Valuation of Capabilities and System Architectural options to Meet Affordability Requirement

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Motivation

- DoD projects meet conditions that make the Real Options approach attractive for the valuation of flexibility in system architectures:
  - High uncertainty due to long anticipated operational life with technological change and a dynamic, changing operational environment
  - Flexible, modular, open architectures are a means to mitigate against the risk inherent in the uncertainty

Real Options values the flexibility built into a system architecture

Can help justify investment in flexibility up front and support analysis of alternatives

Real Options

Traditional cost analysis:

- Estimate cashflows
- Discount to obtain NPV
- Make a invest/not invest decision

- **Real Options** estimate a dollar value on the ability to make choices – decision flexibility has value!

Black-Scholes Equation

$$C = S \times N(d_1) - Ee^{-rt} N(d_2)$$

$$d_1 = \frac{\left[\ln\left(\frac{S}{E}\right) + \left(r + \frac{1}{2}\sigma^2\right)t\right]}{\sqrt{\sigma^2 t}} \qquad d_2 = d_1 - \sqrt{\sigma^2 t}$$

Real Options for Capabilities

- DoD acquires systems to deliver capabilities to the warfighter

Real Options values the flexibility based on a cost-benefit analysis assuming all benefits can be put in dollar terms

Capabilities are not measured in dollars $$$$$

- The Real Options framework needs to be adapted to the way DoD values and acquires systems

Value of Weapon Systems

- Value is in capabilities delivered by system
- Options are for additional future capabilities

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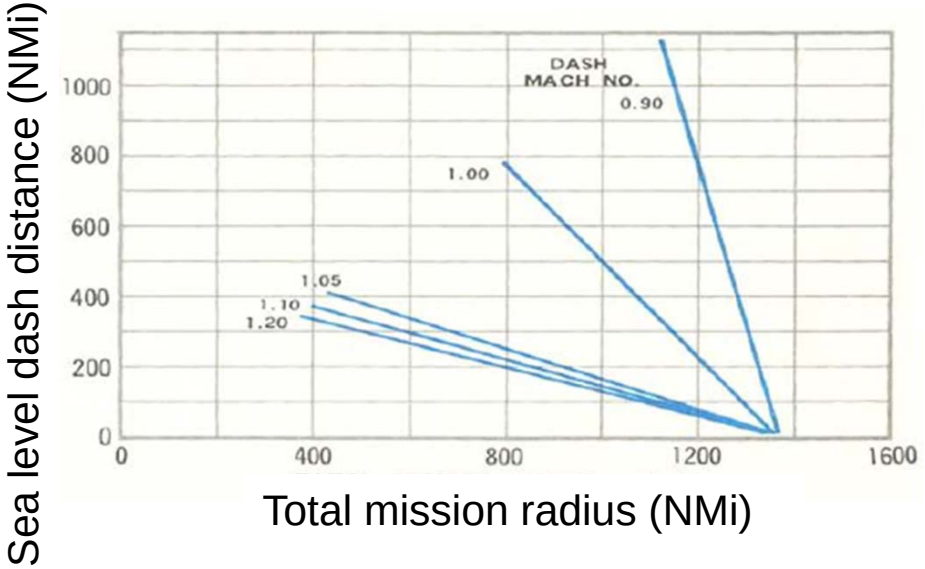
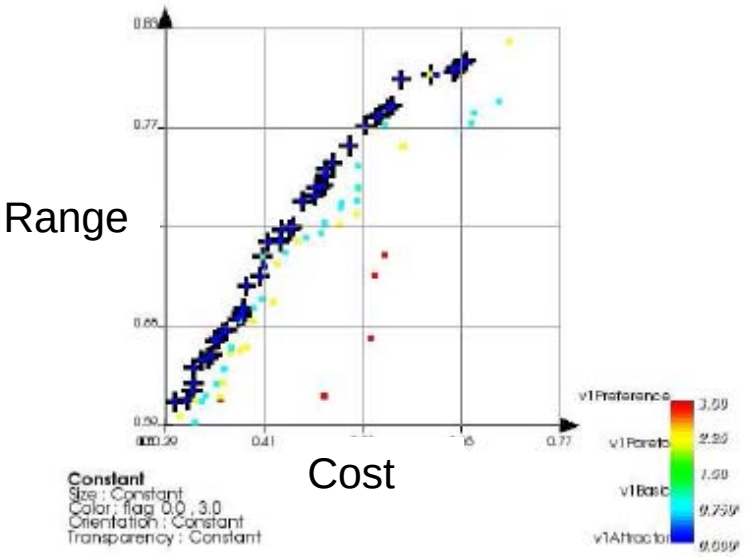
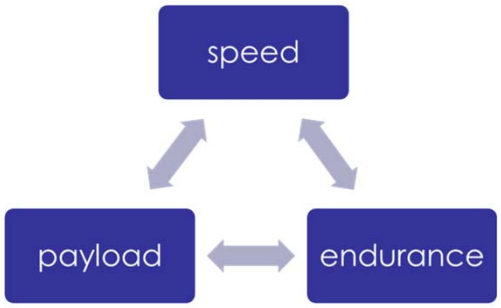


