Lean Enablers for Systems Engineering

Handout
LAI Conference
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INCOSE
International Council on Systems Engineering

INCOSE Lean Systems Engineering Working Group

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Part 1
Introduction

INCOSE Lean SE Working Group

- **Initiated in Jan. 2006 in ABQ**
- **June 2006: 60 participants in Orlando**
- **April 2008: 89 names and growing**
- **WG Core Team (all volunteers, working in spare time.)**
- **Co-chairs identified with asterisk:**
  - **Dave Cleotelis*, Raytheon, FL**
  - **Ray Jorgensen*, Rockwell Collins, IA**
  - **Earll Murman, MIT, ret.; WG Core Team Member Emeritus**
  - **Bo Oppenheim*, LMU, Los Angeles**
  - **Deb Secor*, Rockwell Collins, IA**

Development of Lean Enablers for Systems Engineering

- **Alpha and Beta Versions**
  - ➤ **Core Team of eight individuals kicks off the work at LMU, Los Angeles, Oct. 30, 2007.**
  - ➤ **Numerous Edits on Alpha and Beta releases**
  - ➤ **Organized the Enablers under 8 topical headings**
  - ➤ **Survey on Beta Version (10 WG members, 19 Major American Aerospace Company SEs)**
- **INCOSE IW in ABQ, Jan. 2008**
  - ➤ **Beta version presented to the WG**
  - ➤ **Survey conducted and collected**
  - ➤ **Decision to redraft under the headings of the Lean Principles**
  - ➤ **Lean Enablers Subgroup formed to Edit the Lean Enablers. 4 major edits. Results presented in this document.**
  - ➤ **Subgroup for the Integration with INCOSE formed (to explore common interests and overlaps with other WGs, and the integration options with the Handbook WG)**
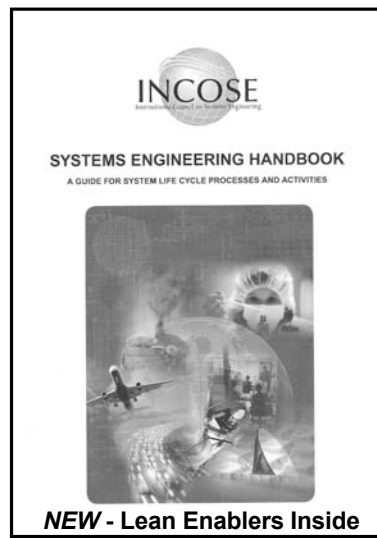
Who is the Intended Audience for the Lean Enablers for SE ?

- To paraphrase Samantha Brown, INCOSE President Elect: "*There is a Valley of Death between Academia and Industry*". Our WG attempts to bridge the Valley.
- Lean Enablers for Systems Engineering have been formulated for Industry Systems Engineering practitioners
- But the development strongly benefited from academic depth, breadth, and rigor.
- Focused on providing affordable, timely solutions to increasingly complex challenges
- Integrating Systems Engineering and Program Management
- Improving response time from the identification of need to the release of the system

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Selected Approach

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SYSTEMS ENGINEERING HANDBOOK

A GUIDE FOR SYSTEM LIFE CYCLE PROCESSES AND ACTIVITIES

NEW - Lean Enablers Inside

New Chapter or Appendix

Lean Enablers for Systems Engineering

Lean Enablers are not a tool or a process, but a way of Thinking!

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Overall Strategy for the Lean Enablers I

- The underlying philosophy is to apply Lean Thinking to capture the wisdom of best Systems Engineering (SE) practices, the do's and the don'ts of SE, an asymptote of excellence in SE, the way to make Systems Engineering as Value driven and as Waste free as possible.

- The grammatical form selected is a checklist of "do's and don'ts"

- Lean Enablers for Systems Engineering (LE for SE) are formulated under the headings of the classical Five Lean Principles plus the Sixth "People" Principle.

- The Enablers are not intended to become a regulation or mandatory procedure. Thus, if a particular program or organization falls short of one or more of the Lean Enablers, this is not a reason yet to reject or resist the Enablers.

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Overall Strategy for the Lean Enablers II

- The prototype should fit seamlessly into a future INCOSE Systems Engineering Handbook, <u>expanded from bullet to text form</u>, either as an Appendix or a Chapter, per INCOSE choice, with all Lean terms and Principles defined, explained, and with numerous examples.

