SERC Technical Overview: First-Year Results and Future Directions

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Outline

- General context
  - First year objectives
    - Show ability to herd academic cats
    - Create foundations for transforming SE effectiveness
  - Team organization and practices
- First year project approaches and results
  - Task 1: Determine SE effectiveness measures (EMs): USC lead
    - Ultimate focus: Major Defense Acquisition Programs (MDAPs)
  - Task 2: Evaluate available SE methods, processes, and tools (MPTs): Stevens-DC lead
    - Ultimate focus: Quick-response net-centric services
  - Lessons learned for future projects
- Future directions

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Team Organization and Practices

- Common team organizations formed during SERC proposal
  - FC-MD: measurement, tools, best practices, agility
  - Stevens-DC: best practices, agility, SE EM tools
  - UAH: SE EM practices, program support
  - USC: SE EM MPTs, agility, program support
  - (MIT: INCOSE Leading Indicators, Lean Aerospace Initiative)
- Weekly joint telecons
- Sponsor-performer-prospective user workshops
  - USC: January; Stevens-DC: March, May, September
  - Services, FFRDC's, INCOSE, NDIA, industry
- Formulate, test hypotheses via surveys, tool piloting

Key EM Research Objective: Create SE EM's Enabling Evidence-Based Decisions

- Schedule-based reviews (contract-driven)
  - We'll hold the PDR on April 1 whether we have a design or not
  - High probability of proceeding into a Death March
- Event-based reviews (artifact-driven)
  - The design will be done by June 1, so we'll have the review then
  - Large "Death by PowerPoint and SysML" event
    - Usually results in proceeding with many unresolved risks and interfaces
- Evidence-based commitment reviews (evidence/risk-driven)
  - Evidence provided in Feasibility Evidence Description (FED)
    - A first-class deliverable
    - Based on concurrently engineered ConOps, specs, and plans
    - SE effectiveness measured by evidence of key-issue resolution progress
  - Shortfalls in evidence are uncertainties and risks
  - SE EMs provide early warning of likely SE shortfalls
    - Enabled by SE effectiveness measurement framework and tools

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SEPAT Seeks Performance Evidence

