Honeywell

PSP, TSP and 6 Sigma at Honeywell International

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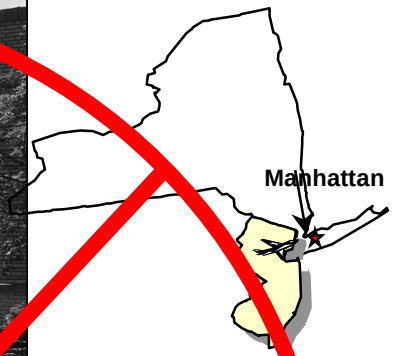
DSS Overview

DSS Headquarters:
Teterboro, New Jersey



Facilities

- 1500 employees
- 800 engineers
- 30 Ph.D. s
- 400 Masters degrees

Awards

- Operational Excellence
- Lean Manufacturing
- Six Sigma
- VOC
- Kaizen
- Technical Excellence

Core Competencies

- Systems engineering
  - –Avionics
  - –Vehicle management
  - –Flight control
  - –Displays
  - –Navigation & pointing
  - –Fire control systems
- Systems software
- Advanced sensors
- Program management

Software Capabilities

- Approximately 100 software engineers
- 40 systems engineers
- 7 SCM/SQA engineers
- Full military standard 498, 2167A, 2168 software development capability
- Typical projects
  - –Embedded real-times systems
  - –Object oriented designs (UML)
  - –Ada, C, C++
  - –20-150 KSLOC

Honeywell Avionics & Integrated Systems

Location:

Teterboro, New Jersey

Facilities

- 600 employees
- 250 engineers

Awards

- Operational Excellence
- Lean Manufacturing
- Six Sigma
- VOC
- Kaizen
- Technical Excellence

Core Competencies

- Systems engineering
  - Avionics
  - Vehicle management
  - Flight control
  - Displays
- Systems software
- Program management

Software Capabilities

- Approximately 50 software engineers
- 40 systems engineers
- 3 SCM/SQA engineers
- Full military standard 498, 2167A, 2168 software development capability
- Typical projects
  - Embedded real-times systems
  - Object oriented designs (UML)
  - Ada, C, C++
  - 20-150 KSLOC

Software Process Center of Excellence

- Chartered with providing process support to Honeywell A&IS, transitioning software process best practices to other Honeywell sites, and providing SPI related services to Honeywell customers
- 12 Software Process Professionals, former members of DSS process staff
- Licensed SEI PSP transition partner
  - 4 PSP instructors

Teterboro's Process Improvement History

Executive Sponsorship Established

Automated Metrics Collection

SEPG Formed

Introduced Inspections

Launched Defect Prevention Teams

Fully Automated Metrics Analysis

First PSP Instructors Authorized

First PSP pilot

First TSP launch w/ SEI

6σ Software Services

SEI Transition Partner

100% PSP Trained SW Staff

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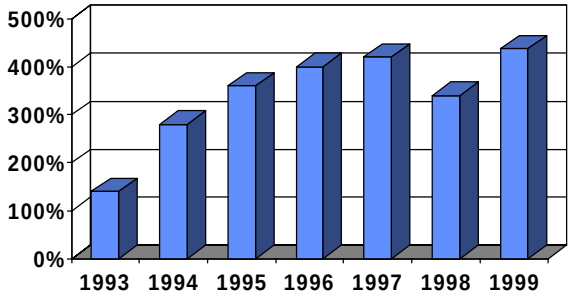
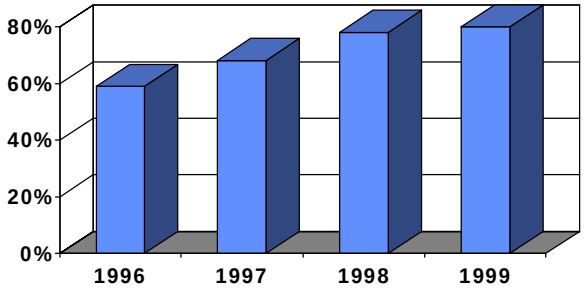
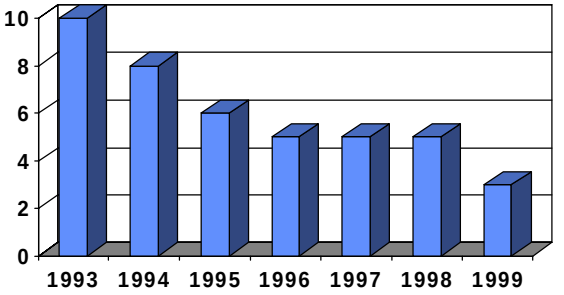
Return On Investment