- LE for SE should not:
  - ➤ repeat information already covered in the handbook, e.g. requirements management, risk management, IPTs
  - ➤ require considerable editing of the Handbook

- The present draft is based on the Handbook version 3.1

- LE for SE should be framed in a broad enough way that it would fit into other SE reference sources such as company handbooks.

INCOSE Handbook Overview

- **Chs 1-2 are introductory material**
- **Ch 3 covers Generic SE Lifecycles**
- **Chs 4-6 cover major SE Process areas (next slide)**
  - **Ch 4 - Technical Processes**
  - **Ch 5 - Project Processes**
  - **Ch 6 - Enterprise and Agreement Processes**
- **Chs 7-9 cover supporting activities**
  - **Ch 7 - Enabling Systems Engineering Process Activities**
    Requirements mgmt; risk & opportunity mgmt;decision-making
  - **Ch 8 - Systems Engineering Support Activities**
    Acquisition & supply; architectural design; config mgmt; info mgmt; investment mgmt; project planning; quality mgmt; resource mgmt; validation; verification
  - **Ch 9 - Specialty Engineering Activities**
    Acquisition logistics; EM compatibility; environmental impact; human factors; modeling, sim & prototyping; safety & health hazards; sustainment; training
- **Ch 10 covers Tailoring SE (very briefly)**
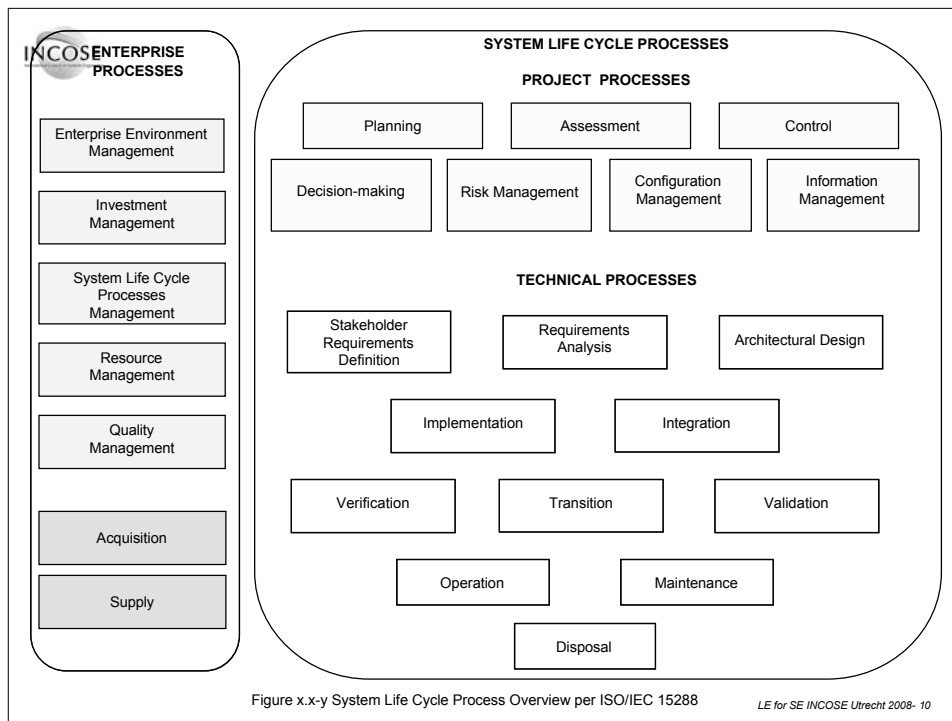
LE for SE INCOSE Utrecht 2008- 9

ENTERPRISE PROCESSES

SYSTEM LIFE CYCLE PROCESSES

PROJECT PROCESSES

| Planning | Assessment | Control |

| Decision-making | Risk Management | Configuration Management | Information Management |

Enterprise Environment Management

Investment Management

System Life Cycle Processes Management

Resource Management

Quality Management

Acquisition

Supply

TECHNICAL PROCESSES

| Stakeholder Requirements Definition | Requirements Analysis | Architectural Design |

| Implementation | Integration |

| Verification | Transition | Validation |

| Operation | Maintenance |

| Disposal |

Figure x.x-y System Life Cycle Process Overview per ISO/IEC 15288

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Part 2
Lean Enablers

Organization of the Lean Enablers for Systems Engineering into the Six Lean Principles

