



Acquisition Research Program:
Creating Synergy for Informed Change

**Application of Transaction Cost Economics
to Capabilities-Based Acquisition:
Exploring Single Service vs. Joint Service Programs and
Single Systems vs. Systems-of-Systems**

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Outline

- Background and Challenges (R. Flowe)
 - » Joint Programs and Systems-of-Systems
- The TCE Model (F. Melese)
 - » Key Characteristics that Spell Trouble, and What TCE Tells Us To Do About Them.
- Testing the Model (D. Angelis)
 - » Data, Tests, and Preliminary Results
- Summary (R. Flowe)



BACKGROUND AND CHALLENGES

- Background
 - Weapon system investments capture a significant share of defense budgets
 - Strong emphasis on “Jointness” generated by new Joint Capabilities Integration and Development System (JCIDS)
- Challenges
 - Could benefits of “Jointness” be lost through increased cost and schedule breaches?
 - Can Transaction Cost Economics (TCE) offer insights to mitigate adverse program outcomes from increased interdependence of Joint programs?



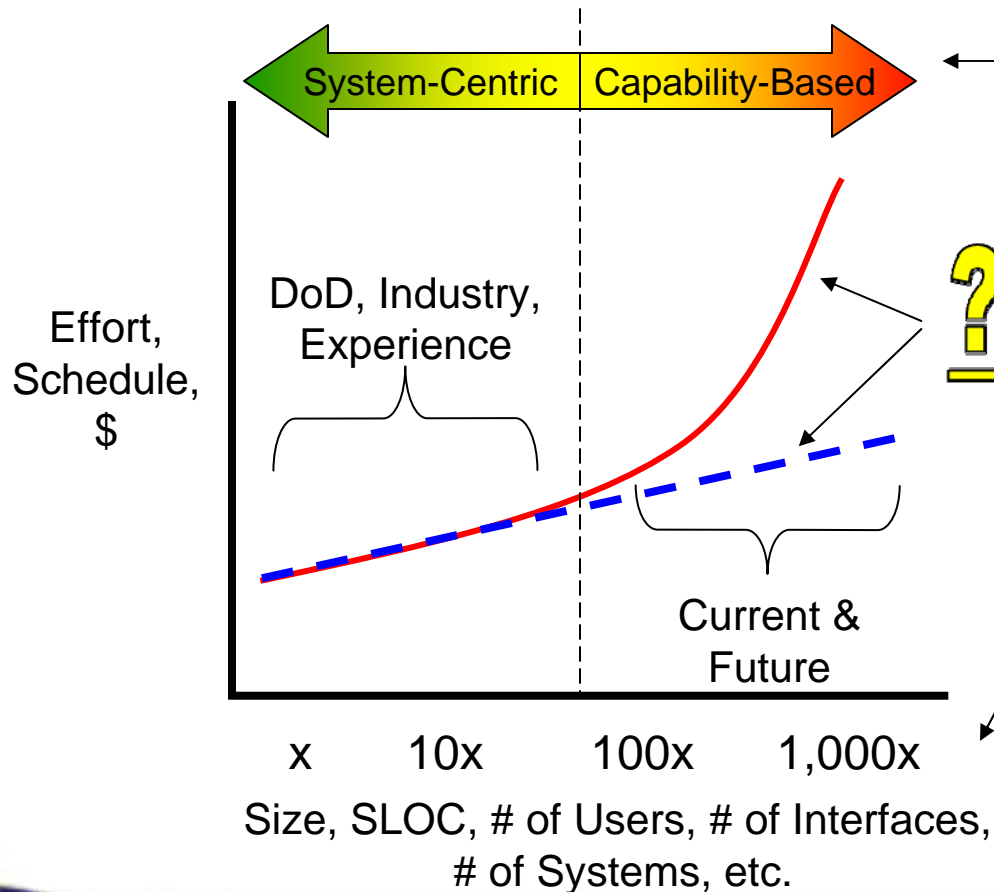
Implications of JCIDS joint “Capabilities Focus” in Systems Acquisition

