7 Processes that Enable NASA Software Engineering Technologies

Value-Added Process Engineering

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Helen Housch
NASA MSFC
Helen.I.Housch@nasa.gov

Sally Godfrey
NASA GSFC
Sara.H.Godfrey@nasa.gov

Agenda

- Agency Process Requirements
- 7 Software Engineering Processes
  - Purpose, Benefits, and Experiences
- Honorable Mention

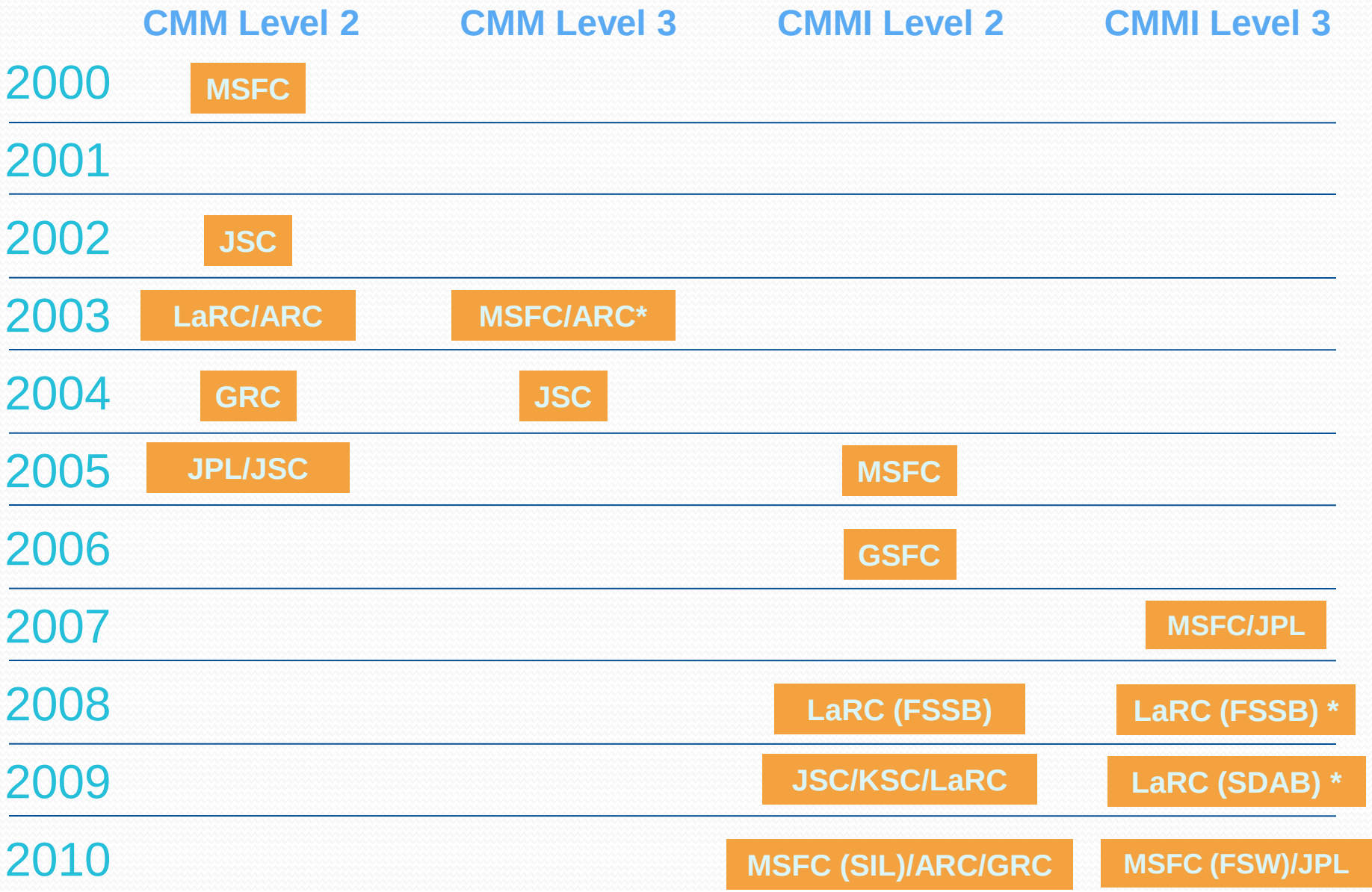
NASA's Software Engineering Requirements

