Software Design-for-Six Sigma (SDFSS) and SEI Technologies meet!

By Robert W. Stoddard
Motorola Six Sigma Master Black Belt
Senior Member of Technical Staff
Software Engineering Institute
This material is approved for public release.

Sponsored by the U.S. Department of Defense
© 2005 by Carnegie Mellon University
# Software Design-for-Six Sigma (SDFSS) and SEI Technologies meet!

**Report Title:**
Software Design-for-Six Sigma (SDFSS) and SEI Technologies meet!

**Abstract:**

**Security Classification:**
- a. Report: unclassified
- b. Abstract: unclassified
- c. This Page: unclassified

**Limitation of Abstract:**
Same as Report (SAR)

**Number of Pages:**
36
CMU Service Marks

The following are service marks of Carnegie Mellon University:

- Personal Software Process℠
- PSP℠
- Team Software Process℠
- TSP℠

The following are registered in the U.S. Patent & Trademark Office by Carnegie Mellon University:

- Capability Maturity Model®
- CMM®
- Capability Maturity Model Integration®
- CMMI®
- SEI’s Architecture Tradeoff Analysis Method®
- ATAM®
Product Experience
SDFSS Opportunities

Impacts without SDFSS

• Multi-year development projects failed to deliver a working product (min cost=$7M)

• Failure 1: Did not model performance of new chipset, processor or language

• Failure 2: Did not adequately characterize the market and business case

• Failure 3: Did not adequately test the product

Benefits with SDFSS

• Business cases modeling all reasonable uncertainties in market and customer segments

• Schedules with uncertainties modeled

• Req’ts identified, with KJ analysis, to delight customers

• Design of Experiments used to: optimize and patent fuel efficiency; test object-oriented software; test robustness with fault insertion testing; reduce flight test by 10x
Purpose of this Talk

• To proclaim that software DFSS, within a holistic DFSS approach to product development, is coming of age,

• To demonstrate that many gaps, in translating traditional DFSS concepts to software engineering, may be solved by the adoption of a number of Software Engineering Institute (SEI) technologies.

Thus, DFSS does not have to be re-invented for Software Engineering!
Target Audience

• Executives and Directors contemplating investing in Software DFSS

• Deployment champions who may be tasked with the training and roll-out of Software DFSS

• DFSS and Software Engineering Leaders who need to understand both disciplines, and who can lead in translating and interpreting key concepts and tools between the two disciplines.
A Philosophy

From the inception of Six Sigma, the overriding objective has been “the degree of confidence a customer has that his (or her) product and service-related expectations will be met by the producer.”¹

Today, it is “a business process that allows companies to drastically improve their bottom line by designing and monitoring everyday business activities in ways that minimize waste and resources while increasing customer satisfaction.”²

Example Six Sigma Measures

The most-cited measure is “3.4 ppm.”

Other measures

- defect rate, parts per million (ppm)
- Sigma level
- defects per unit (dpu)
- defects per million opportunities (dpmo)
- yield
### Alternative Six Sigma Approaches

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMAIC</td>
<td>Define-Measure-Analyze-Improve-Control</td>
</tr>
<tr>
<td>DMAD(O)V</td>
<td>Define-Measure-Analyze-Design-(Optimize)-Verify</td>
</tr>
<tr>
<td>Lean</td>
<td>5S’s; Value Stream Mapping; Cycle Time Analysis</td>
</tr>
<tr>
<td>DFSS</td>
<td>Design-For-Six-Sigma</td>
</tr>
</tbody>
</table>

- **DMAIC**: To solve problems and drive incremental business improvements (e.g. fine-tuning an existing process or product).
- **DMAD(O)V**: To solve problems and drive radical improvement (e.g. blowing up and re-engineering an existing process or product).
- **Lean**: To lean a process by simplification, reducing non-value added tasks, optimizing cycle times.
- **DFSS**: Applying the Six Sigma toolkit and intent to product development beginning with portfolio, marketing, engineering, research, sales, and supply chain.
Holistic View of Software DFSS

