Application of Lean Process To Software Engineering via Value-Stream Mapping

13th Annual NDIA Systems Engineering Conference – Oct 2010

Prepared by:
Shawn Rahmani, Lew Nelson, and Tom Treffner
Boeing Defense, Space & Security
Huntington Beach, California

Agenda

- VSM introduction and process
- Workshop charter
- Process flow development
- High-level VSM implementation process
- VSM workshop results and lessons learned
- Summary

Definition

- **Value stream mapping is a technique used to identify and strip wasteful steps out of a company's flow of information and materials. The end goal of the technique is to make the company "lean," meaning free of wasted effort. Toyota is generally given credit for the development of lean production techniques, which have been adapted and added to by succeeding generations of managers and consultants .**

VSM – Process Example

- **When we talk about process, we mean every step that occurs from the supply chain to the point where the customer receives the finished product. For example, value stream mapping for a paper mill might begin at the receipt of raw materials, such as wood and chemicals, and end at the shipment of finished, packaged paper products. Note that lean techniques such as value stream mapping may be applied to any segment of the larger process. More often than not, companies divide their process into discrete sections, allowing several teams of experts to apply lean techniques simultaneously.**

VSM – Value and Waste

- **Value is adding to the product something which the customer wants or needs. Returning to the paper mill example, value steps are those that give the paper the desired dimensions, color, composition, etc. Waste, on the other hand, is any step that does not add value. The most commonly cited forms of waste are movement of the product, equipment or employees unnecessarily; maintaining an inventory of raw materials or products waiting to be worked upon; making more parts or products than there is customer demand for; processing a component more than the customer actually needs or expects; quality checks; or the subsequent reprocessing of defects.**

VSM General Process

- **First pass - Understand the Current State**
- Train your Value Stream Mapping team
- Physically walk the path of the thing being processed -
  documenting process steps
- Create your As Is value stream map – **Current State**
- Choose the metrics you want to measure

- Enter your data
  (start with your most common scenario)
- Set preliminary improvement goals (e.g., cycle time reduction by > 10%)

VSM General Process

- **Second Pass - Analyze and Reflect**
- Analyze and gain consensus for your value stream analysis
- Identify problems and root causes
- Reflect, ponder, and think...

VSM General Process

- **Third Pass – Improve – Set/update improvement goal**
- It is common to improve your value stream in phases:
  - Meet customer demand (immediately)
  - Organize for continuous flow
  - Level the work flow
- For each phase, create a Value Stream Plan, with specific assignments and deadlines
- Each "next phase" should have a timeline of no more than six months to have everything on that Value Stream Plan completely implemented.
- **Continuously Improve**
- Add data for multiple scenarios

Steps to Analyze a Current State Value Stream Map

Look for Typical Types of Waste

1. **Excessive hand-offs**
2. **Review cycles (lengthy/ multiple)**
3. **Product sitting in long queues**
4. **Series steps that could be performed in parallel**
5. **Built-in rework loops**
6. **Product moving to pre-defined schedules**
7. **Excessive Inventory**
8. **Products being pushed throughout system**
9. **Observed cycle times not captured (missing/ estimated)**
10. **Multiple (or no) info-arrows going into process boxes (Unclear communication of requirements)**
11. **Cycle time imbalance (between processes)**
12. **Lack of continuous flow – decoupled processes**
13. **Unnecessary movement of product via crane/ forklift/ etc.**
14. **Lots of shared resources (less than 100% utilization/ availability)**
15. **Defects/ rework loops**

VSM Workshop Charter

- **Title:** Lean/VSM Assessment Workshop for Software Engineering Process
- **Mission Statement:** Perform an initial lean assessment of SW Eng process using Value Stream Mapping. Main objective is to reduce the Cycle Time.
- **Duration**: Preparation, 3 day workshop, post workshop tasks

Deliverables:

- Future state of SW process (flow diagram) based on lean/VSM assessment
- Prioritized list of opportunities for SW process cycle time reduction

Development of Product Flow Timing Diagram (Current State)

- A hypothetical (typical) program was defined for high-level VSM assessment
- Assumptions: size of 500 KSLOC, mission critical, C2 application, with nominal complexity, resources, etc.
- Existing process data flow was converted to a product flow for timing allocation
- % of Development Cycle-Time/Effort was estimated for each activity

High-level VSM Process -1 of 3

- With focus on VSM objectives, examined the products of Software Requirements activity with respect to Value Added (VA) / Non-value Added (NVA)/NVA but Necessary
  - Was difficult to identify NVA at total top process level
- Examined high level process steps identified for Requirements and Integration & Test activities
  - Attempt to identify VA/NVA did not work – similar to the above
  - Attempt to correlate "Typical Wastes" to the high level process steps resulted in no additional useful information
- Concluded VSM assessment of top level SW Eng Development Cycle not practical and feasible within given schedule