- Software engineering is a core capability and key enabling technology for NASA's missions and supporting infrastructure
- NASA Software Engineering Requirements (NPR 7150.2A)
  - Provide a minimal set of requirements established by the Agency for software
    - Applies to all software created by or for NASA – during all phases
    - For use by both the contractor and in-house communities
  - Support NASA programs/projects to accomplish planned goals (e.g., mission success, safety, schedule, and budget) while satisfying specified requirements
  - Are implemented through Center-specific process definition documents

NPR 7150.2A CMMI Requirement

- [SWE-032] The project shall ensure that software is acquired, developed and maintained by an organization with a non-expired Capability Maturity Model Integration® for Development (CMMI-DEV) rating as measured by a Software Engineering Institute (SEI) authorized lead appraiser as follows:
  - For Class A software: CMMI-DEV Maturity Level 3 Rating or higher for software, or CMMI-DEV Capability Level 3 Rating or higher in all CMMI-DEV Maturity Level 2 and Maturity Level 3 process areas for software.
  - For Class B software: CMMI-DEV Maturity Level 2 Rating or higher for software, or CMMI-DEV Capability Level 2 Rating or higher for all Maturity Level 2 process areas.
  - For Class C software: The required CMMI-DEV Maturity Level for Class C software will be defined per Center or project requirements.

NASA CMM/CMMI Implementation



* Partial implementation

What's your frustration?

Lack of planning?

Vague requirements?

Poor Quality?

Let's look at a few of our favorite processes!

7 Product Integration

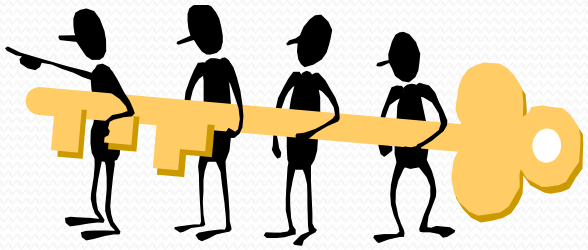
- Product integration is the assembly of software components to ensure correct product functionality
  - Product integration is:
    - a highly critical and non-trivial part of the development
    - frequently overlooked during planning phase
  - Critical elements of product integration include:
    - defining and implementing the integration environment
    - management of interfaces
    - component integration sequences
    - communication between stakeholders
  - For software systems, integration is typically the first opportunity to observe implementation results

7 Product Integration

- Benefits
  - Exposes and drives out defects prior to formal testing
    - Reduces costs for error correction and re-testing
    - Can reduce the length of formal testing (fewer error corrections necessary)
  - Last opportunity to create new functionality before formal test begins
  - Encourages well-defined interfaces and components for easier inspection, integration, and automation
  - Increases the probability for high quality products and timely deliveries to verification and validation activities

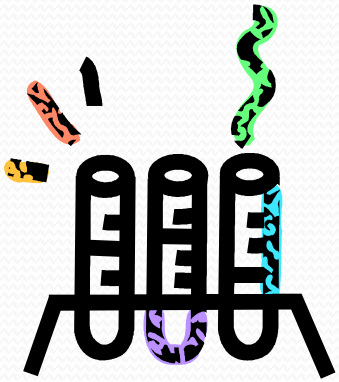
7 Product Integration

- Who makes it happen?

