.

Why WARCON? A number of other methods exist by which SBA can be accomplished. All have as their foundation the required M&S tools with which to make acquisition decisions, rapidly field new systems and involve the warfighter early in that process. What makes WARCON unique is that it provides a tested methodology for linking operations analysis to the warfighter and the M&S toolset. In addition, the WARCON Process provides the decision-maker with the ability to not only provide a rapid response to acquisition issues, but also a way to link systems and design engineers, often from different and/or competing defense contracting firms, and manage a project in a virtual environment.

For example, during the development of the WARCON Process, a linkage between Northrop-Grumman Newport News, Lockheed-Martin Corp. and ONR was established to improve the outmoded Carrier Weapons Handling System (CWHS) on NIMITZ-Class Aircraft Carriers for the next generation of platform, the CVNX. Use of the WARCON Process will increase long-term effectiveness, decrease acquisition cycle time, and reduce Total Ownership Cost (TOC) of new carrier weapons systems.

WARCON achieves this through co-development of operational concepts and weapons system designs in an end-to-end, strategy-to-task collaboration of warfighters and weapons system designers.

Depending upon the issue under study, the WARCON process can employ a synthetic battlespace with a range of models across a distributed, federated, simulation network, enabling the warfighter to apply technology concepts to anticipated threats. A Collaborative Engineering Enterprise (CEE) permits the engineer to apply design processes that are cognizant of total life cycle costs while satisfying the warfighter's requirements.

The WARCON Process is centered on the establishment of Integrated Process Teams (IPTs) and Virtual Project Management techniques, which allow for the rapid tracking and completion of the WARCON Process for participants in diverse organizations and locations. At a minimum, the IPT structure includes a Management IPT, which consists of senior managers and representatives from the Operations Analysis, Engineering Concepts, and M&S groups. It also includes IPTs that comprise each of those groups individually. Working Group can be established under the IPTs as needed for specific tasks.

HOW DOES WARCON WORK?

Six major steps have been developed and tested for the WARCON process (see Figure 1). A detailed depiction of the generic process has been formulated using the Integration Definition for Function Modeling (IDEF0) format. This process is then tailored for each specific application and depicted in Program-specific IDEF0 diagrams. The six major steps in the process are discussed below.

Project Planning

The WARCON Process begins with the Project Planning Phase, during which the generic WARCON process is tailored by the user to best suit the requirements of the issue under study. The issue or problem is defined, the personnel and tools required are identified, and a Project Management Plan developed. In addition, a review of relevant DoD requirements and policies is conducted and reflected in the management and analysis plans as appropriate.

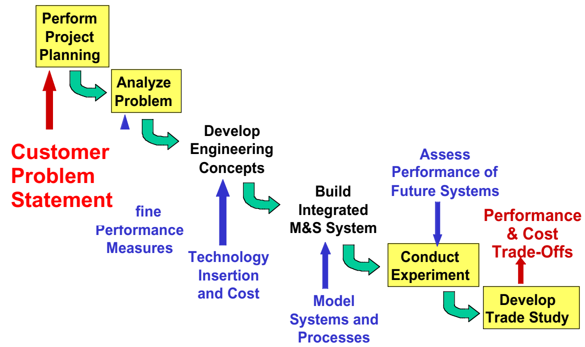

Figure 1. The WARCON Process

Defining the Problem: The first step in developing a WARCON Project Management Plan is to define and refine the warfighter requirements from the Customer Problem Statement (i.e., What question does the customer really want answered?). Questions become more clearly articulated problem statements, the scope is defined, planning assumptions are made and listed, resource costs are examined, and affected functional areas are identified. Often there is only one problem or issue to be studied. However, there are times when a customer has a number of problems or issues related to the acquisition decision. In these cases, a review of the available resources (i.e., personnel, tools, funding) is necessary and those resources balanced against the problems.

Tailoring the WARCON Process: Project Planning is based on the tailored WARCON process. What kinds of factors should be considered in the tailoring process? Clearly the time and resources available for the project are limiting factors. Other factors may include:

- Whether the focus of the problem is related to systems improvements, process improvements, or both
- Availability of knowledge and data on the existing system or process for studying the baseline
- The anticipated availability of existing technologies for system improvements, which will determine if concept development will focus on designing new systems or assessing existing Commercial or Government Off-the-Shelf (COTS/GOTS) technologies

- The anticipated availability of models that can be federated with reasonable changes, or whether extensive new model development will be required
- The anticipated availability of data to support determination of total ownership costs for alternative solutions
- Whether experiments are likely to include participation of warfighters or other users as part of the experiment design
- The anticipated degree to which the customer is expected to be an active participant in the process
- The anticipated relative amount of time and resources required for each of major part of the WARCON process.

