2013

SURVEY REPORT: IMPROVING INTEGRATION OF PROGRAM MANAGEMENT AND SYSTEM ENGINEERING

Results of a Joint Survey by PMI and INCOSE

Whitepaper presented at the
23rd INCOSE Annual International Symposium,
Philadelphia, June 2013

Data Analysis and Report by
Edivandro Conforto, Monica Rossi,
Eric Rebentisch and Josef Oehmen
(Massachusetts Institute of Technology)
and
Maria Pacenza
(Project Management Institute)

MIT Consortium for ENGINEERING PROGRAM EXCELLENCE

INCOSE International Council on Systems Engineering

PMI Project Management Institute

Authors

Edivandro Conforto, PhD – MIT Postdoctoral Research Fellow
Massachusetts Institute of Technology, MIT Consortium for Engineering Program Excellence

Monica Rossi, PhD Candidate at Politecnico di Milano – MIT Visiting Scholar
Massachusetts Institute of Technology, MIT Consortium for Engineering Program Excellence

Eric Rebentisch, PhD – Research Scientist
Massachusetts Institute of Technology, MIT Consortium for Engineering Program Excellence

Josef Oehmen, PhD – Research Scientist
Massachusetts Institute of Technology, MIT Consortium for Engineering Program Excellence

Maria Pacenza – Market Researcher
Project Management Institute – PMI

Cited as

Conforto et al. (2013). **Improving the Integration of Program Management and Systems Engineering.** Whitepaper presented at the 23rd INCOSE Annual International Symposium, Philadelphia, USA, June 2013

TABLE OF CONTENTS

Introduction

In January 2011, International Council on Systems Engineering (INCOSE) and Project Management Institute (PMI®) formed a strategic alliance to advance the integration of the systems engineering and program management disciplines. That integration will lead to the delivery of better solutions for their organizations.

For many years, a cultural barrier has existed between practitioners of systems engineering and of program management. Some systems engineers and program managers have developed the mindset that their work activities are separate from each other rather than part of an organic whole. Consequently, work often costs more, takes longer, and provides a suboptimal solution for the customer or end user. The leaders of INCOSE and PMI believe this cultural barrier and mindset can and must be overcome. By working together, the organizations hope to foster a team approach that will benefit their members and their organizations, and ultimately the stakeholders who depend on them.

In October 2012, the organizations conducted a joint survey to better understand the roles of program manager and chief systems engineer and to gauge their current level of integration. The Consortium for Engineering Program Excellence (CEPE) at the Massachusetts Institute of Technology (MIT) provided strategic support in analyzing, reviewing and finalizing the survey results with INCOSE and PMI. The results of the analysis are presented here and validate that the cultural barrier does exist in many organizations.

INCOSE, PMI and MIT plan to use the survey findings to raise awareness of the implications of that cultural barrier to practitioners of both disciplines and to uncover potential areas of collaboration between the three organizations. CEPE's complimentary research efforts will help develop new knowledge, insights, and tools that enable better integration and outcomes in engineering programs. Together, they will help to create a new mindset. The new mindset is the understanding that both disciplines are two interlocking pieces of a puzzle. When they are separate, only partial views of reality can be seen. Only when they are synergistically brought together can the larger picture become clear, and the puzzle can be solved.

INCOSE/PMI Alliance Working Group and MIT

Edivandro Conforto, Monica Rossi, Eric Rebentisch, Josef Oehmen and Maria Pacenza: **Survey Report: Improving the Integration of Program Management and Systems Engineering. Results of a Joint Survey by PMI and INCOSE.** Whitepaper presented at the 23rd INCOSE Annual International Symposium, Philadelphia, June 2013.

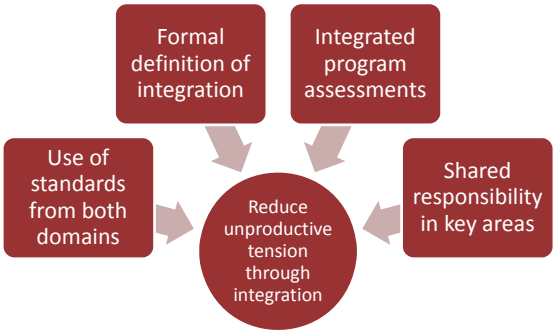
SURVEY REPORT: IMPROVING INTEGRATION OF PROGRAM MANAGEMENT AND SYSTEMS ENGINEERING

EXECUTIVE SUMMARY

Joint INCOSE-PMI Survey

~680 Chief Systems Engineers and Program Managers Responded

Goal: Reduce unproductive tension between Systems Engineering and Program Management



Result of the survey: **Key lever is improving the integration of SE and PM by**

- Using standards from both domains: Training and alignment
- Formalizing the definition of integration
- Developing integrated engineering program assessments
- Effectively sharing responsibility for risk management, quality, lifecycle planning and external suppliers.

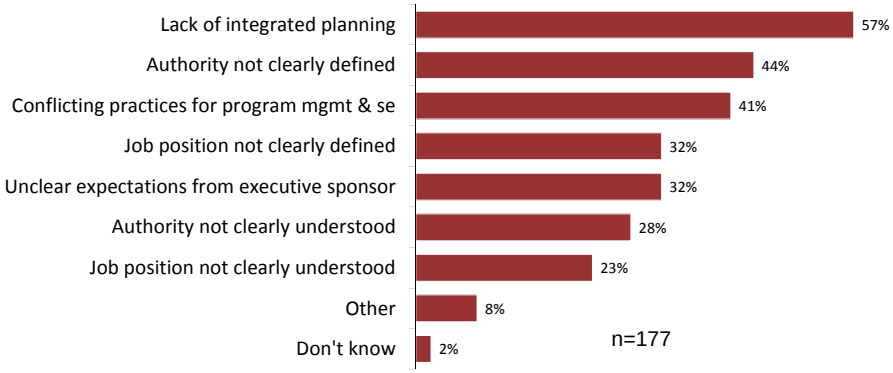
Unproductive Tension between Program Management and Systems Engineering

- About 30% of respondents indicate some or significant unproductive tension. About 20% indicate no unproductive tension.
- Smaller organizations (below $500 million annual revenue) and large organizations (above $5 billion) are particularly at risk of suffering from unproductive tension.
- Higher levels of integration support effectiveness of collaboration between SE and Program Management.
- Better **integrating program management and systems engineering** significantly lowers unproductive tension. Fully integrated organizations show almost no or only minimal unproductive tension.

Key Lever to Reducing Unproductive Tension:
Integrate Program Management and Systems Engineering

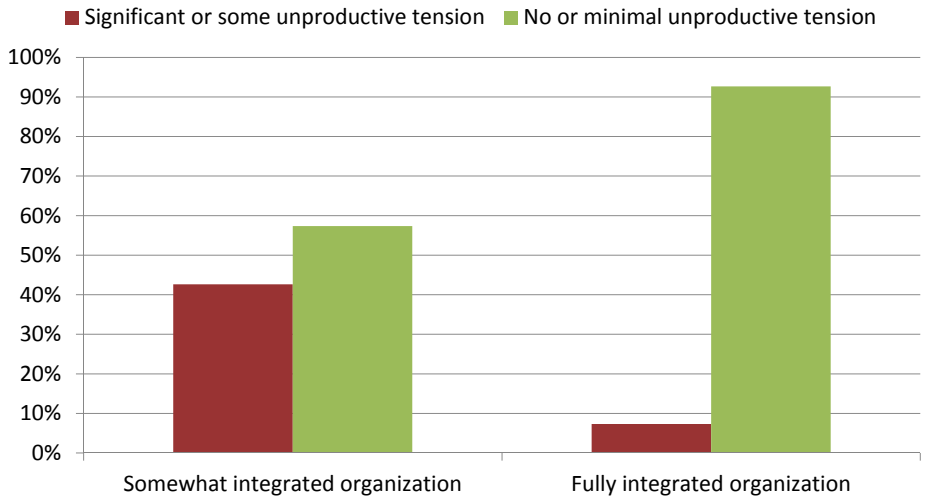
Lack of Integrated Planning is Key Source of Unproductive Tension

Also contributing to tension between the roles are not having clearly defined authority (44%) and conflicting practices between the two roles (41%).



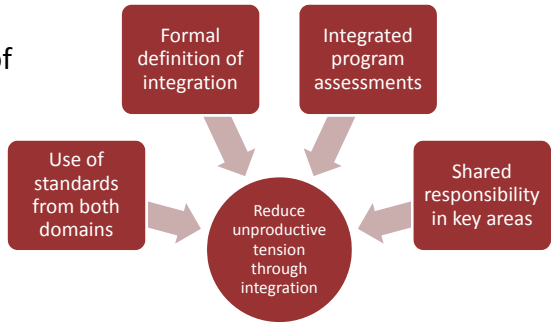
Q23. You identified that there is unproductive tension that affects team or program performance. Please describe the applicable source of the tension.

