# On the Pursuit of Enterprise Systems Engineering Ideas

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**Abstract.** Many organizations are considering the differences, if any, between "complex" or "enterprise" systems engineering (ESE) and "traditional" systems engineering (TSE). As ESE ideas are being pursued more vigorously within a systems engineering organization, it is important to harmonize the collective understanding of individual members as to the relative meanings of these and other terms. This paper provides the results of two simple surveys recently conducted within MITRE to sample staff opinions on 1) the relationship between TSE and ESE; and 2) one important ESE idea of focusing more on enterprise-scale opportunities as opposed to system-scale risks. This work was motivated as part of an attempt to measure the flow and acceptance of relatively new ideas within such an organization.
**Keywords:** Systems engineering, enterprise systems engineering, traditional systems engineering, complex systems, enterprise opportunity.

## 1 Introduction

Driven primarily by an officer objective, a cadre of MITRE staff embarked on a focused revitalization of the engineering discipline within the company. This includes the further definition, institutionalization, and recognition of MITRE's brand of enterprise systems engineering (ESE) while strenthening the application of traditional systems engineering (TSE). Although MITRE is well known as a major practitioner of entire systems engineering spectrum, it is good to continually reexamine the impact of the company's performance and to resensitize the staff to the mission.

In conjunction with this activity two simple internal surveys were conducted to gauge staff opinion as to the distinction between TSE and ESE and the receptivity to the idea of increasing the emphasis on opportunity management, particularly in some of the more complex environments in which MITRE works.

The main purpose of this paper is to report on the new results of the TSE/ESE survey. Also summarized is closely related material, including a brief introduction to enterprise opportunity and a survey surrounding that idea, which are elaborated upon in two companion papers.

## 2 TSE vs. ESE

There have been several attempts to clarify the differences and similarities between traditional systems engineering (TSE) and enterprise systems engineering (ESE). Some of these are summarized below. It seems clear that reaching consensus on any set of definitions is difficult. Rather a better understanding of various points of view can be sought. The constructive dialog that fosters mutual understanding so that meaningful

work can proceed, without getting bogged down in arguments about definitions, is what is important. This was the intent of a recent survey where MITRE staff were invited (via intranet web sites) to comment on the five possible relationships between TSE and ESE of Fig. 1 without even providing candidate definitions for them to consider.

## 2.1 The Survey

Each respondent was asked to rate every view on a ordinal scale of 1, 2, 3, 4, or 5 (the highest) as to the extent s/he viewed that view as being appropriate. The average ratings of the 78 participants are shown in Fig. 2. In addition, each person was asked to pick the one view they preferred ; these results are shown in Fig. 3.