Project Management Plan: The product of the Project Planning step, the *Project Management Plan* provides the requisite guidance to the WARCON teams. In addition to a scheduling POA&M, this document, agreed upon by all participants, establishes organizational responsibility, realistic delivery and cost schedules, and the key analysis approach and M&S architecture. It also provides the flexibility to continue to fine-tune the tailored WARCON process.

Problem Analysis

The next step in the process is a detailed analysis of the customer problem. Through the systematic use of operations analysis techniques, the user s problem statement is refined in the context of the current operational and threat environment. The process is not necessarily limited to new systems development. The problem/issue may be resolved through modification of the existing system, providing upgrades, improving processes or changing the projected operational environment. The problem or issue under study normally includes requirements from the warfighter. A Systems Command (e.g. NAVAIR or NAVSEA) may issue the requirement after studying inputs from the various warfare communities or Operational Advisory Groups (OAGs). The WARCON process also provides for additional warfighter input at other points throughout the process.

Operations Analysis provides an assessment of the current operating environment of the operational forces. Changes based upon this dynamic environment can be rapidly inserted into the process thereby reducing development and testing costs. In addition, because the WARCON Process can link competing technologies, it can identify the most cost-effective system that meets and/or exceeds established operational performance requirements.

Defining M&S Functional Requirements: When presented an acquisition decision for a system that is open to a technical solution, analysts and systems engineers must initially study the problem to determine if an appropriate M&S environment already exists or if appropriate M&S tools could be designed. The WARCON Systems Engineer selects or builds models based on the M&S system functional requirements defined by the Analysis Group. This is a critical aspect of the WARCON process.

M&S functional requirements are initially based solely on the Customer Problem Statement and detailed problem definition, unconstrained by M&S availability or future system design limitations. They include M&S capabilities needed to address all aspects of the customer problem. Functional requirements may include detailed warfare process models, future aircraft or ship technical characteristics, subject system engineering data, or detailed scenario and virtual warfare concepts and operations simulations.

Meeting all of these M&S functional requirements, however, may not be possible within available WARCON project resources. In addition, some of the technical M&S requirements may be unavailable or pose significant risk to project completion. The *Problem Definition, Scenario, and M&S Systems Requirements* document lays out the unconstrained requirements for assessment by systems engineers and concept development engineers for feasibility within project constraints. These constraints must be factored into the M&S system functional requirements before the Experiment and Trade Study Plans can be drafted. Soliciting inputs from Subject Matter Experts (SMEs) provides another method of determining weapons system functional requirements.

Defining MOEs and MOPs: Operational Measures of Performance (MOPs) and Measures of Effectiveness (MOEs) are defined based upon the operational objective established by the acquisition PM. Examples of MOEs may include number of bombs on target or strike response time. Examples of MOPs may include speed, payload, range, time on station, or other quantifiable performance features. MOPs and

MOEs are used to identify data extraction and collection requirements in the *Draft Experiment Plan*, which drives Engineering Concept and M&S system development. The focus of the *Experiment Plan* is on measuring performance of future system alternatives. In addition, the *Experiment Plan* identifies resources, objectives, analysis methods and input data requirements.

The objective of the WARCON Trade Study is to identify and provide quantitative data to compare desirable and practical alternatives among process or system alternatives. Technical objectives, design, program schedule, functional and performance requirements, and life cycle costs are identified in the *Trade Study Plan.* The Trade Study will support comparison of alternative design options through a visual depiction of relevant operational performance and cost metrics in a top-level format that can be decomposed to show underlying detail. The visual depictions represent the trade space region (shown in Figure 2) with the objective and threshold or baseline requirement values for the various MOPs and MOEs.