Integration between SE and Program Management Combats Unproductive Tension



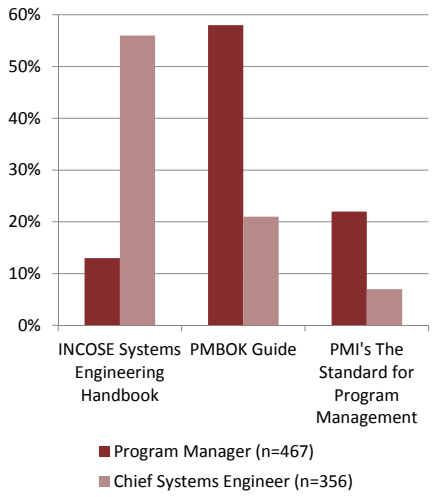
Integrating Program Management and Systems Engineering: How?

1. Using standards from both domains: Training and alignment
2. Formalizing the definition of integration
3. Developing integrated engineering program assessments
4. Effectively sharing responsibility for risk management, quality, lifecycle planning and external suppliers.



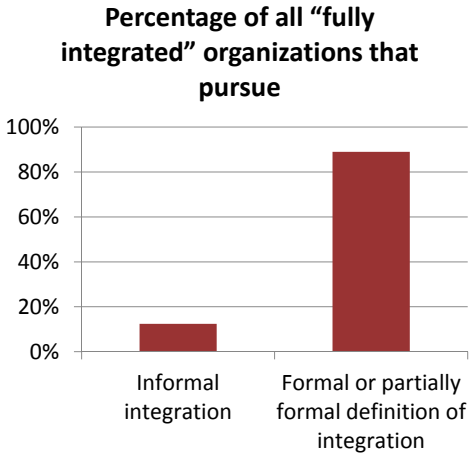
1. Using Standards from Both Domains

- Use of standards does not yet span disciplines sufficiently.
- It is strongly associated with formal role.
- While some respondents use the SE and Project Management standards in parallel, almost none use the SE standard in parallel with PMI's Program Management Standard.
- Organizations that are better integrated use standards. They are also more effective.



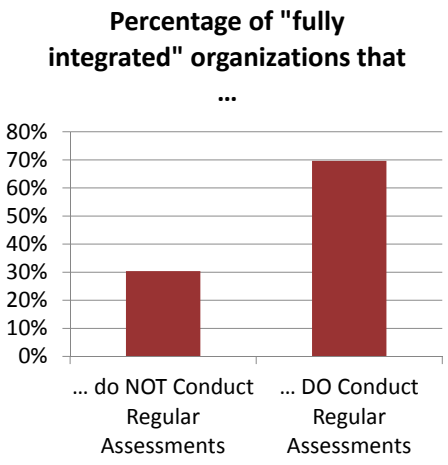
2. Formalize the "Integration" of Program Management and Systems Engineering

- Formalization supported by the use of systems engineering, project and program management standards.
- Larger companies are better at formally integrating SE and program management.
- For full integration, formalization is critical.



3. Develop Integrated Engineering Program Assessments

- Regular integrated assessments drive integration, support formalization and effectiveness of integration.
- Assessments are critical to ensure that "fully formally integrated" organizations are also "highly effective."
- In some cases, assessments directly contribute to the reduction of unproductive tension.

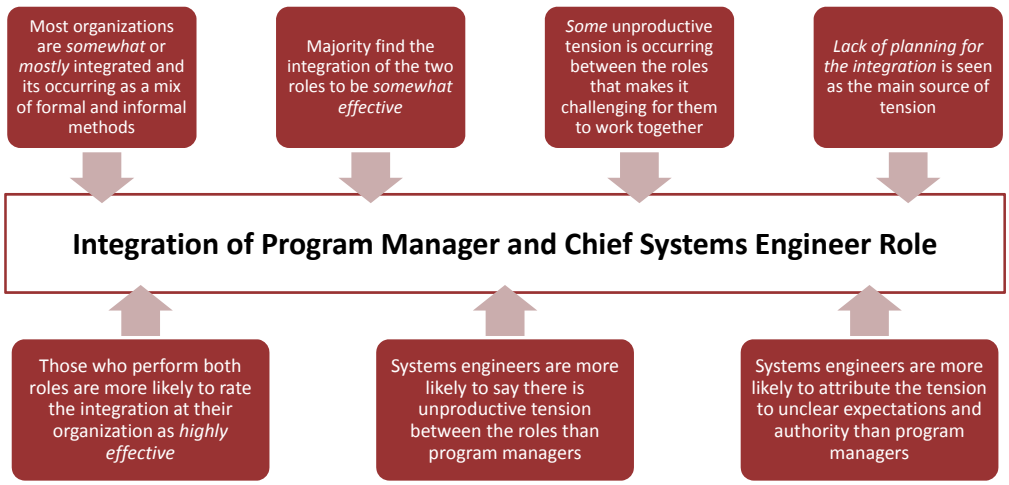


4. Program Manager and Chief Engineer are Distinct Roles – With Some Important Overlap

Program Managers (PM) view their responsibilities as:	**Chief Systems Engineers (CSE)** view their responsibilities as:	**Both** roles are responsible for:
• Overall Results • Goals & Objectives • Program & Project Risk • External Supplier Relations • Lifecycle Planning	• Technical Requirements • Systems Definition • Systems Requirements • Configuration Management	• Program/Project Risk • External Supplier Relations • Quality Management • Lifecycle Planning

The integration must clarify how
- **Responsibility can be effectively shared** for risk management, external suppliers, quality management and lifecycle planning; and
- **Communication optimized** for the other domains of responsibility.

4. Few organizations have "fully" integrated the roles



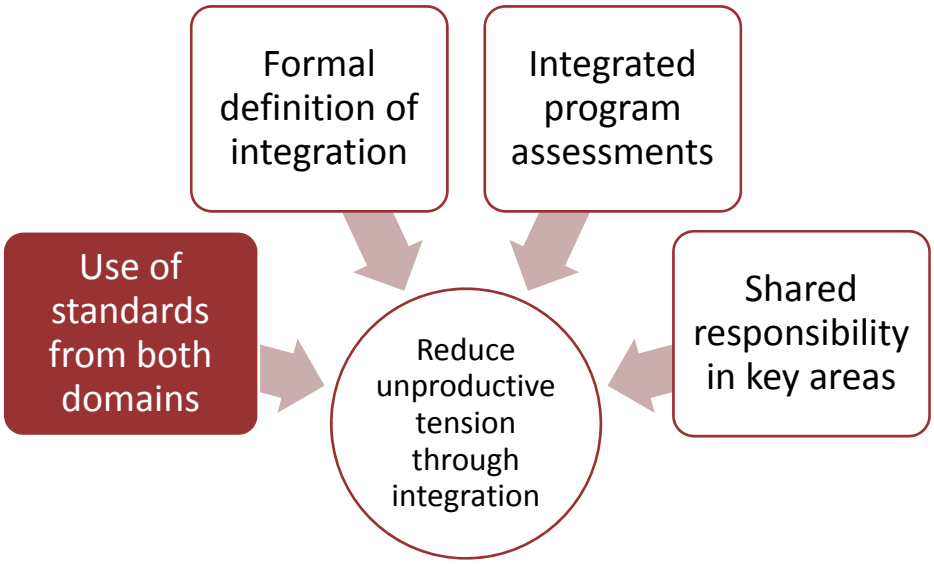
NOTE: In this section we present some snapshots of the detailed results according to the following framework. These snapshots have supported the conclusions and managerial implications from the survey analysis presented in the executive summary.

SNAPSHOTS OF THE DETAILED RESULTS

Analysis Approach

- Respondents were given options on how to describe their current position in their organization:
  - Program manager (**PM**)
  - Chief systems engineer (**CSE**)
  - Filling both program manager and chief systems engineer roles, but self-identifying mostly as program manager (**Both PM**)
  - Filling both program manager and chief systems engineer roles, but self-identifying mostly as chief systems engineer (**Both CSE**)
- Analysis that follows is based on these self-reported distinctions.

