Using Decision Analysis in Early Program Decision Making

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Four Reasons To Be Optimistic About the State of System Engineering & Decision Analysis Within Defense Acquisition & One Survey

Senior Leadership Directing Use of System Engineering Tradeoff Analysis

Multiple Objective Decision Analysis Offers Sound Foundation for System Engineering Tradeoff Analysis

General Purpose Decision Support Tool Prototype Automates Common Tasks

Major Acquisition Program Utilizing Multiple Objective Decision Analysis

Survey to help understand tradeoff analysis data sources and aggregation techniques to aid decision makers

Senior Leadership Directing Use of System Engineering Tradeoff Analysis

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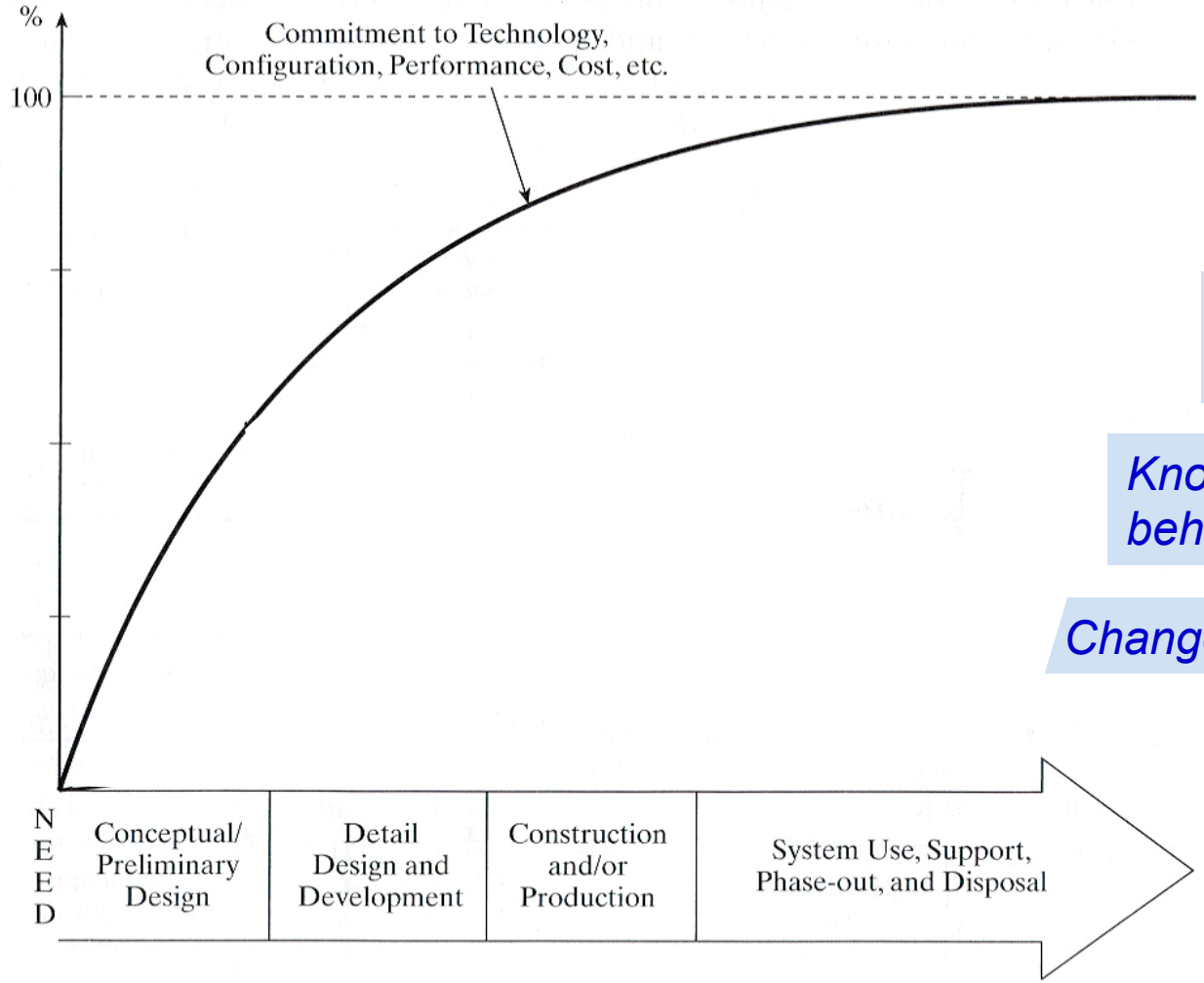
Life Cycle Commitment, System Specific Knowledge, & Costs



Commitment to an approach builds rapidly

Significant life cycle cost is incurred late

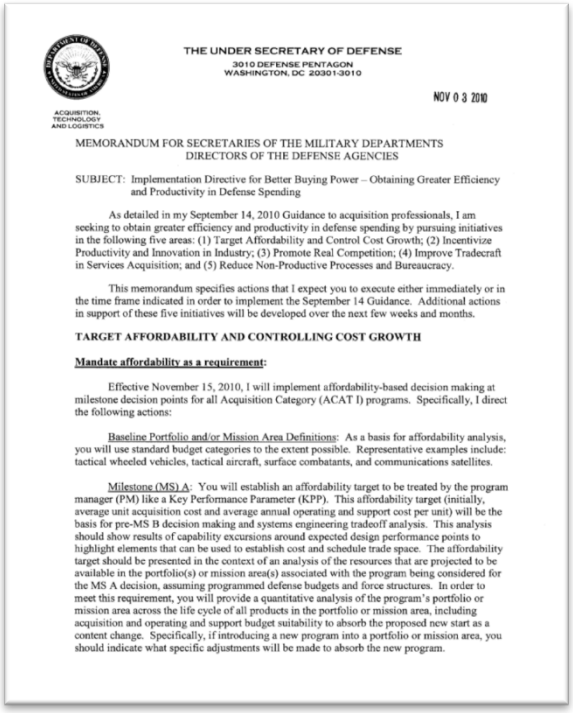
Knowledge of the system lags behind commitment to approach

Change is easiest early in lifecycle

Figure 2.12 Life-cycle commitment, system-specific knowledge, and cost.

