Fostering Intra-Organizational Communication of Enterprise Systems Engineering Practices

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MITRE

This is an annotated presentation; see the Notes Pages

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

Focus on the nation's most critical needs

Objective 2A
Continue to develop within MITRE a well-defined discipline for enterprise systems engineering, which encompasses and enriches traditional systems engineering, apply it to our work, and be recognized externally for this expertise.

Become more integral to our sponsors' missions

Senior leadership and program managers say:

- **"Anticipate needs, avoid surprises, and tell us the brutal truth" – S1**
- **"Drive integration and interoperability" – S2**
- **"Leverage your depth, breadth, and relationships" – S3**
- **"Help us achieve mission success" – S4**

Provide best-in-class value to our customers

Definition	*Application*	*Reputation*
Evolve and communicate TSE and ESE knowledge – V1	**Institutionalize and consistently apply disciplined TSE and ESE processes to advance customers' missions – V4**	**Brand MITRE as a leader in ESE as well as TSE – V5**
Develop and articulate the TSE and ESE value proposition – V2	**Nurture trusted strategic relationships to influence decisions affecting enterprise outcomes – V3**	

Cultivate a highly-engaged workforce and world class work environment

- **Incorporate ESE and TSE *systems thinking* into MITRE's mindset – W1**
- **Leverage and enhance TSE foundational excellence and build ESE capability – W2**
- **Deepen understanding of customers' changing missions and environment – W3**

MITRE

[Grasso, 2006]

