

LEAN SYSTEMS ENGINEERING

The Need: Systems engineering is an established practice capable of delivering technically complex systems, but not always delivered effectively. Recent studies have identified a significant amount of waste in government programs - sometimes reaching 70 percent or more of charged time. This waste represents a vast productivity reserve and offers major opportunities to improve program efficiency.

Lean Thinking to the Rescue: Lean Thinking is credited for the extraordinary success of Toyota. It is the dynamic, knowledge-driven, and customer-focused process through which all people in a defined enterprise are aligned to continuously eliminate waste with the goal of creating value.

Three concepts are fundamental to the understanding of Lean Thinking: 1) Value, 2) Waste, and 3) the process of creating value without waste, (known as the six Lean Principles).

Lean Systems Engineering (LSE) is the application of Lean Thinking to systems engineering, with the goal to deliver the best life-cycle value for technically complex systems with minimal waste.

LSE does not mean *less SE*. It means better systems engineering with higher responsibility, authority, and accountability, leading to better, waste-free workflow with increased mission assurance. Under the LSE philosophy, mission assurance is non-negotiable, and any task which is legitimately required for success must be included; but it should be well-planned, prepared and coordinated, and executed with minimal waste.

Fundamentals of Lean Thinking:

1) Value

Value is a measure of worth of a specific product or service by a customer, and potentially other stakeholders and is a function of (1) the product's usefulness in satisfying a customer need, (2) the relative importance of the need being satisfied, (3) the availability of the product relative to when it is needed, and (4) the cost of ownership to the customer.

In LSE, Value is defined as mission assurance (the delivery of a flawless complex system, with flawless technical performance, during the product or mission development life cycle), satisfying the customer and all other stakeholders, which implies completion with minimal waste, minimal cost, and the shortest possible schedule. In early lifecycle phases, value is created by reducing uncertainty, building a stakeholder consensus, and providing clear evidence to support good and timely decisions.



2) Waste: The work element that adds no value to the product or service in the eyes of the customer. Waste only adds cost and time. Waste is classified into seven categories. The following illustrates examples of waste in common systems engineering practice, in the order of decreasing occurrence in programs.

- 1. Waiting:** Waiting for material or information, or information or material waiting to be processed, e.g.,
 - Late delivery of material or information
 - Excessively serial tasking-not enough concurrency
 - Waiting for approvals
- 2. Over-Processing:** Processing more than necessary to produce the desired output
 - Too many hands on the "stuff"
 - Excessive/ custom formatting or reformatting
 - Excessive refinement, beyond what is needed for Value
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- 3. Transportation:** Moving material or information
 - Unnecessary hand-offs between people
 - Communication failures
- 4. Inventory:** Maintaining more material or information than you need
 - Too much "stuff" stockpiled on desks or in storage
 - Complicated retrieval of needed "stuff"
 - Outdated, obsolete information
- 5. Defects:** Errors, mistakes and lack of communication causing the effort to be redone to correct the problem
 - Item delivered different from the item needed
 - Incorrect information
- 6. Over-Production:** Creating too much material or information
 - Creating unnecessary data and information
 - Information over-dissemination (e.g., emails)
- 7. Unnecessary Movement:** People moving to access or process material or information
 - Lack of direct access
 - Time spent finding what you need
 - Manual intervention

3) **Lean Principles:** (creating value without waste)

1. **The customer defines value.** The value proposition must be captured with crystal clarity early in the program, (applies to both external and internal customers)
2. **Map the value stream.** Prepare for and plan all end-to-end linked activities necessary to realize value, streamlined, after eliminating waste, using the best decision-making processes
3. **Make value flow continuously along the value stream.** This should happen without stopping, rework, or backflow (legitimate optimized iterations are okay).
4. **Let customers pull value.** The customer's *pull/need* defines all tasks and their timing, (internal or external)
5. **Pursue perfection.** Constantly improve your processes, and make all imperfections visible to all, which is motivating to the continuous improvement.
6. **Respect for people.** Create a system of mutually respectful, trusting, honest, cooperating, and synergistic relationships of key stakeholders, motivating staff to exhibit top capabilities.

LSE Working Group of INCOSE: initiated in 2006, the Working Group has grown to 113 members (as of Sept. 25, 2009). **All are invited.**
The web page:
www.incose.org/practice/techactivities/wg/leansewg/
includes our Charter, leadership & contacts, major products, definitions, recommended readings, and meeting announcements.

LEAN ENABLERS FOR SYSTEMS ENGINEERING

In 2009, the Lean SE Working Group released a major online product named Lean Enablers for Systems Engineering (LEfSE) (see the LSE WG webpage). It is a list of 194 practices and recommendations formulated as “dos” and “don’ts” of SE based on Lean Thinking. They have been collected from most successful industrial practices and from the wisdom and experience of the 14 Lean and SE experts working on the project. The practices cover a large spectrum of SE and other relevant enterprise management practices. Every practice will improve program value and stakeholder satisfaction, and reduce waste, delays, cost overruns, and frustrations.

LEfSE are grouped into the six Lean Principles:

- Under the **Value Principle**, the enablers promote a robust process of establishing the value of the end-product or system to the customer with crystal clarity. The process should be customer-focused, and aligning the enterprise employees accordingly.
- The enablers under the **Value Stream Principle** emphasize waste-preventing measures, solid preparation of the personnel and processes for subsequent efficient workflow; detailed program planning; frontloading; best decision making processes, and use of leading indicators and quality metrics.
- The **Flow Principle** lists the enablers which promote the uninterrupted flow of robust quality work and first-time right; steady competence instead of hero behavior in crises; excellent communication and coordination; concurrency; frequent clarification of the requirements; and making program progress visible to all.
- The enablers listed under the **Pull Principle** are a powerful guard against the waste of rework and overproduction. They promote pulling tasks and

outputs based on need and rejecting others as waste.

- The **Perfection Principle** promotes excellence in the SE and enterprise processes; the use of the wealth of lessons learned from previous programs in the current program; the development of perfect collaboration policy across people and processes; and driving out waste through standardization and continuous improvement. A category of these enablers calls for a more important role of systems engineers, with responsibility, accountability and authority for the overall technical success of the program.
- Finally, the **Respect-for-People Principle** contains enablers that promote the enterprise culture of trust, openness, respect, empowerment, cooperation, teamwork, synergy, good communication and coordination; and enable people for excellence.

Major publications about LSE and Lean Enablers:

1. *Lean Enablers for Systems Engineering*, B. W. Oppenheim, CrossTalk Defense Journal, July-Aug.2009
2. *Lean Enablers for Systems Engineering*, B. W. Oppenheim, E. Murman and D. Secor, Journal of SE (submitted in 2009)

All INCOSE members are welcome to join the LSE WG. **Contact:** The names and emails of the current Co-Chairs are listed at:

www.incose.org/practice/techactivities/wg/leansewg/

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