- DoD emphasizes investments in “capabilities” to support Joint Operations
 - Focus on benefits of multiple systems working together in a ‘systems of systems’ (SoS) or ‘net-centric’ context
 - Existing (legacy) and new systems are required to work together towards the capability objective
- In most cases, DoD acquires individual systems
 - Systems, programs defined to fulfill specific requirements, usually in functional, service-specific terms
 - Capability-oriented needs (e.g., net-centric, SoS) may put added demands on systems beyond specified requirements
 - This places additional risks, costs & constraints on program execution
 - Programs required to attend to “external” issues or be impacted by them (interdependencies)
 - Difficult to capture in baseline estimates
 - Manifested as cost growth, schedule delay & performance shortfall



The New Systems Acquisition Context: Focus on “Capabilities”

**DoD manages at the “Program” level
and engineers at the “System” level**



Nagging Questions

As the magnitude and complexity of DoD systems increase, how do we develop Realistic cost, schedule, & performance baselines?

Are linear assumptions valid? Which assumptions are?

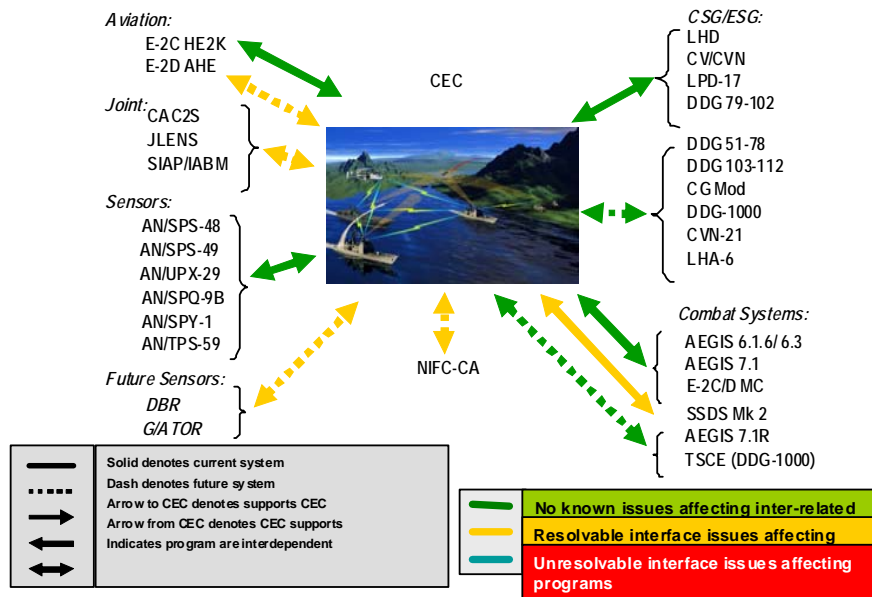
Are we measuring the right drivers of cost/schedule?

At what point do our assumptions and predictive ability “break down”?