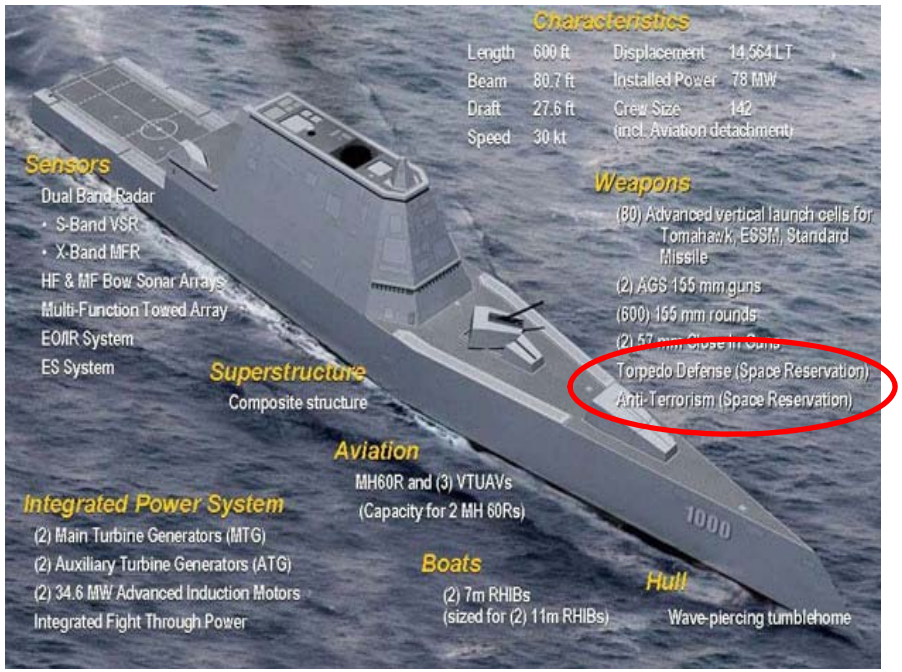


(b) Combined Pareto front v1 (Pareto points denoted by +)



