EXPANDING THE TRADE SPACE: AN ANALYSIS OF REQUIREMENTS TRADEOFFS AFFECTING SYSTEM DESIGN

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The Department of Defense Simulation-Based Acquisition (SBA) initiative focuses on identifying opportunities to improve materiel procurement by using information technologies to increase military utility, decrease life cycle costs, and decrease the time to develop and field the system. Implementing this initiative requires identifying the necessary analysis tools, constructing a collaborative environment, and developing a method to make timely decisions based on the results of the analysis. This paper focuses on the latter two components. In particular, it analyzes the opportunities to implement the SBA initiative during the development and analysis of the system's requirements trade space. We present a methodology for a holistic approach to determining the system's requirements. This methodology seeks to use models and simulations to support decisions that occur throughout the system's life cycle while in the system's concept development phase and then revisit these decisions as the program matures.

The Department of Defense Simulation-Based Acquisition (SBA) initiative focuses on improving the acquisition process through the integrated use of models and simulation. Consequently, acquisition issues concerning interoperability, training, education, research and development, production, testing, operation, and support must be factored into the life cycle development of a system from the origin of its need to its retirement from the force. This requires the acquisition community to establish effective procedures and processes that develop systems that are interoperable with other systems and integrated into our force structures and cultures. This will maximize system capabilities and increasing strategic, operational, and tactical force performance. The research methodology presented in this paper provides a means of integrating modeling and simulations

throughout a system's acquisition life cycle. This follows to the precepts and principles of SBA in the area of trade space analysis.

THE TRADE SPACE

The "trade space" can be defined as the set of program and system parameters, attributes, and characteristics required to satisfy performance standards. Decision makers define and refine the developing system by making tradeoffs with regard to cost, schedule, risk, and performance; all of which fall within the systems trade space. Traditional trade space methodologies often support "stove-piped" programs that conduct multiple distributed but disparate analyses. These trade space studies compare very specific courses of action against specific criteria. They consider other courses of action only if all of the initial ones are infeasible. Thus, the course of action chosen may not necessarily be the optimal solution or even a more robust solution; it is merely the best solution out of the study set.

However, by using models and simulations (M&S) throughout the system's life cycle, particularly within the requirements generation phase, it is possible to expand the number of feasible alternatives within the trade space analysis. In addition, the systems approach to trade space analysis necessitates the integration of study results.

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This methodology is consistent with SBA initiatives, which envision removing stove-pipes and conducting simultaneous, continuous analysis throughout the life cycle of a program. This is vastly different from the sequential trade studies that relied on developing specific courses of action. M&S used early in the acquisition process impose fewer limitations on finding a set of alternatives within the trade space. The result is a more robust solution space for decision makers. This will allow the exploration of "what if" trade-off scenarios to more effectively and efficiently assess mission performance requirements and provide better stewardship of scarce resources.

The following sections of this paper will further clarify the methodology. First, we present a case study of the traditional trade space analysis methodology and then provide a methodology that will support implementing the SBA initiative.

FAMILY OF MEDIUM TACTICAL VEHICLES (FMTV) CASE STUDY ANALYSIS

The following assessment of the FMTV program is not intended as a critique of the program's analysis. Instead, this section is included to provide examples of the types of studies currently used and to contrast them with the proposed methodology using existing M&S tools from the SBA perspective. The *Tactical Wheeled Vehicle Fleet Requirements Study* in (Department of the Army, 1980) and the *REVAL 80* study (Department of the Army, 1984) were not specifically conducted for the FMTV program. More exactly, the studies were used to establish the continued need for a medium weight cargo vehicle fleet.

Photo courtesy of Stewart & Stevenson Services Inc.

