CMMI Implementation for Software at JPL

NDIA/SEI CMMI Technology Conference and User Group
November 16-20, 2003, Denver, CO

P. A. "Trisha" Jansma
SQI Deployment Element

Software Quality Improvement (SQI) Project
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA 91109-8099

©California Institute of Technology 2003

Topics to be Covered

- Background
  - About JPL and JPL's Software Community
  - Software Quality Improvement (SQI) Project Overview
- JPL's CMMI Implementation Approach
  - JPL CMMI Profile – Process Areas by FY
  - JPL CMMI Achievement Roadmap
- JPL Lessons Learned
  - CMMI Implementation
  - CMMI Class B Appraisals
- Backup Slides
  - SQI Accomplishments to Date
  - SQI Services and Products

About Jet Propulsion Laboratory

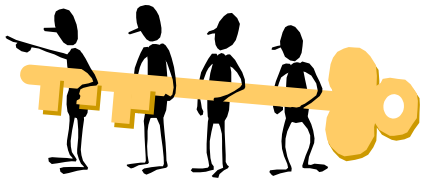
- Non-profit federally funded research and development center (FFRDC), located in Pasadena, California.
- Operated under contract by the California Institute of Technology (Caltech) for the National Aeronautics and Space Administration (NASA).
- Part of the U.S. aerospace industry, and NASA's lead center for robotic exploration of the solar system.
  - Also conducts tasks for a variety of other federal agencies, such as Dept. of Defense, Dept. of Transportation, Dept. of Energy, etc.
- Has approximately 5500 employees:
  - 4500 in the technical and programmatic divisions
  - 1000 in the administrative divisions.
- Annual budget of approximately $1.4 billion.

JPL's Software Community

- JPL's Software Community consists of approximately 1200 - 1300 people, including:
  - Practitioners in the Information Systems and Computer Science Job Family
  - Software Managers in either Line Management or Program/Project Management.
  - Personnel who are categorized as Engineering and Technical, provided at least 50% of their work is software-intensive.

- SQI's initial focus is on mission-critical software for flight projects, their spacecraft and instrument systems, and their ground systems, including the following roles:
  - Project Element Managers (PEMs)
  - Software Line Managers
  - Cognizant Engineers (Cog Es)
  - Software Systems Engineers
  - Software Engineers
  - Software Test Engineers
  - Software Quality Assurance (SQA) Engineers
  - Mission Assurance Managers (MAMs)

Key Motivators for Software Quality Improvement at JPL



- Some recent, highly visible failures occurred in which software was implicated in mission loss (e.g., Mars ’98)
- Experience as well as formal studies revealed frequent 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 must often be developed late in the mission life-cycle, minimizing opportunities for schedule recovery.
- Many missions are in concurrent software development.
  - Institutional processes reduce project start-up times.
- 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 all NASA Centers to implement software quality improvement programs.

Real changes in the external environment implied that serious change was needed.

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, and the quality of mission-critical software
- Reduce project start-up times
- Increase software development productivity
- Reduce software defect rates during testing and operations
- Establish an infrastructure that promotes reuse of software products