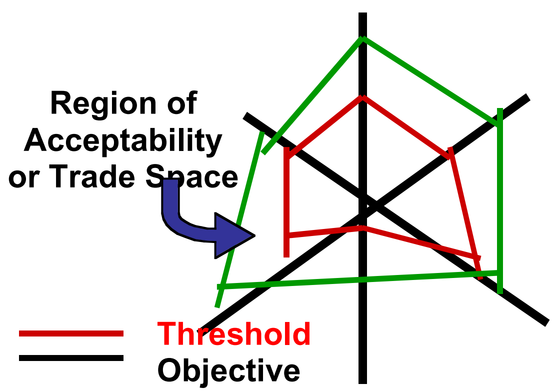

Figure 2. Trade Space Concept

The *Trade Study Plan* summarizes project data requirements, with a focus on TOC data, and presents methods for producing the performance-cost trade-off analyses for each subject system improvement option assessed using the Integrated M&S System. The *Trade Study Plan* also identifies cost metrics and sources of cost data. After the customer completes the review of the drafts, the Analysis Group can promulgate the final *Experiment Plan* and *Trade Study Plan*.

Engineering Concept Development

The Concept Development Engineers use the *Experiment Plan* to proceed in the initial development of alternatives for a new or improved weapons system or subsystem. The engineers build models to assist in designing the system to allow options for different system concepts or changes to the system design to be made rapidly and at a reduced cost.

Using the *Project Management Plan* and the resources available to the design activity, Engineers develop a body of coherent and complimentary system requirements. These engineering-level functional requirements are then transitioned into physical requirements for the designs that can be used to produce material entities that can be priced. Engineering-level models are used to provide estimates for both material and non-material costs.

Determining the Capabilities Gap: The problem operationally defined by the Analysis Group is analyzed in engineering terms. This redefinition involves establishing engineering capabilities of the baseline system; positing an ideal or objective system (as discussed in the previous chapter) that serves as a goal to achieve; quantifying the difference between the baseline capabilities and objective (called the capability gap); and finally, deriving a set of quantified engineering level requirements to meet ideal or objective system capabilities.

The Desired Functional Capabilities delineates the functional capabilities that the engineers must address. Differences between baseline capabilities and the desired functional characteristics of the objective system can now be determined using quantitative metrics. Desired values of the metrics are compared to baseline quantities (using ratios) to establish quantitative criteria for concept acceptability. The documentation for this effort is provided by a *Gap Measures* Report.

Identifying and Selecting Potential Innovation Concepts: Conflicts between current and objective capabilities are resolved by making associations with alternative solutions. Before this can take place, technology information is mined from industry and DoD sources, and deposited into a Research and Development (R&D) roadmap for the project. Candidate technologies in the R&D Database pose as potential solutions for meeting engineering requirements for the future improved system. Technologies are coupled to requirements in a Technologies-to-Requirements Matrix colloquially known as the Concept Box . Candidate technologies that fulfill a requirement are so marked in the matrix.

It is desirable to conceive of at least three Concept System alternatives to support later decision-making. Defining these alternatives presents options involving greater and lesser variants about the foci concept. A Parameter Design phase is entered after the determination of Concept System s architecture in which system variables are balanced with one another to achieve a best solution. Parameter design quantifies what the Concept System architecture qualifies.

Developing Engineering Alternative Concepts: Concept System data developed by the engineering effort is brought into a cohesive package for promulgation to M&S and Trade Study functions in the WARCON process. A Concept Engineering Package is developed for each Concept System alternative developed by the engineering effort. This package presents the *Performance Engineering Data for Alternative Designs*. The package consists of:

- A Concept Schematic
- Software design documents (as applicable)
- A Material List
- Final Engineering Process Maps
- A System Description
- A Concept System Specification
- The concept s prospects for realization.

Part of the Engineering Concept Development process is assessing total ownership costs for each alternative system design. TOC includes acquisition costs, Operation and Support (O&S) costs for the life of the system and disposal costs at the end of the system s lifetime. O&S costs include operations, maintenance and other direct system support, and labor or manpower costs.

Building the Integrated M&S Environment

The alternative designs and associated technical data also are given to the M&S IPT for incorporation into the simulated operational environment. Key outputs for this part of the process are operational performance measures for each scenario and combination of platforms, weapons and systems defined in the *Experiment Plan*. In addition, an output of this part of the process is a *Verification and Validation (V&V) Report*, which verifies that the models developed during this phase of the process accurately represent system performance and warfare operations for the selected operational environments.

Using an Integrated M&S Environment for assessing performance of alternate system designs is an essential element of the WARCON process. Building an M&S Environment includes planning, designing, implementing and testing the federation of models and simulations to meet the requirements established in the *Experiment Plan*.

