Lean Enablers for Managing Engineering Programs

Presented by
David Meza

To
INCOSE Texas Gulf Coast Chapter
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Agenda

- Overview of Coordinating Organizations
- Motivation – Why do we need “Lean Enablers”?
- Development process
- Applicability: Managing Engineering Programs
- Lean Thinking
- Results: Guide to Lean Enablers for Managing Engineering Programs
- Engineering Program Challenges
- Examples of Lean Enablers
- Lean Enablers and Program Success
- Implementing Lean Enablers
Overview Of The Coordinating Organizations
The LAI Operating Model

Consortium Members
- Executive Board
- Champions
- Membership fee

Sponsored Research Programs
- Focused research
- By members and non-members

- LAI Faculty and Researchers
- LAI Students
- LAI Research Project Portfolio
- LAI Educational Network
LAI Research Portfolio - Excerpt

Managing Large-scale Engineering Programs

- Practically all aspects of managing large engineering over the last 15 years
- Lean Engineering Program Management
- Risk management in large engineering programs

Enterprise Change Management

- (Program) Enterprise transformation framework “ESAT”
- Book: “Beyond the Lean Revolution”
- Implementing Lean Engineering Practices

Managing Public Service Programs

- Reforming the military “Post Traumatic Stress Disorder” treatment program
- Part of a $150 billion enterprise
- Several hundred organizations

Time share of different types of activities in PD

- Waste (Activity idle) 52%
- Activity Execute 38%
- Waste 15%
- Value added 12%
- Value added 11%

Clinical Operations
Community Operations
Installation Operations
International Council on Systems Engineering (INCOSE)

- Not-for-profit membership organization
- 8000+ members

- Develop and disseminate the interdisciplinary principles and practices that enable the realization of successful systems
- Share, promote and advance the best of systems engineering from across the globe for the benefit of humanity and the planet.

- Systems Engineering Handbook v. 3.2.2, consistent with ISO/IEC 15288:2008

- January: International Workshop
- July: International Symposium
- www.incose.org
Project Management Institute (PMI)

- World’s leading not-for-profit membership association for the project management profession
- More than 600,000 members and credential holders in more than 185 countries.
- “Products”:
  - globally-recognized standards,
  - credentials, and
  - professional development opportunities
- Standards
  - Guide to the Project Management Body of Knowledge
  - Standard for Program Management
  - Standard for Portfolio Management
  - Organizational Project Management Maturity Model (OPM3)
  - Various practice standards, frameworks and standards extensions
MOTIVATION
US Department of Defense Development Portfolio – Change to initial estimate (2008)

- Total cost growth: $296 billion
- Average schedule overrun: 22 months
- Similar situation in other industries

Sources: GAO 06-368, Bloomberg, GAO 10-374T
DoD Cost Growth 2011: $75 billion

$45 billion = 60%

$30 billion = 40%

- Quantity changes
- R&D and production challenges

Source: GAO-12-400SP
Study Design: Innovation by Bridging Knowledge Domains

Lean Thinking + Systems Engineering + Program Management = Unique, Relevant and Actionable Advice

Unique
- Three world-class organizations and thought leaders joined forces
- Industry, government and academia participation

Relevant
- Massive challenges in program execution: Cost and schedule overruns
- Integration of knowledge and professional domains
- Extensively validated

Actionable
- Concrete advice
- Mapped to known challenges and existing standards
- Guidance for implementation

2 Core Results:
- 160 Program Management Challenges in 10 Themes
- 300 Lean Enablers (= Management Best Practices) in 40 areas
What is a serious engineering program challenge in your organization?

1. Reactive Program Execution
2. Lack of stability, clarity and completeness of requirements
3. Insufficient alignment and coordination of the extended enterprise
4. Value stream not optimized throughout the entire enterprise
5. Unclear roles, responsibilities and accountability
6. Insufficient team skills, unproductive behavior and culture
7. Insufficient Program Planning
8. Improper metrics, metric systems and KPIs
9. Lack of proactive management of program uncertainties and risks
10. Poor program acquisition and contracting practices
DEVELOPMENT PROCESS
Goal: Supporting Existing Standards in Program Management and Systems Engineering

How Standards Proliferate:
(See: A/C chargers, character encodings, instant messaging, etc)

**SITUATION:**
There are 14 competing standards.

14?! Ridiculous!
We need to develop one universal standard that covers everyone’s use cases. Yeah!