Blanchard, B. & Fabrycky, Systems Engineering & Analysis, 5th Edition, Prentice-Hall, 2011

OSD Directs System Engineering Tradeoff Analyses Be Conducted Early in the Lifecycle – MS A



THE UNDER SECRETARY OF DEFENSE
3010 DEFENSE PENTAGON
WASHINGTON, DC 20301-3010

NOV 0 3 2010

ACQUISITION, TECHNOLOGY AND LOGISTICS

MEMORANDUM FOR SECRETARIES OF THE MILITARY DEPARTMENTS
DIRECTORS OF THE DEFENSE AGENCIES

SUBJECT: Implementation Directive for Better Buying Power – Obtaining Greater Efficiency and Productivity in Defense Spending

As detailed in my September 14, 2010 Guidance to acquisition professionals, I am seeking to obtain greater efficiency and productivity in defense spending by pursuing initiatives in the following five areas: (1) Target Affordability and Control Cost Growth; (2) Incentivize Productivity and Innovation in Industry; (3) Promote Real Competition; (4) Improve Tradecraft in Services Acquisition; and (5) Reduce Non-Productive Processes and Bureaucracy.

This memorandum specifies actions that I expect you to execute either immediately or in the time frame indicated in order to implement the September 14 Guidance. Additional actions in support of these five initiatives will be developed over the next few weeks and months.

TARGET AFFORDABILITY AND CONTROLLING COST GROWTH

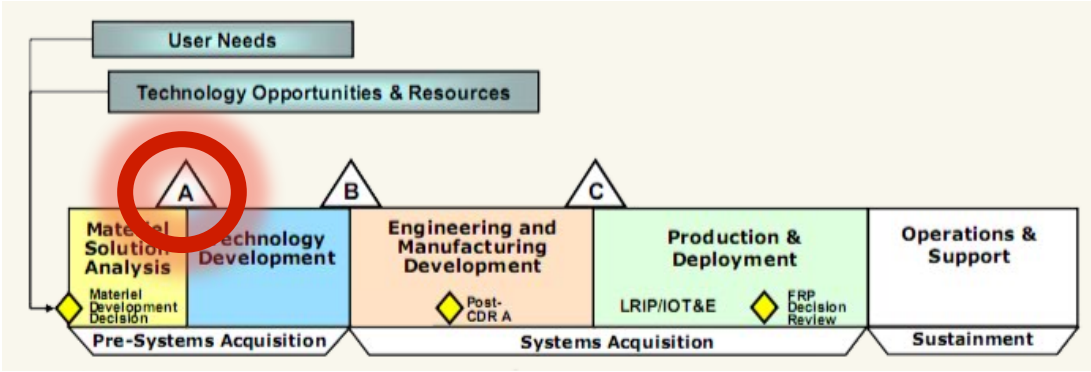
Mandate affordability as a requirement:

Effective November 15, 2010, I will implement affordability-based decision making at milestone decision points for all Acquisition Category (ACAT I) programs. Specifically, I direct the following actions:

Baseline Portfolio and/or Mission Area Definitions: As a basis for affordability analysis, you will use standard budget categories to the extent possible. Representative examples include: tactical wheeled vehicles, tactical aircraft, surface combatants, and communications satellites.

Milestone (MS) A: You will establish an affordability target to be treated by the program manager (PM) like a Key Performance Parameter (KPP). This affordability target (initially, average unit acquisition cost and average annual operating and support cost per unit) will be the basis for pre-MS B decision making and systems engineering tradeoff analysis. This analysis should show results of capability excursions around expected design performance points to highlight elements that can be used to establish cost and schedule trade space. The affordability target should be presented in the context of an analysis of the resources that are projected to be available in the portfolio(s) or mission area(s) associated with the program being considered for the MS A decision, assuming programmed defense budgets and force structures. In order to meet this requirement, you will provide a quantitative analysis of the program's portfolio or mission area across the life cycle of all products in the portfolio or mission area, including acquisition and operating and support budget suitability to absorb the proposed new start as a content change. Specifically, if introducing a new program into a portfolio or mission area, you should indicate what specific adjustments will be made to absorb the new program.

Directive for Better Buying Power – Obtaining Greater Efficiency and Productivity in Defense Spending. NOV 3, 2010. Under Secretary of Defense for Acquisition, Technology, and Logistics, Dr. Ashton Carter



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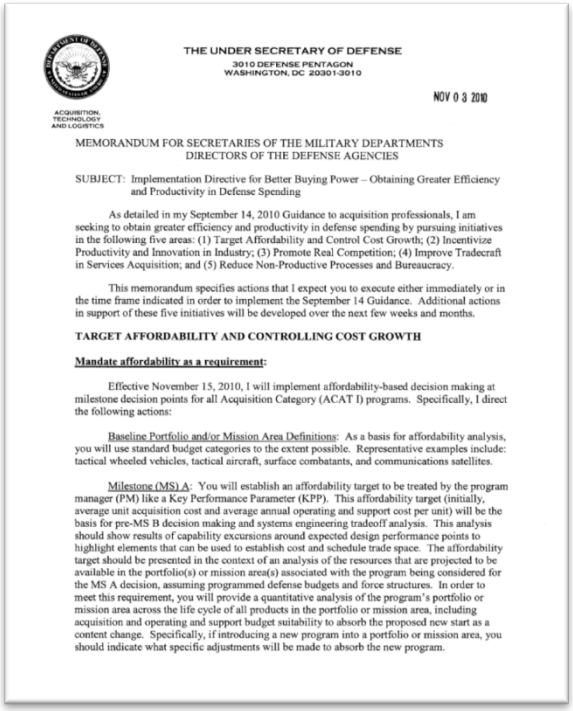
OSD Directs System Engineering Tradeoff Analyses Be Conducted Early in the Lifecycle.



