



2004 IEEE Aerospace Conference
Track 14 Session 14.01



Got Software? What Managers and Engineers Need to Know

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Software Quality Improvement Project

JPL

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Topics To Be Covered

- **Software Training Approach**
 - Training Requirements
 - Role-based Skills Matrices
 - Skill Categories and Skills
 - Course Offerings
 - Expected Role-based Training
 - Lessons Learned
 - Summary
- **Backup Slides**
 - Mapping of Skills vs. Courses
 - CMMI PAs and CMM KPAs
 - Software Training Plan
 - Software Training Process



The work described in this paper was performed at the Jet Propulsion Laboratory, California Institute of Technology under a contract with the National Aeronautics and Space Administration (NASA).

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JPL's Software Community

- JPL's Software Community consists of approximately 1200 to 1300 people (out of 5500 lab-wide) including:
 - Practitioners in the Information Systems and Computer Science (IS&CS) Job Family
 - Software Managers categorized as 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.
- The initial focus of the Software Quality Improvement (SQI) Project is on mission-critical software for flight projects, their spacecraft and instrument systems, and their ground systems.





Training Customers

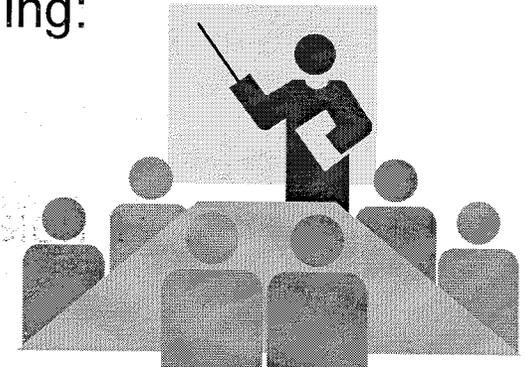
- Training customers primarily include the following roles:

- 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)



- Managers in JPL Program and Project offices including:
(since usually these managers have come from a hardware background)

- Program Managers and Project Managers
- Systems Engineers
- Any others whose decisions impact the way software is developed or acquired



- Members of the Software Quality Improvement (SQI) Project itself, i.e., members of the Software Engineering Process Group (SEPG) and Software Process Engineers

