The System Capability Architecture: Enabling Capability-Based Cost Analysis

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Agenda

- Policy and Background
- Early Cost Definitions and Concepts
- The System Capability Architecture (SCA)
- The SCA Dictionary
- The Capability Mapping Process
- Evolution and Peer Review
- The Capability to Performance Data Progression
- Summary and Conclusions

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Policy and Background

❖**2006 Quadrennial Defense Review**: Called upon the Department of Defense to "better integrate the processes that define needed capabilities, identify solutions, and allocate resources to acquire them in order to enable corporate decision-making that cuts across traditional stovepipes."

❖**DoDI 5000.02 Revision (8 December 2008)**

- Updates include:
  - Mandatory Materiel Development Decision (MDD)
  - Milestone A Independent Cost Estimates
  - Milestone A Component Cost Estimates
  - Milestone A Analyses of Alternatives

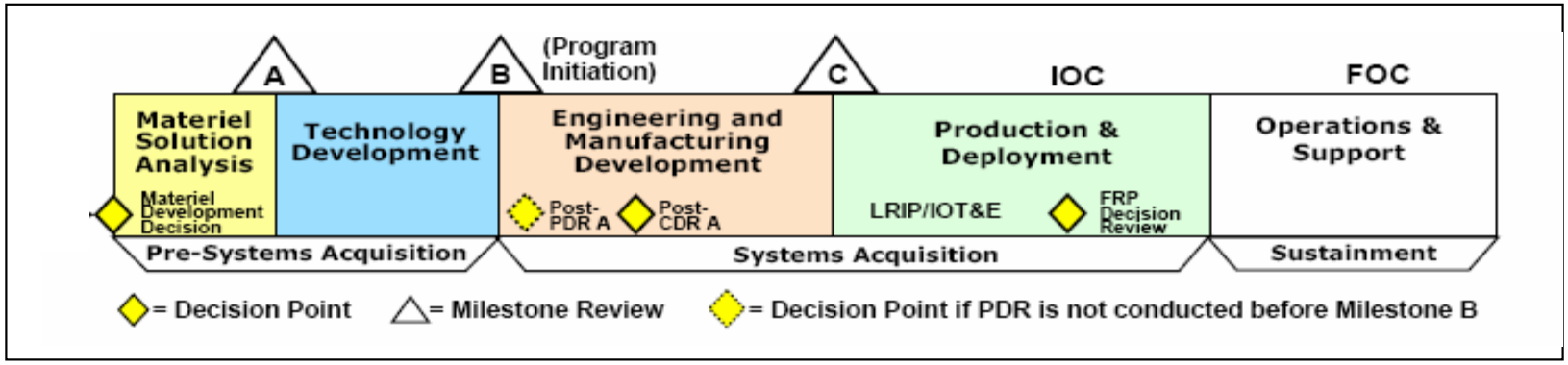

Figure 1: The Defense Acquisition Management System
(Source: DoDI 5000.02 Dated 8 December 08)

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Emergence of Capability-Based Cost Analysis and Why It's Important

Capability-based cost analysis was first conceived of to address the problem of data scarcity early in a system's life cycle. It is a technique for producing an estimate using capability data only.

Capability-Based Cost Analysis Specifically Addresses:

- Data-poor environments (such as Pre-Milestone-A)
- Analysis needs early in the acquisition life cycle
- Enabling the costing of "concepts" or "paper systems"
- Using capability data (which is what is usually most available for early analysis)
- Need for high-level cost analysis to support early investment decisions across portfolios

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Pre-Milestone-A and Capability-Based Cost Estimating

Capability-Based Cost Estimating

❖ *We Can Use the Capabilities of Current Systems and Their Associated Costs to Provide Cost Estimates For Capability-Gap-Filling Solutions*

Pre-Milestone-A Cost Estimating

❖ *Analysis That Uses Information Known Prior to Milestone A to Create a Cost Estimate*