Roles in Process Improvement

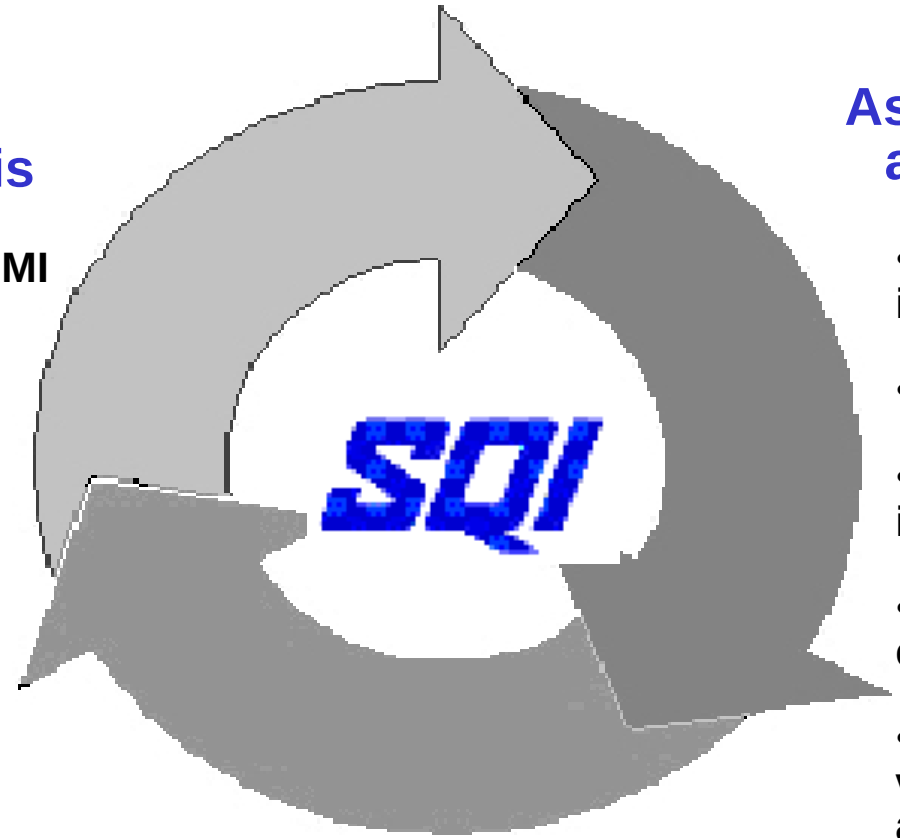
- The SQI Project provides facilitation and support
  - Process asset development and capture of best practices
  - Deployment, training and consulting
  - Appraisals
- Core Engineering & Science Directorate line organizations identify needs, provide commitment, incentives, active communication, and monitoring
- Program Directorates provide project commitment, prioritization and compliance direction
- A Senior Management Group provides overall line, program, and project coordination and integration with systems engineering initiative.
  - Directors For…
  - Software Process Owner and SQI Project Manager
  - Four key Section Managers
  - Systems Engineering Initiative Leader
  - Senior Manager from Office of Safety and Mission Assurance (OSMA)
- SEMOG (Software Engineering Management Oversight Group) provides advice and feedback from lab-wide stakeholder representatives

SQI Approach

A Continuous Improvement Focus

Improvement Planning & Analysis

- Benchmark against CMMI framework
- Conduct CMMI-based assessments
- Conduct general and targeted surveys
- Collect measurements for analysis
- Capture experiences



Asset Development and Deployment

- Leverage from industry best practices
- Involve practitioners
- Build from past JPL & industry experiences
- Focus on role-based education & training
- Conduct outreach via website, brochure and direct contact

SQI transitioned to using CMMI as a framework for achieving JPL's business goals and objectives

Project Support

- Support all mission software development, but initially focus on mission-critical software

Considerations Used for Selecting JPL's CMMI Profile (PAs by FY)

- Although the Continuous Representation will be used, JPL's Senior Management and other oversight groups are more familiar and comfortable with the staged level concept, as per CMM.
- SQI should take into account the interdependencies among the CMMI Process Areas, Generic Goals, and Generic Practices in order to formulate capability profiles that make sense.
- SQI should create some opportunities to show progress early
  - e.g., improvement in Capability Level in one or more process areas relatively quickly (say within a year)

- SQI should strike a balance between choosing improvements that will be perceived by the overall JPL software community as meaningful, vs. improvements that are potentially "less popular," but required by the model.
- SQI should strike a balance between breadth (number of PAs) and depth (capability level) in proposing profiles.