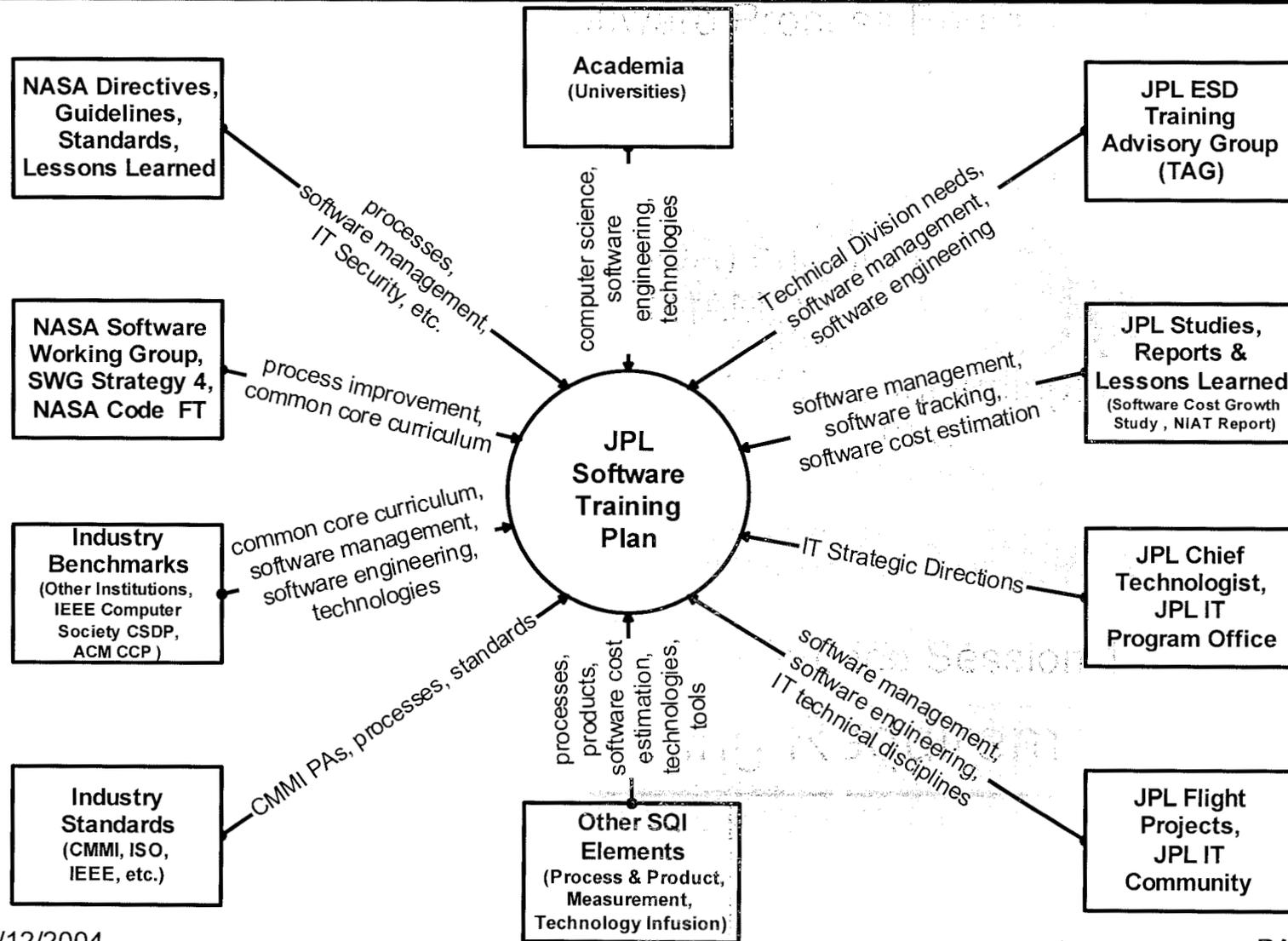


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Sources of Training Requirements



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Usually each entity is thinking only of their requirements.



Role-Based Skills Matrices

- Skills Matrices with categories such as:

technical skills

- Software Management
- Software Engineering
- Systems Engineering
- Hardware Engineering
- Project Planning and Tracking
- Problem Solving & Decision Making
- Vision & Leadership
- Dealing with People
- Communicating and Reporting

Managerial and “soft” skills

Skills and skill categories were derived from dozens of interviews at various levels of the org.

- Skills Matrices for the following roles:

- Project Manager
- Project Element Manager
- Cognizant Engineer
- Software System Engineer
- Software Engineer
- Software Test Engineer
- Software Process Engineer
- SQA Engineer
- Mission Assurance Manager

- Separate Matrices for Software Architects and for Software Assurance Skills that include Software Areas of Expertise



Five Competency Levels

- Adopt a few basic categories and similar terminology for competency levels for all courses
 - None (N)
 - Cursory (C) – Understand basic concepts and terminology
 - Working (W) – Understand details, routine applications
 - Proficient (P) – Solve routine problems
 - Expert (E) – Solve complex and unusual problems, consult for others





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Technical Skill Categories and Skills



- **Software Management**
 - Software Cost Estimation
 - Software Risk Management
 - Software Project Planning
 - Software Development Environments
 - Software Project Monitor & Control
 - Software Measurement, Metrics
 - Software Quality Assurance
 - Software Configuration Management
- **Software Engineering**
 - Software Architecture
 - Software Design
 - Software Reliability and Safety
 - Software Implementation
 - Software Verification & Validation
 - Methodologies, Tools, & Processes
 - Software Technology Awareness
 - Application Domain-Specific Knowledge
- **Systems Engineering**
 - Requirements Definition & Analysis
 - Tradeoffs, Tailoring, Prioritizing
 - System Architecture
 - Analysis, Simulation & Testing Approaches
 - Processes, Procedures, CMMI, ISO
- **Hardware Engineering**
 - Hardware Architecture & Design
 - Hardware Safety & Handling
 - Firmware
 - Hardware Test & Validation
 - Hardware Technology Awareness

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Managerial Skill Categories and Skills

