

# **CMMI Implementation for Software at JPL**

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**Software Quality Improvement (SQI) Project  
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# 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.



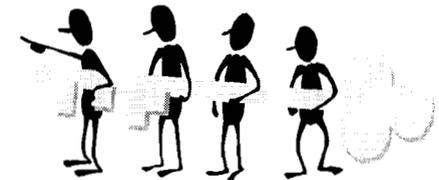
- SQL's initial focus is on mission-critical software for flight projects, their spacecraft and instrument systems, and their ground systems, including the following roles:
  - Project Element Managers (PEMs)
  - Software Line Managers
  - Cognizant Engineers (Cog Es)
  - Software Systems Engineers
  - 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.**



# SQL 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

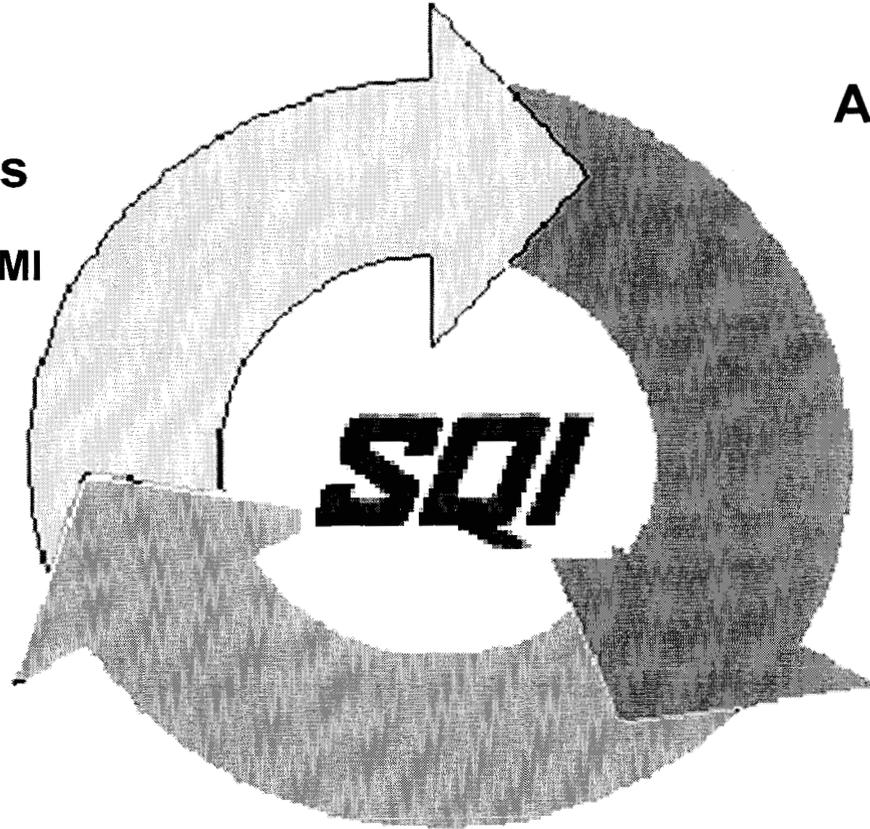


### Improvement Planning & Analysis

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

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

11/16/2003



### 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

### Project Support

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

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# 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



## Level 2 PAs

## Level 3 PAs

Requirements Mgmt.    Supplier Agmt. & Ctrl.    Prod. & Proc. Mgmt.    Configuration Mgmt.    Requirements Mgmt.    Technical Solution    Product Integration    Verification    Org. Process Focus    Org. Process Defn.    Integrated Proj. Mgmt.    Risk Management    Decision Anal. & Resol