Snapshots of the Detailed Results



Use of a Standard

The use of a standards doesn't show a straightforward (causal) link with the company sector, however:

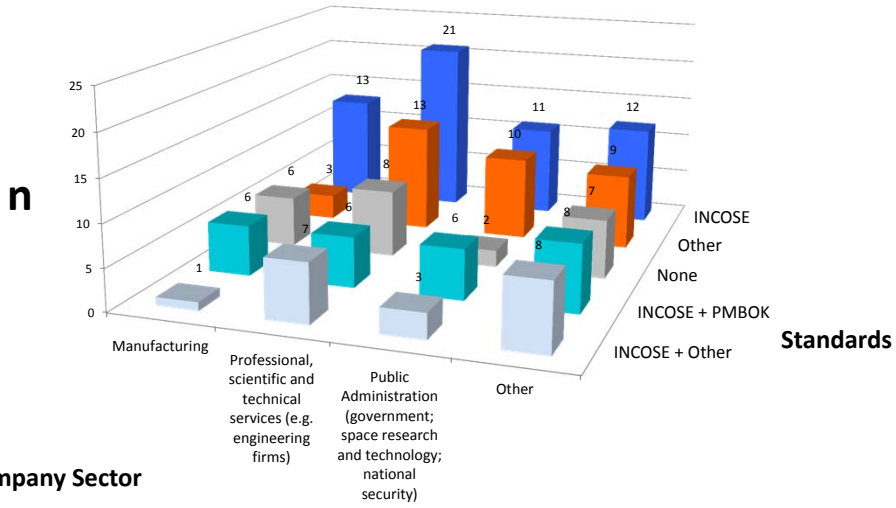
- CSE respondents show a tendency to use INCOSE standards in the manufacturing, engineering, government and space research and technology sectors.
- PM respondents tend to use PMI Standards in engineering firms.
- Respondents filling "both" roles unlikely to use both INCOSE + PM Standards.
- Respondents filling "both" roles (with PM orientation) are more likely to apply both INCOSE + PMI standards in engineering firms and space and defense.
- A relatively high number of respondents do not use any sort of standard, especially in engineering firms.

INCOSE and PMI standards are shown to be used across a diverse group of sectors essentially equally.

Standards by Company Sector

Chief Systems Engineer respondents

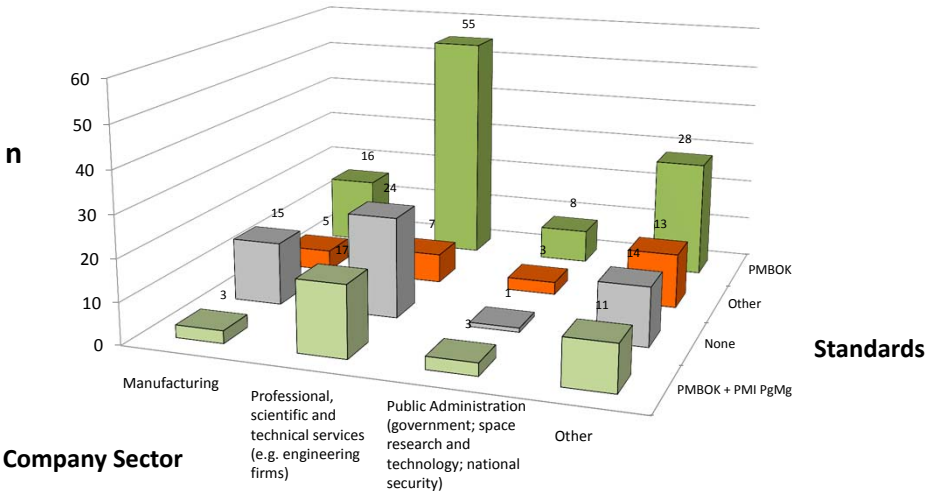
n=160



Standards by Company Sector

Program Manager respondents

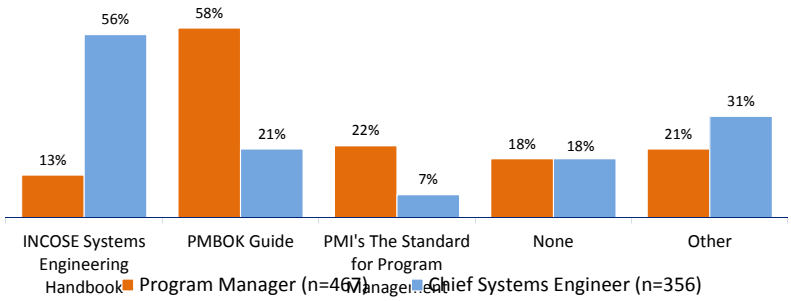
n=223



Standards/Guides used based on role

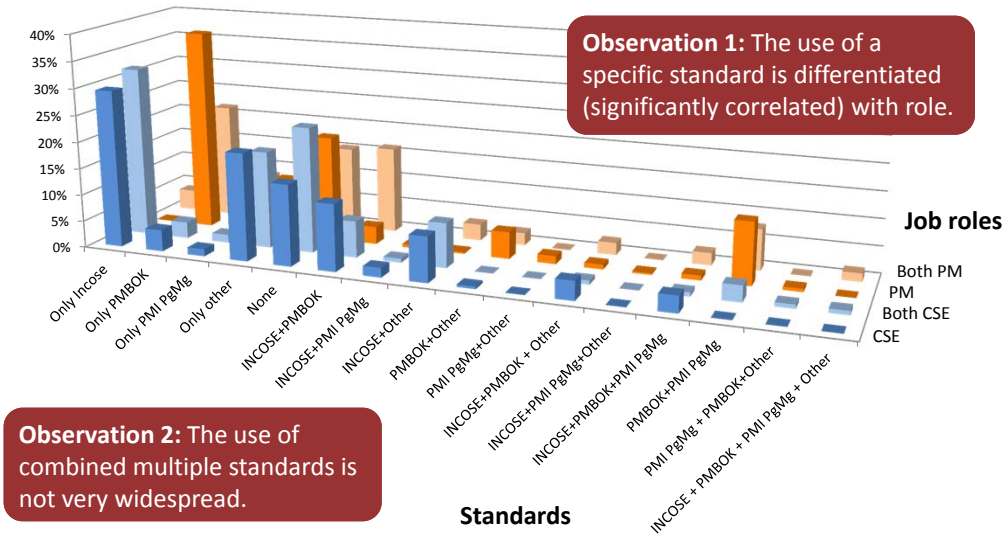
More than half of the program managers (58%) are using the *PMBOK® Guide* and more than half (56%) of the chief system engineers are using the INCOSE *Systems Engineering Handbook*.

- Three out of ten (31%) systems engineers are using something other than PMI or INCOSE. Some of those mentioned were IEEE, CMMi, various DoD guides and handbooks and internally-developed company guides.



Q7/14. Which of the following external standards and practice guides does your organization use in its program management/ systems engineering activities?

Use of Standards by Role (all responses)

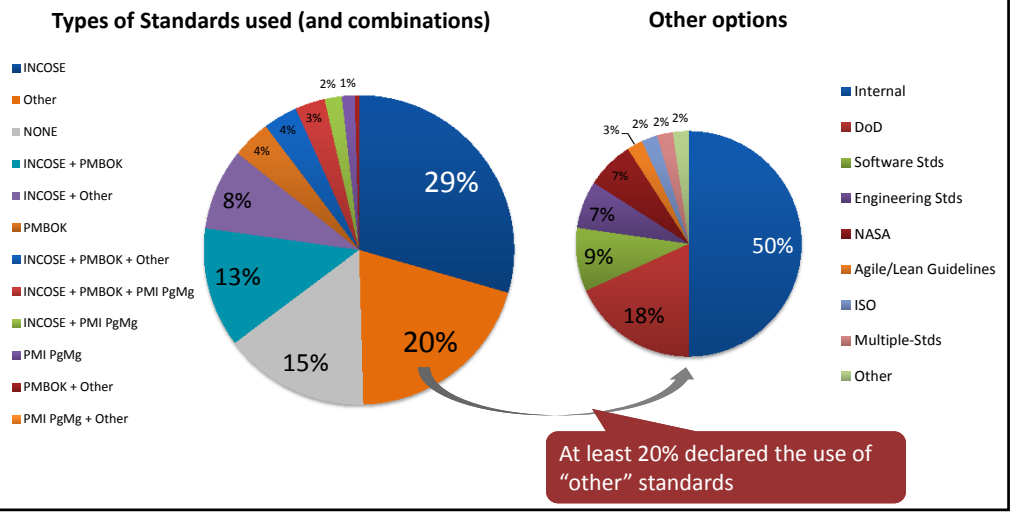


Observation 1: The use of a specific standard is differentiated (significantly correlated) with role.

Observation 2: The use of combined multiple standards is not very widespread.