The Family of Medium Tactical Vehicles M1090 5.0 Ton Dump

Based on projected wartime payload weights and payload dimensions, these studies determined that the optimum cost-effective mix of the tactical wheeled vehicle fleet was in payload categories of 1.25 ton, 2.5 ton, 5 ton, and 10 ton basic cargo trucks. The *Cost and Effectiveness Analysis* (COEA) studies in 1987 and 1991 justified the FMTV program (Department of the Army, 1987a, 1991a). The COEA study analyzed three courses of action for improving the medium tactical vehicle fleet:

1. Maintain and improve the current 2.5-ton and 5-ton fleet;

2. Switch to a pure 5-ton fleet using current force inventory vehicles; and

3. Develop a 2.5-ton and 5-ton FMTV fleet.

Overall the three studies compared the courses of action with the following operational characteristics criteria: deployability; reliability; availability; maintainability; spare and replacement parts required; trafficability; mobility; agility; fuel economy; and life cycle costs. Although the deployability analysis used an automated air load planning system to determine the number of sorties required to deploy light and heavy divisions with these vehicles, the bulk of the study analysis relied heavily on assumptions. The maintenance analysis estimated that existing technology would yield between 29 and 49 percent improvements. The life cycle cost comparisons, within the three

studies, showed the FMTV life cycle cost was 1 percent lower than the existing force structure due to an assumed 10 percent cost reduction from parts and spares commonality. Likewise, the fuel economy for the FMTV was assumed to be 15 percent better than our current fleet of medium cargo tactical vehicles. Finally, the analysis for trafficability, mobility, and agility, within the three studies, was strictly qualitative in nature.

The decision to produce the FMTV led to subsequent studies that analyzed specific portions of the program. For instance, the U.S. Army Logistics Center conducted the *Family of Medium Tactical Vehicles Maintenance Manpower Analysis* (Department of the Army, 1987b) to identify maintenance manpower savings. They incorporated wartime mission analyses; annual maintenance man-hour estimates; the total fielding quantities; estimated vehicle production rates; mechanic productive hours; and estimated mechanic staffing percentages of the authorized strength.

However, the authors warned that the estimated savings are based on the doctrinal force structure and not on the existing force structure. They also acknowledged that the maintenance manpower required also depends on factors not included in their study such as the vehicle usage rate, the vehicle location, the number of times the unit relocates, and the threat conditions. The *Tactical Wheeled Vehicle Modernization Planning (TWELVE) Study*

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(Department of the Army, 1990), conducted by the U.S. Army Concepts Analysis Agency, focused on the production plan for the tactical wheeled vehicle fleet. Their integer-programming model considered fleet age and technology policies, program resources, purchase lot sizes, and vehicle costs to develop a recommended production and retirement schedule. The authors acknowledge a major limitation that "vehicles treated as mutually substitutable for modeling purposes are not equally capable in real life" (Department of the Army, 1990, p. 6). In other words, they assumed that the M939 and M809 series trucks were equally as capable as the FMTV.

Each of these studies provides useful information. However, they lacked an integrated data and information sharing capacity to update analysis for decision makers over the development of the FMTV program. Consider the potential synergy of coordinating, automating, integrating, and sharing data between these studies over the life cycle of the program. It would be possible to maintain a course of action flexibility, more easily adopt and institute program changes, and quickly address internal and external program issues.

Although we expect our hardware and software requirements to be relatively the same as those for conducting distributed analyses, this coordination is not without cost. The data and expertise required up front to link these analyses may be substantial, but the benefits may well be worth the investment. The first step required to improve the current trade space analysis method is to develop a methodology that is designed to effectively evaluate the requirements trade space of a system. The methodology must flexible but

robust enough to evaluate performance and mission requirements. Through the methodology, system stakeholders will be able to fully realize the requirement trade space interactions and determine the impact of policy decisions on the reliability, maintainability, performance parameters, and life cycle costs of a particular system.

METHODOLOGY

The methodology presented seeks to answer three primary questions:

1. What is in the trade space?

2. How do we characterize (quantify and qualify) the effects of the trade space elements?

3. When and how should we make decisions?

The answers to these questions are gained through the following steps:

• Define the problem, identify stakeholders, and construct the trade space.

• Determine essential trade space interactions.

• Establish consistent decision criteria and metrics for each trade space entity.