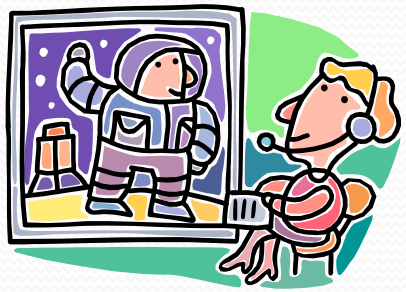


Design/Implementation

Project Management



Test Team



Configuration Management

6 Configuration Management

- Configuration Management (CM) establishes and maintains the integrity of specified work products
  - Typically the most misunderstood and under appreciated process
  - Fundamental CM involves …
    - Identifying configuration items
    - Controlling changes to configuration items
    - Establishing a CM system that supports control objectives
    - Sustaining integrity of baseline products
    - Maintaining accurate status of configuration data

6 Configuration Management

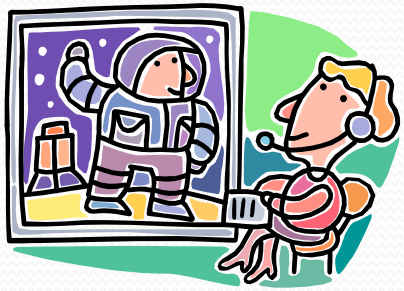
- Benefits
  - Baselines provide a stable foundation for continuing evolution of specified work products
  - Build Variance Detection
    - Knowing the last known good build, changes can be effectively detected and examined or rolling back to the last known good configuration can be achieved
  - Effective Change Management
    - Knowing the configuration of a given CI saves time that would be spent figuring out the configuration versus being able to immediately engineer the change in the known configuration

6 Configuration Management

- Benefits (cont'd)
  - Enhanced Ability to Rebuild
    - If a CI fails or is involved in a disaster, it is far easier to rebuild if the final production build of the CI is known
  - Assists with Cost/Schedule Estimating
    - Understanding what software goes into a given CI allows for proper costing to serve as an input to planning and estimating process

6 Configuration Management

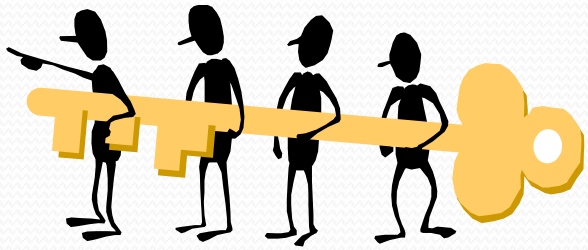
- Who makes it happen?



Configuration Management

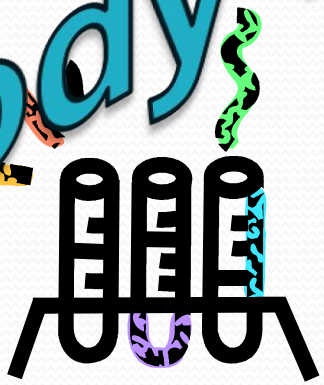
Requirements Team

Project Management



Design/Implementation

Everybody !!!



Test Team

5 Verification

- Software verification is a broad and complex software engineering discipline that ensures transitional and final work products adhere to their specified requirements
- Growth in complexity of designs increases the importance of formal verification techniques
- Key concepts include …
  - Select verification work products
  - Establish verification environment/procedures/criteria
  - Perform verification

5 Verification

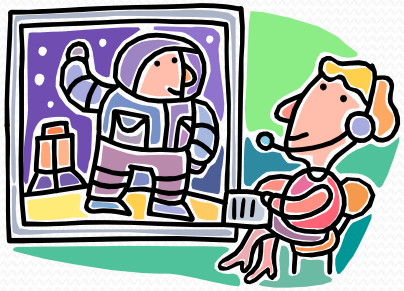
- Benefits
  - Requirements Phase – Ensure requirements are verifiable, achievable, actionable, measurable, related to identified business needs, and defined to a level of detail sufficient for system design
  - Design Phase – Review/analysis using models, simulations, and prototypes

5 Verification

- Benefits (cont'd)
  - Implementation Phase – Analysis to help detect complexity, memory, arithmetic exception, out-of-bounds array access, and coding standard problems
  - Test Phase – verifies software as implemented. It addresses specified requirements and ONLY specified requirements
  - Peer Reviews - one of the most effective methods of verification since they improve product quality by detecting errors as early as possible

5 Verification

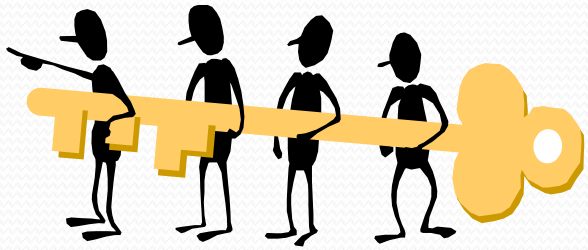
- Who makes it happen?



