A Study of Systems Engineering Effectiveness

Building a Business Case for Systems Engineering

Presenter: Joseph P. Elm
Software Engineering Institute

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Context

The value of SE is appreciated by some, disputed by a few, and not understood by many.

Quantitative evidence of the value of SE is sparse

- Greuhl, Walter: "Lessons Learned, Cost/Schedule Assessment Guide". NASA Comptrollers Office, 1992
- Honour, Eric; "Understanding the Value of Systems Engineering". 2004

Weaknesses in SE continue to impact program success

- GAO-09-362T "… managers rely heavily on assumptions about system[s] … which are consistently too optimistic. These gaps are largely the result of a ***lack of a disciplined systems engineering analysis*** …"

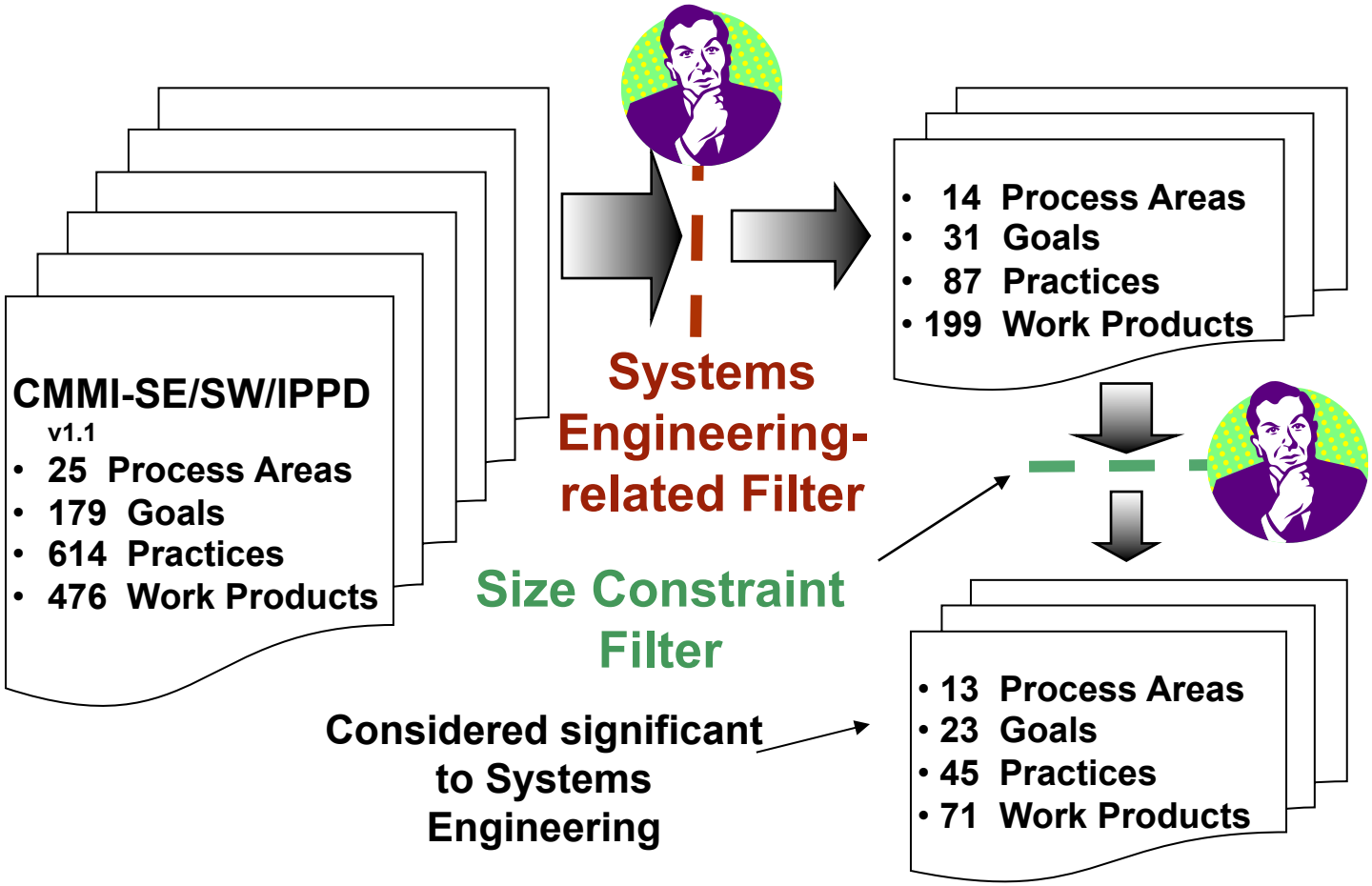
SE Costs are evident	SE Benefits are less obvious and less tangible	
• resources spent • elapsed schedule	• cost avoidance • improved efficiency,	• risk avoidance • better products

Background

In 2006, NDIA embarked on a project to collect quantitative evidence of SE Value

- NDIA formed the SE Effectiveness Committee (SEEC)
- The SEEC conducted the SE Effectiveness Study
  - Developed a survey collecting information from defense contractors
    - Queried individual project s to assess SE capabilities applied, resulting project performance, and other factors influencing project performance
  - Received responses from 64 projects
  - Analyzed the data and identified the strength of relationships between SE activities and project performance
  - Results published results in 2007 and 2008 (http://www.sei.cmu.edu/reports/08sr034.pdf)
- Showed valuable relationships between many SE activities and project performance

Artifact-based assessment of SE Practices



Survey content is based on a recognized standard (CMMI)

