The JPL Software Quality Improvement Project

Software Quality Improvement at JPL: What Does It Mean for Practitioners?

Presentation to the IT Symposium
November 4, 2002

Frank Kuykendall and the SQI Project Team

Agenda

- Why are we doing this?
- What are we doing?
- What does it mean for practitioners?
Key Motivators for Software Quality Improvement at JPL

- Experience and formal studies have revealed consistent budget overruns and schedule slips for mission-critical software
- Software is an increasingly significant risk element for a project
  - Missions require increasing software capability and complexity
  - Software often must be developed late in the mission life cycle, reducing opportunities for schedule recovery
- Many missions in concurrent software development
  - Institutional processes needed to reduce project start-up times
- Software practices must increasingly rely on re-use
  - Addressing complex software with aggressive budgets requires reuse of software implementing common functions
- The NASA CIO, Chief Engineering Office, and Office of Safety and Mission Assurance are requiring NASA centers to implement software quality improvement programs
- Caltech has expressed interest in software improvement at JPL

JPL Cost/Risk Study

- A 1999 study of software costs and risks for seven JPL projects found significant, specific issues in:
  - Project planning
  - Requirements & design
  - Experience and teaming
  - Testing
  - Software inheritance
CMMI-Based Software Assessment

- An assessment of software development practices at JPL was completed on October 22, 2002
  - Based on the Capability Maturity Model-Integrated (CMMI)
  - Examined four JPL projects
- Some strengths observed:
  - Evidence of strong JPL senior management commitment to software improvement
  - Projects appear supportive of process improvement efforts
- Some areas where opportunities for improvement were observed:
  - Software quality assurance
  - Planning of development processes by projects
  - Monitoring and control of process activities
  - Measurement of project products and processes
  - Risk management

Example Business Benefits of Improved Software Practices

<table>
<thead>
<tr>
<th>Organization</th>
<th>Payoff Summary</th>
<th>Reference</th>
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<tbody>
<tr>
<td>Boeing Info. Systems</td>
<td>Project estimate within 20% using historical data, CPI 38% better, defect containment effectiveness at 80%, cycle time improved 30%, staff support needs down 50%, staff size reduced 31%, customer satisfaction score up 10%, $5.5M saved in 1998 alone (1992 – 1998 results)</td>
<td>Vu, J. (1997)</td>
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<td>Boeing BTS</td>
<td>Customer satisfaction rated excellent, pre-release defect containment effectiveness at 80%, 21% reduction in rework/inspection, benefit, employee satisfaction level from mean of 6.7 to 6.8, operational systems performance issues to bull's-eye level, 5 process models into new program</td>
<td>Tamagawa, S. &amp; Higa, G. (1997)</td>
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<td>Balsam</td>
<td>Defects 10X lower than industry average, customer satisfaction rate improved from 60 to 91% over 4 years, achieved 9.5% reduction in 60 to 90 system with no reported defects</td>
<td>Balsam Press Release, Feb. 5, 1997</td>
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<td>HP EDAS</td>
<td>25X productivity gain over norm, 90% defect rate reduction, cycle time down to 5-6 months</td>
<td>Linn &amp; Boss (1996)</td>
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<tr>
<td>Harris ISD CPL</td>
<td>25X productivity gain over norm, 90% defect rate reduction, cycle time down to 5-6 months</td>
<td>Rosson, D., Davidson, S. &amp; Bearden, L. (1997)</td>
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<tr>
<td>Motorola</td>
<td>32% productivity improvement, 2X cycle time reduction, 77% quality improvement, results from 95% of defect discovery in requirements software, 20% of product development starts with code</td>
<td>Winer, J. (1996)</td>
</tr>
<tr>
<td>Motorola GED</td>
<td>On 5 current programs compared to baseline – each CMMI level increases quality by 2X, significant decrease in cycle time as higher levels reached (2-7X), productivity increases of 2-3X at highest levels of maturity, 5.77X NP ROI</td>
<td>Diaz, M. &amp; Skigo, J. (1997)</td>
</tr>
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<td>SAC/Health Tech.</td>
<td>30% improvement in customer satisfaction, 11% reduction in error rate, 14% annual improvement in developer productivity, production rate up 50%</td>
<td>Ham, L. &amp; Judson, D. (1997)</td>
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SQI Project Goal & Objectives

Establish an operational program that results in the continuous, measurable improvement of software quality at JPL

- Improve software cost and schedule predictability
- Reduce software defect rates during test and operations
- Increase software development productivity
- Provide an infrastructure that promotes software reuse
- Reduce project start-up times

SQI Implementation Phasing

- Institutionalize SQI
  - Optimize processes
  - Operationalize Project support
  - Tailor for additional domains
- Execute Defined Process
  - Assess effectiveness
  - Establish engineering models
  - Tailor for specific domains
- Establish JPL SQI Infrastructure
  - Define and deploy core processes & principles
  - Establish JPL software profile
  - Establish measurement program
  - Provide Project consulting resources

FY02-04 FY05-06 FY07-08
Key FY02 Accomplishments

- Formed Software Engineering Management Oversight Group (SEMOG)
- Engaged senior management and obtained buy-in
- Completed & signed SQI Initiation Plan; developed draft detailed Implementation Plan
- Aligned with NASA Software Working Group (SWG)
- Developed a profile of JPL software
- Completed Corrective Action Notice (CAN) 168
- Developed an initial set of SQI core assets, e.g.
  - Developed FP Practices, Software Design Principles, Software Development Requirements, handbooks, and templates
  - Created costing and metrics approaches, models, & documents
  - Expanded Software Tool Service (STS) support to projects for software license acquisition and tool demonstrations
  - Created and delivered many software courses, modules, & briefings; established JPL software web site
- Provided consulting and other services to projects

