Experiences Integrating PSP and TSP with Six Sigma

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Agenda

Purpose & Background
A Few Words about Six Sigma and TSP
Deploying TSP as part of the Six Sigma Initiative at Honeywell
Lessons Learned
Oh Those Initiatives!

“XYZ”
SQA
FDD
XP
UML
CMMI
Scrum
SDLC
Agile
PSP/TSP
6σ
Makes You Just Want To…

Code

Test

PSP/TSP

Agile

SDLC

XP

FDD

SQA

JAD
Discuss *one* example of an approach taken for integrating TSP into a Six Sigma (6σ) initiative

- Large company
- Software not a “core competency” (even though most products depend on it)
- 6σ was an organization with experience primarily outside of development engineering

Many other valid approaches certainly exist
Currently with AIS as a full-time TSP coach and PSP instructor, supporting Microsoft IT organization

11,045,160 minutes in software engineering, first 6,837,480 as a software development engineer, last 4,207,680 in software process and quality

6σ: Green Belt certified in DMAIC in 1998, Black Belt certified in DMAIC in 2003, Green Belt certified in DFSS in 2003

PSP/TSP: Authorized as PSP instructor in 1999; Authorized as a TSP launch coach in 2002
A Few Words about Six Sigma—1

Six Sigma (6σ) is (as I see it, anyway)

- A term
  - Six standard deviations away from the mean of a normal distribution -> 3.4 defects per million “opportunities”

- A philosophy
  - Moving products and processes to optimal target values, and reduction of variation around those targets
  - Defect prevention over (late) defect detection
  - Continuous improvement
A Few Words about Six Sigma—2

6σ is implemented with

- One or more approaches (or strategies), e.g.,
  - “DMAIC” (Define, Measure, Analyze, Improve, Control)
  - “Lean” (“Manufacturing” or “Enterprise”)
  - “DFSS” (Design For Six Sigma—most recent)
  - Approach used depends on context

- One or more toolsets (methods and techniques)
  - Statistical and other methods for analyzing product and process data, and for making improvements to processes and controlling them
  - Many tools are “soft”
  - No standard toolset—toolsets vary by approach, company, organization, wind speed, …
A Few Words about Six Sigma—3

An example *partial* 6σ toolset

- Define
  - Benchmark
  - Baseline
  - Charter
  - Kano Model
  - Voice of Customer
  - Voice of Business
  - Quality Function Deployment
  - Process Map
  - Project Management
  - Mgt. By Fact
  - SIPOC Map
  - Value Stream Map

- Measure
  - Basic Statistics
  - Graphical Methods
  - Defect Metrics
  - Data Collection
  - Forms, Plan, Logistics
  - Sampling Techniques
  - Meas. Systems Analysis

- Analyze
  - Cause & Effect Diagrams
  - Failure Modes & Effects Analysis
  - Decision & Risk Analysis
  - Statistical Inference
  - Control Charts
  - Process Capability
  - Reliability Analysis
  - Root Cause Analysis
  - Systems Thinking
  - Monte Carlo Analysis
  - ANOVA

- Improve
  - Brainstorm
  - Design of Experiments
  - Modeling
  - Tolerancing
  - Robust Design
  - Poka-Yoke
  - “To Be” Process Map

- Control
  - Control Charts
  - Time Series Methods
  - Procedural Adherence
  - Performance Management
  - Preventive Activities
  - Control Plan
  - Mistake Proofing
A Few Words About PSP/TSP

The PSP/TSP philosophy (adapted from the “PSP book”)  
- Plan and manage your work  
- Use effective methods  
- Recognize strengths and weaknesses  
- Practice, practice, practice  
- Learn from history  
- Find and learn new methods

Some key PSP/TSP “tools” (methods)  
- Use of process data for fact-based decision-making  
- PROBE (PROxy Based Estimating)  
- Earned Value Tracking  
- Structured Personal Reviews and Team Inspections  
- Verifiable Designs and Design Verification techniques  
- Postmortems and Improvement Proposals

Consistent with 6σ philosophy!
Evolution of TSP and Six Sigma at AlliedSignal/Honeywell

1991
6σ Introduced at AS

1991 - 1997
DMAIC 6σ applied in Ops, Manufacturing, etc.