Current Assessment of Interdependence

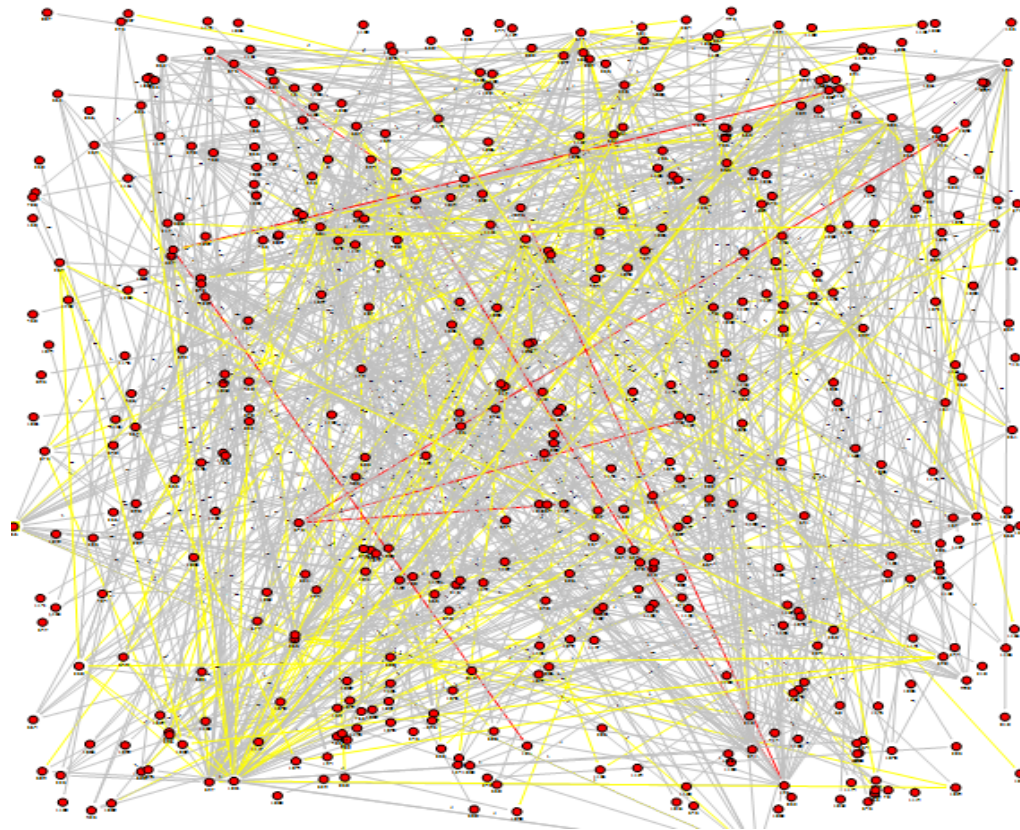
Interrelationships, Dependencies and Synchronization with Complementary Systems for DAES (Chart 5)



- **PRO:**
- Identifies Programs in context of known dependencies
- Provides indications of criticality, directionality, and timing
- **CON:**
- Subjective assessment of critical dependencies
- Not repeatable or consistent from report to report
- Subject to interpretation or “filtering”
- Not comprehensive
- Combines multiple types of interdependence without clear distinction
- No demonstrated linkage to outcomes

OSD considers interdependence important BUT Looking for better ways to characterize the risk