ESE Deskbook Homepage

ESE Deskbook Document Histogram

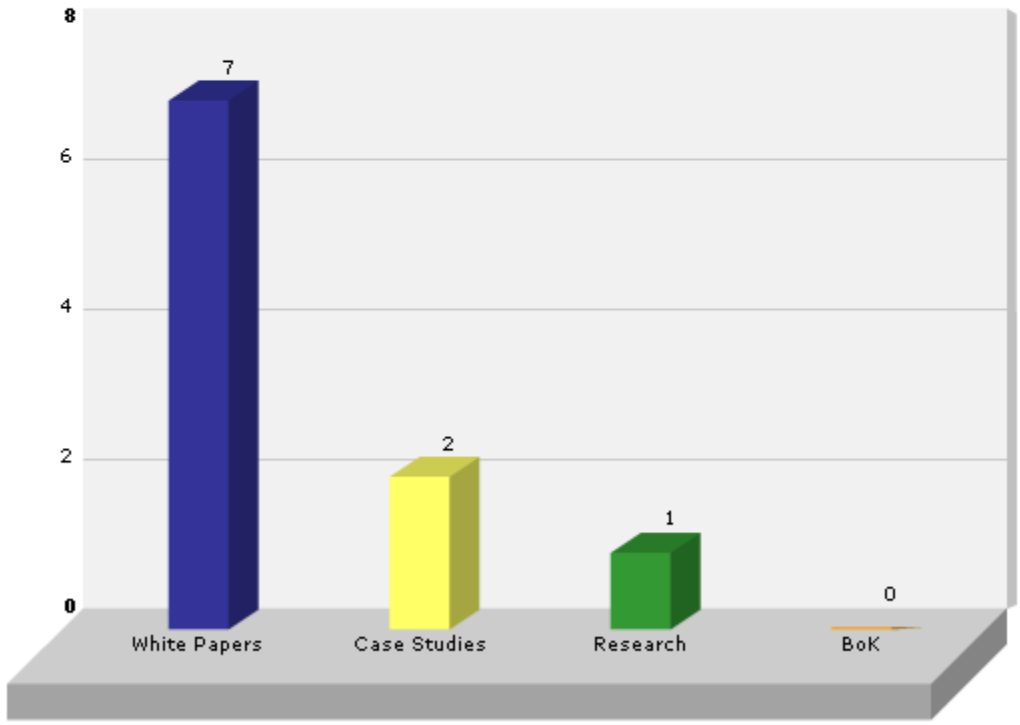
Objective V1h

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

ESE Deskbook Documents

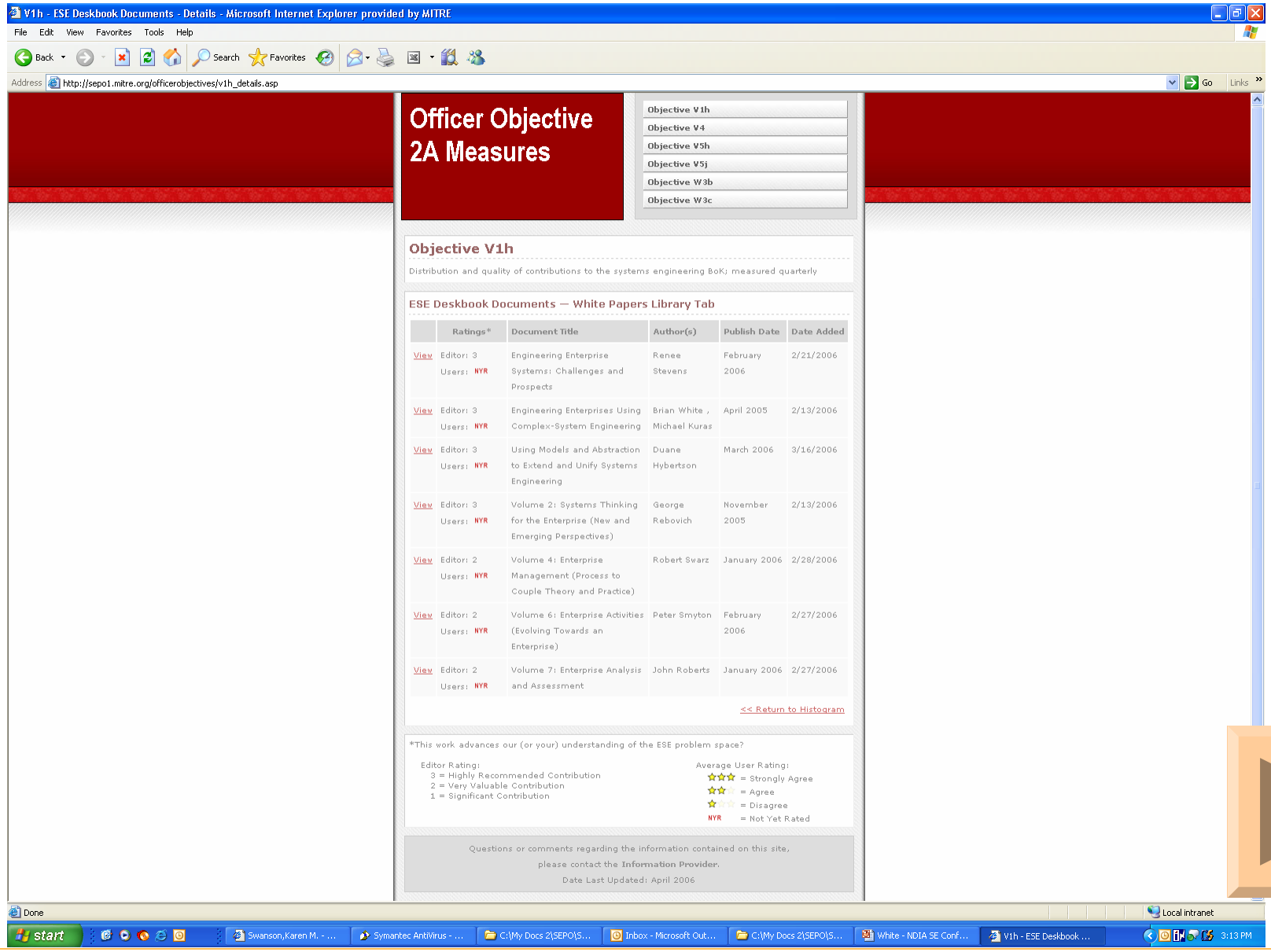
Q1 (Oct - Dec) | FY06 | View

Fiscal Year Rollup



