

## Change Record

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# 1.0 Introduction

## 1.1 Purpose and Background

The purpose of this document is to define the software training approach and plans for the Jet Propulsion Laboratory (JPL). The vision of the Software Quality Improvement Project (SQIP) is to achieve and sustain excellence in software engineering at JPL to enable mission success. Its goal is to establish an operational program that results in the continuous measurable improvement of software quality at JPL. Its objectives include improving cost and schedule predictability, and quality of mission-critical software, reducing software defect rates during testing and operations, increasing software development productivity, promoting software reuse, and reducing project start-up time. In addition, NASA wants each Center to develop a plan for achieving CMM Level 3. Achieving these goals and objectives will necessitate training not only personnel working on the SQI Project itself, but also members of the larger Software Community at JPL.

In order to maintain a vital Software Community and ensure a world-class software workforce, JPL must provide for career growth and enhancement of technical skills for software professionals at JPL. Given the national competition for software professionals, sometimes "growing your own" is the only way to ensure certain skills are available when you need them. Hence, training needs to be viewed as a "cost of doing business". Providing adequate and timely training includes identifying courses, developing curriculum, finding trainers, and conducting courses or procuring training elements from vendors. Each of these activities takes time, money, and commitment. Also, providing adequate training implies that managers need to proactively staff positions early enough to allow schedule time for training and for coming up on the learning curve. Managers also need to be committed to allowing their employees the time away from their jobs to actually take the training.

## 1.2 Scope

This plan describes the training requirements, goals, and scope, as well as the approach, processes, activities, organization, resources, and schedule necessary for implementing the training plan. It covers the period that includes fiscal years 2002 through 2003. This plan covers training to be provided not only to personnel working on the SQI Project itself, but also members of the larger Software Community at JPL, including project managers, project element managers, software line managers, cognizant engineers, systems engineers, and software practitioners.

The activities defined herein will be carried out as a collaborative effort by the following entities:

1. SQI Deployment Element
2. Technical Training Group in HR Professional Development
3. ICIS IT Education and Training (ITET) Group
4. CSMISS IT Workforce Enrichment Element
5. Design Hub in the Project Design Center (PDC).

## 1.3 Applicable Documents

The following documents are applicable to this plan.

1. NASA Software Engineering Initiative Implementation Plan, NASA Code AE, 2001
2. The Capability Maturity Model: Guidelines for Improving the Software Process, Carnegie Mellon University, Software Engineering Institute, Addison-Wesley, New York, 1994
3. CMMI: Guidelines for Process Integration and Product Improvement, Mary Beth Chrissis, Mike Konrad, Sandy Shrum, Addison-Wesley, 2003
4. A Discipline for Software Engineering, Watts S. Humphrey, Addison-Wesley, New York, 1995
5. NASA Program and Project Management Processes and Requirements, NASA Procedures and Guidelines, NPG 7120.5A, 1998
6. NASA Software Management, Engineering, and Assurance, NASA Procedures and Guidelines, NPG 2820
7. Security of Information Technology, NASA Policy Directive, NPD 2810.1

8. Software Independent Verification and Validation (IV&V) Management, NASA Policy Directive, NPD 8730.4, 08/01/2001
9. Software Independent Verification and Validation (IV&V) Management, NASA Procedures and Guidelines, NPG 8730
10. NASA Policy for Safety and Mission Success, NASA Policy Directive, NPD 8730.1
11. NASA Software Policies, NASA Policy Directive NPD 2820.1, 05/29/1998
12. Quality Systems Standard, ISO 9000
13. Information Technology—Software Life Cycle Processes, IEEE/EIA 12207, 03/31/1998
14. Flight Software Cost Growth: Causes and Recommendations, JPL D-18660
15. "Enhancing Mission Success -- A Framework for the Future," NIAT Report, 01/05/2001
16. A Guide to Strategically Planning Training and Measuring Results, U.S. Office of Personnel Management, Office of Workforce Relations, OWR-35, July 2000

## 2.0 Training Requirements, Goals and Objectives

### 2.1 Training Customers

Software training customers encompass JPL's entire Software Community, and include personnel from the following areas:

- Software Sections and groups within the Engineering and Science Directorate (ESD)
  - Division 31, Systems Division
  - Division 33, Telecommunications Science and Engineering Division
  - Division 34, Avionic Systems and Technology Division
  - Division 36, Information Technologies and Software Systems Division
  - Division 38, Observational Systems Division
- Institutional Computing and Information Systems (ICIS) Office (95X)
- Institutional Business Systems (22X)
- Portions of the Office of Engineering and Mission Assurance (5X) Directorate
- Other software elements from ESD and all other Directorates.

JPL's approximately 5500 employees are categorized into thirteen Job Families, and each family has several disciplines and sub-disciplines. An overview of these job families and the number of employees in each family is given in Table 7 in Appendix 2. While the majority of the JPL Software Community consists of practitioners in the Information Systems and Computer Science (IS&CS) Job Family, software Managers are categorized as either Line Management or Program/Project Management. Also, personnel who are categorized as Engineering and Technical would still be considered part of the Software Community provided that at least 50% of their work is software-intensive. Given this range of categories, the Software Community at JPL consists of approximately 1200 to 1300 people.

The primary training customers are members of JPL's Software Community, with an initial focus on flight projects, and their spacecraft and instrument systems, and then their ground systems. This includes project element managers (PEMs), software line managers, cognizant engineers (Cog Es), software systems engineers, software quality assurance (SQA) engineers, mission assurance managers (MAMs), and software practitioners.

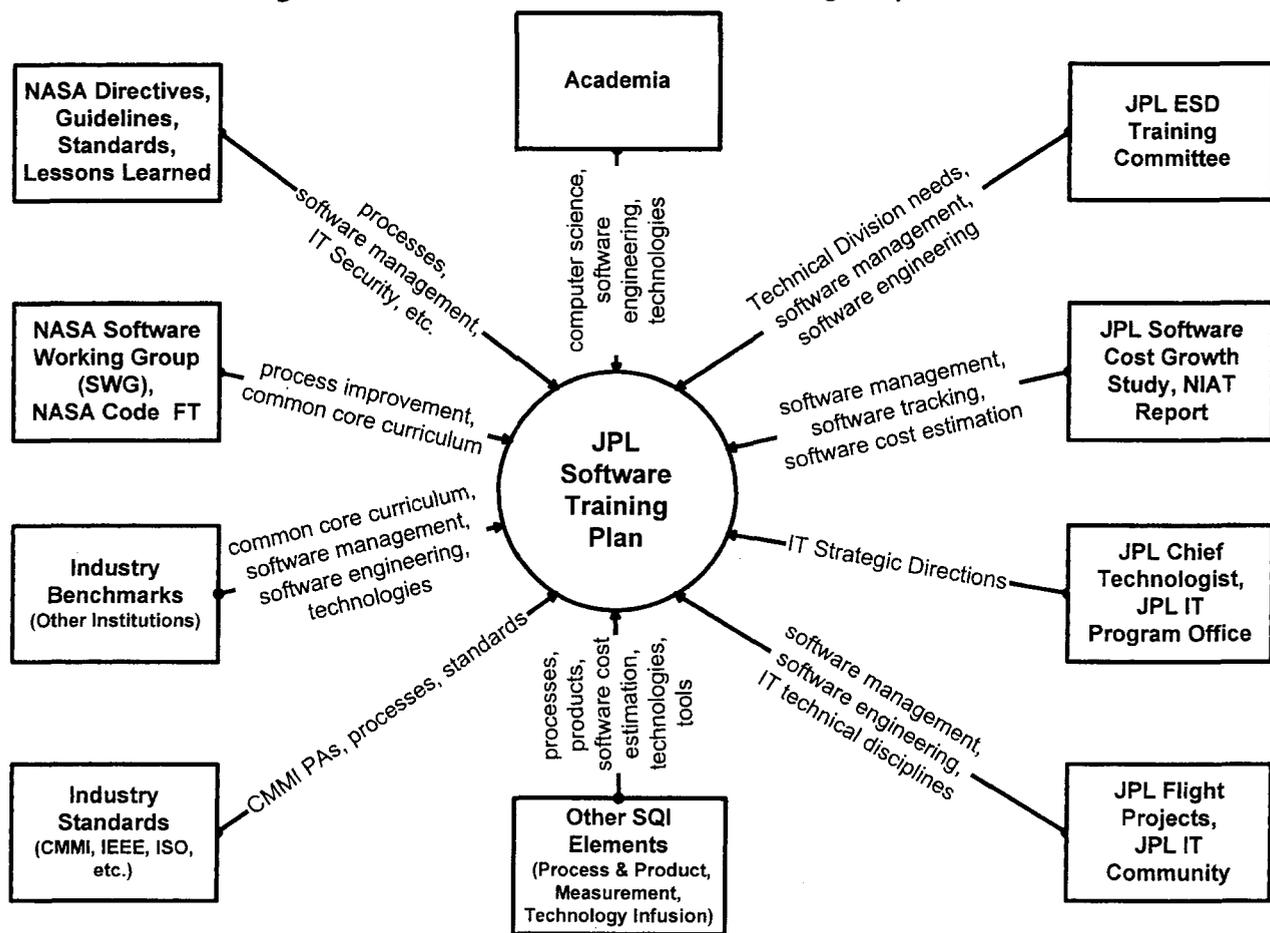
Other training customers are managers in JPL program and project offices whose purview is broader than software, but whose scope encompasses it as well. Usually these managers have come from a hardware background, and require some exposure to the fundamental concepts associated with software management and planning. Hence, other customers include program managers, project managers, systems engineers, and others with whom software personnel interact regularly, and whose decisions impact the way software is developed at or acquired by JPL, as well as members of the SQI Project itself -- members of the Software Engineering Process Group (SEPG).

## 2.2 Training Requirements

### 2.2.1 Sources of Requirements

Training requirements have been derived from a number of sources, as shown in Figure 1 below. Requirements from each of these sources are discussed in the sections below. In addition, an attempt was made to reach a consensus on the desired level of competence or depth (cursory, working, proficient or expert) in specific areas for the roles of Technical Manager, Project Element Manager, Cognizant Engineer, Software Engineer, and Software Architect. In order to accomplish this objective, skills matrices were developed for the above positions in regards to their understanding of various software and managerial concepts. These matrices are provided in the tables included in Appendix 6 Skills Matrices.

**Figure 1 Sources of JPL Software Training Requirements**



#### 2.2.1.1 NASA Requirements

NASA itself is providing requirements via various mechanisms: through the NASA Software Initiative Implementation Plan, through applicable NASA Directives, Guidelines and Standards (NPG 2820, NPG 8730, NPD 8730.1, NPD 2820.1, NPD 7120.5 A/B), through the NASA IT Workforce Challenge Team, the NASA Software Working Group (SWG) Strategy 4 Subgroup, NASA Code FT (Training), and even indirectly through the NIAT Report and the NASA Lessons Learned Information System (LLIS). Also, there are legal requirements imposed by the NASA Prime Contract with Caltech and JPL for such items as IT Security training, compliance with NPD 7120.5 A/B, and the like.

### **2.2.1.2 Industry Standards Requirements**

There are a number of industry standards, such as SEI's Capability Maturity Model (CMMI), ISO 9000, IEEE/EIA 12207, etc. Each of these standards implies that the Software Community is aware of their existence, familiar with the concepts they espouse, and able to apply them as needed in their work.

### **2.2.1.3 Internal JPL Requirements**

There are inputs from JPL's ESD Training Committee, and interviews of key stakeholders within the JPL Flight Projects, Centers of Excellence, Software Quality Assurance (SQA) (SQA) Group, and Software Community. There are recommendations from the recent review of JPL Institutional Software Investments (CSMISS, MDS and SQI), the JPL Software Cost Growth Study, the MCO/MPL failure reports, and JPL Corrective Action Notices (CANs) from previous ISO internal assessments and external audits. Lastly, the SQI Project as a whole and the various elements within it (namely, Process and Product Definition, Measurement and Benchmarking, and Software Technology Infusion) also has certain training requirements in order to carry out their collective and specific objectives.

### **2.2.1.4 Benchmarks from Academia and Industry**

There are informal benchmarks and discussions with relevant industry training personnel (AeroSpace, TRW, etc.), and academia (USC CSE, UCI, Caltech, CSULB, CMU SEI, etc.).

Following analysis of these requirements, it appears that the need for training exists in four broad categories: processes and process improvement, software management, software engineering, and software engineering tools and technologies. Each of these is addressed in the sections below.

## **2.2.2 Types of Training Required**

### **2.2.2.1 Process Management and Process Improvement**

Any process improvement activity requires that the participants understand the basics of process improvement, process models, change management and the like. Most important is a broad understanding of SEI's Capability Maturity Model Integrated (CMMI), and particularly the Level 2 and 3 Process Areas (PAs). The specific CMMI Process Areas for Process Management include Organizational Process Focus, Organizational Process Definition, Organizational Training, Organizational Process Performance, and Organizational Innovation and Deployment.

### **2.2.2.2 Software Management**

Managers of projects and software-intensive systems need to understand the basic concepts of software management, planning, and tracking, as well as the software life-cycle. Software cost estimation is of particular importance since it forms the basis for all future planning and scheduling. The relevant CMMI Process Areas include Project Planning, Project Monitoring and Control, Supplier Agreement Management, Process and Product Quality Assurance, Configuration Management, Integrated Supplier Management, Integrated Teaming, Risk Management, and Decision Analysis and Resolution. In addition, the SQI Process and Product Element has a need for software managers and practitioners to understand the Develop Software Products (DSP) Process, and related management and technical processes.

### **2.2.2.3 Software Engineering**

#### **Software Engineering Methodologies and Practices**

The relevant CMMI Process Areas include Requirements Development, Requirements Management, Technical Solution, Product Integration, Verification, Validation, Process and Product Quality Assurance, and Configuration Management. Of particular importance within verification are the topics of Peer Reviews and formal inspections.

#### **Software Development Requirements and SQI Products**

The SQI Process and Product Definition Element has a need for software practitioners to understand the Software Development Requirements (SDR) and related templates, handbooks and examples.