High-Level VSM Process -2 of 3

- Noted that there was value and waste in all activities/sub-processes, when viewed at a high level, but difficult to measure them from cycle time viewpoint
- Decided to focus on <u>one</u> sub-process from Product Flow Diagram for entire SW Eng Dev Cycle
- Used 4 methods/viewpoints to select sub-process for VSM assessment
  - Independent review and program High Impact Areas
  - Product Flow Diagram
  - Program Defect Data (# defects and hours spent to fix them)
  - Critical Path assessment
- Selected “SW Requirement Development” sub-process for VSM assessment

Independent Review and Program High Productivity Impact Findings Per Life Cycle Category

Independent Review & Interview Summary				
Category	IR/NAR		Proj	
General	10	15%	7	9%
Reqs	15	23%	11	14%
Arch	7	10%	9	12%
Design	2	4%	5	7%
Code&UT	0	0%	6	8%
Integ	5	8%	5	7%
Prog_Mgmt	6	9%	3	4%
Prototype	4	5%	6	8%
SW_Processes	3	5%	6	8%
Sub_Mgmt	1	2%	1	1%
Tools&Env	1	2%	5	7%
Training	3	5%	4	5%
Metrics	3	5%	4	5%
SE_I/F	6	9%	4	5%
	65		76	

Summary Sub-Process Selection Methods for VSM Assessment (H-M-L Potential Lean Impact Level)

	IR/ Interviews	Proj Defect Contain-ment (defect impact)	SEER / Metrics (Parametric Model)	Critical Path Risk/ Impact (team consensus)
Reqs	H	H	L-M	H
Code&UT	M	H	M	M
Integ/Test	M-H	M	H	H

Estimated % of Development Cycle-Time/Effort for General SW Eng Process (notional data)

