Integrating PSP, TSP & Six Sigma

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PS&J Software Six Sigma

Six Sigma Starts with Business Results

- Six Sigma is a measurement driven approach to continuous improvement that starts with business goals of direct value to the customer
- Process data is used to identify specific sub-processes with the greatest leverage to affect the business goals
- Critical inputs affecting process performance are identified
- Improvement goals are related to changes in process outputs
- Improvements are implemented on a pilot basis
- If measurements indicate goals have been achieved, improvements are institutionalized
- Process performance is controlled to new performance levels by controlling critical input variables

What are you going to tell your new boss when she asks you to quantify the return on your SPI activities?

DMAIC

The Six Sigma Continuous Improvement Cycle

- **Define the process**
- **Measure the process**
- **Analyze the process to identify causal variables**
- **Improve the process**
  - **Modify the process**
  - **Measure the modified process**
  - **Verify the improvement**
  - **Define control mechanism**
- **Control the process to new performance levels**
  - **Monitor performance metrics and take designated action when required**
  - **Perform continuous verification of the stability and capability of the process**

Why Apply Six Sigma to SPI?

- Software-dependent businesses have three critical needs
  - better cost and schedule management
  - better quality management
  - cycle time improvement
- With conventional SPI, it is easy to fall into the trap of laying a veneer of process over the same old engineering activities
  - adds overhead while having no significant business value
  - productivity stagnates even as the organization moves up in CMM levels
  - destroys credibility with the developers
- Six Sigma increases the likelihood of sustainable success
  - explicit linkage to business goals retains executive sponsorship
  - objective measurements of the degree of improvement drive organizational consensus
  - active participation by the engineers in measurement and analysis builds credibility for continuous improvement
  - control plan sustains gains in a systematic way

Barriers

- Application of six sigma techniques requires a stable well-defined process along with complete and consistent time, size, and defect metrics
  - The CMM recognizes this. That's why level 2 and 3 are about getting a stable well-defined process in place, while levels 4 and 5 make extensive use of six sigma concepts for Statistical Process Control (SPC) and Quality Management
  - Most conventional software processes produce fragmentary, noisy metrics of limited utility for the application of six sigma
- Level 1 - 3 organizations that want to apply six sigma techniques to software development are forced into having improvement teams begin "from scratch" by
  - mapping the process
  - instrumenting the process,
  - providing training on data collection
  - and base-lining current process performance

  before before they can even identify the improvement opportunities
- This can be slow, expensive, and frustrating

Consequences

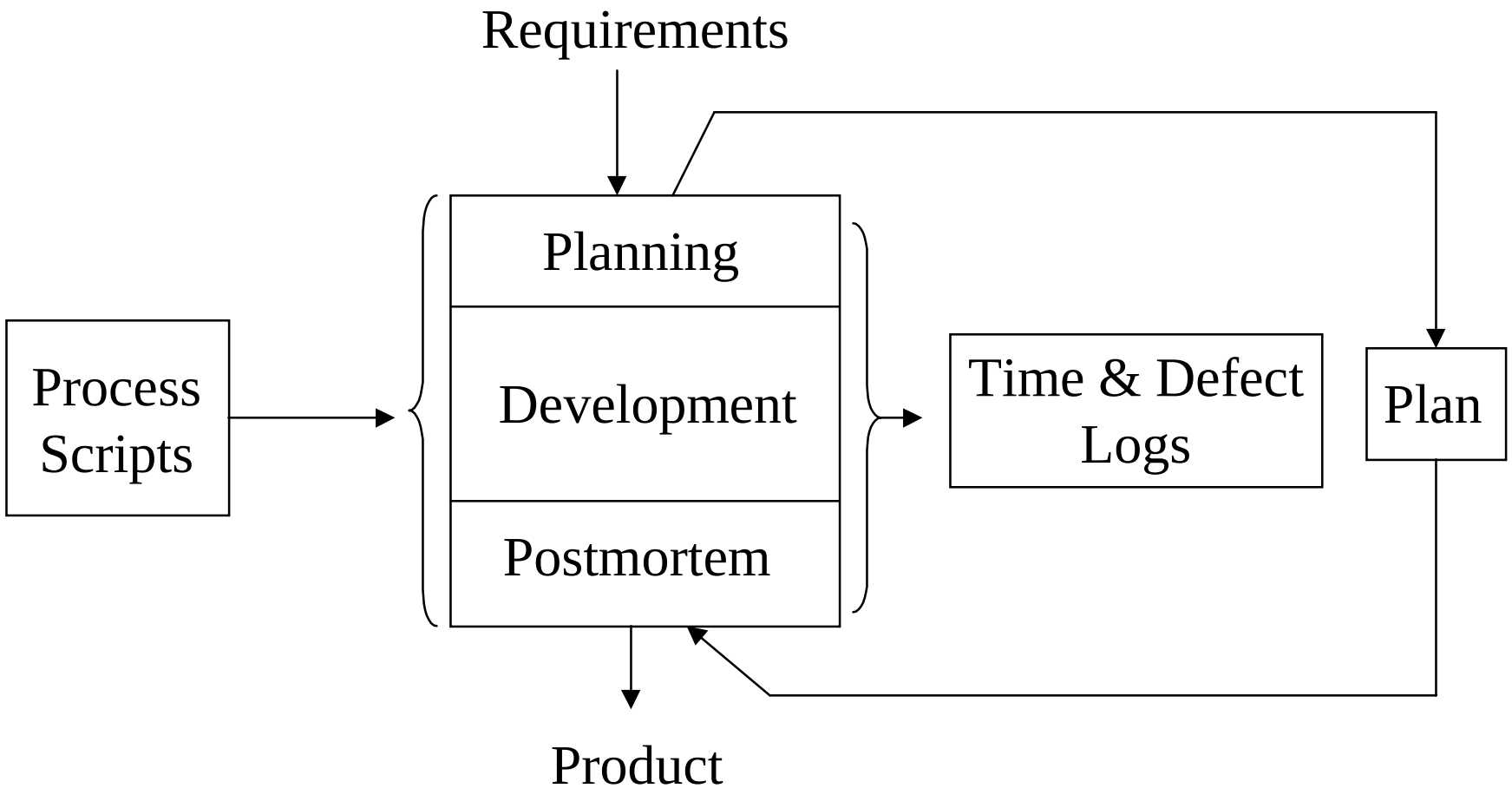
- Many organizations choose to defer applying the Six Sigma toolkit until they are ready to move to level 4
  - Frequently they cannot measure the business value of their level 2 and 3 improvements and cannot calculate ROI
  - Without active management, it is unlikely that their processes perform as well as they should – in fact they may even be counterproductive
  - They often cannot sustain their process improvement initiative through a change in executive sponsorship
- Even level 4 - 5 organizations have some problems with incomplete process data
  - blackbelts that are trying to lead Six Sigma projects are frustrated by noisy and incomplete process data that is difficult to collect and analyze
  - find it difficult to apply Six Sigma beyond the inspection process
  - Productivity sometimes stagnates