1. Customer defines <u>value</u>
2. <u>Map the value stream</u>: plan all end-to-end linked actions and processes necessary to realize value, streamlined, after eliminating waste
3. Make value <u>flow</u> continuously: without stopping, rework or backflow (valid iterations OK)
4. Let customers <u>pull</u> value: Customer's "pull/need" defines all tasks and their timing
5. Pursue <u>perfection</u>: all imperfections become visible, which is motivating to the continuous process of improvement
6. Respect <u>people</u>

Lean Principle 1: Value

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1. **Follow all practices for the requirements capture and development in the INCOSE Handbook. In addition:**

2. **Establish the Value of the End Product or System to the Customer**
   1. Define value as the outcome of an activity that satisfies at least three conditions:
      a. The external customer is willing to pay for "Value"
      b. Transforms information or material or reduces uncertainty
      c. Provides specified performance right the first time
   2. Define value-added in terms of value to the customer and his needs
   3. Develop a robust process to capture, develop, and disseminate customer value with extreme clarity
   4. Develop an agile process to anticipate, accommodate and communicate changing customer requirements
   5. Do not ignore potential conflicts with other stakeholder values, and seek consensus
   6. Explain customer culture to Program employees, i.e. the value system, approach, attitude, expectations, and issues

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Lean Principle 1: Value

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3. **Frequently Involve the Customer**
   1. **Everyone involved in the program must have a customer-first spirit[1]**
   2. **Establish frequent and effective interaction with internal and external customers**
   3. **Pursue an architecture that captures customer requirements clearly and can be adaptive to changes**
   4. **Establish a plan that delineates the artifacts and interactions that provide the best means for drawing out customer requirements.**

Lean Principle 2: Map the Value Stream (Plan the Program)

1. Plan the Program according to the INCOSE Handbook Process. In addition:

Lean Principle 2: Map the Value Stream (Plan the Program)

2.   Map the SE and PD Value Streams and Eliminate Non-Value Added Elements

1. Develop and execute clear communication plan that covers entire value stream and stakeholders
2. Have cross functional stakeholders work together to build the agreed value stream
3. Create a plan where both Systems Engineering and other Product Development activities are appropriately integrated
4. Maximize co-location opportunities for SE and PD[1] planning
5. Use formal value stream mapping methods to identify and eliminate SE and PD1 waste, and to tailor and scale tasks
6. Scrutinize every step to ensure it adds value, and plan nothing because "it has always been done"
7. Carefully plan for precedence of both SE and PD1 tasks (which task to feed what other tasks) with what data and when), understanding task dependencies and parent-child relationships
8. Maximize concurrency of SE and other PD Tasks
9. Synchronize work flow activities using scheduling across functions, and even more detailed scheduling within functions
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
11. Plan for level workflow and with precision to enable schedule adherence and drive out arrival time variation
12. Plan below full capacity to enable flow of work without accumulation of variability[2], and permit scheduling flexibility in work loading, i.e., have appropriate contingencies and schedule buffers.
13. Plan to use visual methods wherever possible to communicate schedules, workloads, changes to customer requirements, etc.

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[1] SE is a part of PD. In this paragraph, the PD should be understood as denoting all PD activities   other than SE, including design, development, manufacturing, integration, testing, etc.)

[2] Queuing theory proves that the flow approaching 100% of capacity always slows down asymptotically due to the accumulation of variability, even in the absence of any bottlenecks (e.g., automobile traffic)

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**Lean Principle 2: Map the Value Stream
(Plan the Program)**

3. Plan for Front-Loading the Program

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 [1]**

2. **Explore trade space and margins fully before focusing on a point design and too small margins.**

3. **Anticipate and plan to resolve as many downstream issues and risks as early as possible to prevent downstream problems**

4. **Plan early for consistent robustness and "first time right" under "normal" circumstances instead of hero-behavior in later "crisis" situations.**

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**Lean Principle 2: Map the Value Stream
(Plan the Program)**

4. Plan to Develop Only What Needs Developing [Leopold]

1. **Promote reuse and sharing of program assets: Utilize platforms, standards, busses, and modules of knowledge, hardware and software**

2. **Insist that a module proposed for use is robust before using it**

3. **Remove show-stopping research/unproven technology from critical path, staff with experts, and include it in the Risk Mitigation Plan**

4. **Defer unproven technology to future technology development efforts, or future systems**

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.**

Lean Principle 2: Map the Value Stream
(Plan the Program)

5. **Plan to Prevent Potential Conflicts with Suppliers**
   1. Select suppliers who are technically and culturally compatible
   2. Strive to develop seamless partnership between suppliers and the product development team
   3. Plan to include and manage the major suppliers as a part of your team
   4. Have the suppliers brief the design team on current and future capabilities during conceptual formation of the project.