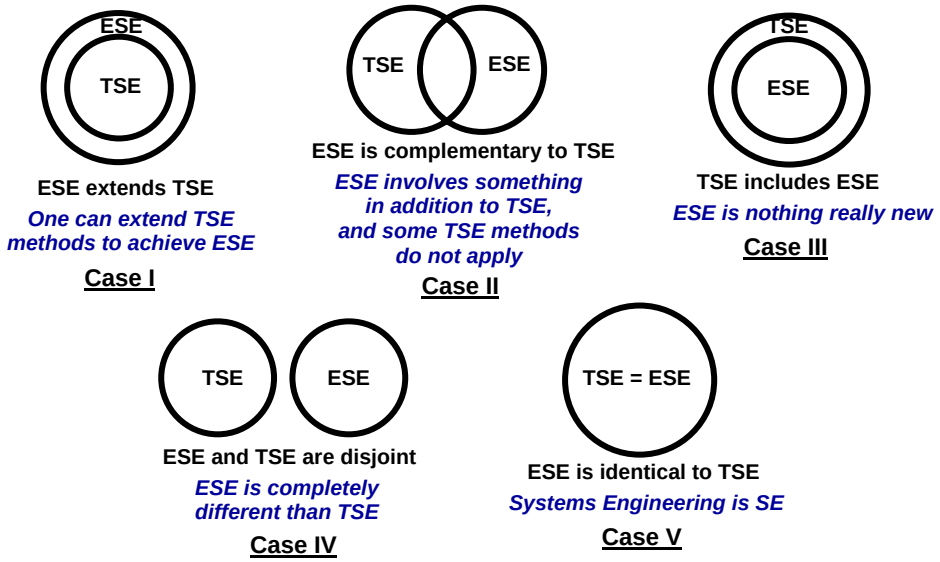


**Figure 1.** Five Possible Views of the TSE vs. ESE Relationship

A representative selection of individual rating explanations is provided below for the five cases by those that voted for the cited case.

Case I

- I believe ESE proceeds from TSE as a starting point. TSE is the foundation upon which the expanded principles of ESE are built.
- Processes are the same, the enterprise simply enlarges the scope of issues that must be addressed to ensure a system or System of Systems (SoS) meets its objectives.
- If you view the enterprise as a system made up of people, processes, physical hardware and software, etc., then the same concepts apply but at a larger/coarser scale.