Peer Review Yields



Defect Density into Integration



SEI's Software Process Initiatives

Software Engineering Institute Process Program

- The SEI Process Program was created in 1986 to improve the practice of software engineering by improving the software engineering process.
- Capability Maturity Model (CMM)
  - A conceptual framework to help organizations
    - characterize the maturity of their process
    - establish goals for process improvement
    - set priorities for immediate actions
    - foster culture of software engineering excellence

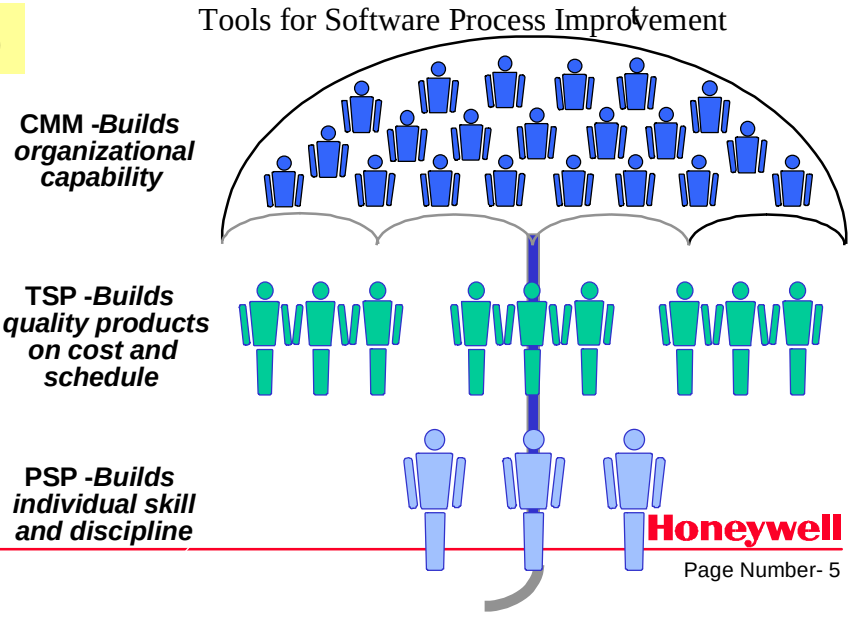
Team Software Process (TSP)

- TSP is a Level 5 process for teams of PSP-trained software engineers with 2 to 20 members.
- TSP addresses software development, enhancement, and repair by high performance, self-directed, interdisciplinary teams
- TSP development started in 1996.
  - Training to be available in late 2000.
  - Multi-team version in pilot phases.

The Personal Software Process (PSP)

- The PSP is a process designed for individual use, based on scaled down industrial software practice.
- It applies to most structured personal tasks.
  - developing program modules
  - defining requirements or processes
  - conducting reviews or tests
  - writing documentation, etc.
- PSP can be extended to support development of large-scale software systems.
- It is a Level 5 process for individuals. It can be used to accelerate an organization from level 2 to level 5