Assessment of Project Performance

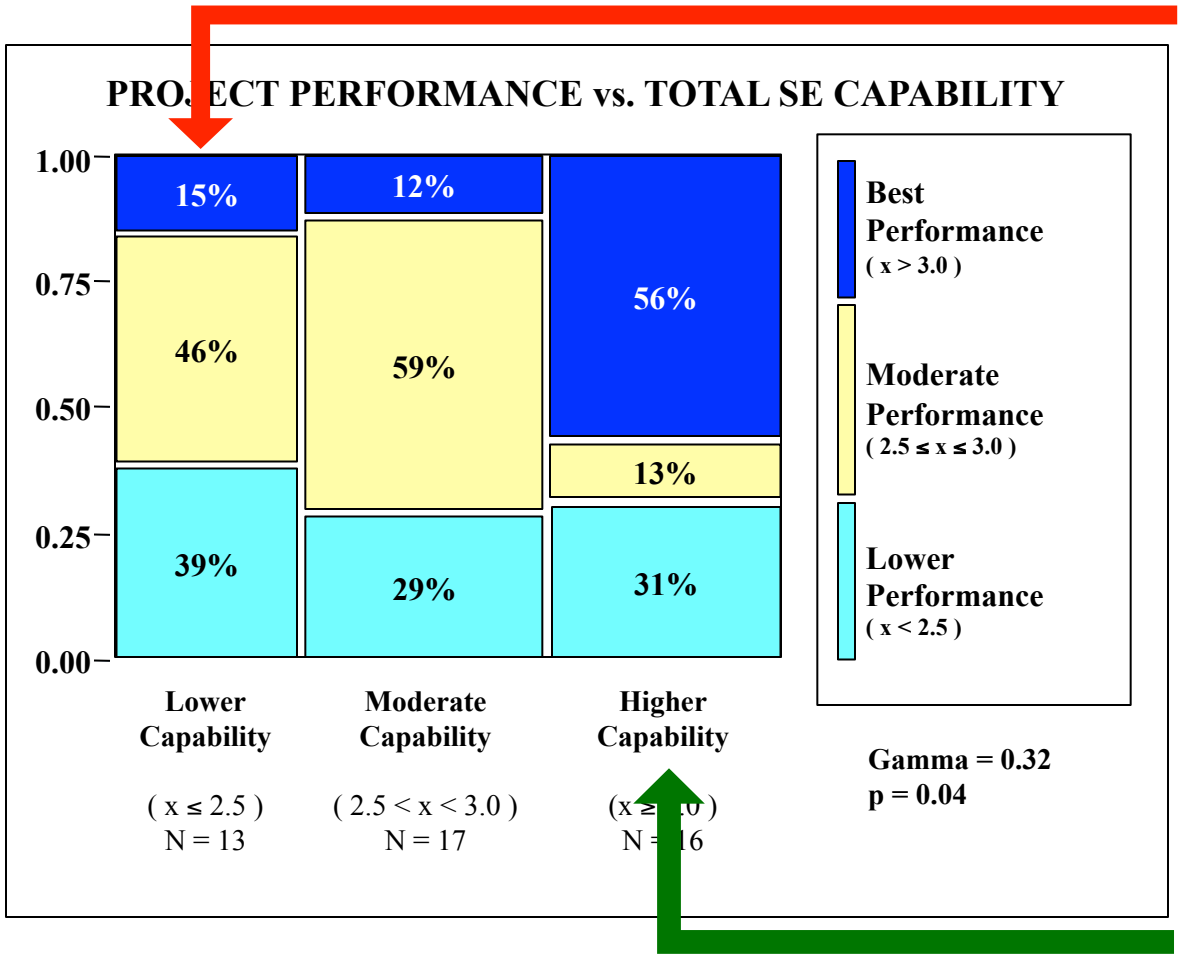
Assess TOTAL Project Performance

- Project Cost, Project Schedule, Project Scope
- Focus on commonly used measurements
  - EVMS, baseline management
  - requirements satisfaction
  - budget re-baselining and growth
  - milestone and delivery satisfaction

Assessment of Other Factors

- **Project Challenge** – some projects are more complex than others
- **Acquirer Capability** – some acquirers are more capable than others
- **Project Environment** – projects executed in and deployed to different environments have different needs

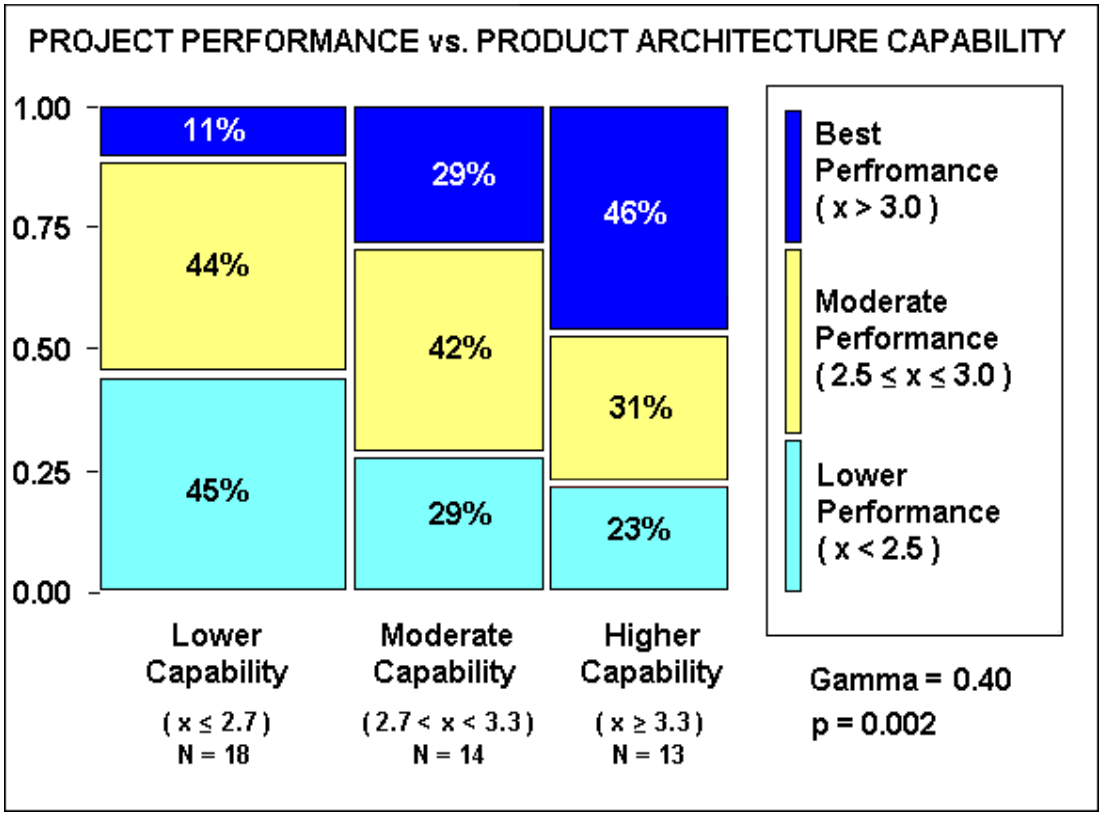
The Bottom Line



For the projects that did the least SE, only 15% delivered the best project performance.

