Applying Cost Analysis to the DoDAF

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Agenda

- Current Acquisition Directives
- Satisfy Acquisition Directives within a Consistent Framework (i.e. DoDAF)
- Apply More Quantitative Analysis that Simultaneously Solves Capability vs. Cost Assessments

DoD Acquisition Direction

- DoD Acquisition policy directs all programs responding to a capabilities or requirements document, regardless of acquisition category, to apply a robust SE approach that balances total system performance and total cost with the family-of-systems, and system-of-systems context.

Current Acquisition Directives

- DoDAF (Department of Defense Architecture Framework)

The DoDAF provides a foundational framework for developing and representing architecture descriptions that ensure a common denominator for understanding, comparing, and integrating architectures across organizational, Joint, and multinational boundaries. It establishes data element definitions, rules, and relationships and a baseline set of products for consistent development of systems, integrated, or federated architectures. These architecture descriptions may include families of systems (FoS), systems of systems (SoS), and net-centric capabilities for interoperating and interacting in the non-combat environment.

- AoA (Analysis of Alternatives)

The AoA assesses potential materiel solutions to satisfy the capability need documented in the approved Initial Capabilities Document (ICD). It focuses on identification and analysis of alternatives, measures of effectiveness (MOE), cost, schedule, concepts of operations, and overall risk, including the sensitivity of each alternative to possible changes in key assumptions or variables. The AoA also assesses critical technology elements (CTE) associated with each proposed materiel solution, including technology maturity, integration risk, manufacturing feasibility, and, where necessary, technology maturation and demonstration needs.

- BBP (Better Buying Power)

The Better Buying Power (BBP) 2.0 directives requiring a commitment to reducing costs and increasing productivity, dedication to supporting the Warfighter, and a strong sense of stewardship of the taxpayers' dollars.

Architecture and Framework [1]

- If you can implement a drawing in ONLY one way, then the drawing contains exact specifications for instantiation and you have a DESIGN
- If you can implement a drawing in more than one way, you have an ARCHITECTURE
- If you can develop more than one architecture, then you have a FRAMEWORK that provides you with the underlying structure for developing these architectures

A framework should enable you to build specific architectures that meet specific needs

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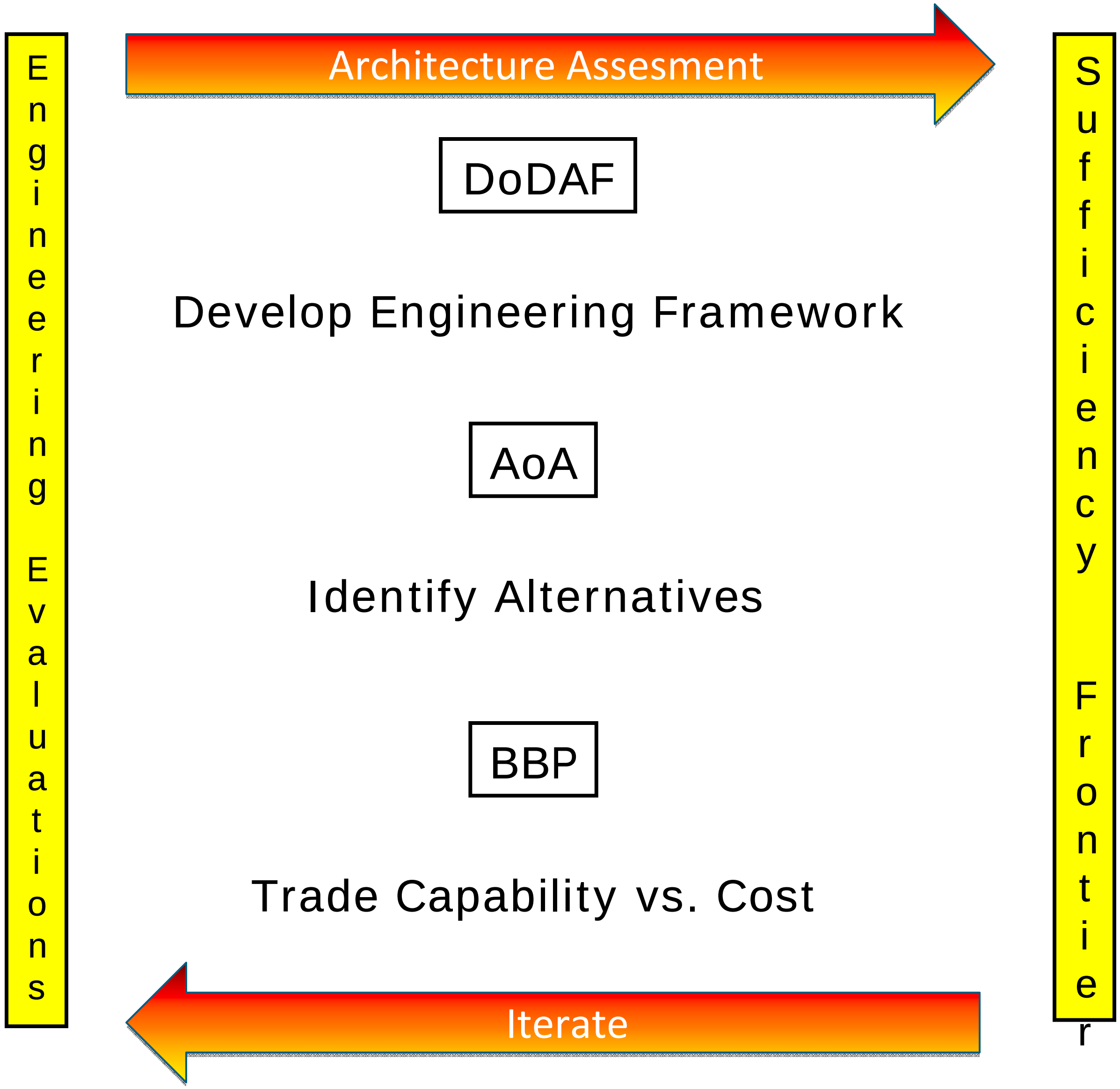
Pull It Together