PSP as an Enabler for Six Sigma

- PSP & TSP provide an ideal foundation for the application of Six Sigma techniques to software development
  - Together they provide the core of a lightweight level 5 process
  - They are designed to be introduced bottoms up in an organization, one team at a time
  - They don't require a high level of process maturity for introduction, basic configuration management and quality assurance are the only pre-requisites
  - They are fact based, data driven, and closed loop
- They are well-defined processes, generally applicable "out of the box", supported by excellent training material, and have extensive performance data available
- PSP training motivates each individual developer to collect process metrics and use them for self-improvement
- Highly granular tasks enable quick process baseline

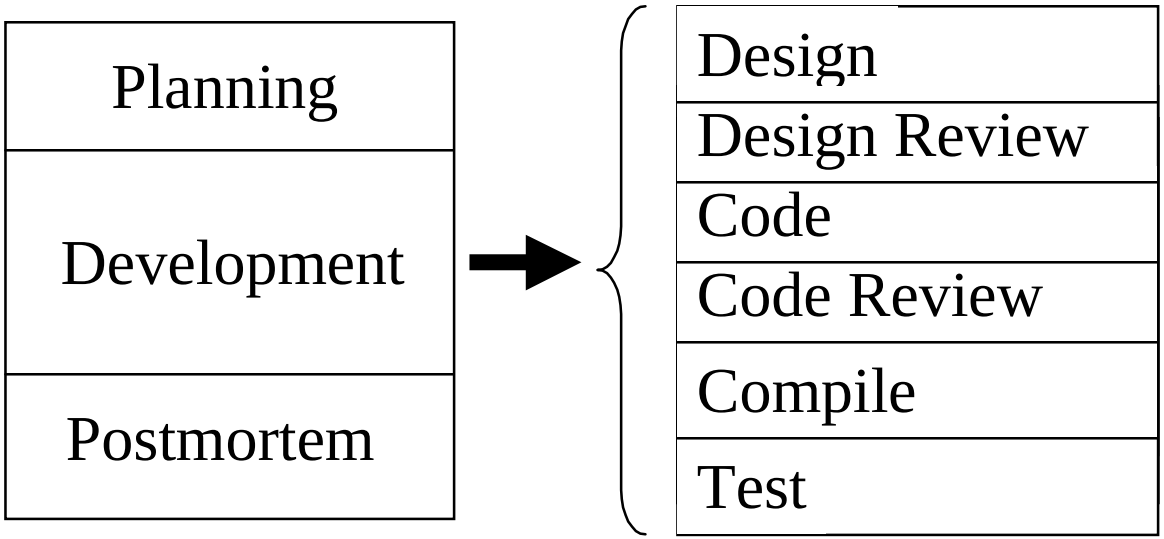
PSP builds individual skill and discipline

PSP Process Flow



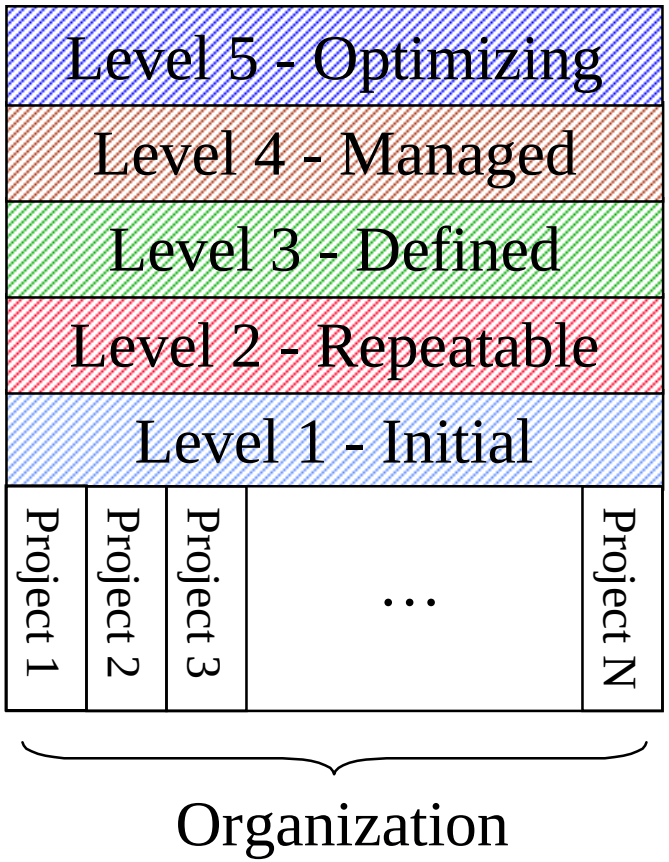
- **PSP is not a waterfall process - best to target an average of two work products per person-week integrated using an iterative life cycle**