Q2 for FY06

ESE Deskbook White Paper Details



Deskbook Document Submissions for FY06

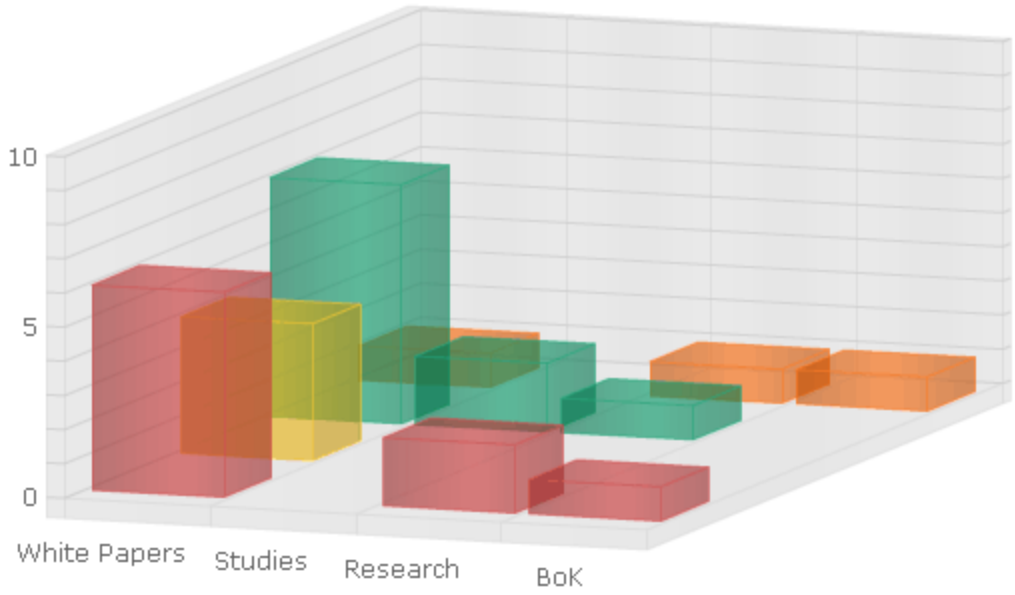
Objective V1h

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

ESE Deskbook Documents

Please Select a Fiscal Year

Quarterly Breakdown