Architecture Concepts Model (2)

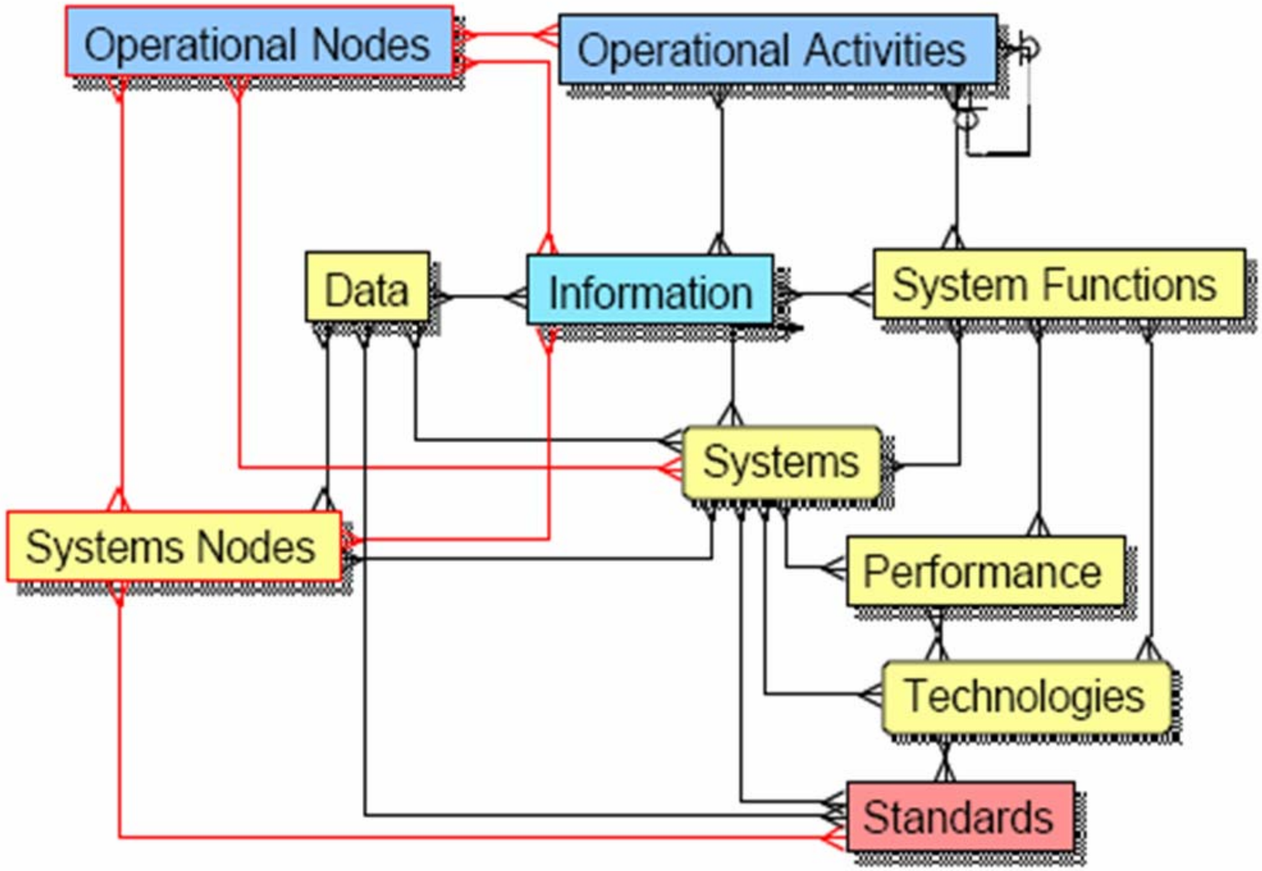
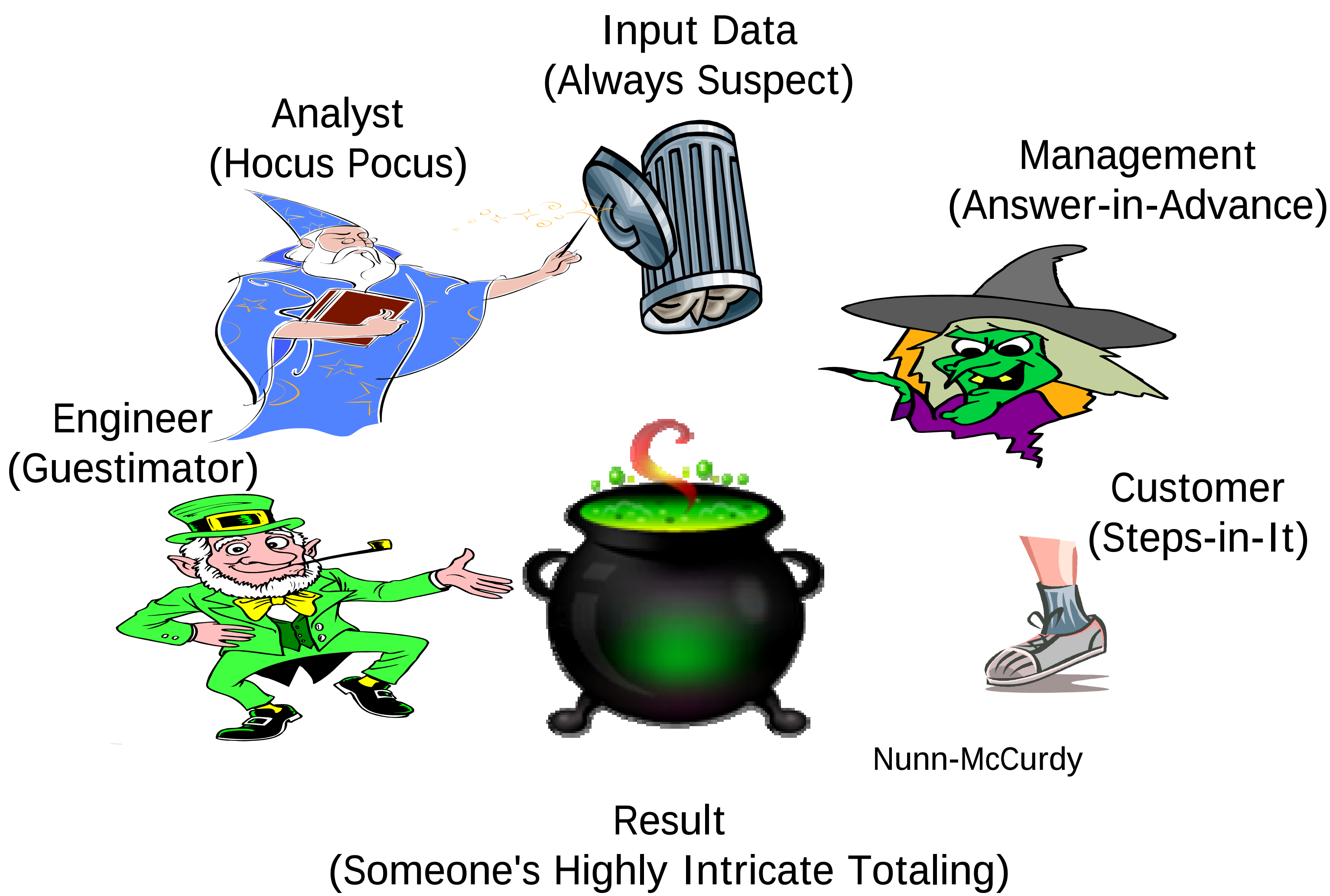


