Governing Systems Engineering as an Enterprise Competence
A Benchmark Study with Pertinence to the US Department of Defense

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Abstract. DoD is reinvigorating SE capabilities so that "system of systems" structures can now be engineered. A benchmarking review reports approaches to the achievement of SE competence in a Research, Development and Engineering Center. For SE competence management most SE organizations contacted reflect tailoring to local and historical conditions more than the effects of integrated development. Current SE governance practices are analyzed here on a continuum between composite models termed the "Strong Form Model" and the "Methods Model." Systems-engineered Competence Development Plans appear to be in order to address growing dynamic complexity inherent in the "system of systems" environment.

INTRODUCTION

The US Department of Defense (DoD) is in a period of reinvigoration of systems engineering (SE) capabilities; very large-scale "system of systems" structures now have to be engineered for best life cycle value. SE competence management is important to this end. This review sought to identify best business practices for the SE Competence Division of an Army Research, Development and Engineering (RDE) Center.

During this study a variety of approaches to SE competence management was found; most cases reflect organization of SE functions tailored to the local and historical conditions of the particular institution. It appears that despite the crosscutting and

integrative character of the SE discipline that the typical enterprise has adopted a traditional functional organization to deploy its SE competence.

To provide a framework for selection of practices that best fit the RDE Center, the study results are compared along a continuum with two composite models termed the "Strong Form Model" and the "Methods Model". The enterprises surveyed generally reflect an intermediate commitment between the two models. A case is made for adoption of a systems-engineered SE Competence Development Plan. This multi-year plan would be based upon the attributes of the Strong Form Model and the expectation that the RDE Center itself functions as a system at a node in the web of the Defense Acquisition System.

Conventions

Systems Engineering is imbedded in projects that comprise the Defense Acquisition portfolio. SE produces a life cycle balance of technical, cost, schedule, and risk baselines.

> *EIA/IS632* defines an SE standard common to the defense industry:
>
> "Systems engineering is an interdisciplinary approach encompassing the entire technical effort to evolve and verify an integrated and life cycle balanced set of system people, product, and process solutions that satisfy customer needs."
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> The Under Secretary of Defense's "*Policy for Systems Engineering in DoD*" (2/20/04) states:
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> "Systems engineering provides the integrating technical processes to define and balance system performance, cost, schedule and risk. It must be embedded in program planning and performed across the entire acquisition life cycle."

Strong Form Model SE, as used here, indicates that SE practices form an integrating technical management umbrella and are applied under the direction of a project-dedicated and seasoned SE Lead who is the Project Manager's strong right arm for achievement of optimum SE discipline.

Business Processes

The study employed a questionnaire and follow up interviews. Lines of inquiry presumed that SE is a manageable cost of doing business and therefore that business processes would be set in place to measure and improve overall Competence performance. Respondents were asked to focus on both the corporate policy context for SE application and to provide insight about the following business processes for their SE Competence Division:

- Flowdown of Corporate Expectations
- Demand Management
- Service Level Reporting and Management

- Financial Management
- Client Relationship Management
- Communications / Interfaces with other Support Organizations
- System of System Interfaces

Flowdown of Corporate Expectations. Corporate expectations for SE application are widespread in the RDE community. In contrast acquisition reform has led to more performance-based contract standards and a reduced reliance on prescriptive requirements. While technical standards exist, high level SE policy strongly influences the rigor and robustness such standards being applied.

Demand Management. Demand management consists of methods / procedures used to develop the long-range outlook for SE deliverables, resources, and strategies. This process concentrates on understanding the overall business drivers in SE client organizations.

Service Level Reporting and Management. These methods / procedures focus on how an SE division tracks, manages, and reports on the performance level of services provided to clients. Project commitment to SE value added is often dependent upon the transparency of SE utility; this should be actively developed as a business concern of the responsible SE competence unit.

Financial. These methods / procedures focus on how budgets are created, measured, and reported from functional areas and for project-specific support; these include those for allocating costs to specific services and projects. Processes for institutional investment in future capabilities are also considered.