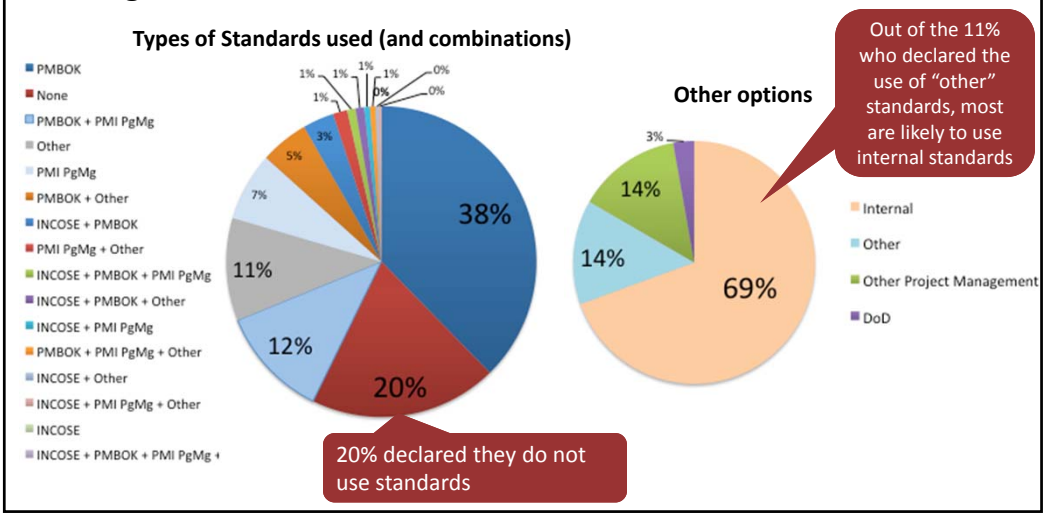
Standards–Chief Systems Engineers

What standards or combination of standards do Chief Systems Engineers use?

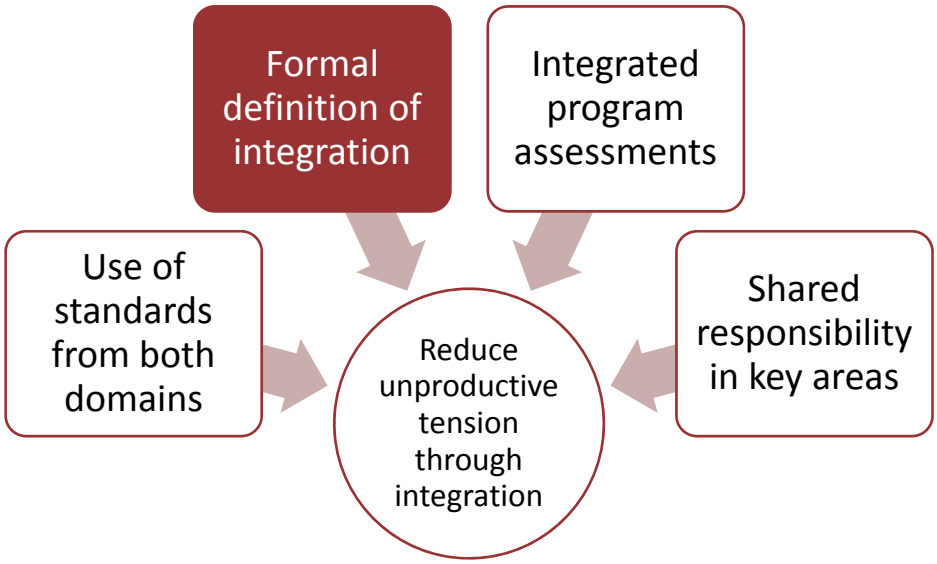


Standards–Program Managers

What standards or combination of standards do Program Managers use?

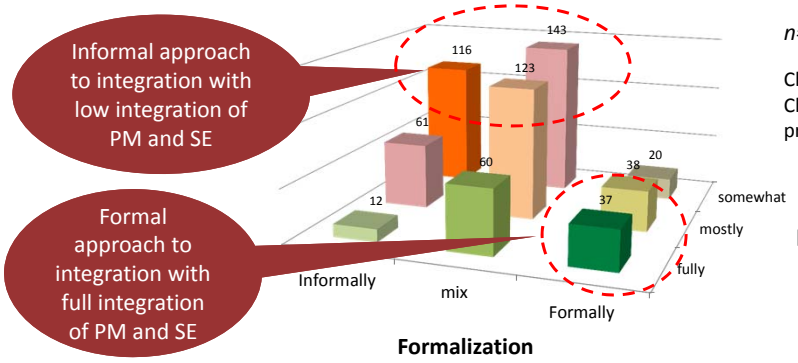


Snapshots of the Detailed Results



Level of Integration by Formality of Integration

Result: There is a statistically significant relationship between the formality of the approach to integrating PM and SE and the level of their integration.



n=610

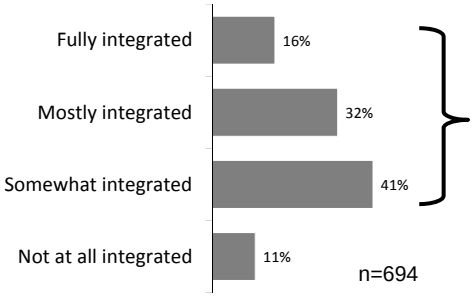
Chi-Square test
Chi-squared probability = p < ***0.000***

Implication: Companies that have more formal approaches to integrating PM and SE are more likely to show more complete integration of those disciplines.

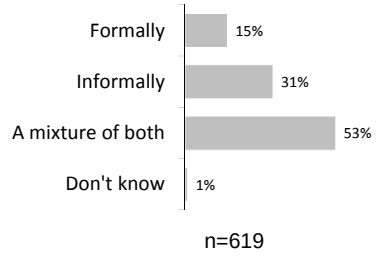
Integration is occurring at different levels

About half of the organizations (48%) have integrated either fully (16%) or mostly (32%) the roles of program manager and systems engineer.

In the majority of organizations, integration occurred both formally and informally.



Q19. What is the level of integration between program management and systems engineering in your organization?



Q20. Does the integration occur formally (i.e., processes that transcend the boundaries across the job position) or informally (e.g., people make the integration occur)?

Use of Standards by Level of Integration (1/2)

Is there any difference in the level of integration of PM and SE between those who used any standard(s) and those who didn't?

The sample was divided into two groups:

Group 1: used any standard(s) (n=571)

Group 2: did not use standards (n=120)

Question 21) What is the level of integration between program management and systems engineering in your organization?

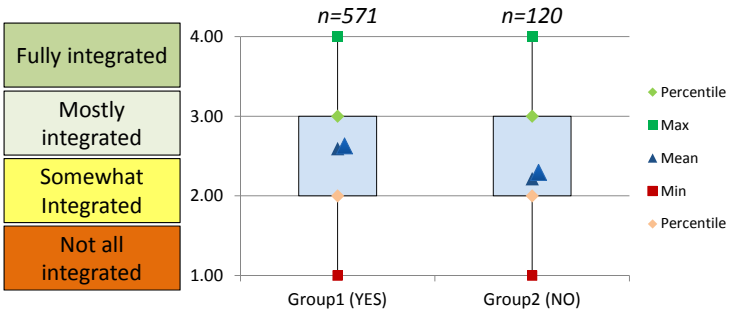
Not all integrated | Somewhat Integrated | Mostly integrated | Fully integrated

Method overview:

We used the **Kruskal Wallis** test to investigate if there is a statistically significant difference between the two groups. We verified the result with **Wilcoxon Mann-Whitney.** Since the data aren't normally distributed these two tests are most suitable. The hypothesis is that there is a difference between the two groups' level of integration.

Use of Standards by Level of Integration (2/2)

Result: The group that applied any standard(s) had a statistically significant difference in level of integration compared with those that did not use any standard.



Kwallis chi-squared probability = p < ***0.0001***

Mann-Whitney probability = p < ***0.0000***

Median G1: 3
Median G2: 2

Implication: The use of standard(s) contributes to greater integration between program management and systems engineering.

Level of Integration by Formality of Integration

Is there any relationship between the level of integration of PM and SE and the formality of the approach to integration?

Q21. Integration) What is the level of integration between program management and systems engineering in your organization? Would you say it is…

Q.21 (considered answers)
2. Somewhat
3. Mostly
4. Fully Integrated

Q22. Formalization) Does the integration occur formally (i.e., processes that transcend the boundaries across the job position) or informally (e.g., people make the integration occur)?