SQI Project Thrust Areas

<table>
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<tr>
<th>Process &amp; Product Definition (PPD)</th>
<th>Measurement &amp; Benchmarking (M&amp;B)</th>
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<tbody>
<tr>
<td>Capture, define, and refine repeatable processes and a set of engineering practices for project use</td>
<td>Provide measurement infrastructure for projects, conduct empirical analyses, and package experiences for future use</td>
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<table>
<thead>
<tr>
<th>Software Technology Infusion (STI)</th>
<th>Deployment</th>
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<tr>
<td>Identify, evaluate, and support software tools and techniques to facilitate process and product improvement</td>
<td>Infuse practices into project use; provide training, products, mentoring and consulting for projects</td>
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The Software Tool Service

Practitioners

- Available licenses
- Ideas and needs
- Awareness and vendor training
- MIST Lab license server
- Project Licenses
  - Green Hilleli Multi-integrated development environment
  - Wind River real-time operating system
  - Others
- Commercial suppliers

Projects

- Needs and Funding
- MDS
- DI
- MER
- PRs
- Institutional POC
- Negotiation of scope
- POs
- JPL Acquisitions

FY03 Plans in Brief

- Define and measure success criteria
- Define, collect, and analyze measurements of current practices, products, and SQI asset utilization
- Work with senior management to plan & implement new improvement opportunities

- Primary focus is on mission-critical software—others supported as resources permit

SQI at JPL for IT Symposium, FNOCL-11

SQI at JPL for IT Symposium, FNOCL-12
Practitioner Experiences:
Enhanced Morale

![Bar chart showing percentage of employees who rate their own morale as "Good" or "Excellent" for different levels of the Software Capability Maturity Model (SW-CMM) level.]

Source: James Herbsleb et al., "Software Quality and the Capability Maturity Model," CACM, June 1997

Practitioner Experiences:
Ogden Air Logistics Center, Software Engineering Division

<table>
<thead>
<tr>
<th>Survey Question to Practitioners Who Had Been In CMM-Based Process Improvement Effort for Its Duration</th>
<th>Responses (n=18)</th>
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<tbody>
<tr>
<td>Have you been more constrained or less constrained in performing your job?</td>
<td>More constrained: 10</td>
</tr>
<tr>
<td></td>
<td>No difference: 4</td>
</tr>
<tr>
<td></td>
<td>Less constrained: 4</td>
</tr>
<tr>
<td>Is it easier to perform your duties with respect to tools, working environment, etc.?</td>
<td>Much easier: 13</td>
</tr>
<tr>
<td></td>
<td>A little easier: 2</td>
</tr>
<tr>
<td></td>
<td>About the same: 2</td>
</tr>
<tr>
<td></td>
<td>A little harder: 1</td>
</tr>
<tr>
<td>Are there more project surprises or fewer?</td>
<td>Fewer: 13</td>
</tr>
<tr>
<td></td>
<td>No difference: 4</td>
</tr>
<tr>
<td></td>
<td>More: 1</td>
</tr>
<tr>
<td>Do you feel that you have more input and control into project planning or less?</td>
<td>More: 12</td>
</tr>
<tr>
<td></td>
<td>A little more: 2</td>
</tr>
<tr>
<td></td>
<td>Same: 2</td>
</tr>
<tr>
<td></td>
<td>Less: 2</td>
</tr>
<tr>
<td>Do you feel that our CMM efforts have been a positive influence?</td>
<td>Yes: 18</td>
</tr>
<tr>
<td></td>
<td>No: 0</td>
</tr>
<tr>
<td>Do you feel you are producing better quality software?</td>
<td>Has improved: 16</td>
</tr>
<tr>
<td></td>
<td>Always was good: 2</td>
</tr>
</tbody>
</table>

Source: Leon G. Oldham et al., "Benefits Realized from Climbing the CMM Ladder," Crosstalk, May 1999

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Practitioner Experiences: Boeing Space Transportation Systems (CMM Level 5)

- Extremely Satisfied 10
- Highly Satisfied 9
- Very Satisfied 8
- Satisfied and Comfortable 7
- Not quite satisfied 6
- Neutral or don't care 5
- Not very excited about it 4
- Dissatisfied 3
- Very Dissatisfied 2
- Highly dissatisfied 1


Practitioner Experiences: Ericsson (CMM Level 3)

Employee Satisfaction vs CMM

Source: Hena-Juergen Kugler, "Is Software Engineering Feasible?", 1997

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Potential Benefits and Drawbacks for Practitioners at JPL

- More reasonable and predictable schedules
- Less stress
- Ability to produce better products
- Less rework
- Earlier detection of defects
- Higher productivity
- Easier transitions from project to project
- Better interactions within and among teams
- Faster start-up of projects

- Less freedom in creating processes
- Increased need for documentation
- More scrutiny in use of defined processes
- More peer review of work products
- Increased need to produce measures of performance
- Higher expectations from management

For Further Information

- Attend upcoming panel discussion with practitioners from software organizations with high-maturity processes
  - Tentatively planned for mid-December or mid-January
- Visit the JPL Software web site:
  http://software
- Contact the Software Quality Improvement Project:
  - Frank Kuykendall, Project Manager, x32828
    - Frank.Kuykendall@jpl.nasa.gov
  - Trisha Jansma, Deployment Element Manager, x40647
    - P.A.Jansma@jpl.nasa.gov