2000
Software Productivity Center Formed
Six Sigma Org. Re-formed

2000 - 2001
DFSS/TSP Strategy Formed
2000 - 2001

2001 - 2002
SW-DFSS Development

2002 - 2004
SW-DFSS Deployment

1997
TSP Pilot at Teterboro
DMAIC 6σ Introduced in Engineering
Honeywell SW DFSS Strategy

Strategy, Take 1: PSP/TSP is 6σ for Software
- Good start, but not sufficient

Refined Strategy: Build a SW DFSS toolset from
- PSP and TSP
- Existing 6σ tools most useful for software development
  - QFD, Process Map, FMEA, SPC, Control Plan,…
  - Provide software-specific usage examples
- Existing software development methods consistent with 6σ philosophy
  - Software Inspections, Software Scorecard, DFT, DFR,…
## Six Sigma and the TSP Launch—1

<table>
<thead>
<tr>
<th>Meeting</th>
<th>Primary Six Sigma Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: Allow management to review business and product needs, explain project constraints, and ensure team understands these needs and constraints</td>
<td>Quality Function Deployment (QFD)</td>
</tr>
<tr>
<td>2: Define team goals and roles</td>
<td>QFD Process Mapping (PMAP)</td>
</tr>
<tr>
<td>3: Produce the project conceptual design and strategy, identify major deliverables, and produce the process and support plans</td>
<td>Measurement System Evaluation (MSE)</td>
</tr>
<tr>
<td>4: Produce an overall team-level project plan</td>
<td>PMAP (update)</td>
</tr>
<tr>
<td>5: Produce the Quality Plan</td>
<td>Design For Reliability (DFR)</td>
</tr>
<tr>
<td>6: Produce the bottom-up next phase plan for each engineer and consolidated next-phase plan</td>
<td>Scorecard Lean Principles</td>
</tr>
<tr>
<td>7: Identify project risks and produce the risk management plan</td>
<td>Failure Mode and Effects Analysis (FMEA)</td>
</tr>
<tr>
<td>8: Prepare the plan presentation for the management meeting</td>
<td></td>
</tr>
<tr>
<td>9: Present team plan to management and obtain approval of the plan</td>
<td></td>
</tr>
<tr>
<td>PM: Identify what went well during the launch and what could be improved</td>
<td>Lessons Learned</td>
</tr>
</tbody>
</table>
Six Sigma and the TSP Launch—2

Quality Function Deployment
- Structured method used to identify/prioritize customer’s needs and development activities, mapping the What’s and Why’s from meetings 1 and 2 into How’s and Who’s in meetings 2 through 4

Process Mapping
- Used during Meeting 3 to document development strategy & processes
- “Big Y” is determined in meetings 1 and 2
- Process map x’s can be used as inputs to the FMEA used in Meeting 7

Kappa MSE
- Used during Meeting 3 to determine appropriate defect type categorization
Six Sigma and the TSP Launch—3

Design for Reliability (DFR) and the (Software) Scorecard
– Extensions to the Quality Plan used to set quality goals in order to actively manage the process to meet the goals
– Scorecard includes Quality Plan “defect leakage matrix” actuals plus other typical TSP quality data such as DLRs, COQs & A/FRs

Lean Principles
– Used in Meeting 5, which focuses on removing defects where it is most efficient

FMEA
– Extension of the Risk Analysis and Management Plan, using data from Process Maps to identify and prioritize risks, and to develop risk plans
### Example QFD

#### Calculator House of Quality (HoQ)

<table>
<thead>
<tr>
<th>Technical Correlations</th>
<th>Design Variables</th>
<th>Planning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Software</td>
<td>Hardware</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
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<td></td>
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</table>

#### Technical Response

**Voice of the Developer (How)**

<table>
<thead>
<tr>
<th></th>
<th>1st Level</th>
<th>2nd Level</th>
<th>3rd Level</th>
<th>Units</th>
<th>Dir</th>
<th>Goal</th>
<th>UTL</th>
<th>LTL</th>
</tr>
</thead>
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<tr>
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<td>Base</td>
<td>TB</td>
<td>10</td>
<td>10</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Integer and floating point</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>9</td>
<td></td>
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<td></td>
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<td>Positive and negative numbers</td>
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<td>1</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>High accuracy</td>
<td>Digits</td>
<td>MTB</td>
<td>10</td>
<td>9</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>5</td>
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<tr>
<td></td>
<td>Add, Subtract, Multiply, Divide</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>9</td>
<td></td>
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#### Customer Needs