For the projects that did the most SE, 56% delivered the best project performance

Product Architecture Capability vs. Project Performance

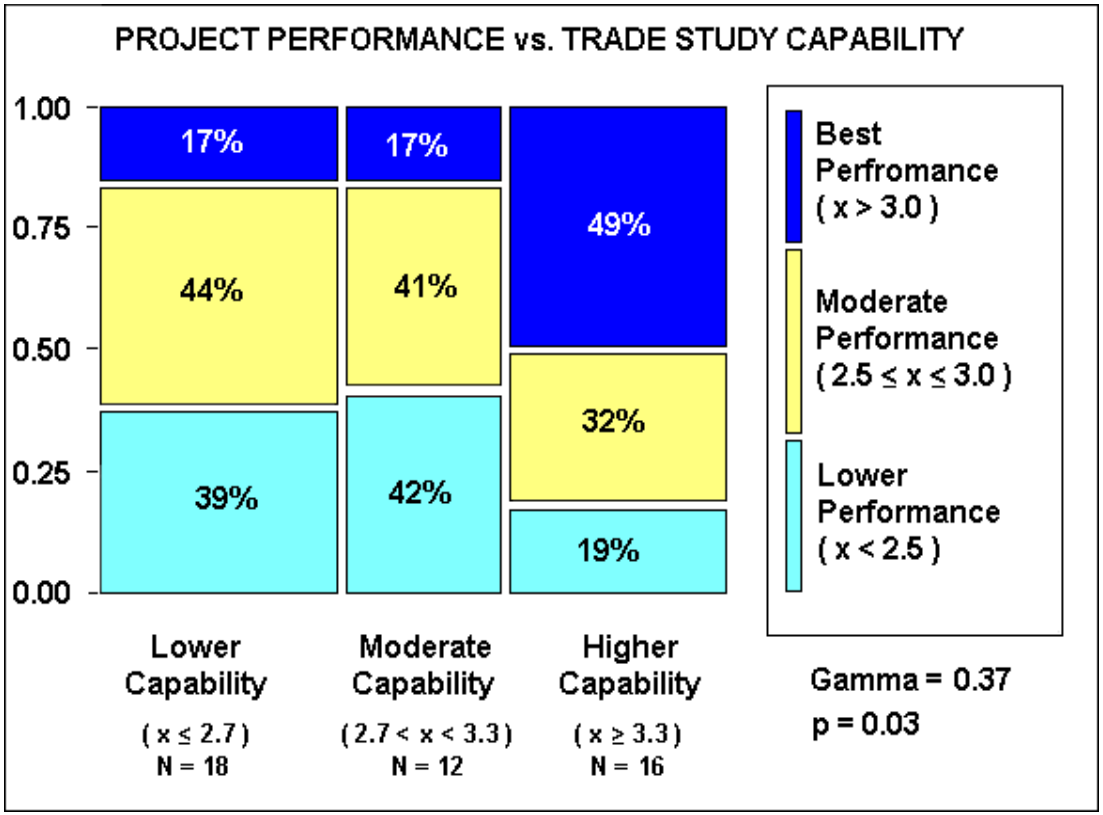


Product architecture assessment examined

- High-level product structure documentation
  - Including multiple views
- Interface Descriptions

Better Product Architecture has a "Moderately Strong / Strong" positive relationship with Better Performance

Trade Study Capability vs. Project Performance

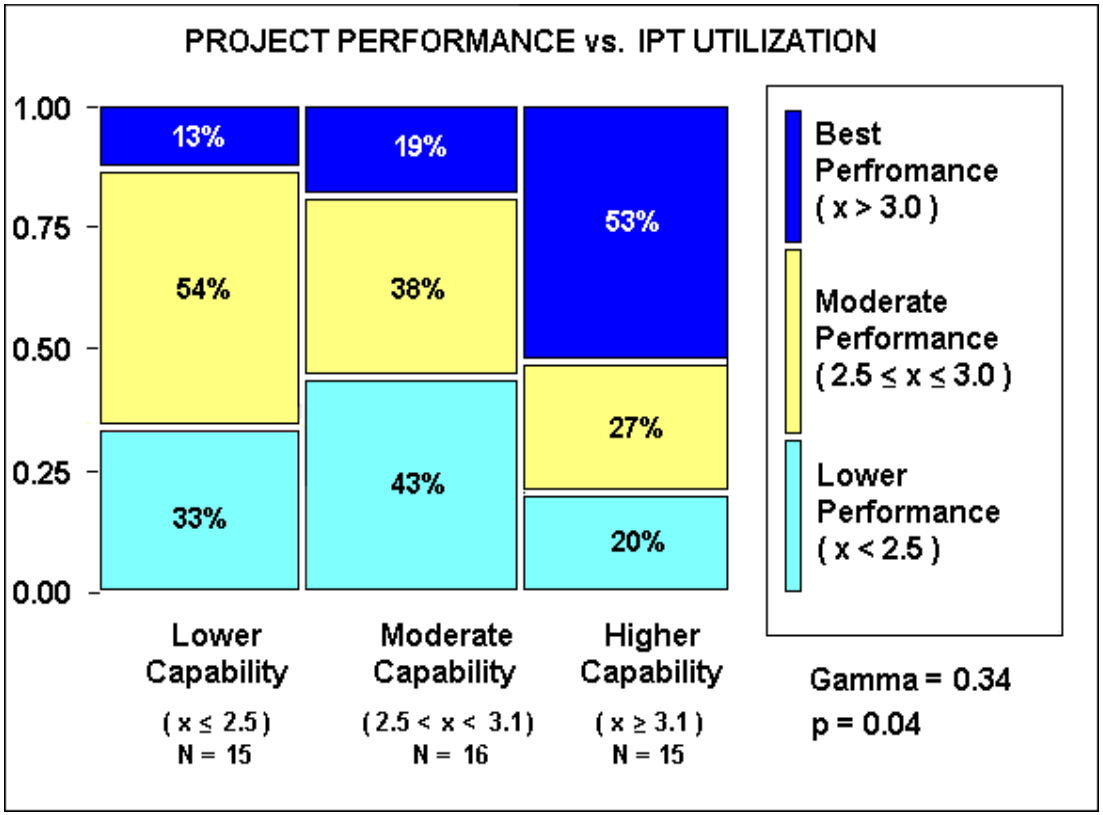


Trade Study assessment examined

- Documentation of Trade Study selection criteria
- Documentation of Trade Study results
- Stakeholder involvement in Trade Studies

Better Trade Studies have a "Moderately Strong / Strong" positive relationship with Better Performance