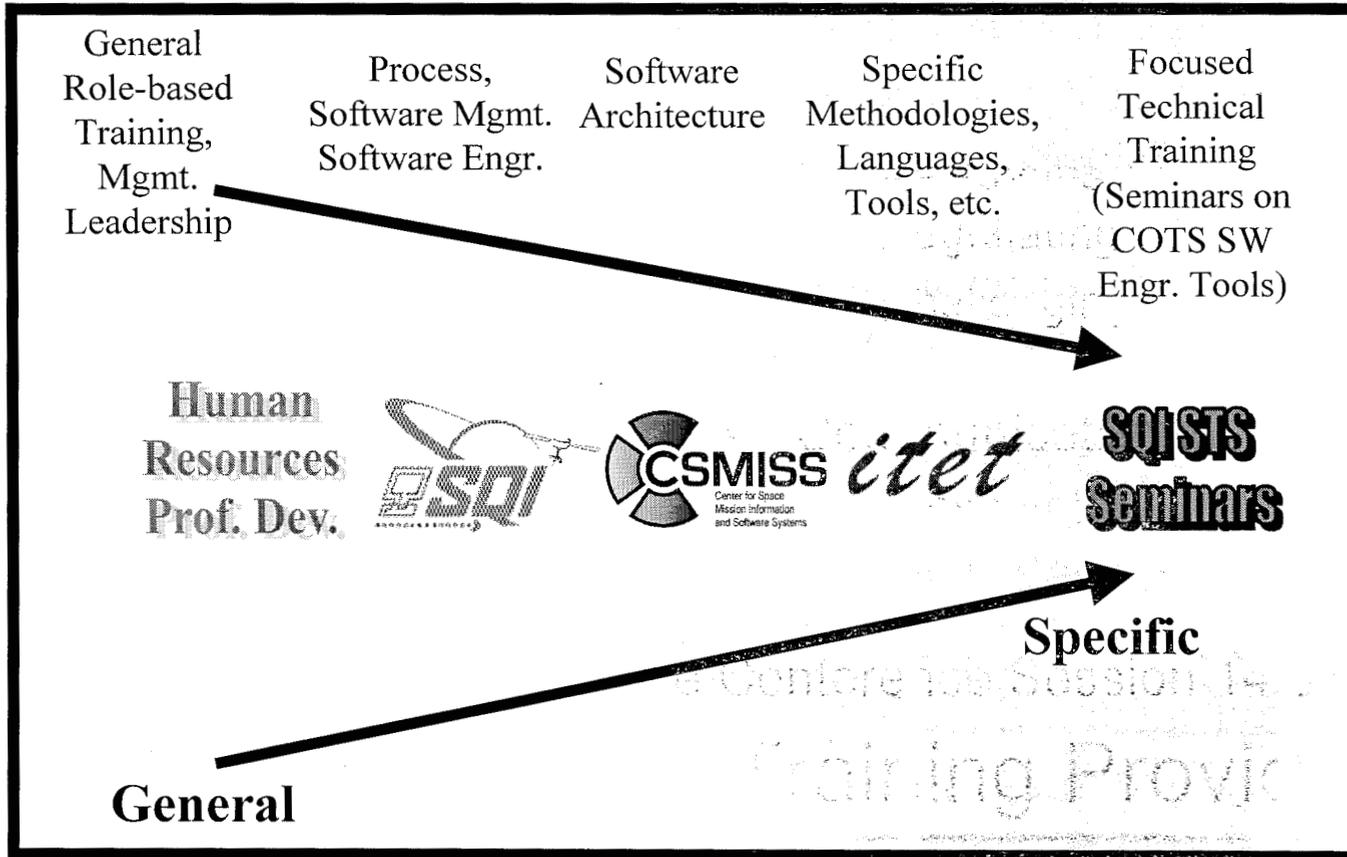


- **Project Planning and Tracking**
 - Task Planning, Task Allocation
 - Schedule Development, Tracking
 - Budget Development, Tracking
- **Problem Solving and Decision Making**
 - Problem Identification, Solution, Escalation
 - Timely Decisions, Follow Through
- **Vision and Leadership**
 - “Big Hat”, “Big Picture” Approach
 - Clear Picture of Problem
 - Ownership of Problem
- **Dealing with People**
 - Staffing, Team Selection
 - Team Building
 - Conflict Resolution
 - Delegating
 - Negotiating
 - Challenging, Inspiring, Motivating
- **Communicating and Reporting**
 - Presentations, Reviews, Reports
 - Customer Focus & Awareness
 - Sponsor Interface
 - Open Communication with
 - Team, Management
 - Meeting Management



Internal Software Training Providers

“The Wedge”



Legend:

CSMISS = Center for Space Mission Information & Software Systems

ITET = Information Technology Education & Training

SQI STS = Software Quality Improvement Project, Software Tool Service



Software Training Providers

- **JPL Internal Training Providers**
 - HR Professional Development (internal, NASA Code DT)
 - SQI Project (internal, CSM)
 - CSMISS IT Workforce Enrichment Element (via USC CSE)
 - ICIS IT Education and Training (ITET)
- **External Training Providers**
 - NASA Code DT: NET, SOLAR, APPL
 - Center for Systems Management (CSM)
 - CMU's Software Engineering Institute (SEI)
 - Learning Tree International (LTI)
 - Software Quality Engineering (SQE)
 - IEEE Computer Society Distance Learning Campus
 - ACM Professional Development Centre
- **Local Universities**
 - Graduate programs, extension classes, special offerings – tuition supported via the JPL Tuition Reimbursement program
 - USC, Caltech, Claremont
 - UCLA, UCI, UCR, CSUN, CSULB





