

Fall 2010

# The Mapping of Lean Enablers for Systems Engineering (LEfSE) onto INCOSE Systems Engineering Processes

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## Recommended Citation

Makiewicz, Dana, "The Mapping of Lean Enablers for Systems Engineering (LEfSE) onto INCOSE Systems Engineering Processes" (2010). *Systems Engineering Research Projects and Oral Presentations*. 10.  
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# The Mapping of Lean Enablers for Systems Engineering (LEfSE) onto INCOSE Systems Engineering Processes

The Application of Lean Thinking into Systems Engineering Practices

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SELP 695

Dr. Oppenheim

December 8, 2010

# Agenda

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- Project Goals
- Organization of INCOSE SE Handbook 3.2
- Fundamentals of Lean
- Lean Systems Engineering
- History of LEfSE
- Awards (Shingo, INCOSE 2009)
- Explanation of Lean enablers
- Proposed process diagram
- Overall strategy for the Mapping
- Lean enabler mapping
- Ethical issues
- Summary
- References

# Project Goals

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- Map the 147 LEfSE onto the 26 INCOSE Systems Engineering processes
- Propose a new Enterprise Preparation Process focused on corporate preparation for all programs
- Identify ethical issues associated with the integration of Lean and the practice of Systems Engineering as defined by INCOSE



# Organization of INCOSE SE Handbook v3.2

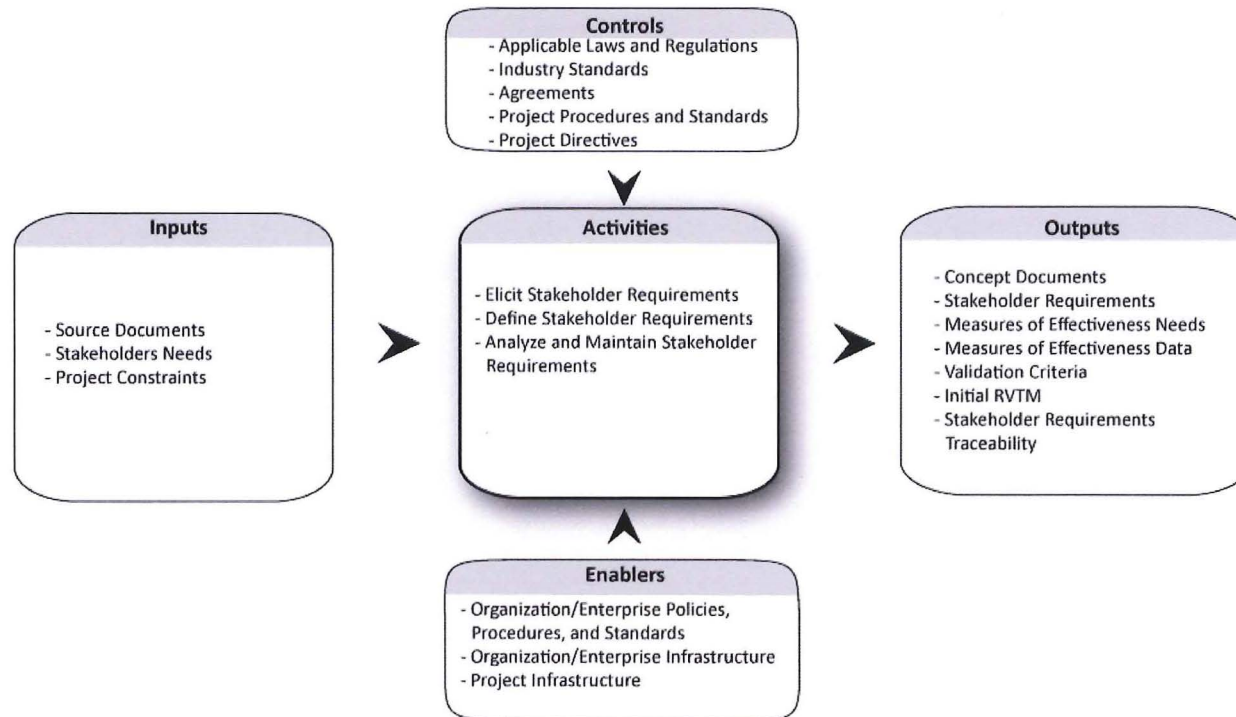
# INCOSE SE Handbook v3.2

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- Provides a description of key process activities performed by systems engineers
  - Serves as the framework for mapping the LEfSE
- Partitions SE activities into 26 processes organized under 5 topical headings
  - Technical processes (11 processes)
  - Project processes (7 processes)
  - Agreement processes (2 processes)
  - Organizational Project-Enabling processes (5 processes)
  - Tailoring processes (1 process)

# Current State Process Diagram

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Stakeholder Requirements Definition Process Diagram [1]