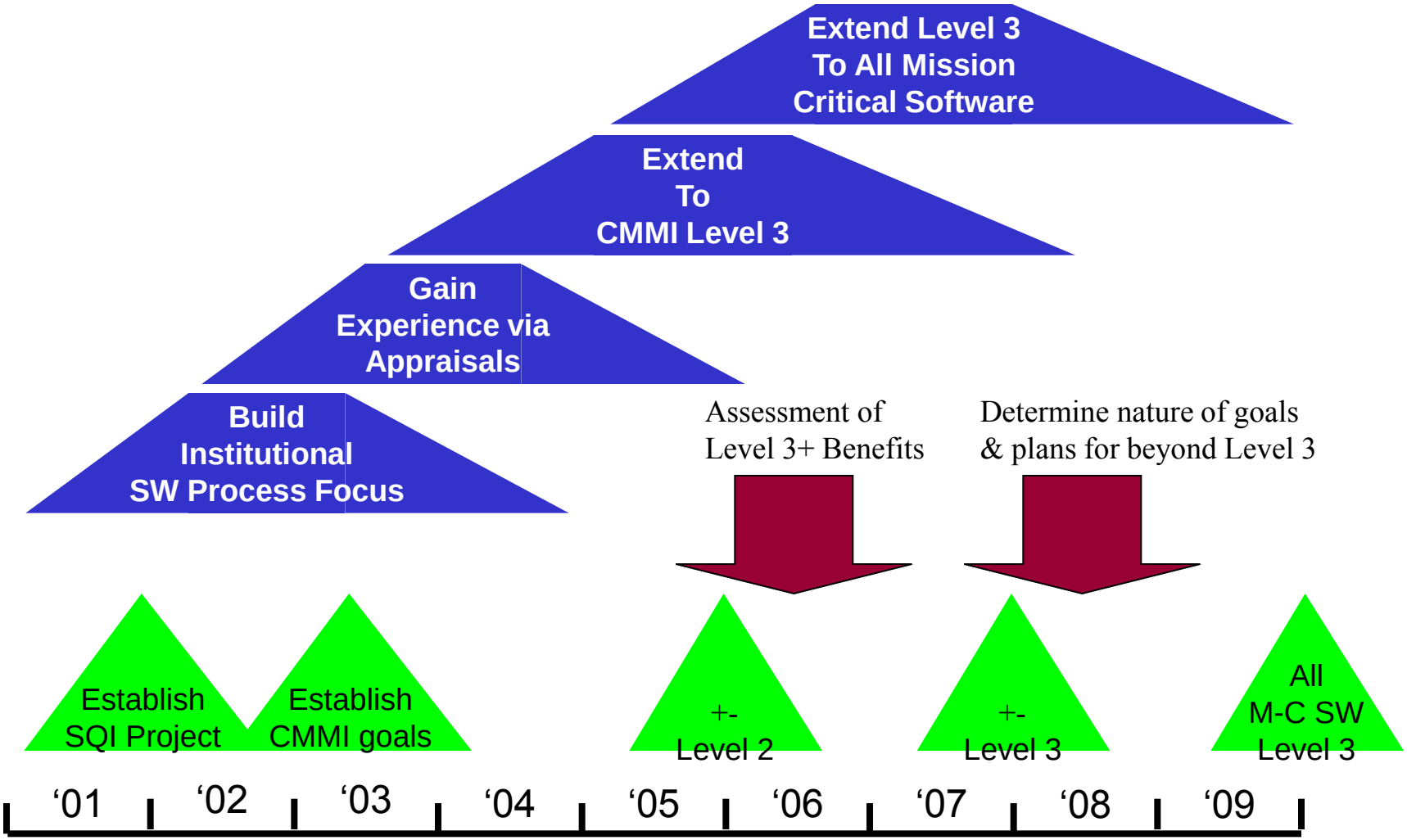
JPL's Initial Target CMMI Profile

Key

- p — Partial Level 2
- 2 — Capability Level 2
- 3 — Capability Level 3

	Level 2 PAs							Level 3 PAs										
	Requirements Mgmt.	Project Planning	Proj. Mon. & Ctrl.	Supplier Agrmt. Mgmt.	Measurement & Anal.	Prod. & Proc. QA	Configuration Mgmt.	Requirements Defn.	Technical Solution	Product Integration	Verification	Validation	Org. Process Focus	Org. Process Defn.	Org. Training	Integrated Proj. Mgmt.	Risk Management	Decision Anal. & Resol.
	REQM	PP	PMC	SAM	MA	PPQA	CM	RD	TS	PI	Ver	Val	OPF	OPD	OT	IPM	RSKM	DAR
FY04													2	2	2			
FY05	2	2	2	p	2	p	2						3	3	3		2	
FY06	2	2	2	2	2	2	2	2	2		2		3	3	3		2	
FY07	3	3	3	3	3	3	3	3	3	2	3	2	3	3	3	2	3	2