## **IT and Software Technical Disciplines**

The IT and software technical disciplines applicable to the JPL Software Community include: software architectures, system modeling, operating systems, real-time systems, computer languages, Middleware, data engineering, data and information modeling, database management, data management, network architectures and protocols, Internet and Web technology, performance modeling and simulation, performance tuning and optimization, software security, artificial intelligence, high-performance computing, advanced technologies, etc.

### **2.2.2.4 Software Engineering Tools and Technologies**

The SQI Software Technology Infusion Element has a need for software practitioners to be aware of various technologies, methodologies and tools, and to know how to apply them effectively to their own projects.

## **2.3 Training Goals and Objectives**

### **2.3.1 Training Goals**

The SQI Project as a whole is chartered to provide education, training, mentoring, and consulting for projects in order to enable and promote software best practices, and to leverage JPL experience in software engineering in support of major software projects, throughout the entire software life-cycle. The SQI Deployment Element has a number of specific training goals that it hopes to achieve, in collaboration with the other JPL training providers identified in Section 1.2.

- 1) 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 (See Appendix 4 for more details):
  - a) 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.
  - b) Training necessary for individuals to perform their roles effectively is provided.
    - Training is delivered
    - Training records are established
    - Training effectiveness is assessed.
  - c) The training process is institutionalized as a defined process.
- 2) Ensure that all SQI Project personnel understand process improvement, SEI's Capability Maturity Model Integrated (CMMI), organizational change management (OCM), etc.
- 3) 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.
- 4) Ensure that JPL 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.
- 5) 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.
- 6) Ensure that the Software Community receives the mandatory IT training specified by NASA and JPL, e.g., annual IT Security training.

Skills matrices for various roles have been developed that describe the desired level of competence in specific skills, and are contained in Appendix 6. These matrices identify the desired skills for each type of role, and also serve as a way to focus the training needed to achieve these levels. Recommended training for each role is provided in Appendix 7.

### **2.3.2 Training Objectives and Strategies**

The training objectives include providing the following four broad categories of training to the JPL Software Community:

1. Process management and process improvement
2. Software management planning, monitor and control
3. Software engineering – from requirements to design and through verification and validation
4. Software methodologies, tools, technologies and languages.

In addition, the SQI Project should encourage the software community to obtain training in “soft skills” such as conflict resolution, group dynamics, negotiating, communicating effectively, presentations, customer satisfaction, etc. The training strategy involves utilizing a number of existing training providers at JPL for classroom instruction, as well as contracting with several external training providers as appropriate. The training to be provided by JPL training providers is described in Sections 3.3.1 through 3.3.5. Training that could be provided by external training providers is described in Sections 3.3.6 and 3.3.2.5. Other sources of external training could include professional conferences and seminars, as well as academic programs at universities. In addition to classroom instruction, other strategies could include computer-aided instruction, guided self-study, mentoring programs, facilitated videos, noon-time briefings and lectures, as well as structured on-the-job training (OJT) and internships.

## 3.0 Training Process and Approach

### 3.1 Training Process

The JPL Training Process includes a number of activities ranging from requirements collection to performing the following activities:

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. Internally review new software training modules
8. Schedule training rooms, instructors and course offerings
9. Publish and publicize software training offerings
10. Register students and maintain training history
11. Conduct course offerings and gather course evaluations and metrics
12. Analyze course evaluations and feedback and identify possible updates.
13. Generate periodic updates to course content to correct errors and to reflect new practices.

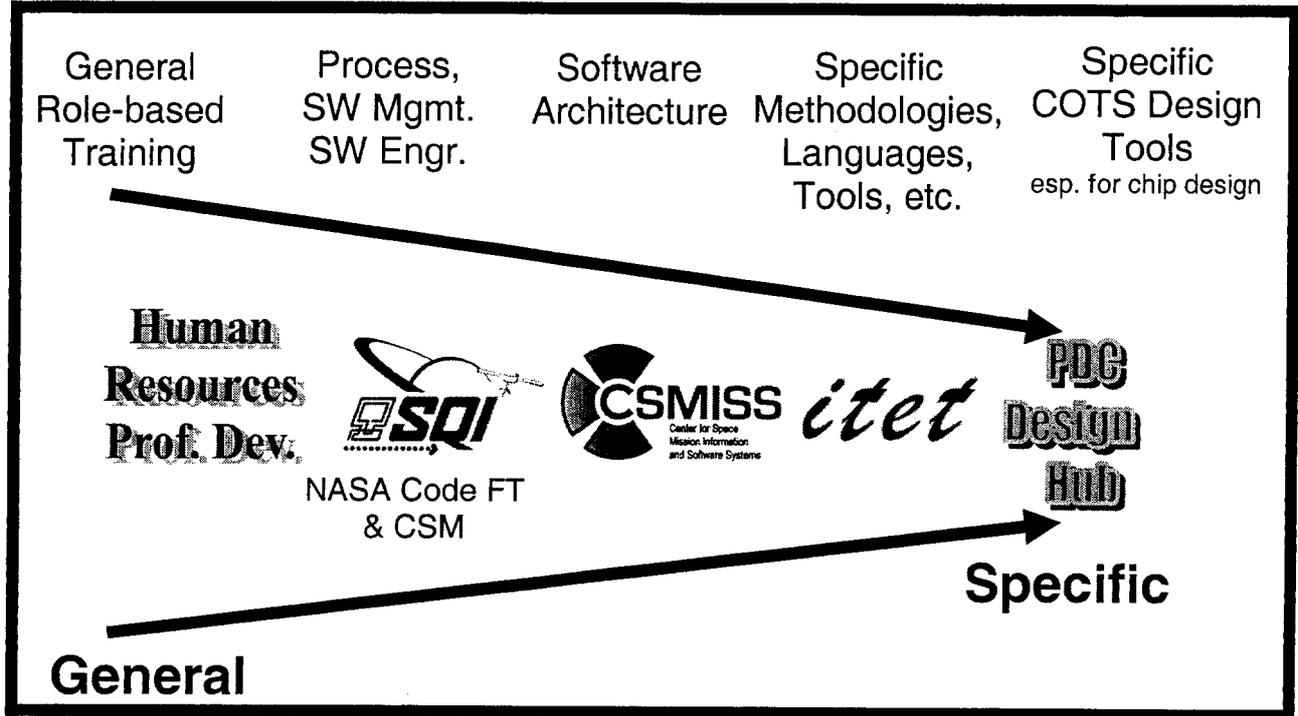
### 3.2 Organization, Roles and Responsibilities

Various organizations and vendors offer technical training at JPL. JPL has an Education and Training Consortium that is made up of ten internal organizations that offer education and training to JPL employees, in support of the technical and business priorities of the Laboratory. Each Consortium member offers training relevant to its own area. The type of training offered by each member of the Consortium is shown in Table 1. The most relevant member of this consortium, as far as software training is concerned, is the Information Technology Education and Training (ITET) Group, sponsored by the Institutional Computing and Information Services (ICIS) Office. However, the following six entities offer software training at JPL:

1. JPL Professional Development Technical Training Group (in collaboration with ESD)
2. SQIP Deployment Element (internally and through other vendors)
3. NASA Code FT (at JPL and other NASA Centers)
4. CSMISS IT Workforce Enrichment Element (through USC CSE and other vendors)
5. IT Education and Training (ITET) Group (internally and through other vendors)
6. PDC Design Hub

The training provided by each of these entities is discussed in Sections 3.2.1 through 3.2.6. The training offered by each of these entities ranges from general role-based training to very specialized training on specific COTS design tools. See Figure 2 below for a graphical depiction of this range. For the most part, SQIP DE offers high-level introductory courses, and ITET offers more detailed courses. See Table 11 in Appendix 8 for a comparison of some courses offered by SQIP DE versus those offered by ITET.

**Figure 2 JPL Software Training Providers**



**Table 1 Training Offered by JPL Education and Training Consortium Members**

| <b>Consortium Member</b>  | <b>Type of Training Offered</b>   |
|---|---|
| 1. Acquisition Division   | 1. Procurement training for all JPL personnel involved in the acquisition process   |
| 2. Develop New Products (DNP) Domain  | 2. a.) Training in project management skills and processes, offered through JPL's Professional Development organization, and including direct interface with NASA's Academy of Program and Project Leadership;<br>b.) Training on new and specialized project engineering tools (over 230 tools) and processes, offered through JPL's Design Hub, including tools for analysis, circuit description, configuration management, documentation, electrical simulation, layouts, magnetic analysis, mechanical models, optical analysis, simulation, software design, structural/thermal analysis, systems modeling, test, verification, visualization, etc. |
| 3. Information Technology Education and Training (ITET), Institutional Computing and Information Services (ICIS) Office | 3. Courses and technology-based training (TBT) on topics such as software security, database tools, methods, architecture and tools, programming and object-oriented technologies, and core office and desktop productivity tools.  |
| 4. ISO 9000 (Enterprise Process and Standards Program Office)   | 4. Online introductory course to ISO 9000 that provides a clear and comprehensive overview of ISO 9000 background, content, and the implementation process  |
| 5. New Business Solutions (NBS), Institutional Business Systems Division  | 5. Classes for the Oracle/NBS business applications: planning/budgeting, procurement, asset management, services, human resources, timekeeping, etc.  |
| 6. Professional Development, Human Resources Directorate  | 6. Courses to help employees expand their knowledge and skills in a variety of areas related to their work, including technical courses, management and supervisory programs, and work effectiveness skills.  |
| 7. Quality Assurance  | 7. Technical training courses in fabrication, assembly and inspection of Flight and Ground support hardware.  |
| 8. Occupational Safety  | 8. 48 safety and health courses designed to promote safety awareness at JPL as well as meet requirements set forth by regulatory agencies.  |
| 9. Project Business Management Division (formerly Project Resource Administration Division)                             | 9. Various courses for the project resource administrators in business processes and tools  |
| 10. Center for Space Mission Information and Software Systems (CSMISS)  | 10. Course in Software Architecture   |
| 11. Software Quality Improvement (SQI) Project  | 11. Courses in process improvement, software management and software engineering  |

## 3.3 Training Components

### 3.3.1 Software Training Offered by ESD & JPL Professional Development

#### 3.3.1.1 Program 2000 Role-Based Training

JPL's Engineering and Science Directorate (ESD) (<http://esd.jpl.nasa.gov/>) in collaboration with HR Professional Development (PD) (<http://hr.jpl.nasa.gov/>) has developed a series of role-based courses as part of its Program 2000 initiative. Each course is aimed at a different role and level: *The JPL Project Manager*, *The JPL Project Element Manager*, and *The JPL Cognizant Engineer*. These courses are offered two to three times per year, by invitation only, and participants are coordinated with Division representatives. Within each of these courses are software modules as follows:

*The JPL Project Manager*  
Develop Software Products

*The JPL Project Element Manager*  
Develop Software Products

*The JPL Cognizant Engineer*  
Software Development Overview  
Flight Software  
Science Instrument Software  
Science Software  
Mission Design & Navigation Software  
Ground Software DSN  
Ground Software AMMOS

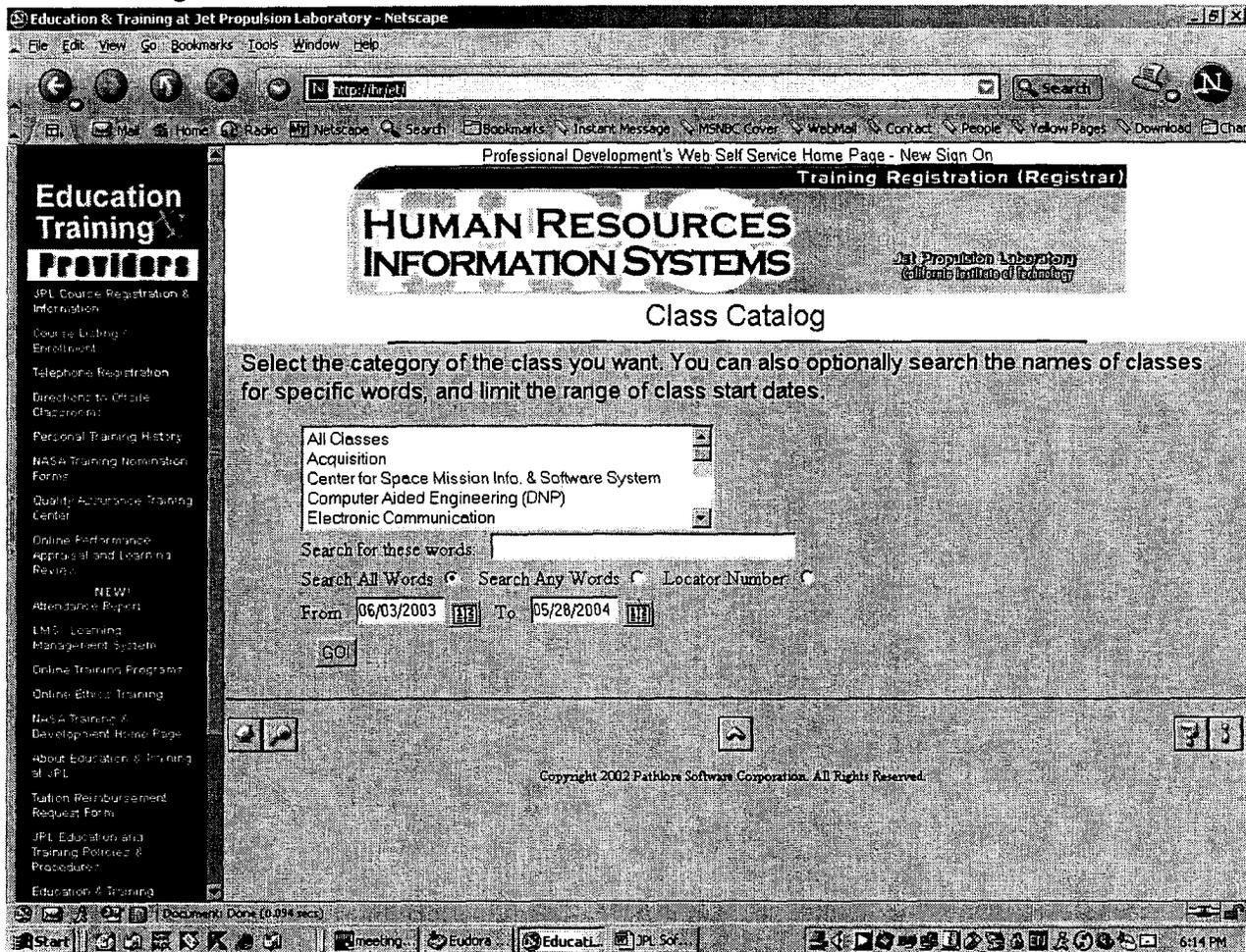
The software modules within the PM and PEM courses are merely a one-hour overview of the DSP Process. The software modules within the Cog E course are focused on the various application domains at JPL, and the unique aspects of working in each domain.