Q4 Q3 Q2 Q1 Show Values

2D Print

for FY06

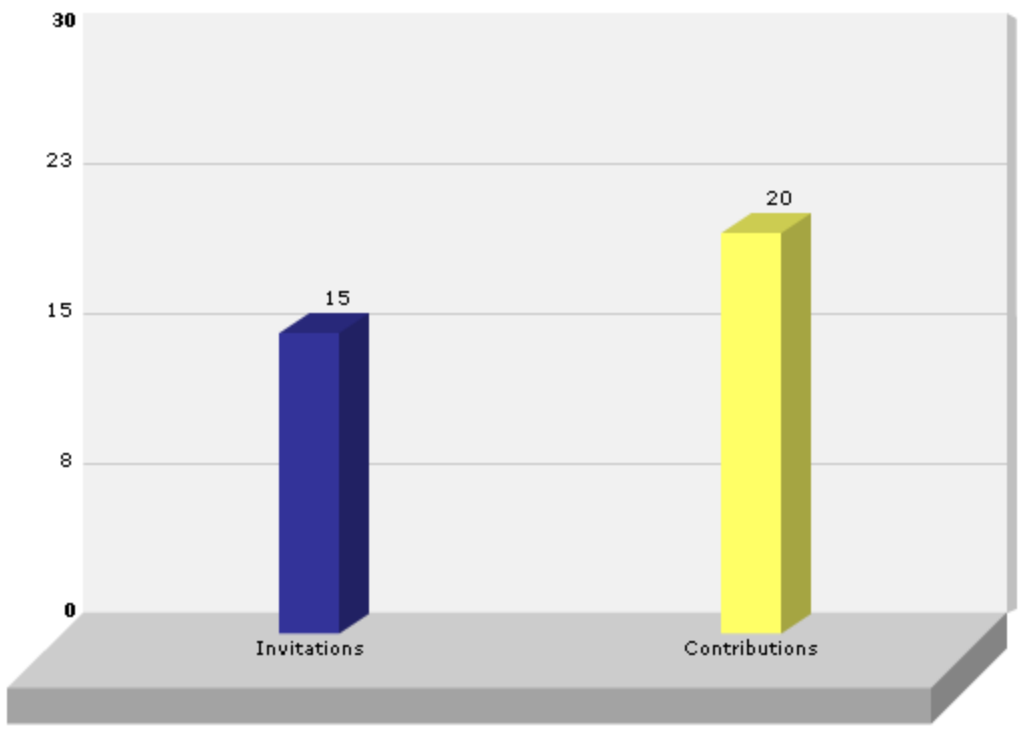
Objective V5h Metrics for FY06

Objective V5h

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

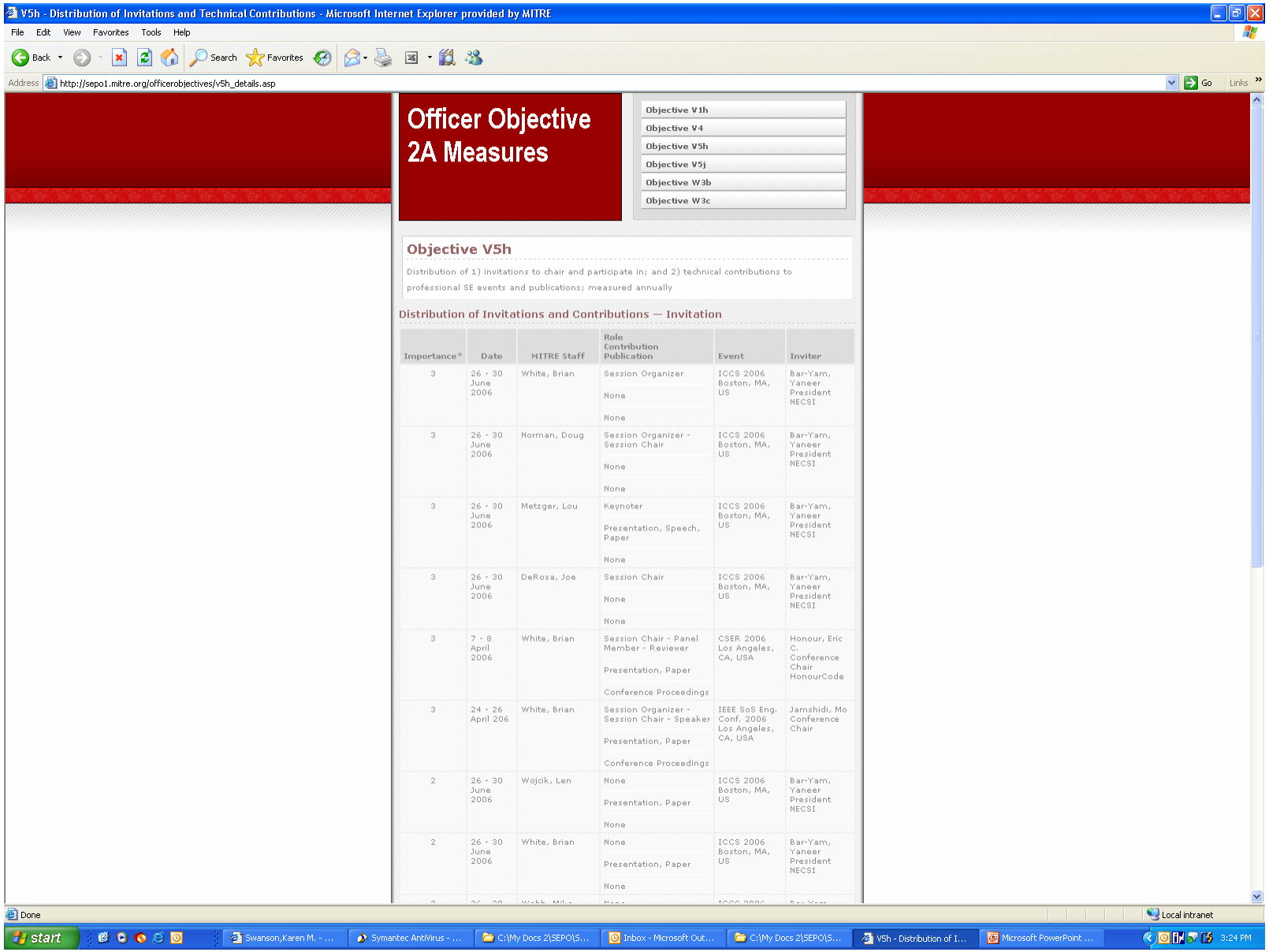
Distribution of Invitations and Technical Contributions