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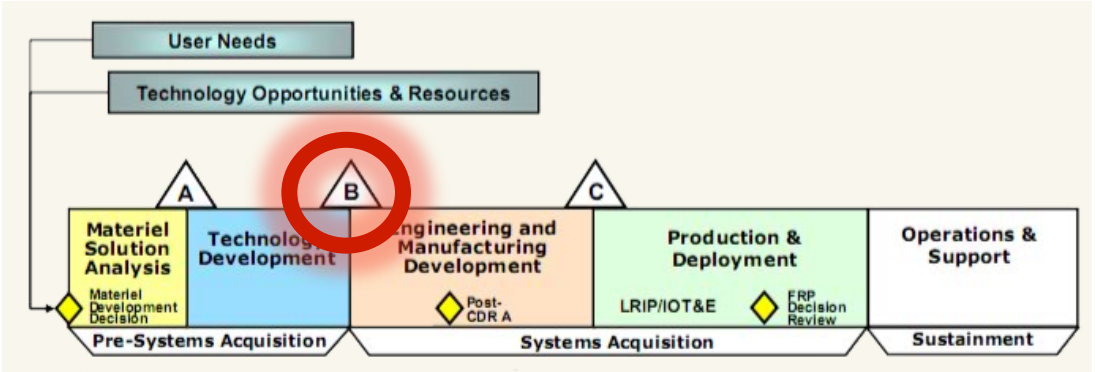
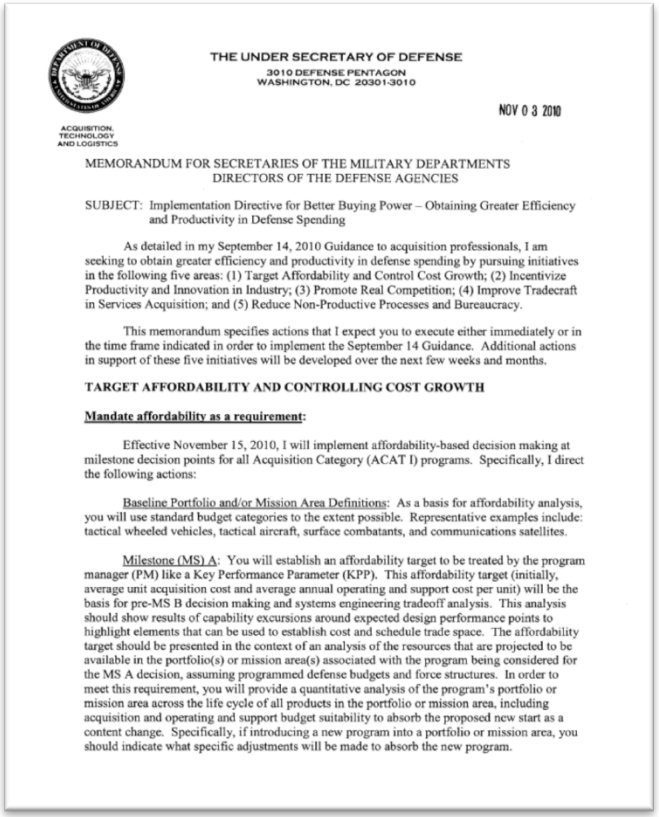


"Milestone B: You will present a **systems engineering tradeoff analysis** showing how cost varies as the major design parameters and time to complete are traded off against each other. The analysis will pay due attention to spiral upgrades. You will recommend for my approval to establish and document, in the Acquisition Decision Memorandum (ADM) and in the program baseline, an 'Affordability Requirement' for acquisition cost and for operating and support cost. This requirement will be the functional equivalent of Key Performance Parameters (KPPs) for baseline establishment and monitoring. You will provide cost tradeoff curves or trade space around major affordability drivers (including KPPs when they are major cost drivers) to show how the program has established a cost-effective design point for these affordability drivers."

Directive to SE Handbook Crosswalk



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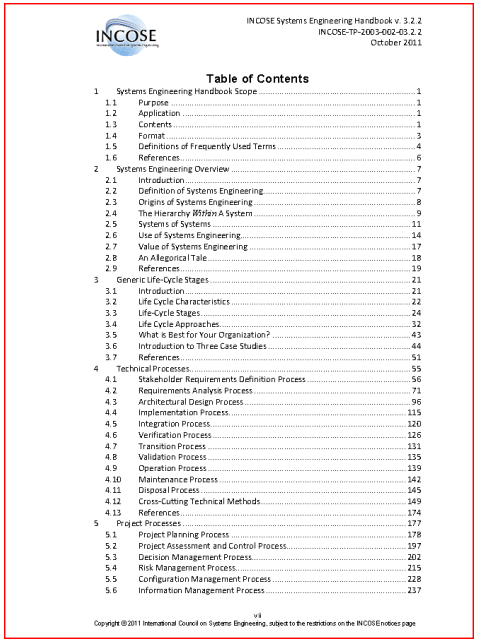

INCOSE Systems Engineering Handbook v. 3.2.2
INCOSE-TP-2003-002-03.2.2
October 2011

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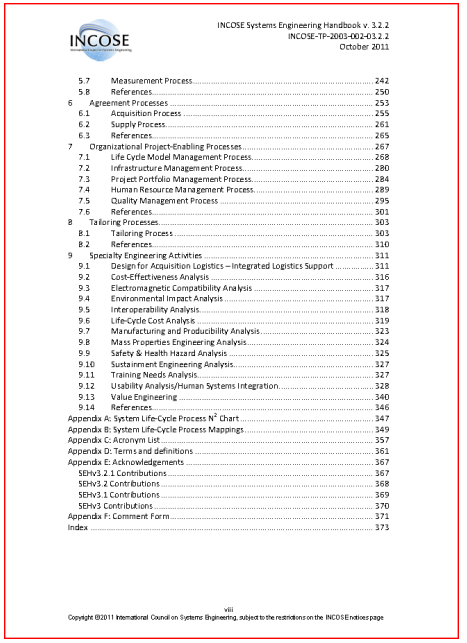
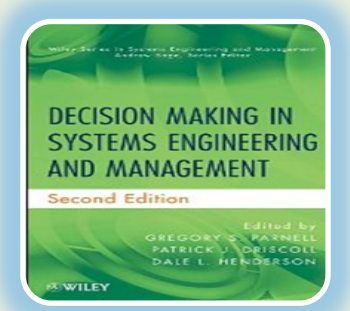


System Engineering Tradeoff Analysis is called out twice in the seven page "Directive for Better Buying Power – Obtaining Greater Efficiency and Productivity in Defense Spending." No other System Engineering Process is mentioned in the Directive. Curiously, the INCOSE SE Handbook dedicates less than 5% of the 370+ page document to this important process.

Multiple Objective Decision Analysis Offers Sound Foundation for System Engineering Tradeoff Analysis