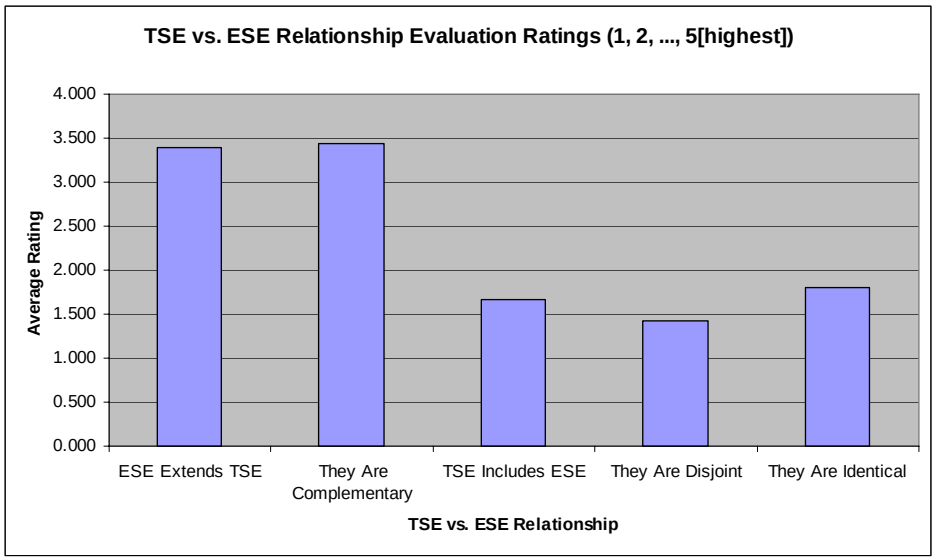


**Figure 2.** Individual Average Ratings of Each TSE vs. ESE Relationship

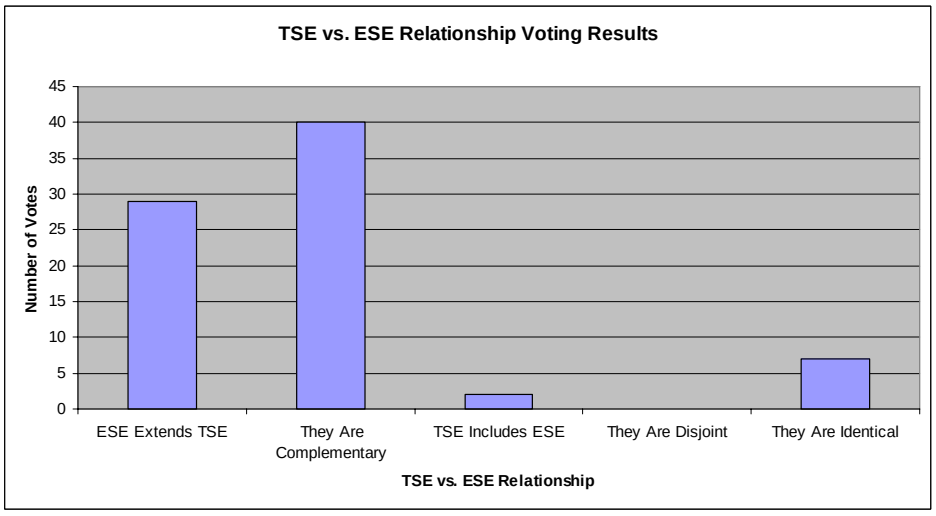


**Figure 3.** Voting Results of Selecting Exactly One Relationship as Most Appropriate

- TSE tools are still needed to work individual product lines; ESE is broader and includes engineering across traditional system boundaries.
- ESE involves fairly fundamental changes relative to TSE. However, any part of TSE could potentially be an element of ESE.

Case II

- TSE is more associated with a single system whereas ESE is more associated with a SoS or Enterprise, i.e., different engineering scales.

- The methods used for TSE and ESE cannot be applied to all problems. There's some overlap, but there are TSE methods that don't work in Enterprise Systems, and ESE methods that don't work in Traditional systems.
- I have no idea what ESE is. It has never been defined for me in a way that I can understand other than, not TSE, exactly. If one makes the assumption that ESE is cSE exactly, then both TSE and cSE are branches of a more inclusive General System Engineering. TSE and ESE share the three predicates of GSE, but interpret them differently.
- I believe that most TSE methods apply in the ESE world. However, there are also some intangible "macro" level considerations that ESE engineers must maneuver; i.e., politics, funding, structure and alignment, and compensatory enticement to encourage Enterprise thinking and evolution.
- They share a common systems foundation. Beyond that, they each have some unique aspects.
- The enterprise view can extend the traditional view while the traditional view contains levels of detail not within the purview of the enterprise view.
- ESE includes factors that must be considered at the enterprise level (e.g., politics), but which are generally not applicable at the TSE level. At the same time, some aspects of TSE may require a level of detail that just is not available at the enterprise level.
- ESE should provide great agility, and TSE does not achieve that. Some subsystems, and some aspects of systems, may be amenable to TSE. ESE should depend less on knowing requirements for the future.

Case III

[There were no explanations from the two voters that preferred this view.]

Case IV

[No one voted for this view.]

Case V

- This is reality, a model that reflects the global view of systems. A holistic systems thinking approach views systems engineering in its entirety, the whole picture, taking into account the environment which contains the system(s). The traditional vs. enterprise fad creates a false dichotomy that contradicts a holistic approach or way of thinking, it decomposes where decomposition isn't applicable. Neither term is well defined today, nor agreed upon in the future as to what becomes traditional, and probably never will be. It creates a lot of energy around definitions that is not a productive use of time. Each generation struggles with its own messy frontiers complexities, and large scale efforts - it's nothing new, simply more electronic and digital. Separating these terms confuses the system(s) with its environment. It implies socio-technical methods have been irrelevant until the enterprise arose, which is not the case. It reveals a naivete about work in other fields that have already approached government environments as large inter-organizational networks of people, processes, and technology, where social and technical aspects are blended into a view of the whole system.

- In theory, should be the same - in practice TSE did not always include some relevant portions of the "system".
- Represents the whole system(s) in its (their) environment. All other models decompose systems engineering into two camps, but academically and in practice, this is not what a systems thinker does. It creates a schism in the SE community. It's poor politics to divide and conquer by using terms which do not facilitate some basis of consensus about SE practices and activities, internal and external to MITRE. Good politics is based on united we stand, one systems engineering practice, with different SE methods and approaches applied in different scaleable environments. Drop the "T" and the "E". Use one term, Systems Engineering, and one clear objective, enhance our SE capability. This is a mission statement that is understood, rallies the troops under one flag, and generates grassroots support. Strategically and tactically, it connects the head to the body.
- Not sure if I think this one or the one TSE includes ESE. I do believe that good TSE takes everything into consideration to suit the level of complexity of the system and therefore it handles the enterprise level issues that "enterprise systems engineering" claims to include. I think it comes down to how one defines traditional systems engineering. My definition and practice of SE is broad and includes systems engineering activities at whatever levels are critical to the program.