IPT Utilization vs. Project Performance

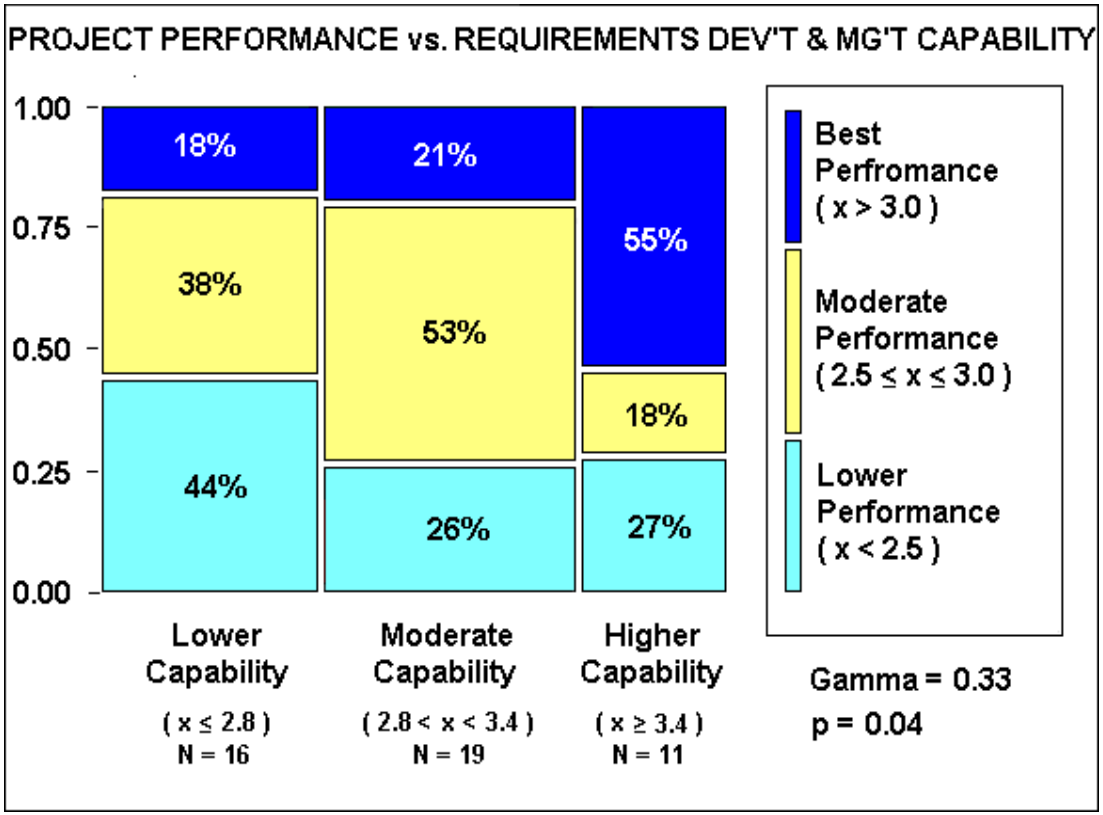


IPT (Integrated Product Team) assessment examined

- Effective IPT Usage on Project
- Supplier participation in IPTs
- IPT for Systems Engineering
- SE Representation on each IPT

Better IPT Deployment has a "Moderately Strong" positive relationship with Better Performance

Requirements Development & Management vs. Project Performance

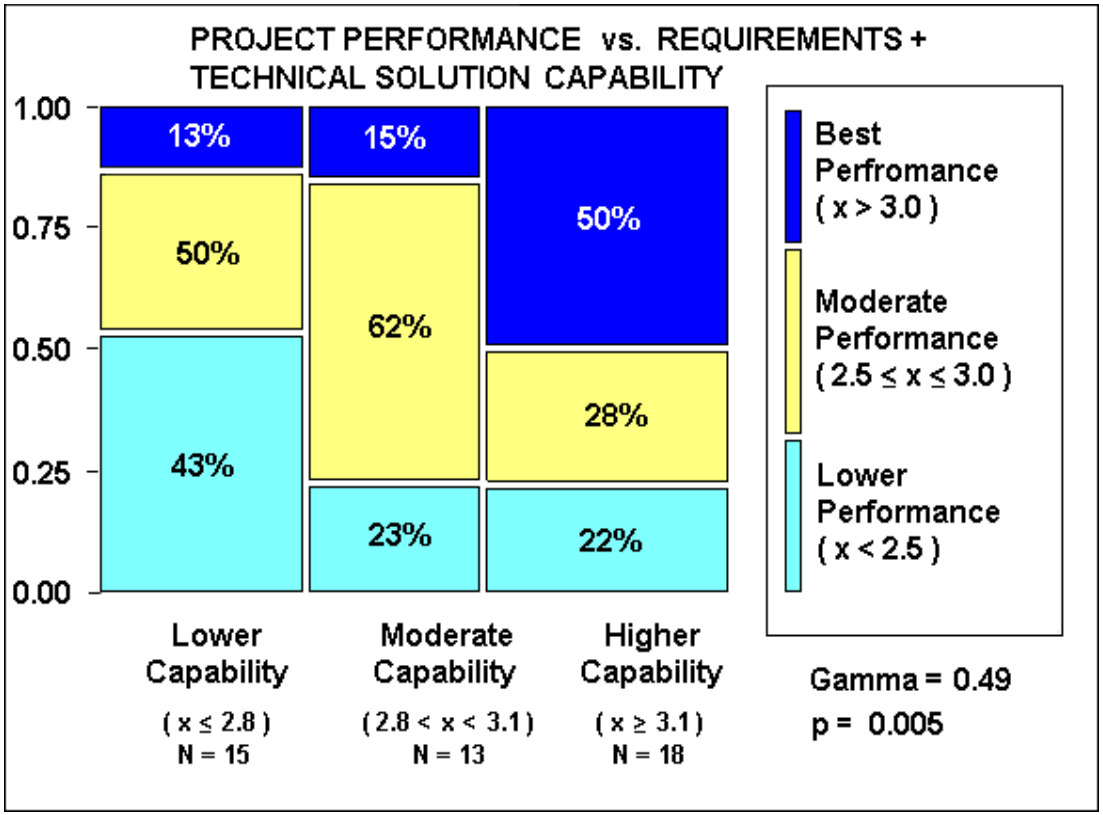


Requirements assessment examined

- Customer & derived requirements lists
- Hierarchical allocation to system elements
- CONOPs, scenarios, and Use cases
- Criteria for authorization of req'ts providers and acceptance of req'ts
- Change control process
- Traceability to Stakeholder needs