Senior Leadership Directing Use of System Engineering Tradeoff Analysis



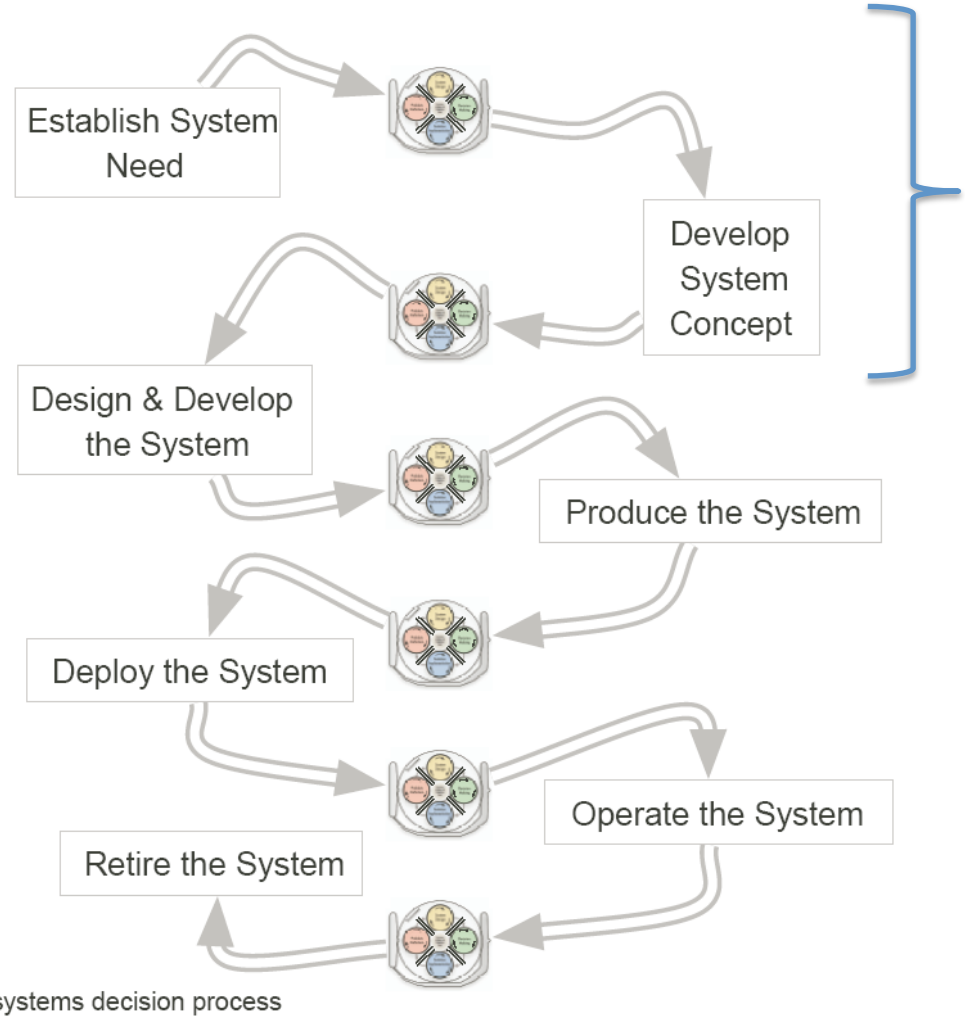
Multiple Objective Decision Analysis Offers Sound Foundation for System Engineering Tradeoff Analysis

General Purpose Decision Support Tool Prototype Automates Common Tasks

Major Acquisition Program Utilizing Multiple Objective Decision Analysis

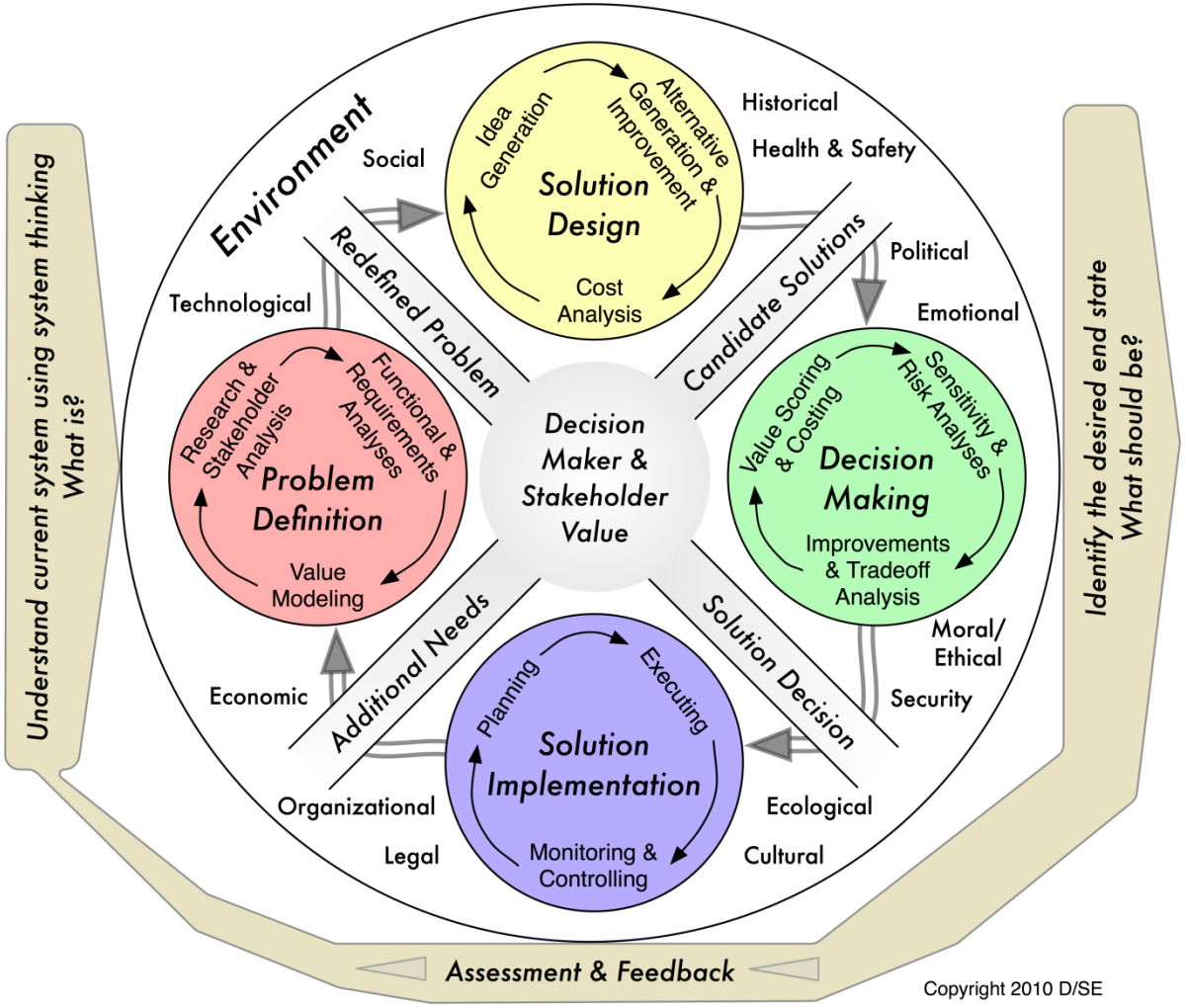
Survey to help understand tradeoff analysis data sources and aggregation techniques to aid decision makers

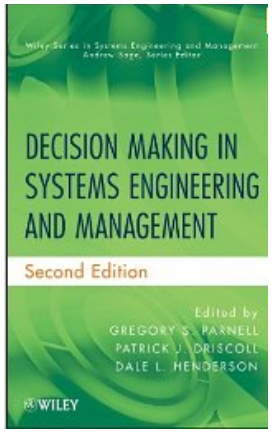
The Systems Decision Process can be used in each stage of the system life cycle.