# Fundamentals of Lean

# Fundamentals of Lean

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The organization of work based on the pursuit of value and the elimination of waste

*Lean Enablers for Systems Engineering, Version 1.0, February 1, 2009*

- Organized around six principles:
  - **Value** – Defined by the customer
  - **Map the value stream** – planning all actions and processes necessary to realize value, after eliminating waste
  - **Flow** – no stopping, rework or backflow
  - **Pull** – need defines tasks and their timing
  - **Perfection** – imperfections made visible, spurring continuous improvement
  - **People** – respect people



# Lean Systems Engineering

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“The application of lean six sigma principles, practices and tools to systems engineering in order to enhance the delivery of value to the system’s stakeholders”

*Lean Enablers for Systems Engineering, Version 1.0, February 1, 2009*

- Value is defined as flawless mission or product assurance with minimum waste
- This does *not* mean less Systems Engineering, or cutting corners
- It means adding the wisdom of Lean to the traditional Systems Engineering practices
  - Doing *everything* that is required, but doing it with a minimum of waste



# Common Myths About Lean

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- “Lean SE means less SE”
- “Lean applies only to manufacturing”
- “Lean applies only to repeated activities and not to one-off like PD or SE”
- Emphatically not true:
  - Lean SE means “More and better SE, for streamlined program”
  - Lean has been applied with success in: PD, Supply Chain, Parts Engineering, Health, Office, Accounting, ...
  - Leans means, basically: “ Create best value with minimum waste” – how can that not apply to SE?

# History of LEfSE

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- 1992: Lean Aerospace Initiative consortium started at MIT
- 2003: LAI invited universities to join the LAI Educational Network (EdNet). Grew to 54 universities worldwide. LMU was the charter university in EdNet
- 2004: Lean SE working group was formed within the EdNet
- 2006: Lean SE migrated to INCOSE
- 2006 – 2009: Lean SE working group develops the LEfSE
- 2010: Major publication, two major awards
- 2010: INCOSE President invited Lean SE WG to map LEfSE onto INCOSE Systems Engineering Processes
- 2010: INCOSE President invited Lean SE WG to add questions about Lean SE to the INCOSE SE Certification exam
- 2010: The WG has 171 members - second largest INCOSE Working Group

# Two Prestigious Awards for LEfSE

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- INCOSE 2009 Best Product Award to the leaders (Oppenheim-LMU, Murman-MIT, Secor-Rockwell-Collins), and the WG
- 2010 Shingo Prize - Research & Professional Publication Award to the three leaders
- Independent validation from both SE and Lean communities

# Explanation of Lean Enablers

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- Developed by the Lean Systems Engineering Working Group (INCOSE)
- A collection of 194 enablers
  - Organized under the six Lean principles and 47 topical headings (enablers)
  - With 147 actionable subenablers (these are being mapped)
- Provide guidance with respect to preparation of people, processes, tools for programs, program planning, frontloading, executing and practicing Systems Engineering
- Primary goal is Mission Assurance (MA) and the satisfaction of stakeholders with minimum waste
- *Not* a guarantee, rather, a guide post to improved performance
- Usage score from -2.0 to 2.0

# Overall Strategy for Lean Enablers

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- Vehicle for the application of Lean thinking into established SE practices
- Make value drive SE effort, and reduce waste to the greatest extent possible
- Not intended to be imposed as mandatory procedure
  - Supplement the established SE practices with the wisdom of Lean Thinking, not replace it

# Lean Enabler Mapping Strategy



# Mapping Strategy

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- Map all 147 subenablers (and one enabler which has no subenablers)
- Each of the subenablers to be mapped onto only one process or “All Processes”
- The one judged the most appropriate from the point of view of implementation
- Trial and error approach (not easy as many subenablers would fit in several processes)

# Lean Enabler Mapping Summary

INCOSE SE Process	Number of LEfSE subenablers mapped
All Processes	47
Enterprise Preparation Process	10
4.1 Stakeholder Requirements Definition Process	2
4.2 Requirements Analysis Process	0
4.3 Architectural Design Process	7
4.4 Implementation Process	4
4.5 Integration Process	0
4.6 Verification Process	0
4.7 Transition Process	0
4.8 Validation Process	0
4.9 Operation Process	0
4.10 Maintenance Process	0
4.11 Disposal Process	0
5.1 Project Planning Process	32
5.2 Project Assessment and Control Process	0
5.3 Decision Management Process	2
5.4 Risk Management Process	2
5.5 Configuration Management Process	1
5.6 Information Management Process	6
5.7 Measurement Process	5
6.1 Acquisition Process	0
6.2 Supply Process	7
7.1 Life Cycle Model Management Process	0
7.2 Infrastructure Management Process	0
7.3 Project Portfolio Management Process	3
7.4 Human Resource Management Process	10
7.5 Quality Management Process	9
8.1 Tailoring Process	1