Better Requirements Development and Management has a "Moderately Strong" positive relationship with Better Performance

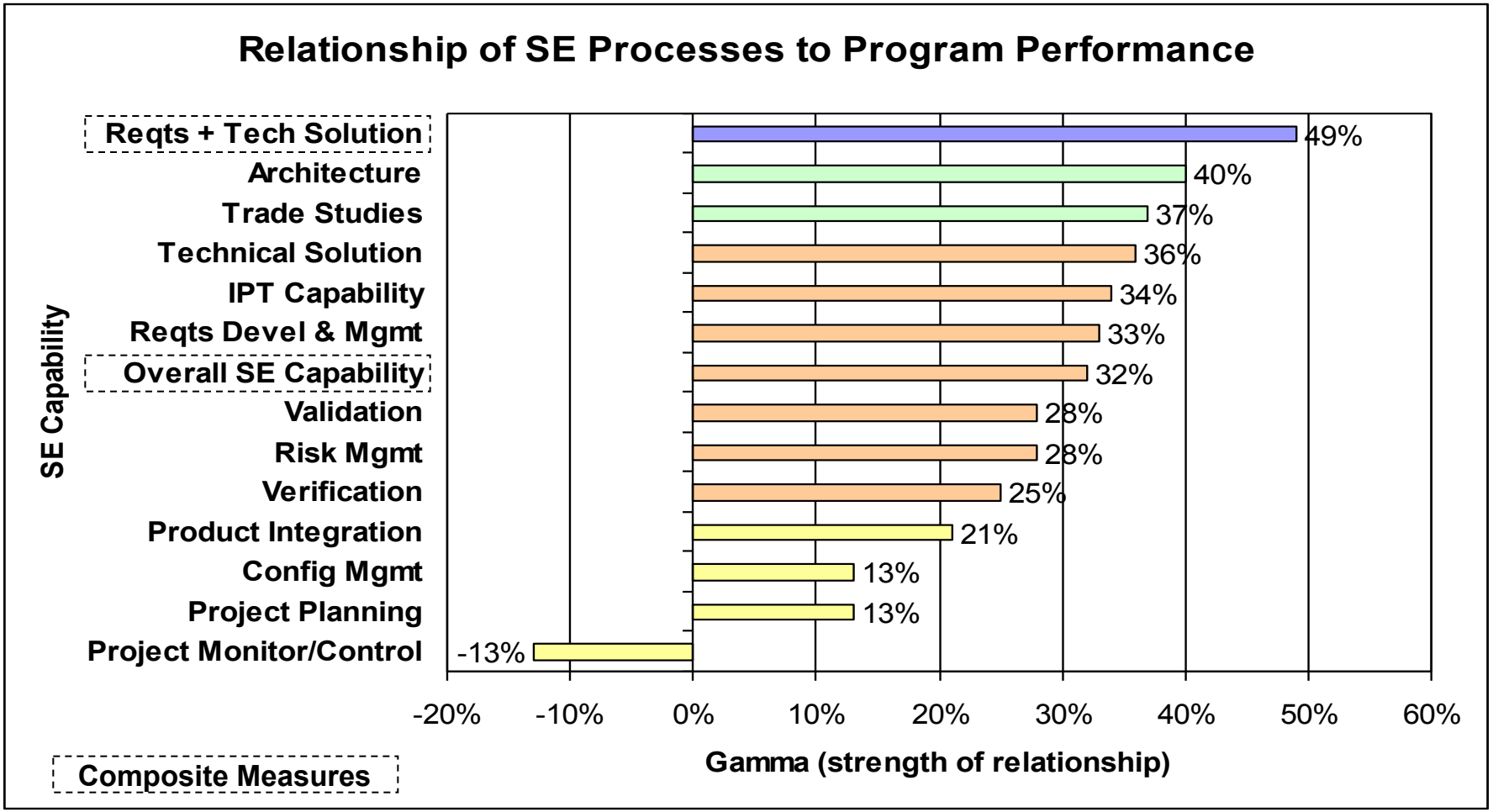
Requirements + Architecture + Trade Studies vs. Project Performance



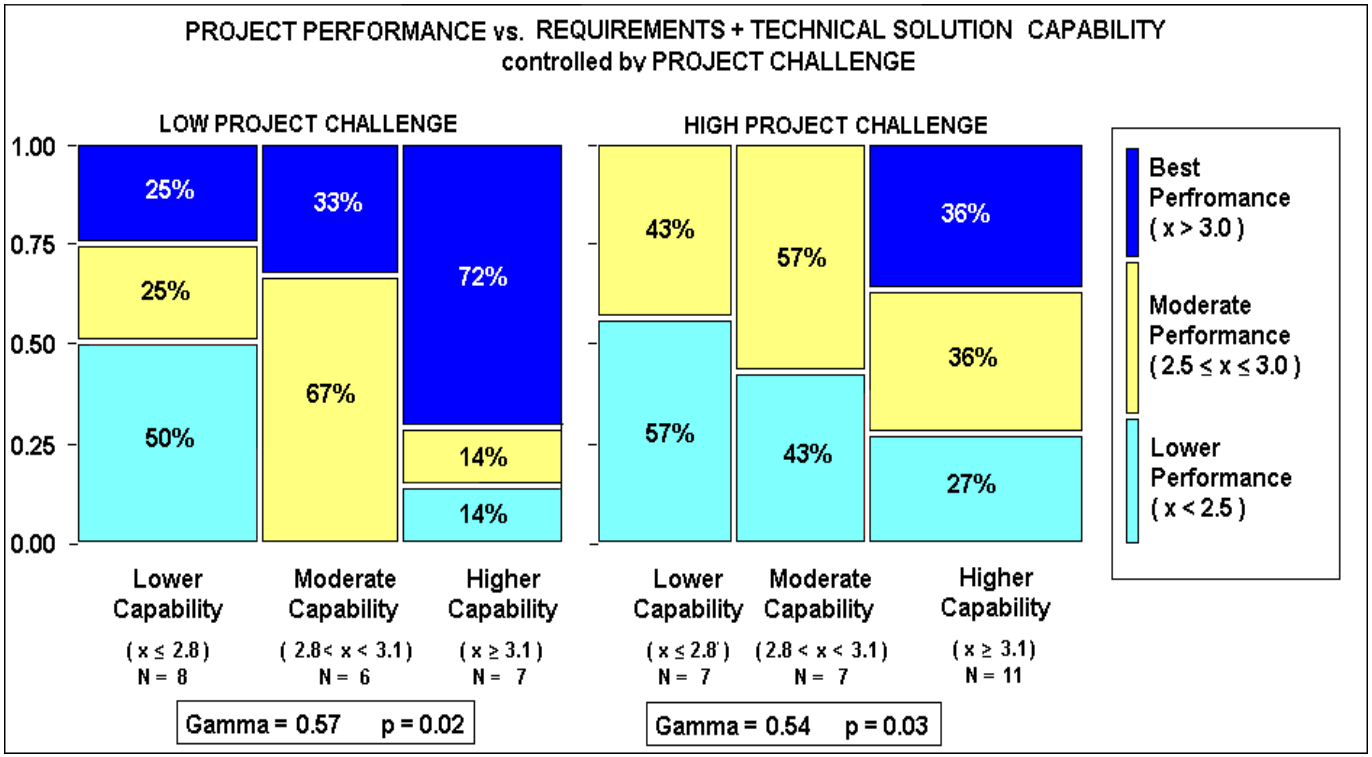
When looking at the impact of <u>COMBINED</u> SE activities, we see even stronger relationships