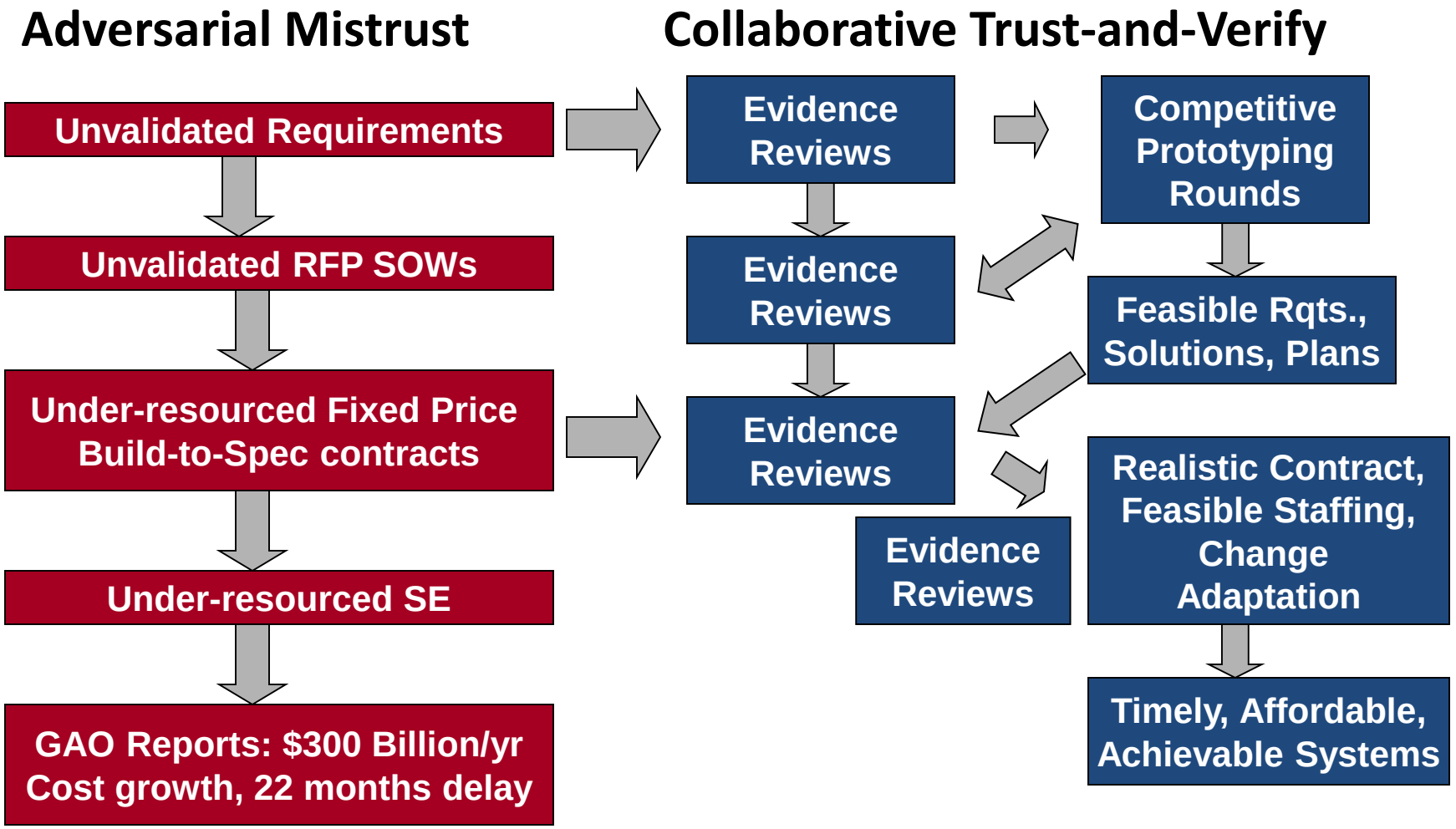
That can be independently validated

Exposure	Question #	Impact: Critical / 40-100%	Impact: Significant / 20-40%	Impact: Moderate / 2-20%	Impact: Little-No impact / 0-2%	Evidence/Risk: Little-None / p(0.4-1.0)	Evidence/Risk: Weak / p(0.2-0.4)	Evidence/Risk: Partial / p(0.02-0.2)	Evidence/Risk: Strong / p(0.0-0.02)	NOTE: Impact and evidence/risk ratings should be done independently. The impact rating should estimate the effect a failure to address the specified item might have on the program. The evidence rating should specify the qualtity of evidence that has been provided, which demonstrates that the specified risk item has been satisfactorily addressed.	Reset / Risk Exposure	
	Goal 1:									**Concurrent definition of system requirements and solutions**		
	Critical Success Factor 1.1									**Understanding of stakeholder needs: capabilities, operational concept, key performance parameters, enterprise fit (legacy)**	4	
1	1.1(a)			●			●			At Milestone A, have the KPPs been identified in clear, comprehensive, concise terms that are understandable to all stakeholders?		No forma
3	1.1(b)			●				●		Has a CONOPS been developed showing that the system can be operated to handle both nominal and off-nominal workloads, to meet response time requirements, and generally to meet the defined KPPs?		IT system
3	1.1(c)			●				●		Has the ability of the system to meet mission effectiveness goals been verified through the use of modeling and simulation?		IT system effectiven
4	1.1(d)	●						●		Have the success-critical stakeholders been identified, their roles and responsibilities negotiated, and their needs clearly represented by the KPPs and CONOPS?		Developm Stakehold
4	1.1(e)	●						●		Have issues about the fit of the system into the stakeholders' context -- acquirers, end users, administrators, interoperators, maintainers, etc. -- been adequately explored?		Explored after syst related to different