# Lean Enabler Mapping Summary - Continued

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- New category: **All Processes** with the most LEfSE mapped – 47
  - Addressing the critical aspects of SE which are often ignored in traditional programs and SE handbooks, and which flow naturally from Lean Thinking:
    - excellent coordination and communication
    - alignment for customer value
    - teamwork
    - better interactions between stakeholders
    - emphasis on performing work *right the first time*
    - excellent interpersonal relations and human habits, etc.
- These 47 subenablers improve all SE Processes
- The large number of subenablers indicates how much room for improvement there is in the traditional SE

# Lean Enabler Mapping Summary - Continued

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- New process proposed: **Enterprise Preparation Process**
  - Corporate Preparations for all programs, serving all programs, to be paid for with corporate funds
- **Project Planning Process** is the category with the next most LEfSE mapped – 32
  - Focus on improving front-end activities:
    - Preparation of people, processes, tools
    - Better planning for value capture
    - Better planning of program based on VSM
    - Planning for best communication and coordination means
    - Planning for better frontloading
    - Planning for stronger integration of SE and PD
    - Planning for better human relations among stakeholders
  - These practices are often performed in traditional programs not as well as they could be.
- Twelve processes with no LEfSE mapped
  - These processes are improved indirectly via:
    - The subenablers listed under “All Processes”
    - The front-end Processes when most critical decisions are made affecting the entire program
- Addition of enabler 6.5 results in a total of 148 subenablers listed in the table



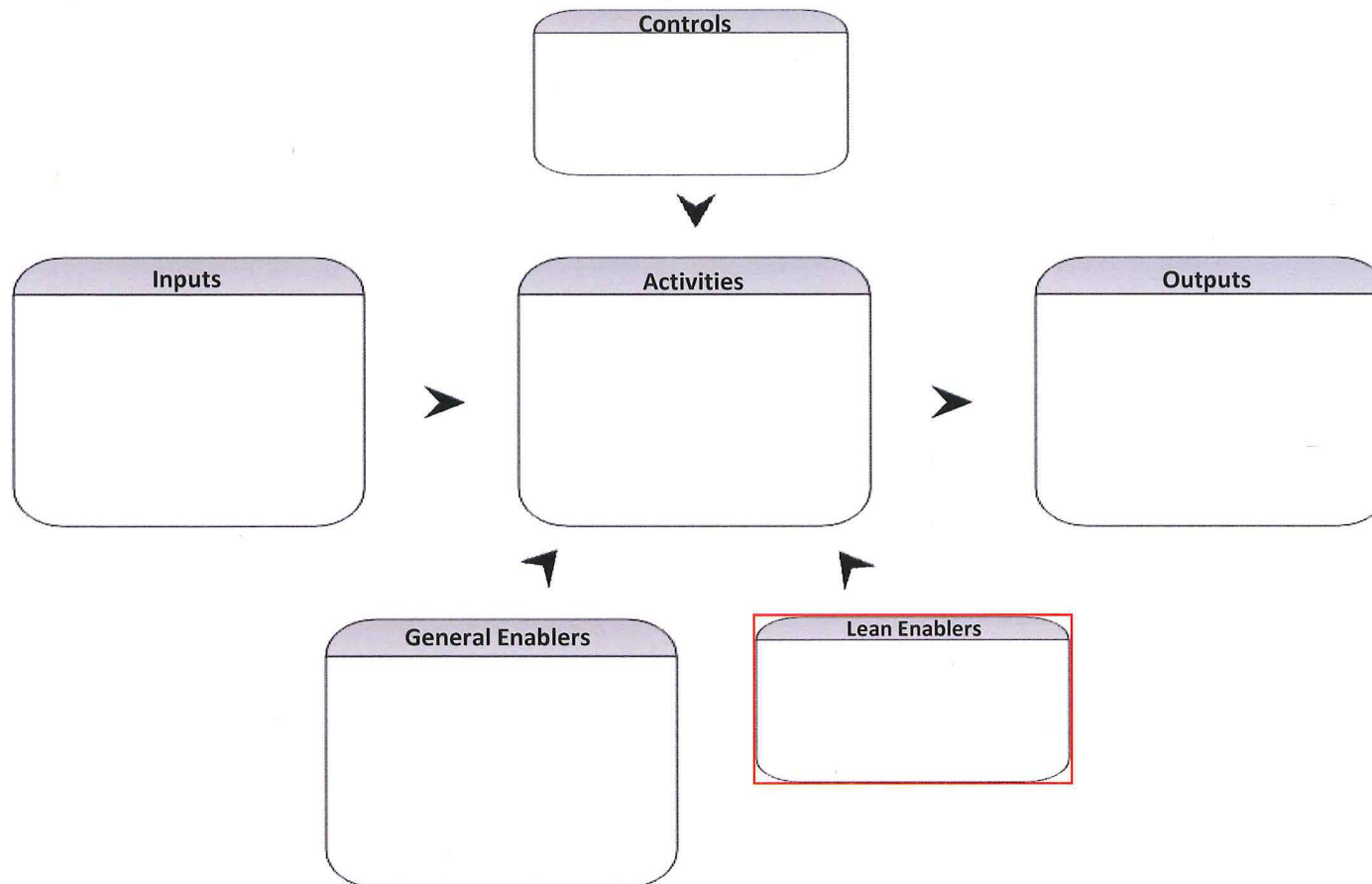
# SE Processes with no dedicated Subenablers