- Portfolio for Six Sigma
- Marketing for Six Sigma
- Product Commercialization for Six Sigma
- Technology Platform R&D for Six Sigma
- Sales & Distribution for Six Sigma
- Supply Chain for Six Sigma
Holistic View of Software DFSS

Using Statistical Methods:
1. Identify Opportunities, Markets and Market Segments,
2. Gather Long Range Voice of the Customer,
3. Obtain Technology Roadmap and Technology Characterizations from the R&D / Platform Group,
4. Define Product Portfolio Requirements,
5. Generate Product Portfolio Architectures,
6. Support Portfolio decisions with Real-Options analysis
7. Evaluate and Select a Product Portfolio, and
8. Develop a Prioritized List of Products within a Product Line Strategy.

* Adapted from Clyde Creveling, *Marketing for Six Sigma and Product Development with Six Sigma*
Holistic View of Software DFSS

Using Statistical Methods:

1. Understand Customer Value and create a Customer Value Dashboard,
2. Develop the Value Stream analysis,
3. Conducting Marketing FMEA risk analysis and Business SWOT,
4. Creating Marketing Process measures and data collection methods,
5. KJ and Kano Analysis,
6. Marketing Composite Design and Product Line Strategies
7. Market Forecasting, Price Model Planning, Channel Analysis,
8. Portfolio Management, Branding Decision-making and Promotion Analysis

* Adapted from Clyde Creveling, *Marketing for Six Sigma and Product Development with Six Sigma*
Using Statistical Methods:

1. Participate in KJ and QFD Voice of the Customer Activities,
2. Develop functional models, architecture and behavioral models,
3. Generate product solution concepts and identify critical parameters for CTQs,
4. Develop mathematical and statistical models of CTQs,
5. Select solution, implement robust design and track Critical Parameters,
6. Create optimized designs using designed experiments,
7. Establish critical parameter tolerances, and verify CTQ achievement.

* Adapted from Clyde Creveling, Marketing for Six Sigma and Product Development with Six Sigma
Holistic View of Software DFSS

Using Statistical Methods:

1. Characterize existing technologies, capabilities, gaps, risks, expected life
2. Identify and evaluate anticipated technology breakthroughs including probabilistic assessment of timing and capability
3. Optimize the portfolio of technologies to be pursued in context of the business strategy and latest product portfolio
4. Develop robust platforms that are optimized for the Customer Req’ts and CTQs of product lines
5. Develop performance models of platform technology and its capabilities
SEI Technologies Boost DFSS!

Portfolio for Six Sigma
Marketing for Six Sigma
Product Commercialization
Technology Platform R&D for Six Sigma
Sales & Distribution for Six Sigma
Supply Chain for Six Sigma

The SEI Capability Maturity Model Integrated (CMMI) has a product development perspective that overlaps significantly with all of the DFSS methodologies!
CMMI & Six Sigma (DFSS) Connections

- Many connections exist, specifically with the following basic process areas:
  - RD, REQM, TS
  - VER, VAL
  - DAR, RSKM, MA

- Connections are further highlighted on the following slides with CMMI High Maturity Process Areas:
  - QPM, OPP
  - CAR, OID
CMMI OPP and Six Sigma

SP1.1 Processes
- Big Y Business Goal-to-Vital x Process;
- Processes driving central tendency and variation

SP1.2 Measures
- Critical Parameter Management; CTQ factors; Root Cause Analysis of subprocess factors

SP1.3 Objectives
- KJ Analysis®; Analytic Hierarchy Process; Categorical Survey Data Analysis; Six Sigma Scorecards

SP1.4 Baselines
- Control Charts; Graphical Summaries in Minitab; Central Tendency and Variation; Confidence and Prediction Intervals

SP1.5 Models
- ANOVA; Regression; Chi-Square; Logistic Regression; Monte Carlo Simulation; Discrete Event Process Simulation; Design of Experiments; Response Surface Methodology; Multiple Y Optimization; Probabilistic Models
CMMI QPM and Six Sigma