**Voice of the Customer (What)**

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<tr>
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<th>2nd Level</th>
<th>3rd Level</th>
<th>Units</th>
<th>Dir</th>
<th>Goal</th>
<th>UTL</th>
<th>LTL</th>
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</thead>
<tbody>
<tr>
<td>Delete input characters</td>
<td>1</td>
<td>1</td>
<td>9</td>
<td>9</td>
<td></td>
<td>3</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>1</td>
<td>9</td>
<td>9</td>
<td></td>
<td>3</td>
<td>3</td>
<td>5</td>
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<td>9</td>
<td></td>
<td>3</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Fitted in shirt pocket</td>
<td>Inches</td>
<td>LTB</td>
<td>1</td>
<td>3</td>
<td>9</td>
<td>1</td>
<td>3</td>
<td>3</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>1.33</td>
<td></td>
<td>1.2</td>
<td>8</td>
<td>11.5</td>
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<tr>
<td>Light-weight</td>
<td>Gr.</td>
<td>LTB</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>9</td>
<td>9</td>
<td>1</td>
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<td></td>
<td></td>
<td></td>
<td>1.33</td>
<td></td>
<td>1.2</td>
<td>8</td>
<td>9.2</td>
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<tr>
<td>Low cost</td>
<td>S</td>
<td>LTB</td>
<td>5</td>
<td>8</td>
<td>9</td>
<td>3</td>
<td>3</td>
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<td>4</td>
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<td></td>
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<td></td>
<td>1.2</td>
<td></td>
<td>3.6</td>
<td>5.2</td>
<td>9</td>
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</table>

#### Technical Impacts

**Raw Contribution to Overall Customer Satisfaction**

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<tr>
<th></th>
<th>44.5</th>
<th>44.4</th>
<th>307</th>
<th>215</th>
<th>237</th>
<th>272</th>
<th>224</th>
<th>218</th>
<th>168</th>
</tr>
</thead>
</table>

**Normalized Contribution to Customer Satisfaction (%)**

|                        | 2.3   | 4.4   | 16.0 | 5.1  | 11.3 | 14.2 | 4.8  | 24.1 | 8.5  |

**Ranked Contribution to Overall Customer Satisfaction**

|                        | 10    | 9     | 2     | 6    | 7    | 4    | 3    | 8    | 1    |

#### Measurement Units

<table>
<thead>
<tr>
<th>Software Development Targets</th>
<th>Measurement Units</th>
<th>Hardware Performance Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LTB, MTB</td>
<td>LTB</td>
</tr>
<tr>
<td>Direction of Goodness</td>
<td>LTB, MTB</td>
<td>LTB</td>
</tr>
<tr>
<td>Goals</td>
<td>50, 50</td>
<td>10, 10</td>
</tr>
<tr>
<td>Upper Spec Limit (USL)</td>
<td>100</td>
<td>10, 10</td>
</tr>
<tr>
<td>Lower Spec Limit (LSL)</td>
<td>9</td>
<td>9, 9</td>
</tr>
<tr>
<td></td>
<td>18 AAA, Lower Spec Limit (LSL)</td>
<td></td>
</tr>
</tbody>
</table>
Example Process Map

SQAR Training Process

1003

Legend
X = Critical
C = Controllable
S = SOP
N = Noise
Red = Updates from As-is PMA
## Example Partial FMEA

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the process step/input?</td>
<td>What can go wrong with the process step/input?</td>
<td>What is the impact on the customer (output variables) or internal requirements?</td>
<td></td>
<td>What are the root cause reasons for the process step/input to go wrong?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conduct Training</td>
<td>SQAR does not adequately understand SQAR responsibilities</td>
<td>SOAR does not enforce AEW309 requirements to produce designs for changes</td>
<td>10</td>
<td>Trainee doesn't pay attention</td>
<td>4</td>
<td>None</td>
<td>10</td>
<td>400</td>
</tr>
<tr>
<td>Conduct Training</td>
<td>SQAR does not adequately understand SQAR responsibilities</td>
<td>SOAR does not enforce AEW309 requirements to produce designs for changes</td>
<td>10</td>
<td>Training material does not adequately cover all areas of responsibility</td>
<td>10</td>
<td>None</td>
<td>10</td>
<td>1000</td>
</tr>
<tr>
<td>Conduct Training</td>
<td>SQAR does not adequately understand SQAR responsibilities</td>
<td>SOAR does not enforce AEW309 requirements to produce designs for changes</td>
<td>10</td>
<td>Trainee misses part of class</td>
<td>1</td>
<td>Theoretically, if a trainee missed enough of the class, the SQE can withhold certification</td>
<td>7</td>
<td>70</td>
</tr>
</tbody>
</table>
Example Scorecard