Figure 4.2-1. Architecture Concepts Model

Current Cost Analysis Across Systems

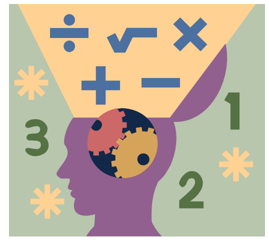


Everyone Has Their Own Agenda

Potential Cost Analysis Across Systems

Wall Street Data

Quant

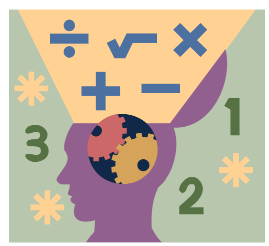


Fat Cat

WHY NOT?

Software/Hardware Drivers

Quant

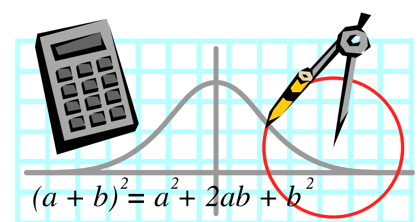


Mathematically Quantify the Analysis

Costing Systems Approach

Current is → Subjective Input and → Output is Manipulated by Inputs

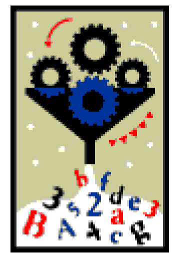
Future could be → Objective Input and → Output is Mathematically Derived



Remove Subjective Inputs to the Degree Possible

New Cost Analysis Approach Across Systems

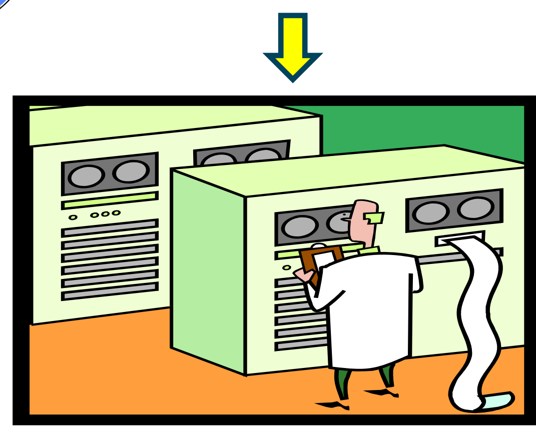
Data
(Unbiased Inputs)



Analyst
(Quantitative Assessment)

Management
(Focused on Capability vs $)

Engineers
(Identify Ripples
and Intersects
Satisfying
Mission)



Result
(Identifies Capability and
Cost Best Value)

Customer
(Gets Best Value
for Warfighter)