• Develop a trade-off methodology, which supports the making of timely trade space decisions.

• Document decisions, the process, and results.

This methodology provides the benefits of maintaining a broad trade space and removing infeasible or less than desirable solutions. It is unencumbered by the current need to immediately develop a course of action pool. But rather it allows for the unfettered analysis of requirements across the system's life cycle functions by developing a solution space via trade space analysis. The program trade space is then used to construct a robust solution set

> "The...assessment of the FMTV program is not intended as a critique of the program's analysis."

that initially meets mission and performance requirements. This is a detailed continuous analysis that requires collaboration among agencies and stakeholders, integration of M&S tools used in the analysis, and product development. The iterative steps are addressed in detail in the following sections, highlighting the benefits and integrative aspect of this methodology.

THE PROBLEM, STAKEHOLDERS, AND TRADE SPACE

The methodology starts by developing the problem statement, conducting a stakeholder analysis, and identifying the potential trade space. For a new system the problem statement would be derived from a revolutionary new concept or technology, mission needs statement, operational requirements document, and stakeholder issues. This study used the problem statement from the 1988 FMTV Joint Service Operational Requirement (JSOR).

This document states that a mission area analysis identified numerous "deficiencies

in strategic and tactical deployability, tactical mobility, ammunition re-supply, general re-supply, medical evacuation, and the ability to support the force" in the current fleet of medium tactical vehicles (Department of the Army, 1988, p. 1). Thus, "a need exists within the U.S. Army (USA), U.S. Marine Corps (USMC), and U.S. Air Force (USAF) for a family of current-technology, medium, tactical, wheeled vehicles in two payload categories, with associated trailers" to meet current and future mission requirements (Department of the Army, 1988, p. 1). The primary purpose of developing the new vehicles was to increase the mission availability of the vehicles while decreasing the platform's life cycle costs. As the FMTV JSOR states,

> The current 2.5 ton fleet is rapidly becoming unsupportable due to age and obsolescence. An inordinate number of man-hours are expended yearly to maintain this fleet in an operable condition. The five-ton fleet has been, and continues to be, markedly short of authorizations and contains many aged, obsolete vehicles (Department of the Army, 1988, p. 2).

Imbedded in the FMTV JSOR are the stakeholder issues. However, these issues and concerns are not easily identified. Thus, they were not appropriately analyzed to determine their true significance to the FMTV program. The analytic, acquisition, and operational communities must recognize that systems interact with many other systems in performing their missions. Consequently, our analysis must be planned and coordinated across functional areas to ensure that a system is integrated within force and operational structures.

The FMTV does not operate independently on the battlefield. It is not the only vehicle or system that can perform this transportation function but rather is part of the family of logistics transportation systems that include other tactical and commercial vehicles, aircraft, watercraft, and trains. The amount of materials transported by the FMTV also depends on the number of logistical requirements generated by all systems in the theater, including those requirements generated by the FMTV. This system-to-system interaction extends to tactical, strategic, and operational transportation requirement demands the FMTV is capable of transporting as well as those it is not capable of carrying.

Another transportation system interaction is FMTV loading and unloading resources. For example, without sufficient loading and unloading resources, the vehicle cannot function at its capacity. A complete and thorough stakeholder analysis provides a means to validate the problem statement and identify the effective need the system must solve within the overall transportation system. Likewise, the stakeholder analysis begins the identification of the important trade space interactions.