**SITUATION:**
There are 15 competing standards.

Source: Randall Munroe, www.xkcd.com
Joint INCOSE-PMI-MIT Lean in Program Management Community of Practice

Key Driver: Industry Need

LAI → INCOSE

Informal relationship

INCOSE → PMI

Mark Langley & Samantha Robitaille

Addressing the Stakeholder Problem

Joint “Lean in Program Management” Community of Practice

http://lean.mit.edu

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January 2011 – March 2012

Conduct a study within 1 year, that
- Identifies the key challenges in managing engineering programs and
- Identifies and documents best practices to overcome these challenges

Ensure highest possible degree of applicability and practicality by
- Focusing on needs of program managers from industry and government,
- Develop the results through a group of subject matter experts and
- Validate the results extensively.
140+ current members representing 35+ organizations

From 0 to ...
Development Process

- Based on **concrete challenges**, not thin air
- Incorporates **start-of-the-art knowledge** from literature
- Developed by group of 15 **subject matter experts** through year-long, weekly meetings
- Feedback through wider **community of practice** (100+ members)
- Discussed at **4 large and very successful workshops**, involving both PMI and INCOSE members
- Backed-up by **two validation surveys**
- Validated by **content analysis** management practices of highly successful programs
Websites

Public website:
www.lean-program-management.org

Internal website
APPLICABILITY: MANAGING ENGINEERING PROGRAMS
5 Program Management Performance Domains

- **Managing all the program activities related to program definition, program benefits delivery and program closure.**

- **Identifying opportunities and benefits that achieve the organization’s strategic objectives through program implementation.**

- **Defining, creating, maximizing, and sustaining the benefits provided by programs.**

- **Establishing processes and procedures for maintaining pro-active program management oversight and decision-making support for applicable policies and practices throughout the entire program life cycle.**

- **Capturing stakeholder needs and expectations, gaining and maintaining stakeholder support, and mitigating/channeling opposition.**
# Applicability – Program Types

<table>
<thead>
<tr>
<th>Focus</th>
<th>Technology, engineering, infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Large-scale engineering programs (e.g. aerospace, defense, civil engineering, product line)</td>
</tr>
<tr>
<td></td>
<td>• Large-scale IT development and implementation programs (e.g. change of ERP system, virtualization of entire software)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Business transformation</th>
<th>Community &amp; Society</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Organizational change programs (e.g. institutionalizing continuous improvement, implementing cost cutting measures)</td>
<td></td>
</tr>
<tr>
<td>• Public management programs (e.g. reducing childhood obesity, reforming military healthcare)</td>
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</tbody>
</table>
Applicability – Engineering Systems Life Cycle

Main focus: all Enablers applicable
Most Enablers applicable

Figure 1: Life-Cycle Phases of an Engineering System and Applicability of Lean Enablers

<table>
<thead>
<tr>
<th>Lean Enablers grouped by Lean Principles</th>
<th>Concept</th>
<th>Development</th>
<th>Production</th>
<th>Utilization &amp; Support</th>
<th>Retirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>LE 1.x: Respect the people in your program</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>LE 2.x: Capture the value defined by the key customer stakeholders</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>LE 3.x: Map the value stream and eliminate waste</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>LE 4.x: Flow the work through planned and streamlined processes</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>LE 5.x: Let customer stakeholders pull value</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>LE 6.x: Pursue perfection in all processes</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>

●: all Enablers apply  ○: some Enablers do not apply
Applicability – Project vs. Program

- All of the Enablers apply to your project, if your project is a program.
- If your project executes program-level activities, the corresponding Enablers apply to your program.
- The Enablers address dependencies and interfaces between projects and programs.
LEAN THINKING
Lean Management:
Buzz-Word and Firing People?

