



Fostering Intra-Organizational Communication of Enterprise Systems Engineering Practices

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National Defense Industrial Association

9th Annual

Systems Engineering Conference

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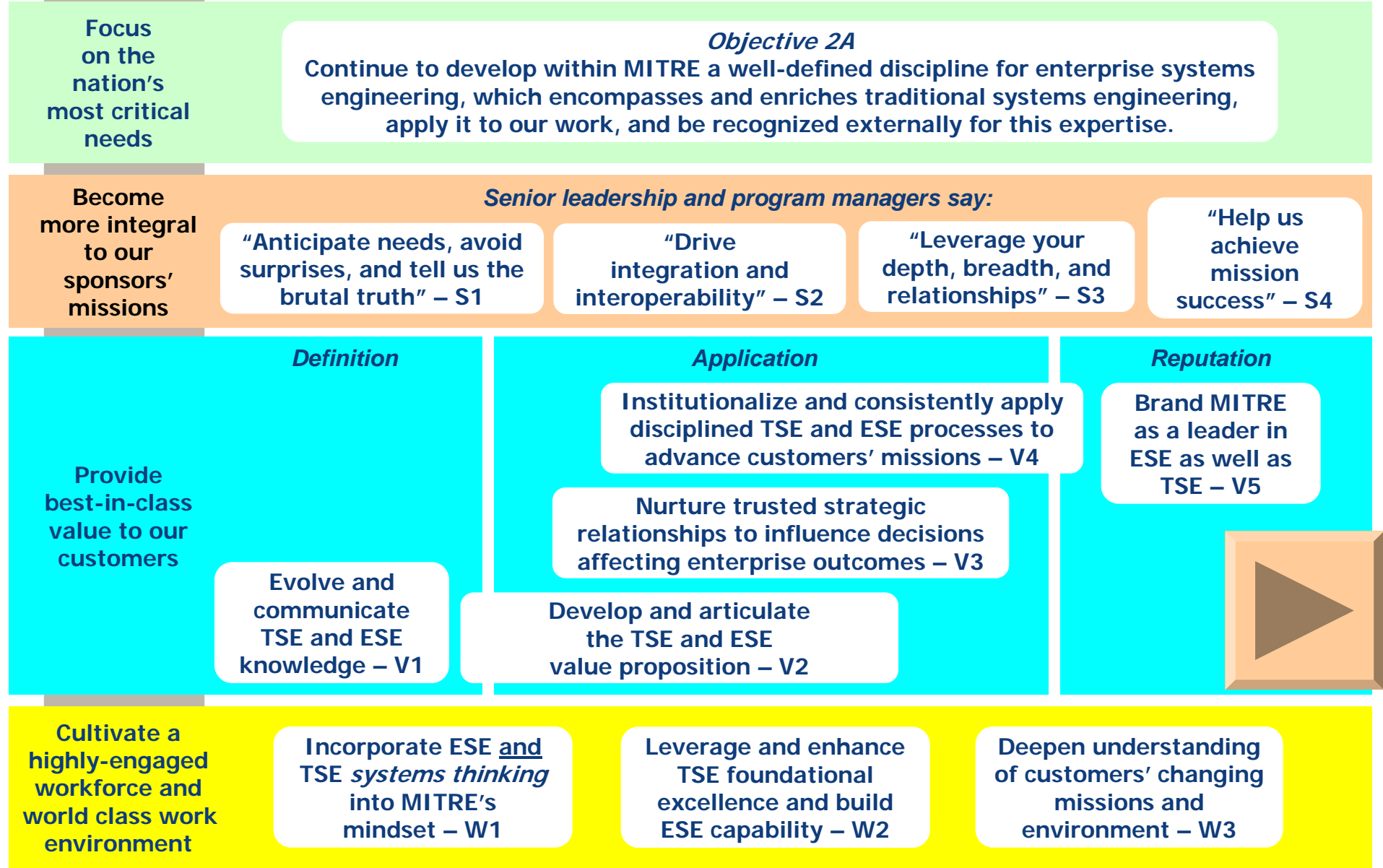
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Enterprise Systems Engineering (ESE) at MITRE

- MITRE manages three FFRDCs partnering with government clients to achieve critical mission capabilities through the development and improvement of large complex systems.
 - Since MITRE's creation in 1958, much of MITRE's major work can be characterized as ESE.
- In FY04 MITRE began formalizing its brand of systems engineering.
 - Greater study of complexity, complex systems, and complex systems engineering (CSE) have yielded insights for improving ESE practices.
- In late FY05 MITRE began setting ESE and traditional systems engineering (TSE) goals, establishing specific objectives, measures, and metrics, and a set of initiatives consistent with those objectives.
 - One of the objectives concerns an ESE body of knowledge (BoK), and MITRE started an ESE Deskbook.
 - The ESE Deskbook includes an evolving lexicon of terms.
 - A good mutual understanding of terminology people use is considered necessary for accelerating progress in ESE.