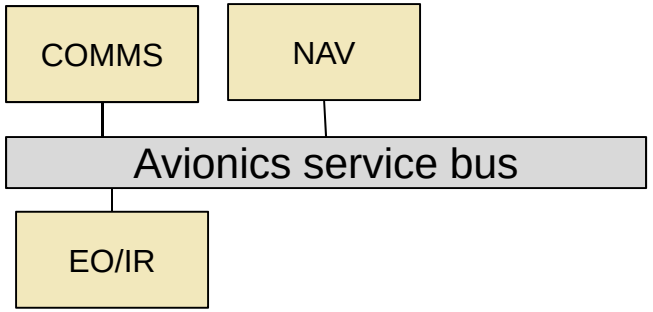
Architecture

The system architecture must be designed to accommodate options



Reserved space and plan for future accommodation

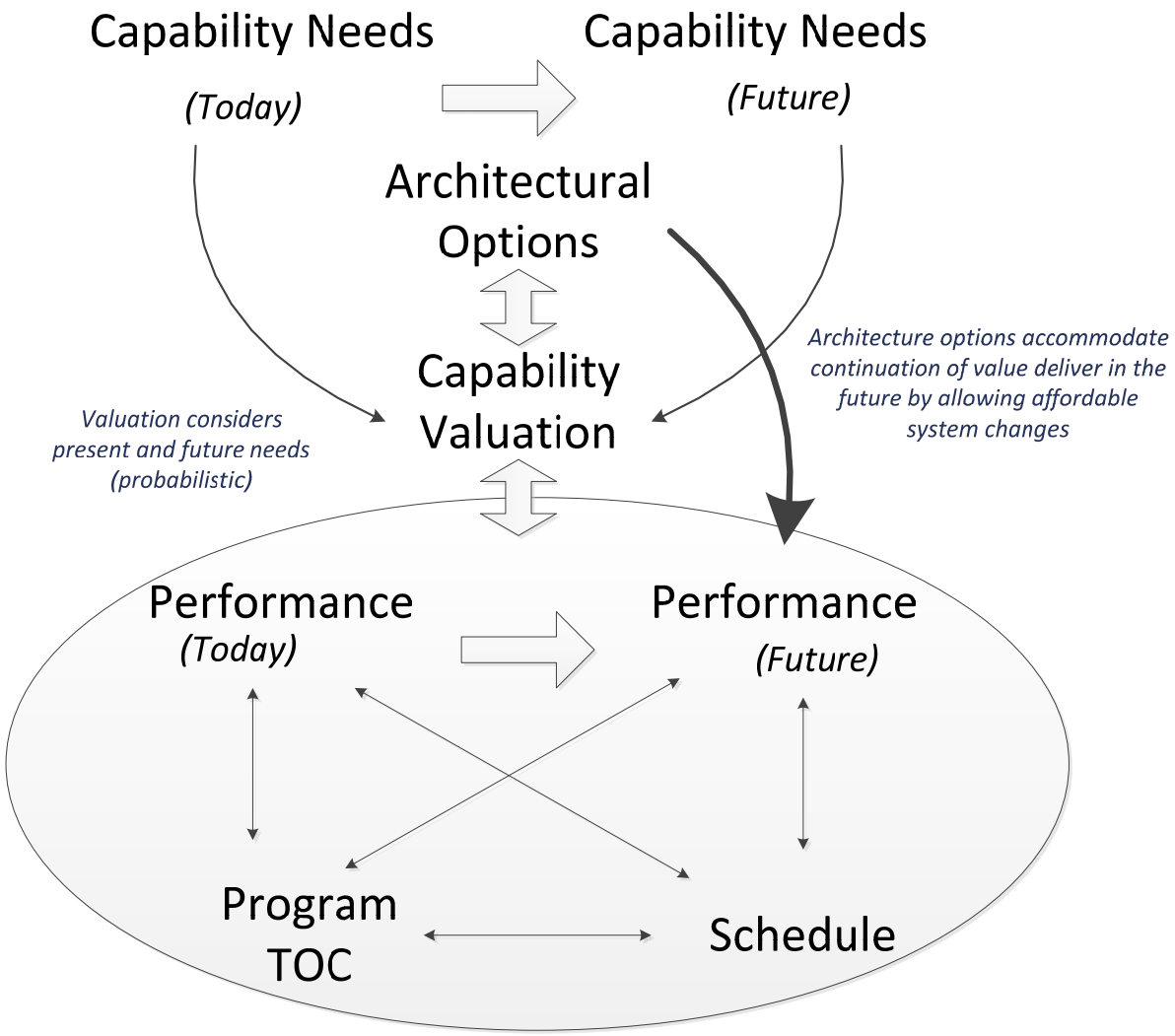
LCS Mission Modules



Architectural Options

The architectural options approach involves the following steps:

1. identify sources of uncertainty,
2. define measures for the capabilities,
3. model uncertainty using scenarios,
4. partition the system architecture into modules,
5. define architectural options in the architecture,
6. value options,
7. present the valuation to the decision-maker.



Operational Uncertainty

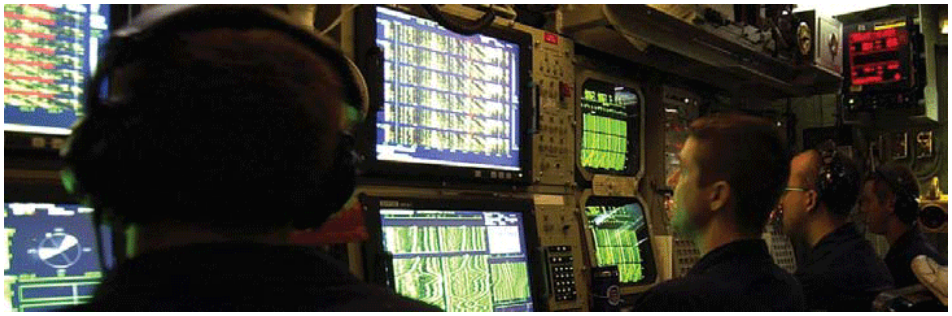
Unknown operational needs during a long lifespan