Highest payoff

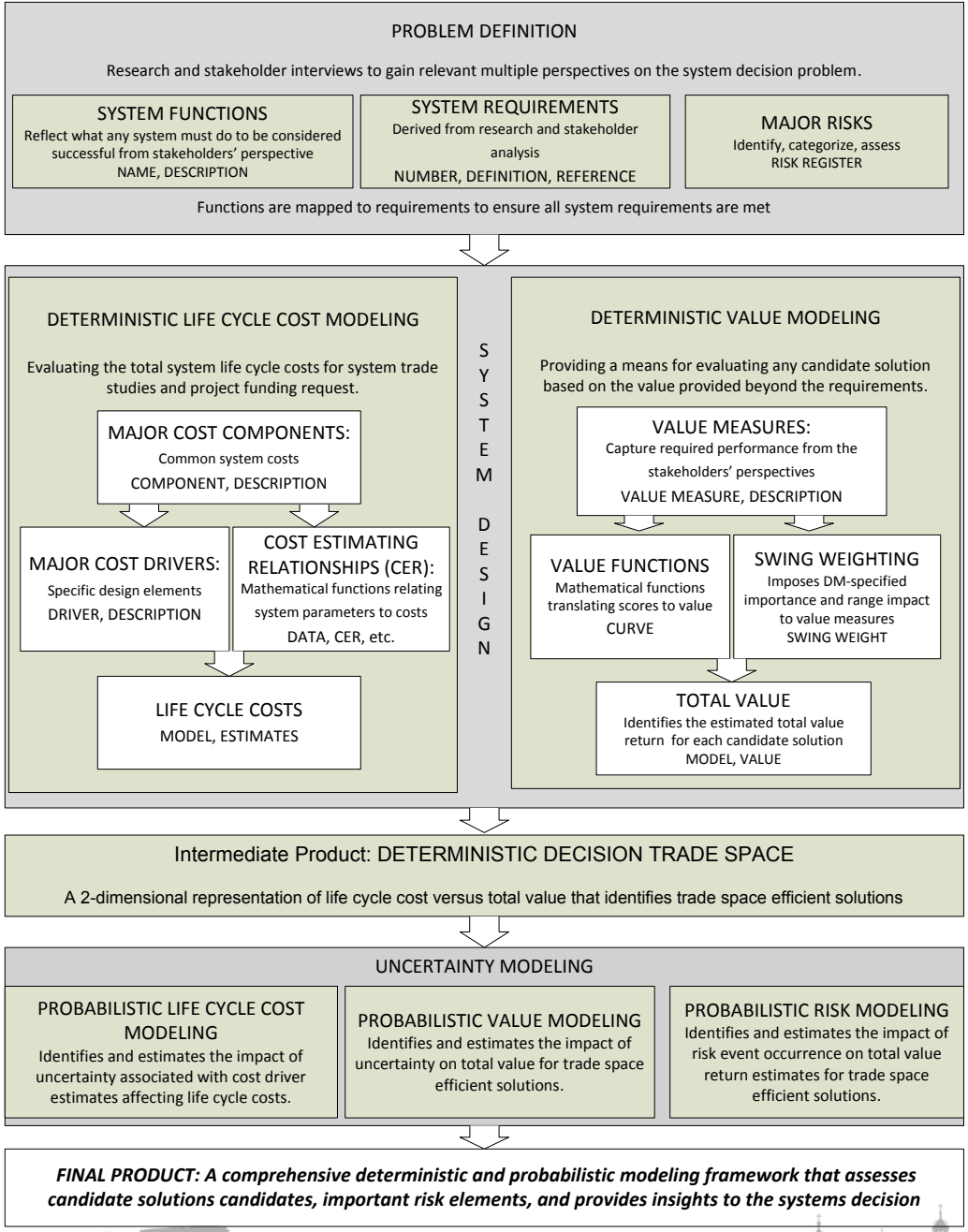
The Systems Decision Process was developed provide decision support for key system decisions.





The mathematical foundation of the SDP is Multiple Objective Decision Analysis and Life Cycle Cost Analysis.

Parnell, G. S., Driscoll, P. J., and Henderson D. L., Editors, **Decision Making for Systems Engineering and Management**, 2nd Edition, Wiley Series in Systems Engineering, Wiley & Sons Inc., 2011