Engineers Working Closely with Cost Analyst

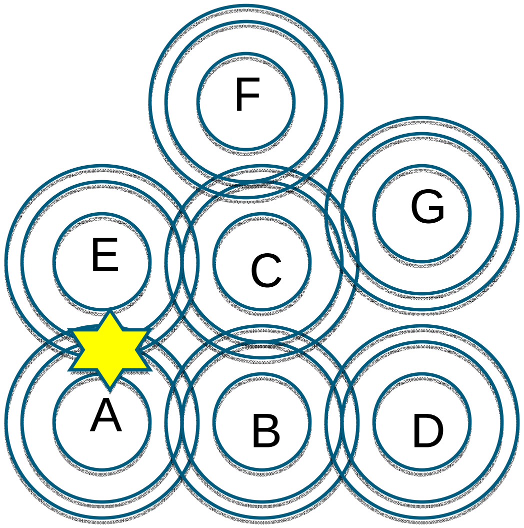
Engineering Ripples

- For System Engineers: Interference patterns result when two or more disturbances through space and time, called a wave, intersect or collide, creating a new wave pattern.

or

- For Cost Estimators: Cost impacts result when one element in a System, changes it's design, causing a design ripple, impacting other system elements, creating an unanticipated cost delta. Apply to System of Systems (SoS) and Family of Systems (FoS) the same way.

Just a Ripple in the Pond



- System A impacts System B
- System B impacts System of Systems C & D
- System C impacts Family of Systems E, F and G
- System E impacts System A

Identify How Systems, SoS and FoS Relate

Parameters Driving Cost

Capabilities/Requirements

Physical
- Mass/Energy
- Composition
- Tolerances
- Heavy/Light

Performance
- Threshold/Objective
- Bandwidth
- Shape
- Accuracy

Programmatic

Technical
- New/Existing Technology
- Design parameters
- Design Life
- Requirement Volatility
- Technology Maturity (i.e. TRL)

Contractual
- Cost Plus
- Fixed Price
- # ECPs & Associated $

Identify Common Drivers Between Systems, SoS and FoS

Common Cost Drivers & Capability Inputs

- Use Analytical Hierarchy Process (AHP) to Find Major Cost Driver Parameters
  - Derives Weighting of Parameter to Other Parameters
- Influence of Parameter
  - Continuous or Discrete Scales
  - Establish a Baseline (Unity Value)
  - Engineer/Cost Analyst Establishes with History (actuals) & Judgment

Use Same Inputs to Determine Capabilities and Cost

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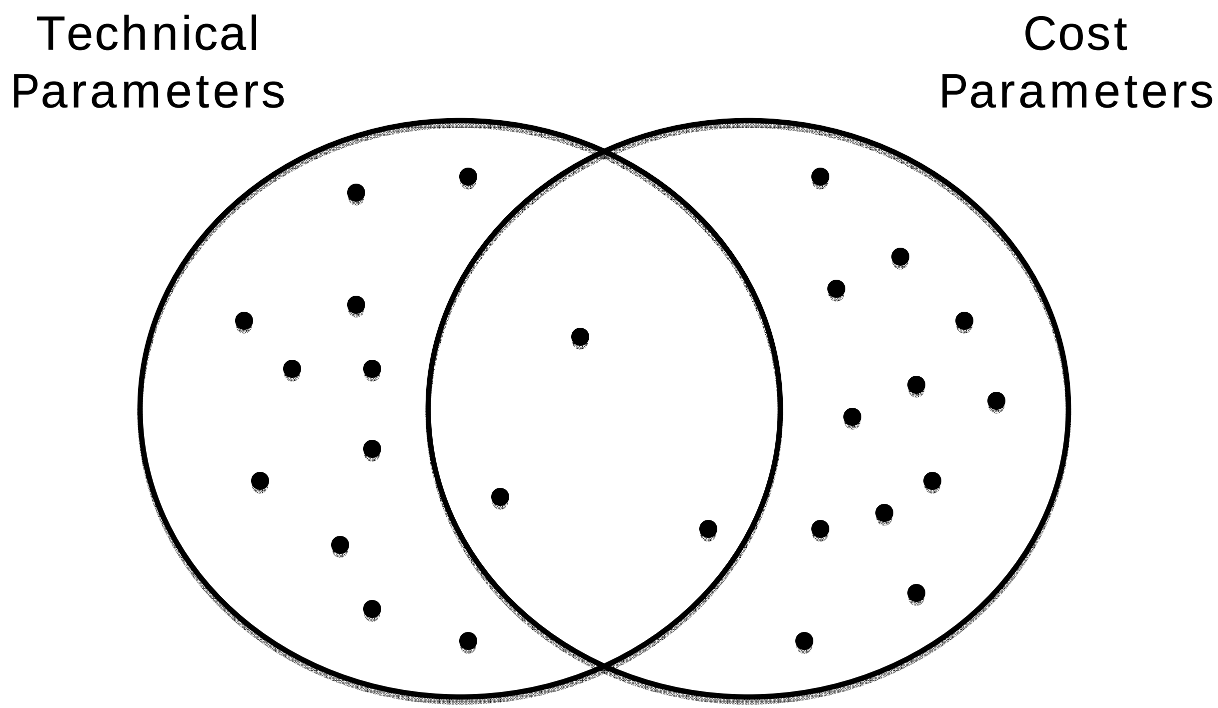
Capability & Cost Overlap



