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Set-Based Design for DoD Acquisition

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Motivation for Set-Based Design (SBD)

- System development takes a long time vs change in operational needs
- Systems have long service lives vs changes in technologies and strategic needs
- Future conditions, needs, technology capabilities and costs are uncertain
- Future conditions and needs are shaped by the capabilities we field
- Acquisition requirements depend on estimates of technology affordability & performance, and system capability

SBD Approach

- Instead of developing a point solution "known" needs and capabilities, develop a set of solutions for uncertain future needs and capabilities
- Value solutions that can be quickly and economically adapted to provide different capabilities and/or incorporate new technologies
- Value sets of solutions that can, in combination span the range of future needs and technology capabilities and burdens
- Effects
  - Robust (adaptable, versatile) systems
  - Parallel solutions together covering operational needs and technology opportunities

Two Dissertation Topics

1. Set-Based Design (SBD) For Change in Need During Protracted Development - Steve Rapp

2. SBD For Change in Need Post-Fielding for Long-Lived Systems - Greg Hartman

SBD For Change in Need During Development

- Problem #1: Changes external "data" during protracted system development
  - Cost and performance targets and priorities
  - Cost, performance, compatibility of technologies
- Example: JLTV cost target and relative priority of cost and performance were changed significantly just prior to MSB
- SBD objective: Enable rapid and economical adjustment during development
- SBD principle: Plan for change
  - Defer design decisions – keep options open as long as possible
  - Pursue parallel paths as long as affordable
  - Build-in reserve capacity (design margin)
  - Use standard interfaces and modular architectures
- Challenges for SBD: Rigorous methods for when, where, how & how much

SBD Is Not Foreign To Current Acquisition Practices

- JLTV addressed engineering risk with a form of SBD
  - 3 parallel competitive prototyping contracts Technology Development, & 3 parallel EMD awards
  - But all designed to the same set of requirements, and were equally exposed to the risk of requirements change
- F35 JSF program added a separate, parallel helmet development contract when new information indicated a higher level of technical risk
- Tiered approach to system requirements allows for tradeoffs
  - Must meet threshold requirements
  - Bidders pick the cost and capability they will bid given requirements tiers and objective levels
- NAVSEA guidelines explicitly call for considering SBD in acquisition, but without rigorous analytic methods

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SE Research Needs for SBD During Development

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- *Methods to calculate the value of a set of configurations at a point in time in the development cycle vs the cost of carrying the set forward*
  - *Formalisms to represent cost and value of solution set, including the cost and benefit of changing the solution set*
  - *"Data" requirements*
  - *Decision points and criteria*
- *Need: Practical, relevant, and "simple" steps for DoD acquisition to harvest the main effects of SBD*

Approach to SBD For Change in Need During Development

- Carry a set of representative configurations that span configuration and capability spaces
- Adjust/prune the set
  - When new information becomes available
  - When further development requires additional funding above the benefit of the full set

Practical Steps for DoD Acquisition

- Simplify how tiered requirements and tradeoffs are framed
  - Threshold requirements, minimum acceptable
  - Define representative targets at different locations in capability space
  - Solution at objective levels for all requirements may be unaffordable or infeasible
- Contractors bid to pursue a set of design alternatives, their choice
  - Neck-down at selected review points
  - Contractors will naturally seek to cover as much of capability space as possible within the total development award to maximize the likelihood of having a good solution at MSC
  - Contractors will naturally seek commonality and modularity among their alternatives to minimize development cost and risk
  - Incentivize contractors to develop versatile and adaptable designs
  - Gives the Government more options and choices including 1 vs 2 vehicle solutions
    - Single GCV vs wheeled and tracked 2-vehicle FFV solution
    - Single EFV vs slow transport and fast fighting ACV solution