Carol: Schedule a staff meeting. What's the topic?

I plan to fuse Six Sigma with Lean methods to eliminate the gap between our strategy and our objectives.

I'll just say "waste of time."

Ted: I don't know how to say this.

We need to lean up the process improvement process so I have to smartsize one resource.

Wow. Usually it's just a figure of speech when people say, "I don't know how to say this."
Why is Lean Product Development Important?

Time share of different types of activities in PD

- Waste (Activity idle) 62%
- Activity Executed 38%
- Waste 15%
- Necessary waste 11%
- Value added 12%

Source: McManus, 2005, Oppenheim, 2004
Lean can do that!

(relative figures)

- Non value adding process steps: Before Lean 100% vs. After Lean 40%
- Rework: Before Lean 100% vs. After Lean 0%

Global Hawk Program
(relative figures)

- Contracting lead time: Before Lean 100% vs. After Lean 63%
- Change process cycle time: Before Lean 100% vs. After Lean 37%

Sources: Oehmen, Rebentisch 2010: Compilation of Lean Now! Project Reports // Pictures: defenseindustrydaily.com
Additional Reading: Murman et al, Lean Enterprise Value

http://lean.mit.edu
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The Strengths of Lean: Value-Focus and Integration

Lean Thinking focusses on 6 Principles:

1. Define **value** to the program stakeholders
2. Plan the **value-adding stream** of work activities during the product lifecycle, from the need to product delivery, until disposal, while eliminating waste
3. Organize the value stream as an uninterrupted **flow** of predictable and robust tasks, proceeding without rework or backflow
4. Organize the **pull** of the work-in-progress as needed and when needed by all receiving tasks
5. Make all imperfections visible and pursue **perfection**, i.e. the process of never ending improvement
6. Base human relations on **respect** for people
Lean Enablers for Systems Engineering

Bo Oppenheim: Lean for Systems Engineering with Lean Enablers for Systems Engineering, Wiley 2011
RESULTS: GUIDE TO LEAN ENABLERS FOR MANAGING ENGINEERING PROGRAMS
Year 1 Results: Baseline Recommendations

Guide to Lean Enablers for Managing Engineering Programs

- Challenges in Managing Engineering Programs
- Lean Enablers for Managing Engineering Programs
- Complimentary Improvement Approaches
- Implementation Suggestions
- Implementation Barriers
- Appendix: Lots of mappings and tables

Introduction to Lean Thinking

Alignment of Program Management and Systems Engineering

Improvement need, program context

http://lean.mit.edu
The Guide to Lean Enablers for Managing Engineering Programs

http://www.lean-program-management.org/

“The Guide to Lean Enablers for Managing Engineering Programs’ offers careful examination of effective programs and illustrates how collaboration between program managers and systems engineers, paired with the adoption of lean enablers, contribute enormously to the success of projects,” said John A. Thomas, president of INCOSE.
CHALLENGES IN ENGINEERING PROGRAMS
Challenges – Collection and Prioritization Process

- Literature review: 90 challenges
- Collection from subject matter experts: 210 challenges
- Consolidation: 160 challenges
- Survey: 140 participants
- Consolidation: Top 60 challenges into 10 themes
### Overall average - Top 10 Challenges

