USING PILOTS TO ASSESS THE VALUE AND APPROACH OF CMMI IMPLEMENTATION

Goddard Space Flight Center

(GSFC)

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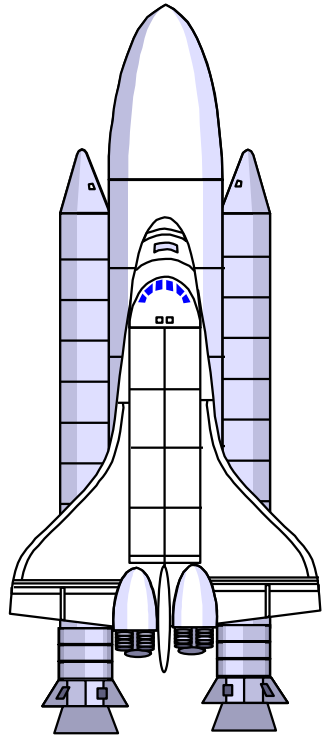
Agenda

- Background
  - NASA Improvement Initiatives
  - GSFC Improvement Plan
  - GSFC/Phase 1
    - Phase 1 Goals
    - Choice of Pilot Areas
- CMMI Pre-Appraisals
  - Goals/Scope
  - Pre-Appraisals
- Evaluation of Phase 1
  - Advantages/Disadvantages of Pre-Appraisal Approach
  - Lessons Learned



The NASA Software & Systems Engineering Initiatives

<u>Software Initiative Goal</u>: ***Advance software engineering practices (development, assurance, and management) to effectively meet the scientific and technological objectives of NASA.***

4 Strategies:
-Process and Product Improvement
-Safety, Reliability, and Quality
-Infuse Research
-Skill of Workforce

<u>Systems Engineering Initiative</u>: …. "Define and pilot a methodology for assessment of the systems engineering capability, which addresses knowledge and skill of the workforce, processes, and tools and methodology."….. NASA Chief Engineer

GSFC Software Development Process Improvement Plan

Developed Software Plan to **improve the processes and practices in use at GSFC** using the Capability Maturity Model Integrated (CMMI) as a measure of progress

-Focuses on Mission Critical Software

-Signed by GSFC Director

Are working with Systems Engineering to help them pilot CMMI

Software Long Term Goals

-Increase percentage of projects that are on-time and within cost by at least 10%

-Increase productivity by at least 5%

-Decrease cycle time by 10-20%

-Reduce error rate after delivery by at least 20%

Implementation Phases in GSFC's Improvement Plan

Phase 1: Pilot Phase (FY02)

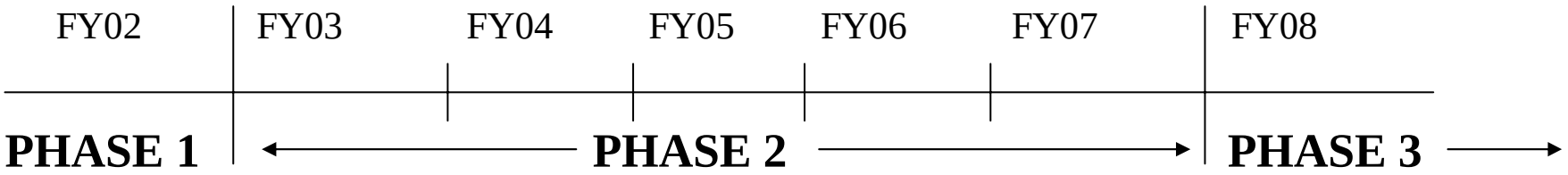
- Benchmark several representative GSFC areas
- Estimate effort, cost to improve identified gaps
- Evaluate implementation approach

Phase 2: Implementation Phase (FY03-FY07)

- Implementation of PI on all critical projects
- Begin by working with new projects to field improvements
- Eventual target …CMMI Level 3