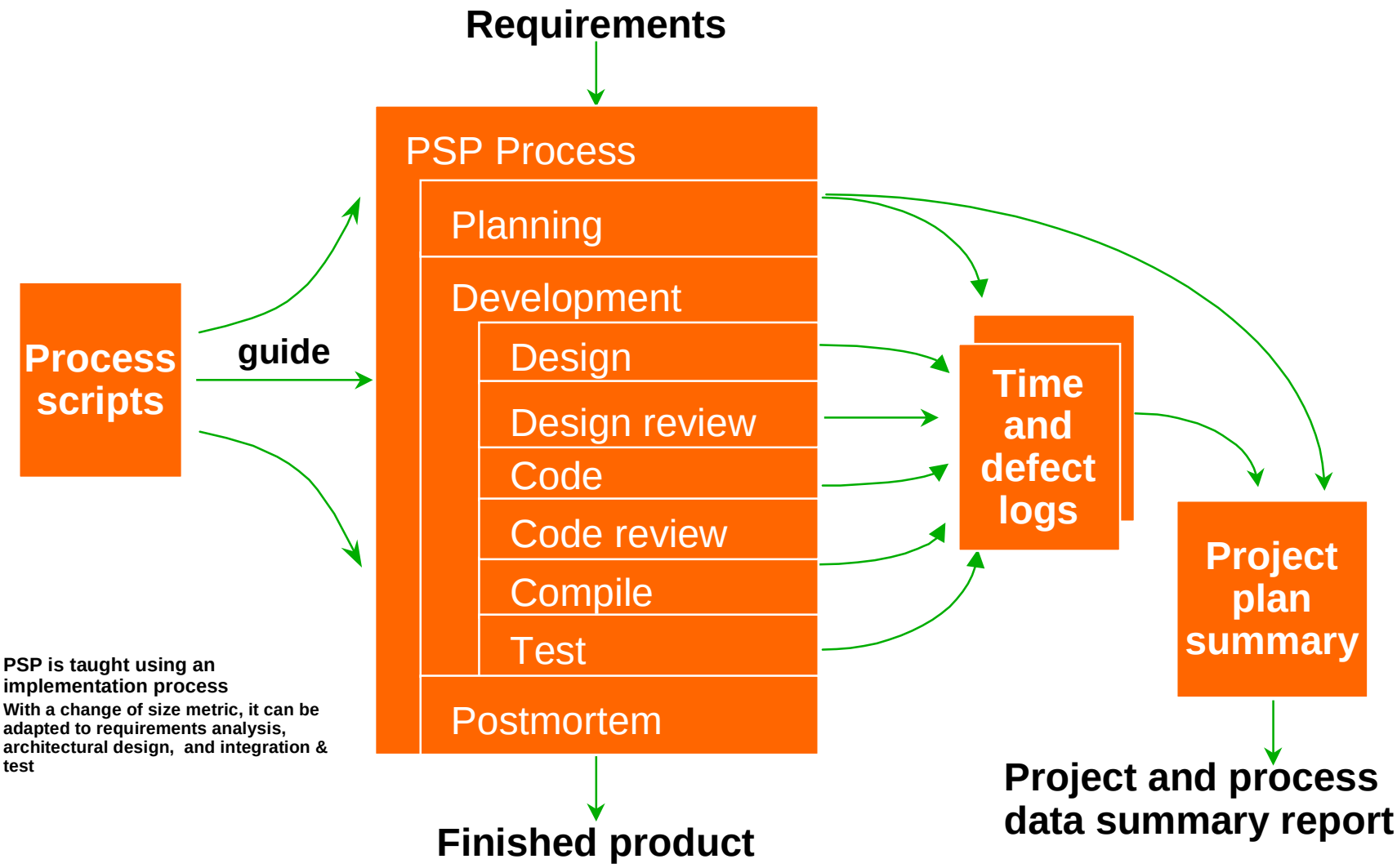
PSP, TSP, & CMM



CMM KPAs Addressed in PSP

Level	Focus	KPAs addressed in the PSP
5 Optimizing	**Continuous process improvement**	**✓Defect prevention** **✓Technology change management** **✓Process change management**
4 Managed	**Product and process quality**	**✓Quantitative process management** **✓Software quality management**
3 Defined	**Engineering process**	**✓Organization process focus** **✓Organization process definition** Training program **✓Integrated software management** **✓Software product engineering** Intergroup coordination **✓Peer reviews**
2 Repeatable	**Project management**	Requirements management **✓Software project planning** **✓Software project tracking** Software subcontract management Software quality assurance Software configuration management
1 Initial		