Software Course Offerings

- Software Management
 - *Software Management for PMs (1 day)*
 - Software Management and Planning (2 days)
 - Quantitative Software Management (2 days)
 - *Software Risk Management (1 day)*
 - Process Improvement
 - Overview of CMMI (half-day)
 - Introduction to CMMI (3 days)
 - *SQI Software Seminar Series*
- Software Technology and Tools
 - *SQI Software Tools Service (STS) Seminar Series*
- Software Engineering
 - Software Product Engineering (1 day)
 - System Requirements and Management (3 days)
 - includes aspects of Software Requirements
 - Software Architecture (10 weeks)
 - *Software Design (1-2 days)*
 - Software Peer Reviews (1 day)
 - System Software Reliability (3 days)
 - *Software Defect Detection (half-day)*
 - Software Testing (3 days)
 - Deep Space Mission System (DSMS) Service Capability Development (SCD) (2 days)

Blue = future courses



Managerial Course Offerings

- Role-Based Training
 - The JPL Project Manager *
 - The JPL Project Element Manager *
 - The JPL Task Manager
 - Contract Technical Management *
 - The JPL Group Supervisor
 - The JPL Cognizant Engineer *
- General Managerial Courses
 - Cost Planning, Scheduling, Estimating and Performance Management
 - How to Balance Priorities
 - Time Management and Organization Skills for Managers and Supervisors
 - The Engineer in Transition to Management
- “Soft” Skills Courses
 - Leadership and Emotional Intelligence
 - How to Handle People with Tact and Skill
 - How to Handle Difficult People
 - Effective Communication for Managers and Supervisors
 - Negotiation Skills for Managers and Supervisors
 - Skills For Managing Conflict and Reaching Resolution
 - Presentation Skills
 - Creating the Coaching Environment
 - Succeed Over Stress



Example Expected Role-Based Training



Roles	Expected Software Courses	Other Recommended Courses
Project Manager (PM) or Task Manager (TM)	Software Management Overview	The JPL Project Manager or The JPL Task Manager Overview of CMMI
Project Element Manager (PEM), or Software Manager or Software Contract Technical Manager (CTM) or IT/Software Line Manager	Software Management & Planning Quantitative Software Management System Software Reliability	The JPL Project Element Manager Cost Planning, Scheduling, Estimating and Performance Management Overview of CMMI Space Science System Requirements & Mgmt. Systems Engineering IT Security
Cognizant Engineer (Cog E) 03/12/2004	Software Product Engineering Software Peer Reviews Software Testing System Software Reliability	The JPL Cognizant Engineer Cost Planning, Scheduling, Estimating and Performance Management Overview of CMMI System Requirements & Mgmt. Systems Engineering IT Security



Lessons Learned



Lessons Learned – Planning (1)

- Allocate sufficient time to lay the groundwork for writing the training plan:
 - Time to gather requirements, document what courses are already being offered, review the CMM/CMMI training KPA/PA, and coordinate with other training providers, including JPL, NASA and third party vendors.
- Promote communication among the various training providers and clarify the roles each will play, ranging from role-based to overview to detailed tools (ala “the wedge”).
- Many roles require managerial and “soft” skills as well as technical skills.
 - Ensure that both types of training are offered.



Lessons Learned – Planning (2)

- Develop skills matrices for various roles to help clarify what training is needed overall and to what depth, i.e., what courses to offer
 - Also, it helps supervisors know what courses to suggest to their group members during performance evaluations.
- Adopt a few basic categories and similar terminology for competency levels as HR Professional Development to help in curriculum discussions and aid in determining content level.
- Be sure to distinguish between training needs that are the responsibility of the organization and those that are the responsibility of the projects themselves.



Lessons Learned – Implementation (1)

- Allocate sufficient lead time for course content development.
 - It can take several months for each module since instructors are not full-time. They're experts so they're out plying their trade.
 - Conduct a peer review or “dry run” of course content.
 - Some modifications are needed occasionally to ensure that content reflects latest standards, processes, and trends.
- Establish presentation templates and enforce strict configuration management on course content:
 - Keep the “gold copy” of each module in an electronic library and ensure that instructors make any updates from there. Otherwise, there is a serious CM problem and past edits may be lost.
 - Maintain separate versions for each session so as to avoid confusion.
- Have students complete evaluation forms for each module and for the course overall in order to:
 - Monitor the quality of each module
 - Gauge various instructor's presentation styles
 - Discern what changes, if any, should be made.