Q.22 (considered answers)
1. Formally
2. Mixed
3. Informally

Method overview:

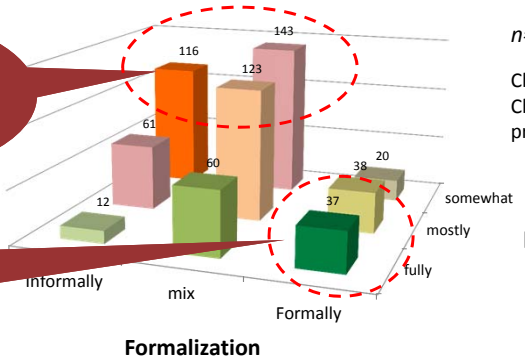
We used the **Chi-square test** to investigate if there is a statistically significant dependence between the two variables. Since the data aren't normally distributed this test is the most suitable. The hypothesis is that the level of integration between PM and SE is related to the formality of the approach to integration.

Level of Integration by Formality of Integration

Result: There is a statistically significant relationship between the formality of the approach to integrating PM and SE and the level of their integration.

Informal approach to integration with low integration of PM and SE

Formal approach to integration with full integration of PM and SE

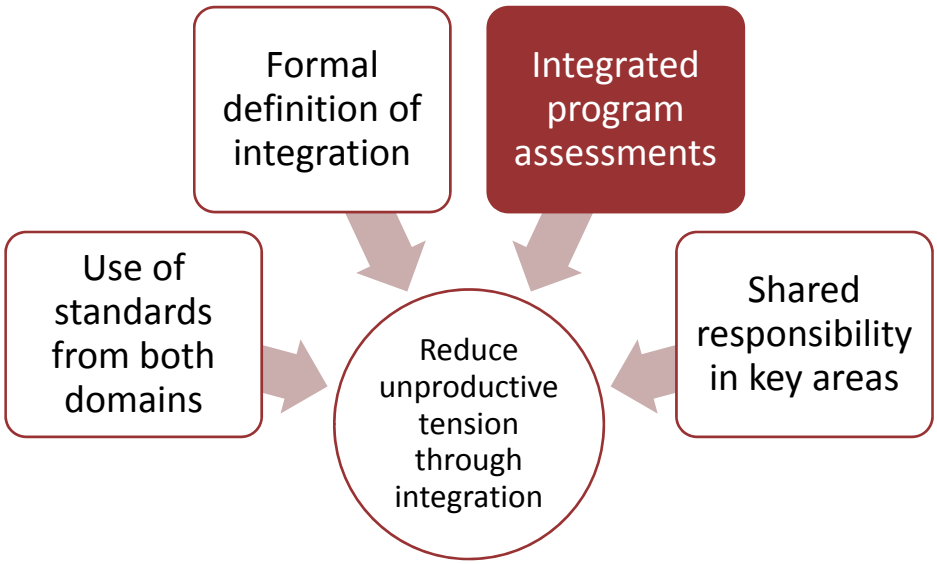


n=610

Chi-Square test
Chi-squared probability = p < ***0.000***

Implication: Companies that have more formal approaches to integrating PM and SE are more likely to show more complete integration of those disciplines.

Snapshots of the Detailed Results



Conducting Assessments

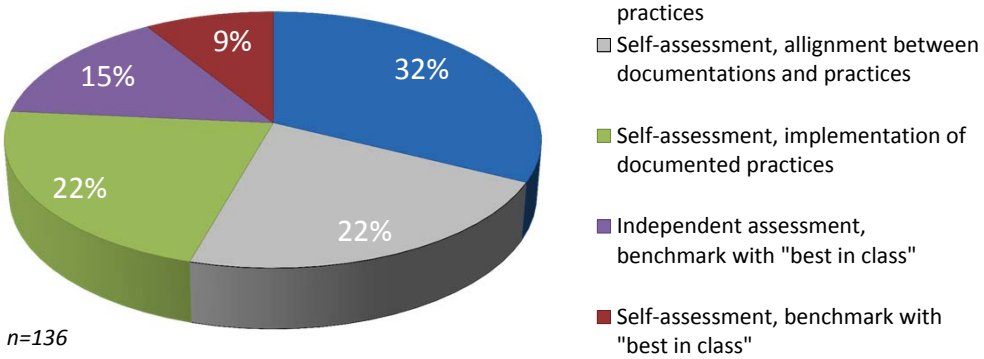
Is there any difference in levels of Integration, Formalization, Effectiveness, and Unproductive Tension between those who conduct assessments and those who don't?

	Integration	Formalization	Effectiveness	Unproductive tension
Both PM	●	●	●	●
Both CSE	●	●	●	●

Implication: Conducting assessments of practices and capabilities may enable greater integration, formalization and effectiveness, and in some cases less unproductive tension.

● Statistically Significant Difference
● No Statistically Significant Difference

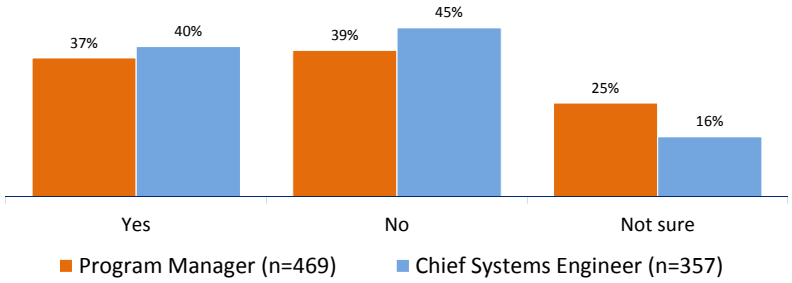
The most-used types of assessment



n=136

Formal assessment is being conducted in less than half of the organizations

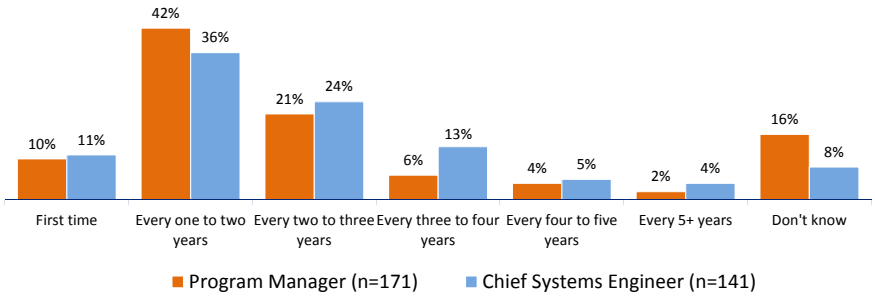
Significantly more program managers than chief systems engineers did not know if assessments were being done (25% vs. 16%) at their organization.



Q8/15. Has your organization conducted a formal assessment of its program management//systems engineering practices and capabilities in the last three years?

Formal assessments conducted every one to two years

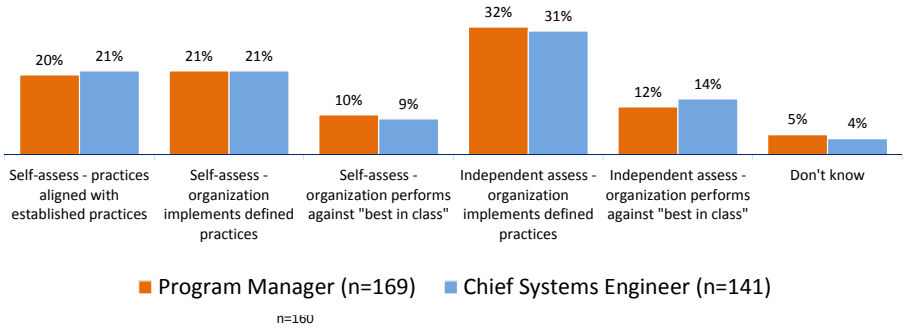
Slightly more organizations formally assess program management practices and capabilities than systems engineering.



Q9/16. How often does your organization formally assess its overall program management/systems engineering practices and capabilities?

A third are conducting independent assessments on how they compare to defined practices

Three out of ten organizations are conducting independent assessments to evaluate how well their organization implements the documented practices and capabilities that they have defined.

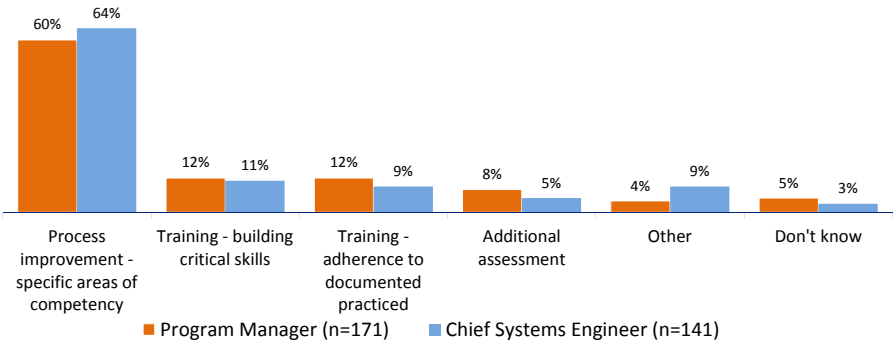


n=160

Q10/17. How would you classify the type of assessment that was used? Please select the example that most closely resembles the assessment type.