Phase 3: Maintain Level and Continue Improvement

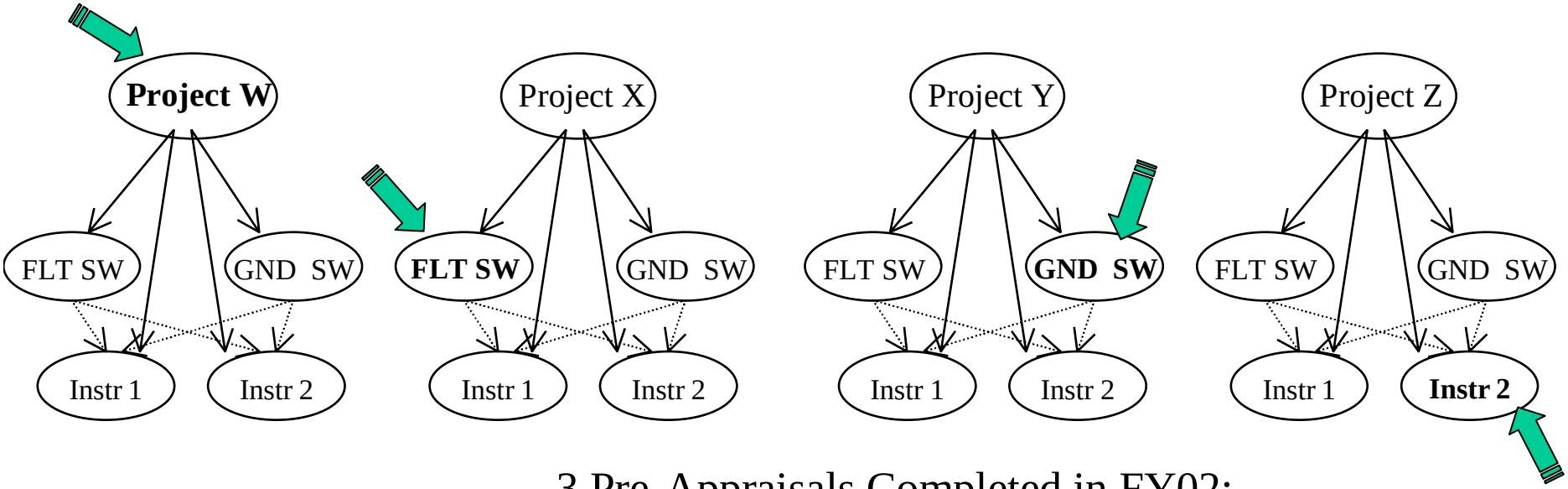
- Include other less critical areas? (e.g. science processing)



Phase 1 -FY02 Goals

- Benchmark several areas against the CMMI model (Where are we?)
- Learn what is involved in using CMMI as a model for improvement (How hard is it? Does it make sense?)
- Get a basis for estimating the cost of a process improvement program that achieves CMMI Level 3 (How expensive is it?)
- Assess our planned implementation approach (Are we doing this the right way?)

Pre-Appraisal Areas Selected for Phase 1



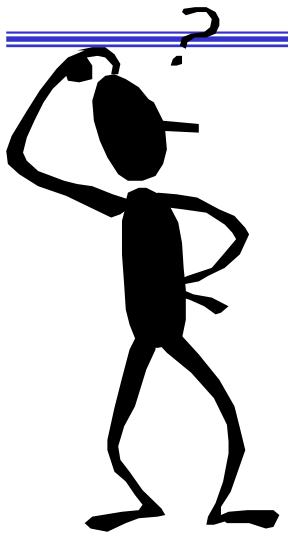
3 Pre-Appraisals Completed in FY02:

1. Flight Software (11/01)
2. Project Level-Focus on Systems Engineering & Acquisition (4/02)
3. Ground Software (9/02)

Note: The Instrument area appraisal was not done due to lack of available projects and time constraints

CMMI Pre-Appraisals During Phase 1

Goals of the Pre-Appraisals



How long does it take?

How does CMMI apply at GSFC??

How much preparation?

SE & CMMI?

Where are we?

Can we do it??