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- Technical Processes
  - 4.2 Requirements analysis process
  - 4.5 Integration process
  - 4.6 Verification process
  - 4.7 Transition process
  - 4.8 Validation process
  - 4.9 Operation process
  - 4.10 Maintenance process
  - 4.11 Disposal process
- Project Processes
  - 5.2 Project assessment and control process
- Agreement Processes
  - 6.1 Acquisition process
- Organizational Project-Enabling Processes
  - 7.1 Life cycle model management process
  - 7.2 Infrastructure management process

# Proposed Process Diagram

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# The Mapping Results

# All Processes

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## Lean Enablers

- 1.2.1. Define value as the outcome of an activity that satisfies at least three conditions: (U 0.36)
  - a. The external customer is willing to pay for “Value.” (U 0.65)
  - b. Transforms information or material or reduces uncertainty. (U 0.57)
  - c. Provides specified performance right the first time. (U 0.09)
- 1.2.2. Define value-added in terms of value to the customer and his needs (U 0.50)
- 1.2.5. Do not ignore potential conflicts with other stakeholder values, and seek consensus. (U 0.28)
- 1.3.1. Everyone involved in the program must have a customer-first spirit. (U 0.56)
- 1.3.2. Establish frequent and effective interaction with internal and external customers. (U 0.56)
- 2.2.6. Scrutinize every step to ensure it adds value, and plan nothing because "it has always been done". (U -0.54)
- 3.2.1. Since formal written requirements are rarely enough, allow for follow up verbal clarification of context and need, without allowing requirements creep. (U 0.36)

# All Processes-Continued

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## Lean Enablers

- 3.2.6. Identify a small number of goals and objectives that articulate what the program is set up to do, how it will do it, and what the success criteria will be to align stakeholders - and repeat these goals and objectives consistently and often. (U 0.28)
- 3.4.2. SE to regard all other engineers as their partners and internal customers, and vice-versa. (U 0.12)
- 3.5.1. Capture and absorb lessons learned from almost all programs: “never enough coordination and communication.” (U -0.52)
- 3.5.4. Use frequent, timely, open and honest communication. (U 0.48)
- 3.5.5. Promote direct informal communications immediately as needed. (U 0.76)
- 3.5.6. Use concise one-page electronic forms (e.g., Toyota's A3 form) rather than verbose unstructured memos to communicate, and keep detailed working data as backup. (U -0.28)



# All Processes-Continued

## Lean Enablers

- 3.6.1. Use formal frequent comprehensive integrative events in addition to programmatic reviews. (U 0.00):
  - a. Question everything with multiple “whys.” (U -0.04)
  - b. Align process flow to decision flow. (U 0.16)
  - c. Resolve all issues as they occur in frequent integrative events. (U -0.08)
  - d. Discuss tradeoffs and options. (U 0.72)
- 3.6.2. Be willing to challenge the customer's assumptions on technical and meritocratic grounds, and to maximize program stability, relying on technical expertise. (U 0.48)
- 3.6.3. Minimize handoffs to avoid rework. (U -0.04)
- 3.6.4. Optimize human resources when allocating VA and RNVA tasks. (U 0.08):
  - a. Use engineers to do VA engineering. (U 0.36)
  - b. When engineers are not absolutely required, use non-engineers to do RNVA (administration, project management, coasting, metrics, program, etc.) (U 0.08)
- 3.6.5. Ensure the use of the same measurement standards and database commonality. (U 0.13)