SG1
Quantitatively Manage the Project

KJ Analysis®; Analytic Hierarchy Process; Categorical Survey Data Analysis; Six Sigma Scorecards; Big Y Business Goal-to-Vital x Process; Process Mapping Methods and Value-Stream Analysis; Processes driving central tendency and variation; Critical Parameter Management; CTQ factors; Root Cause Analysis of Sub-process factors; Cockpit

SG2
Statistically Manage Subprocess Performance

Control Charts; Graphical Summaries in Minitab; Central Tendency and Variation; Confidence and Prediction Intervals; ANOVA; Regression; Chi-Square; Logistic Regression; Monte Carlo Simulation; Discrete Event Process Simulation; Design of Experiments; Response Surface Methodology; Multiple Y Optimization; Probabilistic Models
CMMI CAR and Six Sigma

SP1.1 Select Defect Data for Analysis

SP1.2 Analyze Causes

SP2.1 Implement the Action Proposals

SP2.2 Evaluate the Effect of Changes

SP2.3 Record Data

Measure Phase tools and methods within DMAIC or DMAD(O)V; Models provide insight to the areas of defect data to concentrate on

Root Cause Methods, e.g. Ishikawa Diagrams, statistical hypothesis tests to determine if segments are different

Piloting; Comparative Studies; Technological and Cultural Change Management techniques

Before and After studies and Hypothesis tests; Survey categorical data analysis; compare to results of prediction models

Study results; Lessons Learned shared across the organization; Institutional learning
CMMI OID and Six Sigma

Six Sigma Big Y to Vital x semi-annual workshops; Business Goal simulation and optimization models; Benchmarking; Capability data sharing; Theory of Inventing (TRIZ) methods; Usage of performance models to identify the major opportunities for improvement with innovation; Assumption Busters; Empowered innovative thinking; Incentives for Innovation; Strong Teaming for Innovation; Various decision models such as AHP, Pugh Method, Probabilistic decision trees.

Process and Design FMEA; Organizational Readiness for Change; Change Agents; Sponsors; Champions; Influence Leaders; Adoption Curve; Piloting; Risk-based deployment; Before and After comparisons with Hypothesis tests; Results compared to prediction models; Proactive mitigation of risks.
The CMMI, TSP and PSP

CMMI - for organizational capability

TSP - for quality products on cost and schedule

PSP - for individual skill and discipline

SEI Technologies Boost DFSS!

- Portfolio for Six Sigma
- Marketing for Six Sigma
- Product Commercialization for Six Sigma
- Technology Platform R&D for Six Sigma

The SEI Team Software Process (TSP) and Personal Software Process (PSP) significantly enhance the software development teaming within Product Commercialization and Technology Platform R&D for Six Sigma!
The Personal Software Process

PSP3
Cyclic development

PSP2
Code reviews
Design reviews

PSP2.1
Design templates

PSP1
Size estimating
Test report

PSP1.1
Task planning
Schedule planning

PSP0
Current process
Basic measures

PSP0.1
Coding standard
Process improvement proposal
Size measurement

Team Software Process

Reference: “The TSP and PSP Tutorial” by the SEI (Burton, Davis, McHale), 2000
TSP Builds Software Teams

Reference: “The TSP and PSP Tutorial” by the SEI (Burton, Davis, McHale), 2000
The TSP Launch Process

Day 1
1. Establish product and business goals
2. Assign roles and define team goals
3. Produce development strategy

Day 2
4. Build top-down and next-phase plans
5. Develop the quality plan
6. Build bottom-up and balanced plans

Day 3
7. Conduct risk assessment
8. Prepare management briefing and launch report
Launch postmortem

Day 4
9. Hold management review
New teams: TSP process review

Reference: “The TSP and PSP Tutorial” by the SEI (Burton, Davis, McHale), 2000
SEI Technologies Boost DFSS!

The SEI Product Line Practice work overlaps significantly with both Portfolio for Six Sigma, and Technology Platform R&D for Six Sigma!
Software Product Lines

- Products pertain to the Market strategy/Application domain, which is satisfied by the Architecture.
- Products share an architecture and are built from Components.

Product lines take economic advantage of commonality and bound variability.