PSP Applicable Across the Life Cycle



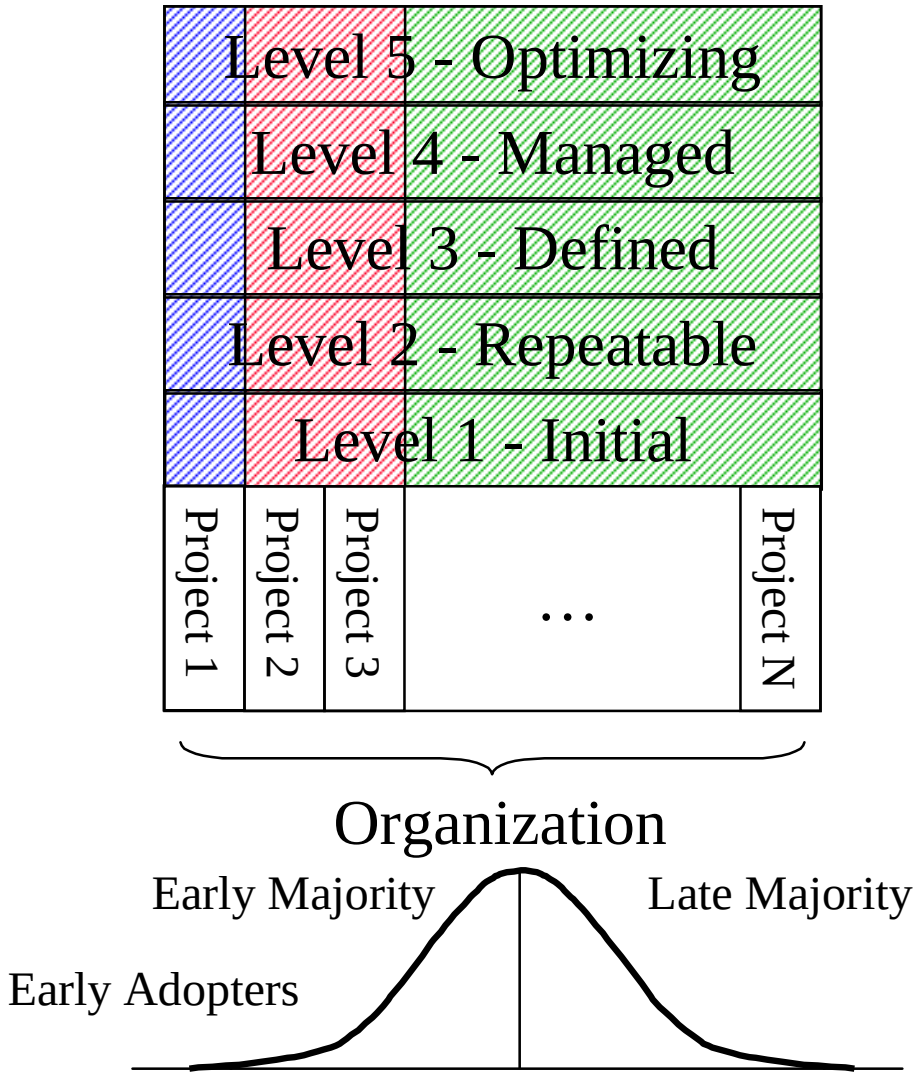
- **PSP training is based on implementation**
- **The PSP process is applicable to analysis, architectural design, integration & test, documentation production, etc. by substituting different development activities, changing the size metric, and modifying estimating algorithm**

Staged Improvement Model



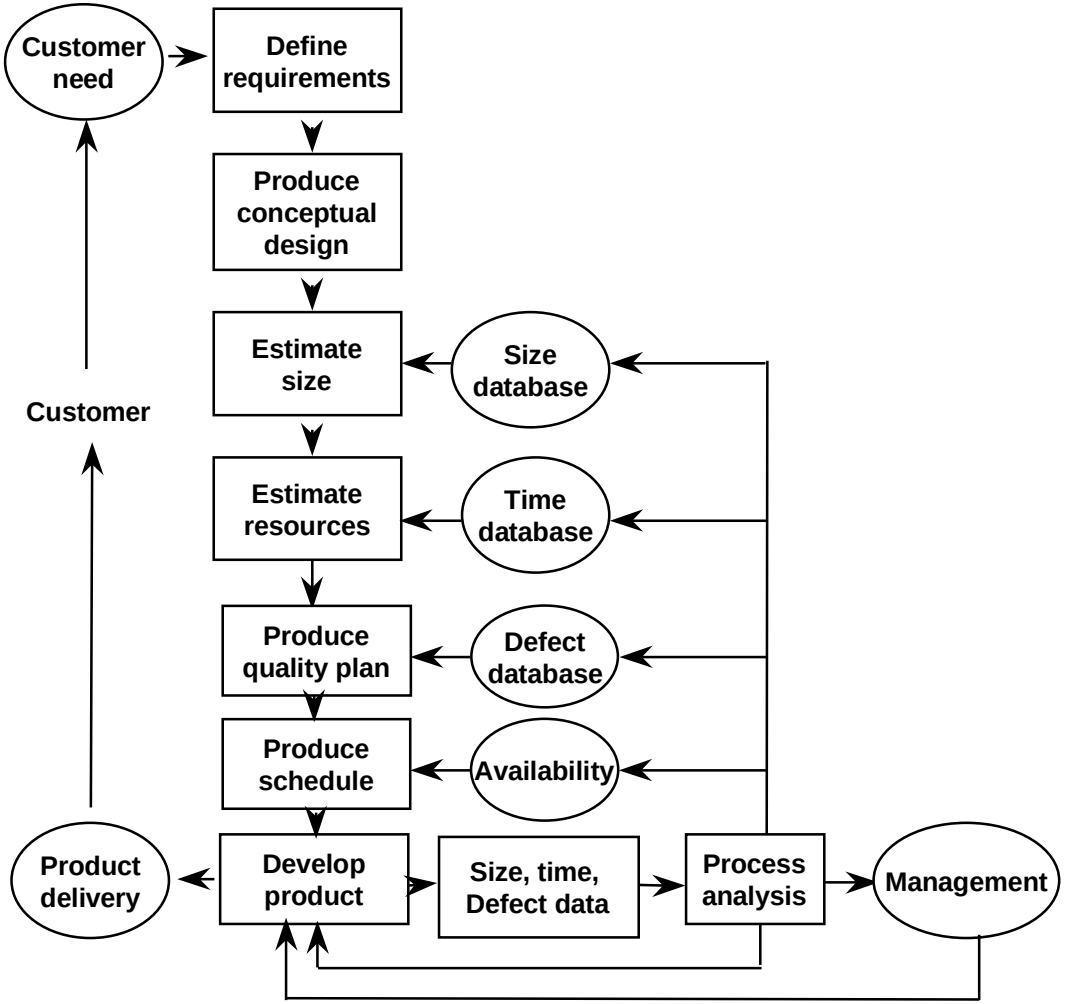
- Processes at the lower levels provide the foundation for processes at the higher levels
- Success at the lower levels prepares the organization to accept the changes required at the higher levels
- Most of the organization's projects move forward more or less in parallel one level at a time
- The main drawback is organizational inertia – it can literally take years to move a level