CMMI Achievement Timeframe



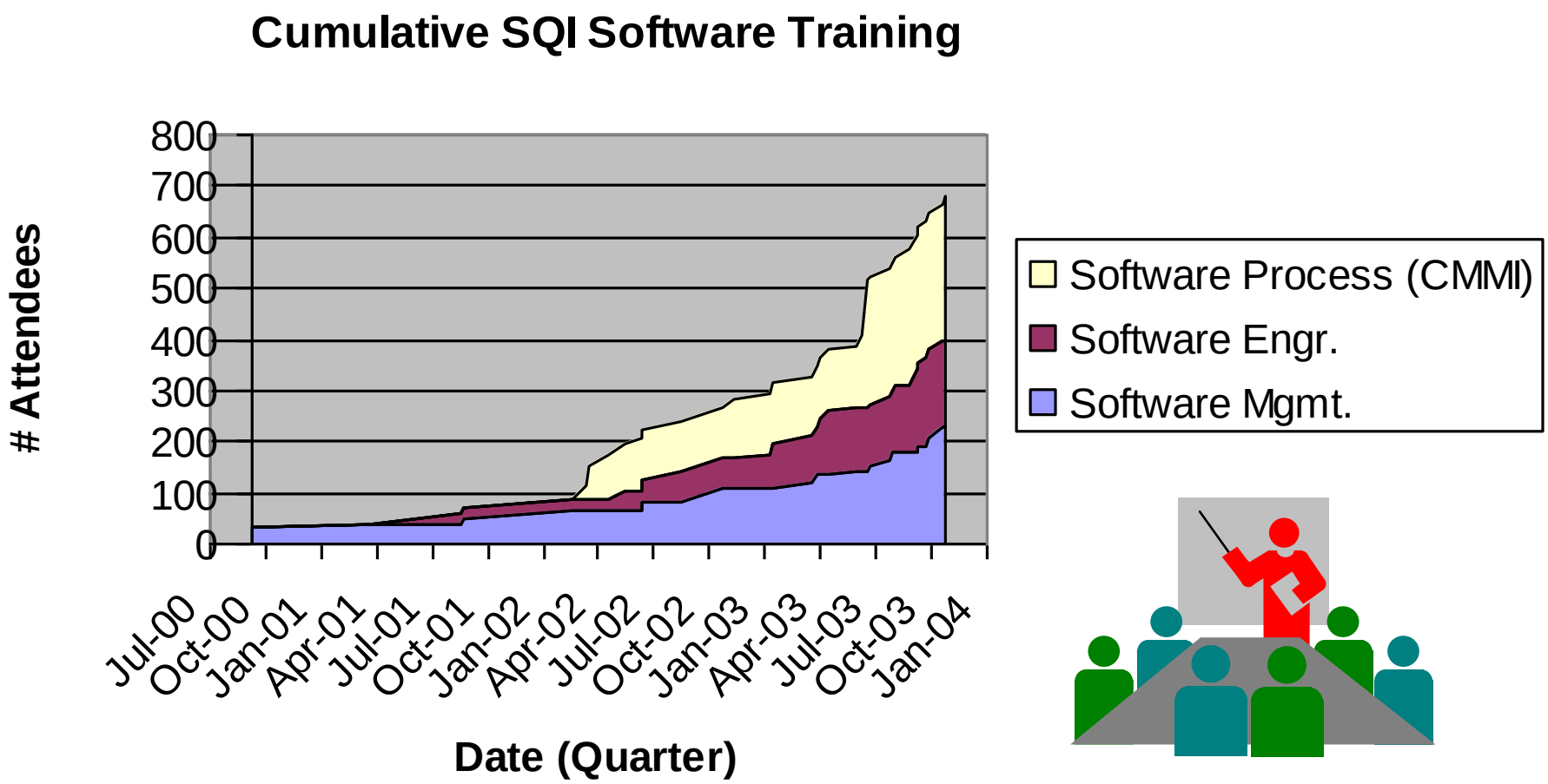
JPL CMMI Lessons Learned

- Commitment of management is very important
  - Director for . . . Section Manager, Technical Group Supervisor
- Bottom-up implementation is tough (vs. “top-down” decree)
  - Need to win the “hearts and minds” at the local level
- Focus CMMI Implementation on a small target audience
  - Focus on four representative “target” sections and at most two projects per section.
    - Focus section efforts on receptive groups and projects.
    - Monitor projects throughout the year to provide guidance on progress.
  - Name a section Process Engineer and assign a corresponding SQI Representative or “Shepherd” to support him.
  - Aim for “Adoption” on the OCM curve for the target sections.
  - Aim for “Awareness” and “Understanding” on the OCM curve for the broader Software Community.
- Shift focus from rote statement of CMMI PAs to a deeper understanding CMMI processes, goals and practices.