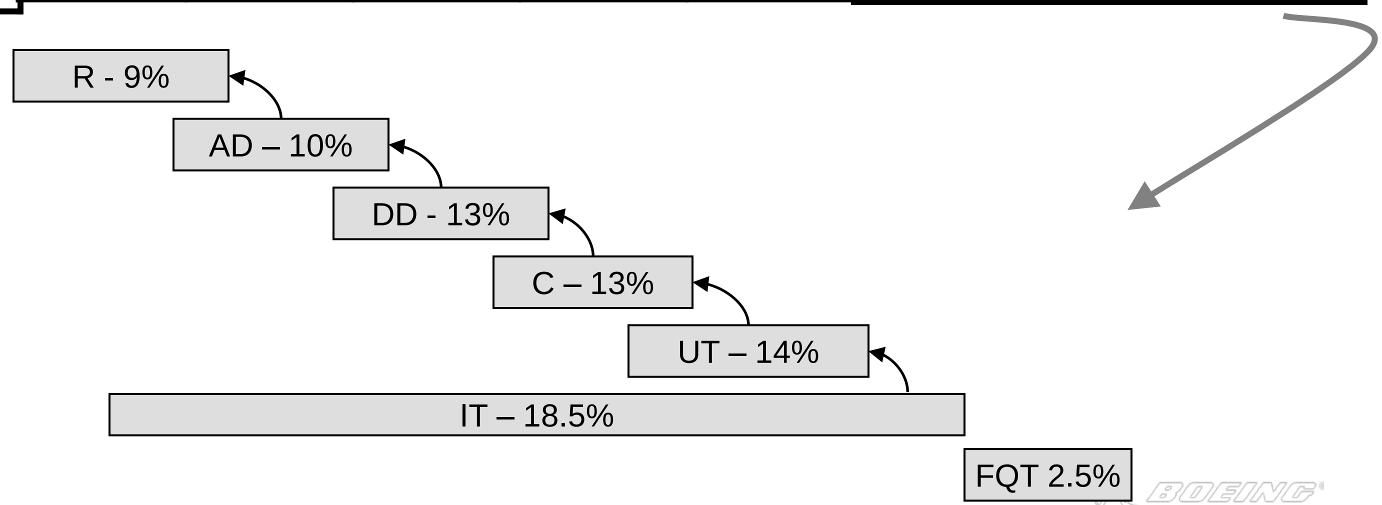
- **Lifecycle % Effort**

QA – 4	Subtotal 20
Env & Tool Acq – 4	
CM – 4	
Planning – 8	

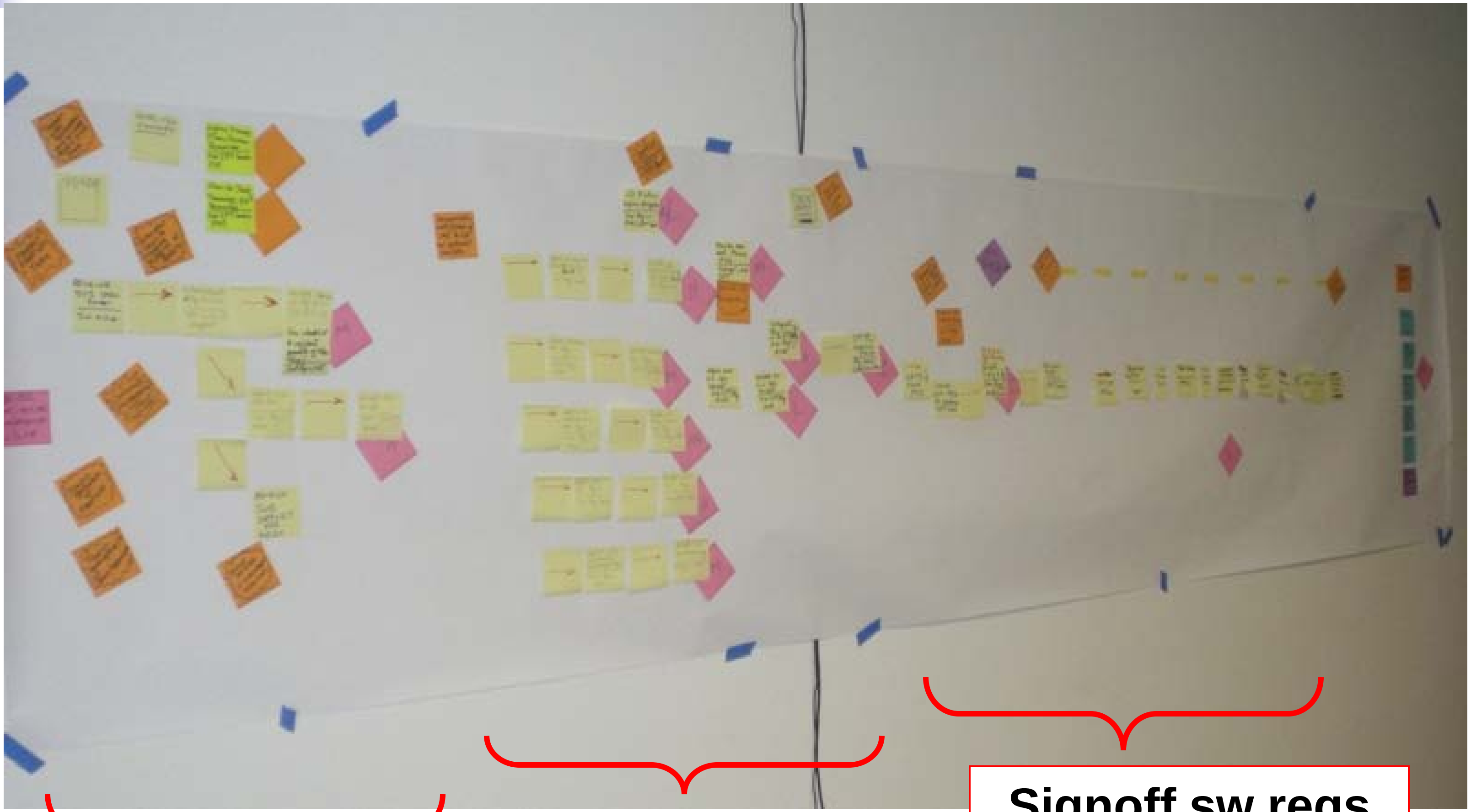
Methods

	R	AD	DD	C	UT	IT	FQT	Subtotal
SEER (1 CI)	5.9	9.3	11.3	20.5	20.5	5.1	5.4	80
SEER (>1 CI)	7.3	8.8	14.6	13.6	13.6	17.8	2.3	80
Internal	10.5	8.8	12.0	11.6	13.6	17.1	2.4	80
Consolidated	***9***	***10***	***13***	***13***	***14***	***18.5***	***2.5***	*80*

- **Lifecycle Phases**



VSM Wall-Chart
SW Requirements Development



Receive & validate reqs allocation to sw, from Sys Eng

Derive, validate & complete sw reqs package

Signoff sw reqs package & deliver

Workshop Findings – Results -1

- VSM workshop was pathfinder analysis of end-to-end SW Eng process that led to focus on SW Requirements Dev sub-process for trial analysis
- Developed a prioritized list of 13 improvement opportunities for “SW Requirements Dev” lean improvements
- Assessment could not quantitatively determine cycle time savings and initial yield improvements due to lack of sufficient data
  - Could identify opportunities using “qualitative VSM” analysis
  - Identified qualitative measures for cycle time savings and initial yield improvements