PSP Deployment Model



- **PSP training moves a project team through the 5 CMM levels during a 12-day training course**
  - **Students make measurements of the impact of process changes on their own performance levels**
  - **Understand how to use the higher level processes effectively**
- **Pilot projects are staffed with early adopters.**
- **Successes are used to pull through the rest of the organization**
- **Number of teams doubles geometrically**

A Closed Loop Process



- Tasks are planned based on historical time, size, and defect data.
- Individuals log time and defect data in process as they perform their tasks
- Individuals manage their own tasks using real-time feedback provided by the difference between planned and actual process metrics
- Planned performance levels serve as phase exit criteria
- Automated in-process data acquisition and data analysis keeps overhead low and provides engineers with real time decision support

PSP Metrics

- There are only three basic metrics in PSP
  - Time: the time required to perform a task, measured in minutes
  - Size: the size of the work product produced, often measured in lines of code (LOC)
  - Defects: the number and type of defects, fix time, point of injection and point of removal, description
- All other metrics can be derived from size, time and defects
  - Productivity, Quality, Defect Removal Rate, COQ, etc.
- Time and defect metrics are collected in process and over the full life cycle
- Data is personal
  - Collected by the individual
  - Used by each individual to manage his or her own tasks
  - Aggregated for team management

Data must be regularly used by the person collecting it. Otherwise they will stop collecting it!

TSP

- Adds a project management layer to the PSP
- Addresses CMM level 2 & 3 management processes using
  - High performance work teams
  - Bottoms up project planning
  - EV tracking
  - Risk Management
- Uses a structured team launch to develop a highly detailed project plan
- Provides a management mechanism through the use of standard tracking metrics and weekly status meetings
- Uses a project quality plan for in process pro-active management of product quality
- Provides a foundation for using Six Sigma tools in project management

TSP builds quality products at planned cost and on schedule

Sample TSP Quality Plan

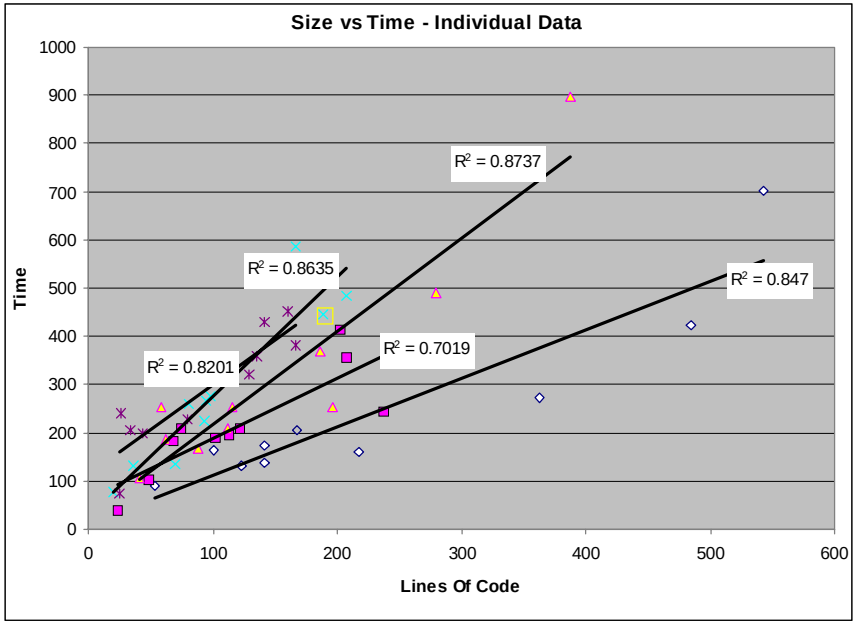
	Defects leaked from prev phase	New Defects Injected	Phase Yield	Defects Contained	Defects Leaked	Defect Removal Cost
Design	0.00	40	0%	0	40	n/a
Design Bench Check	40.00	0	70%	28.0	12.0	10 mins
Design Inspection	12.00	0	70%	8.4	3.6	30 mins
Code	3.60	60	0%	0.0	63.6	n/a
Code Bench Check	63.60	0	70%	44.5	19.1	5 mins
Compile	19.08	0	50%	9.5	9.5	1 min
Code Inspection	9.54	0	70%	6.7	2.9	15 mins
Unit Test	2.86	0	50%	1.4	1.4	15 mins
Integration Test	1.43	0	50%	0.7	0.7	600 mins
System Test	0.72	0	50%	0.4	0.4	900 mins
CUSTOMER	0.36					