Objective 2A Strategy Map



ESE Deskbook Homepage

Enterprise Systems Engineering Deskbook - Microsoft Internet Explorer provided by MITRE

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Address http://sep01.mitre.org/ese_wg/index.html

SITE MAP EXPERTS REFERENCES ACRONYM HELP MII HOME

Enterprise Systems Engineering DeskBook

HOME LEXICON PRINCIPLES WHITE PAPERS LIBRARY CASE STUDIES RESEARCH BODY OF KNOWLEDGE PROCESSES



OUR APPROACH TO ENTERPRISE ENGINEERING IS BASED ON THE PREMISE THAT WE DO NOT BELIEVE THAT IT IS POSSIBLE, OR EVEN DESIRABLE, TO PREDICT A FUTURE END-STATE FOR THE INTELLIGENCE ENTERPRISE.

~ Donald L. Martell

What's New

- Contributing
- TEMs
- Meetings
- Discussion Forum

Internal Links

- Systems Engineering Process Office
- Office of Enterprise Systems Engineering
- D400 Tech Forum
- Capability-Based Acquisition
- Linearity, Complexity, and Systems Engineering
- Megasystems
- SEPO WikiPedia

External Links

- DoD C3I Enterprise Systems Engineering
- MIT Engineering Systems Division
- Stevens Institute of Technology
- UCSD
- System of Systems Engineering Center of Excellence
- Complexity Related Application Papers

Introducing the ESE Deskbook...

Engineering today's systems is becoming sophisticated and complex. Increasingly, systems are being engineered by bringing together many separate systems which, as a whole, provide an overall capability otherwise not possible. Many systems no longer physically exist within clearly defined boundaries; rather, systems are more and more geographically and spatially distributed and interconnected through a rich and sophisticated set of networks and communications technologies.

These large-scale, complex, systems of systems operate to satisfy a comparatively large set of users, stakeholders, or communities of interest. It is no longer enough to find just technology solutions to the engineering of these systems. Such solutions must be adaptable to changes in the enterprise, balanced with respect to expected performance, while also considering the social, political, and economic environments within which the system will operate and change over time.

The ESE Deskbook provides an e-repository that identifies and disseminates to the MITRE community our growing body of knowledge and experiences in the engineering of large-scale complex systems. Seen above, the Deskbook is organized around a series of "tabs" that reflect information repositories on specific ESE-related disciplines. Within these tabs, you'll find information on a wide-variety of topics from architectures and frameworks, to modeling and simulation, to engineering process standards and toolkits. In addition, you'll find a reference library with a body of links to important sites related to large-scale complex systems research and related activities in academe and in the professional communities.

For questions or comments regarding this Web site, please contact our Web Team
Last modified: 07/21/2006 11:07:21

Local intranet

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ESE Deskbook Document Histogram

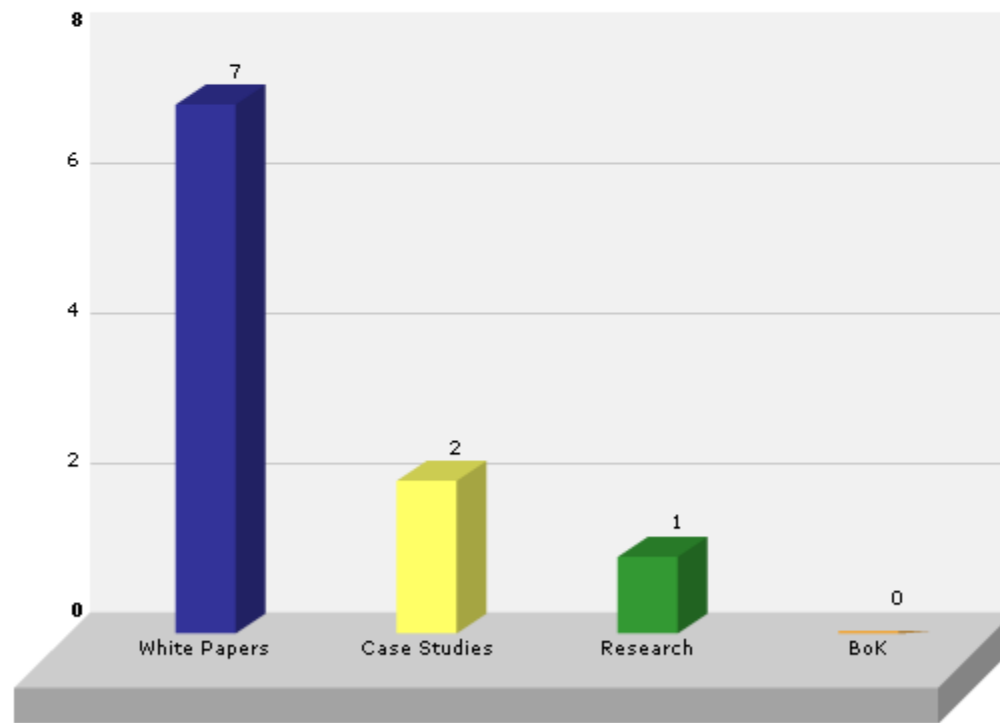
Objective V1h

Distribution and quality of contributions to the systems engineering BoK; measured quarterly