FY06 View

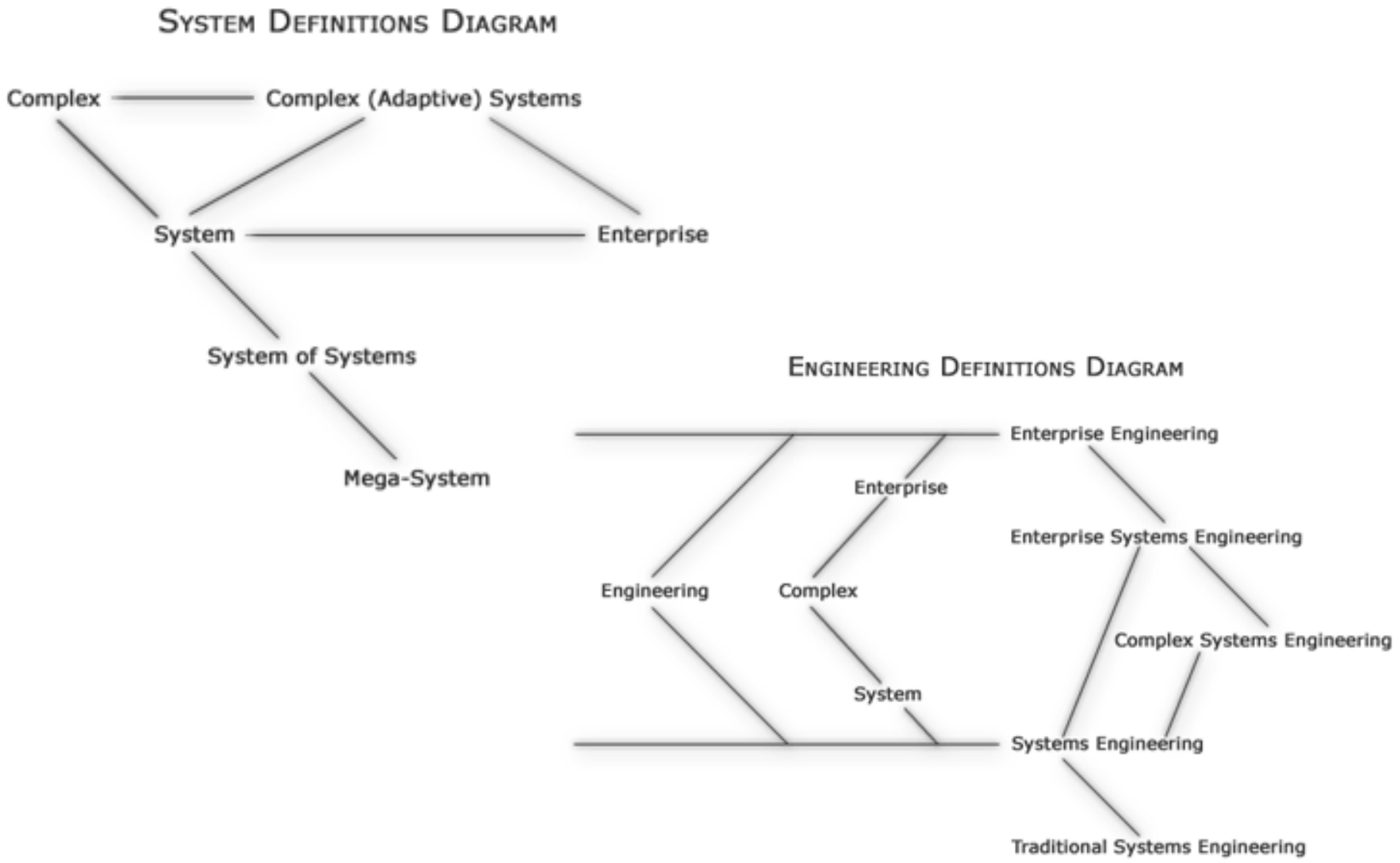


FY06

Details of V5h Invitations for FY06



Some Definition Dependencies



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 *and* extended enterprise mission success
Practice of executing FRED	*Ad hoc*, 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

*** Brian White's suggested acronym for "the thing that cannot be named", FRED: Focused Revitalization of the Engineering Discipline**

[Grasso, 2006]

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

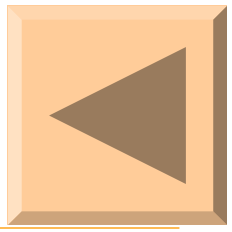
[Grasso, 2006]