B1-B designed for nuclear mission, converted to conventional bombing mission

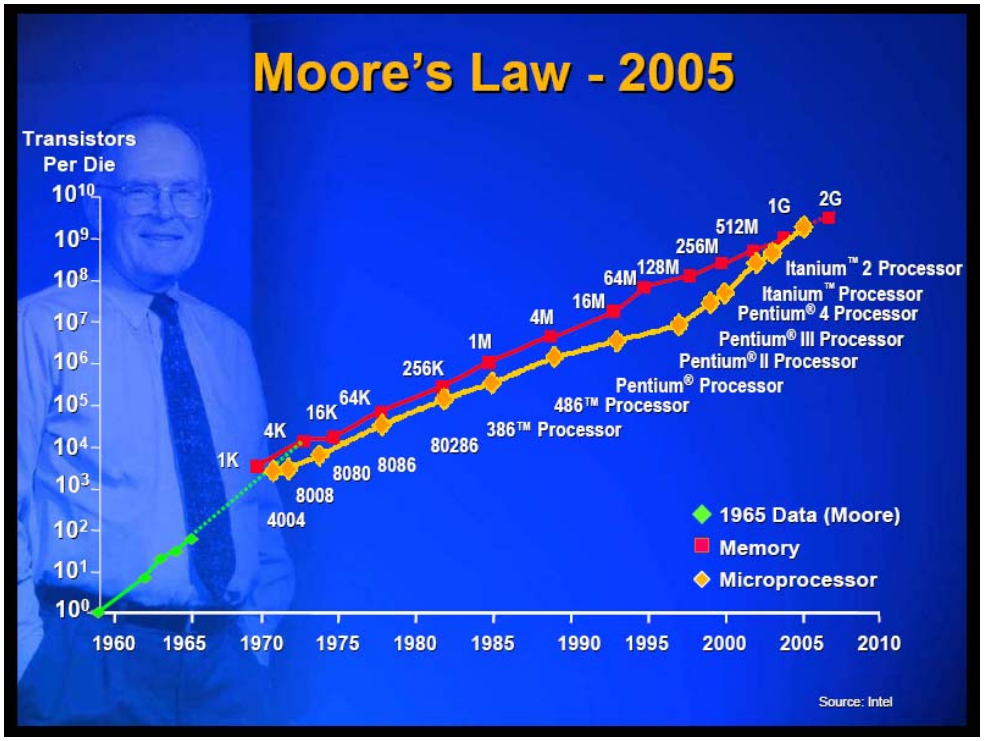
Gerald R. Ford (CVN 78) anticipated operational life of 50 years