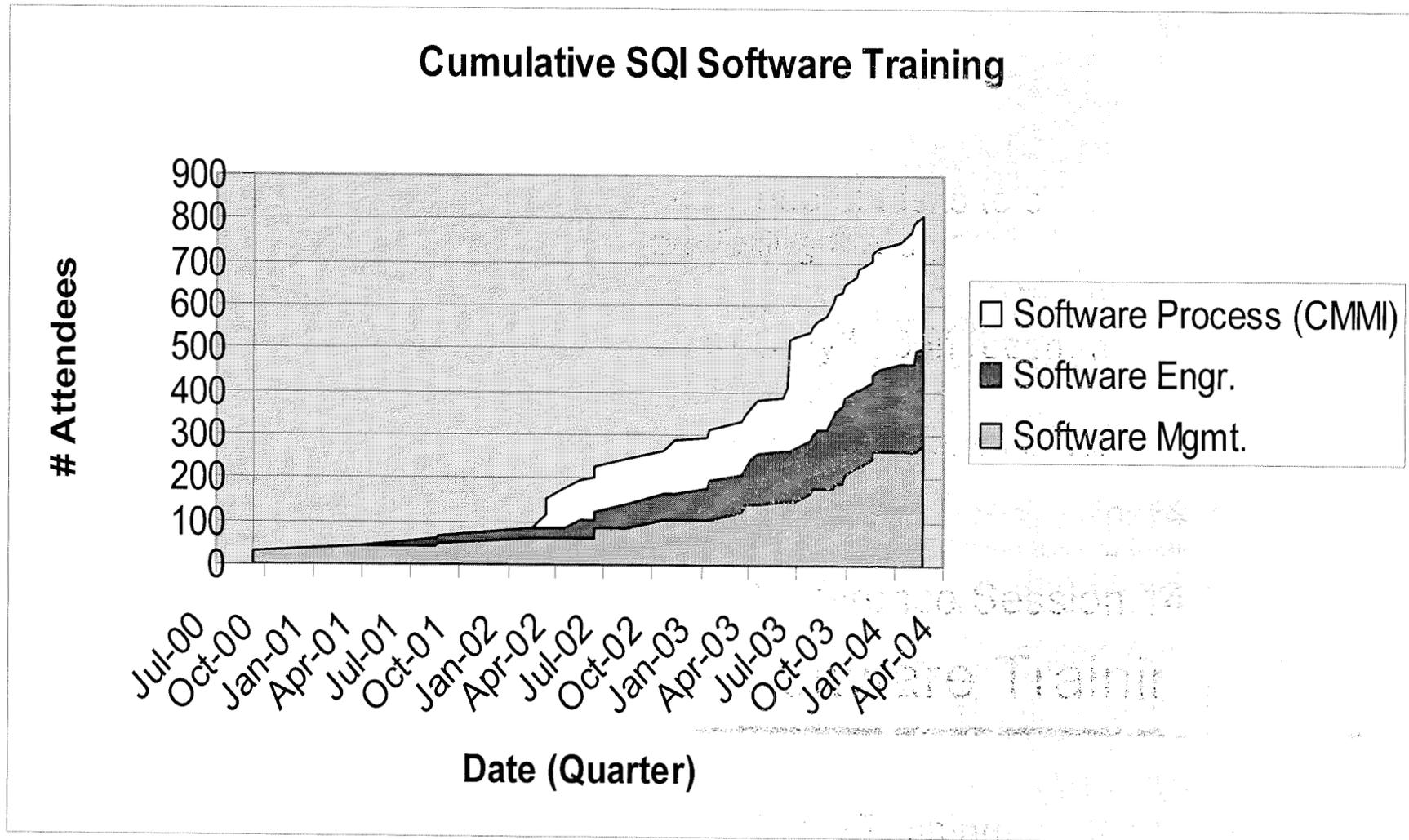
Lessons Learned – Implementation (2)

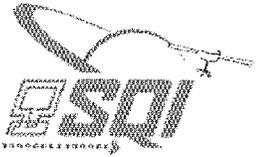


- **Allocate sufficient lead time for logistics coordination and hire a part-time administrator to do it.**
 - Includes scheduling classrooms, coordinating instructor availability, sending invitations for nominations to managers of software-intensive sections, enrolling students in courses, sending e-mail notices and reminders, etc.
 - Begin work on logistics at least six weeks before a class is to be offered.
- **Develop a process sheet** for the myriad of tasks to complete before each course offering to keep items from falling through the cracks and to ensure necessary lead times.
- **Offer some courses by “Invitation Only”** upon recommendation of managers rather than by “Open Enrollment”.
 - Provides not only more attendees, but also more appropriate roles.
- **Overbook registration by at least 15%** in order to guarantee a full class since invariably at the last minute someone fails to show up or cancel.
- **Be flexible and open to change:**
 - the sequence of modules in order to accommodate instructor availability.
 - instructors for various modules over time due to changing assignments, time pressures and personal interests.