<table>
<thead>
<tr>
<th>Process Step Where Defect Injected</th>
<th>Failure Cost (Estimate)</th>
<th>Appraisal Cost (Inspection)</th>
<th>Prevention Cost (Casual Analysis)</th>
<th>Total Software Cost</th>
<th>Cost of Quality (COQ)</th>
<th>Defect Removal Effort (Hour/Defect)</th>
<th>Appraisal Failure Rate (AFR)</th>
<th>Other Measures</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Requirements</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>20</td>
<td>10</td>
<td>0.9</td>
<td>0.9</td>
<td>Size (Developed)</td>
<td>7998 LOC</td>
</tr>
<tr>
<td>SW Requirements</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>20</td>
<td>10</td>
<td>0.9</td>
<td>0.9</td>
<td>Size (Delivered)</td>
<td>10 KSOLOC</td>
</tr>
<tr>
<td>SW Design</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>20</td>
<td>10</td>
<td>0.9</td>
<td>0.9</td>
<td>Software Requirement</td>
<td>2000 LOC</td>
</tr>
<tr>
<td>SW I&amp;L</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>20</td>
<td>10</td>
<td>0.9</td>
<td>0.9</td>
<td>Average Labor Rate</td>
<td>75 1 hour</td>
</tr>
<tr>
<td>Total Number of Defects</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>20</td>
<td>10</td>
<td>0.9</td>
<td>0.9</td>
<td>Average Opportunities</td>
<td>10000 1 hour</td>
</tr>
</tbody>
</table>

Total Defects Injected: 10
Total Defects in Delivered Product: 50
Overall Process Yield: 60%
Six Sigma and TSP Operation

Control Plans
- Used in $6\sigma$ to ensure improvement gains are sustained and to ensure process consistency; intent is fulfilled with the TSP weekly meeting

Basic Statistics and Graphical Methods
- Used routinely in TSP to analyze and control the process and to make process improvements

Statistical Process Control (SPC)
- Used for extra rigor in determining statistically whether a process is under control and to identify special cause variation

Appraisals (Inspections)
- Used to remove defects efficiently
Example SPC Control Chart

I and MR Chart for Milestones M

- Individual Value
  - Mean = 190.1
  - UCL = 323.2
  - LCL = 56.93

- Moving Range
  - R = 50.06
  - UCL = 163.5
  - LCL = 0
Six Sigma and PSP—1

Regression, Basic Statistics, and Graphical Methods
– Used in PROBE to provide statistically-sound estimates, and to interpret PROBE values and select the appropriate method

Design For Testability (DFT)
– Incorporated by using the PSP Design Templates

Functional Maps
– A Process Map extension used during DLD to graphically depict flow & function of a logical sequence of actions & events
Six Sigma and PSP—2

(Personal) Appraisals
- Used to remove defects efficiently; Personal Reviews are essentially software inspections applied at the personal level

Monte Carlo Simulation
- Used during design to select a design approach among several options by providing a potential range of outcomes, probability of reaching specific targets, most likely outcomes, etc.
Example Functional Map

Inputs (X)
- Input A
- Input B
- Input C

Function 1
- C - Input D
- S - Input E

Function 2
- N - Input A
- N - Input B
- S - Input E

Function 3
- C - Input D
- S - Input E

Function 4
- S - Input F
- N - Input G
- S - Input H
- C - Input I

Function 5
- S - Input J
- N - Input K
- N - Input L

Outputs (Y)

Step 1 Outputs
Step 2 Outputs
Step 3 Outputs
Step 4 Outputs

Test1
Pass
Green Belt Certification Considerations

A typical $6\sigma$ initiative requirement is certification
– Training and application of (a subset of) toolset on a $6\sigma$ project

Before SW-DFSS, a typical complaint of $6\sigma$ was that engineers on development teams had to “make up projects” to use the tools and get certified

By making the natural connection between TSP & $6\sigma$, it became realistic to complete a $6\sigma$ project as part of one’s normal work
– No problem applying tools!
– PSP, TSP, Regression, Inspections, FMEA (risk analysis), DFR (Quality Plan), Graphical Methods, Basic Stats, Control Plan (weekly meeting), …

The only extra work for certification was to organize personal and/or project data into a report—much like the PSP Final Report
Lessons Learned Integrating TSP into a 6σ Initiative—1

TSP experts should be familiar with the philosophy and standard toolset(s) of the 6σ organization

Map PSP and TSP methods to company-standard 6σ toolset (not all methods will map, but enough should)

For PSP/TSP methods that don’t map directly to 6σ tools, but meet the 6σ philosophy, document how they do so

Engage the 6σ organization in validating the mappings
Lessons Learned Integrating TSP into a 6σ Initiative—2

Focus on the 6σ philosophy and not just the tools

Developing a SW 6σ curriculum—even with existing SEI PSP training—is a significant undertaking and should be treated as a product development effort

Training time may be an issue

Compromises may be necessary
Summary

TSP can be integrated into a 6σ program
There are significant synergies among TSP, 6σ, and other software methods not traditionally associated with either TSP or 6σ
Keep the goals in mind—don’t get overwhelmed by initiatives and tools
As a first approximation, it may be best to start with TSP as your 6σ program, then extend
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