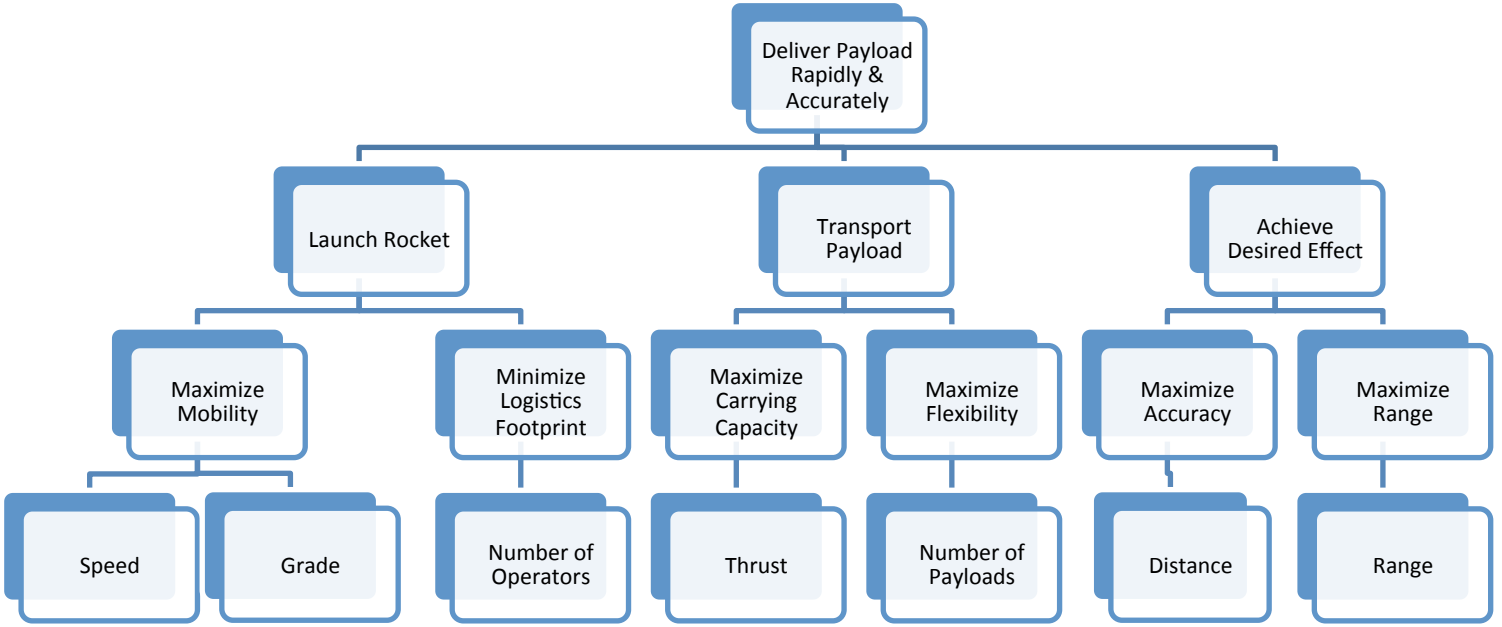


The mathematical foundation of the SDP is Multiple Objective Decision Analysis and Life Cycle Cost.

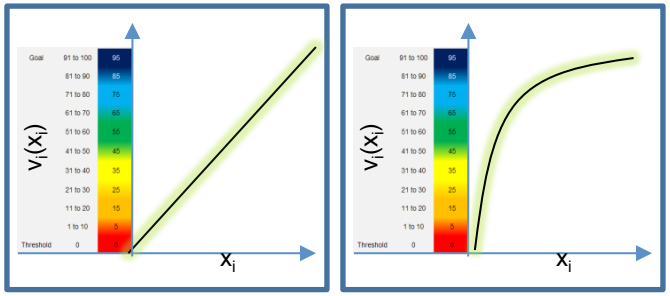
We begin with system functions, requirements, and risks.

The two key components of the trade space are value and cost.

Mathematics of Multiple Objectives Analysis



Swing Weight Matrix		Level of Importance of Value Measure		
		Mission Critical	Mission Effectiveness	Mission Efficiency
Variation in measure ranges	Dramatic improvement over today's capability	**Accuracy (100)**	**Range (50)**	
	Significant improvement over today's capability	**Speed (85)**	**Thrust (45)**	**Grade (5)**
	Small improvement over today's capability	**Number of Payloads (60)**	**Number of People (20)**	



$$v(x) = \sum_{i=1}^{n} w_i v_i(x_i)$$

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Initial Vision Fulfilled

Paper #1569263584

Vision for Multiple Objectives Decision Support Tool for Assessing Initial Business Cases of Military Technology Investments

By

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Dr. Gregory S. Parnell
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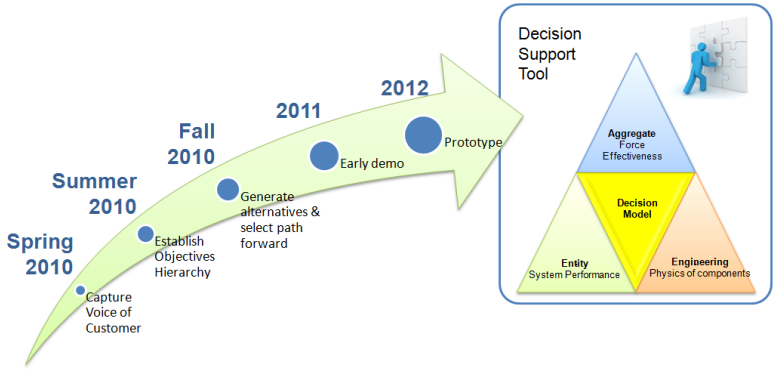
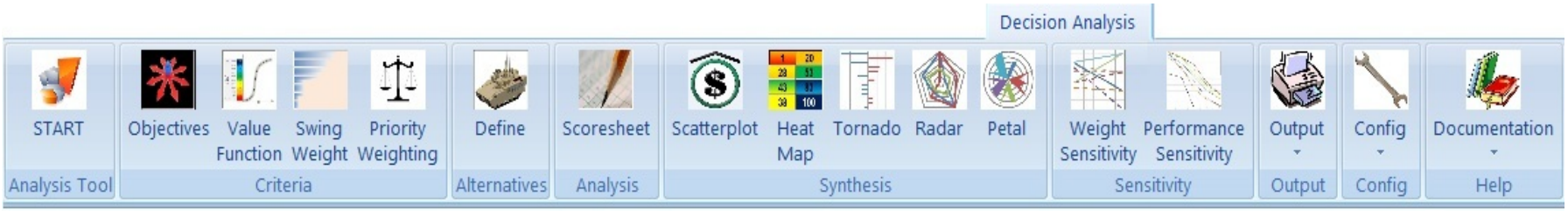
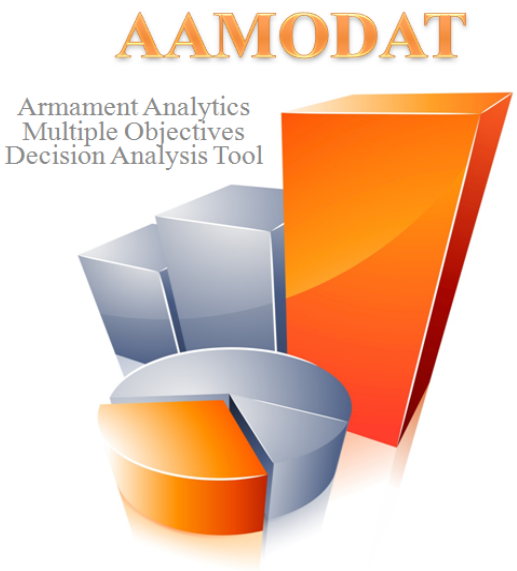
We will develop tool's form and demonstrate its utility by 2012.



In the Spring of 2010 we provided a vision for a decision support tool suitable for initial business case assessments of military technology investments. Since then, we have developed a prototype.

Introducing AAMODAT





AAMODAT is a MS Excel based applications that automates decision theory computations, data management, trade-space visualizations, and report generation thereby increasing decision efficiency and effectiveness.