The PSP Process



- PSP is taught using an implementation process
- With a change of size metric, it can be adapted to requirements analysis, architectural design, and integration & test

In summary

- PSP/TSP is a level 5 process with a 5-6σ capability
- PSP/TSP achieves this quality level by providing a feedback signal consisting real-time metric data that is used by each engineer to optimize his/her personal process
  - The time constants characterizing the feed back paths are quite short, on the order of hours enabling rapid process optimization
- PSP/TSP achieves exceptionally high estimating accuracy by using accurate personal historical data and exploiting basic statistics
- PSP/TSP are efficient processes that impose no cost penalty in achieving exceptionally high quality levels

PSP Deployment

- Began serious consideration of PSP in Q3 97 based on a desire to transfer more SPI responsibility to the individual practitioner
- Started initial pilot in Q1 98, second pilot in Q3 98
- Decided on full scale deployment in Q1 99
- Began revision of organizational level processes and procedures and process automation tools to support PSP/TSP in Q1 99
- Process automation and procedures in place, staff 100% trained Q1 00
- Participated in 10 TSP launches including 2 multi-team launches
- Improvement resources available
  - 5% department budget
  - Average of 40 hrs / person / year for training

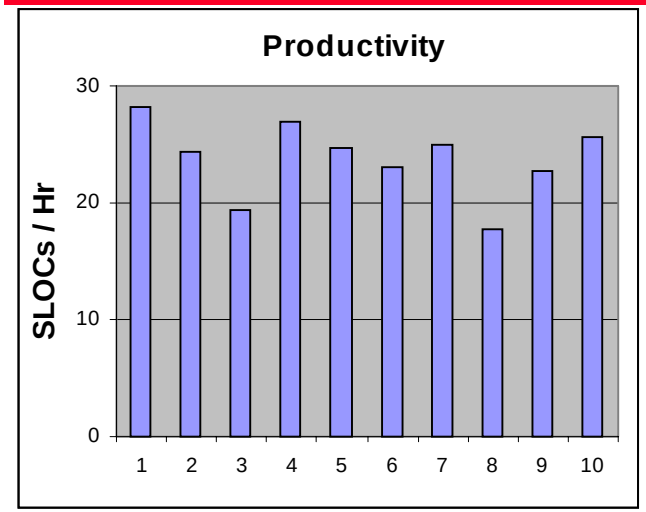
PSP Training

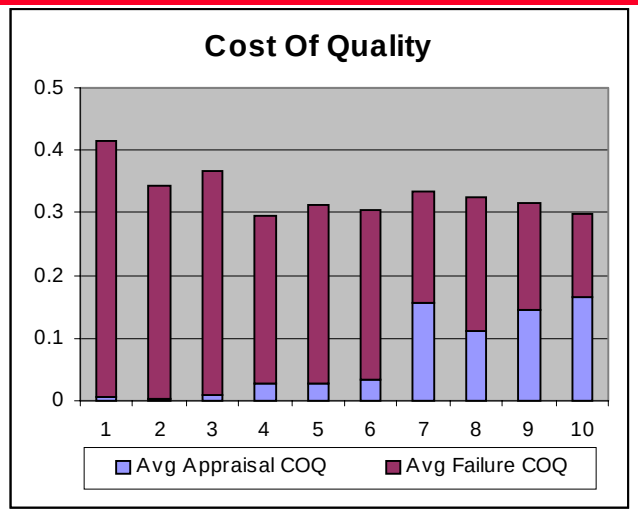
- Approximately 120 students
- Completion rate 79% within 6 months after the course
- Factors affecting completion
  - Persons with limited programming and/or statistics skills had difficulties
  - Programs with tight deadlines cannot find time to do post-course work
  - Resistance to change of existing practice by ~ 5% of students
- Course formats
  - 2 weeks with 2 - 4 week gap
  - 3 weeks
  - Offsite with laptops
  - Average class size 15
  - 2 SEI authorized instructors for adequate personal attention
  - Teams trained as a unit with their first line manager(s)
- Need to provide
  - Automated support for training and grading, e.g. laptops & database
  - Rewards and recognition to motivate employees to complete
  - Time to complete after training is over
  - Post-training coaching/ mentoring