ESE Deskbook Documents

Q1 (Oct - Dec) FY06

[Fiscal Year Rollup](#)



Q2 for FY06

ESE Deskbook White Paper Details

Officer Objective 2A Measures

- Objective V1h
- Objective V4
- Objective V5h
- Objective V5j
- Objective W3b
- Objective W3c

Objective V1h
Distribution and quality of contributions to the systems engineering BoK; measured quarterly

ESE Deskbook Documents — White Papers Library Tab

	Ratings*	Document Title	Author(s)	Publish Date	Date Added
View	Editor: 3 Users: NYR	Engineering Enterprise Systems: Challenges and Prospects	Renee Stevens	February 2006	2/21/2006
View	Editor: 3 Users: NYR	Engineering Enterprises Using Complex-System Engineering	Brian White, Michael Kuras	April 2005	2/13/2006
View	Editor: 3 Users: NYR	Using Models and Abstraction to Extend and Unify Systems Engineering	Duane Hybertson	March 2006	3/16/2006
View	Editor: 3 Users: NYR	Volume 2: Systems Thinking for the Enterprise (New and Emerging Perspectives)	George Rebovich	November 2005	2/13/2006
View	Editor: 2 Users: NYR	Volume 4: Enterprise Management (Process to Couple Theory and Practice)	Robert Swarz	January 2006	2/28/2006
View	Editor: 2 Users: NYR	Volume 6: Enterprise Activities (Evolving Towards an Enterprise)	Peter Smyton	February 2006	2/27/2006
View	Editor: 2 Users: NYR	Volume 7: Enterprise Analysis and Assessment	John Roberts	January 2006	2/27/2006

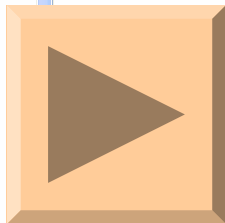
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*This work advances our (or your) understanding of the ESE problem space?

Editor Rating:
 3 = Highly Recommended Contribution
 2 = Very Valuable Contribution
 1 = Significant Contribution

Average User Rating:
 ★★★★★ = Strongly Agree
 ★★★★ = Agree
 ★★★ = Disagree
NYR = Not Yet Rated

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Deskbook Document Submissions for FY06

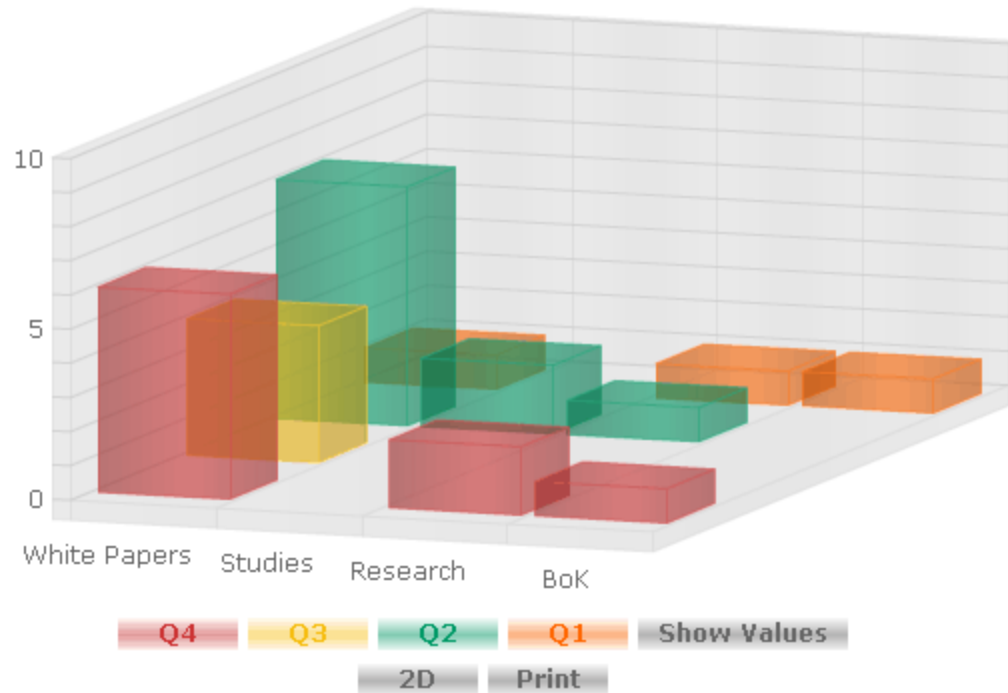
Objective V1h

Distribution and quality of contributions to the systems engineering BoK; measured quarterly