## 2.2 Some Definitions

The author favors Case II above and something like these broad definitions [White 2006] :

- System: An interacting mix of elements forming a whole greater than the sum of its parts.
- SoS: A collection of systems that functions to achieve a purpose not generally achievable by the individual systems acting independently.
- Complex system: An open system with continually cooperating and competing elements.
- Enterprise: A complex system exhibiting a relatively stable equilibrium among many interdependent component systems in a shared human endeavor.
- Engineering: Methodically conceiving and implementing solutions to real problems, with something that is meant to work.
- Enterprise Engineering: Application of engineering efforts to the enterprise with emphasis on enhancing capabilities of the whole and understanding the relationships and interactive effects among the components.
- Systems Engineering: An iterative and interdisciplinary management and development process that defines and transforms requirements into an operational system.
- Traditional Systems Engineering (TSE): Systems engineering but with limited attention to the non-technical and/or complex system aspects of the system.
- Enterprise Systems Engineering (ESE): A regimen for engineering “successful” enterprises.

- Complex Systems Engineering (CSE): ESE but with additional conscious attempts to further open the enterprise to create a less stable equilibrium among many interdependent component systems.

## 3 Enterprise Opportunity

The author hypothesizes [White, Jul 2006] that in systems engineering at an enterprise scale the focus should be on opportunity, as depicted in Fig. 4; enterprise risk should be viewed more as threatening the pursuit of enterprise opportunities.

Fig. 4 is meant to suggest that the importance of opportunity management should increase qualitatively as one proceeds from system, to SoS, to enterprise scales. This is partially based on the premise, supported by historical fact and *ad hoc* observations, that risk management tends to dominate at a system scale. At an enterprise scale, the author has tried to develop the rationale for paying much more attention to opportunity management than risk management. It might then follow that opportunity management and risk management would be roughly co-equal at a SoS scale. These statements can be viewed as both descriptive and prescriptive. Nevertheless, further testing of hypotheses concerning the greater importance of opportunity management at SoS and enterprise scales is appropriate as part of future work. Further, the relative impact of the opportunities and risks themselves at any engineering scale is a topic distinct from the relative importance of opportunity vs. risk management; for example, the potential impacts of risks at the enterprise scale well may be larger than at a single system scale.

Clearly there exist un-assessable uncertainties and unknown uncertainties. So the topic of uncertainty management is more general than was treated. This idea is merely acknowledged in Fig. 4, where there is no attempt to depict relative importance of these other uncertainties at any of the three scales shown.

### 3.1 What is Opportunity?

- Opportunities are events or occurrences that assist a program in achieving its cost, schedule, or technical performance objectives.
- In the larger sense, explored opportunities can enhance or accomplish the entire mission.
- Opportunity also is associated with uncertainty and impact.
- There is a duality or parallelism to risk that can be applied.
- For an opportunity, let $Q_o$ be the probability of occurrence, and $B_s$, the benefit of success

Similarly, to estimated disruption, we can pose the simple formula $E_e = Q_o \times B_s$, the estimated enhancement or expected benefit. Fig. 4 is the "dual" of Fig. 2. Again, do not be confused by Fig. 4. As Paul Garvey (Garvey 2005) pointed out, the range of the benefit variable, $B_s$, could be taken to be [0, 1]; in such a case, $B_s = \infty$ is moot.