Aggregate Program Interdependence

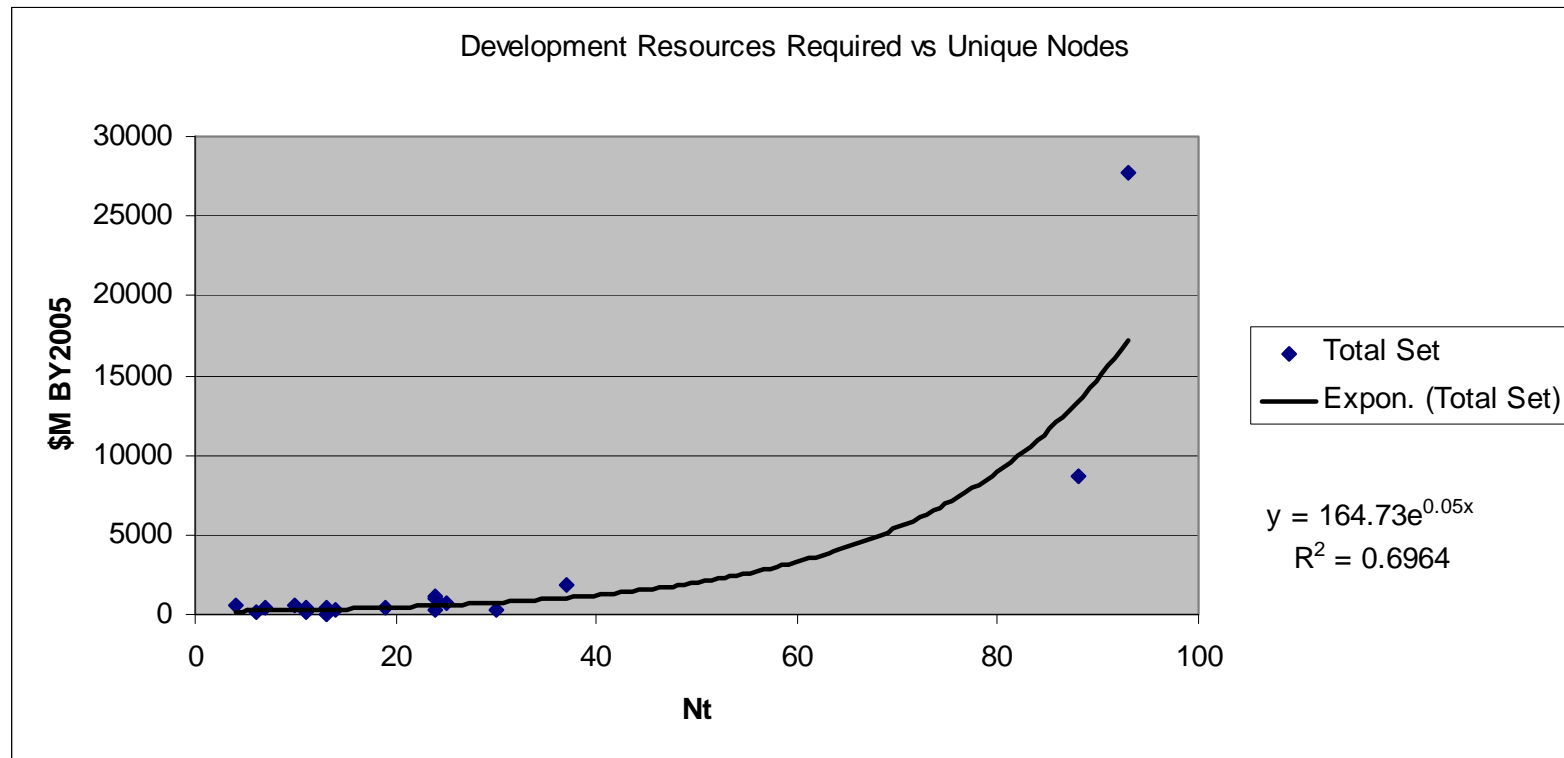


- Combined data from DAES Interdependence charts on 78 MDAPS, resulting in:
 - 442 unique programs of record identified as being interdependent in some way
 - 989 unique linkages identified
 - 804 links (81%) are coded “green” (shown here as gray)
 - 177 links (18%) are coded “yellow”
 - 8 links (1%) are coded “red”
- Interdependencies exist among all MDAPS
- Most interdependencies with and among non-MDAPs

**This insight alone does not support decision making
Need to identify critical interdependencies & discern risks**

Exploring Cost Implications of Complexity

- Architectures of programs gives insight into interdependencies and thus complexity



- Development cost appears to be correlated with number of entities involved
- Nonlinear relationship suggest # of linkages contribute significantly to total cost



Interdependence & Complexity

- Recurring theme of “Interdependence” among individual entities
 - Among units in an operational context
 - Among systems in the engineering context
 - Among programs in the acquisition context
- Interdependence exists in SoS, etc., but also in absence of explicit aggregation
 - No program is an “island”
- Complexity of the problem / solution space driven by the number of entities to be coordinated / integrated

Interdependence emerging as an important driver of complexity in current acquisition environment



THE TCE MODEL

- The Main insight of Transaction Cost Economics (TCE) is that understanding certain key characteristics of a transaction can help anticipate two significant, but frequently neglected weapon system costs: “Coordination” and “Motivation” costs.
 - Understanding underlying characteristics that drive transaction costs can help guide optimal choice of governance (contractual and other) mechanisms.
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- Goal of TCE: Design governance mechanisms that minimize coordination costs and the costs of motivating effort, and that spur specific investments, to achieve “Better, Faster, Cheaper.”



Key Characteristics of Defense Transactions:

1. Complexity

- What is the extent of Interdependence?

2. Uncertainty

- *Imperfect Information*: Do we know Demand/Quantity, Cost, Schedule, Performance/Quality? Can we specify all possible contingencies in the contract?
- *Asymmetric information*: Does someone have information advantage? How can we elicit truth-telling?

3. Frequency

- One-shot or repeated transaction? Does reputation matter?

4. Time Criticality

- Wartime or peacetime? How insensitive to price in emergencies?

5. Asset Specificity

- What are incentives for parties to invest in specific assets?