ESE Deskbook Documents

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[Quarterly Breakdown](#)



for FY06

Objective V5h Metrics for FY06

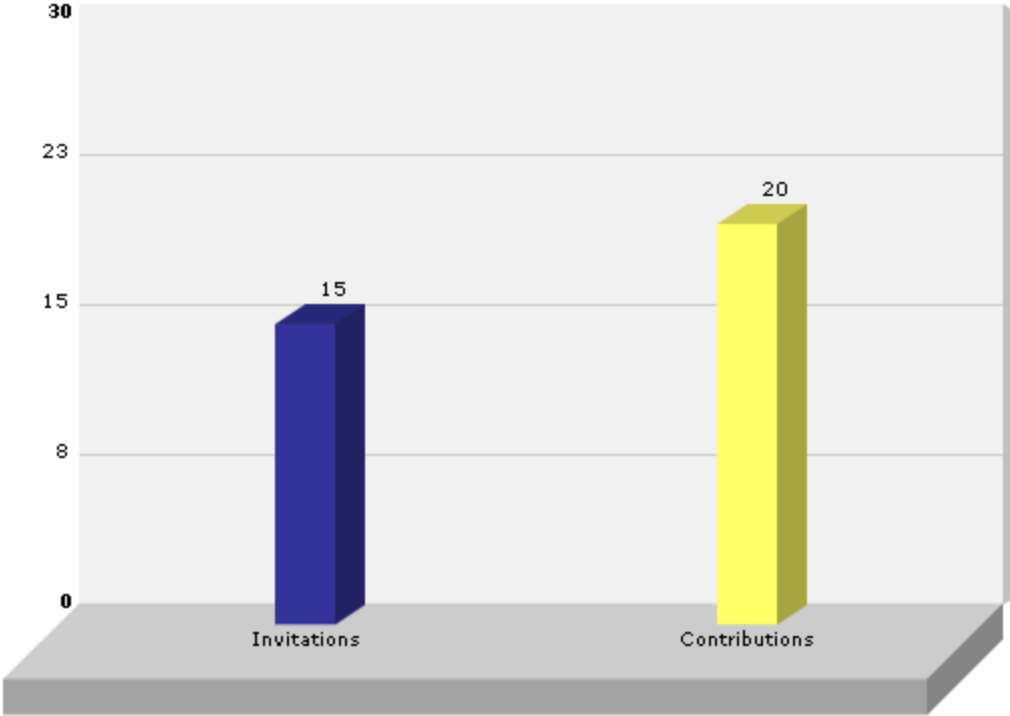


Objective V5h

Distribution of 1) invitations to chair and participate in; and 2) technical contributions to professional SE events and publications; measured annually

Distribution of Invitations and Technical Contributions

FY06 View



FY06

Details of V5h Invitations for FY06

V5h - Distribution of Invitations and Technical Contributions - Microsoft Internet Explorer provided by MITRE

Address: http://sepo1.mitre.org/officerobjectives/v5h_details.asp

Officer Objective 2A Measures

Objective V5h

Objective V4

Objective V5h

Objective V5j

Objective W3b

Objective W3c

Objective V5h

Distribution of 1) invitations to chair and participate in; and 2) technical contributions to professional SE events and publications; measured annually

Distribution of Invitations and Contributions – Invitation

Importance*	Date	MITRE Staff	Role Contribution Publication	Event	Inviter
3	26 - 30 June 2006	White, Brian	Session Organizer	ICCS 2006 Boston, MA, US	Bar-Yam, Yaneer President NECSI
			None		
			None		
3	26 - 30 June 2006	Norman, Doug	Session Organizer - Session Chair	ICCS 2006 Boston, MA, US	Bar-Yam, Yaneer President NECSI
			None		
			None		
3	26 - 30 June 2006	Metzger, Lou	Keynoter	ICCS 2006 Boston, MA, US	Bar-Yam, Yaneer President NECSI
			Presentation, Speech, Paper		
			None		
3	26 - 30 June 2006	DeRosa, Joe	Session Chair	ICCS 2006 Boston, MA, US	Bar-Yam, Yaneer President NECSI
			None		
			None		
3	7 - 8 April 2006	White, Brian	Session Chair - Panel Member - Reviewer	CSER 2006 Los Angeles, CA, USA	Honour, Eric C. Conference Chair HonourCode
			Presentation, Paper		
			Conference Proceedings		
3	24 - 26 April 2006	White, Brian	Session Organizer - Session Chair - Speaker	IEEE SoS Eng. Conf. 2006 Los Angeles, CA, USA	Jamshidi, Mo Conference Chair
			Presentation, Paper		
			Conference Proceedings		
2	26 - 30 June 2006	Wojcik, Len	None	ICCS 2006 Boston, MA, US	Bar-Yam, Yaneer President NECSI
			Presentation, Paper		
			None		
2	26 - 30 June 2006	White, Brian	None	ICCS 2006 Boston, MA, US	Bar-Yam, Yaneer President NECSI
			Presentation, Paper		
			None		

