Abstract:

This presentation describes how the NASA Glenn Research Center planned and implemented a process improvement effort in response to a radically changing environment. As a result of a presidential decision to redefine the Agency’s mission, many ongoing projects were canceled and future workload would be awarded based on relevance to the Exploration Initiative. NASA imposed a new Procedural Requirements standard on all future software development, and the Center needed to redesign its processes from CMM Level 2 objectives to meet the new standard and position itself for CMMI.

The intended audience for this presentation is systems/software developers and managers in a large, research-oriented organization that may need to respond to imposed standards while also pursuing CMMI Maturity Level goals. A set of internally developed tools will be presented, including an overall Process Improvement Action Item database, a formal inspection/peer review tool, metrics collection spreadsheet, and other related technologies.

The Center also found a need to charter Technical Working Groups (TWGs) to address particular Process Areas. In addition, a Marketing TWG was needed to communicate the process changes to the development community, including an innovative web site portal.
Process Improvement in a Radically Changing Organization

NASA Glenn Research Center
Software Engineering Process Group

SEPG 07 Conference
March 26–29, 2007
Topics of Discussion

NASA Glenn Research Center
Process Improvement Strategy
A Change in Focus
NASA Software Requirements Implementation
Tools
Getting the Word Out
SEPG Products
Results and Moving Forward
About NASA Glenn Research Center

• Comprises over 150 buildings containing a unique collection of world-class test facilities
  – Lewis Field, 350-acre main campus is adjacent to Cleveland Hopkins International Airport
  – Plum Brook Station, 6400-acre site is near Sandusky, Ohio, 50 miles west of Cleveland

• Staffed by ~3300 people, including civil service employees and support service contractors
  – >50% are scientists and engineers
  – Other staff consists of technical specialists, skilled workers, and administrative staff

• Performs world-class research in aeronautics, space power and propulsion, and microgravity science
Introduction

• NASA Glenn Research Center (GRC) implemented a CMM-based process improvement effort in 2002

• A Presidential Directive redefined NASA’s mission in January 2004
  – Many ongoing projects were canceled
  – Future projects would be awarded based on relevance to the Vision for Space Exploration

• This presentation outlines how the NASA Glenn Research Center SEPG responded to better position the Center for new work
Background

• Agency-wide Software Engineering Initiative began in 2000
• NASA GRC formed local SEPG in 2002
• Flight Software Engineering Branch assessed at CMM Level 2 in December 2004
  – Branch consisted of 15 software developers
  – Projects were mostly flight and ground software for space shuttle science experiments
• Goals at that time were
  – Improve software development capability
  – Move towards CMM Level 3, and possibly into CMMI
  – Share processes and practices throughout the Center
  – Maintain and reinforce collaboration across NASA
A Change in Focus

- President Bush announces Vision for Space Exploration in January 2004
  - Develop new launch vehicles to return to the Moon and eventually go to Mars

- Columbia Accident Investigation Board (CAIB) report
  - Renewed emphasis on quality and safety

- NASA funds redirected towards new Exploration projects
  - Emphasis on inter-Center collaboration

- New NASA requirements for software development
  - Address recent mission failures attributed to software
The Strategy

• Refocus software process improvement on new NASA Procedural Requirements for Software Engineering
  – Incorporate the requirements into GRC processes
  – Address CMMI practices where practical

• Update Center-Level Procedure for Software Development
  – Local procedure to encapsulate new requirements

• Build supporting elements
  – Organizational processes, templates, and training
  – Web Site/Process Asset Library (PAL)
  – Coaching from SEPG members

• Complete incorporation of CMMI practices
Our Motivation

• Desire to have a significant role in the development of software for the Exploration Initiative

• Improve our practices so we can develop mission critical software in a more predictable, reliable manner

• Improve our ability to add new people to the development team

• Reduce the stress on our developers if schedule and budget problems occur

• Respond to the newly mandated NASA Procedural Requirements for Software Engineering
New NASA Software Requirements