6. **Plan Leading Indicators and Metrics to Manage the Program**
   1. Use leading indicators to enable action before waste occurs
   2. Focus metrics around customer value, not profits
   3. Use only few simple and easy to understand metrics and share them frequently throughout the enterprise
   4. Use metrics structured to motivate the right behavior
   5. Use only those metrics that meet a stated need or objective.

Lean Principle 3: Flow

1. **Execute the Program according to the INCOSE Handbook Process. In addition:**

2. **Clarify, Derive, Prioritize Requirements Early and Often During Execution**
   1. Since formal written requirements are rarely enough, allow for follow up verbal clarification of context and need, without allowing requirements creep
   2. Create effective channels for clarification of requirements (possibly involve customer participation in development IPTs)
   3. Listen for and capture unspoken customer requirements
   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
   5. "Fail early - fail often" through rapid learning techniques (prototyping, tests, digital preassembly, spiral development, models, and simulation)
   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.

Lean Principle 3: Flow

3. **Front Load Architectural Design and Implementation**
    1. Explore multiple concepts, architectures and designs early
    2. Explore constraints and perform real trades before converging on a point design
    3. Use a clear architectural description of the agreed solution to plan a coherent program, engineering and commercial structures
    4. All other things being equal, select the simplest solution[1]
    5. Invite suppliers to make a serious contribution to SE, design and development as program trusted partner

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   [1] "Any fool can make anything complex but it takes a genius and courage to create a simple solution" - Albert Einstein

Lean Principle 3: Flow

4. **Systems Engineers to accept Responsibility for coordination of PD Activities**
    1. Promote maximum seamless teaming of SE and other PD engineers
    2. SE to regard all other engineers as their partners and internal customers, and vice-versa
    3. Maintain team continuity between phases to maximize experiential learning
    4. Plan for maximum continuity of Systems Engineering staff during the Program

Lean Principle 3: Flow

5. Use Efficient and Effective Communication and Coordination

1. Capture and absorb lessons learned from almost all programs: "never enough coordination and communication"
2. Maximize coordination of effort and flow (one of the main responsibilities of Lean SE)
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
4. Use frequent, timely, open and honest communication
5. Promote direct informal communications immediately as needed
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
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
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
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)

Lean Principle 3: Flow

6. Promote Smooth SE Flow

1. Use formal frequent comprehensive integrative events in addition to programmatic reviews
   a. Question everything with multiple "whys"
   b. Align process flow to decision flow
   c. Resolve all issues as they occur in frequent integrative events
   d. Discuss tradeoffs and options
2. Be willing to challenge the customer's assumptions on technical and meritocratic grounds, and to maximize program stability, relying on technical expertise
3. Minimize handoffs to avoid rework
4. Optimize human resources when allocating VA and RNVA tasks[1]
   a. Use engineers to do VA engineering
   b. When engineers are not absolutely required, use non-engineers to do RNVA (administration, project management, costing, metrics, program, etc.)
5. Ensure the use of the same measurement standards and data base commonality
6. Ensure that both data deliverers and receivers understand the mutual needs and expectations

[1] VA = value added, RNVA = Required non value added

Lean Principle 3: Flow

7. Make Program Progress Visible to All

1. Make work progress visible and easy to understand to all, including external customer
2. Utilize Visual Controls in public spaces for best visibility (avoid computer screens)
3. Develop a system making imperfections and delays visible to all
4. Use traffic light system (green, yellow, red) to report task status visually (good, warning, critical) and make certain problems are not concealed.