positive

Summary of Relationships



(Req'ts + Arch. +Trade Studies) vs. Project Performance, controlled by Project Challenge



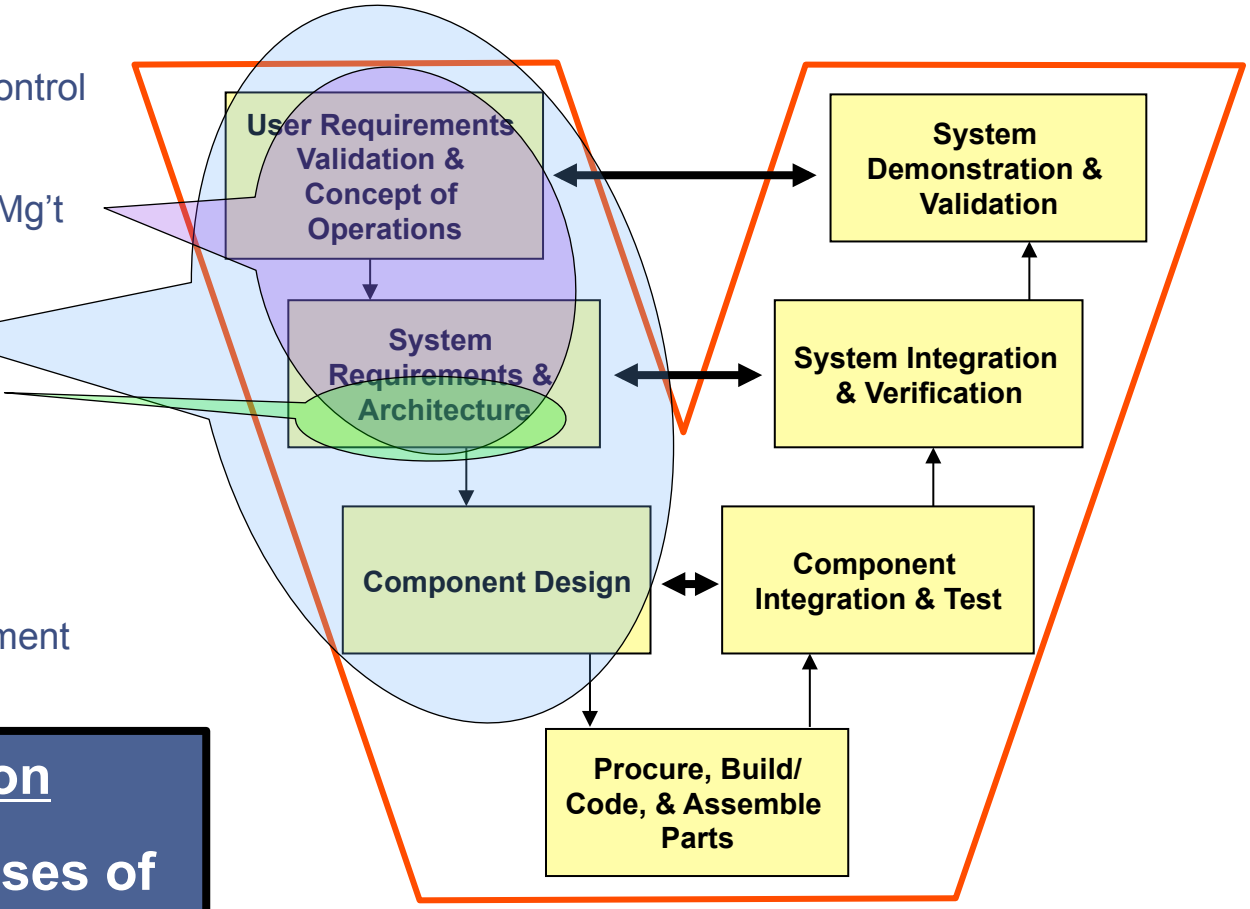
Project challenge factors:

- Life cycle phases
- Project characteristics (e.g., size, effort, duration, volatility)
- Technical complexity
- Teaming relationships

Regardless of Project Challenge, better Requirements Dev't and Mg't and better Technical Solution processes shows a "Strong" positive relationship with Better Performance

Mapping of Results to System Development

- Project Planning
- Project Monitoring & Control
- Risk Management
- Requirements Dev't & Mg't
- Technical Solution
  - Trade Studies
  - Product Architecture
- Product Integration
- Verification
- Validation
- Configuration Management
- IPT-Based Capability



http://ax.losangeles.af.mil/se_revitalization/main.htm

V-Model of System Development

Conclusion

The early phases of SE have the most impact

Moving Forward

Study results have been adopted by several major aerospace and defense suppliers.

- Used the survey instrument to assess their internal projects
- Compared results against benchmarks established by the study
- Used results to guide SE process improvement activities.