Client Relationship Management. This area focuses on how an SE division's relationship with its various clients is managed, and how interfaces between the SE delivery units and client organizations are set up. Included in this process is client satisfaction assessment and management.

Communications/Interfaces with other Support Organizations. These processes / procedures focus on the communication, interface, and relationships between SE/CM and other non-client organizations. The organizations considered provide a direct service or product to the SE portfolio.

System of System Interfaces. These processes / procedures pertain to the increasingly common situation that RDE Center projects are nested within the requirements framework of much larger systems. These higher tier systems influence the adaptability required and ultimately competitiveness of a Center's offerings. Assessing and managing the System of Systems (SoS) environment is an element of SE business strategy.

Demographics of the Survey

Each survey respondent was asked to provide demographic information to support a basis for comparability with the client Center. Four corporate and 9 center level respondents participated in the study. The following demographic data were collected:

Item	Range	Comments
What is the highest organizational level of a dedicated SE champion?	From third-level division managers to a Chief SE for an entire agency (NASA)	There is correlation between the level of the champion and the investment toward the Strong Form SE model
How large is the technical staff that is subject to SE policy?	800 to 6000	This is the range for the individual Center's contacted.
How large is the SE pool?	8 – 15% of all Engineers	This is a rough estimate
How large is the SE core competence and support staff?	In the Methods Model as few as 12 in a smaller Center, up to 70-100	Variability of organizational arrangements makes this local-case specific
How long has the SE support division existed?	10 – 40 years	Reorganizations at 3-5 years intervals are common

ASSESSMENT

Study Context

DoD Interim Defense Acquisition Guidebook (Formerly DoD 5000.2-R) In the mid-1990s the federal government implemented acquisition reform with a new emphasis on performance-based contracting. In such a contracting model the government specifies its requirements (the what) with a minimum prescription of methods and processes (the how). Formerly, MilStd 499 was commonly invoked as the "how to" document for systems engineering on major projects. As a result of contract reform, the contents of this standard, when updated in 2002, were published as interim guidance.

The action of treating former SE requirements as guidance confirmed a perceived reduction in the emphasis on rigorous, consistent systems engineering practice for major defense projects. In particular respondents noted that increased emphasis on cost and schedule elements of project management had been coming at the expense of balanced risk management and thus technical performance in the long run.

The DoD Interim Defense Acquisition Guidebook provides detailed itemization of the expected functions and objectives of systems engineering application. However, it provides no indication of what organizational arrangements are best suited to maintain a Center's SE competence.

Under Secretary of Defense Memorandum: Policy for Systems Engineering in DoD In early 2004, DoD promulgated explicit policy endorsing a concept of SE as the umbrella mechanism for "integrating technical processes to define and balance system performance, cost, schedule, and risk." In particular it required that: "Programs shall develop a Systems Engineering Plan (SEP) for Milestone Decision Authority (MDA) approval in conjunction with each Milestone review and integrated with the Acquisition Strategy." As a result the different military departments and other DoD agencies have begun a process of upgrading SE implementation.

NASA Systems Engineering Handbook An external reference document for the technical practice of SE is given in this NASA internal standard. The Handbook is suitable for use with agency-wide training and when initially developed in 1989, it captured the experience of more than 70 agency staff and contractors. The Handbook identifies the portfolio of SE tools and practices but does not address the experience with organizational arrangements or business processes.

Conclusion. The comparison of DoD and NASA standards for SE demonstrate a strong correlation of the core products and services that would be available under a full service SE program. These portfolios of SE technical processes form this study's basis for defining the term SE competence. No comparable standard was identified for proven organizational arrangements that deliver effective SE.

The Strong Form Model

Many organizations responding to the study are of relatively long standing and mature. However, organizational arrangements among the respondents did not provide a consistent benchmark. The survey showed a variety of historical and local factors are implicated in the structure and policies of a Center SE competence entity. To normalize the specific practices the SE Strong Form Model of organization was defined.

Table 1 illustrates the characteristics of the SE Strong Form Model in comparison to a Methods Model. In the Methods Model an SE Division is organized around a portfolio of specialty practices that are available for discretionary selection by Project Managers.