JPL CMMI Implementation Plans

- Emphasize supporting software development (project work) with the CMMI practices as a guide
- Evaluate findings, plus recommendations provided by findings, to prioritize practices to be addressed
- Plan activities to raise the level of selected specific and generic practices.
  - Avoid slavish creation of artifacts to satisfy the model.
- Conduct annual Class B Appraisals, focusing on CMMI M2 Process Areas for at most six projects and follow up on findings
- Conduct training regularly to support selected CMMI objectives.
- Consider benchmarking other organizations
  - Raytheon, Northrup Grumman, other NASA Centers (MSFC & JSC)
- Address PPQA Process Area and GP 2.9 earlier than originally planned since it affects all other PAs.

Training Is a Key Component



JPL Class B Appraisal Approach

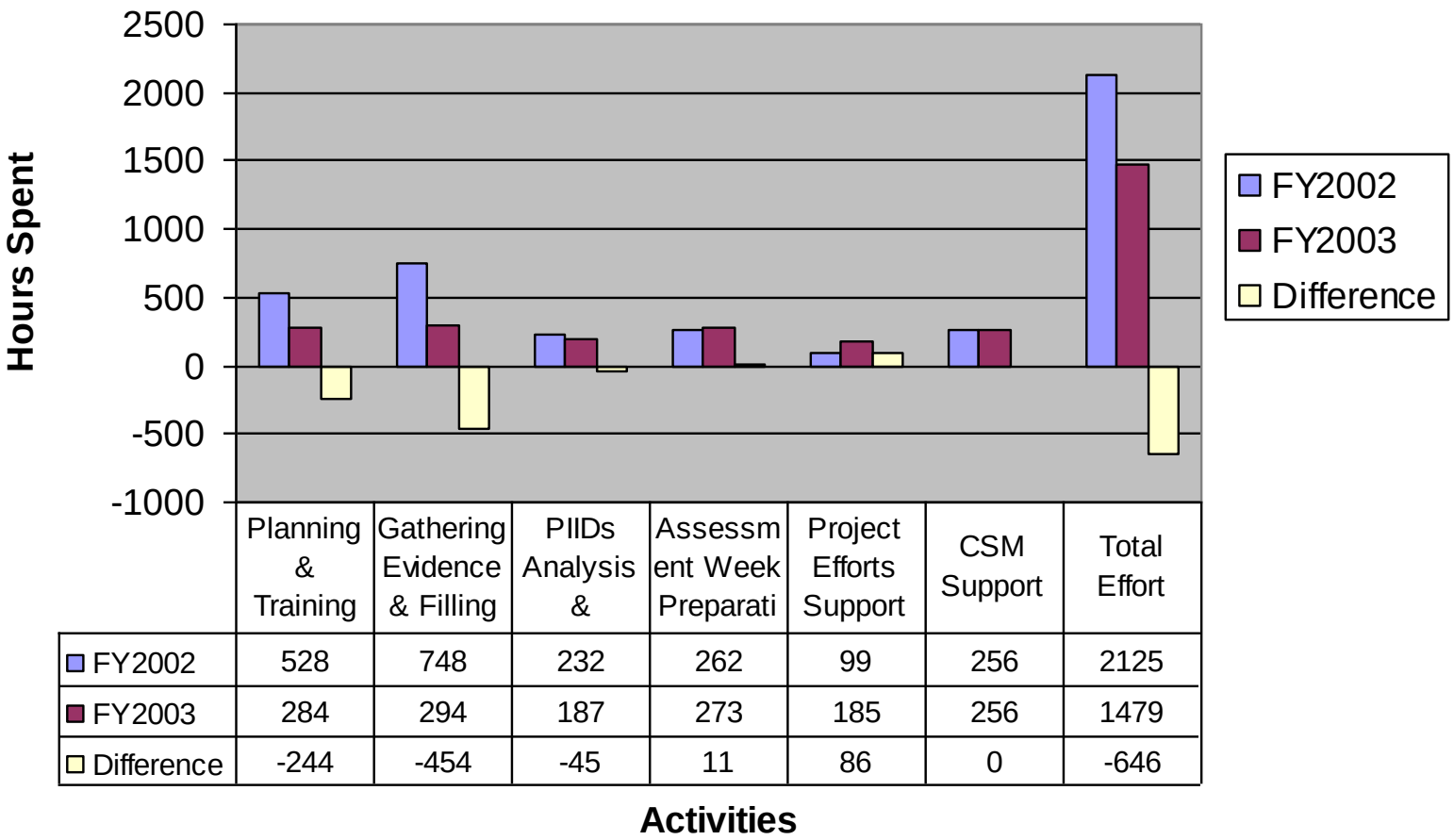
FY2002 Class B Appraisal

- 11 CMMI Process Areas included:
  - Project Planning
  - Project Monitor and Control
  - Supplier Agreement Management
  - Process and Product Quality Assurance
  - Configuration Management
  - Measurement and Analysis
  - Requirements Management
  - Requirements Development
  - Risk Management
  - Organizational Process Focus
  - Organizational Process Definition
- 4 projects included, plus the SQI Project (for Process Mgmt PAs)
- 6 appraisers all new to CMMI
- 2 external CSM Auditors

FY2003 Class B Appraisal

- 8 CMMI Process Areas included:
  - Project Planning
  - Project Monitor and Control
  - Supplier Agreement Management
  - Process and Product Quality Assurance
  - Configuration Management
  - Measurement and Analysis
  - Requirements Management
  - Verification
- 6 projects included
  - 2 each from 3 target sections
- 6 appraisers (3 experienced, 3 new) in 3 “mini-teams” --
  - 1 experienced & 1 new person per team; 1 person per project
- 2 external CSM Auditors

Comparison of Appraisal Effort by FY



	Planning & Training	Gathering Evidence & Filling	PIIDs Analysis &	Assessment Week Preparati	Project Efforts Support	CSM Support	Total Effort
FY2002	528	748	232	262	99	256	2125
FY2003	284	294	187	273	185	256	1479
Difference	-244	-454	-45	11	86	0	-646

FY2003 effort was ~70% that of FY2002

Comparison of FY2002 to FY2003

- Effort for FY2002 Class B Appraisal was ~2100 hours.
- Effort for FY2003 Class B Appraisal was reduced to ~1500 hours due to the following factors:
  - An experienced team, which led to better a understanding of the model and a sharper focus on evidence