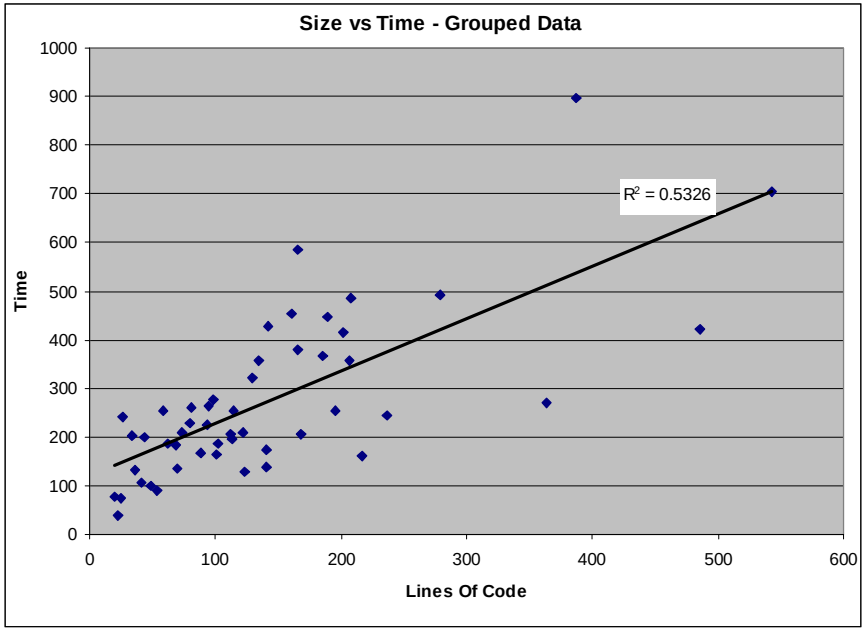
Quality Plan for 1 KLOC Code

PSP, Six Sigma, and Variation

- Six Sigma focuses on minimizing process variation
- PSP eliminates several of the biggest contributors to data variability
  - Time measurement errors and quantization effects
  - Inconsistent size measurements
  - Grouping data from individuals with drastically different skill and performance levels
- From a Six Sigma perspective
  - PSP uses a rational subgroup corresponding to a single individual for most data items
  - PSP produces much less measurement system noise than other approach to software process data collection
- Low intrinsic variation of PSP data vastly improves the ability to predict and control process performance using Six Sigma techniques

Example: Size Time Scatter Plots





- **Grouping data from individuals with varying skills dramatically increases data variability and seriously degrades its usefulness for predictions**
- **One of the key insights provided by PSP is that personal data should be used for prediction "bottoms up", not group data "top down"**

Bottoms Up Estimating Also Reduces Variation

- TSP employs bottoms up estimating to make full use of the lower uncertainty inherent in personal estimates
- Consider the basic statistics about adding errors
  - Consider an estimate of 1000 hours, with an estimating error of ± 50%, the 70% prediction interval is 500 to 1500 hours
  - However for 25 estimates of 40 hours each, each with ± 50% error, total estimate would be 1000 hours, as before, but the error would be $\pm 100 = \sqrt{(25 \times 20^2)}$
  - This reduces the 70% prediction interval to 900 to 1100 hours
- A TSP launch typically involves estimating about 200 independent tasks and the bottoms up approach improves accuracy by about 1/15 relative to a single estimate. This will improve a baseline estimating accuracy of ±100% to about ±7%!

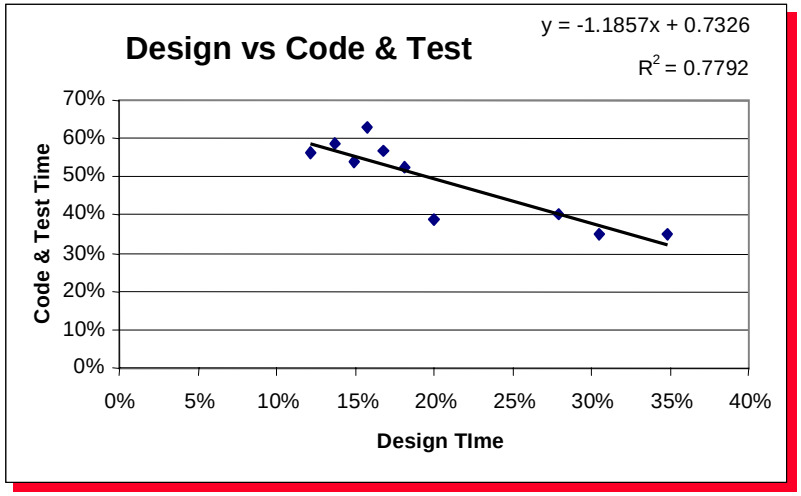
It is common for TSP launches to produce estimates that are accurate to 5% – 20%