Key Features

- **Enables Efficient Creation of Value Functions**
- **Automates Swing Weight Matrix Calculations To Generate Priority Weightings**
- **Captures Key Design Features Of Considered Alternatives**
- **Creates Structured Score Sheets To Capture Voice of the SME**
  - **Captures Rational for assessment**
  - **Automatically maps performance score to value space using value functions**
  - **Allows scores to be entered as probability density functions to account for uncertainty**
- **Generates Compelling Tradespace Visualizations**
  - **5 dimensional scatterplots**
  - **Decision heatmap**
  - **Radar graphs**
  - **Tornado graphs**
- **Conducts one-click sensitivity analyses**

Next Step for AAMODAT

- AAMODAT prototype will be tested by Cadets and Professors at the USMA at West Point during the 2012 – 2013 Academic year

- AAMODAT will be refined based on early user feedback.

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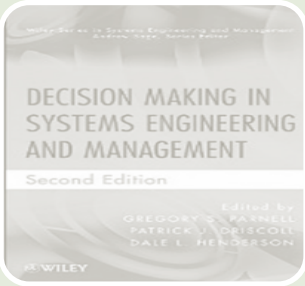

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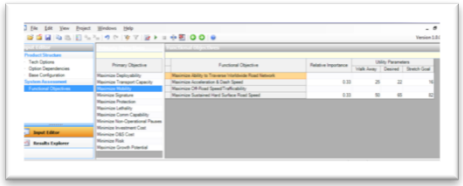
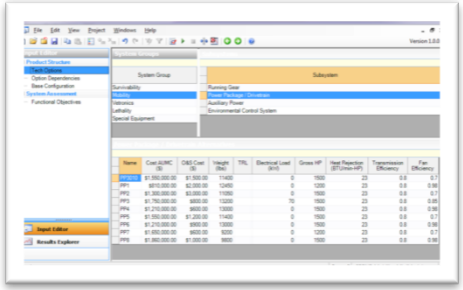
PM GCV Is Using a Multiple Objective Decision Analysis Model To Conduct System Engineering Tradeoff Analyses