The next step in addressing this problem is to identify the trade space. As previously mentioned, this also would be one of the products of the stakeholder analysis. The trade space would further be defined through other exploratory means, such as workshops, M&S, and document reviews. A depiction of the FMTV trade space (Figure 1) was developed by consulting the major program stakeholders and analyzing FMTV program documents

Physical Characteristics	Survivability	Organizational Structure
Weight	Component Failure	Type of Unit
Dimensions	Direct Fire	Mission of Vehicle
Material Components	Indirect Fire	Location of Unit
Ground Clearance	Mines	DAMPL Priority
	High Altitude EMP	Type of Current Vehicles
Subsystems	Electromag Int. (EMI)	Number of Vehicles Assigned
Engine	Vehicle Accident	Number of Soldiers (Crew)
Transmission	Weather Effects	Number of Mechanics
Drive Train		
Suspension	**RAM**	**Costs**
Tires	Reliability	Research and Development
Cooling System	Maintainability	Testing
Electrical System	Durability	Production/Acquisition
	Accessibility	O&S
Transportability	Commonality	Retirement
Cargo Aircraft	Maintenance Facilities	
Helicopter		**Fleet Management**
Rail	**Mission Performance**	Number Produced
Watercraft	Payload	Variants Produced
Airdrop	Towing Capacity	Production Rate
Prep Times	Speed	Production Schedule
	Range	Service Life
Emissions	Loading/Unloading Times	Fleet Average Age
Noise		
Exhaust (EPA)	**Mission Impacts**	**Driver's Training**
Electromagnetic	Transport Requirements	Time
Vertical Absorbed Power	Road Capacity	Facilities
Driver Acceleration	Loading Capacity	Proficiency
Heat	Unloading Capacity	Simulators
	Other Transport Resources	
Mobility		
On/Off Road Capability	**Supportability**	
Grade	Class I	
Side Slope	Class II	
Turning Radius	Class III	
Vertical Step	Class IV	
Fording	Class V	
	Class VI	
	Class VII	
	Class VIII	
	Class IX	
	Class X	

Figure 1. Family of Medium Tactical Vehicles Trade Space

such as the JSOR, the system specification, the test and evaluation master plan, and the integrated logistics support plan. Documents from the Bradley Fighting Vehicle (Department of the Army, 2000) and the Crusader programs were analyzed, as well (Department of the Army, 1999).

The analysis from these disparate programs verified general items contained in a vehicle's trade space and provided insight into the interactions between the FMTV and these programs.

TRADE SPACE INTERACTIONS

Having defined the trade space, it is then important to qualitatively and, if possible, quantitatively describe the interactions between the trade space entities. These interactions highlight stakeholders that are impacted by decisions for each of the trade space entities and identify the critical interactions that will require data collection, modeling, or simulation to understand the relationship. This process can also reduce the problem complexity using known relationships, constraints, and thresholds. To illustrate this concept a simple example is presented that analyzes the width requirements for the FMTV.

The width dimension is a critical variable in determining the transportability of

the vehicle, its cargo capacity, and its side slope operation. However, cargo capacity, transportability, and side slope can be conflicting entities in the FMTV trade space. The transportability of the vehicle will generally improve if we reduce its width. However, a reduction in width reduces the cargo capacity and side slope operation. By examining the interaction between the width of a vehicle and the resources that can transport the vehicle, we can determine the constraints and thresholds associated with this interaction. Simply put, the maximum exterior width possible for each transport system was obtained using the requirements from the *Interface Standard for Transportability Criteria* (Department of Defense, 1998).