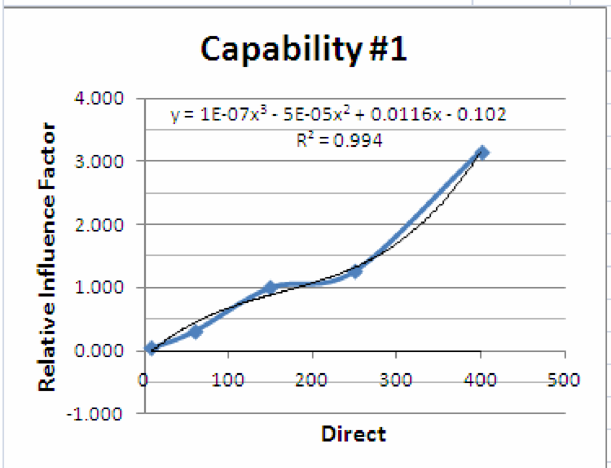
Find the Overlap Needed to Drive Both Simultaneously

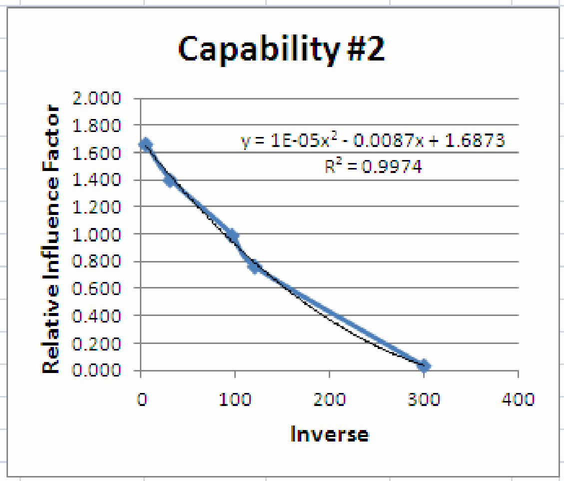
Quantify a Synthesized Mission Capability Value

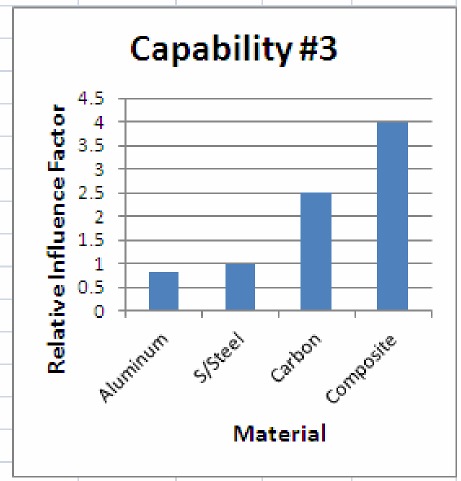
- Prioritize Mission Capabilities
- Ascertain Ordinal/Cardinal Ranking Values
- Determine parameters that are common between capability and cost
- Quantify Synthesized Consolidated Capability Value and Cost with parameters identified

Cost Influence Parameters

COST DRIVERS												
Continuous Capabilites	Units	Minimum	Midpoint 1	Exemplar	Midpoint 2	Maximum		Input	Factor	Weight	Factor * Weight	
Capability #1	Direct	8	60	150	250	400		400	3.040	50%	152.0%	
Relative Influence (w/Exemplar at Unity)		0.042	0.316	1.000	1.263	3.158			y= 1E-07x3 - 5E-05x2 + 0.0116x - 0.102			
Relative Influence Factor		0.042	0.316	1.000	1.263	3.158			R^2 = 0.9887			
Capability #2	Inverse	4	30	95	120	300		300	-0.023	30%	-0.7%	-8
Relative Influence (w/Exemplar at Unity)		1.667	1.405	1.000	0.762	0.036			y = 1E-05x2 - 0.0087x + 1.6873			
Relative Influence		7	5.9	4.2	3.2	0.15			R^2 = 0.9954			
Relative Influence Factor												
Discrete Capabilitys		Capability 1	Capability 2	Exemplar 3	Capability 4							
Capability #3	Material	Aluminum	S/Steel	Carbon	Composite			Composite	2	20%	20.0%	
Relative Influence (w/Exemplar at Unity)		0.8	1	2.5	4							
Relative Influence Factor		0.8	1	2.5	4					100%	171.3%	







Consolidation Capability Matrix

< High - Capability Level - Low >	< Low - Requirement Importance - High >										
	1	2	3	4	5	6	7	8	9	10	11
1	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50
2	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55
3	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60
4	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65
5	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70
6	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75
7	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80
8	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85
9	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90
10	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
11	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00