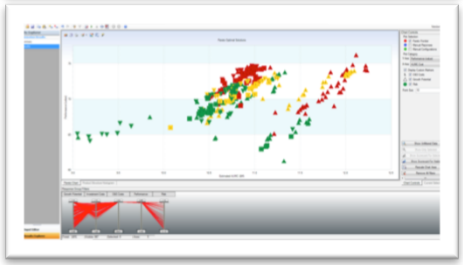
Input Stakeholder Objectives



Input design choices and relationships

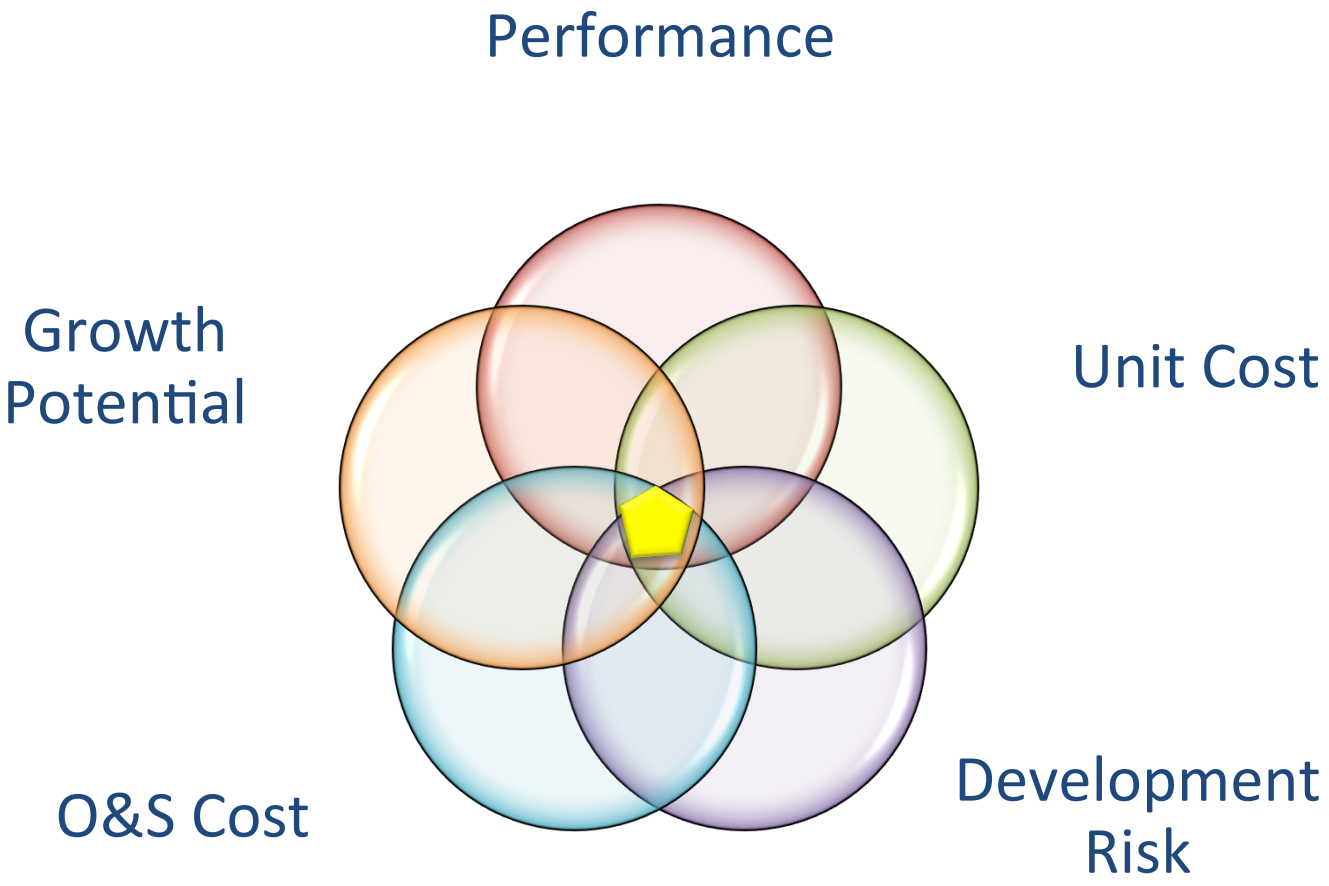


View Holistic System Consequences in terms of stakeholder value

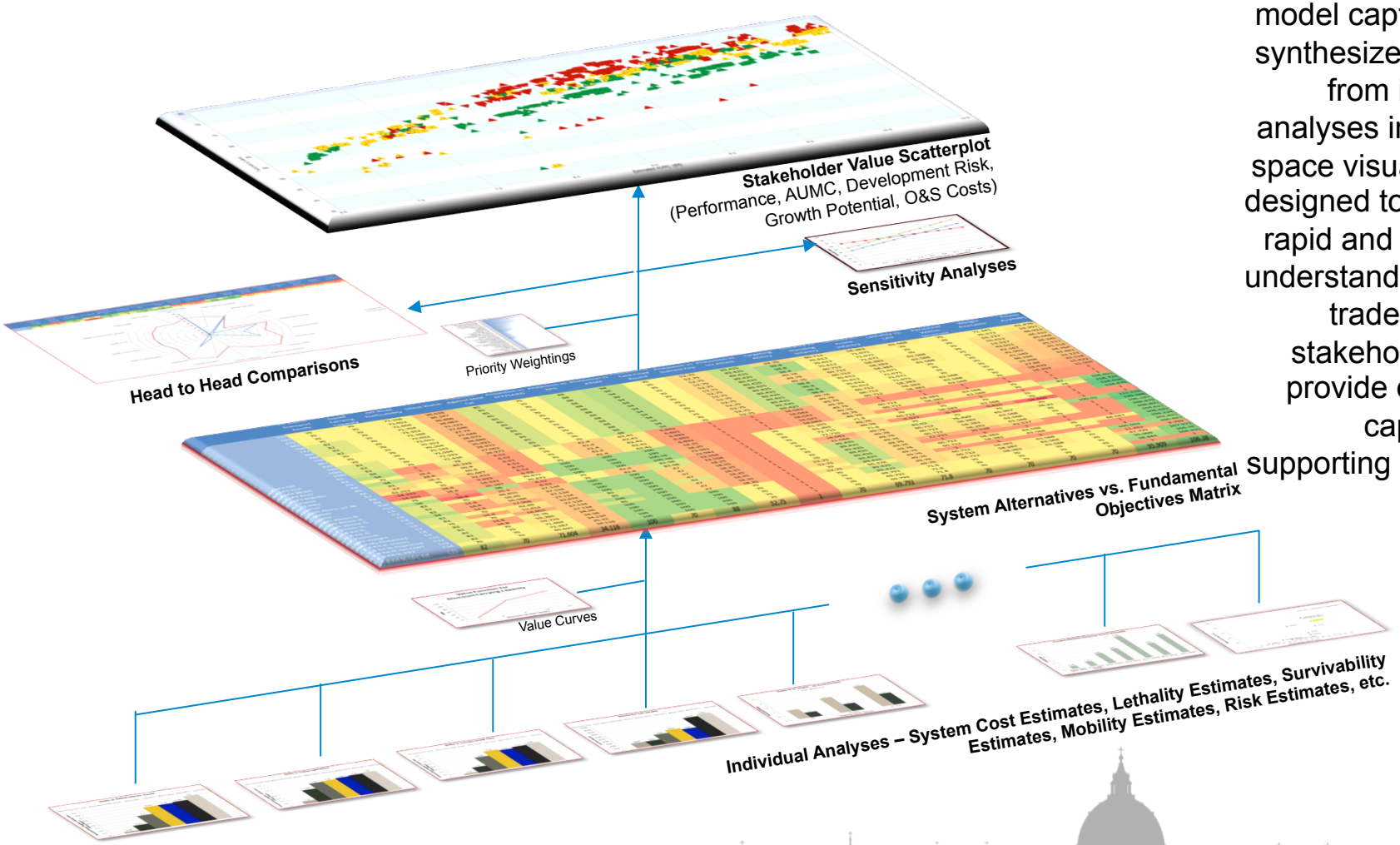


- **Who**: Developed for PM GCV through an ARDEC lead collaboration with PEO GCS, Sandia National Labs, and Booz Allen Hamilton, the Infantry Fighting Vehicle (IFV) Whole System Trade Analysis Tool (WSTAT).
- **What**: WSTAT is a decision support tool that integrates outputs of otherwise separate subsystem models into a holistic system view mapping critical design choices to consequences relevant to stakeholders.
- **Why**: IFV is a complex system with many interrelated subsystems. Finding the sweet-spot among competing objectives is a non-trivial task.

Seeking to Shape Requirements to Balance All Five Elements of Stakeholder Value



Decision Support Model Construct



Decision support model captures and synthesizes outputs from individual analyses into trade-space visualizations designed to facilitate rapid and complete understanding of the trade-space to stakeholders and provide drill down capability to supporting rationale.

Senior Leadership Communications

- PM GCV
- PEO GCS
- ASAALT MILDEP
- Director of MCoE CDID
- Director of TRAC WSMR
- Army G3
- CSA

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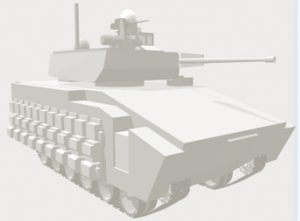

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Survey of Analytical Approaches for System Engineering Tradeoff Analysis

	Please answer the following two questions by placing a check mark in the appropriate box to the right.	0 - 5	6 – 10	11 – 15	16 – 20	21 – 25	> 25
1	How many years experience do you have within system engineering, operations research, or acquisition management?						
2	With how many system engineering tradeoff analyses, analysis of alternatives, or other tradeoff analyses have you been involved?						

3	When involved with system engineering tradeoff analyses, analysis of alternatives, or other tradeoff analyses, what percentage of the time do you use the following techniques to obtain your data?	0	1% - 20%	21% - 40%	41% - 60%	61% - 80%	81% - 100%
A	Subjective opinion from subject matter experts						
B	Engineering / Physics based models (aerodynamic models, ballistic models, etc.)						
C	Item Level Performance Models (Probability of detection, Probability of hit, probability of defeat given a hit,)						
D	Test & Evaluation Data						
E	Operational Data						

4	When involved with system engineering tradeoff analyses, analysis of alternatives, or other tradeoff analyses, what percentage of the time do you use the following analytical techniques to combine data to assist decision makers?	0	1% - 20%	21% - 40%	41% - 60%	61% - 80%	81% - 100%
F	Do not combine. Provide all data separately						
G	Two or Three dimensional plot of most important measures (Measure A vs. Measure B vs. Measure C)						
H	Analytical Hierarchy Process						
I	Quality Function Deployment						
J	Multiple Objective Decision Analysis (Value Focused Thinking)						
K	Operational Effectiveness Models (Force on Force Vignettes), or Business Models						
L	Other						

5	How often was the decision maker satisfied with the following elements of the tradeoff analysis product?	0	1% - 20%	21% - 40%	41% - 60%	61% - 80%	81% - 100%
M	Number and Quality of Alternatives						
N	Reliability of information and models						
O	Credibility of aggregation mathematics / logic (if used)						
P	Recommendation & action plan						