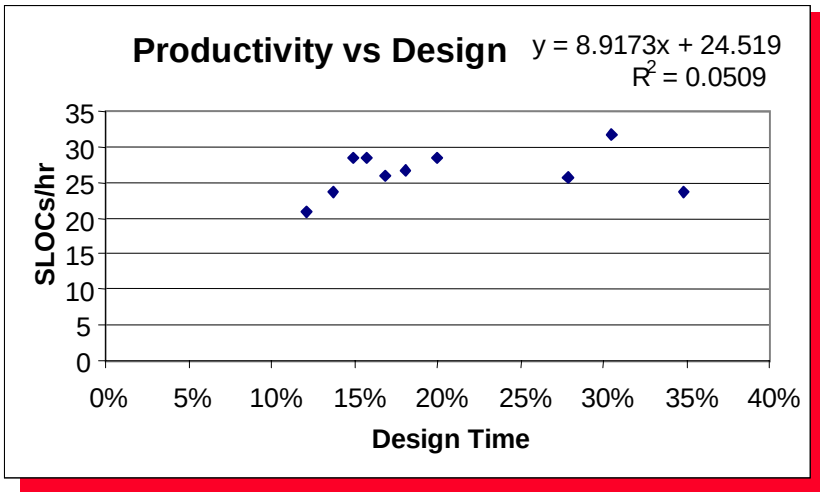
Six Sigma Extends PSP and TSP

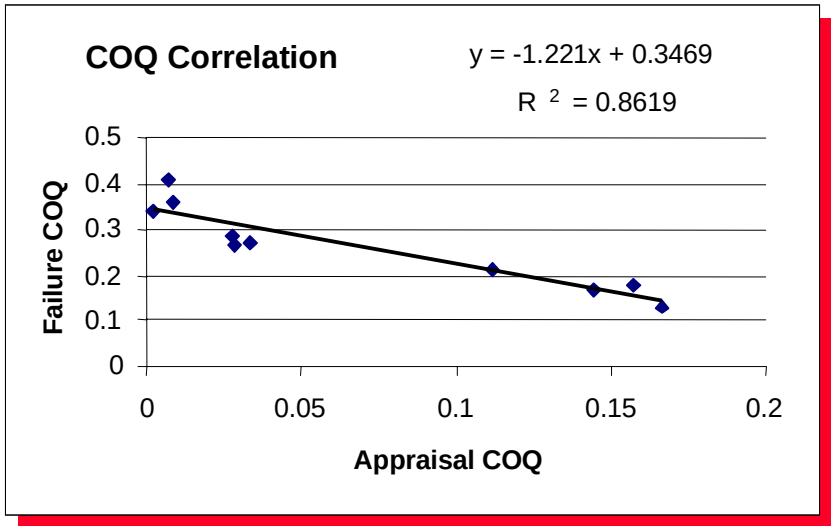
- PSP and TSP provide a stable process and high quality metrics for the application of Six Sigma tools
- Six Sigma complements PSP and TSP by providing a statistical analysis toolkit including
  - Correlation Analysis
  - Analysis of Variance (ANOVA)
  - Failure Modes Effect Analysis (FMEA)
  - Statistical Process Control (control charts)
  - Control Plans
- Six Sigma toolkit is used to
  - perform effective post mortem data analysis,
  - measure the effect of process changes,
  - control process performance to planned values
- DMAIC model "wraps around" the PSP process providing a structure mechanism for continuous improvement at the personal and team levels

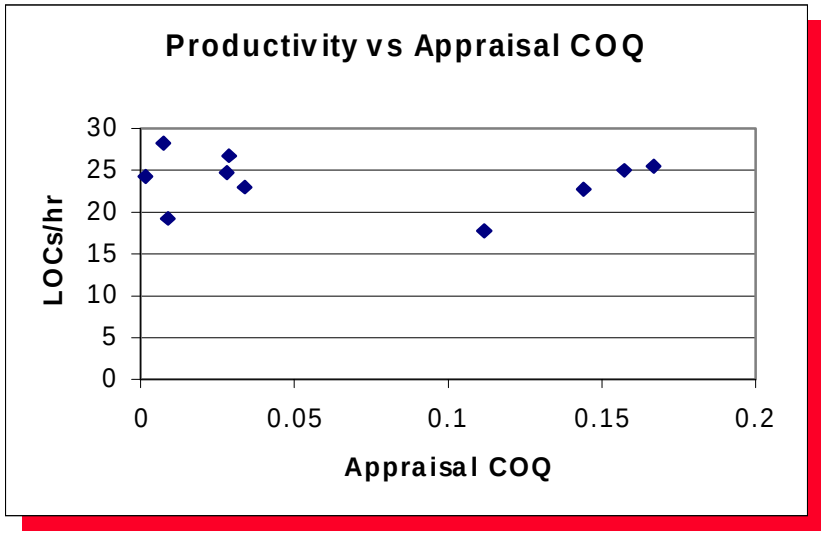
Six Sigma provides PSP and TSP with a tool kit for process analysis, management, and improvement