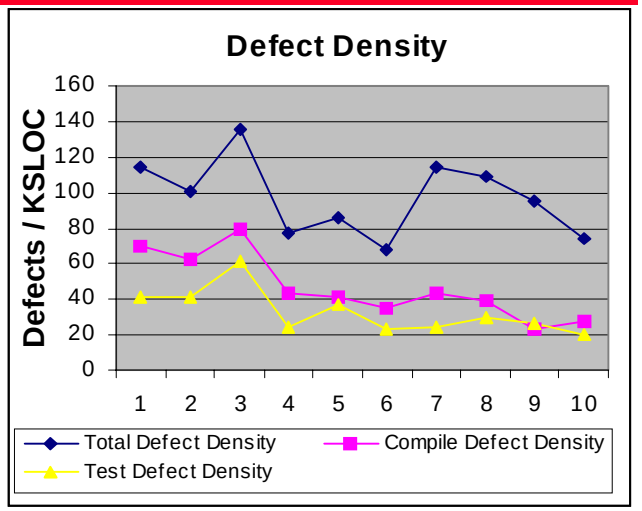
Automation

- Robust automation essential for metrics collection and analysis when using PSP/TSP
- Provided by multi-user client server data base application
- Includes support for
  - Scheduling and keeping records of meetings and inspections
  - Logging and tracking the status of action items
  - Risk management
  - Problem reports
  - TSP launch planning and tracking
  - PSP time and defect logging
  - Estimation (PROBE)
  - Automated metrics collection and analysis

PSP Training Data





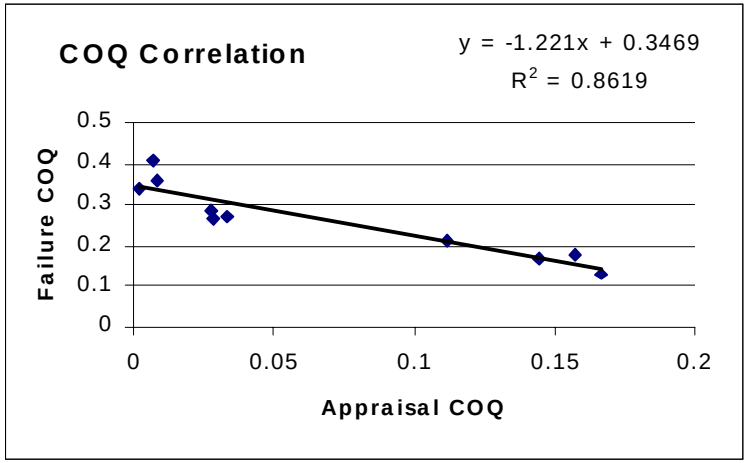


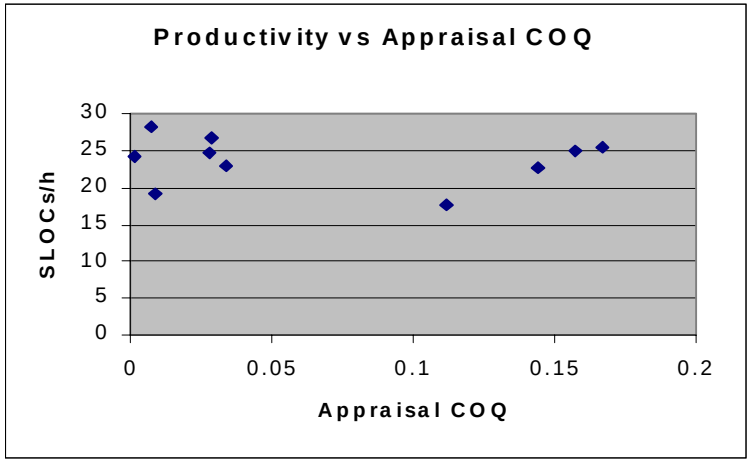
PSP	Productivity (SLOCs/hr)	COQ	Total Defects/KSLOC	Test Defects/KSLOC	Avg Defect Fix Times (minutes)
1.x	24 ± 3.1	33.9 ± 4.5	96.9 ± 23.8	48 ± 11.2	8.9
2.x	23 ± 3.6	31.9 ± 1.5	98.2 ± 17.7	25 ± 4.3	5.4