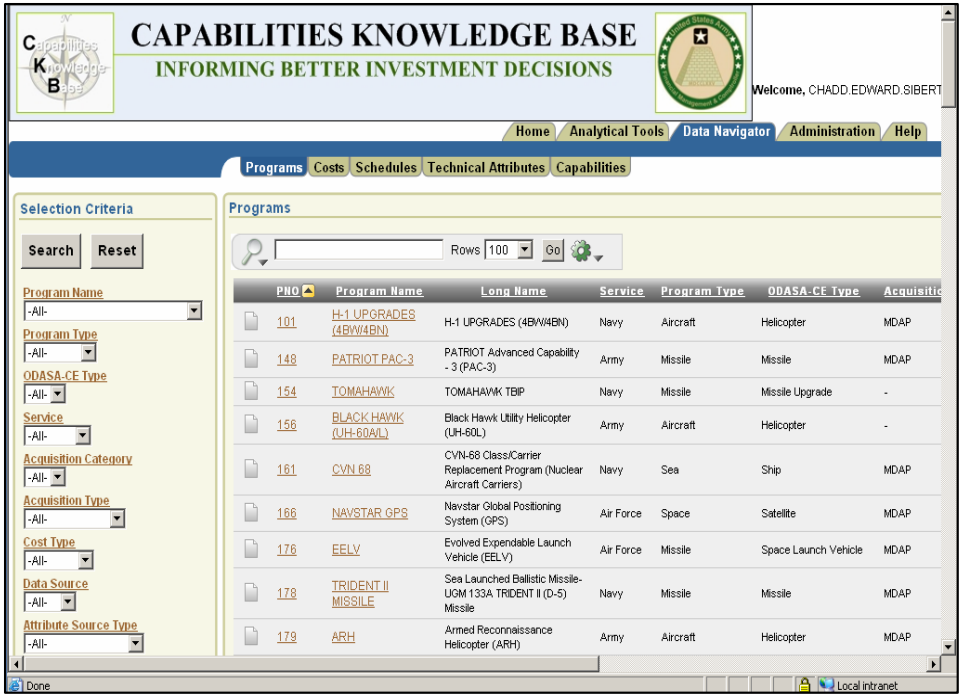
❖ *Theoretical Worst Case Scenario: Capabilities Only*

❖ *If We Know More, We Can Improve Fidelity*

❖ *A Risk-Informed Estimate That Provides a Likely Cost Range*

Key: The Nature of Capability Data/Variables

The Capabilities Knowledge Base (CKB) and the System Capability Architecture (SCA)



Specification	CKB
ACAT Levels Included	I, II, III
Services Included	Army, Air Force, Navy, DoD
Systems Included	188
SAR / DAES Reports Included	1362
Data Fields per System	90
JIAT (Data Standards) Compatible	Yes
Technical Parameters Included	Yes
Automated Downloading	Yes
Analysis Tools Included	Yes

The System Capability Architecture is the foundation of the CKB and provides the structure for mapping systems to their capability sets.

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Introduction to the System Capability Architecture (1 of 2)

1. Maneuver – Environment	**5. Support**	**8. Sense**	**11. Deploy**
1.1 Ground	5.1 Ground	8.1 Detect	11.1 Self
1.2 Maritime	5.2 Maritime	8.2 Locate	11.2 Ground
1.3 Submerged	5.3 Submerged	8.3 Classify	11.3 Air
1.4 Air	5.4 Air	8.4 Identify	11.4 Water
1.5 Space	5.5 Space	8.5 Track	**12. Train**
2. Control	5.6 Personnel	**9. Protect**	12.1 Training
2.1 Manned	**6. Transport**	9.1 Self	12.2 Leader Development
2.2 Unmanned	6.1 Ground	9.1.1 Stealth	12.3 Enroute Rehearsal (Embedded)
3. Shoot	6.2 Maritime	9.1.2 Armor	**13. Manage Data**
3.1 Line-of-Sight (LOS)	6.3 Submerged	9.1.3 Other	13.1 Store
3.2 Beyond-Line-of-Sight (BLOS)	6.4 Air	9.2 Area Defense (Battlefield)	13.2 Distribute
3.3 Non-Line-of-Sight (NLOS)	6.5 Space	9.3 Regional Defense (Theater)	13.3 Process
4. Explode – Penetrate	6.6 Personnel	9.4 Homeland Defense	13.4 Secure
4.1 Small Effect	6.7 Cargo	9.5 Environment	
4.2 Local Effect	**7. C3I**	**10. Sustain**	
4.3 Large Effect	7.1 Local Area	10.1 Supply	
4.4 Mass Effect	7.2 Wide Area	10.2 Maintain	
	7.3 Area Command and Control	10.2.1 Hardware	
	7.4 Theater Battle Management	10.2.2 Software	
	7.5 Net-Centric	10.3 Reconstitute	

- The SCA enables capability-based cost analysis and is the backbone of the CKB
- SCA links systems to their capability sets for use in a relational database environment for viewing, calculations, and analysis.