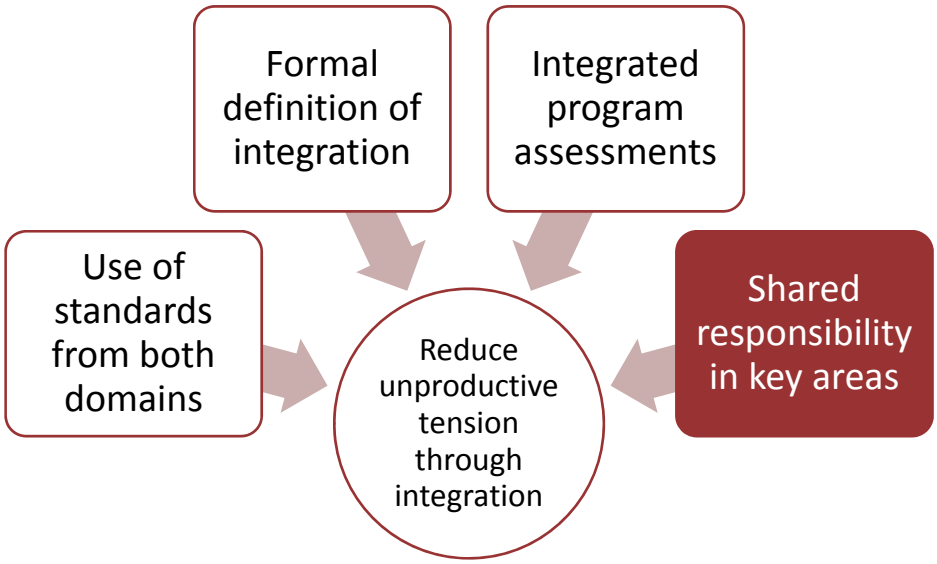
Assessment results used to make process improvements

Six out of ten organizations used the results of their assessment to make process improvements focused on specific areas of competency



Q11/18. How did your organization use the results of the assessments?

Snapshots of the Detailed Results

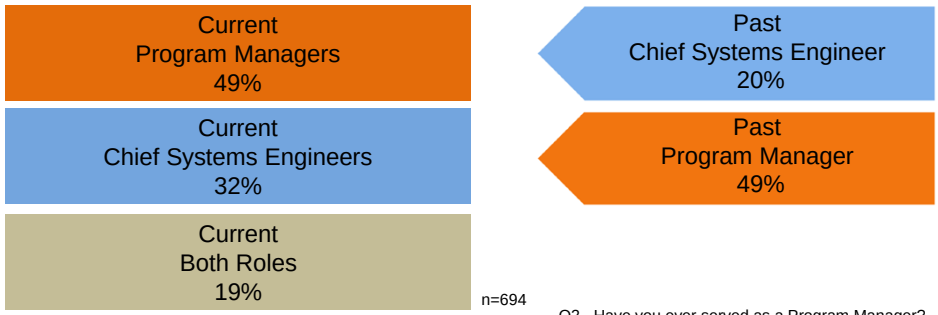


Half of Chief Systems Engineers were Program Managers

Significantly more **program managers** are from **Asia Pacific** than are from North America and EMEA regions.

Significantly more **systems engineers** are from **North America and EMEA** than Asia Pacific

Significantly more **smaller organizations** (<$500 mil annual revenue) have employees performing **both** systems engineering and program management roles than larger organizations.

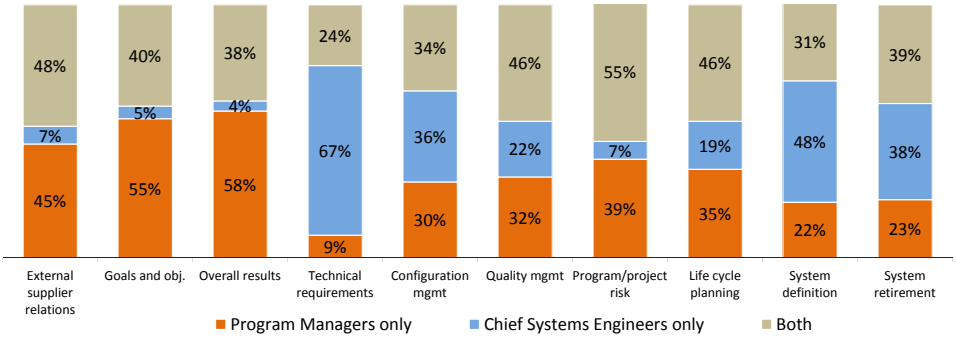


Q1. Which job description best fits your current role?

Q2. Have you ever served as a Program Manager?
Q3. Have you ever served as a Chief Systems Engineer?

Some overlap in job responsibilities

Both program managers and systems engineers play an important part in determining **program/project risk**, **external supplier relations**, **quality management**, and **lifecycle planning**.

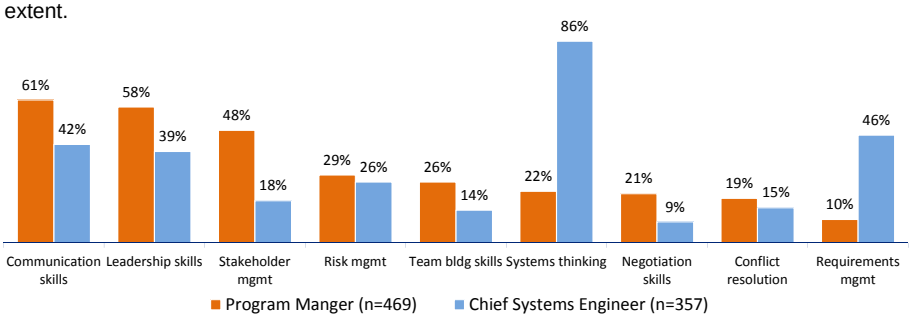


Q4. For the following job responsibilities, please indicate who was primarily accountable. By accountable, we mean the one who has the authority to make and implement final decisions.

Different skills are critical to each role

Critical skills needed for program mangers are **communication skills (61%)**, **leadership skills (58%),** and **stakeholder management (48%).**

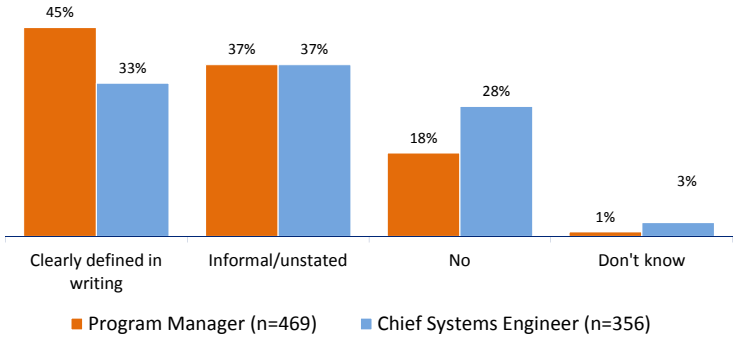
System or integrative thinking (86%) is by far the most important skill for a chief systems engineer. **Requirements management (46%)** is also seen as an important skill but to a lesser extent.



Q5/12. Thinking of your role as Program Manager/Chief Systems Engineer, select the skills that you feel are most critical. Please select up to three skills.