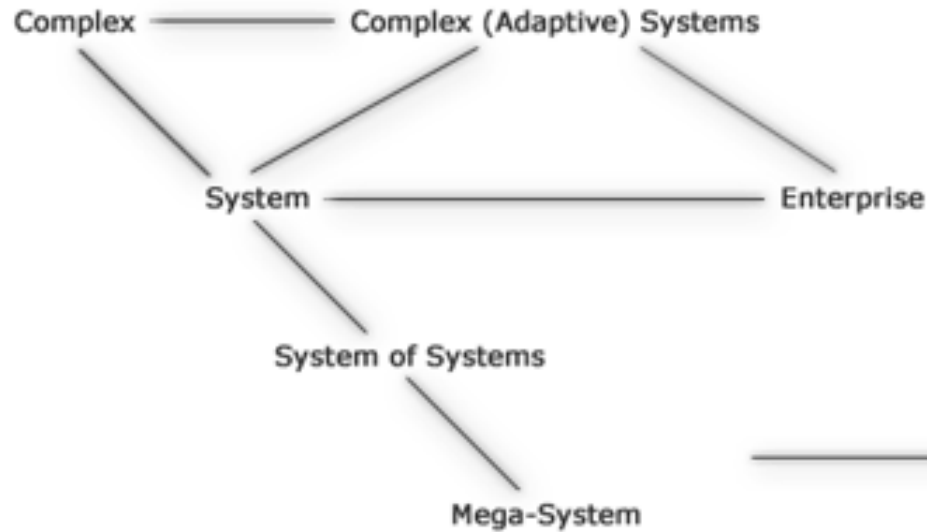
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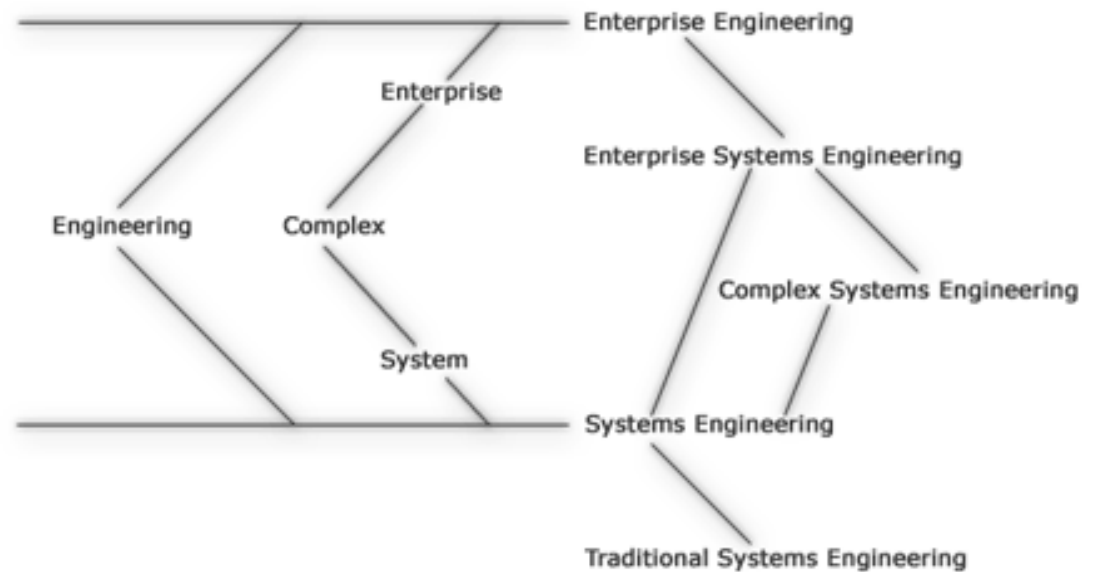
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Some Definition Dependencies

SYSTEM DEFINITIONS DIAGRAM



ENGINEERING DEFINITIONS DIAGRAM





Complexity Terms: Scale and Complexity

- **Scale**: A human conceptualization consisting of scope, granularity, mindset, and timeframe
 - Examples of the first three qualitative factors are field of view (FoV), resolution, and cognitive focus
 - *Note*: In a future paper [White, 2007], “scale” will be changed to “view”
- **Complexity**: Description of the ultimate richness of an entity that
 - Continuously evolves dynamically through self-organization of internal relationships
 - Requires multi-scale analysis to perceive different non-repeating patterns of its behavior
 - Defies methods of pre-specification, prediction, and control
 - *Note*: Complexity as really a continuum extending from its lowest degree, complication, say, to its higher degree, intended here.