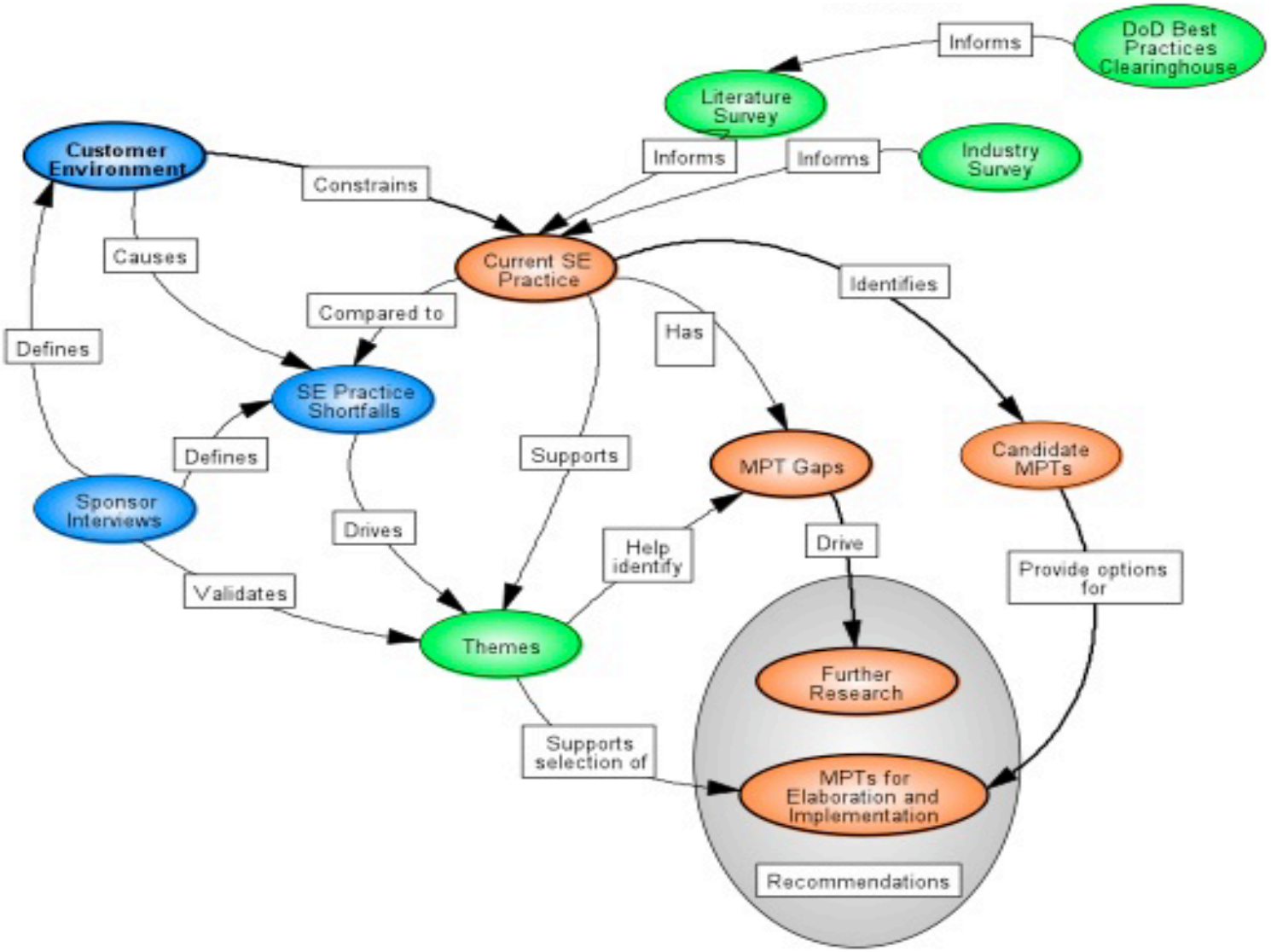
Also SECAT framework and tool for personnel competency

EM Processes and Tools Help Enable MDAP SE Transformation

Implements spirit of July 2009 Augustine BENS Report



MPT Task Approach



MPT Industry Survey: Gap Analysis

116 responses: mix of Govt., contractor, commercial

- **Decision Management (47%)**
  - **Tighten Observe-orient-decide-act (OODA) loop**
- **Stakeholder Requirements Definition (40%)**
  - **Rapid distributed interdisciplinary collaboration**
- **Measurement (28%)**
- **Architectural Design (28%)**
- **Integration (28%)**
- **Project Planning (26%)**
- **Project Assessment and Control (26%)**
- **Risk Management (26%)**

MPT Followons

- Rapid ConOps Development
  - Exploring ConOps-related survey results
- "Innovation Works" surveys, site visits
  - Best practices, critical success factors
- SE Transformation pathfinder study
  - Prepare roadmap for major effort

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Lessons for Future SERC Projects