Through inspection it was determined that the critical thresholds, the value of a change in the width, are best represented as a step function. These thresholds occur when we gain flexibility by being able to transport the vehicle on a new system. We
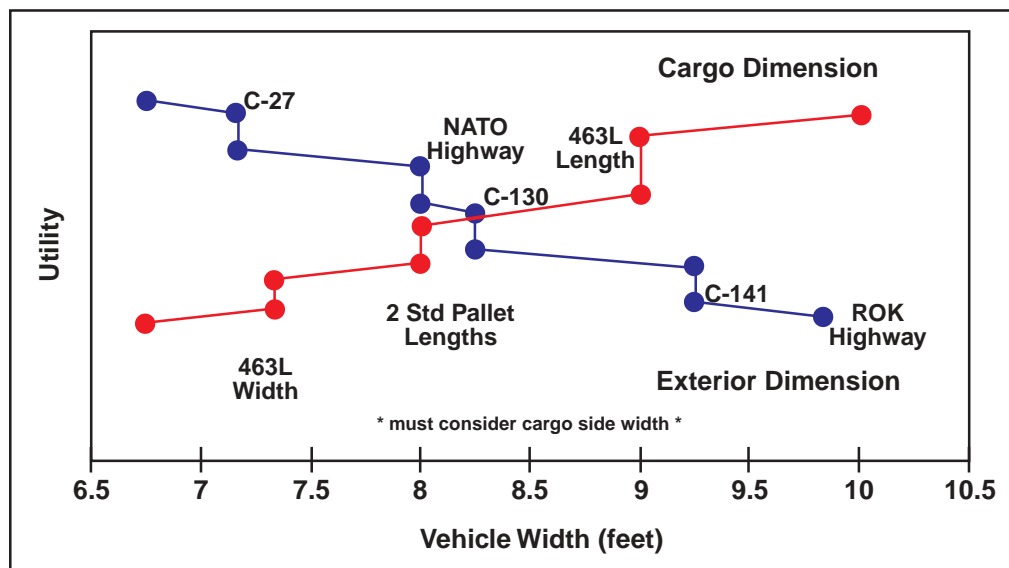

Figure 2. Interaction Analysis: Determining the Vehicle's Width

also expect that between thresholds there is still some value in a decrease in the width of the vehicle. For example, this decrease results in more free space between the vehicle and the side of an aircraft, making it easier and faster to load the vehicle.

Figure 2 presents a description of the transport utility of the FMTV as we change its width. After analyzing this interaction, we then do the same for the other first order interactions. Changing the width proportionally changes the cargo capacity. However, again there are thresholds where the value of the change is a step function. Figure 2 also presents a notional description of this analysis and examples of some potential thresholds. The side slope capability of a vehicle depends not only on its width but also on factors such as its center of gravity. With more technical knowledge of the vehicle, we note a direct relationship between the vehicle's width and its side slope operation. It is important to note that initially these utility functions may only be qualitative descriptors instead of quantitative representations. However, quantitative measures using optimization tools and methods could be employed in this analysis. Also, the results from this early system analysis can be integrated into future requirements analysis, such as COEA, time-phased force deployment, and decision analyses.

DECISION CRITERIA AND METRICS

The analysis plan exists to provide timely information to decision makers in a resource constrained environment. Some decisions will be rather simple and can be made objectively without extensive quantitative analysis. Other decisions may impact many trade space entities and require

extensive M&S. Therefore, consistent and reliable measures and metrics must be established for the FMTV system development. As an example, we determined that the new tactical truck must meet NATO highway standards. Likewise, the FMTV must have the cargo capacity to handle the standard 463L pallet. This pallet is the standard Department of Defense equipment transportation pallet and is an integral part of our cargo-handling system. The new truck must be able to transport these pallets. The NATO highway standards limit the exterior width of the

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vehicle to 96 inches, and the 463L pallet width forces the truck's cargo area width to be at least 88 inches. This leaves 8 inches to optimize the width of the cargo bed while considering whether to use side panels when transporting 463L pallets, and if reducing the exterior width from 96 inches will make air transport loading easier. The 463L pallet decision criteria forces the exclusion of the C-27 as an air transport option. Therefore, we can adjust the utility functions for the vehicle's weight, length, and height to reflect that the C-27 thresholds for these measurements provide no value. This decision greatly affects the trade space analysis and resultant solution set. We could have modeled, simulated, or measured the impact of not meeting NATO highway standards, not being able to transport 463L pallets, and being able to transport this vehicle by a C-27. Instead, we made an objective decision based on general knowledge of

the importance, frequency, and impacts of each of these thresholds.