Satisfaction Levels of Requirements & Capabilities

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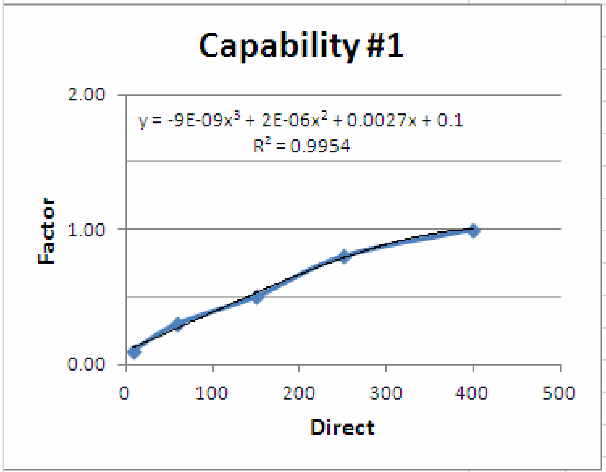
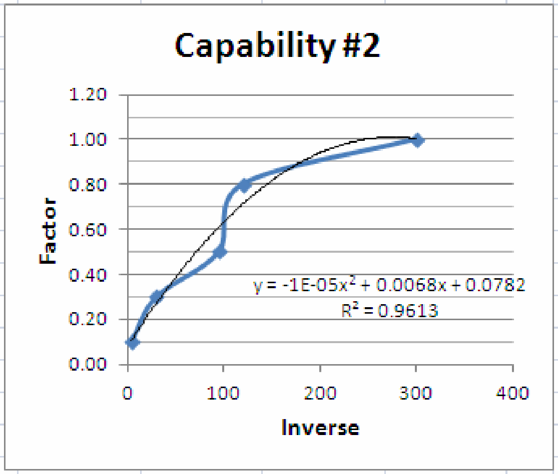
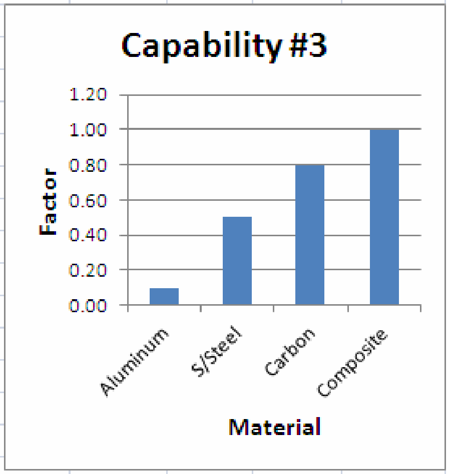
Capability Valuation

CAPABILITY DRIVERS								
Capability #1	Direct	8	60	150	250	400		
Capability		2.000	4.000	6.000	9.000	11.000		$y = -9E\text{-}09x^3 + 2E\text{-}06x^2 + 0.0027x + 0.1$
Requirement		2.000	4.000	6.000	9.000	11.000	400	0.924
Factor		0.10	0.30	0.50	0.80	1.00		
Capability #2	Inverse	4	30	95	120	300		
Capability		2.000	4.000	6.000	9.000	11.000		y = -1E-05x2 + 0.0068x + 0.0782
Requirement		2.000	4.000	6.000	9.000	11.000	300	1.2182
Factor		0.10	0.30	0.50	0.80	1.00		
		1	2	3	4			
Capability #3	Material	Aluminum	S/Steel	Carbon	Composite			
Capability		2.000	6.000	9.000	11.000			
Requirement		2.000	6.000	9.000	11.000			
Factor		0.10	0.50	0.80	1.00			







Generate Scatter Diagram Containing Frontier

Continuous Parameters	Units	Input	Factor	Weight	Impact		Units	Input	Factor	Weight	Impact	Discrete Parameters	Units	Input	Factor	Weight	Impact %	Cost Factor	Consolidated Capability Factor	P#1 MCM	P#2 MCM	P#3 MCM
Capability #1	**Direct**	355	2.007	50%	100%	Capability #2	**Inverse**	274	0.054	30%	2%	Capability #3	**Material**	4	4.000	20%	80%	**1.820**	**4.498**	0.908	2.590	1.000
Capability #1	**Direct**	266	1.210	50%	60%	Capability #2	**Inverse**	288	0.011	30%	0%	Capability #3	**Material**	3	2.500	20%	50%	**1.108**	**4.350**	0.790	2.760	0.800
Capability #1	**Direct**	218	0.969	50%	48%	Capability #2	**Inverse**	276	0.048	30%	1%	Capability #3	**Material**	4	4.000	20%	80%	**1.299**	**4.305**	0.690	2.614	1.000
Capability #1	**Direct**	332	1.745	50%	87%	Capability #2	**Inverse**	256	0.115	30%	3%	Capability #3	**Material**	4	4.000	20%	80%	**1.707**	**4.268**	0.887	2.380	1.000
Capability #1	**Direct**	133	0.692	50%	35%	Capability #2	**Inverse**	289	0.008	30%	0%	Capability #3	**Material**	4	4.000	20%	80%	**1.148**	**4.246**	0.473	2.772	1.000
Capability #1	**Direct**	244	1.088	50%	54%	Capability #2	**Inverse**	265	0.084	30%	3%	Capability #3	**Material**	4	4.000	20%	80%	**1.369**	**4.231**	0.747	2.484	1.000
Capability #1	**Direct**	211	0.941	50%	47%	Capability #2	**Inverse**	268	0.074	30%	2%	Capability #3	**Material**	4	4.000	20%	80%	**1.293**	**4.194**	0.674	2.519	1.000
Capability #1	**Direct**	325	1.674	50%	84%	Capability #2	**Inverse**	291	0.002	30%	0%	Capability #3	**Material**	2	1.000	20%	20%	**1.038**	**4.177**	0.880	2.797	0.500
Capability #1	**Direct**	353	1.982	50%	99%	Capability #2	**Inverse**	260	0.101	30%	3%	Capability #3	**Material**	3	2.500	20%	50%	**1.522**	**4.133**	0.906	2.426	0.800
Capability #1	**Direct**	221	0.982	50%	49%	Capability #2	**Inverse**	257	0.112	30%	3%	Capability #3	**Material**	4	4.000	20%	80%	**1.324**	**4.089**	0.697	2.392	1.000
Capability #1	**Direct**	376	2.287	50%	114%	Capability #2	**Inverse**	253	0.126	30%	4%	Capability #3	**Material**	3	2.500	20%	50%	**1.681**	**4.066**	0.920	2.346	0.800
Capability #1	**Direct**	62	0.448	50%	22%	Capability #2	**Inverse**	288	0.011	30%	0%	Capability #3	**Material**	4	4.000	20%	80%	**1.027**	**4.033**	0.273	2.760	1.000
Capability #1	**Direct**	144	0.724	50%	36%	Capability #2	**Inverse**	279	0.038	30%	1%	Capability #3	**Material**	3	2.500	20%	50%	**0.873**	**3.954**	0.503	2.650	0.800
Capability #1	**Direct**	285	1.336	50%	67%	Capability #2	**Inverse**	248	0.145	30%	4%	Capability #3	**Material**	3	2.500	20%	50%	**1.211**	**3.914**	0.824	2.290	0.800
Capability #1	**Direct**	169	0.798	50%	40%	Capability #2	**Inverse**	251	0.134	30%	4%	Capability #3	**Material**	4	4.000	20%	80%	**1.239**	**3.894**	0.570	2.324	1.000
Capability #1	**Direct**	53	0.408	50%	20%	Capability #2	**Inverse**	278	0.042	30%	1%	Capability #3	**Material**	4	4.000	20%	80%	**1.016**	**3.886**	0.247	2.638	1.000
Capability #1	**Direct**	71	0.485	50%	24%	Capability #2	**Inverse**	281	0.032	30%	1%	Capability #3	**Material**	3	2.500	20%	50%	**0.752**	**3.773**	0.299	2.674	0.800
Capability #1	**Direct**	40	0.344	50%	17%	Capability #2	**Inverse**	288	0.011	30%	0%	Capability #3	**Material**	3	2.500	20%	50%	**0.676**	**3.770**	0.211	2.760	0.800
Capability #1	**Direct**	44	0.365	50%	18%	Capability #2	**Inverse**	286	0.017	30%	1%	Capability #3	**Material**	3	2.500	20%	50%	**0.687**	**3.757**	0.222	2.735	0.800