The SQIP Deployment Element, and formerly the CSMISS IT Workforce Enrichment Element, works with both ESD and the Technical Training Group in HR Professional Development to identify instructors, determine course topics, and review course content for these software modules.

#### 3.3.1.2 Logistics and Registration Support

The Training Systems and Operations Group in HR Professional Development handles all the classroom logistics and the student registration via Registrar, an on-line class registration system that is part of the Human Resources Information Systems (HRIS). See Figure 3 for a screen shot of the Training Registration portion of the HRIS. Students may register on-line at the HR Education and Training website at <http://hr/et>. This registration service is performed, not only for the Program 2000 courses, but also for all the other software training courses as well.

**Figure 3 Screen Shot of Human Resources Information Systems (HRIS)**



### 3.3.2 Training Offered by SQIP Deployment Element

The SQIP Deployment Element (<http://software.jpl.nasa.gov/>) offers courses in Software Management, Software Engineering, and Software Engineering Tools and Technologies.

#### 3.3.2.1 Software Management Courses

The two software management courses include Software Management and Planning (SMP), and Quantitative Software Management (QSM).

#### Software Management and Planning

The purpose of the two-day Software Management and Planning (SMP) course is to provide experienced JPL Project Managers (PMs) and Project Element Managers (PEMs) with relevant information about software issues that may affect the success of their projects. The goals of this course are that JPL PMs and PEMs will have an increased understanding of the software issues relative to the management of projects, and that they will be able to more effectively manage the software in their projects. Topics covered in the course include:

- Software Management Overview
- Software Life-Cycles
- NASA and JPL Standards
- Software Planning and Tracking
- Staffing Considerations
- Software Acquisition

- Software Development Environments
- Systems Engineering Considerations
- COTS Software and Reuse of Software
- Software Cost Estimation Software
- Requirements Management
- Software Testing
- Software Quality
- Software Configuration Management (CM)
- Software Perceptions
- Software Management Summary

### **Quantitative Software Management**

The purpose of the two-day Quantitative Software Management course is to train PEMs and Cog Es in how to generate preliminary and detailed cost estimates and schedules for the entire software development life-cycle. Topics covered include software estimating methods and models, software development estimation, software development metrics, cost drivers, productivity, common errors in software estimation, rules of thumb, software productivity databases, and risk reduction and mitigation.

#### **3.3.2.2 Software Engineering Courses**

The two software engineering courses include Software Product Engineering and Software Peer Reviews.

### **Software Product Engineering**

The purpose of the one-day Software Product Engineering course is to provide more detailed instruction to JPL Cognizant Engineers (Cog Es) and software developers about various aspects of the software life-cycle, as well as the methodologies and tools which facilitate the development process. Topics covered in the course include:

- Software Process Overview
- Software Methodologies and Tools
- Software Requirements Definition and Analysis
- Software Architecture
- Data Engineering, Data Modeling, and Data Management
- *Software Design (future)*
- Software Testing and V&V
- Peer Reviews
- Software Cost Estimation
- Managing and Coordinating Interfaces

### **Software Peer Reviews**

The purpose of the one-day Software Peer Reviews course is to train PEMs and Cog Es in how to conduct various types of peer reviews of software products ranging from desk checks and walkthroughs to formal inspections. It covers activities such as planning and conducting the peer review itself through creating both detailed and summary reports and metrics collection. Checklists will be provided for various types of inspections including system requirements, subsystem functional requirements, software requirements, architectural design, detailed design, code (both C and FORTRAN), test plans and test procedures.

### **Software Testing**

The purpose of the two-day Software Testing course is to provide software engineers and SQA engineers with a thorough understanding of testing approaches, techniques and tools. Topics covered include test planning and management, organizing and developing test cases and reports, unit testing, integration testing, acceptance testing, system testing, and maintenance and regression testing.

#### **3.3.2.3 Software Engineering Tools and Technologies**

The SQIP Deployment Element offers training for the various tools and technologies available through the Software Tool Service and Software Catalog.

### 3.3.2.4 Consulting Support

In addition to classroom training, SQIP engages a number of JPL Subject Matter Experts (SMEs) to provide assistance and consulting support, and indirectly on-the-job training (OJT), to project personnel in key software areas. This assistance takes the form of providing answers to frequently asked questions (FAQs), answering simple queries (less than two hours), and also includes in-depth consulting involving days or weeks of interaction and support. Currently, consulting is available for cost estimation, development planning, metrics definition and implementation, and software assessments.

### 3.3.2.5 Training Under Consideration

In addition, SQIP DE is exploring courses offered through other entities, such as the California State University, Long Beach (CSULB) Systems and Software Engineering Forum for Training (SSEFT), (<http://www.uces.csulb.edu/sseft/>), the Carnegie Mellon University (CMU) Software Engineering Institute (SEI) (<http://www.sei.cmu.edu/>), the Caltech Industrial Relations Center (IRC) (<http://www.irc.caltech.edu/>), the University of California at Irvine (UCI) Dept. of Information and Computer Science (ICS) (<http://www.ics.uci.edu/index.html>), and Learning Tree International (<http://www.learningtree.com/>), etc. Table 2 below indicates the types of training offered by these organizations.

**Table 2 External Training Providers**

| Organization Name                         | Relevant Types of Training Provided   |
|---|---|
| CSULB SSEFT                               | Creating Integrated Project Plans<br>Interpreting ISO 9001 for Software Organizations<br>Introduction to UML<br>Managing Software Development with Metrics<br>Object-Oriented Analysis and Design<br>Principles of Software Engineering<br>Project Management<br>Rapid Development<br>Software Acquisition and Development: What to do with the Choices!<br>Software Architecture<br>Software Estimation and Scheduling<br>Software Project Management<br>Software Reuse for Practitioners<br>Software Testing: A Practical Approach<br>Systems & Software Configuration Management (CM)<br>Systems & Software Requirements Management<br>Systems and Software Risk Management<br>Today's Computer-Aided Software Engineering (CASE) Tools<br>Web Application Testing |
| CMU Software Engineering Institute (SEI)  | Capability Maturity Models (CMM, CMMI, People CMM, SA-SMM)<br>Measurement Curriculum<br>Organizational Management<br>Personal Software Process/Team Software Process (PSP/TSP)<br>Process Improvement<br>Security   |
| Caltech Industrial Relations Center (IRC) | Leadership and Management Development<br>Product Development<br>Technology Management<br>Strategic Planning and Performance Measurement   |
| UCI ICS                                   | Undergraduate and graduate programs in ICS<br>( <a href="http://www.editor.uci.edu/98-99/ics/ics.3.html">http://www.editor.uci.edu/98-99/ics/ics.3.html</a> )   |
| Learning Tree International (LTI)         | Software Testing<br>Software Project Monitor and Control  |

### 3.3.3 Training Offered by CSMISS IT Workforce Enrichment Element

#### 3.3.3.1 Software Architectures

The CSMISS IT WE Element (<http://csmis.jpl.nasa.gov/>) offers a 10-week course (30 hours total) in Software Architectures taught by either Dr. Nenad Medvidovic or Ed Colbert of the Center for Software Engineering (CSE) at the University of Southern California (USC) (<http://sunset.usc.edu/>). Topics covered in the course include:

- Overview of Software Engineering Principles
- Origins of Software Architectures
- Overview of Software Architectures
- Introduction to Software Architectures
- Software Architects: People and Teams
- Scope of Software Architectures: Canonical Case Studies
- Arriving at an Architecture
- Domain-specific Software Architectures (DSSAs)
- Architectural Styles
- Examples of DSSAs
- Modeling Software Architectures: Architecture Description Languages (ADLs)
- Role of UML in Modeling Software Architectures
- Software Connectors
- Architecture Implementation Issues
- Software Interoperability Technologies
- Middleware and its Role in Software Architectures
- Dynamism in Software Architectures
- Architecture-based Testing and Analysis
- JPL's Mission Data System: A Case Study

#### 3.3.3.2 Software Architect Program

The CSMISS IT WE Element has developed a Software Architect Program (SWAP) that is intended to help train the next generation of software architects who will design and implement software for future JPL missions. These software architects will provide a system-level view of software across a project or program. They will help ensure that a consistent software architecture is utilized across missions, that software components fit together, and that the appropriate methodologies, tools, practices and technologies are applied and utilized. They will be an important part of the interface between technical (software engineers, software developers and testers, data engineers, data archive team, etc.) and managerial (customers, managers, scientists, hardware engineers, mission architects, etc.) considerations for a project or program.

The CSMISS Software Architect Program is a half-time, one-year paid internship. At least two candidates are chosen each year to participate. The training, internship, and other activities are funded by CSMISS. Applicants must be full-time, benefit-based JPL employees, possess a bachelor's degree or equivalent and have a minimum of five years of work experience that includes a significant software engineering background and/or flight project experience. In the selection process, CSMISS seeks candidates with strong technical and problem-solving skills, leadership in technical innovation, communication, and mentoring skills, and software engineering, software management and/or flight project experience.

Areas in which the software architects receive education, training, mentoring and work experience include the following technical areas:

- Software Architecture and System Modeling
- Operating Systems
- Computer Languages, Groupware and Middleware
- Data Engineering and Data Modeling
- Database Management and Data Management
- Network Architectures and Protocols

- Internet and Web Technology
- International Industry Standards
- Performance Modeling, Simulation, Tuning and Optimization
- Advanced Technologies
- Security Issues and Concerns
- IT Vendor and Product Awareness (COTS applications and tools)
- Space Science

In addition, their training includes non-technical areas such as project cost estimating, assertive management, negotiation, leadership, high performance teams, and process improvement. This training is provided mostly by NASA Code FT at various NASA Centers and by the Caltech Industrial Relations Center (IRC) (<http://www.irc.caltech.edu/>). However, additional training is provided by Bredemeyer Consulting of Tacoma, WA, (<http://www.bredemeyer.com/>) a specialist in training software architects and architecture program managers, and CMU's Software Engineering Institute (SEI).

### 3.3.3.3 IT Spotlight Series and IT Seminar Series

The CSMISS IT WE Element also sponsors two monthly seminars on IT-related topics. The CSMISS IT Spotlight Series features internal JPL speakers presenting information technology that is significant to JPL missions. The CSMISS IT Seminar Series features external speakers presenting information technology, methodologies, tools and best practices used in industry and academia.

### 3.3.4 Training Offered by IT Education and Training (ITET) Group

The ITET Group (<http://itet.jpl.nasa.gov/>) offers courses in the following five areas:

1. Information Technology Security
2. Methods, Architecture and Tools
3. Programming and Object-Oriented Technologies
4. Database Tools
5. Core Office Skills (Non-technical software Skills)

A list of the courses offered by the ITET Group in each of the above five areas is given below.

In addition, ITET provides a Technology-Based Training (TBT) service that offers on-line self-paced learning via the Web. It consists of CDs/e-courses for PC users only; and, videotapes for users of PCs, MACs, or UNIX systems. The TBT Service provides a total of 226 items covering 58 titles, and includes media for the following nine areas: C++, Java, Visual Basic, UNIX, Microsoft Office, Database Tools, Windows NT, Web Tools, and others.

#### Information Technology Security

- NASA software Security Awareness Briefing
- Windows 2000 Security Series

#### Database Tools

- Access
- Oracle
- FoxPro
- Paradox

#### Methods, Architecture and Tools

- Introduction to CCC/Harvest Configuration Management (CM) Tool
- Applying DOORS (Dynamic Object Oriented Requirements System)
- Software Inspections
- Software Requirements Management
- Embedded Real-Time Systems
- Intelligent Software Agents
- Rational Rose Workshop
- Software System Safety
- Tornado II Training Workshop
- Overview of the Unified Modeling Language (UML)

**Programming and Object-Oriented Technologies**

- Introduction to Object-Oriented Concepts
- Java as an Object-Oriented Programming Language
- Java for GUI Development
- Java Programming
- Object-Oriented Analysis and Design using UML
- Object-Oriented Design (OOD) and Programming in Java
- Object-Oriented Design (OOD) with Patterns and Frameworks
- Using Design Patterns, Frameworks and CORBA
- Programming in C++
- Programming in Perl
- UNIX

**Core Office Skills**

- Introduction to Adobe Acrobat
- Introduction to Adobe Illustrator
- Using the AFS File Server
- Electronic Communications
- Eudora (E-mail system)
- FileMaker Pro
- HTML (Hyper-Text Markup Language)
- Microsoft Office 97
- Microsoft Excel
- Microsoft Word
- Microsoft PowerPoint
- Microsoft Project
- Photoshop
- Introduction to Visual Basic
- Windows NT

**3.3.5 Training Offered by PDC Design Hub**

The Design Hub of JPL's Project Design Center (PDC) (<http://pdc.jpl.nasa.gov/>) offers courses on the use of various COTS design tools, not only for software design, but for hardware design as well. These courses are quite relevant to the Software Community as the distinction between software and hardware becomes more vague, with the development of ASICs and FPGAs. Tools featured in past have included:

- Alatek HES, an HDL simulation acceleration product
- Verilog Fundamentals, IC Design using Verilog Hardware Description Language(HDL) and Verilog Logic Simulation
- Innoveda's Visual Elite, a verification tool for performing analysis of cause and effects of HDL based design
- I-Logix Model Based Technologies
- Avanti V20, an ASIC hardware verification tool
- C Level Design Cycle C, a hardware design tool
- AutoDesk tools such as AutoCad, Inventor, and Mechanical Desktop.

more TBS Mike Jahan.