  - Assessed 8 PAs for 6 projects vs. 9 PAs for 4 Projects + 2 SQI PAs
  - A change in the way artifacts were collected:
    - Used relaxed criteria for artifacts (“one artifact” rule)
    - Exhortation not to over-engineer things (i.e., “Cut time in half.”)
  - Involvement of task lead in characterization (on one project)
  - Interleaving evidence collection, pre-characterization, and leveling
  - Consultant support throughout the evidence collection and pre-characterization
  - But project “protection” of personnel may have excluded relevant data and did hamper project learning about CMMI best practices

Lessons Learned from CMMI Class B Appraisals (1)

- Focus assessors on an entire project for all PAs, rather than collecting artifacts for PAs across several projects.
- Leveling sessions are very important in gaining understanding of the model.
- Need 3-4 months to do discovery and find evidence
  - 2 months is just too short
- Call in experts to support internal Class B Appraisals rather than just depending on the *Intro. To CMMI* class for understanding the model
- Set aside time (a couple of months) to get project buy-in to participate in the Class B Appraisal.
  - Just getting Line Organization commitment is not enough, you need project commitment too.
- PPQA Process Area and GP 2.9 needs to be addressed early on since it affects all other PAs.

Lessons Learned from CMMI Class B Appraisals (2)

- Having a strong site coordinator helped a lot
  - Aggregation went well
- Able to collect data and artifacts more easily second time.
  - We knew what to look for. We looked for the answer instead of the artifact.
- Involving project being appraised in the characterization process aided practitioners in understanding the model.
  - Possible only in informal appraisals.
- Having CSM Auditors involved on site half-time for 3-4 months provided leveling of the characterization
- Helpful to start characterization early
- JPL was close to a Class A so we learned what a real SCAMPI might look like.
  - Class C could be done much cheaper with less fidelity.
- Used the same team to collect data and to assess it
  - Better to have projects fill out PIIDs themselves with guidance from the “Section Shepherds”.
- Ensure assessment life-cycle is not too compressed.
  - Otherwise it makes it difficult to ensure you have the right evidence.
  - Spread preparation time over several months.