Strong Form Model	**Methods Model**
Agency/command policy establishes a specific standard for what is expected when SE is specified as a requirement	Agency/command expectations for SE are limited to instructions in project management guidance
SE is viewed as an umbrella process that is essential to achieving technical, risk, cost and schedule balance on a major project; a corporate sponsor for SE exists	SE is viewed as another form of specialty engineering similar to human factors or safety; there is little perceived need for a corporate SE sponsor
The Lead SE on a major project functions explicitly as the technical director for the project on behalf of the Project Manager who is seen as being the principal decision maker for project execution	The application of SE on a major project is achieved by piecemeal assignments to functional engineers to accomplish needed integration tasks

The Lead SE on a major project is a senior engineer with relevant experience and specific, advanced training, qualification or certification of SE competence	Under the auspices of the Project Manager services are bought from the SE Division; Where assigned, a SE Lead is a relatively junior assignment with emphasis on administration
A SE Management Plan is an action document, approved by the Milestone Decision Authority; it is developed, maintained current throughout the life cycle of the project	The project is run without a formal SE plan or one is developed as a one time deliverable rather than an action document. There is extensive reliance upon contractor SE functioning
The agency develops a formal SE lessons learned capacity, provides training standards and courses or course material to build and SE Community of Practice	The SE Competence Division lacks a framework of peers and must be self-reliant for the development and maintenance of competence
Systems engineering is a career path that can be chosen by functional specialists or accessed by new hires	SE Division staff may be specialists in one or more tools but do not have a distinctive development track available
SE assignments are rotated to develop competence; changing an SE Lead is not a disruptive step for a project	SE Division staff is organized into functional branches. SE experts are available to projects but function primarily on the basis of relevant experience applied to individual tasks within the project

Table 1: Strong Form and Methods Model Comparison of Attributes

Observations – Business Processes

The study objective was to determine how those responsible for achievement of SE competence approached the associated business tasks. A great deal of variety was found in organizational arrangements. It appears SE competence maintenance is still in a grass roots stage of formal organization despite the existence of specific requirements.

It seems reasonable to surmise that if systems thinking had taken root at the level of an RDE Center (i.e. thinking of the Center as a system and a node in a larger network) there would be ready evidence of the products of SE applied to the definition of that Center system. Such evidence was not encountered in this fairly rapid survey.

Some organizations have begun to knit together a corporate approach to the SE competence development process. Typically the emphasis is primarily on technical competence in the SE discipline practitioners. The interest of this study in the more logistical aspects of organizing, developing, defending and forecasting the future needs for SE discipline appeared to surprise a number of respondents. No explicit business standard or normative SE Competence Center was identified.

Flowdown of Corporate Expectations. At the highest level, federal government acquisition policy drives the basic requirements that SE discipline be applied. The Air

Force, NASA, and corporate giants such as Lockheed Martin and Boeing face many internal or client requirements to apply SE discipline. Today it is not uncommon that these requirements are met in an essentially ad hoc and case-specific fashion.

There exist national, international and even agency standards that describe the elements of a SE technical approach. Almost exclusively, these standards are organized as an adjunct to project management standards and scaled to the needs of a single project. SE directors report there is much concern about how to apply SE products and services in a graded approach. There were numerous reports indicating that Project Managers and others in authority have difficulty assessing the value of specific SE disciplines to their project. They often tend to view investment in SE only as a series of specific risk management decisions (i.e. discretionary choices).

Project Manager skepticism points to judgment and broad experience as strongly desired client needs of an SE Competence Division. None of the SE standards examined speak to the systematic accumulation of such resources. This survey observed some solutions for remedying this trust gap, but these are surprisingly new. Given the fact that SE discipline is 40 years old in NASA, the appointment of a Chief Systems Engineer at NASA HQ just two years ago is telling. It suggests that better management through adequate SE discipline is only lately becoming of systematic concern at the corporate/agency level.