<table>
<thead>
<tr>
<th>Rank</th>
<th>Challenge</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>High-level program issues-Firefighting - Resources focused on fixing problems instead of preventing them</td>
<td>4.3</td>
</tr>
<tr>
<td>14</td>
<td>Multi-project coordination- Competing resource requirements (e.g. allocation and choice of resources)</td>
<td>4.2</td>
</tr>
<tr>
<td>105</td>
<td>Definition of stakeholder needs and requirements- Incomplete understanding of stakeholder requirements</td>
<td>4.1</td>
</tr>
<tr>
<td>107</td>
<td>Definition of stakeholder needs and requirements- Lack of appreciation of requirements complexity, derived requirements are...</td>
<td>4.0</td>
</tr>
<tr>
<td>15</td>
<td>Multi-project coordination- Unstable project priorities</td>
<td>3.9</td>
</tr>
<tr>
<td>104</td>
<td>Definition of stakeholder needs and requirements- Stakeholder do not clearly articulate their requirements (e.g. implicit requirements)</td>
<td>3.9</td>
</tr>
<tr>
<td>62</td>
<td>Program Stakeholder Management- Insufficient management / alignment of differing priorities within collaborating organizations</td>
<td>3.8</td>
</tr>
<tr>
<td>9</td>
<td>Program Leadership- Problematic allocation of responsibility and decision rights</td>
<td>3.8</td>
</tr>
<tr>
<td>50</td>
<td>HR Development, Staffing, Expertise- Ineffective process to transfer knowledge from experienced employees / team members to...</td>
<td>3.7</td>
</tr>
<tr>
<td>87</td>
<td>Knowledge management- Lack of feedback mechanisms to turn lessons learned into action; no implementation of lessons learned...</td>
<td>3.7</td>
</tr>
</tbody>
</table>
Poll 5: What is your organization’s most serious engineering program challenge?

1. Reactive Program Execution
2. Lack of stability, clarity and completeness of requirements
3. Insufficient alignment and coordination of the extended enterprise
4. Value stream not optimized throughout the entire enterprise
5. Unclear roles, responsibilities and accountability
6. Mismanagement of team competency and knowledge
7. Insufficient Program Planning
8. Improper Metrics, Metric Systems and KPIs
9. Lack of Active Program Risk Management
10. Poor Program Acquisition and Contracting Practices
## Prioritization and consolidation of 160+ challenges into 10 major themes

<table>
<thead>
<tr>
<th>#</th>
<th>Theme</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Reactive Program Execution</td>
<td>Program is executed in a reactive mode towards outside influences, instead of proactively managing and coordinating stakeholders, risks and issues.</td>
</tr>
<tr>
<td>2</td>
<td>Lack of stability, clarity and completeness of requirements</td>
<td>Changing, unclear and incomplete requirements from customers and other stakeholders seriously affect the efficient and effective execution of the program.</td>
</tr>
<tr>
<td>3</td>
<td>Insufficient alignment and coordination of the extended enterprise</td>
<td>The complex network of organizations and departments involved in delivering the program value is not aligned in their priorities. This includes the alignment and optimization of strategic priorities and portfolios.</td>
</tr>
<tr>
<td>4</td>
<td>Value stream not optimized throughout the entire enterprise</td>
<td>The value stream is only locally optimized. There is a lack of visibility of the value stream, and / or barriers between organizational units to implement a seamless flow. There are insufficient trade-offs between organizations to reach overall optimum.</td>
</tr>
<tr>
<td>5</td>
<td>Unclear roles, responsibilities and accountability</td>
<td>The roles, responsibilities and accountability of individuals, teams, project, staff organization and organizations are not clearly defined.</td>
</tr>
<tr>
<td>6</td>
<td>Mismanagement of team competency and knowledge</td>
<td>The expertise and knowledge of individuals, teams and the organization is insufficient, not transferred sufficiently, or not applied appropriately during the program.</td>
</tr>
<tr>
<td>7</td>
<td>Insufficient Program Planning</td>
<td>The program planning is inaccurate and / or unable to accommodate uncertainties, leading to unrealistic expectations and base plans.</td>
</tr>
<tr>
<td>8</td>
<td>Improper Metrics, Metric Systems and KPIs</td>
<td>The metrics and KPIs used during the program do not capture the intended performance attribute, incentivize the wrong behavior, or are lagging instead of predictive.</td>
</tr>
<tr>
<td>9</td>
<td>Lack of Active Program Risk Management</td>
<td>Budgetary and time constraints force limited or no risk management activity to be undertaken by the program team. The program team attempts to function without clear offramps and mitigation approaches. Ownership of risks is ill-defined.</td>
</tr>
<tr>
<td>10</td>
<td>Poor Program Acquisition and Contracting Practices</td>
<td>Time constraints force inadequate quality of the Request for Proposal (RFP) or contract bid. Improper incentives, improper management of low-TRL-technologies, insufficient leadership and interference of laws and regulations all exacerbate this challenge.</td>
</tr>
</tbody>
</table>
Challenge 2: Requirements stability and cost