Key Points for Pre-Appraisals

- EPG tried to minimize time required from project participants
- Pre-appraisals were conducted less formally than SCAMPI
  - More reliance on interviews
  - Less verification of information and document review
  - *No maturity ratings determined*
- Pre-appraisal methodology evolved during course of year
- Findings were the result of team consensus, supported by multiple data points from multiple sessions.
- Results pre-appraisals were reported as findings of strengths and improvement opportunities in the CMMI Process Areas.

Phase 1 Pre-Appraisals

- **Pre-Appraisal #1: Flight Software -2 projects**
  - Both projects in-house, integrated contractor/civil servant teams
  - One project complete with all documentation in place
  - Other project at PDR point -Development started under ISO system
- **Pre-Appraisal #2: Flight Projects -3 projects**
  - Project 1: Start 2000, In Formulation, Large budget, International with multiple spacecraft, Core spacecraft will be in-house developed
  - Project 2: Start ‘91, In Implementation, (CDR in ‘99), L-’04, Large budget, ~30 Civil Servants , Multiple contractors
  - Project 3: Part of program with 3 project series, Several launches complete, (turn-key), Spacecraft budget about 1/2 of other two, mostly contractors, few Civil Servants
- **Pre-Appraisal #3: Ground Software -2 projects**
  - Both projects in-house, integrated contractor/civil servant teams
  - One project complete with all documentation in place
  - Other project in testing -Development started under ISO system

Differences in the Pre-Appraisals

	#1	#2	#3
Level of Focus	Subsystem	Code 400 Project	Subsystem
Emphasis	Software Development	Systems Engineering, Acquisition	Software Development
Mode	Discovery -1/2 Doc. Review -1/2 Interviews	Discovery -Heavy emphasis on interviews	Verification -Few interviews -Doc. Review
Use of PIIDs?	No	No	Yes
Draft Findings Briefing Held?	No	Yes	Yes
Days Spent	6 Days	9 Days	13 Days
Interviewee Preparation	Minimal	Gave sample questions	Minimal
Interviewed Support Orgs.	No	Yes	No

PIIDs (Process Implementation Indicator Documents)

RM	Direct Artifact	Indirect Artifact	Affirmation	Char.
RM SP 1.1-1	Requirements Doc	Req. Q & A	PM-affirms	FI
RM SP 1.2-1	Signatures on Req.	Presentation Mat.		FI
RM SP 1.3-1	Req. Change History	Slide 11 of CDR	PM affirms	FI
RM SP 1.4-1	Test Matrix (partial)		PM affirms	LI
RM SP1.5-1		Slide 14 of CDR	Done sometimes	PI
GP 1.1	Req. Doc., DB's….		PM affirms	FI
GP1.2			No org. policy	NI

Key:
FI: Fully Implemented
LI: Largely Implemented
PI: Partially Implemented
NI: Not Implemented

Appraisal Participants (Interviewees)

Role	#1	#2	#3
Line Manager	X		
Project Managers/Instr. Mgrs		X	
Senior Systems Engineers		X	
Software Manager	X	X	X
Requirements Developers	X	X	X
Software Developers	X		X
Testers	X		X
QA Representatives	X	X	
Configuration Managers	X	X	X
Schedulers		X	
Contracting Officers		X	
Training Coordinators		X	
EPG Members	X	X	

Appraisal Teams

Appraisal Team	#1	#2	#3
SEI-Authorized Lead Appraisers	3	3	3
GSFC Appraisal Team Members (Total)	3	3	4

GSFC Appraisal Team Characteristics:	#1	#2	#3
Experience: All were EPG Members			
Took Introduction to CMMI	3	3	4
Took Intermediate CMMI	1	1	4
Background:			
Software Development	3	1	4
Systems Engineering		1	
Quality Assurance		1	

Process Flow of Pre-Appraisal #1

Pre On-Site	Day 1	Day 2 - 3	Day 4	Day 5	Post On-Site
Analyze Requirements	Lead Assessor Opening Briefing	Conduct interviews and Review Documents	Conduct Interviews and Review Documents	Prepare Final Findings	Produce Reports and Support Follow-on Activities
Develop Appraisal Plan	Conduct Interviews	Review Documents	Work to reach consensus	Deliver Final Findings	
Select and Prepare Team	Conduct Interviews	Consolidate Information			
Obtain Organizational Information	Conduct Interviews				
Select and Prepare Participants					
Prepare for Data Collection					