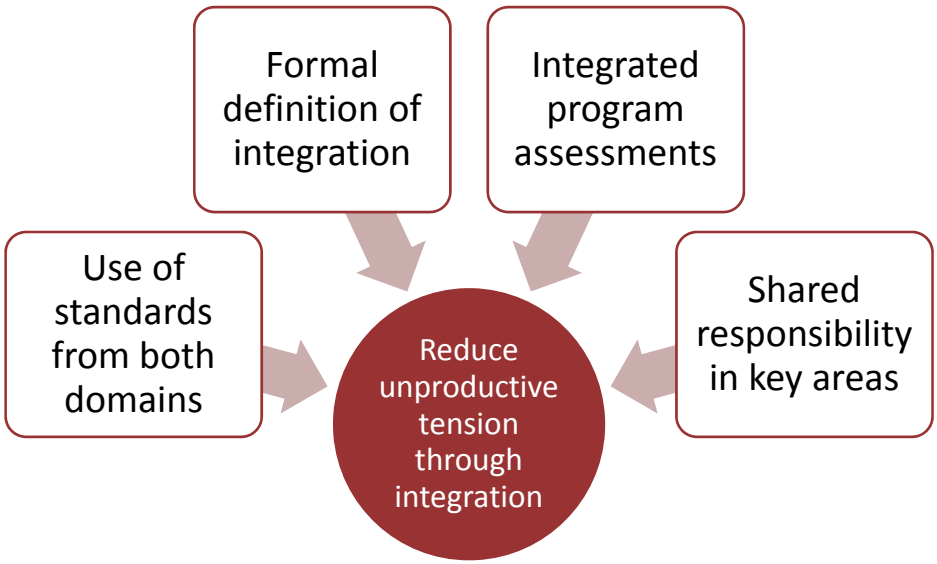
Program Manager position is more clearly defined

Nearly half of the organizations have clearly and formally defined program manager job positions. About a third have clearly and formally defined chief systems engineer positions.



Q6/13. Are responsibilities for the program manager/chief systems engineer job position clearly and formally defined within your internal organization?

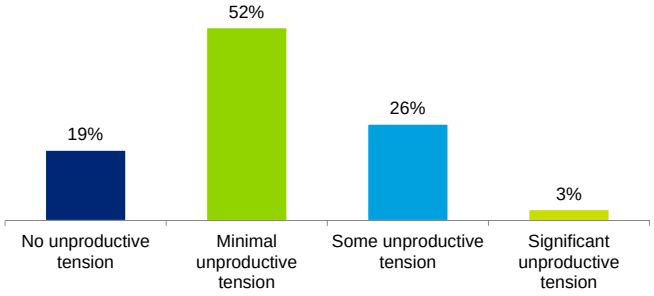
Snapshots of the Detailed Results



Minimal unproductive tension between the roles

About three out of ten found that there is some (26%) or significant (3%) unproductive tension between program management and systems engineering.

Chief Systems Engineers are significantly more likely to feel that there is unproductive tension between the roles at their organizations than program managers.

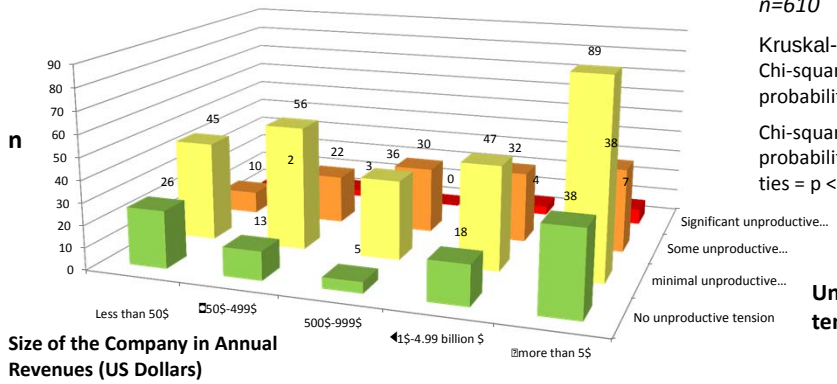


n=610

Q22. Please rate the degree of unproductive tension between program management and system engineers in your organization.

Company Size by Degree of Unproductive tension

Is there a relationship between the size of the company and the degree of unproductive tension between PM and SE?



n=610

Kruskal-Wallis Chi-squared probability = p < ***0.0007***

Chi-squared probability with ties = p < ***0.0001***

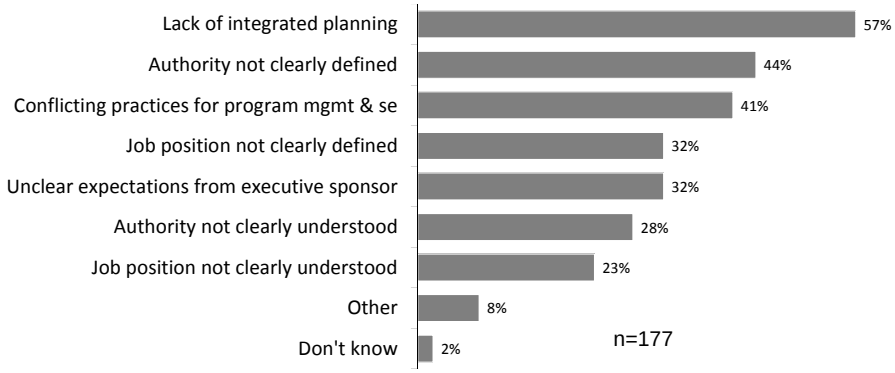
Implication: There is a statistically significant relationship between the size of the company and the level of unproductive tension between PM and SE. Mid-size firms appear to have relatively lower levels of unproductive tension between PM and SE.

Greater Integration Between PM and SE Reduces Unproductive Tension

- We found these statistically significant relationships:
  - Lower levels of unproductive tension are more likely at higher levels of integration between PM and SE; Higher levels of unproductive tension are more likely at decreased levels of integration.
  - Experiencing no/minimal unproductive tension is more likely when the level of effectiveness of integration between PM and SE is higher.
  - Organizations that conduct assessment(s) are more likely to have less/no unproductive tension between PM and SE.

Lack of integrated planning is the main source of tension

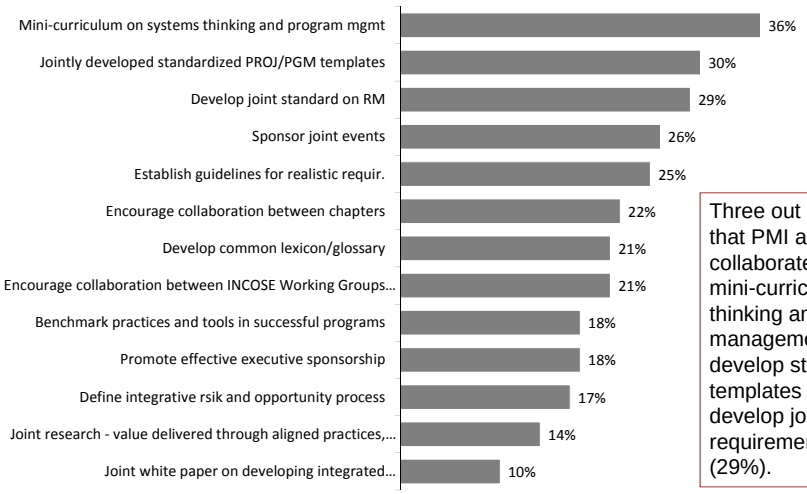
Also contributing to tension between the roles are not having clearly defined authority (44%) and conflicting practices between the two roles (41%).



Q23. You identified that there is unproductive tension that affects team or program performance. Please describe the applicable source of the tension.

POTENTIAL AREAS OF COLLABORATION

Members identified several areas where PMI and INCOSE could collaborate

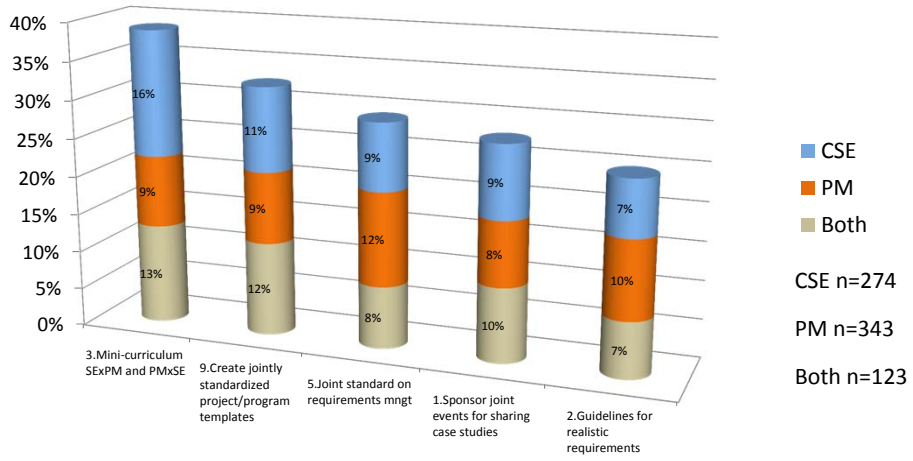


Three out of ten or more felt that PMI and INCOSE could collaborate on developing mini-curriculums on systems thinking and program management (36%), jointly develop standardized P/PM templates (30%), and develop joint standards on requirements management (29%).

Q24. Below are potential areas of collaboration between PMI and INCOSE to better align systems engineering and program management practices. Please select three areas that you feel would be most effective in creating better alignment of systems engineering and program management.