Complexity Terms (Concluded): Order, Fitness, and Emergence

- **Order**: A qualitative measure of the instantaneous nature and extent of all specific internal relationships of an entity.
 - **Notes**: If something has only a few relationships, i.e., patterns of attributes defined by values, it has a small order.
- **Fitness**: The orthogonal combination of **complexity** and **order**.
 - **Note**: Both aspects of fitness (order: what currently is; complexity: what could be) are a part of perceiving an entity.
- **Emergence**: Something ***unexpected*** in the collective behavior of an entity, not attributable to any subset of its parts, that appears at a given **scale** which is not present at the comparative **scale**.
 - **Notes**: Some people employ a broader definition where things that emerge can be ***expected*** as well as ***unexpected***. Emergence can have **benefits** or **consequences**.



System Terms: System, SoS, and Megasystem

- **System**: An interacting mix of elements forming an intended whole greater than the sum of its parts.
 - *Features*: These elements may include people, cultures, organizations, policies, services, techniques, technologies, information/data, facilities, products, procedures, processes, and other human-made or natural) entities. The whole is sufficiently cohesive to have an identity distinct from its environment.
- **System of Systems (SoS)**: A collection of systems that functions to achieve a purpose not generally achievable by the individual systems acting independently.
 - *Features*: Each system can operate independently (in the same environment as the SoS) and is managed primarily to accomplish its own separate purpose.
- **Megasystem** [or Mega-System]: A large, man-made, richly interconnected and increasingly interdependent SoS.



System Terms (Concluded): Complex System, CAS, and Enterprise

- **Complex System**: An open system with continually cooperating and competing elements.
 - **Features**: Continually evolves and changes according to its own condition and external environment. Relationships among its elements are difficult to describe, understand, predict, manage, control, design, and/or change.
 - **Notes**: Here “open” means free, unobstructed by artificial means, and with unlimited participation by autonomous agents and interactions with the system’s environment.
- **Complex Adaptive System (CAS)**: Identical to a complex system.
- **Enterprise**: A complex system in a shared human endeavor that can exhibit relatively stable equilibria or behaviors (homeostasis) among many interdependent component systems.
 - **Feature**: An enterprise may be embedded in a more inclusive complex system.



Engineering Terms: Engineering, Enterprise Engineering, and Systems Engineering

- **Engineering**: Methodically conceiving and implementing viable solutions to existing problems.
- **Enterprise Engineering**: Application of engineering efforts to an enterprise with emphasis on enhancing capabilities of the whole while attempting to better understand the relationships and interactive effects among the components of the enterprise and with its environment.
- **Systems Engineering**: An iterative and interdisciplinary management and development process that defines and transforms requirements into an operational system.
 - *Features*: Typically, this process involves environmental, economic, political, social, and other non-technological aspects. Activities include conceiving, researching, architecting, utilizing, designing, developing, fabricating, producing, integrating, testing, deploying, operating, sustaining, and retiring system elements.



Engineering Terms (Concluded): TSE, ESE, and Complex Systems Engineering

- **Traditional Systems Engineering (TSE):** Systems engineering but with limited attention to the non-technological and/or complex system aspects of the system.
 - *Feature:* In TSE there is emphasis on the process of selecting and synthesizing the application of the appropriate scientific and technical knowledge in order to translate system requirements into a system design.
- **Enterprise Systems Engineering (ESE):** A regimen for engineering “successful” enterprises.
 - *Feature:* Rather than focusing on parts of the enterprise, the enterprise systems engineer concentrates on the enterprise as a whole and how its design, as applied, interacts with its environment.
- **Complex Systems Engineering (CSE):** ESE that includes additional conscious attempts to further open an enterprise to create a less stable equilibrium among its interdependent component systems.
 - *Feature:* The deliberate and accelerated management of the natural processes that shape the development of complex systems.



Summary and Recommendation

- **MITRE officers initiated the emphasis on understanding and properly applying ESE methods.**
 - Thought-leaders were asked to help shape how we move ESE forward.
- **We are fostering the effective intra- and inter-organizational communication of ESE best practices.**
 - An ESE body of knowledge (BoK) is growing.
 - An internal Deskbook web site is being used for selected ESE practices, white papers, case studies, principles, definitions, etc.
- **The Lexicon serves as a central repository for ESE terminology.**
 - We are sharing these definitions with others to stimulate and enhance greater understanding and constructive dialog about ESE.
- **Various definitions and associated discussions, though quite useful in their own right, have their place.**
 - One should always strive to move beyond the definitions and concentrate on discovering and applying the best ESE practices.