Technological Uncertainty

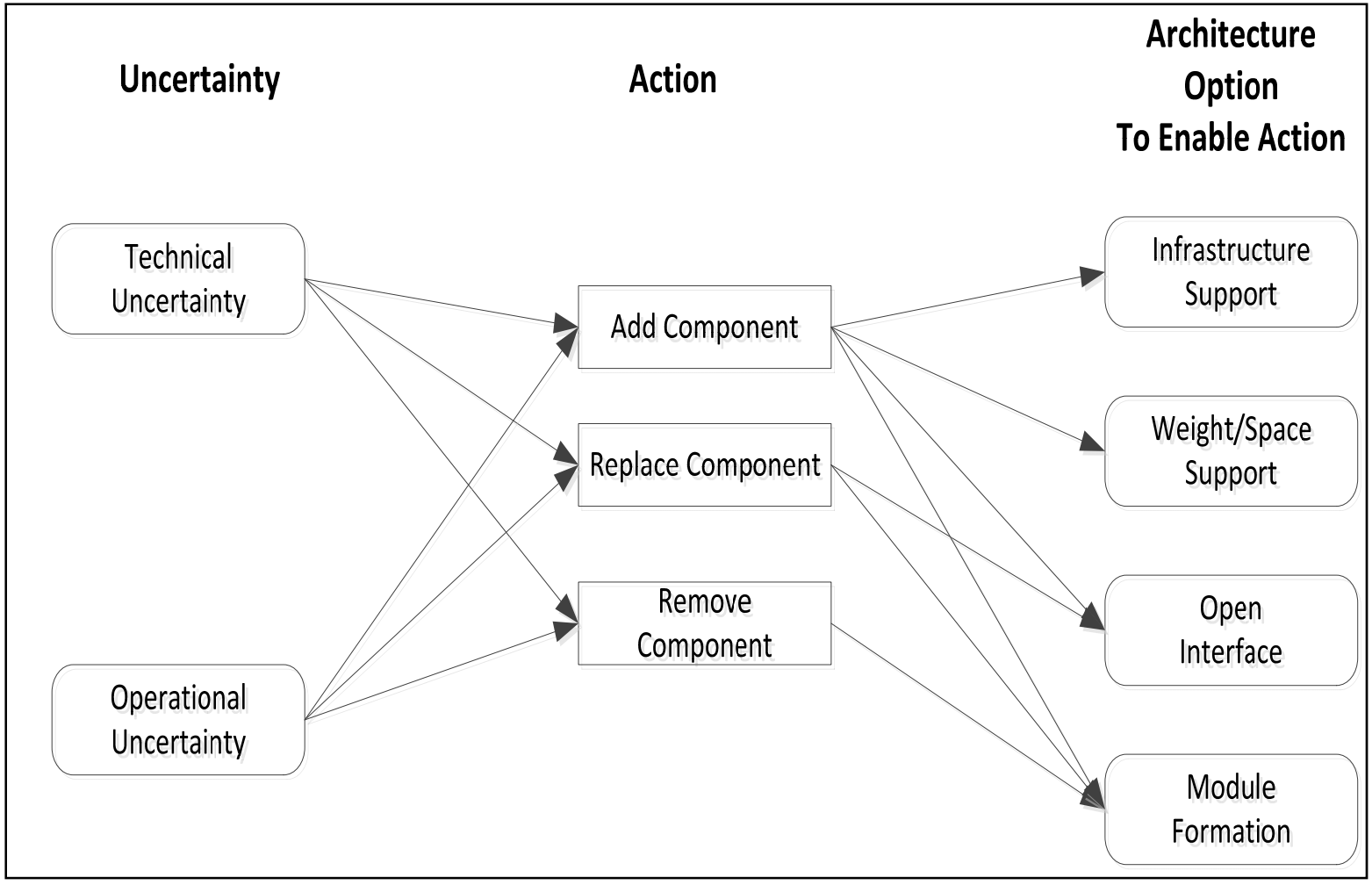
Technological Evolution



Sailors in submarine
(source: undersea warfare)