Another decision criteria and metric interaction takes place among the vehicle's movement terrain classification, the testing plan, and the design priorities. Most of the variants of the FMTV require a classification of tactical standard mobility that estimates the vehicle will operate 20 percent on primary roads, 50 percent on secondary roads, 15 percent on cross-country roads, and 15 percent on trails. Obviously, the profile of the testing plan should be similar, if not identical, to this movement terrain profile. The design priorities should also support this profile. One way to verify the design priorities is to consider the impact of this movement terrain profile from a user's perspective. Given a particular profile, a user wants to be able to complete missions over that profile in the least amount of time possible. The amount of time required to complete a mission can be represented by the following function:

$$Time = \frac{\% \, primary}{speed \, primary} + \frac{\% \, sec.}{speed \, sec.} +$$

$$\frac{\% \, xcntry}{speed \, xcntry} + \frac{\% \, trail}{speed \, trail}$$

If we want to minimize the time required, we take the gradient of the time function. This highlights the performance areas that should be emphasized during the design process. For example, let us assume that the vehicle is capable of going 55 mph on primary roads, 45 mph on secondary roads, 15 mph cross-country, and 25 mph on trails. If we evaluate the gradient function with these capabilities and the movement terrain percentages, we obtain the following normalized vector:

– ∇ *time = (0.088, 0.328, 0.885, 0.319)*

This gradient evaluation indicates that the primary emphasis of our design efforts should be to improve the cross-country mobility of the vehicle, that we obtain some value by improving its performance on secondary roads and trails, and that we obtain very little value by improving its primary road performance. To emphasize how important it is to have good movement terrain profile information, let us contrast these results with those obtained if the vehicle requires a tactical support mobility profile consisting of 30% on primary roads, 55% on secondary roads, 5% on cross-country roads, and 10% on trails. If we evaluate the gradient using this profile and the vehicle capabilities used in the tactical standard example, we obtain the following normalized vector:

– ∇ *time = (0.249, 0.682, 0.558, 0.402)*

For this profile we gain the most benefit by increasing the performance on secondary roads. But, we also get value by improving the performance in each of the other three terrain categories. It is important that we emphasize a few points. The differences in the gradient vectors obtained from the two terrain profiles illustrate the importance of having good movement terrain profile information. Also, this analysis considered only the interaction between the vehicle performance and the time it takes to complete missions over a specific terrain profile. This analysis must be combined with analyses for other performance trade space interactions. For example, although the time gradient for the tactical standard profile indicated that the primary emphasis should be on the

vehicle's cross-country performance, it may be much more expensive to improve in this area when compared to the other terrain categories.

A final example regards the parts commonality among FMTV variants. Ideally, we do not want to maximize the commonality of a system but instead maximize the benefits of the system and minimize the costs through repair parts commonality. The potential benefits of commonality include reduced costs associated with purchasing and stocking repair parts, reduced training on different variants for mechanics, and reduced costs associated with developing and producing maintenance manuals. These are all monetary cost benefits.

However, the ability to achieve the monetary benefits of commonality is offset by other systems. For instance, these monetary costs are impacted by the reliability of each subsystem or component; the supply system and its associated costs of purchasing, stocking, and replacing these subsystems and components; the production system for the vehicle; and the fielding plan (system) for the vehicle. Ultimately, any benefits gained through commonality may be lost due to monetary cost increases in other systems in the FMTV's life cycle.

Parts that are readily available on the commercial market, have a high reliability, or are not mission critical (and hence may not be important to stock in large quantities) could also dilute the anticipated monetary benefits of commonality. We also will not achieve many benefits unless the vehicles are produced and fielded in a manner requiring commonality. Again the interplay of system-to-system interaction is a critical aspect to effective analysis of

the FMTV program. Trade space analysis of these critical systems would help decision makers understand whether commonality would truly yield substantive cost savings to warrant its inclusion in the FMTV program. The benefits associated with solving this complex problem justify an extensive M&S effort to answer this critical question for this program.