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Monte Carlo Was Constrained to Input Range

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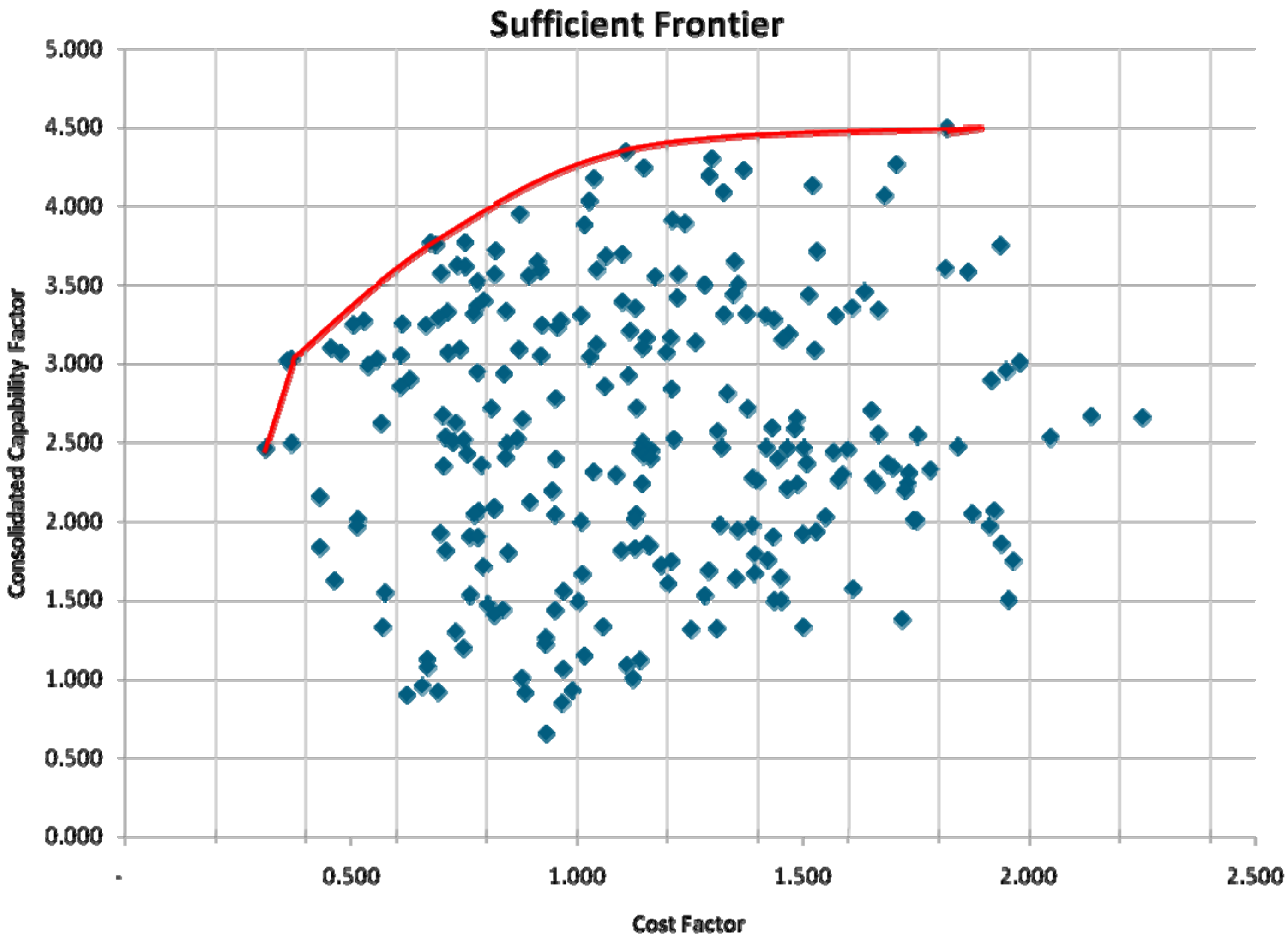
Capability vs Cost and the Sufficient Frontier