6. Market Contestability

- Is there ex-ante competition? What about ex-post?



The TCE Model: “Transaction Costs”

- **COORDINATION COSTS**

- ***Planning: Identify Alternatives***

- Search & Information Costs
 - Costs to acquire timely, accurate & relevant information (AoA)

- ***Programming: Choose an Alternative***

- Decision & Bargaining Costs (source selection)
 - Costs of negotiating and writing contracts

- ***Budgeting & Execution***

- Policing & Enforcement Costs
 - Costs of paying, executing, monitoring, measuring, and evaluating contracts (and re-negotiation)

- **MOTIVATION COSTS**

- ***Costs of Encouraging Specific Investments & Countering Opportunistic Behavior***

- Specific Asset investments can lead to “Hold-Up”



Transaction-Specific Asset Investments

(Specific assets lose their value in alternative use)

- Examples of Specific Assets :
 - Physical Assets (specialized equipment)
 - Human Assets (special skills, knowledge, training)
 - Site Specificity (special location that economizes on inventory (EOQ), transport costs)
 - Temporal Specificity (investment in key bottleneck activities (PERT/CPM) that impact overall project completion costs and schedules)
- The “HOLD UP” Problem
 - From Ex-ante competitive bidding to Ex-post “Bi-lateral Monopoly”



Minimizing Transaction Costs

- **To Cut Coordination & Motivation Costs of Joint SoS**
 - ***Reduce complexity***
 - Invest in more complete contract (search & information costs)
 - Use Mature technology
 - ***Reduce uncertainty***
 - Invest in more complete contract (bargaining & decision costs)
 - Measurement, Monitoring to reduce information asymmetries
 - Credible deterrents (enforcement, penalty clauses, warranties/bonding)
 - Align interests to induce truth-telling (accurate forecasts, etc.)
 - ***Increase frequency***
 - Multi-year contracts
 - Screening & selection using Reputation (incentive to build “goodwill”)
 - ***Address asset specificity***
 - Reduce government requirements for specific investments
 - Design governance mechanisms that protect specific investments
 - Government Furnished Equipment, GOCO facilities, etc.
 - ***Increase contestability***
 - Preserve some Government Standby Capacity/Expertise
 - Credible Threat of vertical integration (“back sourcing”)



TESTING THE MODEL

- System of Systems (SoS)
 - Interdependence: Independent systems combined/integrated into a larger system to provide unique capabilities
 - Hypothesis: Increased coordination and motivation costs from complexity, uncertainty, and issues of asset specificity, manifested in cost and schedule breaches.
- Joint System
 - A defense system that involves more than one service during any phase of the program (development, production, operation)
 - Hypothesis: Increased coordination and motivation costs from complexity, uncertainty, and issues of asset specificity, manifested in cost and schedule breaches.



METHODOLOGY

- 84 Major Defense Acquisition Programs were examined for baseline breaches:
 - Schedule
 - Research, Development, Test & Evaluation (RDT&E)
 - Program Acquisition Unit Cost (PAUC)
 - Average Procurement Unit Cost (APUC)
- System of System vs. Single System
 - originally examined by Brown, Flowe, & Hamel, 2007
- Joint Service vs. Single Service
- Kruskal-Wallis (H-test) to determine if there was a significant difference in the mean rank of breaches
 - Null hypothesis: no difference



STATISTICAL TESTS

Kruskal-Wallis (H-test)

Variable	Single System	System of Systems (SoS)		Single Service	Joint Service (Joint)	
	Mean Rank (n=39)	Mean Rank (n=45)	p-value	Mean Rank (n=58)	Mean Rank (n=26)	p-value
Schedule breaches	34.36	49.56	0.0039	38.56	51.31	0.0246
RDT&E breaches	32.44	51.22	0.0002	39.34	49.56	0.0631
PAUC breaches	39.14	45.41	0.2244	41.70	44.29	0.6418
APUC breaches	39.60	45.01	0.2633	42.09	43.42	0.7977



Preliminary Results

- In this sample, System-of-Systems (SoS) programs had significantly higher risk of cost and schedule breaches than single system acquisition programs.
- While “Jointness” by itself explained schedule overruns, it only weakly explained cost growth.
 - The mild impact on cost growth could be because “Joint programs” in our sample included a mix of single “Systems” and “Systems-of-Systems” (SoS).
- Future research should test whether Jointness in SoS programs attenuate or reinforces cost and schedule breaches.
 - Jointness might Attenuate SoS outcomes if, once approved, consensus is required to make any changes in the program so few changes occur.
 - Jointness might Reinforce SoS outcomes if increasing the number of players increases complexity, uncertainty and asset specificity.