- **Don't expect to follow your initial plan**
  - **Changing sponsor priorities, opportunities, technology**
  - **Early insights change priorities**
  - **May need to renegotiate scope**
- **Maintain a regular project pace**
  - **Weekly telecons with sponsors included**
  - **Workshops with sponsors and prospective users**
- **Engage the community**
  - **Government, industry, nonprofits, academia**
  - **Surveys, pilots, related-project workshops**
- **Keep the ultimate objective in mind**
  - **Make a significant difference in DoD SE, mission capabilities**

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Research Topics Now Underway

#	Topic	Description
1	Graduate SE Body of Knowledge and Reference Curriculum	Create mature SE BoK and graduate reference curriculum with broad community involvement
2	Modular Reconfigurable Architecture for Tailored and Rapid SE Knowledge Dissemination	Create way to rapidly publish and maintain currency of SE artifacts and other documents, extensively tailoring them to audience
3	Rapid CONOPS Development Environment for Agile SE	Develop approach to quickly construct a CONOPS that strongly informs all key stakeholders and can evolve quickly and easily – lead to coordinated RTs
4	Developing SE Technical Leaders	Create way to educate SE technical leaders rapidly and effectively using innovative educational technologies
5	Evolutionary Acquisition	Create MPTs for evolutionary acquisition in the context of new 5000.2 and emphasis on early SE prior to Milestone B
6	Software Data Quality and Estimation Research In Support of Future Defense Cost Analysis	Create improved ways to cost complex software-intensive systems, especially systems of systems
7	MPT Extension	Continue efforts to explore agile MPTs identified in the original MPT research project
8	Early Exploration in Systems Engineering Transformation	Create a roadmap of research to transform SE into a much faster, more responsive discipline

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Research Topics Expected Soon

#	Topic	Description
1	Early Exploration in Security SE	Create a roadmap of research on security SE
2	System Readiness Level	Explore the equivalent of technology readiness levels, but for systems integration and other facets of engineering maturity
3	Exchange of SE Data	Explore ways to enable systematic data exchange of SE data among DoD programs using AP-233 and similar standards
4	SE Effectiveness Measures Extension	Research, develop, apply, evaluate, improve extensions to Effectiveness Measures results to date
5	SE Development Experience Accelerator	Significantly reduce the amount of time it takes for an SE to become proficient
6	Change-Adaptive Systems	Develop architectural and other approaches to enabling systems to be highly adaptive to change

Backup charts

General Context

- **Overall systems engineering (SE) research focus**
  - **Basic research, but sponsor-focused**
  - **Mix of near-term and long-range payoffs**

- **First-year tasks**
  - **Initial scope very general**
    - **Domains: weapons platforms, systems of systems, net-centric services**
    - **Level: project, program, enterprise**
    - **Topics: SE methods, processes, and tools; SE effectiveness measures**
  - **Serve to identify, prioritize future research**
    - **With significant impact on DoD mission effectiveness**

Summary of major scope decisions: EM

Decision	Rationale
• MDAP vs. multi-type EMs	• SE shortfalls a major MDAP problem
• Core vs. all-domain EMs	• Avoid numerous inapplicable EMs
• Ease of tailoring, extension	• Enable special-community tailoring
• Cover SE functional performance and personnel competency	• Sponsor priority
• Rate both degree of impact and degree of satisfaction evidence	• Relation to risk exposure RE=P(L)*S(L), ease of tailoring out zero-impact questions
• Hierarchical goal - critical success factor – question framework	• Ease of use, understanding; compatibility with related frameworks
• Compatibility with INCOSE Leading Indicators	• Complementary coverage: continuous vs. discrete; quantitative vs. qualitative
• Framework and tools	• Early SERC tangible product
• Pilot use and evaluation	• Evidence of strengths and shortfalls
• Initial focus on project assessment vs. practice ROIs	• ROI data unavailable; could be generated via tool use