Increase of R&D Cost in DoD Programs

- Decreased, deferred or deleted requirements: 80%
- New or enhanced requirements: 70%
- Stable requirements: 10%
OVERVIEW OF LEAN ENABLERS
Finding the Enabler that is right for you:
Various mappings

5 Program Management Performance Domains

6 Systems Engineering Process Categories (and 28 processes)

10 Challenges

43 Enablers
286 Sub-Enablers

6 Lean Principles

Earned Value Management, CMMI, Agile

http://lean.mit.edu

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Lean Enablers: 300 Best Practices in 40 Categories

- Lean Enablers 1: Respect for people
  - 6 enablers
  - 37 sub-enablers

- Lean Enablers 2: Capture the value as defined by the customer
  - 7 enablers
  - 44 sub-enablers

- Lean Enablers 3: Map the value stream
  - 10 enablers
  - 69 sub-enablers

- Lean Enablers 4: Flow the work processes
  - 10 enablers
  - 67 sub-enablers

- Lean Enablers 5: Let customer pull value
  - 2 enablers
  - 8 sub-enablers

- Lean Enablers 6: Pursue perfection in all processes
  - 8 enablers
  - 50 sub-enablers
Lean Enablers 1.x: Treat People as Your Most Important Asset (Lean Principle 6) 
6 Enablers, 43 Sub-Enablers

1. Build a program culture based on respect for people

2. Motivate by making the higher purpose of the program and program elements transparent

3. Support an autonomous working style

4. Expect and support people in their strive for professional excellence and promote their careers

5. Promote the ability to rapidly learn and continuously improve

6. Encourage personal networks and interactions

Watch Dan Pink at: http://www.youtube.com/watch?v=u6XAPnuFjJc
Example of Lean Enablers

Addressing Requirements Stability

- 10 challenges
- 6 categories of Lean Enablers
- 43 Lean Enablers
- 286 Sub-Enablers (54 regarding requirements)

**Challenge**
- #2: Lack of stability, clarity and completeness of requirements

**Category of Lean Enabler**
- 2.: Lean Enablers to Maximize Program Value

**Lean Enabler**
- 2.4: Develop high-quality requirements among customer stakeholders before bidding and execution
- 2.5: Derive, clarify and prioritize requirements early, often and pro-actively

**Sub-Enablers**
- 2.5.9: Fail early and fail often through rapid learning techniques (e.g. prototyping, tests, simulations, digital models, spiral development)
Example Enablers addressing stability, clarity and completeness of requirements (1)

- Understanding what customer wants: **2.1 Establish value of the program to the stakeholders**
  - 2.1.1. Define value as the outcome of an activity that satisfies at least three conditions. 
    a. The external customer stakeholders are willing to pay for value. 
    b. Transforms information or material or reduces uncertainty. 
    c. Provides specified program benefits right the first time.
  - 2.1.2. Define value - added in terms of value to the customer stakeholders and their needs
  - 2.1.3. Develop a robust process to capture, develop, and disseminate customer stakeholder value with extreme clarity.
  - 2.1.4. Proactively resolve potential conflicting stakeholder values and expectations, and seek consensus.
  - 2.1.5. Explain customer stakeholder culture to Program employees, i.e. the value system, approach, attitude, expectations, and issues.
Major Themes of the Lean Enablers

- Respect for people
- Focus on value and benefits
- Frequent engagement of all stakeholders. Direct and efficient communication.
- Clear responsibility, authority and accountability
- High-quality requirements up-front and effective management of requirement change
- Front-loading of program planning
- Organize program around value and benefits, not departments and companies
- Use of effective metrics: Leading indicators, transparency regarding status on all levels, clear line-of-sight to strategic goals
- Continuous improvement, inclusive towards all best practices
Content analysis: PMI Project (Program) of the Year Winners of the last 10 years
Application of Lean Enablers in “Best Practice Programs”– The more detailed the reports, the more Enablers we found