• NASA Procedural Requirements for Software Engineering (NPR 7150)
  – Agency-level document levying 129 requirements on projects containing software
  – Based on CMMI, IEEE 12207, and MIL–STD–498
  – Classifies software by its usage (manned space flight, robotic space flight, business applications, etc.)
  – Requirements apply to projects based on classification
  – Mandates compliance with other NASA requirements and standards for project formulation, systems engineering, software assurance, and software safety
Summary of 7150 Requirements

• 129 total requirements

• 114 apply at project level
  – Software Life Cycle Planning (14)
  – Project Formulation (7)
  – Acquisition & Supplier Monitoring (11)
  – Software Life Cycle Execution (34)
  – Documentation Requirements (18)
  – Peer Reviews, Configuration Management, Metrics, Training, and Other (30)

• Projects required to maintain a compliance matrix
7150 Requirements Example

3.1.1.4 The project shall perform, document, and maintain bidirectional traceability between the software requirement and the higher level requirement. [SWE-052]

Note: The project should identify any orphaned or widowed requirements (no parent or no child) associated with reused software.
Implementation (1)

- Performed gap assessment of existing processes to NPR 7150
- Chartered Technical Working Groups (TWG) to tackle specific areas
  - Existing TWGs based on CMM L2 KPAs (e.g., CM, RM)
  - Created new TWGs to better match CMMI (e.g., PMC)
  - Created Compliance TWG to allocate NPR requirements to TWGs
  - TWGs updated software processes to be compliant with allocated requirements
- Updated the process for developing processes
- Involved process improvement consultant throughout implementation
Implementation (2)

- TWGs worked to achieve compliance with requirements
  - Reviewed and modified or created new processes
  - Created templates for software products
  - Developed training for each process
  - Peer-reviewed processes, templates, and training
- Technical writer provided consistency across TWGs
- SEPG and MSG provided final review before release
- Completed processes, templates, and training released to internal Web Site and NASA PAL
- Center-Level Procedure for Software Development updated and released for Center-wide review
The Results

Progress Towards Compliance

- Comply
- In Work
- Not Started
- Total Requirements
Tools (1)

- MS Access database to help track 7150 compliance
  - Contains one record for each 7150 requirement
  - For each requirement, allows for
    - Assignment to a TWG
    - Assignment and tracking of action items to individuals
    - Tracking compliance status
    - Entry of additional comments and issues
    - Relationship indication to CMMI ML2
    - Location of compliance
  - Allows for various reports to be generated
### Requirements Database Screen Shot

**NPR 7150: Noncompliance**

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Responsibility</th>
<th>Descriptor</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWE-013</td>
<td>Project</td>
<td>SW Plan</td>
</tr>
</tbody>
</table>

**NPR 71502 Requirement Text:**

The project shall develop software plan(s). [SWE-013]

**Notes:** The requirement for the content of each software plan (whether stand-alone or condensed into one or more project level or software documents) is defined in Chapter 5. These include, but are not limited to:

- Software development or management plan.
- Software configuration management plan.
- Software test plan.

**Comment:**

Maintain needs to be added to 2.6.4.

**ISSUE:** Phases are not addressed in 7150 but are in the Engineering of Systems NPR. Major disconnect between the two documents.

**TWG Info**

<table>
<thead>
<tr>
<th>Primary TWG</th>
<th>Secondary TWG</th>
<th>TWG Approved</th>
<th>Location</th>
<th>Last Updated</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td>PFP 2.5, 5, RFC, P2, E.4, 7.0, Transition Process</td>
<td>7/19/2006</td>
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**Action Items**

<table>
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<th>Action ID</th>
<th>Action</th>
<th>Action Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Map to classes of software</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Add wording to 2.6.4 that any software that flies is at least Medium control. Assume: Medium control level and above covers classes A, C, and F.</td>
</tr>
</tbody>
</table>

**Record:** 7/13/05 Meet but need to map to classes of SW
Tools (2)

- **InSpec**
  - Web-based formal inspection tool based on Fagan process
    - Plan inspections
    - Notify participants by e-mail
    - Enter defects into online inspection logs
    - Collect and collate inspection logs
    - Track defects and open items to closure
    - Collect metrics
  - Developed in collaboration with the NASA IV&V Facility
InSpec Screen Shot