**3.3.6 Training Offered by NASA Code FT**

Code FT, the training branch of NASA's Office of Human Resources and Education, has developed an agency-wide training and development program that is based on specific career development models and roadmaps (<http://www.hq.nasa.gov/office/codeft/codeft/welcome.html>). Not only does the program include courses on software, engineering, and mission support, but also courses on leadership and management, via the NASA Academy of Program and Project Leadership (<http://appl.nasa.gov/>) and the Leadership and

Management Development Program (<http://www.creativesolutions-home.com/nasa/lmd/home.htm>). In addition, NASA sponsors the NASA Site for On-Line Learning and Resources (SOLAR), a series of web-based courses in various disciplines, including IT Security (<https://solarap2.nis.nasa.gov:443/solar/delivery/public/html/newindex.htm>).

As indicated in the NASA Software Initiative Implementation Plan, the NASA Software Working Group (SWG) maintains the "NASA Software Training Course Listing" (NASA-TM-209370) that describes the courses that are available from a core group of providers for software managers, software engineers and software assurance engineers. This course listing is based upon the Key Process Areas of the CMM. A copy of this TM is included in Table 13 of Appendix 8 NASA Software Training Courses. The agency-wide training master schedule is located on NASA Code FT's web site. ([http://www.hq.nasa.gov/office/codeft/codeft/training\\_master.pdf](http://www.hq.nasa.gov/office/codeft/codeft/training_master.pdf)) Currently, there are only five software-related classes shown as being available this fiscal year. These classes are SPA: Software Process Appraisal, SPI: Software Process Improvement, MPI: Mastering Process Improvement, SEPG: Software Engineering Process Group, and O-CMMI: Overview of CMMI. Other courses that could involve both hardware and software include REQ: System Requirements, SD: System Design, and VWT&E: Verification, Validation, Test and Evaluation of Systems.

In addition, NASA Code FT contracts with CSM and the Software Engineering Institute (SEI) to provide training to each NASA Center in process improvement and software-related topics. Tables 3 and 4 below contain the list of courses offered by CSM and the SEI, respectively. For a list of the actual courses to be offered at JPL by CSM and SEI during the period covered by this plan, see Table 5 in Section 3.3.2.

**Table 3 Courses Offered by CSM and funded by NASA Code FT**

| Course Title  | Course Description  | # of days |
|---|---|-----------|
| Process Improvement   |   |           |
| CMM-based Software Process Improvement                                    | Introduction of CMM and 18 Key Process Areas (KPAs), benefits of process improvement  | 4         |
| Software Capability Pre-Evaluation  | Prepares participants for a software capability pre-evaluation  | 2         |
| Software Capability Evaluation  | Prepares participants for a Software Capability Evaluation (SCE) to attain a Level 2 rating   | 3         |
| Overview of the CMM or Overview of the CMMI                               | A concise overview of the Capability Maturity Model Integrated (CMMI), its two representations, (staged vs. continuous), and what it means to your organization | 0.5       |
| Introduction to CMMI  | Introduction to the CMMI model and its process areas  | 3         |
| Standard CMMI Assessment Method for Pre-Evaluation of Process Improvement | Prepares participants for a Standard CMMI Assessment Method for Process Improvement (SCAMPI) pre-evaluation   | 3         |
| Standard CMMI Assessment Method for Evaluation of Process Improvement     | Prepares participants for a Standard CMMI Assessment Method for Process Improvement (SCAMPI) evaluation to attain a Level 2 rating                              | 3         |
| Intermediate Concepts of CMMI Models                                      | Provides a deeper understanding of CMMI Model and its fundamental concepts; deep understanding of the five maturity levels and process areas                    | 5         |
| Intermediate Concepts of CMMI   | More in-depth discussion of CMMI process areas, generic goals, specific goals and assessment approaches   | 5         |
| Software Process Engineering Group (SEPG) Workshop (MPI)                  | Describes activities of the SEPG and gives examples and guidelines  | 2         |
| Mastering Process Improvement (MPI)                                       | Details the steps necessary for an effective SEPG and successful TWGs   | 5         |

|  |  |        |
|--|--|--------|
| Software Acquisition (SA-CMM) Overview   | Describes the key elements of managing and improving the software acquisition and management process         | 2      |
| Management Steering Group (MSG) Workshop | Executive overview of CMM and MPI, and role of MSG   | 2 hrs. |
| <b>Technical Management</b>              |  |        |
| Software Requirements Management         | Teaches participants how to collect, evaluate and manage user requirements to ensure customer satisfaction   | 2      |
| Software Configuration Management (CM)   | An integrated approach to SCM, theory, functions, and "hands on" exercises                                   | 2      |
| Software Quality Assurance (SQA)         | Basic infrastructure and life-cycle quality assurance methodologies, SQA "how to's"                          | 2      |
| <b>Estimating and Costing</b>            |  |        |
| Software Estimating and Costing          | Gives background, skills, techniques and tools to accurately forecast software cost, resources and schedules | 3      |

**Table 4 Courses Offered by SEI and funded by NASA Code FT**

| Course Title                            | Course Description  | # of days |
|---|---|-----------|
| <b>Process Improvement</b>              |   |           |
| Intermediate CMMI                       | Provides participants with a deeper understanding of the Capability Maturity Model Integrated (CMMI) and its fundamental concepts   | 5         |
| Introduction to SA-CMM                  | Introduction to the Software Acquisition Capability Maturity Model (SA-CMM); describes the key elements of managing and improving the acquisition process for software systems and products.                          | 2.5       |
| Defining Software Processes             | Helps SEPG members to identify and document their current baseline processes, analyze process deficiencies, and specify needed process improvements.  | 3.5       |
| <b>Technical Management</b>             |   |           |
| Managing Software Projects with Metrics | Teaches project managers how software measurement can help them meet their goals, and includes capabilities and limitations of software measurement; covers performance measurement and earned value management (EVM) | 3         |
| Managing Technological Change           | Provides participants with skills and knowledge that will help them introduce new technology or continuous improvement initiatives smoothly and effectively.  | 3.5       |

### 3.4 Training Schedule

#### 3.4.1 Schedule of SQI Training Activities

The schedule for SQI training activities is part of the overall SQI Deployment Element schedule. As such, it includes the full range of activities in the training process, defined in Section 3.1, particularly the following:

1. annual review of training requirements and curriculum, and subsequent updating of the Software Training Plan
2. scheduling and publicizing of course offerings for the fiscal year
3. analysis of course evaluations and feedback, and collection of metrics.

### 3.4.2 Schedule of Software Course Offerings

For a tentative list of software course offerings and their approximate dates for this fiscal year, see Table 5 below.

**Table 5 Software Training Courses Offered in FY 2002 - FY 2003**

| Training Provider                   | Training Courses   | Date(s) Offered   |
|-------------------------------------|--|---|
| SQIP DE<br><br>Internal Instructors | Software Management & Planning (SMP I, II)                           | Feb. 15, 22, 2002<br>Jun. 12, 27, 2002<br>Oct. 22, 29, 2002<br>Mar. 18, 25, 2003<br>Jun. 2, 3, 9, 10, 2003<br>Sept. 2, 9, 2003      |
|                                     | Quantitative Software Management (formerly Software Cost Estimation) | Mar. 26, 2003<br>Jun. 18, 2003<br>Aug. 19, 2003   |
|                                     | Software Product Engineering (SPE)                                   | May 16, 2002<br>Aug. 13, 2002<br>Jan. 14, 2003<br>Apr. 15, 2003<br>Aug. 5, 2003   |
|                                     | Software Peer Reviews (formerly Software Formal Inspections)         | Jan. 10, 2003<br>May 28, 2003<br>Sept. 16, 2003   |
|                                     | Software Testing   | July 17-18, 2003  |
|                                     | Software Tools Workshop  | Fall 2003 ?   |
|                                     | Model-based Verification Workshop                                    | June 8-9, 2002  |
| Instructors from CSM                | MSG (for PEMC or EC ?)   | TBD if needed   |
|                                     | Overview of CMMI   | Mar. 14 & 15, 2002<br>June 17, 2003   |
|                                     | Introduction to CMMI   | April 16-18, 2002<br>Nov. 12-14, 2002<br>June 11-13, 2003   |
|                                     | Intermediate CMMI  | Mar. 24-28, 2003 at ARC   |
|                                     | Acquisition and the CMMI   | June 10, 2002   |
|                                     | Performance Team Support -- Pre-Evaluation for SCE or SCAMPI         | July 17-19, 2002<br>Sept. 16-20, 2002   |
|                                     | Mastering Process Improvement  | June 24-28, 2002 at ARC   |
|                                     | Pre-Assessment for SCAMPI  | Oct. 16-22, 2002  |
|                                     | Managing Technological Change  | Fall 2003 ?   |
| CSMISS IT WE                        | Software Architecture  | Mar. 4 - May 6, 2002<br>Aug. 2 - Oct. 11, 2002<br>Apr. 11 - June 13, 2003<br>July 11- Sept. 12, 2003                                |
| ESD and HR PD                       | <i>The JPL Project Manager</i>                                       | Oct. 21-25, 2001<br>May 19-24, 2002<br>Oct. 13-18, 2002   |
|                                     | <i>The JPL PEM</i>   | Nov. 27, 2001- Jan. 15, 2002<br>May 7 - June 4, 2002<br>Jan. 21 - Feb. 18, 2003<br>May 6 - June 3, 2003<br>Sept. 16 - Oct. 14, 2003 |
|                                     | <i>The JPL Cog E</i>   | Mar. 5 - Apr. 9, 2002<br>June 25 - July 30, 2002<br>Nov. 5 - Dec. 17, 2002<br>Mar. 4 - Apr. 8, 2003                                 |

|              |   |                                      |
|--------------|---|--------------------------------------|
|              |   | June 24 – July 29, 2003              |
| NASA Code FT | Systems Engineering (SE-83)<br>Offered by NASA APPL | July 15-18, 2002<br>Sept. 9-13, 2002 |
|              | System Requirements                                 |                                      |
| ITET         | See the ITET Web Site                               | http://itet                          |

### 3.5 Training Budget

Since the software courses are offered by various organizations across the lab as well as external providers, the budget for them is spread across these organizations as well. Table 5 below shows the approximate allocations for each area. In some cases, the numbers are just estimates for now.

**Table 6 Training Budgets for Various Software Training Providers**

| Software Training Providers  | Training Budget for FY 2002 & FY 2003 (\$K) | Training Provided  |
|--|---|--|
| 1. IT Education and Training (ITET) Group<br>Internal Instructors and various vendors  | \$700<br>**                                 | Information Technology Security Methods, Architecture and Tools<br>Programming and Object-Oriented Technologies<br>Database Tools<br>Core Office Skills<br>(Non-technical IT Skills) |
| 2. SQIP Deployment Element<br>Internal Instructors, other entities                     | \$60  | SMP I/II, SPE, QSM, SPR, etc.  |
| CSM Instructors<br>(funded by NASA Code FT)  | \$200                                       | Process Improvement: Overview of CMMI, Intro. to CMMI, Pre-Assessment, SCAMPI  |
| 3. CSMISS IT Workforce Enrichment Element<br>USC CSE<br>NASA, Caltech, Bredemeyer, SEI | \$20<br>\$40                                | Software Architecture<br>SWAP courses  |
| 4. JPL Professional Development<br>(2-3 offerings/year → 8 offerings/yr)               | \$200<br>???                                | <i>The JPL Project Manager,</i><br><i>The JPL PEM, The JPL Cog E</i>   |
| <b>TOTAL</b>   | <b>~\$1220</b>                              |  |

\*\* Note that the ITET Budget is just an estimate and includes reimbursed costs (via a holding account), such as when ITET offers a course to students for a fee and the students pay for it with funds from their direct project account.

Given that there are approximately 1200 to 1300 people in the JPL Software Community, this budget averages to approximately \$1K per person. This could be considered a modest investment, given JPL and NASA's goal of achieving CMM/CMMI Level 3 in the near future.