- **Teterboro training data, PSP 1.x is a level 2 process, PSP 2.x is a level 5 process**
- **Avg. COQ remains flat, variability drops by a factor of 3 increasing predictability**
- **Avg. defect fix time decreases by 40% per defect due to extensive use of reviews**
- **Test defects drop by factor of 2, quality of product entering integration at least doubles, resulting in expected integration improvement of 50%**

Quality Is Free

- **Improved predictability: Average COQ remains flat, but variability drops by a factor of 3**
- **Total defect density stable: 100 defects/KLOC**
- *Since test defect density drops by a factor of 2, quality of product entering integration at least doubles, resulting in an expected decrease of integration effort by 50%*
- **Decrease in average fix time (from 8.9 to 5.4 minutes per defect) due to extensive use of reviews**
- **Linear correlation between appraisal time and decrease in failure time**
- **No correlation of increased appraisal time with productivity**





Pilot Data

- Introduced on last cycle of embedded avionics program
  - Software staff approximately 30
  - Program has a history of missed commitments
  - About half complete at the time
- PSP used for the last build cycle
  - Overall estimating accuracy 7% low (27 weeks planned vs. 29 weeks actual)
  - Reduction in defect escapes into integration & test over pervious cycle > 4x
- Other data
  - Attrition rate 3% vs. site average 15%
  - Second level manager on TSP: “I would never go back to doing it the old way.”
  - On completion the program manager stated: “I never missed a significant milestone once PSP was deployed.”