# All Processes-Continued

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## Lean Enablers

- 3.6.6. Ensure that both data deliverers and receivers understand the mutual needs and expectations. (U 0.36)
- 3.7.1. Make work progress visible and easy to understand to all, including external customer. (U 0.36)
- 3.7.2. Utilize Visual Controls in public spaces for best visibility (avoid computer screens). (U 0.08)
- 3.7.3. Develop a system making imperfections and delays visible to all. (U 0.16)
- 3.7.4. Use traffic light system (green, yellow, red) to report task status visually (good, warning, critical) and make certain problems are not concealed. (U 0.80)
- 4.2.2. Promote the culture in which engineers pull knowledge as they need it and limit the supply of information to only genuine users. (U -0.04)
- 4.2.4. Train the team to recognize who the internal customer (Receiver) is for every task as well as the supplier (Giver) to each task- use a SIPOC (supplier, inputs, process, outputs, customer) model to better understand the value stream. (U -0.04)
- 4.2.5. Stay connected to the internal customer during the task execution. (U 0.32)

# All Processes-Continued

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## Lean Enablers

- 4.2.7. Promote effective real time direct communication between each Giver and Receiver in the value flow. (U 0.24)
- 4.2.8. Develop Giver-Receiver relationships based on mutual trust and respect. (U 0.36)
- 4.2.9. When pulling work, use customer value to separate value added from waste. (U 0.00)
- 5.2.2. Promote excellence under “normal” circumstances instead of hero-behavior in “crisis” situations. (U -0.40)
- 5.2.3. Use and communicate failures as opportunities for learning emphasizing process and not people problems. (U 0.04)
- 5.2.4. Treat any imperfection as an opportunity for immediate improvement and lesson to be learned, and practice frequent reviews of lessons learned. (U -0.20)
- 5.2.5. Maintain a consistent disciplined approach to engineering. (U 0.52)
- 5.3.2. Create mechanisms to capture, communicate, and apply experience-generated learning and checklists. (U 0.17)
- 5.3.4. Identify best practices through benchmarking and professional literature. (U 0.26)



# All Processes-Continued

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## Lean Enablers

- 6.2.3. Promote excellent human relations: trust, respect, honesty, empowerment, teamwork, stability, motivation, drive for excellence. (U 0.71)
- 6.2.5. Promote direct human communication. (U 0.63)
- 6.2.9. Eliminate fear and promote conflict resolution at the lowest level. (U 0.29)
- 6.2.10. Keep management decisions crystal clear but also promote and reward the bottom-up culture of continuous improvement and human creativity and entrepreneurship. (U 0.04)
- 6.2.11. Do not manage from cubicle; go to the spot and see for yourself. (U 0.17)
- 6.2.12. Within program policy and within their area of work, empower people to accept responsibility by promoting the motto “ask for forgiveness rather than ask for permission.” (U 0.28)
- 6.2.13. Build a culture of mutual support (there is no shame in asking for help). (U 0.36)
- 6.4.3. Provide knowledge experts as resources and for mentoring. (U 0.45)
- 6.4.4. Pursue the most powerful competitive weapon: the ability to learn rapidly and continuously improve. (U 0.55)

# All Processes-Continued

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## Lean Enablers

- 6.4.5. Value people for the skills they contribute to the program with mutual respect and appreciation. (U 0.45)
- 6.4.8. Immediately organize a quick training in any new standard. (U -0.27)
- 6.5. Treat People as Most Valued Assets, not as Commodities. (U 0.70)\*

\*While “6.5 Treat People as Most Valued Assets, not as Commodities” is not a Lean *subenabler*, it is an enabler of such significance that it is included in the mapping

# (New) Enterprise Preparation Process

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## Lean Enablers

- 5.4.3. Promote good coordination and communications skills with training and mentoring. (U 0.33)
- 5.5.1. The Chief Engineer role to be Responsible, with Authority and Accountability for the program technical success. (U 0.48)
- 5.5.2. Have the Chief Engineer role lead both the product and people integration. (U 0.04)
- 5.5.3. Have the Chief Engineer role lead through personal influence, technical know how, and authority over product development decisions. (U 0.17)
- 5.5.4. Groom an exceptional Chief Engineer role with the skills to lead the development, the people, and assure program success. (U 0.04)
- 5.5.5. If Program Manager and Chief Engineer are two separate individuals (required by contract or organizational practice), co-locate both to enable constant close coordination. (U 0.29)
- 5.6.1. Promote design standardization with engineering checklists, standard architecture, modularization, busses, and platforms. (U 0.57)
- 5.6.2. Promote process standardization in development, management, and manufacturing. (U 0.67)

# Enterprise Preparation Process-Continued

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## Lean Enablers

6.3.1. Establish and support Communities of Practice. (U 0.67)

6.4.7. Develop Standards paying attention to human factors, including reading and perception abilities. (U -0.18)



# 4.1 Stakeholder Requirements Definition Process

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## Lean Enablers

- 3.2.2. Create effective channels for clarification of requirements (possibly involve customer participation in development IPTs). (U 0.56)
- 3.2.3. Listen for and capture unspoken customer requirements. (U 0.20)