Correlation Analysis – Design & Quality are Free

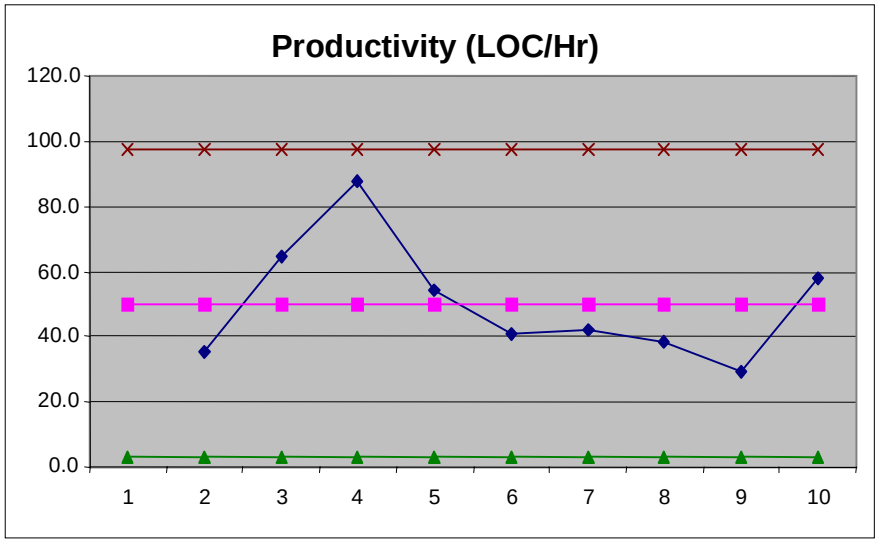


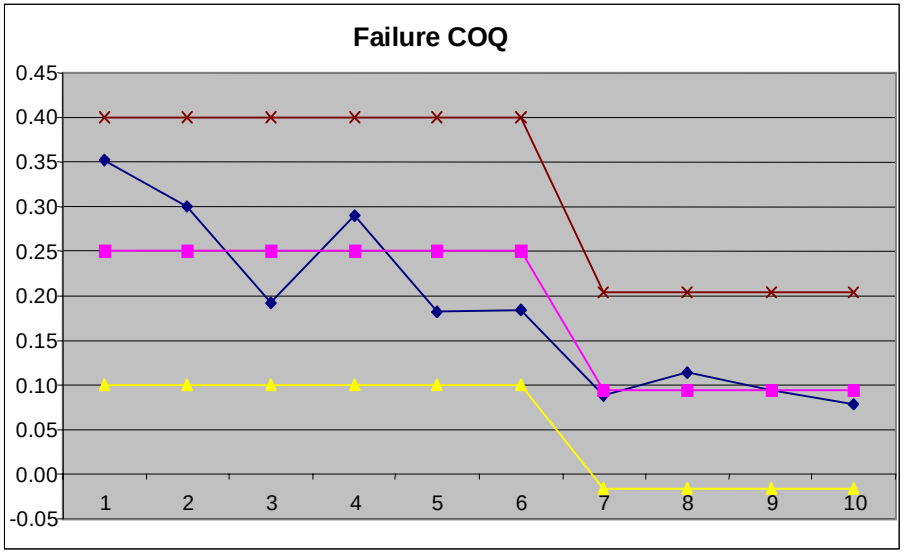






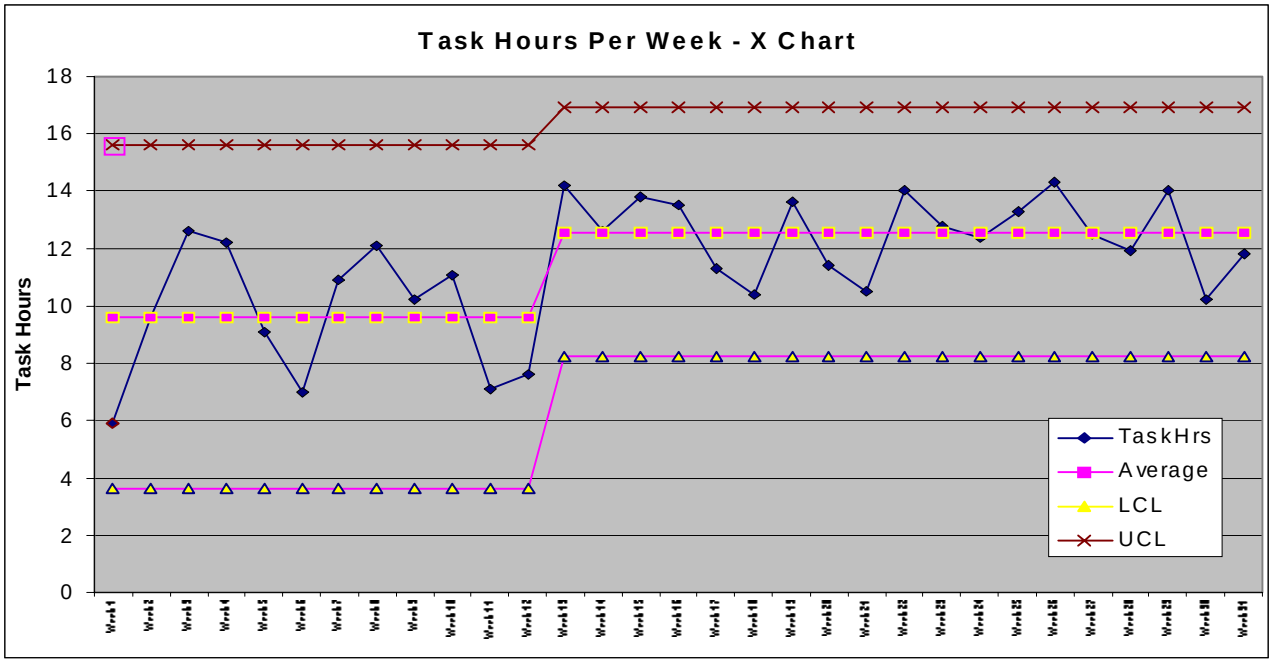
Is There a Trend? Was there a change?





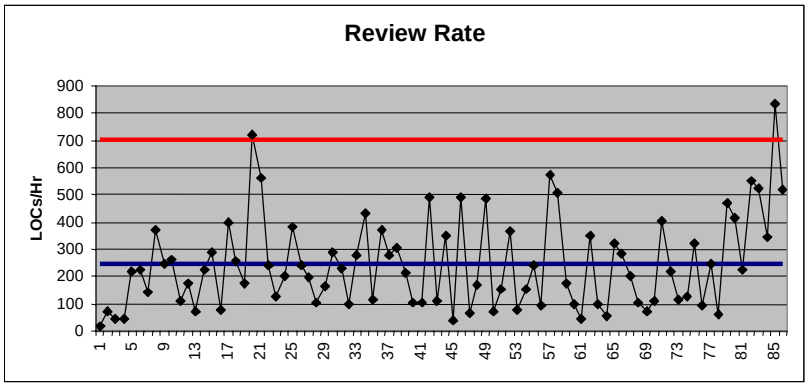
- SPC is the perfect tool for PSP postmortem data analysis
- XmR charts provide PSP with a mechanism to recognize and quantify shifts in process performance
  - The graphs show PSP training data, productivity is noisey but essentially flat.
  - Failure COQ makes a dramatic decrease when personal reviews are injected into the process
- XmR charts can be used to recognize trends in data and special cause variation
  - Typical application: identifying outliers to be excluded estimation data sets