Configuration Management

Requirements Team

Project Management



Design/Implementation

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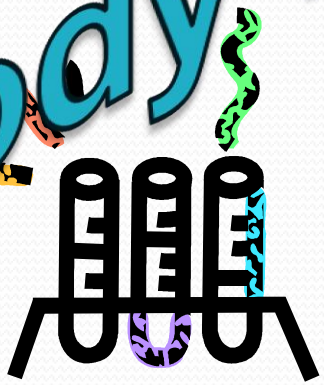


Test Team

4 Software Assurance

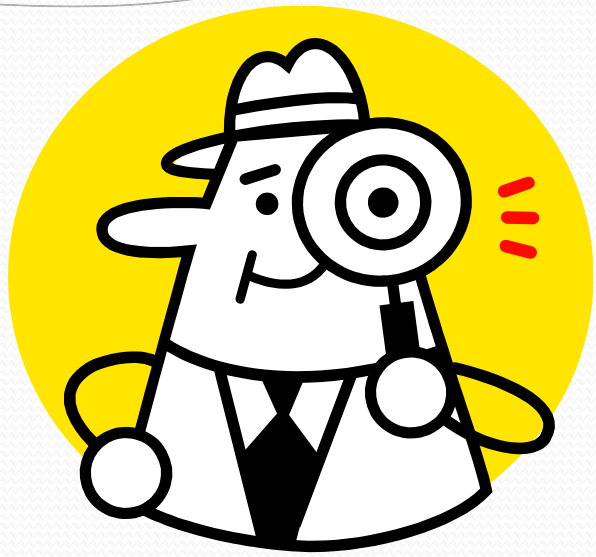
- Product assurance provides management and staff an objective evaluation of organizational processes and associated work products
- Key concepts include …
  - Objectively evaluate processes/products against specified standards
  - Document non-compliance issues and provide feedback to management and staff
  - Ensure non-compliances are addressed

4 Software Assurance

- Benefits
  - Product assurance provides insight into process implementation as compared to process definition
    - Identifies process improvement opportunities
    - Monitors process implementation effectiveness
  - Ensures critical work products align with specified standards in support of customer/contract requirements
  - Provides management with visibility into process effectiveness and product quality

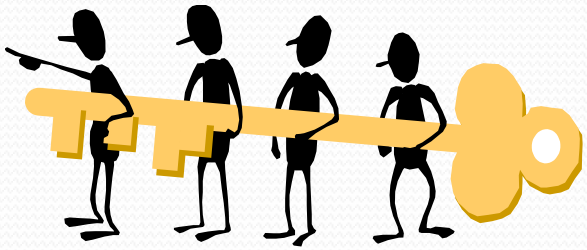
4 Software Assurance

- Who makes it happen?

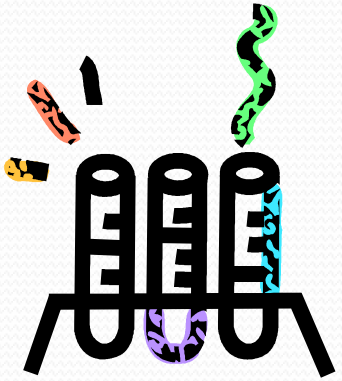


Software Assurance

Requirements Team



Design/Implementation



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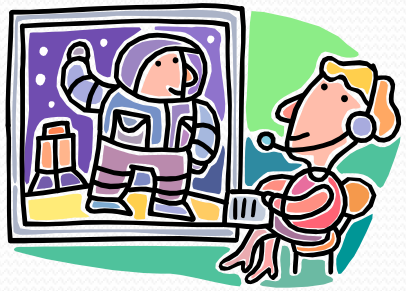


Configuration Management

3 Measurement and Analysis

- Measurement and analysis defines and maintains a measurement capability that supports management information needs as they relate to mission objectives
- Key concepts include …
  - Identify mission objectives
  - Derive measures from mission objectives
  - Select analysis techniques
  - Define data collection, storage, and reporting mechanism

3 Measurement and Analysis

- Benefits
  - Provides quantitative determination of how well you are doing relative to mission objectives, other projects, the past, and/or the plan
  - Provides a mechanism to monitor selected aspects of a project to provide timely information for management decision making
  - Improves communication
  - Encourages appropriate behavior
  - Pinpoints opportunities for improvement

3 Measurement and Analysis

- Who makes it happen?