## 4.0 Appendices

### 4.1 Appendix 1 Acronyms and Abbreviations

|         |   |
|---------|---|
| ADL     | Architecture Description Languages                          |
| AMMOS   | Advanced Multi-Mission Operations System                    |
| ASIC    | Application Specific Integrated Circuit                     |
| Caltech | California Institute of Technology                          |
| CAN     | Corrective Action Notice                                    |
| CM      | Configuration Management                                    |
| CMM     | Capability Maturity Model                                   |
| CMMI    | Capability Maturity Model Integrated                        |
| CMU     | Carnegie Mellon University                                  |
| CogE    | Cognizant Engineer  |
| COTS    | Commercial Off-the-Shelf                                    |
| CSE     | Center for Software Engineering                             |
| CSM     | Center for Systems Management (Training vendor for Code FT) |
| CSMISS  | Center for Space Mission Information and Software Systems   |
| CSULB   | California State University, Long Beach                     |
| CTM     | Contract Technical Manager (or Monitor)                     |
| DE      | Deployment Element  |
| DOORS   | Dynamic Object Oriented Requirements System                 |
| DNP     | Develop New Products  |
| DSN     | Deep Space Network  |
| DSP     | Develop Software Products                                   |
| DSSA    | Domain-specific Software Architecture                       |
| ESD     | Engineering and Science Directorate                         |
| FPGA    | Field Programmable Gate Arrays                              |
| HR      | Human Resources   |
| HTML    | Hyper-Text Markup Language                                  |
| ICIS    | Institutional Computing and Information Systems             |
| IEEE    | Institute of Electrical and Electronics Engineers           |
| IRC     | Industrial Relations Center                                 |
| IS&CS   | Information Systems and Computer Science                    |
| ISO     | International Standards Organization                        |
| ISR     | Institute for Software Research                             |
| IT      | Information Technology                                      |
| ITET    | IT Education and Training                                   |
| ITWE    | IT Workforce Enrichment                                     |
| JPL     | Jet Propulsion Laboratory                                   |
| ICIS    | Institutional Computing and Information Systems             |
| KPA     | Key Process Area  |
| LLIS    | Lessons Learned Information System                          |
| LTI     | Learning Tree International                                 |
| MCO     | Mars Climate Orbiter  |
| MDS     | Mission Data System   |
| MPL     | Mars Polar Lander   |
| MSG     | Management Steering Group                                   |
| NASA    | National Aeronautics and Space Administration               |
| NIAT    | NASA Integration Action Team                                |
| NPD     | NASA Policy Directive                                       |
| NPG     | NASA Procedures and Guidelines                              |
| OOD     | Object-Oriented Design                                      |
| PD      | Professional Development                                    |
| PDC     | Project Design Center                                       |

|            |   |
|------------|---|
| PEM        | Project Element Manager                                 |
| PRAD       | Project Resource Administration Division                |
| QSM        | Quantitative Software Management                        |
| SCAMPI     | Standard CMMI Assessment Method for Process Improvement |
| <b>SCE</b> | <b>Software Capability Evaluation</b>                   |
| SCM        | Software Configuration Management (CM)                  |
| SEI        | Software Engineering Institute                          |
| SEPG       | Software Engineering Process Group                      |
| SME        | Subject Matter Expert                                   |
| SMP        | Software Management and Planning                        |
| SPE        | Software Product Engineering                            |
| SPR        | Software Peer Reviews                                   |
| SQA        | Software Quality Assurance (SQA)                        |
| SQIP       | Software Quality Improvement Project                    |
| SSEFT      | Software and System Engineering Forum for Training??    |
| SWAP       | Software Architect Program                              |
| SW         | Software  |
| SWG        | Software Working Group                                  |
| TBD        | To Be Determined  |
| TBS        | To Be Supplied  |
| TBT        | Technology Based Training                               |
| TM         | Technical Manager                                       |
| TWG        | Technical Working Group                                 |
| UCI        | University of California, Irvine                        |
| UML        | Unified Modeling Language                               |
| USC        | University of Southern California                       |
| V&V        | Validation and Verification                             |
| WBS        | Work Breakdown Structure                                |
| XML        | X Markup Language                                       |

## 4.2 Appendix 2 JPL Job Families

**Table 7 Job Families in the JPL Base Pay Program**

| <b>Job Family Name</b>                      | <b>Job Family Description</b>  | <b>* Approx. Number of Employees</b> |
|---|--|--------------------------------------|
| 1. Line Management                          | Primary responsibility for an organization, including employees, functions and processes   | 520                                  |
| 2. Program/Project Management               | Primary responsibility for delivery of a program/project and related processes.  | 430                                  |
| 3. Enterprise Development and Operations    | Performs combination of or specialized duties in institutional or business support of JPL's mission  | 590                                  |
| 4. Technical Assistant                      | Collaborates in/supports design, prototype, testing and implementation of engineering products or scientific experiments/analysis.   | 100                                  |
| 5. Administrator                            | Provides administrative support to home organization in such areas as finance/budgeting, workforce planning, human resources, facilities, procurement/acquisition, property and safety.              | 120                                  |
| 6. Site Services Support                    | Includes such jobs as trades, security, mechanics, and material handling   | 20                                   |
| 7. Site Services                            | Performs combination of or specialized duties which support the physical plant and its physical assets (e.g., facilities, safety, security areas).   | 100                                  |
| 8. Enterprise Support                       | Includes such jobs as secretary, clerical support, and communications support.   | 330                                  |
| 9. Information Systems and Computer Science | Designs, builds and delivers information systems; may do research; OR performs system, network and data management.  | 910                                  |
| 10. Engineering                             | Designs, builds and delivers engineering products and processes; may do research.  | 1550                                 |
| 11. Engineering/Science Support             | Includes such jobs as electronic technicians, assemblers, machinists, etc.   | 130                                  |
| 12. Technical                               | Performs work across engineering, science and computer science fields; may do research; OR performs collaborative research in sciences; OR performs operations research or configuration management. | 240                                  |
| 13. Science                                 | Performs independent research in the sciences; publishes in peer reviewed journals; typically a Principal Investigator (PI).   | 210                                  |
| 14. Student Support                         |  | 280                                  |
| <b>TOTAL</b>                                |  | <b>5530</b>                          |

\* Information provided by IBS Human Resources Applications Group as of June 6, 2003, and rounded to the nearest tens.

### 4.3 Appendix 3 Capability Maturity Model Integrated

Figure 4 CMMI Process Areas (PAs)

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

## 4.4 Appendix 4 CMMI Organizational Training Process Area

### 4.4.1 Organizational Training Purpose

The purpose of the Organizational Training process area is to develop the skills and knowledge of people so they can perform their roles effectively and efficiently. The Organizational Training process area involves first identifying the training needed by the organization, projects, and individuals, then developing or procuring training to address the identified needs.

Organizational Training includes training to support the organization's strategic business objectives and to meet the tactical training needs that are common across projects and support groups. Specific training needs identified by individual projects and support groups are handled at the project and support group level and are outside the scope of Organizational Training. Project and support groups are responsible for identifying and addressing their specific training needs.

Effective training requires assessment of needs, planning, instructional design, and appropriate training media, as well as a repository of training process data. The main components of training include a managed training-development program, documented plans, personnel with appropriate mastery of specific disciplines and other areas of knowledge, and mechanisms for measuring the effectiveness of the Organizational Training. Skills and knowledge may be technical, organizational, or contextual.

### 4.4.2 Organizational Training Goals

The Organizational Training process area has the following three goals:

- SG 1** Establish an Organizational Training capability -- A training capability that supports the organization's management and technical roles is established and maintained.
- SG 2** Provide necessary training -- Training necessary for individuals to perform their roles effectively is provided.
- GG 3** Institutionalize a defined training process -- The training process is institutionalized as a defined process.

### 4.4.3 Organizational Training Specific Practices by Goal

**SG 1** Establish an Organizational Training capability -- A training capability that supports the organization's management and technical roles is established and maintained.

- SP 1.1** Establish and maintain the strategic training needs of the organization.
- SP 1.2** Determine which training needs are the responsibility of the organization and which will be left to the individual project or support group.
- SP 1.3** Establish and maintain an organizational training tactical plan.
- SP 1.4** Establish and maintain a training capability to address organizational training needs.

**SG 2** Provide necessary training -- Training necessary for individuals to perform their roles effectively is provided.

- SP 2.1** Deliver the training following the organizational training tactical plan.
- SP 2.2** Establish and maintain records of the organizational training.
- SP 2.3** Assess the effectiveness of the organization's training program.

**GG 3** Institutionalize a defined training process -- The training process is institutionalized as a defined process.

#### Commitment to Perform

- GP 2.1** Establish and maintain an organizational policy for planning and performing the organizational training process.

**Ability to Perform**

- GP 3.1** Establish and maintain the description of a defined organizational training process.
- GP 2.2** Establish and maintain the plan for performing the organizational training process.
- GP 2.3** Provide adequate resources for performing the organizational training process, developing the work products, and providing the services of the process.
- GP 2.4** Assign responsibility and authority for performing the process, developing the work products and providing the services of the organizational training process.
- GP 2.5** Train the people performing or supporting the organizational training process as needed.

**Directing Implementation**

- GP 2.6** Place designated work products of the organizational training process under appropriate levels of configuration management.
- GP 2.7** Identify and involve the relevant stakeholders of the organizational training process as planned.
- GP 2.8** Monitor and control the organizational training process against the plan for performing the process and take appropriate corrective action.
- GP 3.2** Collect work products, measures, measurement results, and improvement information derived from planning and performing the organizational training process to support the future use and improvement of the organization's processes and process assets.

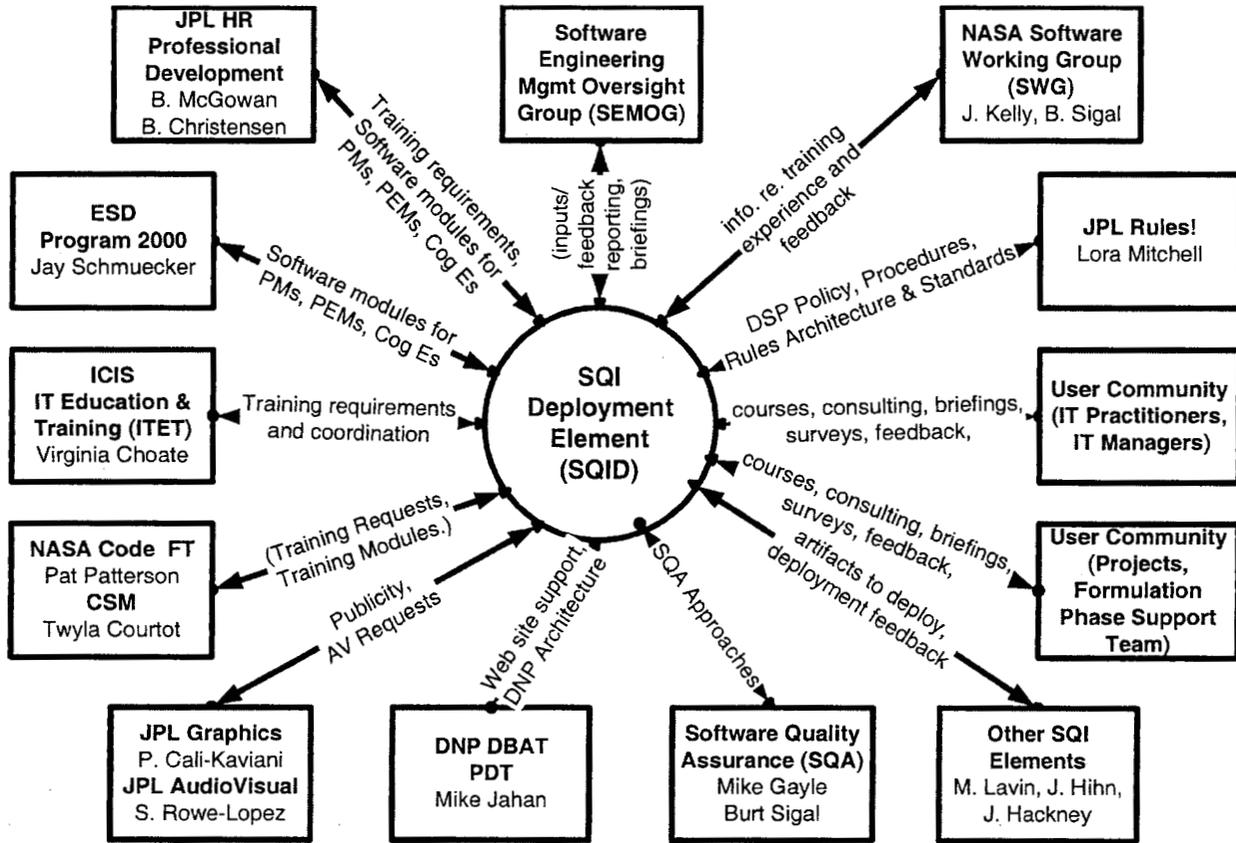
**Verifying Implementation**

- GP 2.9** Objectively evaluate adherence of the organizational training process against its process description, standards, and procedures, and address non-compliance.
- GP 2.10** Review the activities, status, and results of the organizational training process with higher level management and resolve issues.

Excerpted from The Capability Maturity Model Integration Version 1.1: Staged Representation, March 2002, pages 348-363

## 4.5 Appendix 5 SQI Deployment Element Interfaces

Figure 5 SQI Deployment Element Interfaces



## 4.6 Appendix 6 Skills Matrices

A number of skills matrices have been developed for various roles at JPL in regards to understanding of various software and managerial concepts, namely matrices for Technical Managers, Project Element Managers, Cognizant Engineers, Software Engineers, Software Quality Assurance (SQA) Engineers, Mission Assurance Managers and Software Architects. These matrices are an attempt to indicate the desired level of competence or depth (cursory, working, proficient or expert) in each area for a particular role. The competency levels have the following meanings:

- 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

Table 8 contains the skills matrix for Project Managers (PMs) and Table 9 contains the skills matrix for Project Element Managers (PEMs). Table 10 contains the skills matrix for Cognizant Engineers (Cog Es) and Table 11 contains the skills matrix for Software Engineers (SWEs). Table 12 contains the skills matrix for Software Quality Assurance (SQA) Engineers (SQA Engrs) and Table 15 contains the skills matrix for Mission Assurance Managers (MAMs). Table 13 contains the Software Assurance Skills for SQA Engineers and Table 14 contains the Software Assurance Skills for MAMs or PEMs and Cog Es. Lastly, Table 16 contains the skills matrix for Software Architects upon completion of the Software Architect Program (SWAP).