Cumulative SQI Software Training





Summary

- Training needs to be tailored for each software role.
 - One size does not fit all.
 - For some roles cursory or working knowledge is sufficient.
- Plan for the fact that many roles require managerial and “soft” skills as well as technical skills.
- Training is part of an overall approach of deploying and inculcating software quality improvement.
- Training helps solve part of the question, “Are they willing and are they able?”
- No amount of processes, procedures or training can make up for lack of communication or teamwork!
 - It’s all about people!



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- ACM Professional Development Centre website <http://pd.acm.org/>
- Institute for Certification of Computer Professionals (ICCP) website <http://www.iccp.org/certify.html>
- Software Quality Engineering – education in testing and quality practices <http://www.sqe.com/>
- Learning Tree International – IT Training <http://www.learningtree.com/>



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Backup Slides



Training Requirements

Training requirements tend to fall into the following five categories:

- Software Engineering
 - Software product engineering
 - Software Verification and Validation (V&V)
 - Software testing
- Software Management
 - Planning, estimating, tracking, monitor and control
 - JPL/NASA standards, policies, and processes
- Software Technology, Tools, and Methodologies
- Process Improvement
 - CMMI Model and Process Areas (PAs)
 - Process improvement approaches and strategies
- Managerial Skills
 - e.g., Delegating, team building, negotiation, conflict resolution



Software Training Process

Training Planning and Preparation

1. Collect and analyze software training requirements at least annually.
2. Analyze the gap between training requirements and the current course offerings.
3. Establish the desired software curriculum.
4. Identify new software courses needed and review the purview of training providers.
5. Identify potential internal instructors and/or external providers.
6. Conduct course content development and/or negotiate course content with external providers.
7. Generate periodic updates to existing course content to correct errors or to reflect new practices.
8. Internally review new or modified software training modules.
9. Store instructor and student training materials in a CM-controlled area.

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Training Implementation

10. Schedule training rooms, instructors and course offerings.
11. Publish and publicize software training course offerings.
12. Register students and maintain training history.
13. Prepare or obtain copies of training materials as needed.
14. Conduct course offerings and gather course evaluations and metrics.
15. Analyze course evaluations and feedback and identify possible updates.
16. Follow-up a representative sample of course attendees to measure training impact.
17. Report training metrics and results at monthly and quarterly management reviews.



Training Goals

1. Ensure that JPL Project Managers, Project Element Managers, Software Managers and Cognizant Engineers have a good understanding of:
 - software management concepts, especially software cost estimation, planning, monitor and control, and risk management.
2. Ensure that JPL Software Systems Engineers and software practitioners have a good understanding of:
 - software engineering best practices, the SDR and related processes and procedures, SQI templates and handbooks, and are familiar with the SQI Software Tool Service.
3. Ensure that SQA Engineers and Mission Assurance Managers (MAMs) have a good understanding of:
 - software engineering best practices, the SDR and related processes and procedures, and software assurance disciplines.
4. Ensure that all SQI Project personnel have a good understanding of:
 - process improvement, SEI's Capability Maturity Model Integrated (CMMI), organizational change management (OCM), etc.
5. Ensure that the lab-wide Software Community receives
 - the mandatory IT training specified by NASA and JPL,
 - e.g., annual IT Security training.



Training Goals (Cont.)

6. Ensure that JPL, as an institution, has a training capability that complies with the goals of the CMMI Level 3 Organizational Training (OT) Process Area (initially only for software).
 - A training capability that supports the organization's management and technical roles is established and maintained.
 - Strategic training needs are established
 - The training needs that are the responsibility of the organization are determined.
 - An organizational training tactical plan is established
 - A training capability is established.
 - Training necessary for individuals to perform their roles effectively is provided.
 - Training is delivered
 - Training records are established
 - Training effectiveness is assessed.
 - The training process is institutionalized as a defined process.