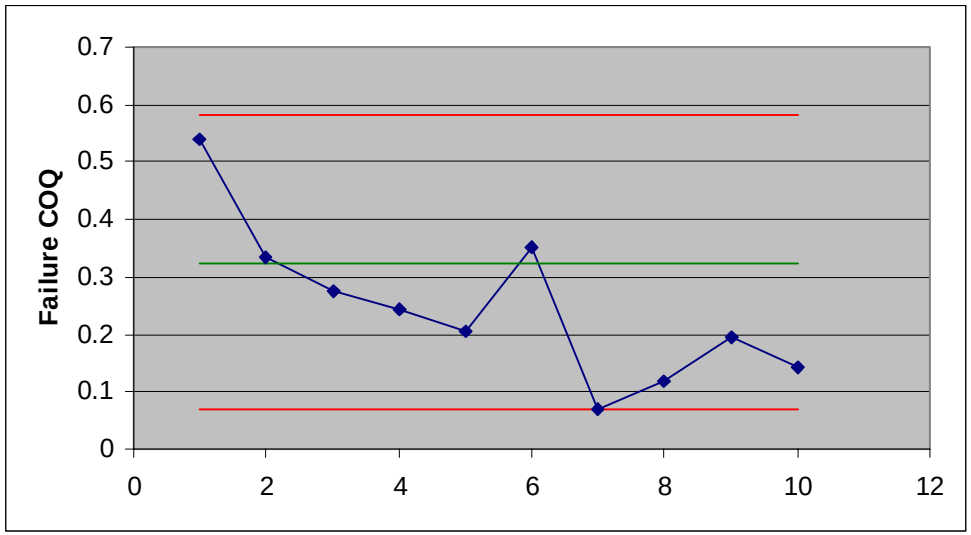
PSP Extensions and 6σ Techniques

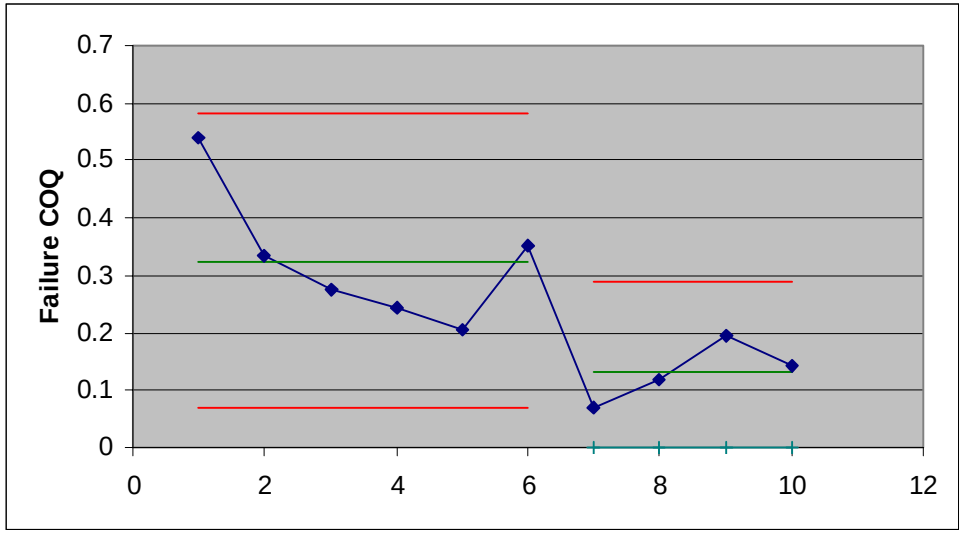
- PSP phases and defect taxonomy extended to cover: requirements analysis, architectural design, integration & system test, as well as implementation
- Development of size metrics for UML diagrams, MatrixX autocode applications
- Application of 6σ statistical analysis techniques to PSP/TSP post mortem phase
  - use of XmR run charts for Statistical Process Control (SPC)
  - Design Of Experiment (DOE) and Analysis of Variance (ANOVA) for dependencies in data

XmR Charts

- X is time series of variables x_i, i = 1,2,...
- R is time series for $r_i = |x_i - x_{i-1}|$
- x_{avg} is average value of X
- mR is average value of R
- X chart shows
  - x_i vs. time
  - X_{avg}
  - $CL_x = X_{avg} \pm 2.660$ mR
- R chart shows
  - r_i vs time
  - mR
  - $CL_r = 3.628$ mR