TIMELY DECISIONS

In a perfect world, all of our decisions would be as easy as the process we used to narrow the range of values for the width of the vehicle. In reality, as we analyze the trade space interactions and determine the decision criteria, we are constructing what can be referred to as a core methodology for the system. This is a representation of "all logical and physical relations between variables representing the decision problem being examined. It defines a set of feasible solutions but does not contain any preferential structure" (Granat & Makowski, 1999, p. 2). Decision makers provide this preferential structure by defining the importance of the trade space elements. The sheer complexity of most problems will not permit a brute force check of all possible combinations and degrees of importance of the trade space elements. The challenge is identifying, refining, and analyzing the critical set of trade space elements from which to select a robust solution. This is predicated on timely decisions on performance and mission criteria and metrics. It also requires clearly designated

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decision makers, determining the times to make decisions, and establishing methods to help make the decisions.

If we are conducting analysis across the domains then we are also impacting decisions across the same domains. This does not necessarily change the methods and tools used to manage a program. It just makes their integration more critical. The collaborative environment increases the number of stakeholders contributing their concerns but does not increase the number of decision makers. Instead, the program's decision makers have more information from more sources to make their decisions. This collaborative program environment must also have a structured decision timeline. Traditional management tools such as the program evaluation and review technique, the critical path method, or engineering management software are sufficient to establish most of the decision times in a program. The key difference is that the analysis management plan is a critical portion of the program and must be outlined, detailed, and integrated into the program timeline. Within the analysis management plan the many analysis methods and tools used must be linked.

The coordination and integration of analysis tools, techniques, methods, and processes refines the system's trade space and helps to facilitate timely decisions. However, this is a challenging endeavor. The system's trade space entities will be represented in various forms to include database entries; mathematical models;

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linear programs; simulations; nonlinear programs; discrete event simulations; reports; and rule-based decision trees. Solving each of these individual representations is relatively easy. The challenge that our methodology accomplishes is solving these representations simultaneously or iteratively. The tools used will depend on the time, resources, and expertise available to the program. One approach is to use concurrent engineering and multidisciplinary design optimization (MDO). Hulme, Bloebaum, and Nozaki state that in the MDO approach we "divide a single large task into a grouping of smaller, interrelated (coupled), and more manageable sub-tasks" (Hulme, Bloebaum & Nozaki, 1999, p. 1). Other possible methods are to use hierarchical optimization techniques, gradient based techniques, or greedy algorithms. Hierarchical methods assign an ordinal value to each objective and sequentially optimize each objective according to its priority. Gradient methods and greedy algorithms seek improvements by going in the direction that yields the best local solution. These three methods can reduce the complexity of the problem but produce local optima solutions.

DOCUMENT PROCESS AND RESULTS

Establishing a completely collaborative environment will not eliminate changes to a program and threats to its existence. Budget cuts, doctrinal changes, organizational redesigns, other materiel developments, and technology improvements are expected. Thus, there is a need to establish methods to track versions of the core methodology, periodically revalidate assumptions, and document major decisions that resulted in the trade space refinement. Equally important is the ability

to disseminate critical information and obtain feedback from stakeholders throughout the process. These steps will minimize delays in the program, reduce duplication of analysis, and utilize M&S in the requirements phase of the program life cycle. Ultimately, through effective trade space analysis, system requirements will drive the set of feasible materiel solutions. This is a fundamental change from evaluating given options to determine whether they can meet performance and mission requirements.

SUMMARY

The methodology presented to implement the SBA initiative represents a fundamental change in the way we conduct program analysis. The early use of M&S allows program managers to fully analyze their trade space and make decisions based on analytic rigor. Also, this methodology yields a solution space, in which all solutions meet mission and performance standards. Decisions made early on lock the program within a specific range of options, but do not dictate a certain solution. If the developed solution space is not adequate, decisions can be reviewed and the analysis reworked to develop a new solution space.

Also, the methodology integrates system requirements, system-to-system interactions, and program life cycle functions. The front-loaded analysis effort can be expensive in terms of dollars, time, data, and expertise. However, the potential benefits associated with this initiative are significant. As more programs adopt this methodology or similar methodologies, new programs can reuse and mirror previous efforts to reduce their analysis costs. The methodology will integrate the acquisition, analysis, and operational communities to produce systems that function within current and future force structures, operational environments, and our changing culture.

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