Presented study results and recommendations to OSD in 2007

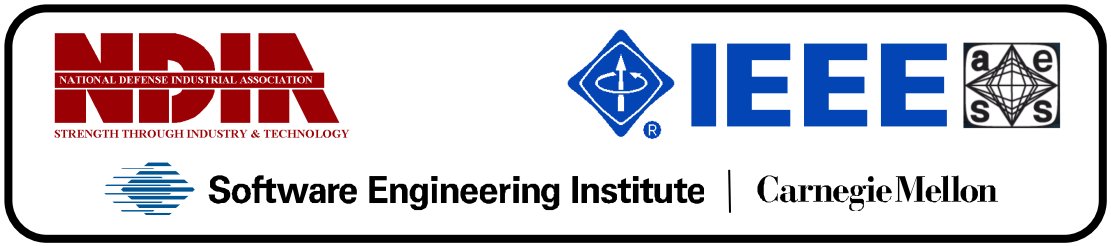
Held discussions with IEEE in 2009 regarding extension of the study to a wider audience

Briefed OSD leadership (Mr. Stephen Welby) in May-2010

- Received an enthusiastic response
- Interest in gathering more data
- Some interest in disseminating data throughout DoD
- Some interest in incorporating findings into DoD acquisition guidance

So, Here we are today …

The 'NEW' SE Effectiveness Committee



Role	Designee	Affiliations
Project Manager	William Lyons	• IEEE AESS Board of Governors • The Boeing Company
Deputy Project Manager	Robert C. Rassa	• President, NDIA Systems Engineering Division • Raytheon Systems Company
Deputy Project Manager	Alan R. Brown	• Chair, NDIA Systems Engineering Effectiveness Committee • The Boeing Company
OSD Liaison	Michael McLendon	• OSD (DDR&E) *
Lead Researcher	Joseph P. Elm	• Software Engineering Institute

Companies Represented on the SE Effectiveness Committee		
Boeing	Oliva Engineering	Textron System
Georgia Tech	OSD	USAF - AFMC/EN
Harris	Raytheon	USAF - SAF/AQRE
INCOSE	Sikorsky	Northrop Grumman
Lockheed Martin	Software Engineering Institute	

* On IPA assignment from Software Engineering Institute

The Mission

Promote the achievement of quantifiable and persistent improvement in project performance through appropriate application of systems engineering principles and practices

- Identify principles and practices shown to provide benefit
  - This is an extension and a confirmation of the prior NDIA study
- Assist DoD, industry, and academia in developing the guidance and direction to implement those principles and practices
- Assist DoD, industry and academia in establishing a means of monitoring / tracking the results of these efforts
  - An on-going data collection and analysis process

The Plan 1

Phase I

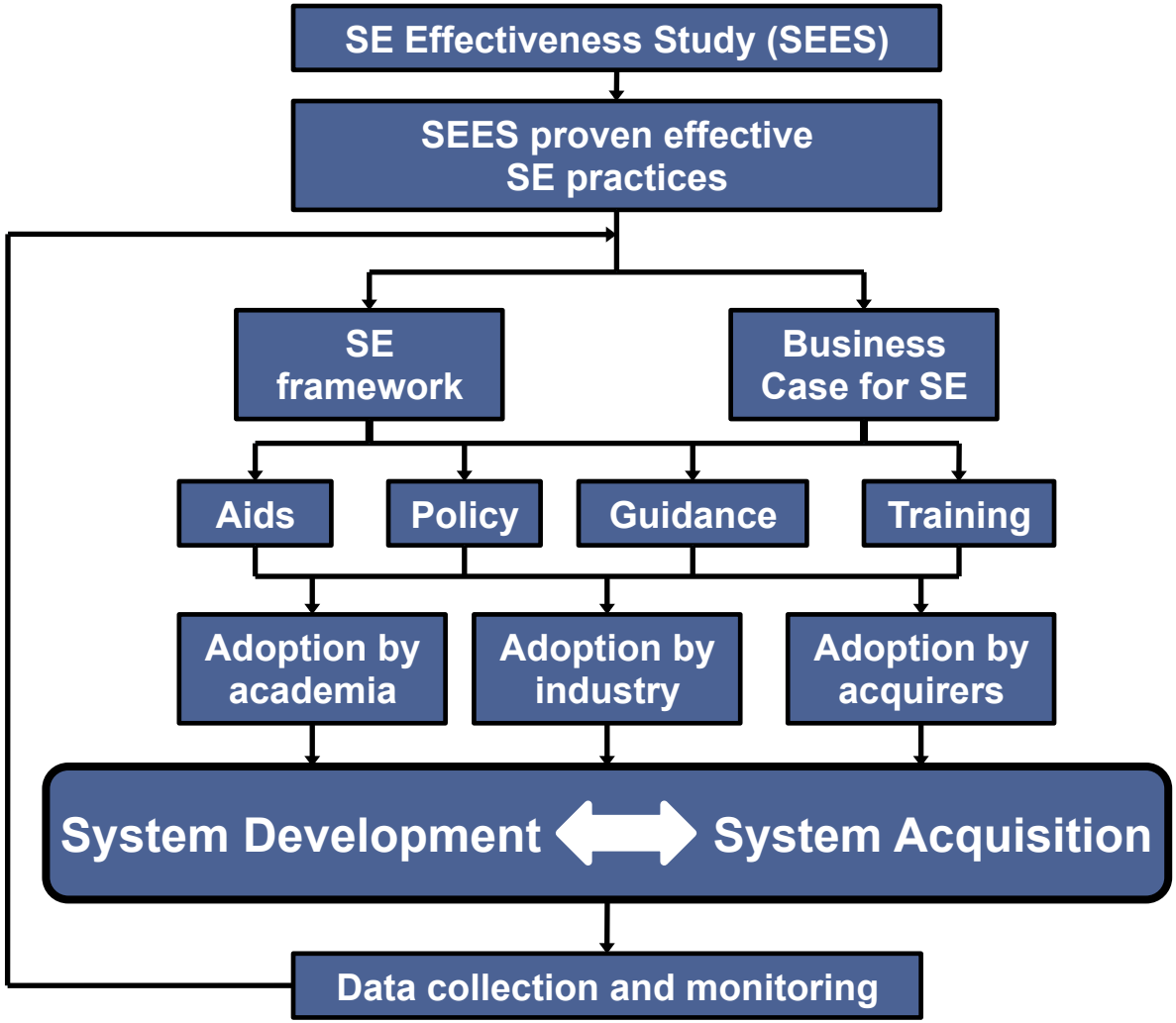
Jun-2010 thru Mar 2012

Phase II

Mar-2012 thru Jun 2013

Phase III

Jun-2013 thru Oct 2013



Status

Committee formed and organized

- Weekly teleconferences
- Collaborative web site established

Project planning completed

- Task Plan developed

Survey preparation in progress

- Questionnaire developed with collaboration from NDIA, IEEE, and INCOSE
- Survey sampling process developed
- Survey analysis plan developed
- Survey infrastructure (web sites, data repositories) developed
- Survey presently in test

Survey Tenets

All data will be submitted anonymously

- No data collected will identify the respondent, project, or organization

All data will be handled confidentially

- Data will be submitted directly to a secure web site managed by the SEI
  - The SEI is a federally funded research and development center. It does not compete with any responding organizations, and frequently operates as a trusted broker in matters of confidential and proprietary information.
- Only authorized SEI staff will have access to the submitted data

Only aggregated data will be released to the participants and the public

- No released data will be traceable to a project, person, or organization.