References

[Grasso, 2006] Grasso, A., 12 October 2006, “Developing the Strategy-Centered Organization,” Invited Presentation for a Balanced Scorecard Conference, Points of Contact: Lois Bruss of The MITRE Corporation, and Robert Gold, of the Balanced Scorecard Consortium

[White, 2007] White, B. E. TBD 2007, “On Interpreting View (aka Scale) and Emergence in Systems Engineering,” TBD conference paper, in draft

Note: See the companion paper for many other references.



Back-Up Charts

MITRE Objective 2A – Current Situation

Objective 2A leaders developed this view of the current and desired future states.

Topic	From ...	To ...
Commitment to FRED*	Top-down, limited	Self-motivated, reinforced
Strategic awareness and communication of FRED	Pockets of knowledge about FRED, limited, sporadic, chaotic	Broad understanding, rich content
Core competency	Traditional Systems Engineering (TSE) (we think), inconsistent	Demonstrable application of TSE and FRED
Knowledge management	Local, disconnected, incomplete, available but not fully leveraged	Globally integrated, analyzed, acted upon
Enabling technologies	Product based, well-defined, bounded systems	Web, global, boundary-spanning, convergence with commercial applications, net-centric, complexity and behavioral science
Primary impact on customers	Individual program success	Program <i>and</i> extended enterprise mission success
Practice of executing FRED	<i>Ad hoc</i> , historical basis, reactive or responsive, uneven accountability	Consistent, evolutionary, learning-based, adaptive, institutionalized consideration and accountability
Clarity of FRED	Need to call it FRED, because we can't agree otherwise	Shared understanding of FRED and MITRE's role
Project leader expectation and accountability	Know the program, meet requirements, technical and engineering focus	Know context, avoid stovepipes, "whatever it takes" behaviors, business and customer savvy in everyone's DNA, mobilizing MITRE resources
MITRE reputation with regard to FRED leadership	Good technical people, player among others	Be the standard, not just another player, known as leaders in FRED ideas and practice
Organization approach, structure, and migration path	Individual ownership model, stovepipe business model	Shared ownership model, yet sustained personal accountability, flexible business model



Sample Measures

Objective	Measure
S1: “Anticipate needs, avoid surprises, and tell us the brutal truth”	Percentage of major changes in direction that were anticipated in the shared watch list
V3: Nurture trusted strategic relationships to influence decisions affecting enterprise outcomes	Percentage of MITRE organizations that use value metrics to increase our mission impact
V5: Brand MITRE as a leader in Enterprise Systems Engineering (ESE) as well as TSE	Distribution of (1) invitations to chair and participate in professional events, (2) technical contributions to professional events and publications
W1: Incorporate ESE and TSE systems thinking into MITRE’s mindset	Percentage of employees who are familiar with ESE and TSE systems thinking and can recognize which problems need which approach to solve

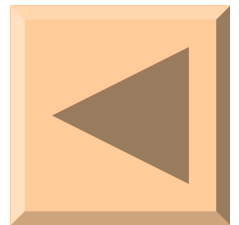
[Draft] Objective 2A Initiative Matrix

		101 - AF ESE	102 - CIIS ESE	103 - ESE specific processes	104 - ESE Deskbook	105 - C3I ESE Research	106 - Collaborative ESE Research	107 - CIIS Social Science Program	108 - ESE Capstone	109 - GIG Council	110 - ESE/TSE certification	111 - SE Competency Model	112 - ESE Challenge Case	113 - WC3 Lecture Series, TEMS	114 - Publish TSE and ESE papers	115 - Influence INCOSE	116 - DHS ESE Officer Objective 4
Become more integral to our sponsors' missions	S1 - "Anticipate needs, avoid surprises, and tell us the brutal truth"																
	S2 - "Drive integration and interoperability"								X								
	S3 - "Leverage your depth, breadth, and relationships"								X								
	S4 - "Help us achieve mission success"								X								
Provide best-in-class value to our customers	V1 - Evolve and communicate TSE and ESE knowledge	X	X		X		X									X	
	V2 - Develop and articulate the TSE and ESE value proposition	X					X										
	V3 - Nurture trusted strategic relationships to influence decisions affecting enterprise outcomes								X								
	V4 - Institutionalize and consistently apply disciplined TSE and ESE processes to advance customers' missions																
	V5 - Brand MITRE as a leader in ESE as well as TSE				X		X		X							X	
Cultivate a highly-engaged workforce and world class work environment	W1 - Incorporate ESE and TSE <i>systems thinking</i> into MITRE's mindset											X					
	W2 - Leverage and enhance TSE foundational excellence and build ESE capability				X							X					
	W3 - Deepen understanding of customers' changing missions and environment																