There is evidence from the survey that having an SE experienced corporate sponsor for SE proficiency increases the strength of policy messages regarding implementation. In both the Air Force and the NASA systems it is common that SE is viewed as an umbrella process that integrates technical management of the project. The project Chief Engineer is the position that is normally assigned responsibility for implementation of SE requirements. This is another indication of emphasis by high position in the organizational structure.

Were the corporate practice of SE disciplines to be fully systematized, it would be expected that standing processes would exist for performance assessment of individual Centers and specific practice areas. This survey identified little such practice at the corporate level. At present NASA is conducting a CMMI® (Capability Maturity Model Integration) assessment of SE practices at each of its 11 Centers. In addition to NASA, one commercial organization described a regime of corporate SE assessment mechanisms.

Demand Management. Many of the individual Centers have developed listings of the products and services they offer. These are typically displayed on a web site for easy connectivity within their organization. In this survey little detail was identified from these written descriptions. Both NASA and the Air Force have made substantial agency commitments to corporate development of an SE knowledge base. In the Air Force, a relatively new Center for Systems Engineering is progressing toward the establishment of a Community of Practice based upon its multi-level professional training programs and its development as a hub for SE case studies and other lessons learned.

In NASA and the Air Force the reporting level of the SE Competence Division tends to be high enough that specific functional head count is established in multi-year budget forecasts. Skill mix varies within that FTE count based upon someone such as a Chief Engineer's evaluation of both project needs and policy trends. Generally trends are assessed at a portfolio level. No system of activity-based costing and resource forecasting was identified.

In the case of one NASA RDE center, the SE Competence Division provides the administrative "homeroom" for those professional SE's in a project lead position (Project Chief Engineer). The SE competence division retains responsibility for that individual's performance and for placement in the next job once a project no longer needs a lead SE. Individuals who function in this manner have high experience level (GS-14 or15).

Overall there are strategic dilemmas evident in the future course of SE process maturation, particularly for government-operated organizations. However it seems evident that for the RDE Center there will be an increase in demand for two SE disciplines: 1) full life-cycle project and program risk management, and 2) SoS definition and management of external interfaces. This study suggests that this "Center as a system" competence is unlikely to develop out of an SE division operating on the Methods Model alone.

Service Level Monitoring and Reporting. This study indicates that for an SE Competence Division the question of SE effectiveness is typically engaged on one of two levels: 1) the Center portfolio level or 2) the individual practitioner level. In July 2004, a large industry/government conclave of SE proponents concluded that a lack of data on SE effectiveness was a top-level concern in the revitalization of SE commitment. This meeting was sponsored by the Air Force and held at MIT. (See the Lean Aerospace Initiative, http://lean.mit.edu/) It appears that industry-wide study is being directed toward data that supports the SE benefits evident over the long run of multiple projects.

Benefit evidence has appeared for the past decade but its quantitative reliability appears to be often challenged by the unpersuaded. On the Center level one contemporary example of a metrics suite was identified at the AF Space and Missile Center. Some 21 indicators, both leading and lagging, have been defined. Deployment of this suite is less than a year old. As some classified information was involved, details were not available to judge the distribution of metrics between project SE effectiveness and that of individual contributors. In general it appears that metrics systems that would serve to advertise the value added of an individual Competence Division are developmental.

Typically, Centers operating closer to the Methods Model rely on the seniority and reputation of individual practitioners as a basis for achieving client satisfaction. With an SE lead who is at GS-14 or above, the tendency is to rely upon this individual's judgment to determine what specialty SE services are needed. Acquisition of these skills may come from in house if available, but may also be outsourced to contractors despite in house availability. This would be a project manager decision that could be affected by factors

such as timely availability of an in house resource – a factor not directly related to applied competence but adversely impacting Center competence development.

In summary, it appears that identification of benchmark service indicators will need to be in the future. Increased understanding of the SE approach and the overall benefit of Strong Form SE will need to mature before divisional effectiveness metrics become reliable. Fortunately, there is evident industry-wide interest in better parameterization of cost/benefit utility. ARDEC SE champions have a potential network of interested parties in this business practice development.