Interdependence isn't "bad", it just "is"

- Joint Operations require interdependence
 - Multiple systems working together in a 'systems of systems' (SoS)
- Interdependence exists within SoS, FoS, Portfolios, Force Capability Packages, **or in the absence such designations**
- Interdependence among systems and programs is unavoidable, **in fact, it is essential**
 - Pro: Enables the Joint Force:
 - flexibility, agility, mass, maneuver, etc.
 - Con: Has the potential for adverse "emergent" behaviors due to complexity

Essential to understand interdependence and its effects

Dealing with Interdependence & Complexity

- Recognize interdependence exists in distinct contexts
 - Among units in an operational setting
 - Among systems in the engineering setting
 - Among programs in the acquisition setting
- Each context has distinct characteristics and effects, involves different “players” with distinct interests & equities
 - Essential to acknowledge and “harmonize” among these domains
- DoD must learn to effectively manage interdependence and the complexity it engenders



Conclusions

- Interdependence is significantly correlated with cost and schedule overruns and therefore should be examined as an important factor in Joint SoS programs
- Interdependence is manifested as several key characteristics in defense transactions: *Complexity*, *Uncertainty* and issues of *Asset Specificity*.
- TCE recommends focusing on these key characteristics to help design contracts and other governance mechanisms to anticipate and mitigate potentially adverse (cost, schedule, performance) outcomes.
 - Use TCE for basis of contract types and incentive structures
 - Manage the relationship and ownership of specific assets
 - Anticipate how transactions might change due to Jointness
- **The Main insight of Transaction Cost Economics (TCE) is that understanding certain key characteristics of a transaction can help design governance mechanisms that minimize coordination costs and the costs of motivating effort, and that spur specific investments, to achieve “Better, Faster, Cheaper.”**



Back-Up Slide

Current Acquisition Practices Address Some TCE Concerns

1. Multi-Year Contracting and Frequency
2. Integrated Product and Process Development and Asset Ownership
3. Cost as an Independent Variable (CAIV) – Heightened Awareness/Shared Risk
4. Alpha Contracting for ex-ante Discovery
5. Evolutionary Acquisition Addresses Uncertainty Incrementally
6. Single Process Initiative Uses Frequency and Specialization
7. Reputation and the Use of Past Performance Data and Award for Best Value



Back-up Slide

- A principal insight of TCE is that the choice of optimal governance structure (contracts, warranties, bonding, GOCO, etc.) depends on the characteristics of the transaction.
- Understanding transaction characteristics can improve outcomes if:
 - Transactions are sorted into categories based on their principal characteristics (complexity, uncertainty, frequency, asset specificity, market contestability)
 - **Alternative Governance Mechanisms: lifetime employment (fixed price contracts); bonuses, promotions & pay-for-performance (incentive contracts); efficiency wages (extra profits); deferred compensation (contract completion bonuses); screening & selection (reputation); posting bonds (termination clauses); cost plus contracts; monitoring; warranties;**



Back-Up Slide

- Among all MDAP's (1995-2005) most cost growth comes from estimating errors in program baselines (MDAP's mostly experienced schedule and PAUC breaches)
 - cost estimating must anticipate re-negotiation costs (hold-up, change orders, etc.) that can rapidly overwhelm initial “production” cost estimates.
 - If these ex-post opportunistic transaction costs are ignored, then future cost increases may not be properly anticipated.
 - **Transactions that require specific investments normally also require credible protection against early termination or opportunistic re-negotiation.**
 - Multi-year contracts (long-term contractual relationship)
 - Posting a bond (enforceable termination commitments)
 - **Reputation**