- Deepwater (GAO-06-546) 74%
- 2011 Prairie Waters 65%
- 2010 Dallas Cowboys Stadium 60%
- 2009 Flour Power Plant 37%
- 2009 BAA Heathrow 19%
- 2008 QIT - Fer et Titane 23%
- 2007 Nuclear Cleanup 35%
- 2006 Rocky Flats Plant 26%
- 2005 Quartier International de 26%
- 2004 Haradh Gas Plant 37%
- 2003 Winter Olympics 42%
- 2002 Hawiyah Gas Plant 42%
- 2001 River of Aluminum 35%
- 2000 The Troja Reactor 35%

Based on application documents & GAO report

Based on brief reports
Every Lean Enabler was used at least once.

Relative Use of the Lean Enabler

- Flow 3: 93%
- Value 3: 93%
- Respect 1: 79%
- Value Stream 1: 79%
- Perfection 6: 71%
- Value Stream 6: 71%
- Flow 6: 71%
- Respect 5: 57%
- Value 4: 54%
- Value stream 4: 54%
- Perfection 5: 54%
- Respect 4: 54%
- Value Stream 4: 54%
- Flow 2: 50%
- Perfection 4: 50%
- Perfection 7: 50%
- Value Stream 7: 50%
- Flow 4: 43%
- Pull 2: 43%
- Respect 2: 43%
- Value 1: 36%
- Value 6: 36%
- Flow 4: 36%
- Flow 6: 29%
- Perfection 8: 29%
- Respect 6: 29%
- Value Stream 9: 29%
- Flow 7: 21%
- Flow 9: 21%
- Perfection 3: 21%
- Respect 3: 21%
- Value 2: 21%
- Value Stream 1: 21%
- Value Stream 3: 21%
- Perfection 1: 14%
- Value 6: 14%
- Value 7: 14%
- Value Stream 2: 14%
- Flow 1: 14%
- Flow 6: 14%
- Pull 1: 7%
- Perfection 2: 7%
- Value Stream 5: 7%
Almost always found

- Build a program culture based on respect for people
- For every program, use a program manager role to lead and integrate program from start to finish
- Frequently engage the stakeholders throughout the program lifecycle
- Develop a Communications Plan

Rarely found

- Pull tasks and outputs based on need, and reject others as waste
- Pursue Lean for the long term
- Use probabilistic estimates in program planning
Use of Lean Enablers in Successful and Unsuccessful Programs:
Level of Agreement of Respondents

- LE 1.x: Respect
- LE 2.x: Value
- LE 3.x: Value Stream
- LE 4.x: Flow
- LE 5.x: Pull
- LE 6.x: Perfection

Disagree that Lean Enablers were used
Neither agree, nor disagree that Lean Enablers were used
Agree that Lean Enablers were used

average N: 63 programs per category; all differences are statistically significant
IMPLEMENTING THE LEAN ENABLERS: THE ROAD AHEAD
Implementing Lean Enablers: What we have

- Mapping to challenges, program management performance domains, systems engineering processes, lean principles
- Brief examples on the “enabler” level
- High-level discussion of using Lean Enablers in change management process
Implementing Lean Enablers: The Road Ahead

- System of metrics to track implementation and performance contribution of Lean Enablers. The metrics walk the fine line between being overly burdensome in their collection and analysis versus being too coarse to provide specific incentives and decision support.

- Extended documentation for each enabler, including a more description, implementation suggestions, examples, metrics, and references to background material.

- Training courses and teaching material

- Providing a forum for the exchange of implementation experiences, both successes and challenges.
• For more information on the Lean Enablers contact David Meza at david.meza-1@nasa.gov
• Join us on www.lean-program-management.org and sign up for our monthly update
• Join us as a Subject Matter Experts: Contact Josef at oehmen@mit.edu
• Sponsor a research project for a pilot implementation at your organization