**Table 8 Skills Matrix for Project Managers (PMs)**

| Technical Competence and Technical Depth→         | N    | C       | W       | P          | E      |
|---|------|---------|---------|------------|--------|
|   | None | Cursory | Working | Proficient | Expert |
| <b>Skill Category and Skill Description</b>       |      |         |         |            |        |
| <b>Software Management</b>                        |      |         |         |            |        |
| Software Cost Estimation                          |      |         | W       |            |        |
| Software Development Environments                 |      |         | W       |            |        |
| Software Planning, Management & Control           |      |         | W       |            |        |
| Software Quality Assurance (SQA)                  |      |         | W       |            |        |
| Software Configuration Management (CM)            |      |         | W       |            |        |
| <b>Software Development</b>                       |      |         |         |            |        |
| Software Architecture                             |      | C       |         |            |        |
| Software Design                                   |      | C       |         |            |        |
| Methodologies, Tools and Processes                |      | C       |         |            |        |
| Software Technology Awareness                     |      | C       |         |            |        |
| <b>Hardware Development</b>                       |      |         |         |            |        |
| Space Flight Hardware Paperwork Reqmts.           |      |         | W       |            |        |
| Hardware Procedures and Handling                  |      |         | W       |            |        |
| Hardware Qualifying Procedures                    |      |         | W       |            |        |
| Hardware Parts Acquisition                        |      |         | W       |            |        |
| Hardware Test and Validation                      |      |         | W       |            |        |
| Hardware Technology Awareness                     |      |         | W       |            |        |
| <b>Systems Engineering</b>                        |      |         |         |            |        |
| Requirements Definition and Analysis              |      |         |         | P          |        |
| Tradeoffs, Tailoring and Prioritizing             |      |         |         |            | E      |
| System Architecture                               |      |         |         | P          |        |
| Testing Approaches                                |      |         |         | P          |        |
| Processes and Procedures, ISO 9000                |      |         |         | P          |        |
| <b>Planning and Tracking Skills</b>               |      |         |         |            |        |
| Task Planning (WBSs, WIPs, etc.)                  |      |         |         |            | E      |
| Task Allocation (WAs, Workforce estimates)        |      |         |         |            | E      |
| Schedule Development and Tracking                 |      |         |         |            | E      |
| Budget Development and Tracking                   |      |         |         |            | E      |
| <b>Problem Solving and Decision Making Skills</b> |      |         |         |            |        |
| Problem Identification, Solution, Escalation      |      |         |         |            | E      |
| Timely Decisions and Follow Through               |      |         |         |            | E      |
| <b>Vision and Leadership</b>                      |      |         |         |            |        |
| “Big Hat” and “Big Picture” Approach              |      |         |         |            | E      |
| Forms Clear Picture of Problem to be solved       |      |         |         |            | E      |
| Takes Ownership of the Problem/Task               |      |         |         |            | E      |
| <b>People Skills</b>                              |      |         |         |            |        |
| Staffing/Team Selection                           |      |         |         |            | E      |
| Team Building                                     |      |         |         |            | E      |
| Conflict Resolution                               |      |         |         | P          |        |
| Challenging, Inspiring & Motivating Others        |      |         |         |            | E      |
| Delegating  |      |         |         |            | E      |
| Negotiating                                       |      |         |         | P          |        |
| <b>Communicating and Reporting Skills</b>         |      |         |         |            |        |
| Presentations, Reviews and Reports                |      |         |         |            | E      |
| Customer Focus and Awareness                      |      |         |         |            | E      |
| Sponsor Interface                                 |      |         |         |            | E      |
| Open communication lines with team & mgmt.        |      |         |         |            | E      |
| Meeting Management                                |      |         |         | P          |        |

**Table 9 Skills Matrix for Software Managers and Software PEMs**

| Technical Competence and Technical Depth→         | N<br>None | C<br>Cursory | W<br>Working | P<br>Proficient | E<br>Expert |
|---|-----------|--------------|--------------|-----------------|-------------|
| <b>Skill Category and Skill Description</b>       |           |              |              |                 |             |
| <b>Software Management</b>                        |           |              |              |                 |             |
| Software Cost Estimation                          |           |              |              |                 | E           |
| Software Development Environments                 |           |              |              |                 | E           |
| Software Planning, Management & Control           |           |              |              |                 | E           |
| Software Quality Assurance (SQA)                  |           |              |              | P               |             |
| Software Configuration Management (CM)            |           |              |              | P               |             |
| <b>Software Development</b>                       |           |              |              |                 |             |
| Software Architecture                             |           |              |              | P               |             |
| Software Design                                   |           |              |              |                 | E           |
| Methodologies, Tools and Processes                |           |              |              |                 | E           |
| Software Technology Awareness                     |           |              |              | P               |             |
| <b>Hardware Development</b>                       |           |              |              |                 |             |
| Space Flight Hardware Paperwork Reqmts.           |           | C            |              |                 |             |
| Hardware Procedures and Handling                  |           | C            |              |                 |             |
| Hardware Qualifying Procedures                    |           | C            |              |                 |             |
| Hardware Parts Acquisition                        |           | C            |              |                 |             |
| Hardware Test and Validation                      |           | C            |              |                 |             |
| Hardware Technology Awareness                     |           | C            |              |                 |             |
| <b>Systems Engineering</b>                        |           |              |              |                 |             |
| Requirements Definition and Analysis              |           |              |              |                 | E           |
| Tradeoffs, Tailoring and Prioritizing             |           |              |              |                 | E           |
| System Architecture                               |           |              |              | P               |             |
| Testing Approaches                                |           |              |              | P               |             |
| Processes and Procedures, ISO 9000                |           |              |              | P               |             |
| <b>Planning and Tracking Skills</b>               |           |              |              |                 |             |
| Task Planning (WBSs, WIPs, etc.)                  |           |              |              | P               |             |
| Task Allocation (WAs, Workforce estimates)        |           |              |              | P               |             |
| Schedule Development and Tracking                 |           |              |              | P               |             |
| Budget Development and Tracking                   |           |              |              | P               |             |
| <b>Problem Solving and Decision Making Skills</b> |           |              |              |                 |             |
| Problem Identification, Solution, Escalation      |           |              |              |                 | E           |
| Timely Decisions and Follow Through               |           |              |              |                 | E           |
| <b>Vision and Leadership</b>                      |           |              |              |                 |             |
| “Big Hat” and “Big Picture” Approach              |           |              |              | P               |             |
| Forms Clear Picture of Problem to be solved       |           |              |              |                 | E           |
| Takes Ownership of the Problem/Task               |           |              |              |                 | E           |
| <b>People Skills</b>                              |           |              |              |                 |             |
| Staffing/Team Selection                           |           |              |              | P               |             |
| Team Building                                     |           |              |              | P               |             |
| Conflict Resolution                               |           |              |              | P               |             |
| Challenging, Inspiring & Motivating Others        |           |              |              | P               |             |
| Delegating  |           |              |              | P               |             |
| Negotiating                                       |           |              |              | P               |             |
| <b>Communicating and Reporting Skills</b>         |           |              |              |                 |             |
| Presentations, Reviews and Reports                |           |              |              | P               |             |
| Customer Focus and Awareness                      |           |              |              | P               |             |
| Sponsor Interface                                 |           |              | W            |                 |             |
| Open communication lines with team & mgmt.        |           |              |              | P               |             |
| Meeting Management                                |           |              |              | P               |             |

**Table 10 Skills Matrix for Software Cognizant Engineers (Cog Es)**

| Technical Competence and Technical Depth→         | N<br>None | C<br>Cursory | W<br>Working | P<br>Proficient | E<br>Expert |
|---|-----------|--------------|--------------|-----------------|-------------|
| <b>Skill Category and Skill Description</b>       |           |              |              |                 |             |
| <b>Software Management</b>                        |           |              |              |                 |             |
| Software Cost Estimation                          |           |              |              | P               |             |
| Software Development Environments                 |           |              | W            |                 |             |
| Software Planning, Management & Control           |           |              | W            |                 |             |
| Software Quality Assurance (SQA)                  |           |              |              | P               |             |
| Software Configuration Management (CM)            |           |              |              | P               |             |
| <b>Software Development</b>                       |           |              |              |                 |             |
| Software Architecture                             |           |              |              | P               |             |
| Software Design                                   |           |              |              |                 | E           |
| Methodologies, Tools and Processes                |           |              |              | P               |             |
| Software Technology Awareness                     |           |              |              | P               |             |
| <b>Hardware Development</b>                       |           |              |              |                 |             |
| Space Flight Hardware Paperwork Reqmts.           | N         |              |              |                 |             |
| Hardware Procedures and Handling                  | N         |              |              |                 |             |
| Hardware Qualifying Procedures                    | N         |              |              |                 |             |
| Hardware Parts Acquisition                        | N         |              |              |                 |             |
| Hardware Test and Validation                      | N         |              |              |                 |             |
| Hardware Technology Awareness                     |           | C            |              |                 |             |
| <b>Systems Engineering</b>                        |           |              |              |                 |             |
| Requirements Definition and Analysis              |           |              |              | P               |             |
| Tradeoffs, Tailoring and Prioritizing             |           |              |              | P               |             |
| System Architecture                               |           |              | W            |                 |             |
| Testing Approaches                                |           |              | W            |                 |             |
| Processes and Procedures, ISO 9000                |           |              | W            |                 |             |
| <b>Planning and Tracking Skills</b>               |           |              |              |                 |             |
| Task Planning (WBSs, WIPs, etc.)                  |           | C            |              |                 |             |
| Task Allocation (WAs, Workforce estimates)        |           | C            |              |                 |             |
| Schedule Development and Tracking                 |           |              | W            |                 |             |
| Budget Development and Tracking                   |           | C            |              |                 |             |
| <b>Problem Solving and Decision Making Skills</b> |           |              |              |                 |             |
| Problem Identification, Solution, Escalation      |           |              |              | P               |             |
| Timely Decisions and Follow Through               |           |              |              | P               |             |
| <b>Vision and Leadership</b>                      |           |              |              |                 |             |
| “Big Hat” and “Big Picture” Approach              |           |              | W            |                 |             |
| Forms Clear Picture of Problem to be solved       |           |              |              | P               |             |
| Takes Ownership of the Problem/Task               |           |              |              | P               |             |
| <b>People Skills</b>                              |           |              |              |                 |             |
| Staffing/Team Selection                           |           |              | W            |                 |             |
| Team Building                                     |           |              | W            |                 |             |
| Conflict Resolution                               |           |              | W            |                 |             |
| Challenging, Inspiring & Motivating Others        |           |              | W            |                 |             |
| Delegating  |           |              |              | P               |             |
| Negotiating                                       |           |              | W            |                 |             |
| <b>Communicating and Reporting Skills</b>         |           |              |              |                 |             |
| Presentations, Reviews and Reports                |           |              | W            |                 |             |
| Customer Focus and Awareness                      |           |              | W            |                 |             |
| Sponsor Interface                                 |           |              | W            |                 |             |
| Open communication lines with team & mgmt.        |           |              |              | P               |             |
| Meeting Management                                |           |              | W            |                 |             |

**Table 11 Skills Matrix for Software Engineers (SWEs)**

| Technical Competence and Technical Depth→         | N<br>None | C<br>Cursory | W<br>Working | P<br>Proficient | E<br>Expert |
|---|-----------|--------------|--------------|-----------------|-------------|
| <b>Skill Category and Skill Description</b>       |           |              |              |                 |             |
| <b>Software Management</b>                        |           |              |              |                 |             |
| Software Cost Estimation                          |           |              | W            |                 |             |
| Software Development Environments                 |           |              | W            |                 |             |
| Software Planning, Management & Control           |           | C            |              |                 |             |
| Software Quality Assurance (SQA)                  |           |              | W            |                 |             |
| Software Configuration Management (CM)            |           |              | W            |                 |             |
| <b>Software Development</b>                       |           |              |              |                 |             |
| Software Architecture                             |           |              | W            |                 |             |
| Software Design                                   |           |              |              | P               |             |
| Methodologies, Tools and Processes                |           |              |              | P               |             |
| Software Technology Awareness                     |           |              |              | P               |             |
| <b>Hardware Development</b>                       |           |              |              |                 |             |
| Space Flight Hardware Paperwork Reqmts.           | N         |              |              |                 |             |
| Hardware Procedures and Handling                  | N         |              |              |                 |             |
| Hardware Qualifying Procedures                    | N         |              |              |                 |             |
| Hardware Parts Acquisition                        | N         |              |              |                 |             |
| Hardware Test and Validation                      | N         |              |              |                 |             |
| Hardware Technology Awareness                     |           | C            |              |                 |             |
| <b>Systems Engineering</b>                        |           |              |              |                 |             |
| Requirements Definition and Analysis              |           |              | W            |                 |             |
| Tradeoffs, Tailoring and Prioritizing             |           |              | W            |                 |             |
| System Architecture                               |           |              | W            |                 |             |
| Testing Approaches                                |           |              | W            |                 |             |
| Processes and Procedures, ISO 9000                |           |              | W            |                 |             |
| <b>Planning and Tracking Skills</b>               |           |              |              |                 |             |
| Task Planning (WBSs, WIPs, etc.)                  |           | C            |              |                 |             |
| Task Allocation (WAs, Workforce estimates)        |           | C            |              |                 |             |
| Schedule Development and Tracking                 |           | C            |              |                 |             |
| Budget Development and Tracking                   |           | C            |              |                 |             |
| <b>Problem Solving and Decision Making Skills</b> |           |              |              |                 |             |
| Problem Identification, Solution, Escalation      |           |              | W            |                 |             |
| Timely Decisions and Follow Through               |           | C            |              |                 |             |
| <b>Vision and Leadership</b>                      |           |              |              |                 |             |
| “Big Hat” and “Big Picture” Approach              |           |              | W            |                 |             |
| Forms Clear Picture of Problem to be solved       |           |              | W            |                 |             |
| Takes Ownership of the Problem/Task               |           |              | W            |                 |             |
| <b>People Skills</b>                              |           |              |              |                 |             |
| Staffing/Team Selection                           |           | C            |              |                 |             |
| Team Building                                     |           | C            |              |                 |             |
| Conflict Resolution                               |           |              | W            |                 |             |
| Challenging, Inspiring & Motivating Others        |           | C            |              |                 |             |
| Delegating  |           | C            |              |                 |             |
| Negotiating                                       |           | C            |              |                 |             |
| <b>Communicating and Reporting Skills</b>         |           |              |              |                 |             |
| Presentations, Reviews and Reports                |           |              | W            |                 |             |
| Customer Focus and Awareness                      |           |              | W            |                 |             |
| Sponsor Interface                                 |           | C            |              |                 |             |
| Open communication lines with team & mgmt.        |           |              | W            |                 |             |
| Meeting Management                                |           | C            |              |                 |             |