Recommendations

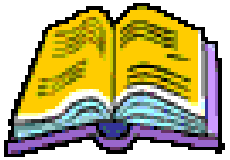
- Select your on-site appraisal coordinator carefully.
  - When he/she is well-organized and works all the logistical details, it greatly facilitates the process.
- Hold the project Intro meeting early so that you understand the characteristics and nature of the project being assessed.
- Involve projects in the characterization for informal appraisals.
- Establish criteria to determine when a specific practice is fulfilled.
- Identify a small set of artifacts in the projects that map to the specific practices, and include in PIID templates.
- Schedule the In-briefing so that senior management can attend and demonstrate commitment.
- Have the assessment team meet weekly to discuss progress & issues.
- Record effort for each person weekly by type of activity.
- Maintain a good sense of humor. *("He who laughs, lasts.")*

Backup Slides

SQI Project Elements

Process & Product Definition

Capture, define, and refine repeatable processes and a set of engineering practices for project use



Measurement & Benchmarking

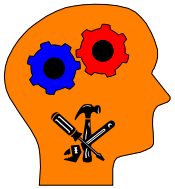
Provide measurement infrastructure for projects, conduct empirical analysis, and package experiences for future use

Project Engineering

Provide overall technical work element integration

Software Technology Infusion

Identify, evaluate, and support software tools and techniques to facilitate process and product improvement



Deployment

Promote communication and infuse practices into project use; provide education, training and consulting for projects; provide SQI Project infrastructure.

SQI Accomplishments to Date

- **SQI Project Management**
  - SQI Project Plan
  - $olid budget and funding $ources
  - PEMs and element teams staffed
  - Quarterly Management Reviews (QMRs), PEMC and SEMOG meetings
  - Draft CMMI OPF and OPD PA practices
- **Processes, Products & Artifacts**
  - Software Development Requirements
  - Software process hierarchy
  - Numerous handbooks, guides, templates, checklists & sample docs
- **Measurement**
  - Software Profile
  - Software Metrics program
    - Rationale and Approach
    - Software Project Measures Guide
- **Software Technology & Tools**
  - Software Tool Service
  - Software Tool Catalog
  - Software Tool Survey
- **CMMI Assessments**
  - Two internal CMMI Class B Appraisals
  - CMMI Profile and Timeframe Approval
- **Infrastructure & Operations**
  - SQI Electronic Library (DocuShare)
  - Action Item Tracking System (AITS)
  - Remedy ARS Service Group for SQI
  - SQI Customer Lists
  - SQI Intellectual Property (IP) Approach
    - Document Review
- **Communications, Inreach & Outreach**
  - Draft OCM/Communications Plan
  - Software Website releases
  - SQI Brochure, Bookmark, Cubicle clip
  - SQI Overview presentation
  - SDR Awareness Briefings
  - Participation in NASA SWG, numerous shared artifacts
- **Education & Training**
  - Software Training Plan
  - CMMI Org. Training PA practices
  - Offered numerous courses in:
    - Software Management
    - Software Engineering
    - Process Improvement (CMMI)
- **Project Support**
  - Identified 4 Target Sections and Software Process Support Reps
  - Supported nearly 100 JPL projects with artifacts, tools and consulting

SQI Services and Products
"Shopping List" by Process Category

SQI Consulting Service Areas	Available SQI Products
Software Project Management	
Software Project Planning	Software Management Plan (SMP) Template
Software Cost Estimation	Software Cost Estimation Handbook
Software Acquisition Management	Software Supplier Agreement Management Plan Template
Risk Management	*Draft* Risk Management Handbook
Software Project Monitor and Control	Software "EVM Lite" -- Point Counting Methodology
Management Reviews	Software Reviews Handbook
Software Engineering	
Software Documents	Handbooks, Guides, Document Templates, Examples
Software Requirements Management	SRD Template, SW Requirements Engr: Practices & Techniques
Software Verification	Software Stress Testing Guideline, STP Template
Peer Reviews & Inspections	Software Reviews Handbook, Peer Review Checklists
Software Support	
Software Quality Assurance	SQA Processes and Templates, SQA Activity Checklist
Project Measures/Metrics	Software Project Measures Guide, Defect Tracking/Analysis Tool
Software Configuration Management	Software Configuration Management procedures and tools
SDR Conformance and Tailoring	SDR Compliance Matrix, Software Process Tailoring Guide
Implementing CMMI Practices	Internal evaluations and assessments
Software Technology and Tools	
Software Technology Studies	Software Technology Reports, Tool Survey, Experience Capture
Software Tools Support	Software Tool Service, Software Tool Catalog