<table>
<thead>
<tr>
<th>#</th>
<th>Location*</th>
<th>Description*</th>
<th>Suggested Classification*</th>
<th>Suggested Actions</th>
<th>Details</th>
</tr>
</thead>
</table>
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□ Open  
□ Wrong  
□ Typo  
Type: Interfaces  
Origin: Duplicate Of:  
✓ Minor  
✓ Missing  
✓ Extra | □ Open->Defect  
□ Open->Closed  
✓ Accept  
□ Reject | Finder: Varga, Denise  
Comments: Rob  
Correction Locations: QA Notes: Closed: |
| 0155 | Page: All  | When links are clicked, the color does not change to show that they have been viewed. | □ Major  
□ Open  
□ Wrong  
□ Typo  
Type: Interfaces  
Origin: Duplicate Of:  
✓ Minor  
✓ Missing  
✓ Extra | □ Open->Defect  
□ Open->Closed  
✓ Accept  
□ Reject | Finder: Varga, Denise  
Comments: Herb will fix CSS  
Correction Locations: QA Notes: Closed: |
Getting the Word Out

• Created a Marketing TWG
  – Published a tri-fold brochure to highlight NPR 7150, Center-Level Procedure, and supporting elements available from the SEPG
  – Released a newly designed “Software@Glenn” Web site as our PAL
  – Planned a “Software Fair” to spread the word about SEPG software products and services across GRC

• Conducted training on new processes as they were released

• Offered coaching to assist new projects in using our assets
Other SEPG Products

Processes
- Center-Level Procedure
- Project Planning
- Project Monitoring and Control
- Requirements Development
- Requirements Management
- Configuration Management
- Managing Software Process and Product Measurement
- Performing Software Process and Product Measurement
- Software Acquisition Statement of Work Guidelines
- Transition of Software to a Higher Classification

Templates
- Software Management Plan
- Software Maintenance Plan
- Software Users Manual
- Software Version Description Document
- Requirements Traceability Matrix
- Software Requirements Specification
- Software Test Plan
- Software Test Procedure
- Software Test Report
- Software Configuration Management Plan
- Software Metrics Report
- Software Data Dictionary
- Interface Design Document
- Software Change Request
- Software Design Document
What Went Right

• Use of 7150 database gave us an extremely versatile tool for tracking and reporting

• Use of process improvement consultant provided us with a broad background of experience in process improvement

• Use of configuration management tool for processes and products helped manage multiple simultaneous changes

• Use of local Subject Matter Experts (SME) and commitment from dedicated SEPG team sustained effort
Obstacles to Success

• Lack of evidence for SCAMPI appraisals
  – Existing mature pilot projects were canceled
  – New projects have not had sufficient time to fully use processes

• Transition from CMM to CMMI was confusing
  – Processes and TWGs had name changes
  – Difficult to relate between “legacy” and “new” processes

• Difficulty in getting broad participation from software developers across the Center

• Limited funding and turnover of personnel
Next Steps

• Identify new software projects and assist in the use of processes, templates, and tools
• Collect metrics and feedback on use of processes, templates, and tools
• Perform gap analysis of our processes and practices against CMMI ML2
• Update processes to meet CMMI ML2
• Perform pre-assessment of Flight Software Engineering Branch against CMMI ML2 in late 2007
• Assist GRC Engineering Process Group in becoming compliant with the new NPR 7123 Systems Engineering Requirements
Lessons Learned (1)

• Utilize the processes and tools you create and recommend
  – Much easier to get projects to follow your lead
  – An excellent opportunity for improving your own processes
  – Helps with organizing and streamlining activities

• Make extensive use of peer reviews and inspections
  – Great communication tool
  – Means of including expertise external to the SEPG
  – Common repository for document changes, status, and metrics
Lessons Learned (2)

• Share products and processes
  – Collaboration with other organizations leverages work

• Use process improvement consultant
  – Regularly scheduled week-long visits focus efforts
  – Provides SEPG with outside perspective
  – A source of “on-the-spot” training
  – Helps maintain alignment with CMMI
  – Provides another pair of hands and eyes
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