Financial Management. Most Centers use a combination of direct and indirect cost accounting. Where these conditions have been in place for a decade or more (e.g. NASA) the divisions appear to have well defined budgeting and accounting rules. A variety of accounting practices were observed. In one Air Force center, budgeting was functional to SE competences that are cross cutting to all projects and funding was strictly through overhead allocation.

It appears that changes in federal acquisition practices and related manning allocations have much to do with what budgeting and cost accounting practices apply. The trend of the past decade toward more performance-based contracting and a downswing in the prescription of management process standards in major contracts has negatively impacted SE Competence Divisions in their capacity as keepers of a variety of standards.

No comprehensive SE competence development standard was identified during the study, but it is evident that some large organizations have multiyear initiatives to strengthen the contribution of SE to program performance. Further study would be needed to investigate the precise mechanisms and the associated funding basis for these initiatives. There is evidence of considerable industry cross communication about SE but the questions of interest appear to be more functional in nature and haven't yet gotten down to the level of organization and financial models.

In the context of historical autonomy, SE Competence Divisions appear to be treated for financial purposes as functional cost centers (e.g. as part of a central engineering technical function). If the Center is committed to a Strong Form Model, there is a broad view of who is engaged in the attainment of SE effectiveness. Within this framework up to 25% of the engineering staff are considered SE practitioners.

A representative case had a ratio of 70 SE divisional personnel supporting 9 major acquisition domains among 6000 engineers total. In the mid-1990's at the LM Aerospace "Skunk Works", an SE division of less than 20 people supported 30-40 R&D programs. A very approximate ratio across the entire survey was 1:2:10 (SE Competence Staff: SE practioner in another organization: SE affected engineers). In this small sample the variance observed for this distribution is large.

In conclusion, at this stage it appears that core competence-driven financing models are not being seriously examined. This is likely attributable to the stronger influence of

general pressures to minimize total federal staff over attempts to have needs-based forecasting. Despite this obstacle many believe that increased SE effectiveness would be promoted by knowledge of how to deliver SE services most cost effectively. Efforts to determine how to model the cost/benefit equation were not found in this survey.

Client Relationship Management. Survey respondents were generally oriented toward their efforts to maintain desired levels of competence and to assure their "fair share" of the Center's overall resource allocation. With respect to client relations there is a sense that two types of situation exist. In one case there is a cadre of highly experienced and respected Systems Engineers; these are people known to the various Program Managers and their services are requested by name. Characteristic of such individuals appear to be a suite of integrating/facilitation skills in addition to a general knowledge of the various SE tools; their reputation precedes them.

The second situation is where there is less depth to the roots of SE reliance. In these cases the program management often operates with ad hoc SE. As a result the PM relates to an SE Competence Division at a source of discretionary technical support. Often PM's gain SE support from contractors who are downstream in the acquisition cycle rather than draw upon an independent group within their own organization. In this situation, the SE Competence Division, with or without the "superstar" practitioner, is in the sales mode to an individual who is primarily driven by cost considerations. In the relative absence of agreed upon metrics, it appears difficult to establish more objective measures of client satisfaction.

A prevalent quality model in use to judge SE effectiveness appears to be the CMMI® maturity framework. As it focuses on technical proficiency it leaves little room for concerted development in this area of business interface management. One very experienced commercial respondent indicated that as a matter of SE effectiveness SE practioners often encountered resistance to their services if they were presented in an overly prescriptive way. He expressed concern that use of the CMMI® ran the risk of elevating process objectives over product quality.

Some total quality models such as the Baldrige Criteria for Performance Excellence or the Balance Scorecard would draw added emphasis toward client service values. This would be true at the SE Competence Division's interface with its clients and would be an aid for those in the SE Community of Practice. Given the degree of flux and the SoS trends in the overall DoD SE development picture, it appears that Centers would benefit from the incorporation of a service value assessment process.