Set Value Function Research

- Value of a set of design/configuration options at MSC is the maximum value over all completed designs
  - At MSC, AUPC cost and performance targets and relative priorities are known, performance of alternative designs/configurations are known
  - Standard multi-attribute utility formulation
- Prior to MSC, set value function
  - Needs to include continued development cost from one decision point to the next
  - Needs to include the options and costs of adding alternatives
  - Cost of adding an alternative depends on how different it is from configurations and technologies already in the set solution
  - Final targets, priorities, and performance at MSC are uncertain, random variables
  - Set value function is a measure of the distribution of final value, e.g., the XXth percentile over external random variables

SBD For Change in Need Post-Fielding

- Problem #2: Changes in function and performance need after fielding
  - Unplanned operational conditions & missions
  - Emerging technologies mature
- Example: HMMWV in OIF and OEF up-armoring and weapon cupola
- SBD objective: Enable rapid and economical adjustment after fielding
- SBD principle: Robust platform to host a set of potential future variants
  - Build-in reserve capacity (design margin)
  - Use standard interfaces and modular architectures
- Challenges for SBD: Rigorous methods for when, where, how & how much

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SBD Approach To Consider Post-Fielding Variants

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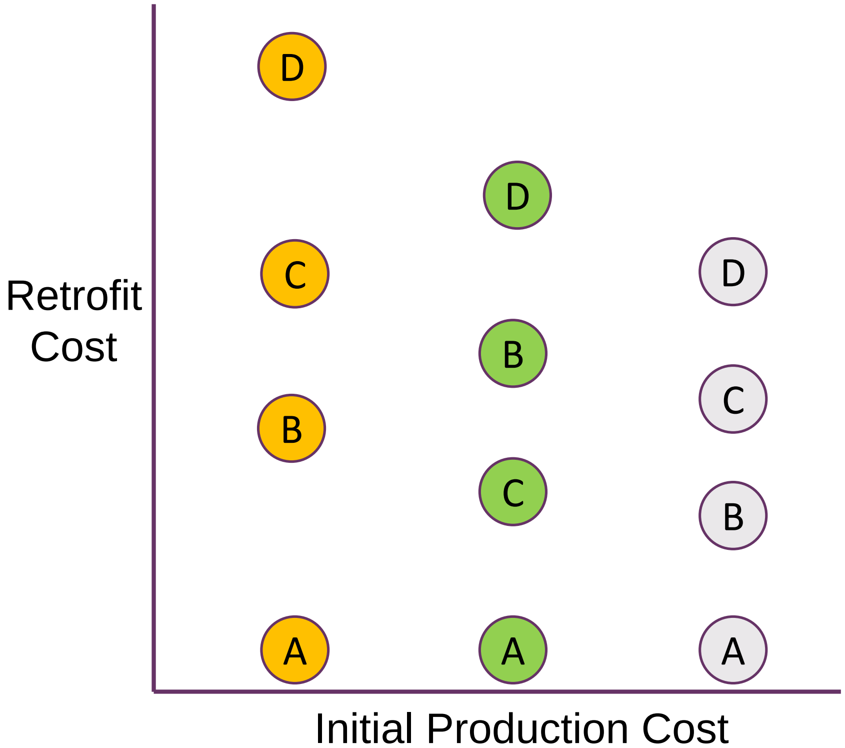
- During development examine the platform needs to support the range of potential future variants' functional and performance capabilities, and the cost of the upgrades
  - Size, weight, power, cooling, computing, communications, etc. levels
  - Architecture modularity (units of replacement)
  - *Recent acquisition practice to contract for a family of variants moves towards this approach*
- Analyze the likelihood of future needs relative to the capability fielded
  - Adversarial risk models
- Analysis informs tradeoffs
  - Between initial production and future upgrade costs
  - Between initial capabilities and future upgrade costs