Workshop Findings – Results -2

- Assessment of one sub-process took 1.5 days to perform “qualitative VSM”, not including creation of future-state map
  - Only worked on one of sub-processes
- Limited use of defect containment data from projects (to reduce waste)
  - Project unique variations

Workshop Lessons Learned -1

- Could not do a real quantitative VSM on a high-level process
  - Few applicable cases or lessons learned from other "qualitative VSM" assessments of general and high level engineering processes
  - Waste and value added items are mixed in most cases, but difficult to quantify without using actual data
- Complete SW lifecycle qualitative VSM assessment needs significant time (i.e., much greater than one week of workshop)

Workshop Lessons Learned -2

- Continuous presence and involvement of core team during VSM workshop is key, i.e. no part-timers
- Typical SW Eng process does not represent product flow and dynamics of using the process
  - Simulated process tool/model (process conops) driven by program selectable assumptions and constraints are needed
- Defect containment metric is an excellent way to assess process (e.g., waste/value) if consistent and correct data is available

Lean/VSM Identified Opportunities

VSM Rank	Lean / VSM Opportunity
1	Continuous collaboration with customers (internal and external) and end users
2	Formation and use of a team to facilitate use of Project Startup Kit deployment
3	Timely availability of tools/training – ready to go when needed by project
4	Improvement in collaboration of system & sw eng in the areas of system & sw requirements & architectures
5	Define and implement integration mechanisms to accommodate multiple lifecycles within a project as applied to requirements
6	Timely readiness of staffing (role/proficiency registry)
7	Ensure implementation of process for checking (checklist), validating and measuring completeness, maturity, consistency, correctness, quality of reqs
8	Improve budget/WBS allocation to focus on work products and their cycle time reduction
9	Sign-off & release cycle process is too lengthy
10	Active sw eng involvement in subcontract activities
11	Use of automated tools to improve clarity of reqs text
12	Customer review package e.g. SW Requirements Rev
13	Requirements repository

Summary

- Quantitative VSM requires program specific data, focused on repeated activities (e.g., SARs)
- Was difficult to apply (quantitative) VSM method to general SW Eng process via identifying VA/NVA in and looking for “Typical Wastes”
- Qualitative VSM method, as a good compromise, was applied to Software Requirements activity with respect to VA/NVA/NVA but Necessary
- Approach identified lean/VSM driven opportunities and recommendations
- Even with qualitative VSM, program specific defect containment data is key for lean applications (e.g., reduction of waste)

Backup Information

Abstract

- With the increasing role of software in the complex DoD systems, the application of Lean principles and practices for rapid development of software systems has become a priority focus area within the DoD community. Value Stream Mapping (VSM) is a Lean method that has been successfully applied to a large number of manufacturing and production processes worldwide. The main emphasis of the VSM method is to reduce the process cycle time.
- This presentation describes the VSM method and its implementation approach for software engineering (a similar approach can be used on other engineering disciplines). It describes how a quantitative model of the conventional software engineering was selected, and how a sub-set, Software Requirements Engineering, was selected for the VSM application. It then covers the systematic approach and logical path for tailoring the VSM process, including the role of the software engineers and the internal and external customers. Multiple viewpoint methods were used for conducting the VSM methods. The presentation describes the results of

  the VSM task, lessons learned and recommendations.

Six Sigma

- Six sigma is a set of methodologies used by businesses to achieve extremely low failure rates in any process. The term *six sigma* derives from the mathematical use of sigma in statistics as a standard deviation. Six sigma is therefore six standard deviations.
- In theory, a six sigma would be approximately two failures per billion attempts. In practice, due to a drift of plus or minus 1.5, six sigma status means less than 3.4 failures per million. This is an extremely low rate of failure, but has been proven possible in industry after industry over the past twenty years.

Lean Six Sigma

- Lean Six Sigma, also known as Lean Sigma, is a marriage of two otherwise distinct business management strategies, lean manufacturing and Motorola's Six Sigma system. While the lean manufacturing methodology concentrates on creating more value with less work, the Six Sigma system strives to identify and eliminate defects in product development. Thus, Lean Six Sigma provides a method to accelerate a company's decision-making processes, while both reducing production inefficiencies as well as increasing product quality.

Author's Bio

- Dr. Shawn Rahmani is a Senior Technical Fellow at the Boeing Defense, Space and Security Unit, Network and Tactical Systems Division, in Huntington Beach, California. He leads the Systems and Software Development and Integration Core Technology activities for Boeing, including technology roadmap and plan development, and their implementation. He is a member of the NDIA Software Industry Experts Panel. Shawn received the Exceptional Public Service Medal from the head of NASA for his technical contributions on the space programs. He has a Ph.D. in Electrical Engineering from the Ohio State University.