[Draft] Objective 2A Initiative Matrix

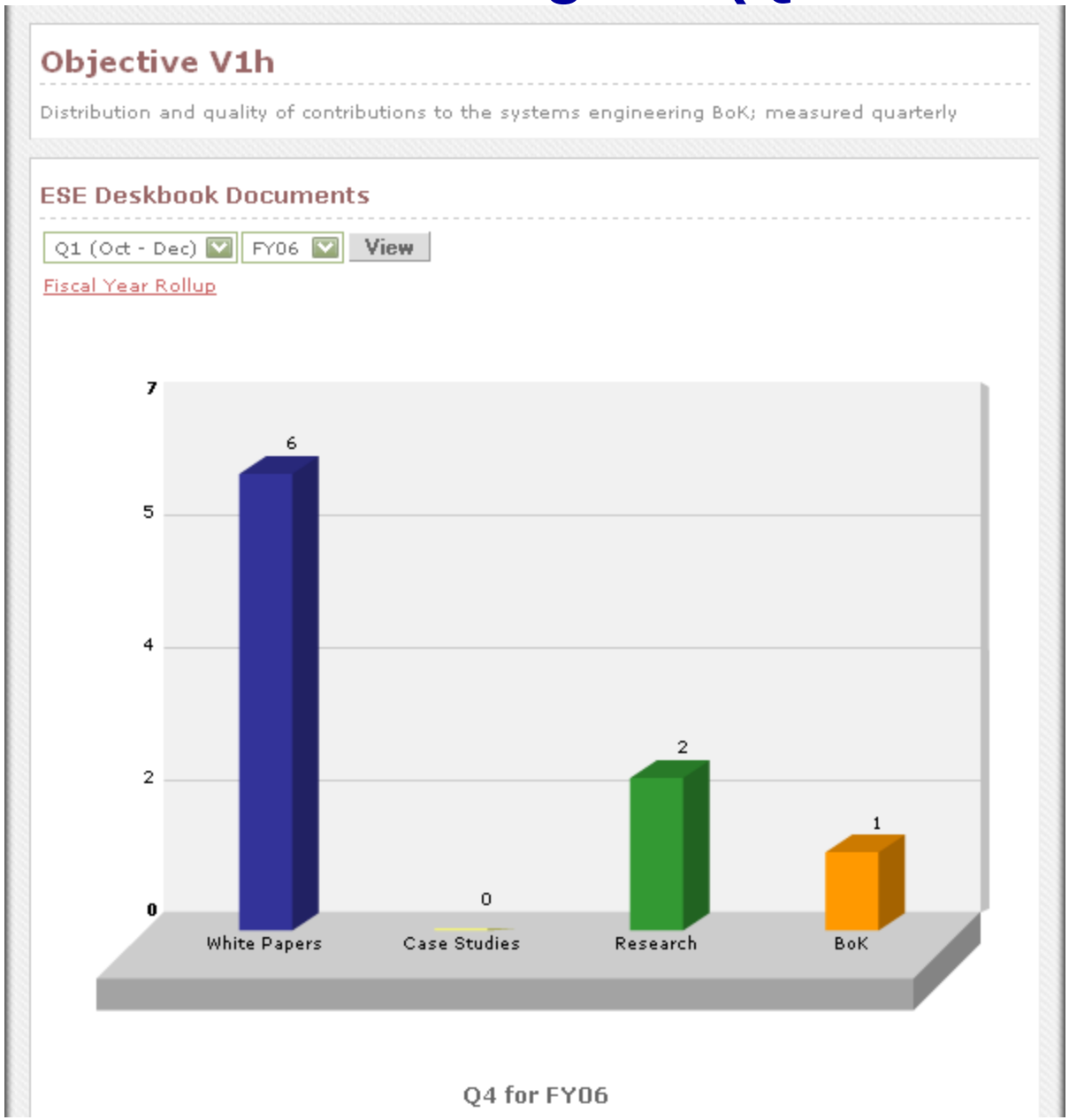
		I01 – AF ESE	I02 – CIIS ESE	I03 – ESE specific processes	I04 – ESE Deskbook	I05 – C3I ESE Research	I06 – Collaborative ESE Research	I07 – CIIS Social Science Program	I08 – ESE Capstone	I09 – GIG Council	I10 – ESE/TSE certification	I11 – SE Competency Model	I12 – ESE Challenge Case	I13 – WC3 Lecture Series, TEMs	I14 – Publish TSE and ESE papers	I15 – Influence INCOSE	I16 – 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 *systems thinking* 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)



Deskbook White Paper Details (Q4 of FY06)