Key Points:

-Little advance preparation

-Discovery mode with half interviews, half doc review

-No draft findings

Process Flow of Pre-Appraisal #2

Pre On-Site	Day 1	Day 2 - 3	Day 4	Day 5	Post On-Site
Analyze Requirements	CMMI Overview Training	Conduct Interviews	Conduct Interviews and Review Documents	Prepare Final Findings	Produce Reports and Support Follow-on Activities
Develop Appraisal Plan	GSFC, SE Overview Presentations	Review Documents	Consolidate Information	Deliver Final Findings	
Select and Prepare Team	Conduct Interviews	Consolidate Information	Deliver Draft Findings		
Obtain Organizational Information	Consolidate Information				
Select and Prepare Participants					
Prepare for Data Collection					

Key Points:
-More advance preparation
-Discovery mode-heavy reliance on interviews
-Draft findings

Process Flow of Pre-Appraisal #3

Pre On-Site

- Analyze Requirements
- Develop Appraisal Plan
- Select Team
- Conduct Team Training
- Obtain Organizational Information/Docs

Pre-On-Site

- Review Documentation
- Fill in PIIDs
- Obtain Additional Docs

Day 1

- Discussion of Projects for Appraisers
- Document Review
- Fill in PIIDs
- Identify Missing Information

Day 2-3

- Conduct Interviews
- Add interview Info to PIIDs
- Consolidate Information- Begin Assessing Gaps

Day 4

- Review Documents and Complete PIIDs
- Consolidate Information
- Deliver Draft Findings

Day 5

- Prepare Final Findings
- Deliver Final Findings

Key Points:
-Heavy advance preparation
-Verification mode-interviews used to verify & complete PIIDS
-Draft findings

Post On-Site

- Produce Reports and Support Follow-on Activities

Evaluation of Phase 1

What did we learn?

Would we choose the same approach again?

Advantages of CMMI Pre-Appraisal Approach

- CMMI Pre-Appraisals provided fairly accurate bench-mark of state of all three areas evaluated
- Pre-appraisal was a “quick-look” -Provided a wealth of information in a short period of time (1 week)
- Involvement of external appraisers helps facilitate cooperation from projects; Provides credibility for Senior Managers
- Pre-appraisal was excellent training for internal appraisers involved
- Future pre-appraisals and bench-marking could now be done by internal appraisers (Have experience base)

Disadvantages of CMMI Pre-Appraisal Approach

- Whole pre-appraisal approach was very time-consuming
  - Majority of our resources expended on convincing projects to participate, appraisal preparation, appraisals
  - Little time left to actually support improvement activities with projects
- More difficult to estimate costs of addressing weaknesses (doing actual improvements) than anticipated
- Difficult to show Senior Management that projects were "better" because we were doing pre-appraisals, not process improvement (*Early wins are important!)*

Lessons Learned on Pre-Appraisals

- It takes time to prepare …….
  - Scheduling interviews hard- allow lots of time
  - Assign internal appraisers process areas
  - Gather documents, fill out PIIDS
  - Prepare interviewees
  - Set expectations for pre-appraisal team
  - Brief pre-appraisal team
- Choose projects in various phases
  - Early phase: more opportunity to change
  - Mid-stream: probably typical of current processes
  - Late or done: all documentation in place

Lessons Learned

- Choose interviewees to cover all process areas
- Use of PIIDs captured more information on strengths & weaknesses by *Specific Practice* for later improvement work
  - Need a process for completing PIIDS
  - Too time intensive for Projects to fill out, but some EPG/Project interaction necessary
  - Projects didn't have CMMI knowledge to complete
- Conduct a draft findings briefing
- Knowledge of org. process structure more important than CMMI knowledge

Next Steps

- Prioritize improvement opportunities based on the Goddard business direction.
  - Use Continuous Model of CMMI
  - Focus on improving smaller part of s/w organization
  - Expand using assets developed as resources
- Continue working with the NASA Systems Engineering Working Group on the use of CMMI for evaluating systems engineering capability.
  - Start small pilot in systems engineering area
- Cost estimates for next year will be based on WBS developed to address gaps identified in appraisals