Initial EM Coverage Matrix

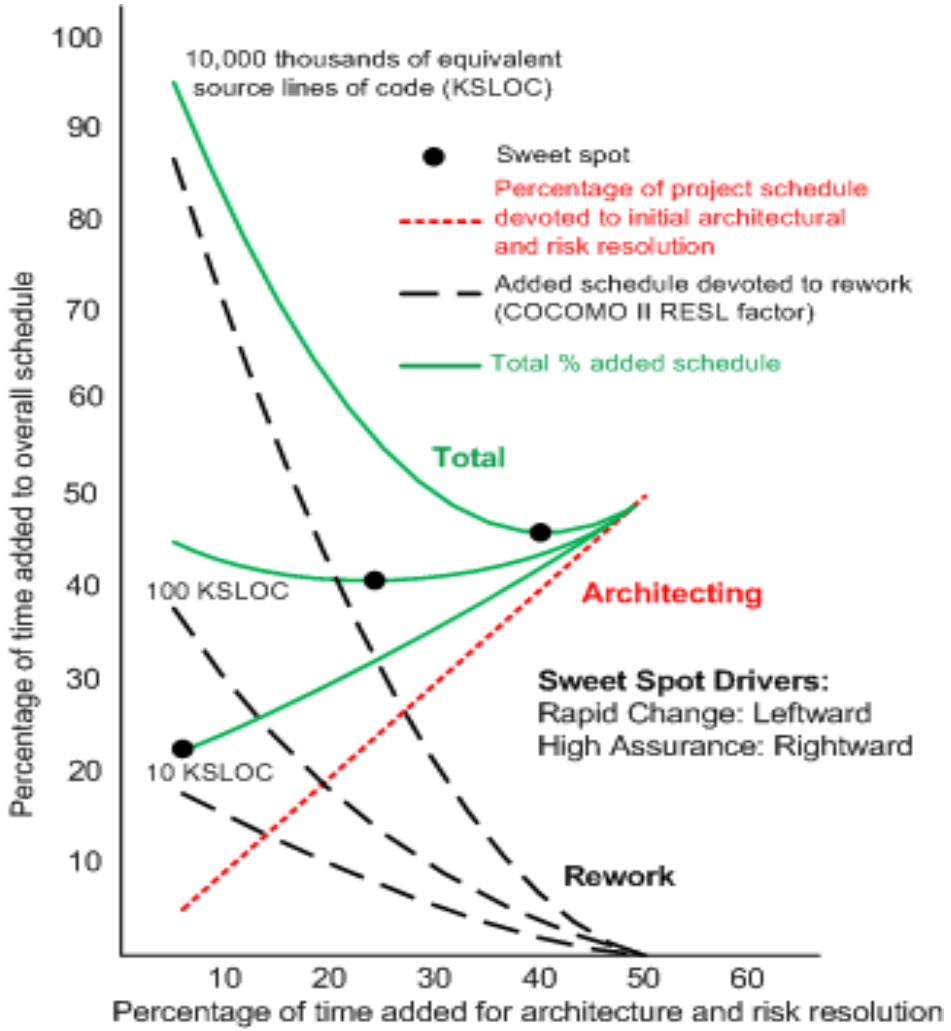
SERC EM Task Coverage Matrix V1.0

	NRC	Probability of Success	SE Leading Indicators	LIPSF (Stevens)	Anchoring SW Process (USC)	PSSES (U. of Alabama)	SSEE (CMU/SEI)	Macro Risk Model/Tool
Concept Dev								
Atleast 2 alternatives have been evaluated	X			x	x	x (w.r.t NPR)	(x)	
Can an initial capability be achieved within the time that the key program leaders are expected to remain engaged in their current jobs (normally less than 5 years or so after Milestone B)? If this is not possible for a complex major development program, can critical subsystems, or at least a key subset of them, be demonstrated within that time frame?	X		(x)	x	x (5 years is not explicitly stated)		(x) (seems to be inferrable from the conclusions)	(x) (implies this)
Will risky new technology mature before B? Is there a risk mitigation plan?	x	x	x		(x)		x	x
Have external interface complexities been identified and minimized? Is there a plan to mitigate their risks?	x		x		x	x	x	x
KPP and CONOPS								
At Milestone A, have the KPPs been identified in clear, comprehensive, concise terms that are understandable to the users of the system?	x	(x)	x	(x)	x (strongly implied)	(x) (implied)	x	x
At Milestone B, are the major system-level requirements (including all KPPs) defined sufficiently to provide a stable basis for the development through IOC?	x	x	(x)	x	x	(x)	(x) (There is no direct reference to this but is inferrable)	x
Has a CONOPS been developed showing that the system can be operated to handle the expected throughput and meet response time requirements?	x	x	(x)	(x)	x	(x) (there is a mention of a physical solution. That's the closest in this regard)	x	x

Legend:
x = covered by EM
(x) = partially covered (unless stated otherwise)

Business case for SE EMs

Payoff largest for MDAPs; less needed for quick response



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SECAT Seeks Competency Evidence