Lessons Learned

- 1. Make it a priority at the senior level**
- 2. Develop a complete project plan at the beginning of the process**
- 3. Rely on a small group to develop the map, objectives, and measures**
- 4. Compress the time to develop the map, objectives and measures**
- 5. Resist the urge to wordsmith excessively**
- 6. Don't wait until your measures are perfect**
- 7. Get experience using the measures before managing the initiatives**



Deskbook Document Histogram (Q4 of FY06)

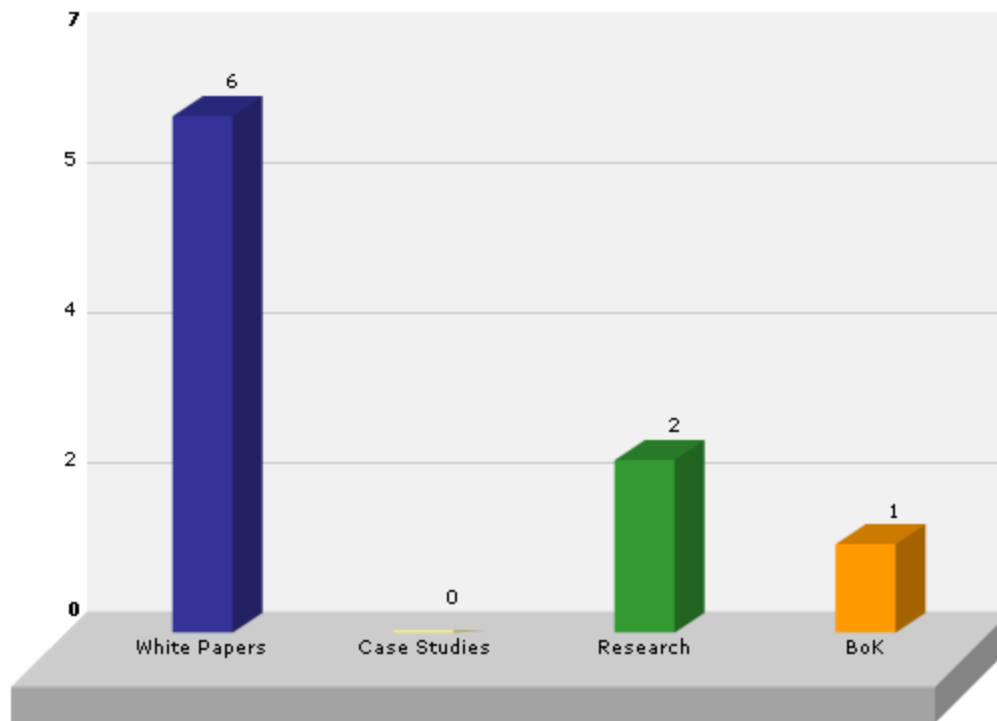
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Q1 (Oct - Dec) FY06

[Fiscal Year Rollup](#)



Q4 for FY06

Deskbook White Paper Details (Q4 of FY06)

Officer Objective 2A Measures

- Objective V1h
- Objective V4
- Objective V5h
- Objective V5j
- Objective W3b
- Objective W3c

Objective V1h
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ESE Deskbook Documents — White Papers Library Tab

	Ratings*	Document Title	Author(s)	Publish Date	Date Added
View	Editor: 2 Users: NYR	Complex Systems Engineering Position Paper: A Regimen for CSE	Michael Kuras , Brian White	July 2006	8/22/2006
View	Editor: 3 Users: ★★☆☆	MITRE, Complexity, and Engineering Enterprises	Louis Metzger	June 29, 2006	7/6/2006
View	Editor: 2 Users: NYR	On the Pursuit of Enterprise Opportunities by Systems Engineering Organizations	Brian White	April 2006	8/22/2006
View	Editor: 2 Users: NYR	On the Pursuit of Enterprise Systems Engineering Ideas	Brian White	July 2006	8/21/2006
View	Editor: 2 Users: NYR	Systems Thinking for the Enterprise: A Thought Piece	George Rebovich	August 2006	8/21/2006
View	Editor: 2 Users: NYR	Volume 8: Capabilities-Based Engineering Analysis (CBEA)	Steven Anderson	May 2006	8/3/2006

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Editor Rating:
 3 = Highly Recommended Contribution
 2 = Very Valuable Contribution
 1 = Significant Contribution

Average User Rating:
 ★★★★★ = Strongly Agree
 ★★★★ = Agree
 ★★★ = Disagree
NYR = Not Yet Rated

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 Date Last Updated: April 2006