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Back-up Slides

The NASA Software Engineering Initiative

Goal: ***Advance software engineering practices (development, assurance, and management) to effectively meet the scientific and technological objectives of NASA.***

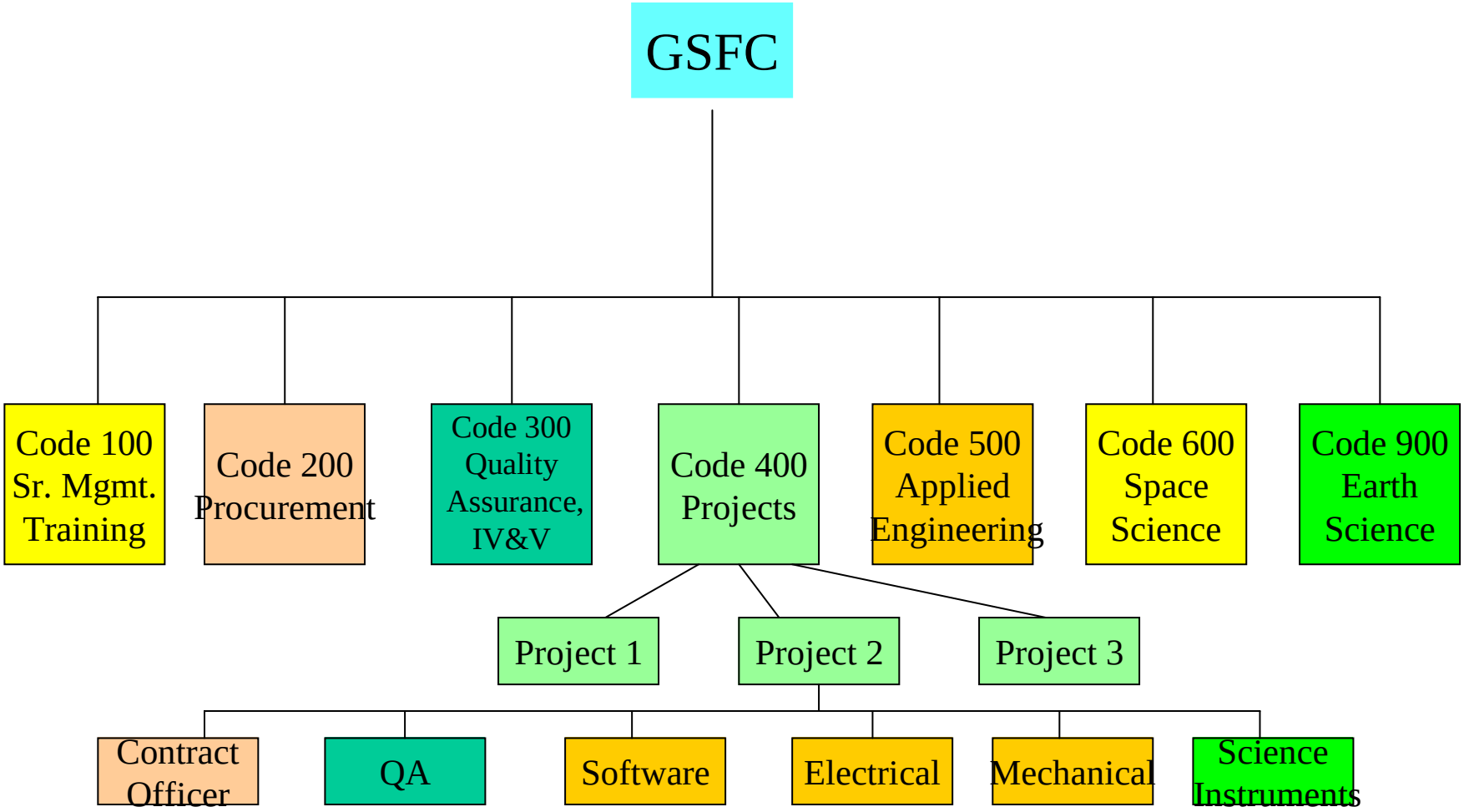
Strategy 1. Implement a continuous software process and product improvement program across NASA and its contract community.