8. Use Lean Tools

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.
2. Use minimum number of tools and make common wherever possible
3. Minimize the number of the software revision updates and centrally control the update releases to prevent information churning
4. Adapt the technology to fit the people and process
5. Avoid excessively complex "monument" tools

Lean Principle 4: Pull

1. Tailor for a given program according to the INCOSE Handbook Process. In addition:

2. Pull Tasks and Outputs Based on Need, and Reject Others as Waste
    1. Let information needs pull the necessary work activities.
    2. Promote the culture in which engineers pull knowledge as they need it and limit the supply of information to only genuine users
    3. Understand the Value Stream Flow
    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
    5. Stay connected to the internal customer during the task execution
    6. Avoid rework by coordinating task requirements with internal customer for every non-routine task
    7. Promote effective real time direct communication between each Giver and Receiver in the value flow
    8. Develop Giver-Receiver relationships based on mutual trust and respect
    9. When pulling work, use customer value to separate value added from waste

Lean Principle 5: Perfection

1. **Pursue Continuous Improvement according to the INCOSE Handbook Process. In addition:**

2. **Strive for Excellence of SE Processes**
    1. **Do not ignore the basics of Quality:**
        a. Build in robust quality at each step of the process, and resolve and do not pass along problems.
        b. Strive for perfection in each process step without introducing waste
        c. Do not rely on final inspection; error proof wherever possible
        d. If final inspection is required by contract, perfect upstream processes pursuing 100% inspection pass rate
        e. Move final inspectors upstream to take the role of quality mentors
        f. Apply basic PDCA method (plan, do, check, act) to problem solving
        g. Adopt and promote a culture of stopping and permanently fixing a problem as soon as it becomes apparent.
    2. Promote excellence under "normal" circumstances instead of hero-behavior in "crisis" situations
    3. Use and communicate failures as opportunities for learning emphasizing process and not people problems
    4. Treat any imperfection as opportunity for immediate improvement and lesson to be learned, and practice frequent reviews of lessons learned
    5. Maintain a consistent disciplined approach to engineering
    6. Promote the idea that the system should incorporate continuous improvement in the organizational culture, but also...
    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 overprocessing waste)
    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

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Lean Principle 5: Perfection

3. **Use Lessons Learned from Past Programs for Future Programs**

    1. **Maximize opportunities to make each next program better then the last**

    2. **Create mechanisms to capture, communicate, and apply experience-generated learning and checklists**

    3. **Insist on workforce training of root cause and appropriate corrective action**

    4. **Identify best practices through benchmarking and professional literature**

    5. **Share metrics of supplier performance back to them so they can improve**

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Lean Principle 5: Perfection

4. **Develop Perfect Communication, Coordination and Collaboration Policy across People and Processes**
    1. Develop a plan and train the entire program team in communications and coordination methods at the program beginning
    2. Include communication competence among the desired skills during hiring
    3. Promote good coordination and communications skills with training and mentoring
    4. Publish instructions for e-mail distributions and electronic communications.
    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
    6. Publish a directory of the entire program team and provide training to new hires on how to locate the needed nodes of knowledge
    7. Ensure timely and efficient access to centralized data.
    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.

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Lean Principle 5: Perfection

5. **For Every Program Use a Chief Engineer Role[1] to Lead and Integrate Development from Start to Finish**
    1. The Chief Engineer role to be Responsible, with Authority and Accountability for the program technical success
    2. Have the Chief Engineer role lead both the product and people integration
    3. Have the Chief Engineer role lead through personal influence, technical know how, and authority over product development decisions
    4. Groom an exceptional Chief Engineer role with the skills to lead the development, the people, and assure program success
    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.

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[1] A frequent practice in recent U.S. governmental programs is to have two program managers: the "Program Manager" responsible for the program business success, and "Chief Systems Engineer" responsible for Systems Engineering. Numerous functional engineers are responsible for various technical areas. In some programs this causes split responsibilities, authorities and accountabilities, often with imperfect results. In contrast, many U.S. and overseas commercial programs use only one person fully responsible for the entire program success (both technical and business). The person is called by various names, e.g. Chief Engineer (very successful Toyota model, see Morgan and Liker's *Toyota Product Development System),* Product Manager, Product Engineer, or similar. Early U.S. aerospace programs also used extremely successful single-person "Chief Engineer" role (e.g., early Jack Northrop, Howard Hughes, Kelly Johnson of the Skunk Works, early NASA space programs, and others). Murman (*Lean Aerospace Engineering,* AIAA 092407, 2007) discusses some more recent successful programs with a single top manager in the dual technical and business leadership role. Since this document is intended for INCOSE Handbook, dealing with the scope of Systems Engineering rather than entire program management, the editors have addressed only the technical role of the Chief Engineer, saying nothing whether that person should also be the overall manager of the program, or share the management with a separate business manager person. However, nothing in this document should be taken as promoting the dual-head model. The dual-head model is not required under the U.S. government acquisition policies, and is not promoted in the INCOSE Handbook version 3.1.