Planning the Modeling and Simulation Environment: The *Experiment Plan* places a number of functional requirements on the M&S environment: experiment objectives, data extraction and collection requirements, scenarios to be developed and examined, and explicit guidelines defining how the experiment will be run. Alternative designs must be modeled and incorporated into the Integrated M&S Environment.

It is likely that available models can satisfy many of these requirements. Still more may be attainable by simple modification of existing codes. Maximizing reuse of existing models is a significant factor is reducing the cost of applying the WARCON process for SBA. The requirements for the integrated system are distilled and codified in a *System Requirements Document* (SRD). This document may include engineering design, software development, warfare operations, and cost models and simulations required for in designing and building the M&S Environment.

Designing the Modeling and Simulation Environment: A *System Sub-System Specification* (SSS) database identifies the specifications and requirements (hardware and software) to design the system as derived from the SRD.

The design information (concept, description and cost) for each alternative subject system is analyzed for acceptability. The model, simulation, or federation of models must meet a set of established standards to be accredited for the intended purpose.

The *System Requirements Specification* is then mapped. The overriding constraint is that the design is derived from real world capabilities, meets all requirements and provides for traceability during system design, implementation and testing.

A *High Level Design* is created. It describes the major components of the M&S environment and how they fit together. A design can afford certain capabilities while curtailing others, so it is important to understand the rough design of the system in order to garner better understanding of what is and is not feasible for the system to simulate. Preliminary HLD information is provided to the Analysis Group during development of the Experiment Plan to ensure experimental data can be generated within resource and technological constraints during the WARCON project timeline.

Further decomposition of the HLD produces the *Detailed Design Document.* This document details what codes need to be written or modified, and how this will be accomplished for the software developers working on the M&S environment.

The *System Test Document* is then created. It has two functions: First, it details how to test the created or modified codes to ensure that they adhere to the detailed design provided. Second, it details testing criteria for the environment as a whole. This part of the testing procedure ensures that the system meets all the requirements listed in the SRD.

Implementing and Testing the Modeling and Simulation Environment: Guided by the Detailed Design document, software engineers produce the vision of the design effort. As with design, there are many styles of implementation, and here the only real constant is that the implementation satisfies the test plan.

Two types of testing take place in this phase: unit testing and system testing. Unit testing consists of ensuring that the design has been properly implemented. Every component that has been created or modified is tested to be sure it does exactly what it is supposed to. If a code performs computations, the computations are verified. For example, if a code is supposed to produce output in a certain manner, the output is scrutinized for formatting errors.

The goal of System Testing is to ensure that the system as a whole is functioning as expected. Systems of codes often have many subtle interactions, and unforeseen side effects may appear when systems are modified. This suite of tests is designed to illuminate any of these unforeseen effects. System testing tests the design for bugs or oversights. A design perfectly implemented does not always achieve what the design intended. The system test will test the M&S environment against the SRD to ensure that the M&S environment performs as required.

After this activity is completed, several key elements are in place: A tested M&S environment that meets WARCON experimentation needs, an M&S Inventory of codes which can be used in future modeling and simulation endeavors, clear instructions on how to use the environment in the proposed experiment, and a *Validation and Verification Report* which lends credence to the M&S environment and any experiments performed within it.

Experimentation

After the Integrated M&S Environment is developed, the WARCON process proceeds to Experimentation. In this phase, outputs of the preceding Phases (i.e.; the *Experiment Plan*, Hypotheses, MOEs/MOPs, and M&S systems) are used to conduct experiments and excursions for the system under study. The warfighter can play a significant role during this part of the process for some customer problems by participating in the experiments by actually using the virtual system under study. The output of this portion of the process is detailed performance data for baseline/ comparison systems and each experiment excursion.

The Experiment Phase can be broken down into a three-step process. First, planning must be done to identify requirements and resources necessary to conduct the experiment. This step is followed by experiment execution. Finally, the data set is reviewed to ensure that sufficient information has been obtained for a Trade Study analysis.

At this point the WARCON Process has produced three key documents that provide the basis on which the experiment is built: *Project Management Plan, Experiment Plan* and *Trade Study Plan*. The experiment is the critical element in the WARCON process because it provides performance data for subject system alternatives for use in the Trade Study.

Experiment Planning: A successful experiment depends upon the orchestration of resources. Resource elements should include event times, people, funds, facilities, hardware, software and connectivity requirements, as well as mission level simulations used for experimentation and analysis. A compilation of this information is used to develop an experiment Concept of Operations (CONOPS) document and Experiment Schedule.