Capability Maturity Model Integrated



Staged
vs.
Continuous

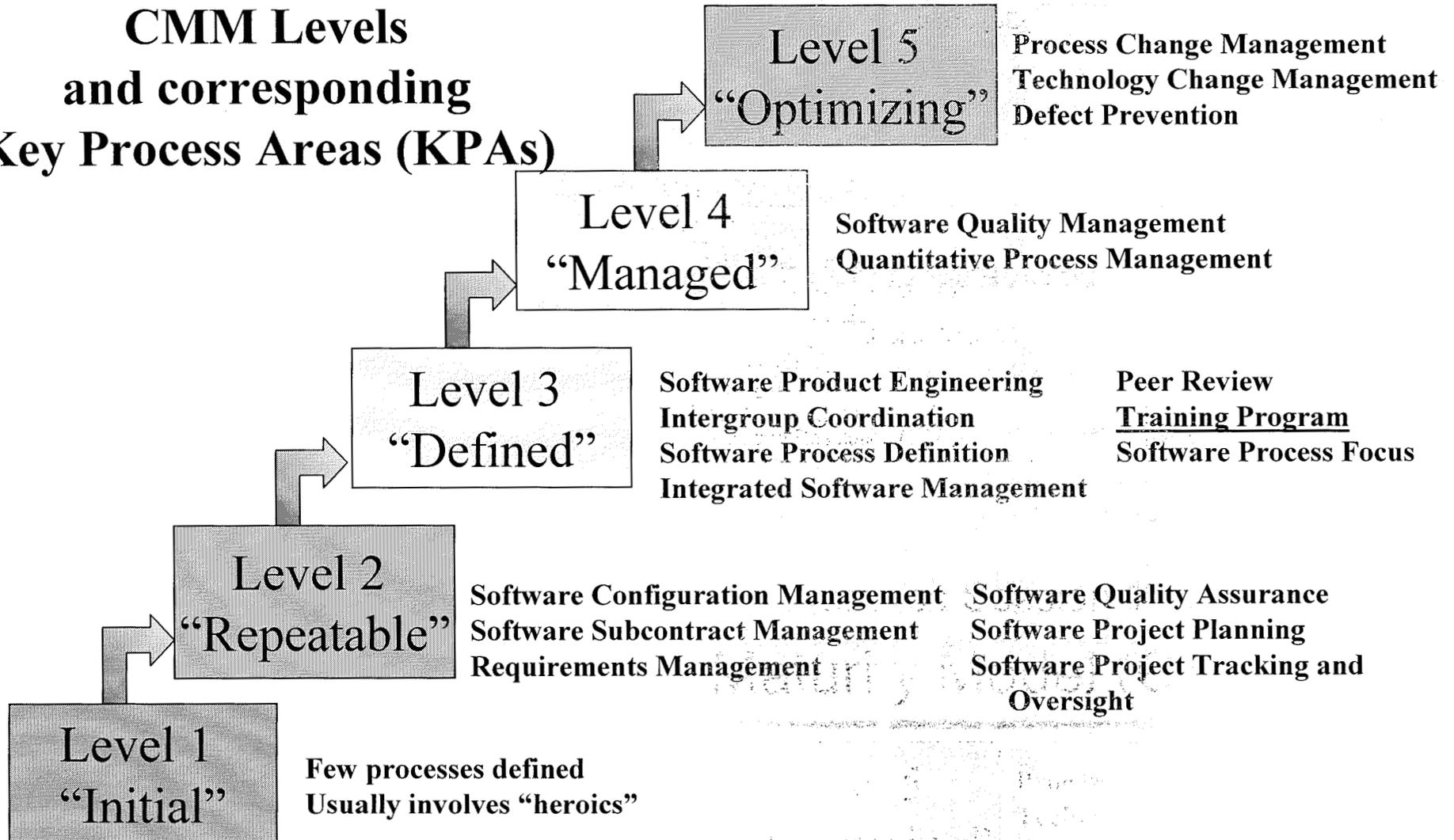
Level	Focus	CMMI Process Areas	Category
5 Optimizing	Continuous Process Improvement	Organizational Innovation and Deployment (OID) Causal Analysis and Resolution (CAR)	Adv. Process Mgmt. Adv. Support
4 Quantitatively Managed	Quantitative Management	Organizational Process Performance (OPP) Quantitative Project Management (QPM)	Adv. Process Mgmt. Adv. Project Mgmt.
3 Defined	Process Standardization	Requirements Development (RD) Technical Solution (TS) Product Integration (PI) Verification (Ver) Validation (Val) Organizational Process Focus (OPF) Organizational Process Definition (OPD) Organizational Training (OT) Integrated Project Management for IPPD (IPM) Risk Management (RSKM) Integrated Teaming (IT) Integrated Supplier Management (ISM) Decision Analysis and Resolution (DAR) Organizational Environment for Integration (OEI)	Engineering Engineering Engineering Engineering Engineering Basic Process Mgmt. Basic Process Mgmt. Basic Process Mgmt. Adv. Project Mgmt. Adv. Project Mgmt. Adv. Project Mgmt. Adv. Project Mgmt. Adv. Project Mgmt. Adv. Support Adv. Support
2 Managed	Basic Project Management	Requirements Management (REQM) Project Planning (PP) Project Monitoring and Control (PMC) Supplier Agreement Management (SAM) Measurement and Analysis (MA) Process and Product Quality Assurance (PPQA) Configuration Management (CM)	Engineering Basic Project Mgmt. Basic Project Mgmt. Basic Project Mgmt. Basic Support Basic Support Basic Support
1 Initial			