Architecture Options

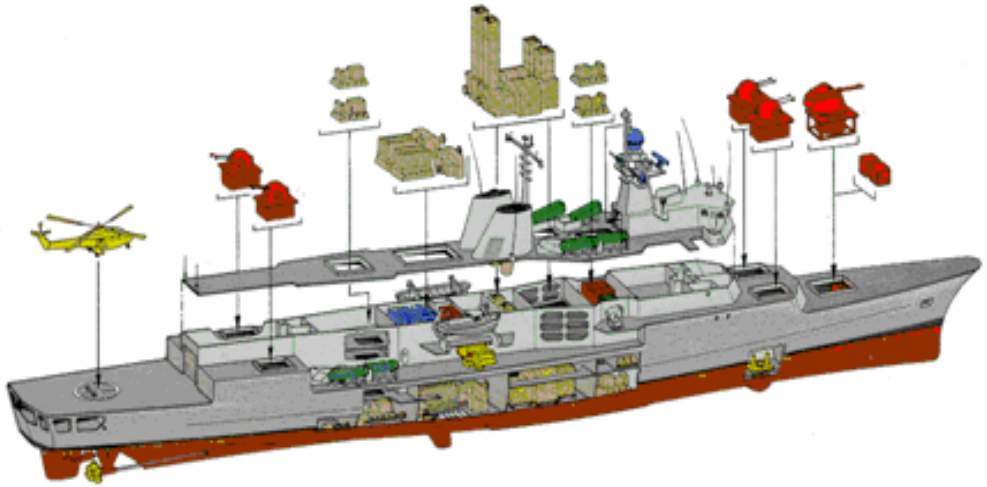


Modularization

Modularization

Open interfaces

infrastructure



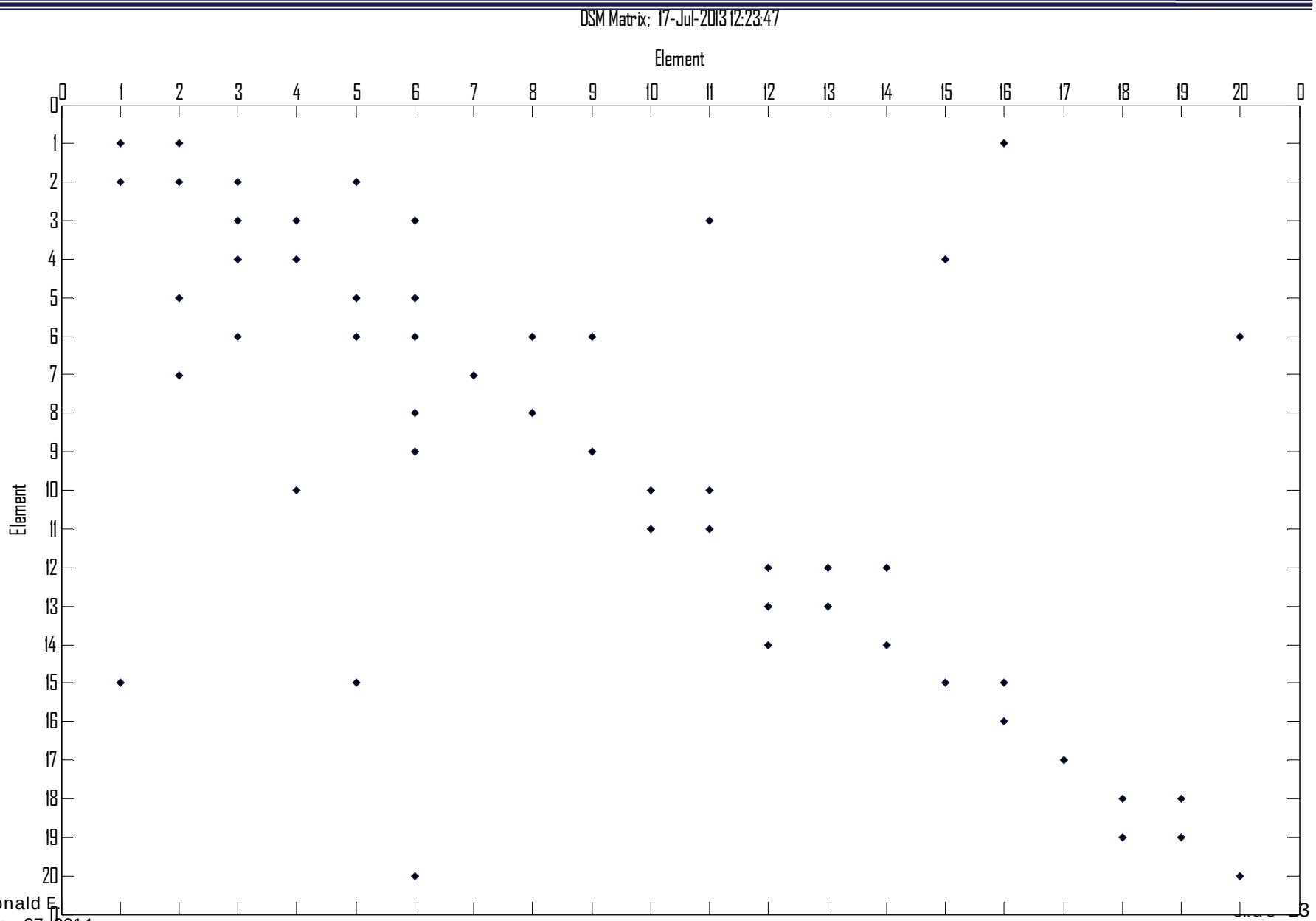
Source: Jack Abbot, AOC Inc.
in presentation to NPS on April 27, 2006

Architecture Heuristic: Minimize coupling between subsystems
Maximize cohesion within subsystem