Experiment Execution: Prior to running the experiment, the experiment team (analysts, systems engineers and M&S engineers) conduct a review of the *Experiment Plan* and the CONOPS to ensure that any last-minute scheduling changes or resource limitations have been taken into consideration.

The establishment of an initial reference point is essential in any experiment. Before you know where you are going, you must first know where you are . A baseline experiment run, usually based on current system or process capabilities, is conducted for each set of variables to provide the foundation on which all subsequent excursions are compared. The baseline/comparison case runs take into consideration all the variables that are defined in the *Experiment Plan*. The analysts perform a quick-look data analysis on the baseline/comparison run output data to determine the need for any fine-tuning of input variables or additional excursions. If it is determined that additional testing is necessary which is not in conflict with the *Experiment Plan*, the refined data becomes input data in the next baseline/ comparison case data production run.

Collecting and reviewing the data, and subsequent testing, continues as planned until experiment data requirements have been met for establishing a baseline/comparison case. Excursion case runs of the variables are designed to test the parameters set forth in the *Experiment Plan* and CONOPS.

Quick-look Analysis: Analysts and M&S personnel review the results of all experiment data to determine experiment requirements have been satisfactorily met, or if additional runs are necessary. A quick-look examination of the results of each model run helps to refine input data for the next run. Analysts also check the output data to ensure that the results make sense for each run as it occurs and in the context of other M&S results.

Trade Study Development

Finally, the WARCON Process culminates in developing and publishing a *Trade Study Report* that summarizes project data and presents the results of the cost-performance trade-off analysis for each alternative future weapon system design. The Trade Study gives the acquisition decision-maker an assessment of the TOC of the system and all alternative engineering designs. Where appropriate, the Trade Study can recommend the best alternative system among a group of candidate systems to the decision-maker.

In addition, the Trade Study may recommend that the production or procurement of a candidate system would not be in the best interests of the government based upon a cost-benefit analysis. In other words, the WARCON Process allows the decision-maker to decide not to procure a system or any alternative based on quantitative cost and performance data.

Analysts combine the TOC data matrix with the results of the experiment conducted earlier (performance data for MOPs and MOEs) for the alternative designs submitted for study (Figure 3). Results for each experiment excursion are tabulated and costs compared. For each excursion, warfighter requirements are reviewed once more to ensure that operational requirements match up with each design alternative under study.

PUTTING IT ALL TOGETHER

An example of how the WARCON Process works can be seen in the area of aircraft carrier weapons handling. The current design of that system is based upon the NIMITZ-Class CVN developed in the late 1960 s. The system was designed for standard ballistic ordnance, an air wing consisting of 65 combat aircraft, and an operational requirement to provide continuous flight operations (i.e.; 24-hours per day).

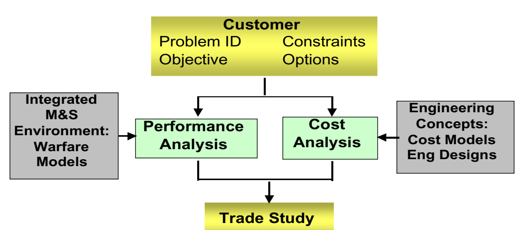

Figure 3. Trade Study Analysis

After introduction to the fleet, the number of combat aircraft aboard the NIMITZ-Class carrier increased to more than 80. This necessitated parking aircraft in areas of the flight deck that covered the weapons elevators, rendering those elevators useless for transporting built weapons to the flight deck for loading on the aircraft. The majority of the ordnance that had to be transferred from the hangar deck to the flight deck had to be moved by using the deck-edge elevators (usually elevator numbers 1 & 2). This process required ordnance movement and aircraft movement to be coordinated between the hangar deck and flight deck.

The current vision for 2010 is an air wing of 50 aircraft armed with Joint-guided (or smart) weapons. Joint weapons are larger than their dumb counterparts. The current weapons elevators are inadequate to meet the high demand of cyclic flight operations using aircraft armed with physically larger, smart Joint weapons.

Using the WARCON Process, we can define the problem in several ways. The first considers the size of the newer joint ordnance (J-Weapons) and adaptations of the weapons magazines. The second considers the number of aircraft available in the 2010 air wing. Lastly, consideration is given to the Projected Operational Environment (POE) and how much ordnance is required to be placed on a target set in a given period of time.