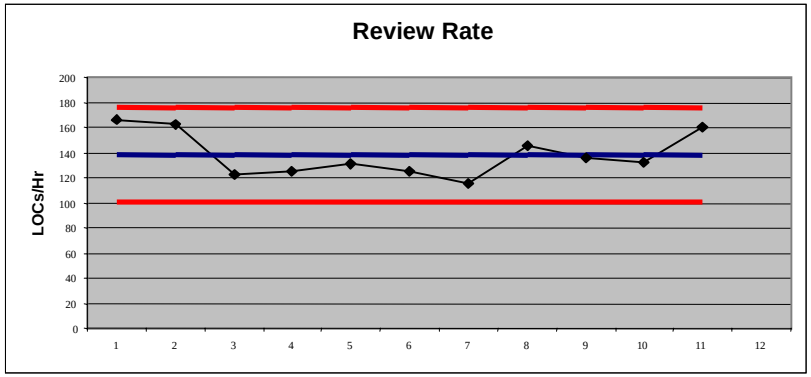
XmR Charts and TSP Time Management

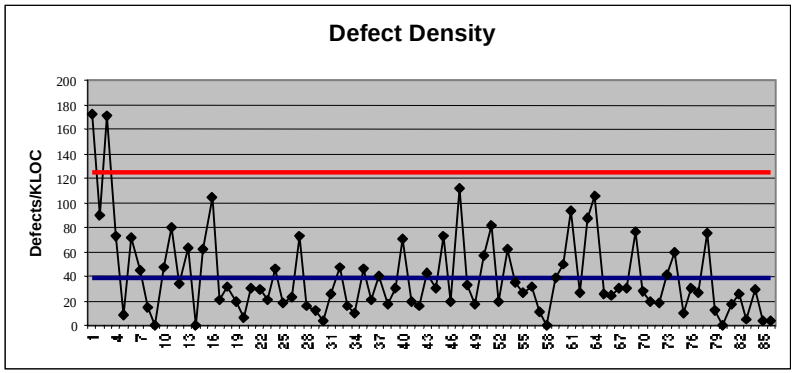


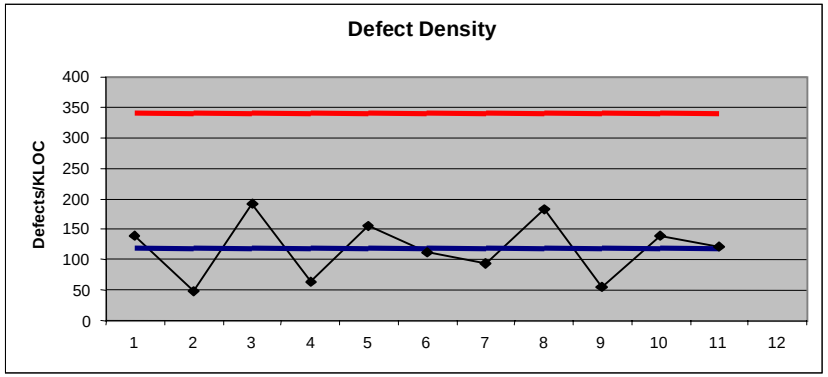
- By focusing on effective time management, TSP can achieve dramatic improvements in time on task, the time per week an individual spends producing product
- XmR run charts are the ideal tool to assess the effectiveness of time management related process changes
- Many TSP projects increase time on task by 50% to 100% in their first 12 months

Optimizing Inspection Process with XmR Charts







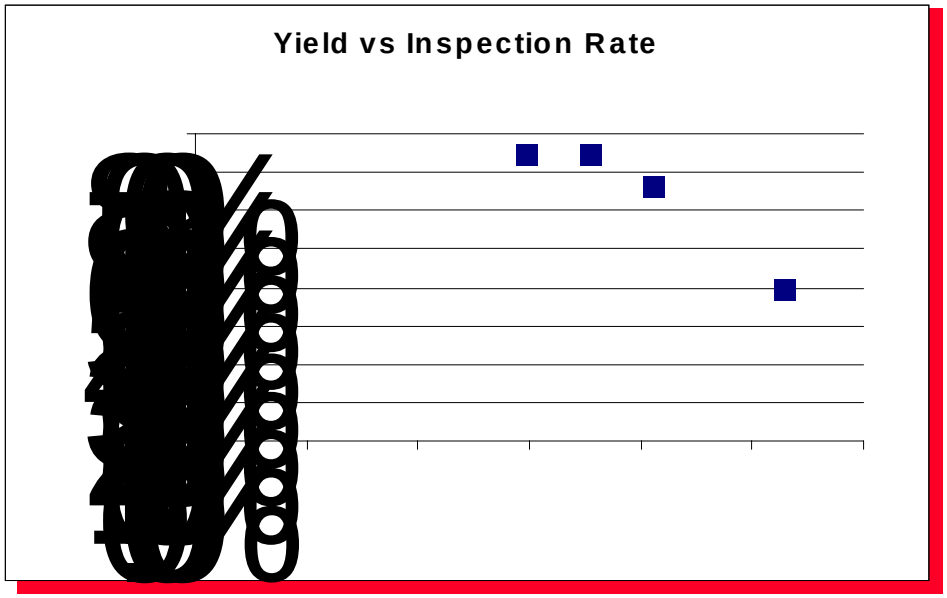


- **Pre-Optimization**
  - average review rate 244 LOCs/hr
  - average defect density 39 defects/KLOC
  - average removal rate 6/hr
- **Post-Optimization**
  - average review rate 138 LOCs/hr
  - average defect density 118 defects/KLOC
  - average removal rate 15/hr

Creating Control Plans For Quality Management

- SPC is used to established control limits on the expected number of defects removed in each process phase
- A control plan is put in place specifying the corrective action to be taken whenever the number of defects removed falls above or below the threshold values
- Example: Too many defects found in test
  - Cancel test and return to review
  - Resume testing after review is complete
  - If still too many defects, decide if scrapping is warranted - A product should be scrapped if the projected removal cost of the remaining defects exceeds the cost of re-working the product with nominal quality levels
  - If the decision is to scrap, assign the product to a different team member

Identifying Control Variables



- Personal yield curves can be developed quickly from the first few weeks of data and used to manage PSP review process
- If the inspection rates correlate with yield, inspection rate can be used as a control variable
- Targeting inspection rate indirectly targets yield

Summary

- PSP & TSP directly address many of the barriers to Six Sigma Introduction
  - Existence of a stable fully instrumented process
  - Willingness of individual engineers to take data and use it for continuous improvement
  - Credibility of process improvement with team members
  - Large data variation normally seen as a result of the wide range of individual skills
  - Noise in effort data caused by inadequate measurement systems
- Six Sigma techniques are natural for analyzing and managing the PSP & TSP processes
- They form a highly synergistic combination that is considerably more than the sum of its parts
- They have the potential move an organization to higher maturity levels quickly while producing significant savings and quality improvements in the near term

If PSP/TSP weren't already available, you would Need to invent something very similar!

Glossary of Terms

CMM®	Capability Maturity Model
COQ	Cost Of Quality
EV	Earned Value
KLOC	Thousand Lines Of Code
LOC	Lines Of Code
PROBE	PROxy Based Estimation
PSP℠	Personal Software Process
ROI	Return On Analysis
SEI	Software Engineering Institute
SPC	Statistical Process Control
SPI	Software Process Improvement
TSP℠	Team Software Process

References

- **A more detailed introduction on using Six Sigma techniques to measure and control process variation and the use of XmR charts was provided earlier at this conference in: *Six Sigma and Software Process Improvement***
- **A more detailed discussion on using Six Sigma techniques to optimize inspections was present earlier at this conference in: *Optimizing Inspections Through the Application of Statistical Management Techniques***
- **For additional information see our web site or to answer any questions contact:**

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