XmR Example

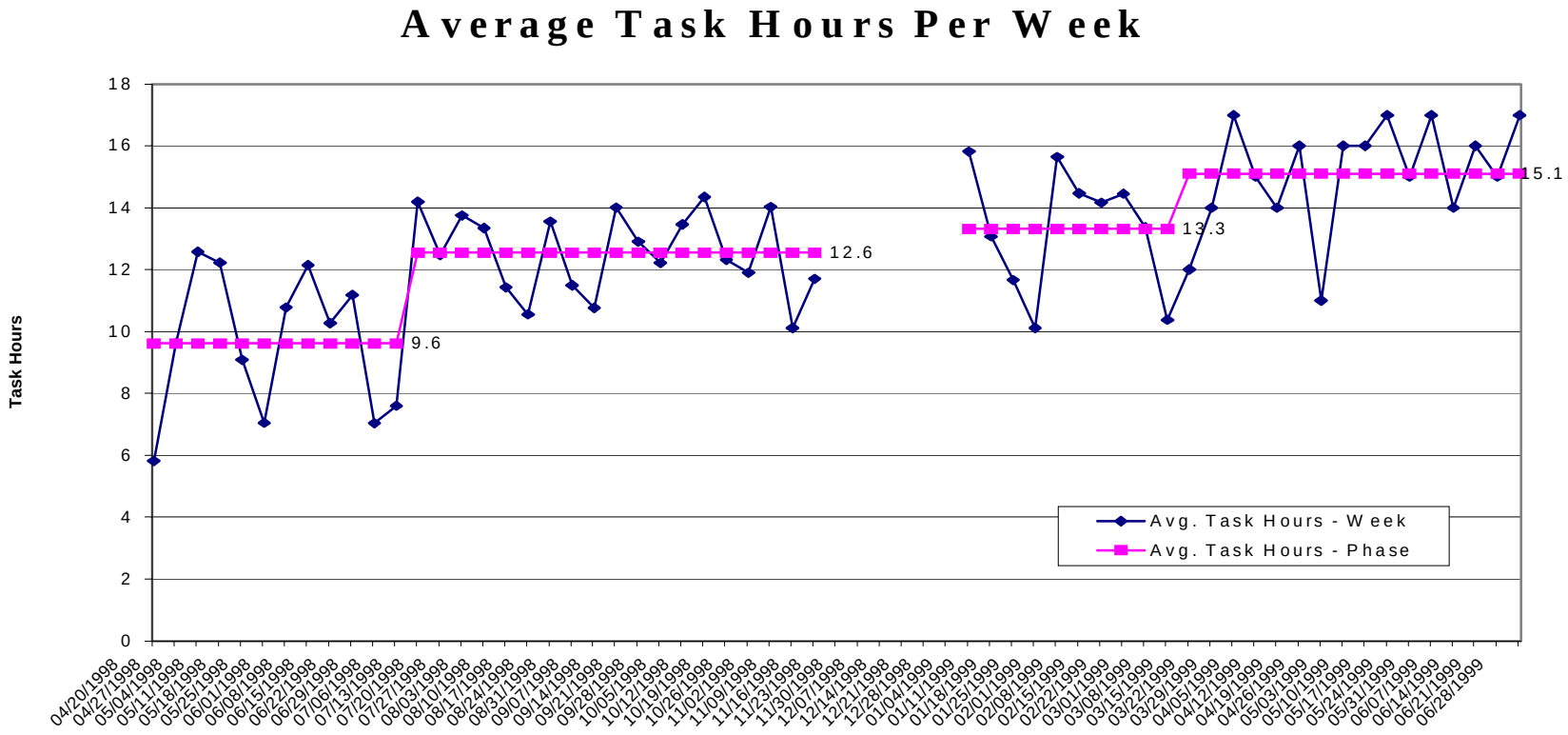




- **A lack of control is indicated whenever**
  - a single point falls outside the three sigma control limits
  - at least two out of three successive values fall on the same side of, and more than two sigma units away from, the central line
  - at least four out of five successive values fall on the same side of, and more than one sigma unit away from, the central line
  - at least 8 successive values fall on the same side of the central line
- **Personal data - reviews introduced at problem 7**
- **Out of control point at 7, plus run more than one σ (8.5%) below mean indicates a significant improvement in process performance**
- **Re-computed mean and range shows the process improvement**

Honeywell

Pilot Task Hours Run Chart



- **Run charts used for task time management and earned value analysis**
- **Initially averaging less than 10 task hours/week**
- **Shifted to 15.1 task hours/week (due to quiet times, better documentation, fewer and more efficient meetings, etc.)**
- **Eventually reach about 18 task hours/week - a direct productivity improvement**

Lessons Learned

- Explicitly identify public and private data “up front”
- TSP teams need to regularly audit their own personal metrics for completeness and consistency
- Quality manager is a critical position on a TSP team
- Robust automation is required for data collection & analysis
- PSP principles can be applied to other life cycle phases provided adequate support and training is provided
- All team members should complete all PSP assignments prior to first TSP launch
- Set uniform standards for everybody and for all work products
- Middle management needs a few weeks to digest the concept of task time being less that 40 hours/week
- Staff design skills emerged as the limiting factor in achieving plan granularity and in increasing task time