That can be independently validated

Exposure	Question #	Impact: Critical / 40-100%	Impact: Significant / 20-40%	Impact: Moderate / 2-20%	Impact: Little-No impact / 0-2%	Competency/Risk: Little-None / p(0.4-1.0)	Competency/Risk: Weak / p(0.2-0.4)	Competency/Risk: Partial / p(0.02-0.2)	Competency/Risk: Strong / p(0.0-0.02)	NOTE: Impact and evidence/risk ratings should be done independently. The impact rating should estimate the effect a failure to competently address the specified item might have on the program. The competency rating should specify the observed, historical experience and competency of the systems engineering staff on past programs with respect to the specified risk item.	Reset / Risk Exposure
	Goal 1:									**Concurrent definition of system requirements and solutions**	
	Critical Success Factor 1.1									Understanding of stakeholder needs: capabilities, operational concept, key performance parameters, enterprise fit (legacy). Evidence of ability to analyze strengths and shortfalls in current-system operations via:	4
4	1.1(a)	◉	○	○	○	○	○	◉	○	Participatory workshops, surveys, focus groups?	
4	1.1(b)	○	◉	○	○	○	◉	○	○	Operations research techniques: operations data collection and analysis?	
3	1.1(c)	○	○	◉	○	○	◉	○	○	Mission effectiveness modeling and simulation?	
3	1.1(d)	○	◉	○	○	○	○	◉	○	Prototypes, scenarios, stories, personas?	
4	1.1(e)	○	◉	○	○	○	◉	○	○	Ethnographic techniques: Interviews, sampled observations, cognitive task analysis?	

Pilot Feedback Highlights

- Primarily useful during early stages
  - SEPAT: Tech Development, 60%; System Development, 100%
  - SECAT: Tech Development, 50%; System Development, 75%
  - Between “Very Effective” and “Somewhat Effective”
- Too many Red and Yellow risks
  - Rating scales reworked
- Overly DoD-specific (NASA responder)
- Need versions for different domains, project types
  - Quick-response/agile; legacy-driven; KPP-driven; sea; space; …
- Make question format uniform across SEPAT and SECAT

Customer Environment Profiling

Overview Of The Target Environment	A quick-reaction environment mixed with ongoing, more traditional acquisition
	Service-oriented approach with many different capabilities on many different platforms, many developed independently
	The complexity of the problems to be solved drive complex solutions
	Development (from concept to use) may be weeks or months
	System-level systems engineering exists, but is seen as secondary and not integral to the acquisition/development cycle
Requirements Handling	Requirements are often reacting to critical real-time needs
	Requirements are often vague, volatile, or immature
System Interdependency	Some services may depend on other services; dependency may be critical with no identifiable work-around
	Some services overlap or are duplicative
System Evolution	Good-enough may be sufficient for initial use
	Effective services may be scaled up, deployed widely, integrated into developing and legacy systems, and require operational support
	Services may evolve independently or based on the evolution of other services
	Services may have a lifetime of weeks or years
	There is a reluctance to replace/upgrade fielded services due to the risk of impacting other services
Governance	Service developers are diverse, dispersed, and have little inter-developer communications; teams often compete rather than collaborate; organizational culture and restrictions exacerbate communications difficulties
	Common oversight and cross-developer governance are inconsistent
	Traditional acquisition programs often have no insight into quick-response activities and vice versa

MPT Survey: Most Frequent MPT Mentions

Practice	Req.	Stake.	Sust.	Int.
Rapid Prototyping	✓	✓		✓
Continuous Integration			✓	✓
Iterative / Incremental Development	✓	✓		✓
Interface Control Document (ICD)	✓	✓		✓
Incremental Commitment Model (ICM)[1]	✓	✓		
Stakeholder Analysis	✓	✓		
Sustainment Plan		✓	✓	
Requirements Arbitration		✓		
Scrum	✓	✓	✓	
Requirements Impact Analysis	✓	✓		
Separate Teams for Development & Sustainment			✓	
Requirements Traceability	✓	✓		
System Modeling / System Modeling Language	✓	✓		
Trade Studies		✓	✓	
Change Impact Analysis	✓		✓	
Integrated Product Team (IPT)	✓			✓
Model-Based Testing (MBT)		✓		✓
Modeling and Simulation	✓		✓	✓
Service-Oriented Architecture (SOA)	✓			✓