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Introduction to the System Capability Architecture (2 of 2)

1. Maneuver – Environment	**5. Support**	**8. Sense**	**11. Deploy**
1.1 Ground	5.1 Ground	8.1 Detect	11.1 Self
1.2 Maritime	5.2 Maritime	8.2 Locate	11.2 Ground
1.3 Submerged	5.3 Submerged	8.3 Classify	11.3 Air
1.4 Air	5.4 Air	8.4 Identify	11.4 Water
	5.5 Space	8.5 Track	**12. Train**
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	7.4 Theater Battle Management	10.2.2 Software	
	7.5 Net-Centric	10.3 Reconstitute	

Through use of the SCA, the CKB enables the study of shared capabilities across groups of systems and analysis of capability redundancies, gaps, costs, and more. One of the key challenges with the development of the SCA is that it required the generation of variables specific enough to meaningfully differentiate among systems and capability sets, but broad enough to be used with the limited information available at Milestone A.

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Development of the SCA/History/Relationship to Other DoD Paradigms

- Capability-Based Cost Analysis Project first began in 2006
- ODASA-CE knew that a capabilities variable set (or architecture) would be required in order to establish system-capability relationships
- Preferred course of action was to use a pre-existing DoD architecture such as the Joint Capability Areas (JCA), it became clear that these did not fit the criteria of the CKB
- In order to develop a wide range of capability-based analysis methods including parametric and binary-variable analysis, we needed a specific, distinguishable, well-defined, and analysis-ready architecture
- SCA is directly mapped to the JCAs in order to allow “translation” between the two

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Joint Capability Areas to System Capability Architecture Mapping

Capability Level	SCA WBS	Level 1	Level 2	Level 3	JCA -- Level 1	JCA -- Level 2	JCA -- Level 3
1	1.0	Maneuver – Environment			Force Application	Maneuver	Maneuver to Engage; Insert; Influence; Secure.
2	1.1		Ground		Force Application	Maneuver	Maneuver to Engage; Insert; Influence; Secure.
2	1.2		Maritime		Force Application	Maneuver	Maneuver to Engage; Insert; Influence; Secure.
2	1.3		Submerged		Force Application	Maneuver	Maneuver to Engage; Insert; Influence; Secure.
2	1.4		Air		Force Application	Maneuver	Maneuver to Engage; Insert; Influence; Secure.
2	1.5		Space		Force Application	Maneuver	Maneuver to Engage; Insert; Influence; Secure.
1	2.0	Control			Command and Control	Direct	Task
2	2.1		Manned		Command and Control	Direct	Task
2	2.2		Unmanned		Command and Control	Direct	Task

- The SCA has been mapped to JCA so an analyst can translate between the two, if need be
- The above is a subset of the SCA/JCA mapping

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The SCA Dictionary

Capability	Capability Level	Definition	Example(s)
1. Maneuver – Environment	I	An entity that maneuvers via the ground, water, or air.	Vehicles; ships; and aircraft.
1.1 Ground	II	An entity that maneuvers on the ground.	Ground vehicles and tanks (ex: Joint Light Tactical Vehicle -- JLTV).
1.2 Maritime	II	An entity that maneuvers on the surface of the water.	Ships (ex: DDG 51).
1.3 Submerged	II	An entity that maneuvers below the surface of the water.	Submarines (ex: SSN-774 Virginia NSSN).
1.4 Air	II	An entity that maneuvers within the air of the Earth's atmosphere.	Aircraft; helicopters; and unmanned aerial vehicles (UAVs). Ex: C-130J Hercules.
1.5 Space	II	An entity that maneuvers beyond the air of the Earth's atmosphere (i.e. space).	Shuttles; rockets; and other spacecraft (ex: Titan IV, Expendable Launch Vehicle -- ELV).
2. Control	I	An entity of any type that is controlled.	Ground vehicles; ships; UAVs; and UGVs.
2.1 Manned	II	An entity of any type that is manned or controlled by a person within the entity.	Any manned water, ground, or air vehicle (ex: Stryker).
2.2 Unmanned	II	An entity of any type that is not controlled by a person within the entity.	Unmanned aerial vehicles (UAVs) or any unmanned ground or water entity (ex: VTUAV -- Fire Scout).