**Table 12 Skills Matrix for Software Quality Assurance (SQA) Engineers (SQA Engrs)**

| Technical Competence and Technical Depth→         | N<br>None | C<br>Cursory | W<br>Working | P<br>Proficient | E<br>Expert |
|---|-----------|--------------|--------------|-----------------|-------------|
| <b>Skill Category and Skill Description</b>       |           |              |              |                 |             |
| <b>Software Tasks</b>                             |           |              |              |                 |             |
| Software Cost Estimation                          |           |              | W            |                 |             |
| Software Development Environments                 |           | C            |              |                 |             |
| Software Planning, Management & Control           |           |              | W            |                 |             |
| Software Quality Assurance (SQA)                  |           |              |              | P               |             |
| Software Configuration Management (CM)            |           |              |              | P               |             |
| <b>Software Development</b>                       |           |              |              |                 |             |
| Software Architecture                             |           | C            |              |                 |             |
| Software Design                                   |           |              | W            |                 |             |
| Methodologies, Tools and Processes                |           |              | W            |                 |             |
| Software Technology Awareness                     |           | C            |              |                 |             |
| <b>Hardware Development</b>                       |           |              |              |                 |             |
| Space Flight Hardware Paperwork Reqmts.           |           |              | W            |                 |             |
| Hardware Procedures and Handling                  |           | C            |              |                 |             |
| Hardware Qualifying Procedures                    |           | C            |              |                 |             |
| Hardware Parts Acquisition                        |           | C            |              |                 |             |
| Hardware Test and Validation                      |           |              | W            |                 |             |
| Hardware Technology Awareness                     |           | C            |              |                 |             |
| <b>Systems Engineering</b>                        |           |              |              |                 |             |
| Requirements Definition and Analysis              |           |              |              | P               |             |
| Tradeoffs, Tailoring and Prioritizing             |           |              |              | P               |             |
| System Architecture                               |           |              | W            |                 |             |
| Testing Approaches                                |           |              |              | P               |             |
| Processes and Procedures, ISO 9000                |           |              |              | P               |             |
| <b>Planning and Tracking Skills</b>               |           |              |              |                 |             |
| Task Planning (WBSs, WIPs, etc.)                  |           |              | W            |                 |             |
| Task Allocation (WAs, Workforce estimates)        |           |              | W            |                 |             |
| Schedule Development and Tracking                 |           |              | W            |                 |             |
| Budget Development and Tracking                   |           |              | W            |                 |             |
| <b>Problem Solving and Decision Making Skills</b> |           |              |              |                 |             |
| Problem Identification, Solution, Escalation      |           |              |              | P               |             |
| Timely Decisions and Follow Through               |           |              |              | P               |             |
| <b>Vision and Leadership</b>                      |           |              |              |                 |             |
| “Big Hat” and “Big Picture” Approach              |           |              | W            |                 |             |
| Forms Clear Picture of Problem to be solved       |           |              |              | P               |             |
| Takes Ownership of the Problem/Task               |           |              |              | P               |             |
| <b>People Skills</b>                              |           |              |              |                 |             |
| Staffing/Team Selection                           |           | C            |              |                 |             |
| Team Building                                     |           |              |              | P               |             |
| Conflict Resolution                               |           |              |              | P               |             |
| Challenging, Inspiring & Motivating Others        |           |              |              | P               |             |
| Delegating  |           |              | W            |                 |             |
| Negotiating                                       |           |              | W            |                 |             |
| <b>Communicating and Reporting Skills</b>         |           |              |              |                 |             |
| Presentations, Reviews and Reports                |           |              |              | P               |             |
| Customer Focus and Awareness                      |           |              |              |                 | E           |
| Sponsor Interface                                 |           |              | W            |                 |             |
| Open communication lines with team & mgmt.        |           |              |              | P               |             |
| Meeting Management                                |           |              |              | P               |             |

**Table 13 Software Assurance Skills for Software Quality Assurance Engineers**

| Technical Competence and Technical Depth→   | N<br>None | C<br>Cursory | W<br>Working | P<br>Proficient | E<br>Expert |
|---|-----------|--------------|--------------|-----------------|-------------|
| <b>Skill Category and Skill Description</b> |           |              |              |                 |             |
| <b>Software Assurance Skills</b>            |           |              |              |                 |             |
| Software Assurance Disciplines              |           |              |              | P               |             |
| Software Reliability                        |           |              | W            |                 |             |
| Software Verification & Validation (V&V)    |           |              |              | P               |             |
| Software Independent V&V                    |           | C            |              |                 |             |
| Software Risk Analysis & Mitigation         |           |              |              |                 | E           |
| Software Fault Tree Analysis                |           |              |              | P               |             |
| Software Failure Mode Effects               |           |              |              | P               |             |
| Software Test Case Analysis                 |           |              |              | P               |             |
| Formal Methods                              |           |              | W            |                 |             |
| Software Acquisition Insight & Oversight    |           |              | W            |                 |             |
| Requirements-Test Traceability Matrix       |           |              |              |                 | E           |
| Flight Rules                                |           |              | W            |                 |             |
| Multi-Mission Software                      |           |              |              | P               |             |
| Autonomy                                    |           |              | W            |                 |             |
| <b>Process Skills</b>                       |           |              |              |                 |             |
| Problem Reporting & Tracking                |           |              |              |                 | E           |
| Process Engineering                         |           |              |              |                 | E           |
| Process Models (CMMI)                       |           |              | W            |                 |             |
| Metrics Definition, Analysis & Reporting    |           |              |              |                 | E           |
| Institutional Requirements (SDR, FPP, etc.) |           |              |              | P               |             |
| Software Quality Improvement (SQI) Project  |           |              | W            |                 |             |

**Table 14 Software Assurance Skills for MAMs (or PEMs, Cog Es & PMs)**

| Technical Competence and Technical Depth→   | N<br>None | C<br>Cursory | W<br>Working | P<br>Proficient | E<br>Expert |
|---|-----------|--------------|--------------|-----------------|-------------|
| <b>Skill Category and Skill Description</b> |           |              |              |                 |             |
| <b>Software Assurance Skills</b>            |           |              |              |                 |             |
| Software Assurance Disciplines              |           |              | W            |                 |             |
| Software Reliability                        |           | C            |              |                 |             |
| Software Verification & Validation (V&V)    |           |              |              | P               |             |
| Software Independent V&V                    |           |              | W            |                 |             |
| Software Risk Analysis & Mitigation         |           |              | W            |                 |             |
| Software Fault Tree Analysis                |           | C            |              |                 |             |
| Software Failure Mode Effects               |           | C            |              |                 |             |
| Software Test Case Analysis                 |           | C            |              |                 |             |
| Formal Methods                              |           | C            |              |                 |             |
| Software Acquisition Insight & Oversight    |           |              | W            |                 |             |
| Requirements-Test Traceability Matrix       |           |              | W            |                 |             |
| Flight Rules                                |           |              | W            |                 |             |
| Multi-Mission Software                      |           | C            |              |                 |             |
| Autonomy                                    |           | C            |              |                 |             |
| <b>Process Skills</b>                       |           |              |              |                 |             |
| Problem Reporting & Tracking                |           |              |              | P               |             |
| Process Engineering                         |           |              | W            |                 |             |
| Process Models (CMMI)                       |           | C            |              |                 |             |
| Metrics Definition, Analysis & Reporting    |           |              |              | P               |             |
| Institutional Requirements (SDR, FPP, etc.) |           |              | W            |                 |             |
| Software Quality Improvement (SQI) Project  |           | C            |              |                 |             |

**Table 15 Skills Matrix for Mission Assurance Managers (MAMs)**

| Technical Competence and Technical Depth→         | N<br>None | C<br>Cursory | W<br>Working | P<br>Proficient | E<br>Expert |
|---|-----------|--------------|--------------|-----------------|-------------|
| <b>Skill Category and Skill Description</b>       |           |              |              |                 |             |
| <b>Software Tasks</b>                             |           |              |              |                 |             |
| Software Cost Estimation                          |           |              | W            |                 |             |
| Software Development Environments                 |           | C            |              |                 |             |
| Software Planning, Management & Control           |           |              |              | P               |             |
| Software Quality Assurance (SQA)                  |           |              | W            |                 |             |
| Software Configuration Management (CM)            |           |              | W            |                 |             |
| <b>Software Development</b>                       |           |              |              |                 |             |
| Software Architecture                             |           | C            |              |                 |             |
| Software Design                                   |           |              | W            |                 |             |
| Methodologies, Tools and Processes                |           |              | W            |                 |             |
| Software Technology Awareness                     |           | C            |              |                 |             |
| <b>Hardware Development</b>                       |           |              |              |                 |             |
| Space Flight Hardware Paperwork Reqmts.           |           |              | W            |                 |             |
| Hardware Procedures and Handling                  |           |              | W            |                 |             |
| Hardware Qualifying Procedures                    |           |              | W            |                 |             |
| Hardware Parts Acquisition                        |           |              | W            |                 |             |
| Hardware Test and Validation                      |           |              | W            |                 |             |
| Hardware Technology Awareness                     |           |              | W            |                 |             |
| <b>Systems Engineering</b>                        |           |              |              |                 |             |
| Requirements Definition and Analysis              |           |              | W            |                 |             |
| Tradeoffs, Tailoring and Prioritizing             |           |              | W            |                 |             |
| System Architecture                               |           |              | W            |                 |             |
| Testing Approaches                                |           |              | W            |                 |             |
| Processes and Procedures, ISO 9000                |           |              | W            |                 |             |
| <b>Planning and Tracking Skills</b>               |           |              |              |                 |             |
| Task Planning (WBSs, WIPs, etc.)                  |           |              |              | P               |             |
| Task Allocation (WAs, Workforce estimates)        |           |              |              | P               |             |
| Schedule Development and Tracking                 |           |              |              | P               |             |
| Budget Development and Tracking                   |           |              |              | P               |             |
| <b>Problem Solving and Decision Making Skills</b> |           |              |              |                 |             |
| Problem Identification, Solution, Escalation      |           |              |              | P               |             |
| Timely Decisions and Follow Through               |           |              |              | P               |             |
| <b>Vision and Leadership</b>                      |           |              |              |                 |             |
| “Big Hat” and “Big Picture” Approach              |           |              |              | P               |             |
| Forms Clear Picture of Problem to be solved       |           |              |              | P               |             |
| Takes Ownership of the Problem/Task               |           |              |              | P               |             |
| <b>People Skills</b>                              |           |              |              |                 |             |
| Staffing/Team Selection                           |           |              |              | P               |             |
| Team Building                                     |           |              |              | P               |             |
| Conflict Resolution                               |           |              |              | P               |             |
| Challenging, Inspiring & Motivating Others        |           |              |              | P               |             |
| Delegating  |           |              |              | P               |             |
| Negotiating                                       |           |              |              | P               |             |
| <b>Communicating and Reporting Skills</b>         |           |              |              |                 |             |
| Presentations, Reviews and Reports                |           |              |              | P               |             |
| Customer Focus and Awareness                      |           |              |              | P               |             |
| Sponsor Interface                                 |           |              | W            |                 |             |
| Open communication lines with team & mgmt.        |           |              |              | P               |             |
| Meeting Management                                |           |              |              | P               |             |

**Table 16 Skills Matrix for Software Architects**

| Technical Competence and Technical Depth→<br>Skill Category and Skill Description  | Desired Skill Level |              |              |                 |             |
|--|---------------------|--------------|--------------|-----------------|-------------|
|  | N<br>None           | C<br>Cursory | W<br>Working | P<br>Proficient | E<br>Expert |
| <b>Software Areas of Expertise</b>   |                     |              |              |                 |             |
| 1. Software Architectures<br>(reference models, architecture styles, ADLs, reference architectures; client/server, 3-tier) |                     |              |              |                 | E           |
| 2. Application Domains (e.g., avionics, flight, ground, instruments, robotics, autonomy)                                   |                     |              |              | P               |             |
| 3. Operating Systems (UNIX, NT, Palm OS)   |                     |              |              | P               |             |
| 4. Computer Languages<br>(C, C++, JAVA, object services, PERL)   |                     |              |              | P               |             |
| 5. Middleware (CORBA, COM/DCOM, EJB)   |                     |              |              | P               |             |
| 6. Data Engineering and Data Modeling<br>(entity relationship modeling, logical & physical schema)                         |                     |              |              | P               |             |
| 7. Database Management and Data Mgmt.<br>(relational & object-oriented DBMSs, SQL, data mining, data warehousing, tuning)  |                     |              | W            |                 |             |
| 8. Network Architectures and Protocols (X.25, Ethernet, FDDI, ATM, , SNMP, TCP/IP)   |                     |              | W            |                 |             |
| 9. Internet and Web Technology<br>(HTML, XML, JAVA, Web brokers)   |                     |              |              | P               |             |
| 10. Industry Standards (ISO, IEEE, CMMI)   |                     |              | W            |                 |             |
| 11. Performance Modeling and Simulation, Performance Tuning and Optimization   |                     |              | W            |                 |             |
| 12. Advanced Technologies  |                     |              | W            |                 |             |
| 13. Software Security Issues and Concerns<br>(Authentication, DCE, CORBA, PKI)   |                     |              |              | P               |             |
| 14. IT Vendor and Product Awareness  |                     |              | W            |                 |             |
| <b>Systems Engineering</b>   |                     |              |              |                 |             |
| 15. Requirements Definition and Analysis   |                     |              |              | P               |             |
| 16. Tradeoffs, Tailoring and Prioritizing  |                     |              |              | P               |             |
| 17. System Architecture (Hardware, Software, Processes, User Interface)  |                     |              |              | P               |             |
| 18. Key Methodologies and CASE Tools<br>(Use Cases – UML, Formal methods, SADT, Object-oriented, Booch, Rumbaugh, , etc.)  |                     |              |              | P               |             |
| 19. Analysis, Simulation & Testing Approaches  |                     |              | W            |                 |             |
| 20. DNP/DNT Processes and Procedures   |                     |              | W            |                 |             |
| 21. Operations Concepts (operability, autonomy)  |                     |              | W            |                 |             |
| <b>Software Management</b>   |                     |              |              |                 |             |
| 22. Software Cost Estimation   |                     |              | W            |                 |             |
| 23. Software Development Environments  |                     |              | W            |                 |             |
| 24. Software Planning, Management & Control  |                     | C            |              |                 |             |
| 25. Software Life-Cycles   |                     |              |              | P               |             |
| 26. Software Quality Assurance (SQA)   |                     |              | W            |                 |             |
| 27. Software Configuration Management (CM)   |                     |              | W            |                 |             |