In this case, the recommended IPT structure consisting of Management, Operations Analysis, Engineering Concepts and M&S/Systems Engineering personnel is well-suited to meet the requirements of the study. The design engineers have a number of technologies available for study. In addition, existing flight deck and hangar deck models can be adapted or new ones developed to represent ordnance-handling operations. The Analysis Group defines operational scenarios, collects inputs from the warfighter, and defines weapons handling system performance MOPs and MOEs. Analysts also develop the Experiment and Trade Study Plans.

The Concept Development Engineers survey the available technologies and provide possible alternative concepts. The first is to retain the weapons elevators as currently designed. The second is to make structural adjustments and place the weapons elevators in different parts of the hull to enable their use on the flight deck during flight operations. Data from the resulting concept designs are given to the M&S group for running within the simulated environment. M&S tools are then produced for performing experiments. During this phase, all aspects of the problem are assessed and evaluated. A number of excursions are run and the results produced are used as inputs to the Trade Study.

The Trade Study adds cost data to the alternative system performance data. In our example, it is determined that the baseline system (i.e.; the elevators remain as originally designed) appears the most cost-effective design for the problem. The cost of moving the weapons elevators appears to be prohibitive for the existing ship class. However, the results of the study will be important in the design of weapons elevators aboard a new class of aircraft carrier.

Using the WARCON methodology, the entire end-to-end process for the weapons handling example takes 6 to 9 months to complete, far less than previous design and acquisition decision-making activities.

COLLABORATIVE ENGINEERING ENTERPRISE

A critical part of WARCON is a powerful virtual management tool, the *Collaborative Engineering Enterprise (CEE)*. The WARCON Process is designed to bring together representatives from government and industry to study a system procurement or change issue. The members of a WARCON team often are geographically dispersed and the efforts of the individual Groups (i.e., Operations Analysis, Concept Design & Systems Engineers), although dedicated to a common goal, are wide-ranging. Accordingly, a tool by which the Program Manager can virtually manage the details of the project and allow for collaboration among the different groups is needed. The WARCON Process uses a CEE to accomplish this task.

The strategy for CEE development is to establish a collaboration framework in step with existing and emerging domain-specific resources to support scientific and engineering collaboration between distributed government *and* industry teams. When two or more enterprises form a team to design and build a complex system, one of the first tasks that must be performed is the exchange of information required for design, specification generation, document review, and system performance evaluation.

Complex projects are usually executed by multi-skilled teams, whose members are often made up of personnel from both inside and outside of the organization. Coordinating a complex project across the country or even around the globe is common. The CEE is a system that electronically links government and industry partners who are members of a multi-tiered enterprise. Going far beyond a simple integrated email and web system, a CEE can be used to distribute and manage documentation and data associated with a large scale enterprise, serve as an on-line meeting place for team collaboration and tasking support as well as providing common tools and management support capabilities.

The CEE provides the methodology for virtual project management. A number of participants from various companies outside the government and from various agencies within the government may participate in the WARCON Process. The CEE allows the Program Manager to dynamically manage the program regardless of the manager s physical location. All tools, texts, and data can reside within the CEE and management of the program can be made simpler and more cost effective. The CEE can reduce the requirements for face-to-face meetings, thus reducing expenditure of travel funds, and can render up-to-date information on tasking and project status to all members of the WARCON team.

SUMMARY

The WARCON Process meets and exceeds the requirements of SBA by enabling the decision-maker to render an informed, data-based decision in a short amount of time. The WARCON infrastructure includes established IPTs, M&S tools, operations analysis and design methods and models, which the Program Manager can adapt and tailor for each individual acquisition program. The management of the program and its milestones are under the direct cognizance of the PM and the Management IPT that the PM establishes.

The key advantage of the WARCON Process is the ability to directly include the warfighter and operations analysis results in decisions regarding the system being procured. These results are defensible because they have integrated the three key process components: operations analysis, engineering concept design, and M&S. In this way, the new system will be able to meet projected requirements at the lowest cost instead of being obsolete and cost-prohibitive by the time it is introduced to operational forces.

The WARCON Process is a powerful decision-support tool which provides the methodology for project management, rigorous determination of cost and performance, and rapid response to the inevitable what if questioning inherent in the current procurement environment. In the era of having to buy more systems for less money, managers are being required to justify every decision they make. WARCON is a tool that enables the PM to answer the barrage of questions that come from those who control the money while simultaneously providing the warfighter the most sophisticated systems for use on the battlefield.

Given the current threat environment, rapid fielding of improved systems helps the United States maintain technical superiority over her adversaries.