## 4.2 Requirements Analysis Process

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Lean Enablers

No Lean enablers mapped

## 4.3 Architectural Design Process

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### Lean Enablers

- 1.3.3. Pursue an architecture that captures customer requirements clearly and can be adaptive to changes. (U 0.36)
- 2.3.2. Explore trade space and margins fully before focusing on a point design and too small margins. (U 0.36)
- 2.4.2. Insist that a module proposed for use is robust before using it. (U 0.20)
- 3.2.4. Use architectural methods and modeling for system representations (3D integrated CAE toolset, mockups, prototypes, models, simulations, and software design tools) that allow interactions with customers as the best means of drawing out customer requirements. (U 0.72)
- 3.2.5. “Fail early - fail often” through rapid learning techniques (prototyping, tests, digital preassembly, spiral development, models, and simulation). (U 0.04)
- 3.3.1. Explore multiple concepts, architectures and designs early. (U 0.44)
- 3.3.3. Use a clear architectural description of the agreed solution to plan a coherent program, engineering and commercial structures. (U 0.44)

## 4.4 Implementation Process

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### Lean Enablers

- 1.2.6. Explain customer culture to Program employees, i.e. the value system, approach, attitude, expectations, and issues. (U -0.52)
- 3.3.2. Explore constraints and perform real trades before converging on a point design. (U 0.46)
- 3.3.4. All other things being equal, select the simplest solution. (U 0.12)
- 4.2.1. Let information needs pull the necessary work activities. (U -0.04)

## 4.5 Integration Process

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Lean Enablers

No Lean enablers mapped

## 4.6 Verification Process

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**Lean Enablers**

No Lean enablers mapped



## 4.7 Transition Process

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Lean Enablers

No Lean enablers mapped

## 4.8 Validation Process

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Lean Enablers

No Lean enablers mapped

## 4.9 Operation Process

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Lean Enablers

No Lean enablers mapped

## 4.10 Maintenance Process

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Lean Enablers

No Lean enablers mapped

# 4.11 Disposal Process

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Lean Enablers

No Lean enablers mapped



# 5.1 Project Planning Process

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## Lean Enablers

- 1.2.3. Develop a robust process to capture, develop, and disseminate customer value with extreme clarity. (U 0.00)
- 1.2.4. Develop an agile process to anticipate, accommodate and communicate changing customer requirements. (U 0.28)
- 1.3.4. Establish a plan that delineates the artifacts and interactions that provide the best means for drawing out customer requirements. (U 0.39)
- 2.2.1. Develop and execute clear communication plan that covers entire value stream and stakeholders. (U -0.29)
- 2.2.2. Have cross functional stakeholders work together to build the agreed value stream. (U -0.04)
- 2.2.3. Create a plan where both Systems Engineering and other Product Development activities are appropriately integrated. (U 0.30)
- 2.2.4. Maximize co-location opportunities for SE and [other] PD planning. (U 0.17)
- 2.2.7. Carefully plan for precedence of both SE and PD tasks (which task to feed what other tasks with what data and when), understanding task dependencies and parent-child relationships. (U 0.42)
- 2.2.8. Maximize concurrency of SE and other PD Tasks. (U 0.42)

# 5.1 Project Planning Process-Continued

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## Lean Enablers

- 2.2.9. Synchronize work flow activities using scheduling across functions, and even more detailed scheduling within functions. (U 0.65)
- 2.2.10. For every action, define who is responsible, approving, supporting, and informing ("RASI"), using a standard and effective tool, paying attention to precedence of tasks. (U 0.39)
- 2.2.11. Plan for level workflow and with precision to enable schedule adherence and drive out arrival time variation. (U -0.30)
- 2.2.12. Plan below full capacity to enable flow of work without accumulation of variability, and permit scheduling flexibility in work loading, i.e., have appropriate contingencies and schedule buffers. (U -0.26)
- 2.2.13. Plan to use visual methods wherever possible to communicate schedules, workloads, changes to customer requirements, etc. (U 0.22)
- 2.3.1. Plan to utilize cross-functional teams made up of the most experienced and compatible people at the start of the project to look at a broad range of solution sets. (U 0.36)
- 2.3.4. Plan early for consistent robustness and "first time right" under "normal" circumstances instead of hero behavior in later "crisis" situations. (U 0.12)

# 5.1 Project Planning Process-Continued

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## Lean Enablers

- 2.5.3. Plan to include and manage the major suppliers as a part of your team. (U 0.42)
- 3.4.1. Promote maximum seamless teaming of Systems Engineers and other Product Development (PD) engineers. (U 0.36)
- 3.4.3. Maintain team continuity between phases to maximize experiential learning. (U0.04)
- 3.4.4. Plan for maximum continuity of Systems Engineering staff during the Program. (U 0.20)
- 3.5.2. Maximize coordination of effort and flow (one of the main responsibilities of Lean SE). (U 0.24)
- 3.8.1. Use Lean tools to promote the flow of information and minimize handoffs: small batch size of information, small takt times, wide communication bandwidth, standardization, work cells, training. (U - 0.12)
- 4.2.3. Understand the Value Stream Flow. (U -0.32)
- 4.2.6. Avoid rework by coordinating task requirements with internal customer for every non-routine task. (U 0.08)