Project Leads

2 Requirements Management

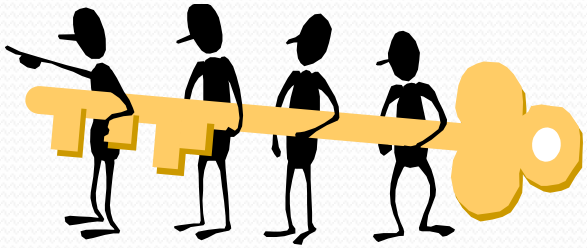
- Requirements management documents and verifies requirements and requirements changes that meet customer expectations
- Key concepts include …
  - Understand operational concepts and system-level requirements
  - Establish and manage changes to detailed software requirements
  - Maintain bi-directional traceability
  - Identify inconsistencies between requirements and work products

2 Requirements Management

- Benefits
  - Encourages development of high-quality requirements and elicitation of requirements from customers
  - Bi-directional traceability enables close evaluation to eliminate lower level requirements that do not support mission requirements
  - Allows detailed requirements definition and tracking to ensure product completeness
  - Enables requirements change management to ensure product lifecycle integrity
  - Helps avoid requirement creep

2 Requirements Management

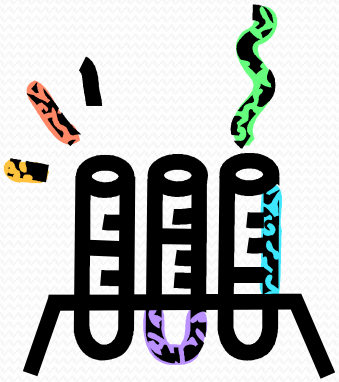
- Who makes it happen?



Design/Implementation

Requirements Team

Customer/User



Test Team

1 Planning & Monitoring

- Project planning defines and documents the necessary project activities so that they may be monitored to ensure deviations are recognized soon enough to take corrective actions
- Key concepts include …
  - Develop and maintain the project plan/schedule
  - Establish work product and task estimates
  - Define communication and monitoring methods
  - Conduct milestone/progress reviews

1 Planning & Monitoring

- Key concepts (cont'd)
  - Obtain commitment to the plan
  - Monitor against the plan
    - Estimates
    - Commitments
    - Risks
    - Stakeholder involvement
    - Take corrective actions when necessary

1 Planning & Monitoring

- Benefits
  - Ensures timely determination of cost/schedule impacts
  - Allows standardization and quantifying of project goals
  - Enables tracking of project schedule milestones
  - Provides insight into technical/cost risk management
  - Identifies stakeholder participation issues
  - Tracks/controls corrective actions to closure
  - Monitors management of project data

1 Planning & Monitoring

- Who makes it happen?

Project Management

Project Leads

Honorable Mention

- Keys to keep all these processes working well…
  - Sponsorship (management support)
    - Stress the importance of maintaining good processes
    - Ensure that adequate resources are available to support processes
  - Standardization of processes
    - Have a library of process assets --process descriptions, tools, templates, lessons learned
    - Use a measurement repository to capture organizational “norms”, improve cost estimation and gauge success of improvements
    - Develop tailoring guidelines to make processes reasonable for all types of projects


Space Shuttle Launch from Disney's Castle

CMMI Benefits at NASA

- Reduces risk of software failure increasing mission safety
- More predictable software cost estimates and delivery schedules
- Smarter buyer of contracted software
- More defects found and removed earlier
- Reduces duplication of efforts between projects
- Increases ability to meet the challenges of evolving software technology
- Software development planning improved across the Agency
- NASA's contractor community has heard the word that the bar has been raised with respect to software engineering and is responding appropriately

Enjoy the journey