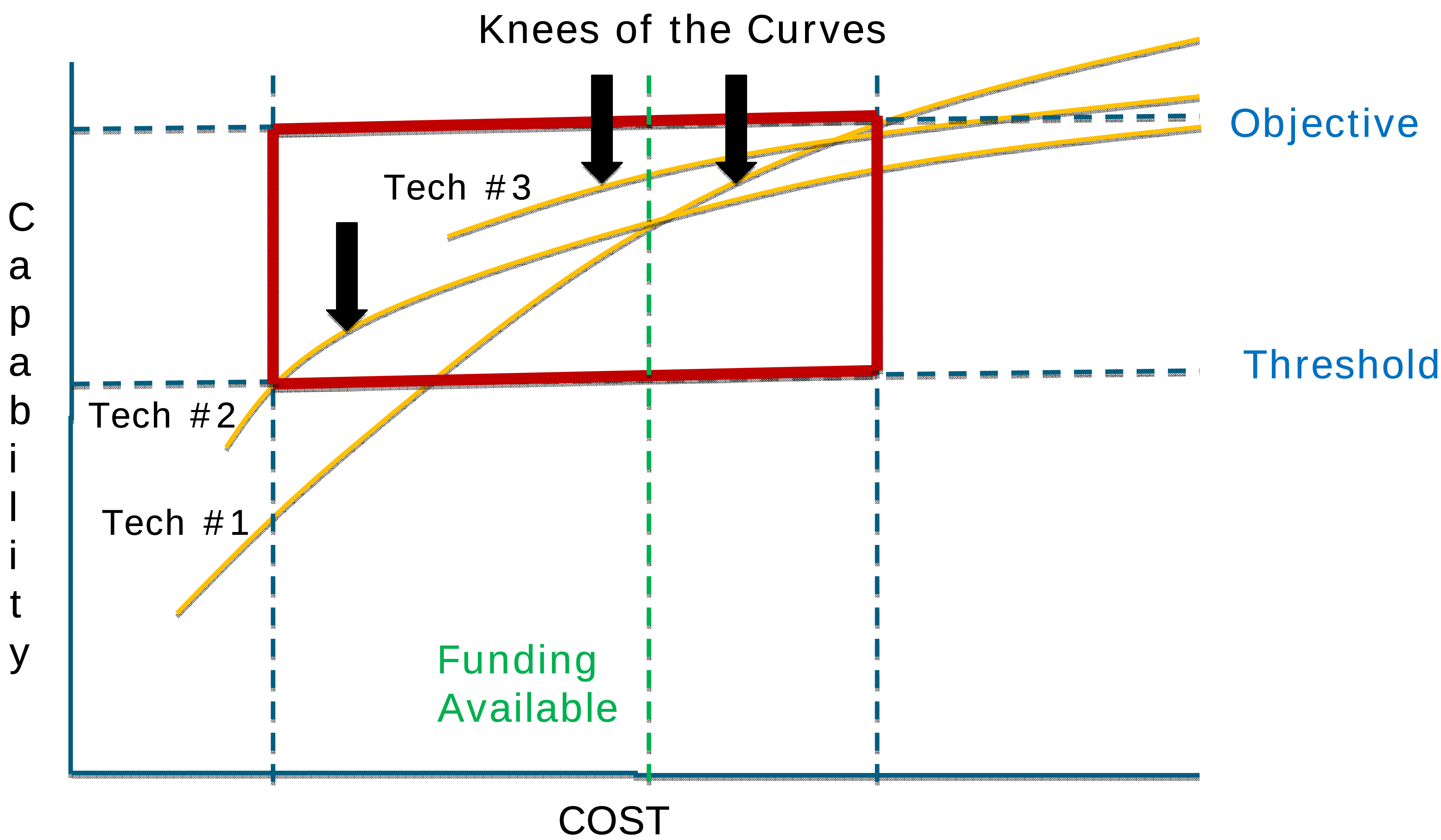
Architectures Providing Most "Bang" for the "Buck"

Establishing Frontier Criteria

- DoD Instruction 4630.8, which defines an integrated architecture as "An architecture consisting of multiples views or perspectives facilitating integration and promoting interoperability across capabilities and among integrated architectures". *The term integrated means that data required in more than one instance in architectural views is commonly understood across those views.*
- A way of valuing a set of choices
  - Determining the Set of Parameters
- Sufficient Frontier may provide a discrete set of solutions as opposed to a statistical representation of the entire trade space.

Allows Down Select to Architectures that Satisfy Mission

Summary



Cost As An Independent Variable in AoA Assessment

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- (1) Saurabh Mittal, “Overview of DoDAF”, Feb 17, 2005, ACIMS Lab, ECE Dept., University of Arizona, saurabh@ece.arizona.edu, www.acims.arizona.edu
- (2) DoD Architecture Framework Version 1.0, “Deskbook”, 15 August 2003
- (3) Robert Shishko, Ph.D., “The Application of Architecture Frameworks to Modeling Exploration Operations Costs”, Aug 24, 2006, Jet Propulsion Laboratory, California Institute of Technology

Questions?

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