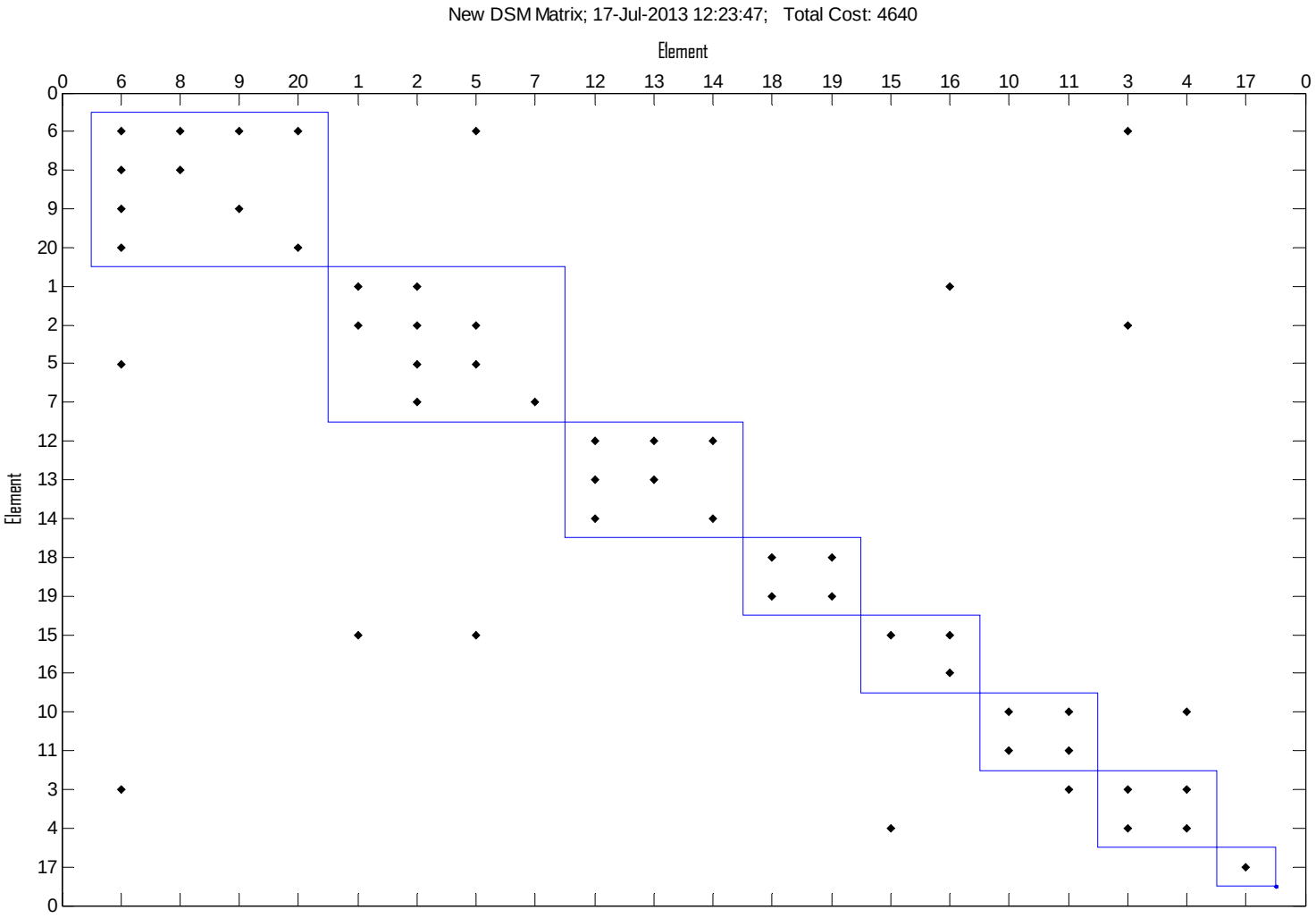
Interactions between subsystems

Spatial	Associations of physical space and alignment, needs for adjacency or orientation between two elements
Energy	Needs for energy transfer/exchange between two elements (e.g., power supply)
Information	Needs for data or signal exchange between two elements
Material	Needs for material exchange between two elements

Modularization Algorithm



Modularization



Example

Desert Patrol Vehicle

Architecture Options:

- Engine
- Weapon
- Fuel
- Passengers
- Mission modules

Cost to design:

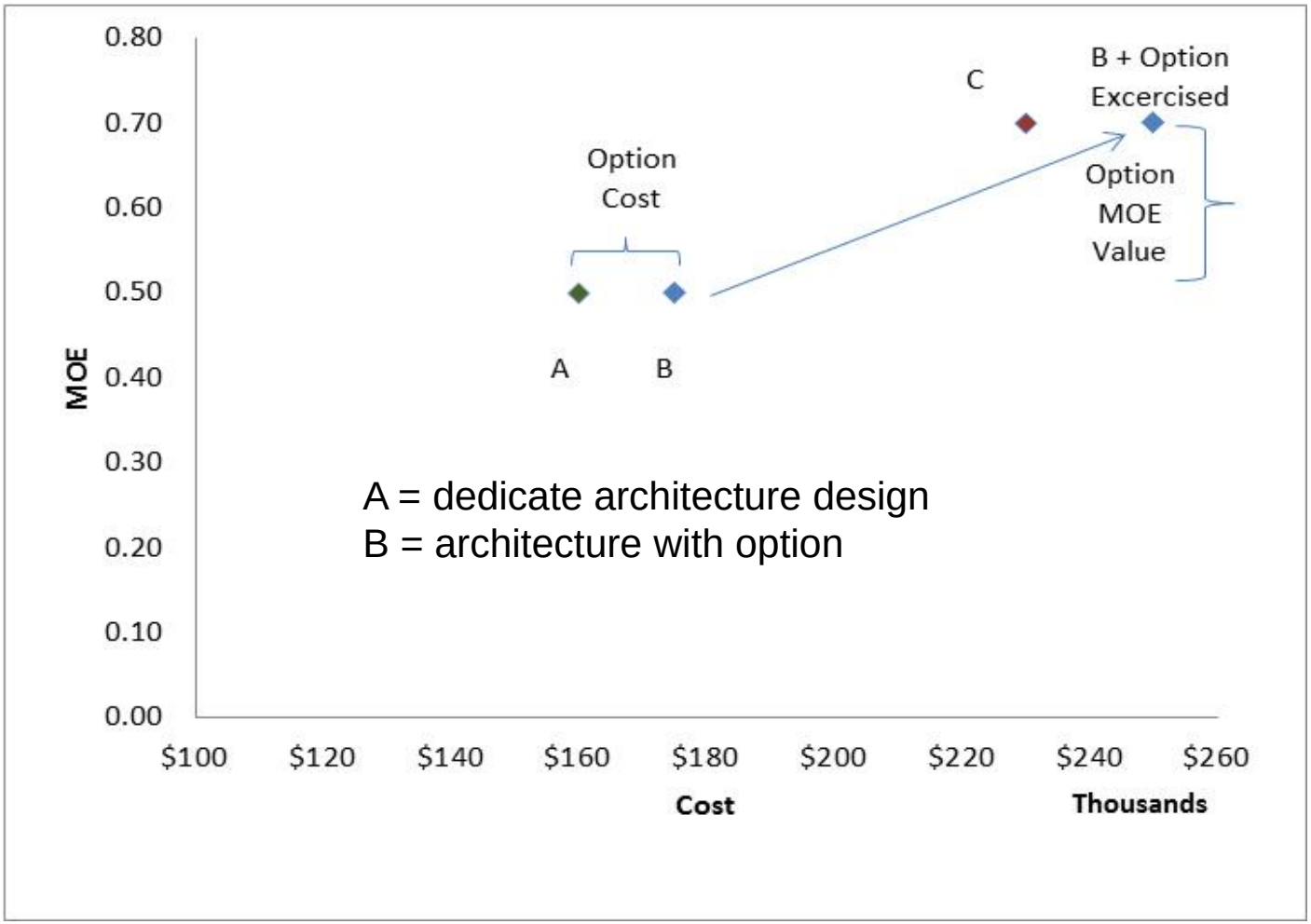
Engine compartment and mounts to enable option for changing engine

Increase/decrease fuel capacity

Mounts/space/interface for various weapon types

Capacity to accept future mission modules

Option Cost and Value



Conclusions

- ***Motivation:*** Flexibility is being left on the table – rethink system architectures in terms of "options" can help recapture and use this flexibility
  - Decision makers do think about these types of options, but the informal approach may miss options, is not based on valuation, and human cognitive limits in evaluating multiple options concurrently
- Almost all work on options has looked at options in the PROJECT, this work examined *options in the system architecture*
- Previous work values options using cost information; this work valued *capabilities using MOEs/MOPs*
- Model goes hand-in-hand with evolutionary acquisition of capabilities