Communications/Interfaces with other Support Organizations In the course of this survey it was concluded that there are few, if any, local support interfaces that are unique to an SE Competence Division. On the other hand, there seems to be a potential benefit from viewing the RDE Center as a system and treating creation of SE Competence as a project that would benefit from the application of SE to its own development. There appear to be many locally contingent factors that affect the organizational arrangement

under which SE is deployed. It is suggested that a prominent role for any SE policy group would be development of a Center Competence Plan.

Included in that Competence Plan's development would be analysis of the communication demands (e.g. an offerings website) that are implicit in any adopted process of competence building. Experience of contemporary management of change principles would suggest that a well-crafted Communications Plan is highly valued in keeping all impacted organizations (e.g. Human Resources regarding expanded qualification needs) current on developments of general interest.

System of Systems Interfaces. As determined in the literature review, SoS considerations are an area of growing interest. This was found to be true with both commercial and government respondents to the survey. It was noted that placement of Lead System Integrator (e.g. the Future Combat System) contracts with commercial firms is resulting in more direct involvement of contractors in defining the requirements that go into acquisition process. Some are concerned that proven precedents about non-delegable government functions may be eroded to the detriment of the government interests. However, one respondent suggested that large military procurement agencies lack the governance mechanisms for advance product portfolio management as it has been developed in broader commercial industry.

The significance of these developing areas of the SoS concept is that RDE Centers may need to develop an SE level subject matter expertise in the liaison of its projects with the SoS external environment. Requirements and configuration management are two prime areas in which the scope of a Center project may be governed in part by technical protocols that are developed outside the command. Given the existing investment in SE management tools and the lead-time in making changes, the SE Competence Division is a logical spot to monitor and participate in the evolution of such SoS process standards.

There is a belief among some respondents that SoS emergence, particularly in conjunction with concepts such a spiral development, represents a fundamental change to the nature of systems engineering. Classical SE is seen to be a relatively linear process of reduction from the general to the particular. Network-based major SoS introduce the characteristic non-linearity of communications webs. This survey determined that governmental forums exist to actively investigate the implications of SoS needs on the practice of SE. In developing a multi-year plan for building SE competence, provision for capability in this area appears to be warranted.

RESULTS

Summarized below, are observations gleaned from the survey process that crosscut specific business process conclusions.

Findings.

- Growing OSD desire for large-scale integration and timely evolution of military systems has created a new order of complexity for weapon systems Program Management. With this added complexity comes a stronger mandate for successful SE at each system level.
- Deeply imbedded SE thinking that crosscuts local specialties is one antidote to added complexity. DoD emphasis on SoS management capability raises the bar for remaining competitive as an RDE Center.
- There are RDE Centers where SE competence is a primary metric of the Center's effectiveness; their programs closely approximate the Strong Form Model. Project-by-project, or discipline-by-discipline SE success may not be sufficient to build a Center's reputation for SE effectiveness.
- The availability of tools and engineering specialty competence forms the nucleus of RDE system capability but it should be programmatically developed as a multi-year project if SE is to become a competitive competence for the Center.
- Some military centers are using the NASA technology readiness level (TRL) model to assess SE impact. Prior to level 6 declaration, in the development stages of the life cycle, aggressive organizations believe that 20-25% of engineering effort applying SE discipline is considered healthy; less than 15% is considered a warning sign.
- Organizations with SE practice since the beginning of the missile and space age (NASA, Air Force, Lockheed Martin, Boeing) are committed to the Strong Form model. They have full system-wide training, career paths and corporate competence centers that maintain and evolve capability. In effect corporate SE competence is viewed as a SoS challenge. They see SE as an evolving, experienced-grounded, and crosscutting capability. There is recognition that effective SE involves craft and aptitude and not just rote prescription.
- SE indoctrination alone is not sufficient to gain commitment to Center SE competence. Long-term operation in the Methods Model comes at the expense of SE not being understood as the fundamental mechanism of technical integration and risk balancing.

Best Practices.