# Product Line Practice Framework

**Essential Activities**

<table>
<thead>
<tr>
<th>Software Engineering</th>
<th>Technical Management</th>
<th>Organizational Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architecture Definition</td>
<td>Configuration Management</td>
<td>Building a Business Case</td>
</tr>
<tr>
<td>Architecture Evaluation</td>
<td>Data Collection, Metrics,</td>
<td>Customer Interface Management</td>
</tr>
<tr>
<td>Component Development</td>
<td>and Tracking</td>
<td>Implementing an Acquisition</td>
</tr>
<tr>
<td>COTS Utilization</td>
<td>Make/Buy/Mine/Commission</td>
<td>Strategy</td>
</tr>
<tr>
<td>Mining Existing Assets</td>
<td>Analysis</td>
<td>Funding</td>
</tr>
<tr>
<td>Requirements Engineering</td>
<td>Process Definition</td>
<td>Launching and Institutionalizing</td>
</tr>
<tr>
<td>Software System Integration</td>
<td>Scoping</td>
<td>Market Analysis</td>
</tr>
<tr>
<td>Testing</td>
<td>Technical Planning</td>
<td>Operations</td>
</tr>
<tr>
<td>Understanding Relevant Domains</td>
<td>Technical Risk Management</td>
<td>Organizational Planning</td>
</tr>
<tr>
<td></td>
<td>Tool Support</td>
<td>Organizational Risk Management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Structuring the Organization</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Technology Forecasting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Training</td>
</tr>
</tbody>
</table>

SEI Technologies Boost DFSS!

- Portfolio for Six Sigma
- Marketing for Six Sigma
- Product Commercialization for Six Sigma
- Technology Platform R&D for Six Sigma
- Sales & Distribution for Six Sigma

The SEI Software Architecture work overlaps significantly with both Portfolio for Six Sigma, Product Commercialization for Six Sigma, and Technology Platform R&D for Six Sigma!
Software Architecture Technology (SAT) Initiative’s Focus

Ensure that business and mission goals are predictably achieved by using effective software architecture practices throughout the development lifecycle.

Axioms Guiding Our Work

- Software architecture is the bridge between business and mission goals and a software-intensive system.
- **Quality attribute requirements drive software architecture design.**
- Software architecture drives software development throughout the life cycle.

SEI’s Architecture Tradeoff Analysis Method® (ATAM®)

ATAM is an architecture evaluation method that

• focuses on multiple quality attributes

• illuminates points in the architecture where quality attribute \textit{tradeoffs} occur

• generates a context for ongoing quantitative analysis

• utilizes an architecture’s vested stakeholders as authorities on the quality attribute goals

Conceptual Flow of the ATAM℠

Reference: "Future Directions of the Software Architecture Technology Initiative", SATURN Workshop, Mark Klein, 2006

June 11-14, 2007
ATAM Led to the Development of Other Methods and Techniques

Quality Attribute Workshop
- What if the quality requirements are not well-understood?
- What if there's no architecture?
- What if I don't know my system's architecture?

Attribute Driven Design
- What if the quality requirements are not well-understood?

Quality Attribute General Scenarios
- Our scenarios tend to be incomplete or ambiguous.

Quality Attribute Tactics
- What are some of the most important questions to ask?
- Which risks should I work on first?

Cost Benefit Analysis Method
- What information should be included in my architecture documentation?

Views and Beyond Approach

In Summary

Software DFSS, within a holistic DFSS approach to product development, is coming of age,

Many gaps, in translating traditional DFSS concepts to software engineering, may be solved by the adoption of a number of Software Engineering Institute (SEI) technologies.

Thus, DFSS does not have to be re-invented for Software Engineering!
Contact Information

Robert Stoddard
Software Engineering Institute (Office 3110)
4500 Fifth Avenue
Pittsburgh, PA  15213
412.268.1121
rws@sei.cmu.edu

Or, contact SEI Customer Relations:
Customer Relations
Software Engineering Institute
Carnegie Mellon University
Pittsburgh, PA 15213-3890
FAX: (412) 268-5800
customer-relations@sei.cmu.edu
Questions