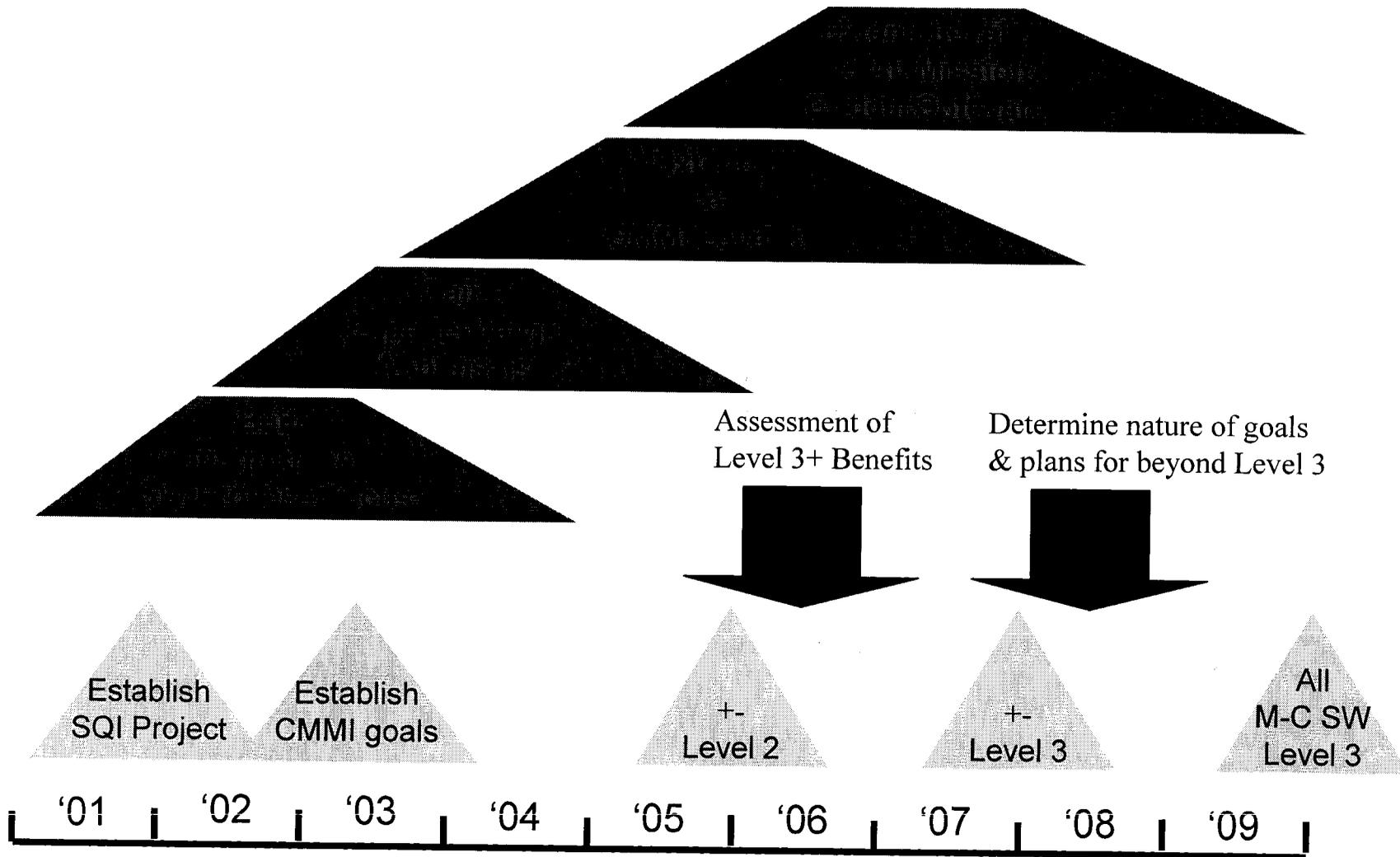
**Key**

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

	REQM	PP	PMC	SAM	MA	PPQA	CM	RD	TS	PI	Ver	Val	OPF	OPD	OT	IPM	RKM	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