# 5.1 Project Planning Process-Continued

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## Lean Enablers

- 5.2.8. Use a balanced matrix/project organizational approach avoiding extremes: territorial functional organizations with isolated technical specialists, and all-powerful IPTs separated from functional expertise and standardization. (U 0.21).
- 5.4.1. Develop a plan and train the entire program team in communications and coordination methods at the program beginning. (U 0.13)
- 5.4.4. Publish instructions for e-mail distributions and electronic communications. (U -0.04)
- 5.4.6. Publish a directory of the entire program team and provide training to new hires on how to locate the needed nodes of knowledge. (U 0.38)
- 6.2.1. Create a vision which draws and inspires the best people. (U 0.58)
- 6.2.2. Invest in people selection and development to promote enterprise and program excellence. (U 0.46)
- 6.2.14. Prefer physical team co-location to the virtual co-location. (U 0.44)
- 6.4.6. Capture learning to stabilize the program when people change. (U 0.09)

## 5.2 Project Assessment and Control Process

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**Lean Enablers**

No Lean enablers mapped



## 5.3 Decision Management Process

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### Lean Enablers

- 3.5.7. Report cross-functional issues to be resolved on concise standard one-page forms to Chief's office in real time for his/her prompt resolution
- 6.2.8. Use flow down of Responsibility, Authority and Accountability (RAA) to make decisions at lowest appropriate level. (U 0.09)

## 5.4 Risk Management Process

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### Lean Enablers

- 2.3.3. Anticipate and plan to resolve as many downstream issues and risks as early as possible to prevent downstream problems. (U 0.40)
- 2.4.3. Remove show-stopping research/unproven technology from critical path, staff with experts, and include it in the Risk Mitigation Plan. (U 0.24)

# 5.5 Configuration Management Process

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## Lean Enablers

5.4.5. Publish instructions for artifact content and data storage: central capture versus local storage, and for paper versus electronic, balancing between excessive bureaucracy and the need for traceability. (U 0.33)

## 5.6 Information Management Process

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### Lean Enablers

- 3.8.2. Use minimum number of tools and make common wherever possible. (U -0.04)
- 3.8.3. Minimize the number of the software revision updates and centrally control the update releases to prevent information churning. (U 0.36)
- 3.8.4. Adapt the technology to fit the people and process. (U 0.17)
- 3.8.5. Avoid excessively complex “monument” tools. (U -0.04)
- 5.4.7. Ensure timely and efficient access to centralized data. (U 0.58)
- 5.4.8. Develop an effective body of knowledge that is historical, searchable, shared by team, and knowledge management strategy to enable the sharing of data and information within the enterprise. (U 0.13)

# 5.7 Measurement Process

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## Lean Enablers

- 2.6.1. Use leading indicators to enable action before waste occurs. (U -0.04)
- 2.6.2. Focus metrics around customer value, not profits. (U -0.33)
- 2.6.3. Use only few simple and easy to understand metrics and share them frequently throughout the enterprise. (U 0.16)
- 2.6.4. Use metrics structured to motivate the right behavior. (U 0.00)
- 2.6.5. Use only those metrics that meet a stated need or objective. (U 0.04)



# 6.1 Acquisition Process

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Lean Enablers

No Lean enablers mapped

## 6.2 Supply Process

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### Lean Enablers

- 2.5.1. Select suppliers who are technically and culturally compatible. (U 0.46)
- 2.5.2. Strive to develop seamless partnership between suppliers and the product development team. (U 0.21)
- 2.5.4. Have the suppliers brief the design team on current and future capabilities during conceptual formation of the project. (U 0.13)
- 3.3.5. Invite suppliers to make a serious contribution to SE, design and development as program trusted partner. (U 0.24)
- 3.5.3. Maintain counterparts with active working relationships throughout the enterprise to facilitate efficient communication and coordination among different parts of the enterprise, and with suppliers. (U 0.50)
- 3.5.8. Communicate all expectations to suppliers with crystal clarity, including the context and need, and all procedures and expectations for acceptance tests, and ensure the requirements are stable. (U 0.35)
- 3.5.9. Trust engineers to communicate with suppliers' engineers directly for efficient clarification, within a framework of rules, (but watch for high risk items which must be handled at the top level). (U 0.36)