## 4.7 Appendix 7 Recommended Training

**Table 17 Role-Based Training Recommendations**

| <b>Roles</b>   | <b>Recommended Software Courses</b>   | <b>Other Recommended Courses</b>  |
|--|---|---|
| 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), Software Manager or Software Contract Technical Monitor (CTM) | Software Management & Planning<br>Quantitative Software Management  | The JPL Project Element Manager Overview of CMMI<br>Space Science<br>System Requirements<br>Systems Engineering<br>Cost Management<br>IT Security |
| Cognizant Engineer (Cog E)   | Software Product Engineering<br>Software Peer Reviews<br>Software Testing   | The JPL Cognizant Engineer System Requirements<br>Systems Engineering<br>IT Security  |
| Software Engineer (SWE)  | Software Product Engineering<br>Software Peer Reviews<br>Software Testing<br><i>Software Design</i>                                   | IT Security   |
| Software Architect   | Software Product Engineering<br>Software Architectures  | Overview of CMMI<br>Space Science<br>System Requirements<br>Systems Engineering<br>IT Security  |
| Mission Assurance Manager (MAM)  | Software Management & Planning<br>Software Peer Reviews<br>Software Testing   | Overview of CMMI<br>System Requirements<br>Systems Engineering<br>IT Security   |
| Software Quality Assurance (SQA) Engineer  | Software Management & Planning<br>Software Product Engineering<br>Software Peer Reviews<br>Software Testing<br><i>Software Design</i> | Overview of CMMI<br>Introduction to CMMI<br>System Requirements<br>Systems Engineering<br>IT Security   |

## 4.8 Appendix 8 Introductory vs. Detailed Courses

**Table 18 Introductory SQIP DE Courses vs. Detailed ITET Courses**

| SQIP DE Series   | SQIP DE Module                                | ICIS ITET Courses   |
|--|---|---|
| <b>Software Management and Planning (SMP I) for PMs and PEMs</b> | Software Management Overview                  |   |
|  | Software Life-Cycles                          |   |
|  | NASA and JPL Standards                        |   |
|  | Software Planning and Tracking                |   |
|  | Staffing Considerations                       |   |
|  | Software Acquisition                          |   |
|  | Software Perceptions                          |   |
|  | Software Management Summary                   |   |
| <b>Software Management and Planning (SMP II) for PEMs</b>        | Systems Engineering Considerations            |   |
|  | Software Requirements Mgmt.                   | Software Requirements Management  |
|  | COTS Software/Reuse                           |   |
|  | Software Cost Estimation                      |   |
|  | Software Dev. Environments                    |   |
|  | Software Quality Assurance (SQA)              |   |
|  | Software Configuration Mgmt.                  | CCC: Intro. To CCC/Harvest  |
|  | Software Testing                              |   |
| <b>Software Product Engineering (SPE) for Cog Es</b>             | Software Process Overview                     |   |
|  | Software Methodologies and Tools              | Rational Rose Workshop<br>UML Overview<br>Tornado II Training Workshop<br>Intro. To Object-Oriented Concepts Using Design Patterns, Frameworks, and CORBA   |
|  | Software Requirements Definition and Analysis | Software Requirements Mgmt. Applying DOORS<br>ITS Requirements for Computer Systems   |
|  | Software Architecture                         | <b>CSMISS 10-week Software Architecture course</b>  |
|  | <i>Software Design (future)</i>               | <i>Software Design</i><br>Embedded Real-Time Systems<br>Intelligent Software Agents<br>Object-Oriented Analysis and Design using UML<br>OOD with Patterns and Frameworks<br>OOD and Programming in Java |
|  | Data Engr./Modeling/Mgmt.                     | Access FoxPro<br>Oracle Paradox   |
|  | Software Testing                              |   |
|  | Software Peer Reviews                         | Software Formal Inspections   |
| Software Cost Estimation   |   |   |
| Managing and Coordinating Interfaces                             |   |   |

## 4.9 Appendix 9 NASA Software Training Courses

*Table 19 NASA Software Training Course Listing*

| Class Acronym | Class Name                         |
|---------------|------------------------------------|
| SPA           | Software Process Appraisal         |
| SPI           | Software Process Improvement       |
| SEPG          | Software Engineering Process Group |
| MPI           | Mastering Process Improvement      |

Excerpted from the Code FT Web Site at  
[http://www.hq.nasa.gov/office/codeft/codeft/training\\_master.pdf](http://www.hq.nasa.gov/office/codeft/codeft/training_master.pdf)

**More TBS by NASA SWG via John Kelly or Maria Babula**



NASA Software Working Group  
Strategy 4 Subgroup

## JPL Software Training Plan

June 25, 2003

P. A. "Trisha" Jansma

Software Quality Improvement Project



Jet Propulsion Laboratory

California Institute of Technology



NASA Software Working Group, Strategy 4 Subgroup



### Topics to be Covered

- Software Training Plan Contents
- Lessons Learned
- References
- Questions and Answers



## 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

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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.
- 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 Quality Assurance (SQA) Engineers
  - Mission Assurance Managers (MAMs)

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### Training Customers

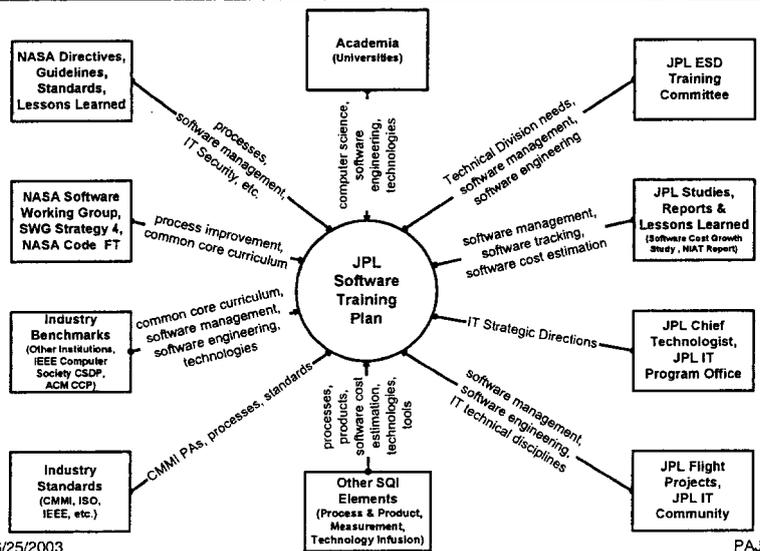
- Training customers primarily include the following roles:
  - Project Element Managers (PEMs)
  - Software Line Managers
  - Cognizant Engineers (Cog Es)
  - Software Systems Engineers
  - Software Engineers
  - Software Quality Assurance (SQA) engineers
  - Mission Assurance Managers (MAMs)
- Managers 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 SQI Project itself, i.e., members of the Software Engineering Process Group (SEPG).

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### Sources of Training Requirements

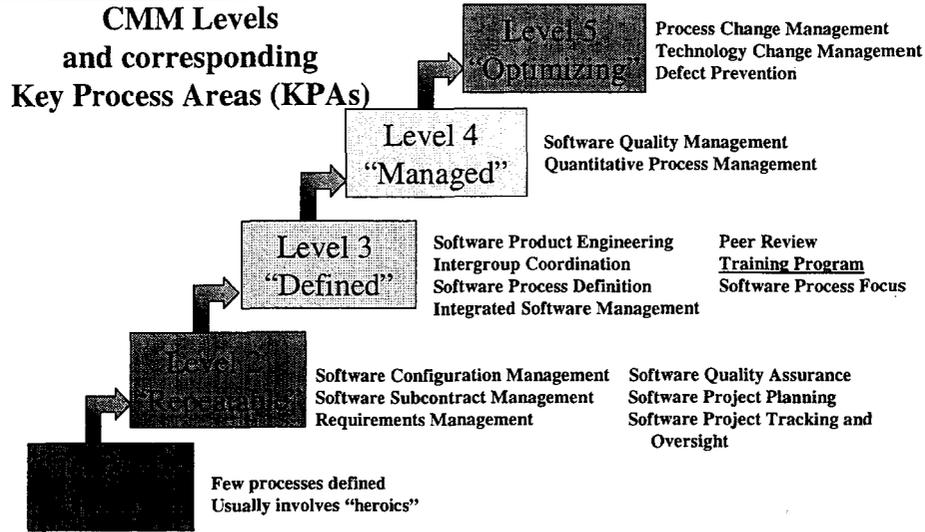


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## Software Capability Maturity Model (CMM)



## Capability Maturity Model Integrated

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

Staged vs. Continuous



## Role-Based Skills Matrices

- Skills Matrices with categories such as:
  - Software Management
  - Software Development
  - Hardware Development
  - Systems Engineering
  - Planning and Tracking
  - Problem Solving and Decision Making
  - Vision and Leadership
  - Dealing with People
  - Communicating and Reporting
- Skills Matrices for the following roles:
  - Project Manager
  - Project Element Manager
  - Cognizant Engineer
  - Software Engineer
  - SQA Engineer
  - Mission Assurance Manager
  - Software Architect
- Five Competency Levels
  - None
  - Cursory
  - Working
  - Proficient
  - Expert
- Separate Matrices for Software Assurance Skills and for Software Architects that includes Software Areas of Expertise

“hard” skills

“soft” skills

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

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## 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
- “Soft Skills”
  - e.g., Delegating, team building, negotiation, conflict resolution

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## 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.
2. Ensure that JPL 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.

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## 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.

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## Software Training Process

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 & review the purview of training providers
5. Identify potential internal instructors and/or external providers (make vs. buy)
6. Conduct course content development and/or negotiate course content with external providers
7. Internally review new software training modules
8. Schedule training rooms, instructors and course offerings
9. Publish and publicize software training offerings
10. Register students and maintain training history
11. Conduct course offerings and gather course evaluations and metrics
12. Analyze course evaluations and feedback and identify possible updates.
13. Generate periodic updates to course content to correct errors & reflect new practices.

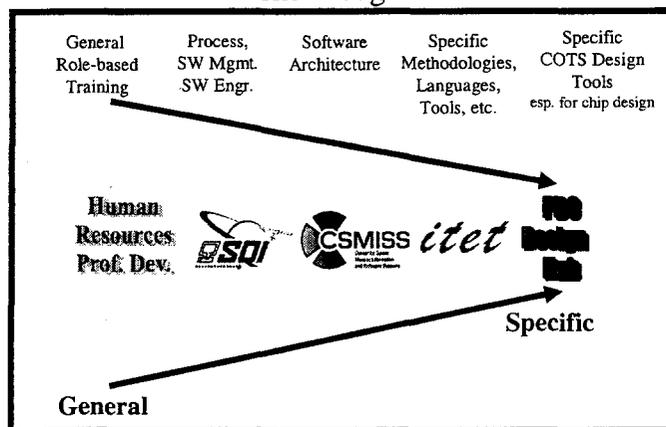
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## Internal Software Training Providers

### "The Wedge"



Legend:

CSMISS = Center for Space Mission Information & Software Systems

ITET = Information Technology Education & Training

PDC = Project Design Center

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## Software Training Providers

- JPL Internal Training Providers
    - HR Professional Development (internal, NASA Code FT)
    - SQI Project (internal, CSM)
    - CSMISS IT Workforce Enrichment Element (USC CSE)
    - ICIS IT Education and Training (ITET)
    - Project Design Center (PDC) Design Hub
  - External Training Providers
    - NASA Code FT: NET, SOLAR, APPL
    - Center for Systems Management (CSM)
    - CMU's Software Engineering Institute (SEI)
    - Learning Tree International
    - IEEE Computer Society, ACM Professional Development Centre
  - Local Universities
    - Graduate programs, extension classes, special offerings – tuition supported via the JPL Tuition Reimbursement program
- USC, UCLA, UCI, UCR, CSUN, Caltech, Claremont, etc. PAJ-15

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## Current SQI Course Offerings

- Software Engineering
  - Software Product Engineering (1 day)
  - Software Peer Reviews (1 day)
  - Software Testing (2 days)
  - *Software Design (future) (1-2 days)*
- Software Management
  - Software Management and Planning (2 days)  
(AKA Software Project Planning and Control)
  - Quantitative Software Management (2 days)
- Process Improvement
  - Overview of CMMI (half-day)
  - Introduction to CMMI (3 days)

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 Role-Based Training Recommendations



| Roles   | Recommended 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 Monitor (CTM) or IT/SW Line Manager | Software Management & Planning<br>Quantitative Software Management   | The JPL Project Element Manager Overview of CMMI<br>Space Science<br>System Requirements<br>Systems Engineering<br>Cost Management<br>IT Security |
| Cognizant Engineer (Cog E)  | Software Product Engineering<br>Software Peer Reviews<br>Software Testing  | The JPL Cognizant Engineer Overview of CMMI<br>System Requirements<br>Systems Engineering<br>IT Security  |
| Software Engineer (SWE)   | Software Product Engineering<br>Software Peer Reviews<br>Software Testing<br>Software Design                                   | IT Security   |
| Mission Assurance Manager (MAM)   | Software Management & Planning<br>Software Peer Reviews<br>Software Testing  | Overview of CMMI<br>System Requirements<br>Systems Engineering<br>IT Security   |
| Software Quality Assurance (SQA) Engineer   | Software Management & Planning<br>Software Product Engineering<br>Software Peer Reviews<br>Software Testing<br>Software Design | Overview of CMMI<br>Introduction to CMMI<br>System Requirements<br>Systems Engineering<br>IT Security   |

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## Lessons Learned



## Lessons Learned -- Planning

- 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”).
- Develop skills matrix 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.

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## 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 a 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.

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Lessons Learned – Implementation (2)



- Allocate sufficient 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.
- 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.
- Begin work on logistics at least six weeks before a class is to be offered.
- Offer 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.

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