- SE is managed as a corporate and competitive asset.
- Development of SE competence is an executive function to ensure visibility of corporate commitment; SE policy is issued at this level.
- The day-to-day project responsibility for application of SE discipline is vested in the project chief engineer; SE SME's aid with this duty.
- All engineers are expected to be proficient in total systems thinking and conscious of the need in all projects for a balanced approach to risk management.
- SE subject matter expertise is cultivated among senior experienced individuals, those with performance reputations that proceed them – pay structures reflect this expectation

- The cost of SE competence is treated as a corporate investment even when provisions are made to back-charge projects for itemized costs.
- A career path exists for experienced SE generalists
- Development or improvement initiatives in SE competence are planned as multi-year initiatives with an emphasis on core capability establishment.
- Corporate SE Manuals are developed as primers and repositories for lessons learned.

Areas of Development.

- In the current defense systems acquisition environment complexity of the systems challenges is increasing but many traditionalists are not convinced that SE has proved its worth. Identification of measures and metrics for SE effectiveness is a development frontier for its adherents.
- Non-linear systems evolution (e.g. net-centric warfare) differs in kind from classical forward engineered development projects. To establish a Center reputation for SE competence, expertise in non-linear systems may be needed.
- Proficiency with teamwork and human conflict facilitation can be valued skills as the inherent stresses, including competition, come to bear in much larger, more complex systems.

Recommendations. The following are based upon a composite of lessons learned in the course of this benchmarking effort.

Adopt an Center-tailored version of the Strong Form Model as the end-in-mind of SE competence building

- Recognize the command-wide change management task inherent in such a decision
- Arrange a forum for Center top management and invite counterpart executives from organizations with mature corporate commitments to share perspectives about the challenges involved with such an initiative

Establish SE as integral to the Center project management model

- Accelerate implementation of OSD direction on the creation of SE Plans for most projects
- Apply a graded approach that allocates scarce SE resources on a risk-informed basis via an Center-wide portfolio risk management mechanism
- Place SE cost management on a business footing by formalizing the necessary service processes and metrics
- Establish an evaluation mechanism that can estimate the extent of SE application; manage the distribution of project-by-project investments as a corporate risk pool

Establish a five-year Systems Engineering Competence Plan

- Promulgation should be by the Center Commander with execution led by a direct reporting executive
- Sponsor the Plan as a corporate infrastructure investment

- Conduct the Plan as a systems development project
- Establish an center-representative IPT to support the prioritization of development initiatives
- Formally establish an SE Community of Practice to network all who provide one or more of the SE products and services

SUMMARY

This benchmarking effort was undertaken at a time when the SE professional community of both government and industry practitioners is facing a bubbling cauldron of concerns, growing pains, initiatives and external demands. The survey conducted probed the business practices of RDE organizations with an established SE Competence Division.

How many SE practitioners to employ and how to cover their cost are real issues, but it was found that these issues were typically engaged as matters of institutional policy not business processes. At the present only one commercial-like, "fee for service" experiment with a client-centered approach was identified at a government center. Elsewhere accounting practices vary and typically budgeting is based on historic usage.

The influence of external developments, particularly the DoD System of Systems management architectures, is causing evolutionary developments within almost all the respondents. NASA is in the performance improvement mode following the Columbia accident, it has moved to upgrade SE across the agency. These sea change initiatives are impacting Centers more broadly than just in SE technical practices.

No organization contacted would say they have SE "down pat", but some are marching forcefully with improvement programs even after many years of having SE Competence Divisions. Broad patterns exist of approach to SE competence maintenance. These patterns where characterized for this report as the Strong Form Model and the Methods Model. This report concludes that the Strong Form Model is the way of the future.

BIOGRAPHY

William P. Mullins has been a practioner and senior consultant for 35 years in the nuclear energy sector. He has designed governance systems for complex, one of a kind enterprises such those for cleanup of former nuclear weapons production facilities. He has extensive experience in regulatory remedial action and other management of change situations.

Mark A. Wilson is the CEO of Strategy Bridge International a consulting firm that helps companies achieve sustained improvements in business performance by bridging the gap between strategy development and bottom-line results through enterprise systems engineering, strategic management, and decision engineering. He has significant expertise in systems engineering and project management and 20+ years direct experience with C4ISR systems. He is proficient in requirements management, space systems operations, information analysis, and dissemination.