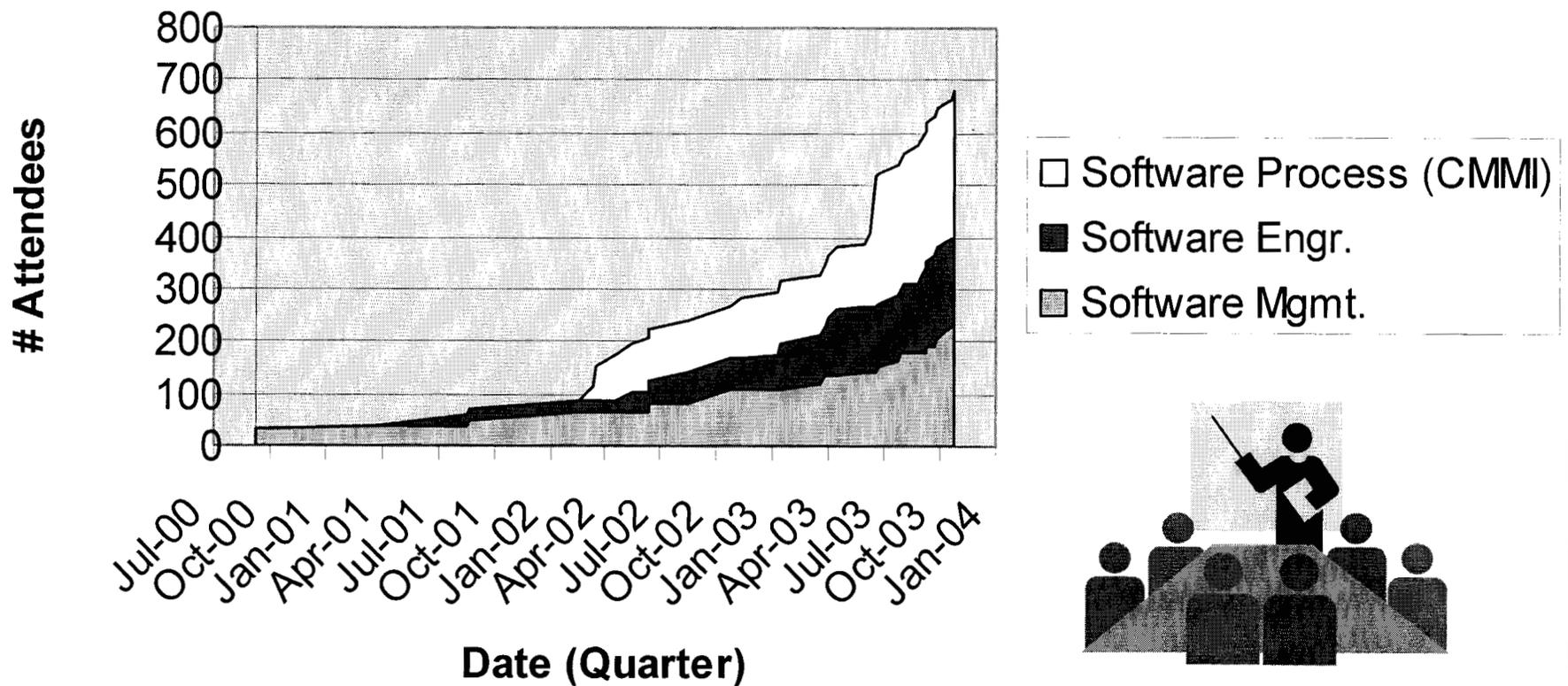
- ❑ Emphasize supporting software development (project work) with the CMMI practices as a guide
- ❑ Evaluate findings, plus recommendations provided by findings, to prioritize practices to be addressed
- ❑ Plan activities to raise the level of selected specific and generic practices.
  - Avoid slavish 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