- Clearly, there are many potential interpretations of the individual capabilities
- To provide clarity, the SCA dictionary accompanies the SCA
- Each capability within the SCA is defined in the SCA dictionary, and changes to the SCA have a corresponding change in the SCA dictionary
- Detailed capability mapping procedures have been developed to make the mapping process transparent and repeatable

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The Capability Mapping Process

o System capabilities are binary variables
o Although inherently complex, the task of assigning capabilities to a system is kept as simple as possible
o It is imperative to involve platform SMEs to the fullest extent possible
o Important to define a system boundary as well as possible --- in other words, to clearly designate what is included and excluded from a system (or capability set)

- Must consider what portions of the system were developed and procured with its allocated funding (ex: government-furnished equipment)

Process

❖All applicable capabilities are included, not just the major ones

❖ When assigning capabilities to a program that is an upgrade to an existing system, only those capabilities specifically addressed by the upgrade are included. (ex: maneuvering via air would only be included if the upgrade also addressed the flight systems)

❖ These examples demonstrate that analyst judgment and expertise is a key in developing and using the SCA (and CKB)

❖ Capability assignment typically begins at the top tier level (13 parent capabilities) --- even defining at this high level allows the use of cost forecasting tools

❖ If further information is available, the second and third level can be evaluated similarly to the first level

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SCA Evolution, Peer Review, and Community of Interest

- Detailed SCA capability mapping procedures have been developed
  - Standardize and expedite the mapping process
  - Make it transparent and repeatable
- Users able to easily trace how a system was mapped to its capability set
- Users able to spot any errors or anomalies quickly
- Mapping is an iterative process subject to the imperative input and continuous improvement efforts by its community of interest

The Capability Data to Performance Data Progression (1 of 2)

- Capability-based cost analysis addresses the problem of data scarcity early in a system's life cycle.
- Used to produce an estimate using capability data only.
- However, such an estimate inherently has a high level of uncertainty associated with it.
- Capabilities alone are useful, but if performance or technical data is available, it behooves an analyst to make the best possible use of the additional information.

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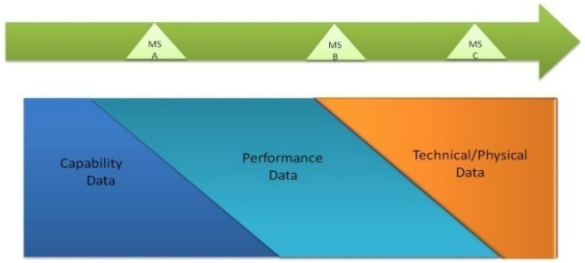
The Capability Data to Performance Data Progression (2 of 2)



- The types of data suitable for analysis within the acquisition life cycle can be thought of as being on a continuum
- Pre-Milestone A, capability data is almost certainly available to support cost analysis, and it is likely that there is at least some performance data available
- As a concept or system matures, available data to support analysis transitions from capability data to performance data and eventually to mostly technical and/or physical data
- SCA capability variable set is what enables cost analysis based on capability data at early decision points
- CKB facilitates the combined usage of capabilities, performance, technical, and physical data
  - For example, the capability of ground-based movement can be used with or without performance data such as average mph or max range; a shooting capability can be used with or without the system's accuracy
  - Joint Effects Targeting System (JETS) used not only capability data, but also performance data

At Milestone A, available performance and/or technical data may reflect requirements, but may not accurately represent the system's actual end state (due to technical impediments or overly optimistic analysis). Analysts must always be attuned to this issue.

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Summary and Conclusions

- DoD is Changing
  - Increased and scrutinized Pre-Milestone-A and Milestone A cost analysis
- Capability-based cost analysis is a way of thinking about cost analysis that is designed to cope with the data-poor environment that exists pre-Milestone A
- Capability-based cost analysis is not limited to the pre-Milestone-A timeframe (and that pre-Milestone-A cost analysis it not limited to capability-based cost analysis only)
- SCA enables capability-based cost analysis and the CKB --- it establishes, defines, and standardizes capability data variables
- SCA leverages the DoD capability-based management and doctrinal architectures and maps directly to both the JCA and the FCB
- It is imperative that the cost analysis community be active participants and provide input into ways to improve/enhance capability-based cost analysis and the SCA