Software Capability Maturity Model (CMM)



CMM Levels and corresponding Key Process Areas (KPAs)





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Roles	Expected Software Courses	Other Recommended Courses
Software Engineer (SWE)	Software Product Engineering Software Peer Reviews Software Testing <i>Software Design</i> System Software Reliability	IT Security
Mission Assurance Manager (MAM)	Software Management & Planning Software Peer Reviews Software Testing System Software Reliability	Overview of CMMI System Requirements & Mgmt. Systems Engineering IT Security
Software Quality Assurance (SQA) Engineer	Software Management & Planning Software Product Engineering Software Peer Reviews Software Testing <i>Software Design</i> System Software Reliability	Overview of CMMI Introduction to CMMI System Requirements & Mgmt. Systems Engineering IT Security



Technical Skills vs. Courses

Engineering or Technical Skills	Courses Addressing Skills
<ul style="list-style-type: none"> • Software Management <ul style="list-style-type: none"> – Software Cost Estimation – Software Risk Management – Software Project Planning – Software Development Environments – Software Project Monitor and Control – Software Measurement and Metrics – Software Quality Assurance – Software Configuration Management 	<ul style="list-style-type: none"> • Software Management Courses <ul style="list-style-type: none"> – SMP, QSM – SMP, QSM – SMP, QSM – SMP – SMP, QSM – SMP, QSM – SMP – SMP
<ul style="list-style-type: none"> • Software Engineering <ul style="list-style-type: none"> – Software Architecture – Software Design – Software Implementation – Software Reliability and Safety – Software Verification and Validation – Methodologies, Tools, Processes – Software Technology Awareness – Application Domain-Specific Knowledge 	<ul style="list-style-type: none"> • Software Engineering Courses <ul style="list-style-type: none"> – Software Architecture, SPE – TBD – TBD – System Software Reliability – Peer Reviews, Software Testing – SPE, DSMS Service Capability Development, STS Seminar Series – STS Seminar Series – Software modules in The JPL Cog Engr.



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Technical Skills vs. Courses (Cont.)



Engineering or Technical Skills	Courses Addressing Skills
<ul style="list-style-type: none"> •Systems Engineering <ul style="list-style-type: none"> -Requirements Definition and Analysis -Tradeoffs, Tailoring, Prioritizing -System Architecture -Testing Approaches -Processes, Procedures, ISO 	<ul style="list-style-type: none"> •Systems Engineering Courses <ul style="list-style-type: none"> -System Requirements and Management -The JPL Cog Engr., System Requirements and Management -System Engineering -System Engineering, The JPL Cog Engr. -System Engineering, The JPL Cog Engr.
<ul style="list-style-type: none"> •Hardware Engineering <ul style="list-style-type: none"> -Hardware Architecture and Design -Hardware Safety and Handling -Firmware -Hardware Test and Validation -Hardware Technology Awareness 	<ul style="list-style-type: none"> •Hardware Engineering Courses <ul style="list-style-type: none"> -The JPL Cog Engr., Fast Analytical Techniques for Electrical & Electronic Circuits, Spacecraft Environment Interactions -Critical Hardware Handling -TBD -The JPL Cog Engr. -PDC Design Hub seminars



Training Plan Outline

1.0 Introduction

- 1.1 Purpose and Background
- 1.2 Scope
- 1.3 Applicable Documents

2.0 Training Requirements, Goals and Objectives

- 2.1 Training Customers
- 2.2 Training Requirements
- 2.3 Training Goals and Objectives

3.0 Training Process and Approach

- 3.1 Training Process
- 3.2 Training Roles and Responsibilities
- 3.3 Training Components
- 3.4 Training Schedule
- 3.5 Training Budget

4.0 Appendices



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That's All Folks !!