Initial Vs Upgrade Cost Tradeoffs



A: Base Functions & Performance

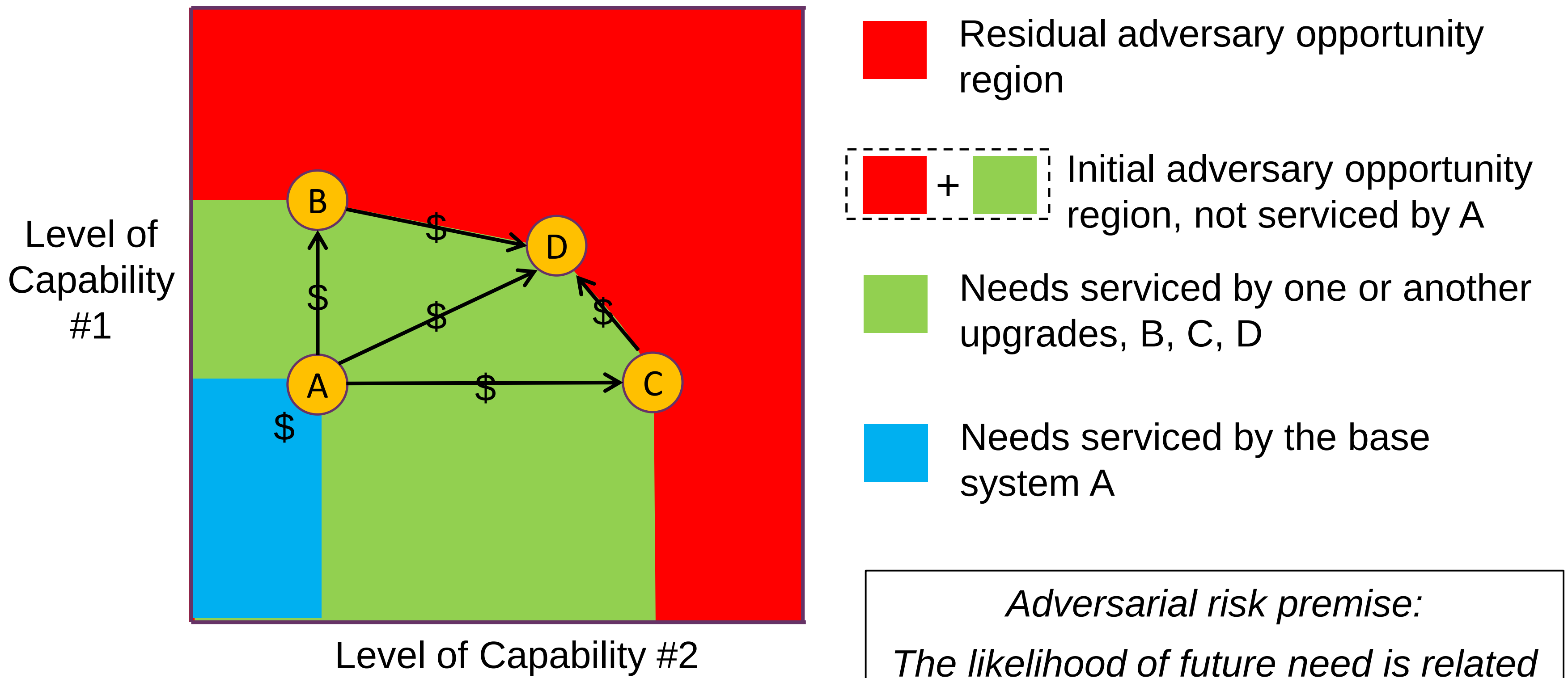
B, C, D: Potential Variants

A A A : Alternative Base Configurations

Informs but does not resolve "pay now or pay later" tradeoff

What about the likelihood that variants B, C, D will be needed?

Adversarial Risk Approach



Adversarial risk premise:

The likelihood of future need is related to the distance from current capability

- Adversaries adapt to avoid our strengths and exploit our limitations.
- Value of variant is the proportion of the adversary opportunity region cut off

Questions?