Lean Principle 5: Perfection

6. **Drive out Waste through Design Standardization, Process Standardization, and Skill-Set Standardization [Morgan & Liker]**

    1. Promote design standardization with engineering checklists, standard architecture, modularization, busses, and platforms
    2. Promote process standardization in development, management, and manufacturing
    3. Promote standardized skill sets with careful training and mentoring, rotations, strategic assignments, and assessments of competencies[1]

Lean Principle 5: Perfection

7. **Promote All Three Complementary Continuous Improvement Methods to Draw Best Energy and Creativity from All Employees**

    1. Utilize and reward bottom up suggestions for solving employee-level problems
    2. Use quick response small Kaizen teams comprised of problem stakeholders for local problems and development of standards
    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.

Lean Principle 6: Respect for People

1. **Pursue People Management according to the INCOSE Handbook Process. In addition:**

2. **Build an Organization Based on Respect for People**
    1. Create a vision which draws and inspires the best people [2]
    2. Invest in people selection and development to promote enterprise and program excellence
    3. Promote excellent human relations: trust, respect, empowerment, teamwork, stability, motivation, drive for excellence
    4. Read applicant's resume carefully for both technical and non-technical skills, and do not allow mindless computer scanning for keywords
    5. Promote direct human communication
    6. Promote and honor technical meritocracy
    7. Reward based upon team performance, and include teaming ability among the criteria for hiring and promotion
    8. Use flow down of Responsibility, Authority and Accountability (RAA) to make decisions at lowest appropriate level
    9. Eliminate fear and promote conflict resolution at the lowest level
    10. Keep management decisions crystal clear but also promote and reward the bottom-up culture of continuous improvement and human creativity and entrepreneurship
    11. Do not manage from cubicle; go to the spot and see for yourself
    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"
    13. Build a culture of mutual support (there is no shame in asking for help)
    14. Prefer physical team co-location to the virtual co-location

Lean Principle 6: Respect for People

3. **Expect and Support Engineers to Strive for Technical Excellence**
    1. **Establish and support Communities of Practice**
    2. **Invest in Workforce Development**
    3. **Assure tailored lean training for all employees**
    4. **Give leaders at all levels in-depth lean training**

Lean Principle 6: Respect for People

4. **Nurture a Learning Environment**
    1. Perpetuate technical excellence through mentoring, training, continuing education, and other means
    2. Promote and reward continuous learning through education and experiential learning
    3. Provide knowledge experts as resources and for mentoring
    4. Pursue the most powerful competitive weapon: the ability to learn rapidly and continuously improve.
    5. Value people for the skills they contribute to the program with mutual respect and appreciation
    6. Capture learning to stabilize the program when people change
    7. Develop Standards paying attention to human factors, including reading and perception abilities
    8. Immediately organize a quick training in any new standard

5. **Treat People as Most Valued Assets, not as Commodities**

Linkage of Lean Enablers to Technical Processes

LEAN ENABLERS **+**

TBD

A mapping of the Lean Enablers to the existing practices in the INCOSE Handbook.

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References

- **Morgan, M. James and Liker, Jeffrey, K.,** *Toyota Product Development System,* **2006, Productivity Press**
- **Leopold, Ray,** *Iridium,* **MIT Minta Martin Annual Lecture, 2004**
- **Murman, Earll,** *Lean Aerospace Engineering***, AIAA 092407, 2007**
- **Oppenheim, Bohdan,** *Lean Product Development Flow***, JSE, Vol.7, No.4, 2004**
- **Numerous other useful references are listed in the above papers/books.**

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Credits for the Work on Lean Enablers

Beta version was developed from Oct 07-Jan 08 by the INCOSE Lean SE WG Core Team:

- **Earll Murman*, MIT, Core Team Co-lead**
- **Col. Jim Horejsi, SMC**
- **Mike Schavietello, Boeing**
- **Jim Zimmer, Toyota**
- **Larry Earnest, NGIS**
- **Deb Secor, Rockwell Collins**
- **Ray Jorgensen, Rockwell Collins**
- **Bo Oppenheim*, LMU, Core Team Co-lead**
    * Prepared Alpha and Beta versions
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