Participation

Our target audience is Project Managers, Chief Engineers, Lead System Engineers, etc. of projects delivering products (not services)

- Not limited to defense industries – all industries are welcome
- Not limited to US companies – all are welcome

Reaching potential respondents

- Grass roots approach
  - Broadcast an invitation to participate to members of participating organizations (NDIA, IEEE-AESS, INCOSE)
- Top down approach
  - Identify SE leadership at major companies
    - Network through participating organizations (NDIA, IEEE-AESS, INCOSE)
  - Contact them directly and solicit their support
    - Identify potential respondents within their company
    - Promote participation

Why should you participate?

It's good for you

- A better understanding of the effectiveness of specific SE practices will help you do your job better, and help you justify SE efforts to your management

It's good for your company

- A business case for SE will help your company apply resources where they can have the most impact

It's good for the world

- Better SE leading to better projects will produce lower costs, faster deliveries, and better performance for systems

As in the prior NDIA study of SE Effectiveness, survey participants will receive early access to study results, enabling them to evaluate their SE practices against an industry benchmark.

Watch your email !

Many of you will be receiving an email participation inquiry, asking the following:

Name _____

Organization _____

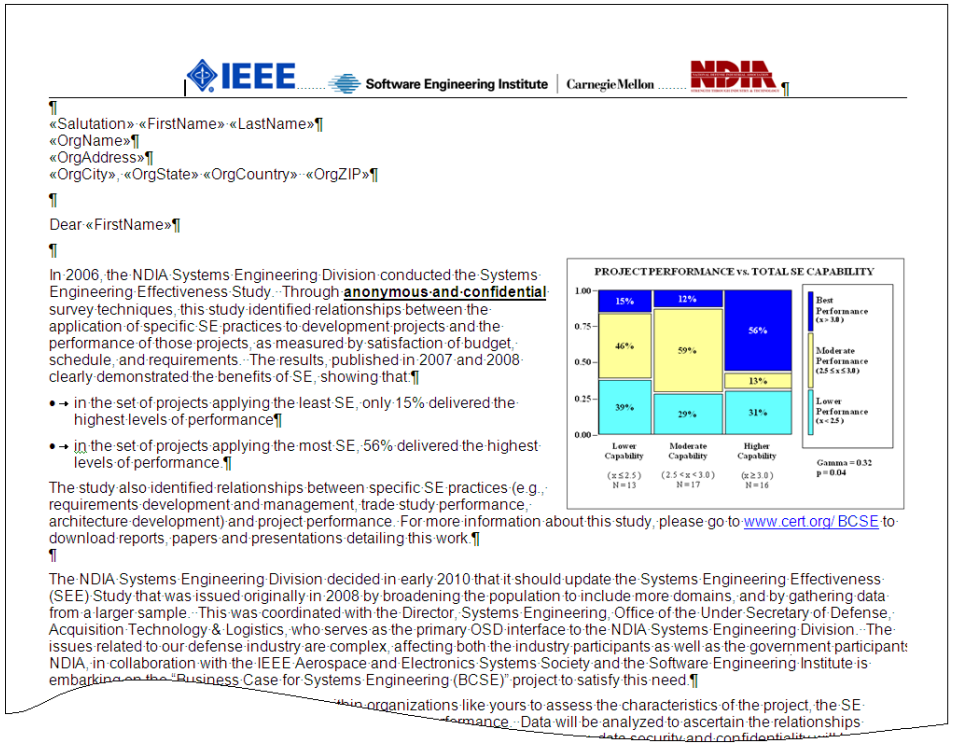
Email address _____

- ☐ **Yes, my organization and/or project is willing to participate in this study**
- ☐ **No my organization is not willing to participate in this study**

  Reason for declining _____

  _____

Anyone else in your organization we should contact _____



IEEE Software Engineering Institute | Carnegie Mellon NDIA

«Salutation» «FirstName» «LastName»
«OrgName»
«OrgAddress»
«OrgCity», «OrgState» «OrgCountry» «OrgZIP»

Dear «FirstName»

In 2006, the NDIA Systems Engineering Division conducted the Systems Engineering Effectiveness Study. Through **anonymous and confidential** survey techniques, this study identified relationships between the application of specific SE practices to development projects and the performance of those projects, as measured by satisfaction of budget, schedule, and requirements. The results, published in 2007 and 2008 clearly demonstrated the benefits of SE, showing that:

- in the set of projects applying the least SE, only 15% delivered the highest levels of performance
- in the set of projects applying the most SE, 56% delivered the highest levels of performance

PROJECT PERFORMANCE vs. TOTAL SE CAPABILITY

The study also identified relationships between specific SE practices (e.g., requirements development and management, trade study performance, architecture development) and project performance. For more information about this study, please go to www.cert.org/ BCSE to download reports, papers and presentations detailing this work.

The NDIA Systems Engineering Division decided in early 2010 that it should update the Systems Engineering Effectiveness (SEE) Study that was issued originally in 2008 by broadening the population to include more domains, and by gathering data from a larger sample. This was coordinated with the Director, Systems Engineering, Office of the Under Secretary of Defense, Acquisition Technology & Logistics, who serves as the primary OSD interface to the NDIA Systems Engineering Division. The issues related to our defense industry are complex, affecting both the industry participants as well as the government participants. NDIA, in collaboration with the IEEE Aerospace and Electronics Systems Society and the Software Engineering Institute is embarking on the "Business Case for Systems Engineering (BCSE)" project to satisfy this need.

...thin organizations like yours to assess the characteristics of the project, the SE ...formance. Data will be analyzed to ascertain the relationships ...data security and confidentiality...

We use your email to send an invitation to the survey web site. Your responses to the web site remain anonymous.

Please Help Us Make this Study a Success !

For more information, contact:

William F. Lyons
IEEE-AESS Board of Governors
william.f.lyons@boeing.com

Alan R. Brown
NDIA SE Effectiveness Committee Chair
alan.r.brown2@boeing.com

Joseph P. Elm
Software Engineering Institute
jelm@sei.cmu.edu

Robert C. Rassa
NDIA SE Division Chair
RCRassa@raytheon.com