# 7.1 Life Cycle Model Management Process

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Lean Enablers

No Lean enablers mapped

## 7.2 Infrastructure Management Process

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Lean Enablers

No Lean enablers mapped

## 7.3 Project Portfolio Management Process

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### Lean Enablers

- 2.4.1. Promote reuse and sharing of program assets: Utilize platforms, standards, busses, and modules of knowledge, hardware and software. (U 0.32)
- 2.4.4. Defer unproven technology to future technology development efforts, or future systems. (U 0.04)
- 2.4.5. Maximize opportunities for future upgrades, (e.g., reserve some volume, mass, electric power, computer power, and connector pins), even if the contract calls for only one item. (U 0.40)



## 7.4 Human Resource Management Process

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### Lean Enablers

- 5.4.2. Include communication competence among the desired skills during hiring. (U 0.29)
- 5.6.3. Promote standardized skill sets with careful training and mentoring, rotations, strategic assignments, and assessments of competencies. (U -0.05)
- 6.2.4. Read applicant's resume carefully for both technical and nontechnical skills, and do not allow mindless computer scanning for keywords. (U 0.50)
- 6.2.6. Promote and honor technical meritocracy. (U 0.83)
- 6.2.7. Reward based upon team performance, and include teaming ability among the criteria for hiring and promotion. (U 0.25)
- 6.3.2. Invest in Workforce Development. (U 0.83)
- 6.3.3. Assure tailored lean training for all employees. (U 0.21)
- 6.3.4. Give leaders at all levels in-depth lean training. (U 0.13)
- 6.4.1. Perpetuate technical excellence through mentoring, training, continuing education, and other means. (U 0.82)
- 6.4.2. Promote and reward continuous learning through education and experiential learning. (U 0.36)

# 7.5 Quality Management Process

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## Lean Enablers

- 5.2.1. Do not ignore the basics of Quality: (U 0.84):
  - a. Build in robust quality at each step of the process, and resolve and do not pass along problems (U 0.17)
  - b. Strive for perfection in each process step without introducing waste. (U -0.16)
  - c. Do not rely on final inspection; error proof wherever possible. (U 0.08)
  - d. If final inspection is required by contract, perfect upstream processes pursuing 100% inspection pass rate (U 0.28)
  - e. Move final inspectors upstream to take the role of quality mentors. (U 0.08)
  - f. Apply basic PDCA method (plan, do, check, act) to problem solving. (U 0.48)
  - g. Adopt and promote a culture of stopping and permanently fixing a problem as soon as it becomes apparent. (U -0.08)
- 5.2.6. Promote the idea that the system should incorporate continuous improvement in the organizational culture, but also... (U 0.42)

## 7.5 Quality Management Process-Continued

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### Lean Enablers

- 5.2.7. ...balance the need for excellence with avoidance of overproduction waste (pursue refinement to the point of assuring Value and "first time right", and prevent over-processing waste). (U 0.25)
- 5.3.1. Maximize opportunities to make each next program better than the last. (U 0.13)
- 5.3.3. Insist on workforce training of root cause and appropriate corrective action. (U 0.04)
- 5.3.5. Share metrics of supplier performance back to them so they can improve. (U 0.39)
- 5.7.1. Utilize and reward bottom-up suggestions for solving employee-level problems. (U 0.17)
- 5.7.2. Use quick response small Kaizen teams comprised of problem stakeholders for local problems and development of standards. (U 0.13)
- 5.7.3. Use the formal large Six Sigma teams for the problems which cannot be addressed by the bottom-up and Kaizen improvement systems, and do not let the Six Sigma program destroy those systems. (U 0.13)



# 8.1 Tailoring Process

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## Lean Enablers

2.2.5. Use formal value stream mapping methods to identify and eliminate SE and other PD waste, and to tailor and scale tasks. (U -0.67)

# Ethical Issues



# Ethical Issues

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- Two strong ethical considerations:
  - Lean Thinking places a huge emphasis on “Respect for People”:
    - Respect for people, better human relations, enthusiasm, passion, teamwork, leadership, honesty, openness, empowerment, ...
  - Fiduciary obligations
    - To stakeholders: *tax payers*, end-users, customers, government
    - Remember: the goal of Lean is the promotion of value while eliminating waste
    - It is our obligation as industry participants to provide the highest quality products within budget and on schedule

# Summary

# Summary

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- Current Systems Engineering practices are sound, but inefficient
  - LEfSE are the vehicle for the application of Lean wisdom into SE practices
  - The LEfSE are intended as a guide post to improved performance
    - Not a guarantee
    - Not mandatory
    - Not a shortcut
    - They do not supersede established SE practices
- SE practice will benefit from the addition of the Enterprise Preparation Process
  - All programs will improve with better preparations of people, processes, tools
- Significant ethical aspects of LEfSE
  - Explicitly addresses Respect for People as an aspect of SE practice
  - Highlights industry obligations to stakeholders

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