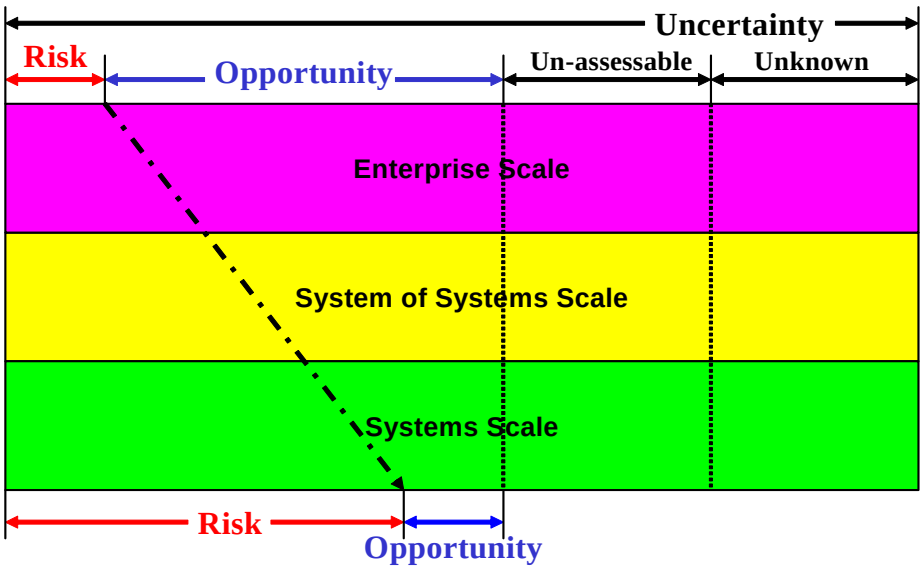


**Figure 4.** Relative Importance of Opportunity and Risk at Distinct Engineering Scales, Acknowledging Other Kinds of Uncertainty

## 3.2 Enterprise Opportunity Survey

Enterprise opportunity was used as new idea as a basis for testing the propagation of information within MITRE [White Apr 2006].

A formal lecture on the theory surrounding this topic, along with a following companion lecture by a colleague on a specific case study application, was given to a wide audience of an estimated 150 staff, mostly members of the directorate, during a video teleconference involving 7 remote sites. The principal location, where the lectures were given, included about 100 attendees; the last 30 minutes of the 90 minute-meeting was devoted to a spontaneous and spirited question/answer session.

A directorate web site was established in advance to provide a feedback and discussion forum for all participants in this lecture, the second, as well as others in a technical forum series. About nine lectures, one per month, are planned through September, 2006. The web site recorded over 230 responses for the opportunity lectures.

Preliminary analysis yields the following observations. About three-quarters of the survey respondents felt the idea of emphasizing opportunities at enterprise scales was NOT a new idea, contrary to the postulate of this paper. Of these, fourteen claimed that they would still pay more attention to risk than opportunity; and nine said they already paid equal attention to opportunity. Of the eight respondents that thought this was a relatively new idea, all but one indicated they would try to pay more attention to opportunities in the future. Almost all (27 of the) 29 respondents felt the case study was useful to understanding the theory. As a result of the case study presentation, 17 (more than half) of these respondents had some notion of how to apply opportunities to their own project. These results certainly reflect less than

enthusiastic support to the idea, at least at "first blush". However, the initial objective – of providing a baseline with which to compare at some point in the future – was achieved.

## 4 Concluding Remarks

The two surveys revealed a spectrum of opinion that provides excellent fodder for a healthy dialog that can lead to a better understanding of the application of systems engineering both inside and outside MITRE. As in most large organizations, it is unrealistic to expect full concurrence with any definition or new idea. The stimulation of open discussions leading to more effective systems engineering practices that serve the sponsors, customers, the customers' customers, the users, and the public is what is important.

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## Biography

Brian E. White received Ph.D. and M.S. degrees in Computer Sciences from the University of Wisconsin, and S.M. and S.B. degrees in Electrical Engineering from M.I.T. He served as an Air Force Intelligence Officer, and for 8 years was at M.I.T.'s Lincoln Laboratory. Dr. White spent 5 years as a principal engineering manager at Signatron, Inc. In his 24 years at The MITRE Corporation, he has held a variety of senior technical staff and project/resource management positions. He is presently Director of MITRE's Systems Engineering Process Office.

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