The most commonly suggested areas of collaboration between PMI & INCOSE

PMI and INCOSE might consider collaborating on the development of mini-curriculum, joint standards, templates, joint events and guidelines to foster greater PM and SE alignment



CSE n=274

PM n=343

Both n=123

PMI and INCOSE can provide additional training

1. Develop guidance on how to better integrate and clearly differentiate the roles
   - Develop a more formalized process for organizations to follow that focuses on planning, role definitions and responsibilities
     - Systems engineers need more guidance in terms of clear expectations and clearly defined authority
   - Conduct further research with those organization that have done it well
2. Offer joint training workshops
   - Begin with areas where both roles have significant responsibility (program and project risk, external supplier relations, quality management, and lifecycle planning)
3. Pay attention to the demographic differences between the roles when developing training materials
   - Customize training materials for specific industries, regions, etc.

Consider looking for more ways for PMI and INCOSE to collaborate

Members of both organizations can benefit from the relationship

1. Start with the areas of interest identified in the research:
   - Jointly developing materials on systems thinking for program managers and program management for systems engineer
   - Jointly developing templates like SOWs, schedules, plans, etc.
   - Jointly develop standard on requirements management
   - Collaborate on efforts to establish guidelines for requirements gathering RFPs
2. Involve volunteer leaders of both PMI and INCOSE chapters and CoPs/Working Groups in developing joint activities.

"I am a certified PMP and CSEP. I also teach graduate level PM and SE courses at UMBC. I think the SE Handbook and PMBOK have laid out a knowledge map that does a good job at capturing best practices. The problem is their is too much overlap between the two, which is not surprising given how both professions evolved. Never-the-less, I would recommend creating integrating all of the processes for both PM and SE into one knowledge map, and then allocating them to respective professions"

SURVEY METHODS

Survey Goals

- To better understand how Program Management and Systems Engineering are integrated within the organization
  - Identify common job skills and responsibilities between the roles
  - Understand the level of interaction and integration between the two roles
  - Learn ways that PMI and INCOSE can collaborate to better align systems engineering with program management practices
- To describe the interactions between the use of standards, integration, formalization, level of effectiveness, and degree of unproductive tension between Program Management and Systems Engineering.

Methods

Survey Methods

- A web-based survey was sent to approximately 3,000 INCOSE members (systems engineers) and 5,000 PMI members (program managers)
  - Dates – October 2 to October 23, 2012
  - 694 completed surveys
  - Response rate 14%, Qualify rate is 68%, Termination rate is 32%

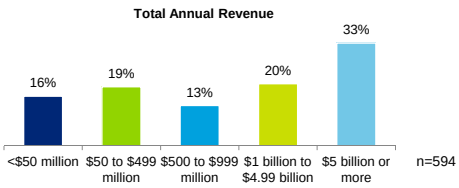
Analysis Methods

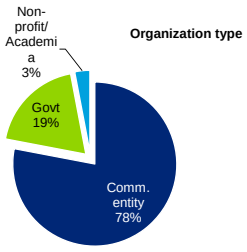
Apply a set of statistical techniques, using multiple statistical methods including descriptive analysis, to identify any relationships between the variables. The unit of analysis was primarily the organization. The variables used for the test were:

- Use of Standards
- Integration of PM and SE
- Formalization of the integration of PM and SE
- Level of Effectiveness
- Degree of Unproductive tension
- Size of the company

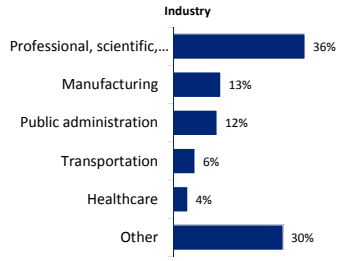
SAMPLE DEMOGRAPHICS

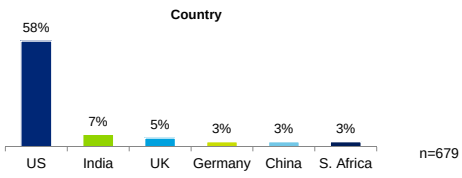
Organizational demographics





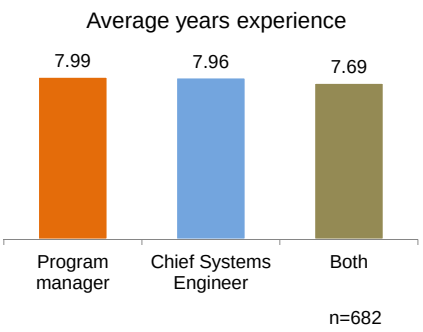
Q35. What is the total annual revenue of your organization (in US$)?
Q36. Which category best describes your organization?

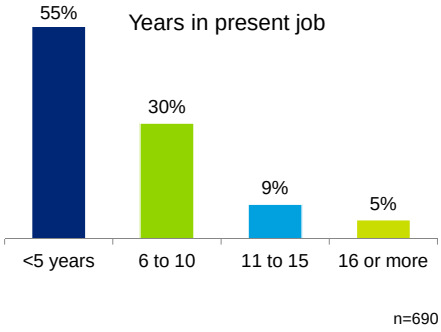




Q37. Please select the category that best reflects your industry focus.
Q38. In which country do you reside?

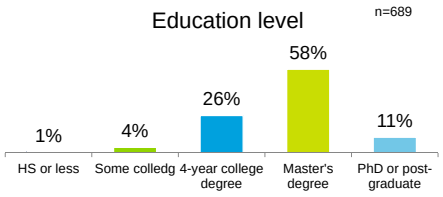
Personal demographics

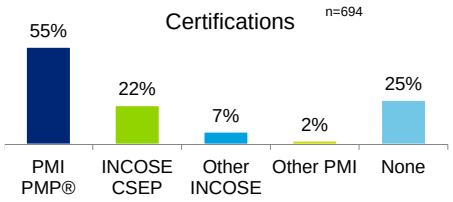


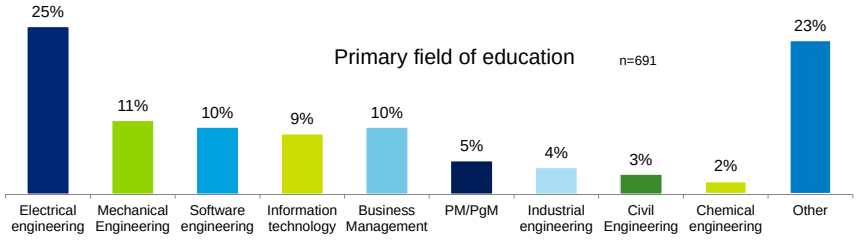


Q26. How many years of experience do you have working on programs either as a CSE, PgMG or a combination of both?
Q27. How long have you been in your present job position as a program manager and/or chief systems engineer?

Personal demographics



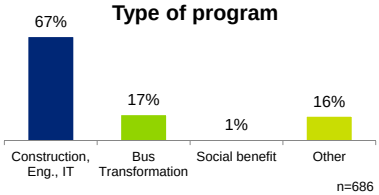




Q28. What is the highest level of formal education you have obtained?
Q29. What is your primary field of education?
Q30 Which of the following certifications do you hold?

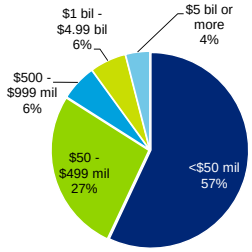
Current programs - demographics

Type of program



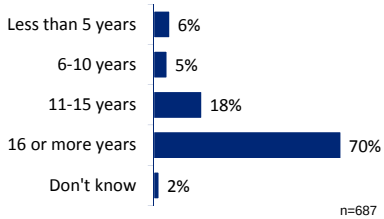
n=686

Size of program in dollars



n=684

Length of current program



n=687

Number of project in current program

- Mean – 14.16
- Std. Deviation – 36.46
- Range – 1 to 500

n=486

Q31. Which type of programs do you primarily manage or participate in?
Q32. How large is the current program you are working on from a monetary perspective?

Q33. How long has your current program been running?
Q34. Approximately, how many projects are part of your current program?

PMI and INCOSE Joint Survey

Edivandro Conforto, Ph.D Postdoctoral Fellow (conforto@mit.edu)
Monica Rossi, Ph.D Candidate (m1rossi@mit.edu)
Eric Rebentisch, Ph.D Research Associate (erebenti@mit.edu)
Josef Oehmen, Ph.D Research Scientist (oehmen@mit.edu)
Maria Pacenza, PMI Market Researcher (maria.pacenza@pmi.org)

2013

MIT Consortium for
ENGINEERING PROGRAM EXCELLENCE