## Cumulative SQI Software Training





# 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

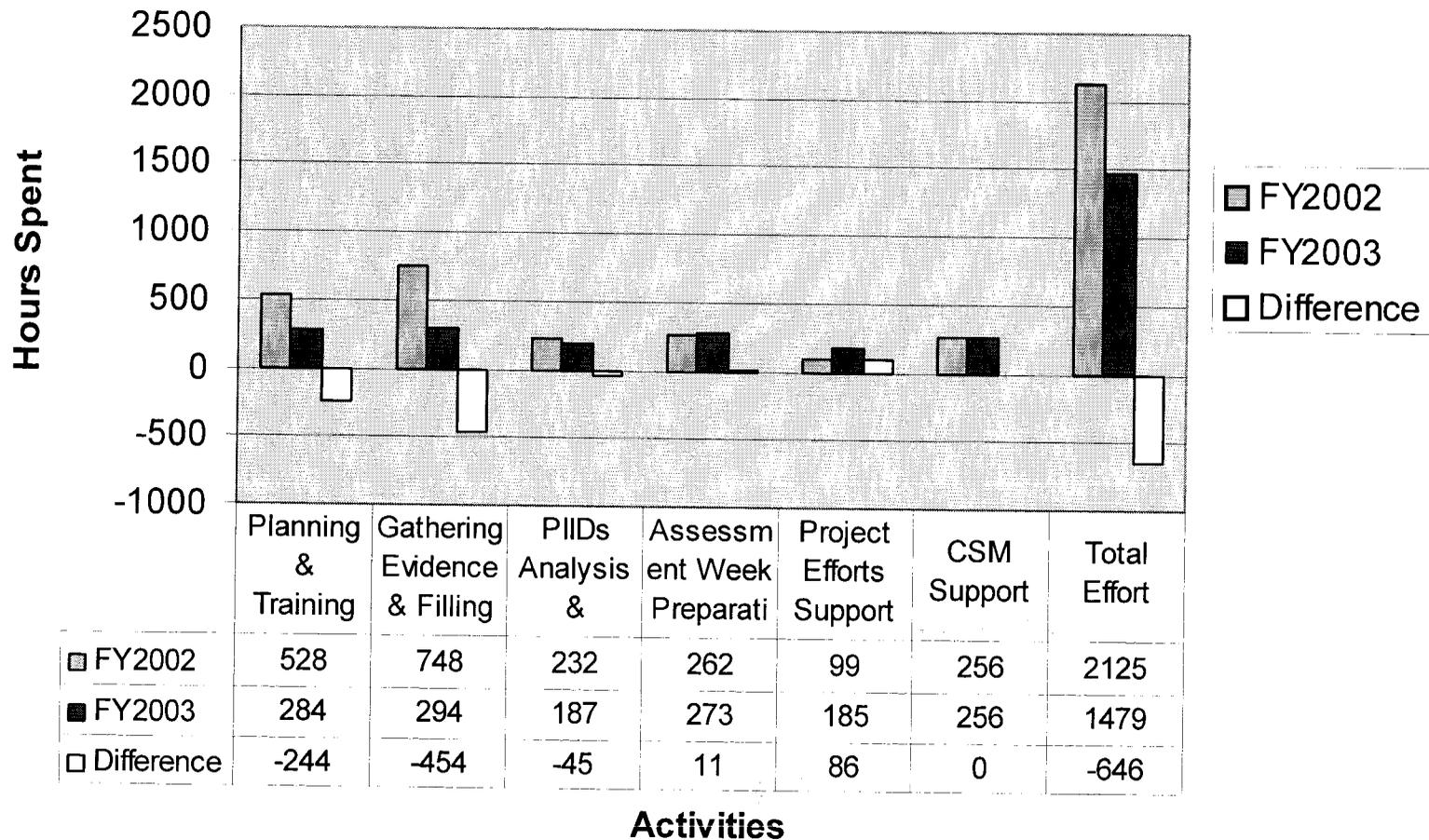
- 8 CMMI Process Areas included:
  - Project Planning
  - Project Monitor and Control
  - Supplier Agreement Management
  - Process and Product Quality Assurance
  - Configuration Management
  - Measurement and Analysis
  - Requirements Management
  - Verification
- 6 projects included
  - 2 each from 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



## JPL CMMI Class B Appraisal Effort Comparison





## 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*

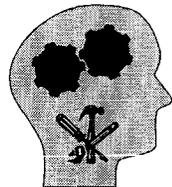
## Project Engineering

*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
- Solid budget and funding sources
- 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 PAJ- 23



# SQL Services and Products

## “Shopping List” by Process Category



### SQL Consulting Service Areas

#### Software Project Management

- Software Project Planning
- Software Cost Estimation
- Software Acquisition Management
- Risk Management
- Software Project Monitor and Control
- Management Reviews

#### Software Engineering

- Software Documents
- Software Requirements Management
- Software Verification
- Peer Reviews & Inspections

#### Software Support

- Software Quality Assurance
- Project Measures/Metrics
- Software Configuration Management
- SDR Conformance and Tailoring
- Implementing CMMI Practices

#### Software Technology and Tools

- Software Technology Studies
- Software Tools Support

### Available SQL Products

- Software Management Plan (SMP) Template
- Software Cost Estimation Handbook
- Software Supplier Agreement Management Plan Template
- Draft* Risk Management Handbook
- Software “EVM Lite” -- Point Counting Methodology
- Software Reviews Handbook

- Handbooks, Guides, Document Templates, Examples
- SRD Template, SW Requirements Engr: Practices & Techniques
- Software Stress Testing Guideline, STP Template
- Software Reviews Handbook, Peer Review Checklists

- SQA Processes and Templates, SQA Activity Checklist
- Software Project Measures Guide, Defect Tracking/Analysis Tool
- Software Configuration Management procedures and tools
- SDR Compliance Matrix, Software Process Tailoring Guide
- Internal evaluations and assessments

- Software Technology Reports, Tool Survey, Experience Capture
- Software Tool Service, Software Tool Catalog