Strategy 2. Improve safety, reliability, and quality of software through the integration of sound software engineering principles and standards.

Strategy 3. Improve NASA's software engineering practices through research.

Strategy 4. Improve software engineers' knowledge and skills, and attract and retain software engineers.

Goddard's Matrix Structure



Example Process Area: Requirements Management

SG 1: Manage Requirements

SP 1.1: Obtain an Understanding of the Requirements
SP1.2: Obtain Commitment to the Requirements
SP1.3: Manage Requirements Changes
SP1.4: Maintain Bi-directional Traceability of Requirements
SP1.5: Identify Inconsistencies between Project Work & Reqmts

GG 2: Institutionalize a Managed Process

GP 2.1: Establish an Organizational Policy
GP 2.2: Plan the Process
GP 2.3: Provide Resources
GP 2.4: Assign Responsibility

Example Process Area: Requirements Management

GG 2: Institutionalize a Managed Process

GP 2.5: Train People
GP 2.6: Manage Configurations
GP 2.7: Identify & Involve Relevant Stakeholders
GP 2.8: Monitor and Control the Process
GP 2.9: Objectively Evaluate Adherence
GP 2.10: Review Status with Higher Level Management

GG 3: Define a Managed Process

GP 3.1:Establish a Defined Process
GP 3.2:Collect Improvement Information

Pre-Assessment Scope

- CMMI® Components Reviewed:
  - Maturity Levels 2 and 3 Process Areas
  - Specific Goals
    - Specific practices are evaluated to determine specific goal coverage based on evidence of weaknesses, improvement activities, strengths and alternative practices.
- CMMI® Components **NOT** Reviewed: (Generic Goals)
  - Actual documented "process" being used on projects
    - Activities, process inputs & outputs, deliverables, roles & responsibilities, measurements, work instructions, templates, tailoring, why & when, etc.
  - Training for use of process
  - Use of process and adherence to process
  - Planning and monitoring of process
  - Providing resources for process

Appraisal Goals for Systems Engineering Pre-Assessment

- Determine the applicability of the CMMI Model for evaluating systems engineering and acquisition activities at Goddard
- Baseline the systems engineering organization against the requirements in the model
- Gain experience in the use of the model as a baselining tool

Level 2 Process Areas

Requirements Management

Project Planning

Project Monitoring & Control

Supplier Agreement Management

Measurement & Analysis

Process & Product Quality Assurance

Configuration Management

General Process Requirements for Each Process Area at Level 2

Document project level processes so that all projects have a starting point for these activities.

Plan and manage these process activities, including:

- Institute an organizational policy
- Plan the process
- Provide resources
- Assign responsibility
- Train people
- Manage configurations
- Identify & involve relevant stakeholders
- Monitor & control the process
- Objectively evaluate adherence
- Review status with higher level management

Level 3 Process Areas

Requirements Development
Technical Solution
Product Integration
Verification
Validation
Organizational Process Focus
Organizational Process Definition
Organizational Training
Integrated Project Management
Risk Management
Integrated Teaming (not assessed)
Integrated Supplier Management
Decision Analysis and Resolution
Organizational Environment for Integration (not assessed)

General Process Requirements for Each Process Area at Level 3

Document organization level processes (and tailoring guidelines) so that all projects have a starting point for all process activities.

Plan and manage these process activities, including:

- Institute an organizational policy
- Plan the process
- Provide resources
- Assign responsibility
- Train people
- Manage configurations
- Identify & involve relevant stakeholders
- Monitor & control the process
- Objectively evaluate adherence
- Review status with higher level management
- Collect information for process improvement

Authority

Directed by NASA Chief Engineer:

"…the SEWG is expected to…define and pilot a methodology for assessment of the systems engineering capability, which addresses knowledge and skill of the workforce, processes, and tools and methodology."

Deputy Chief Engineer for Systems Engineering (Nov. 1, 2000)

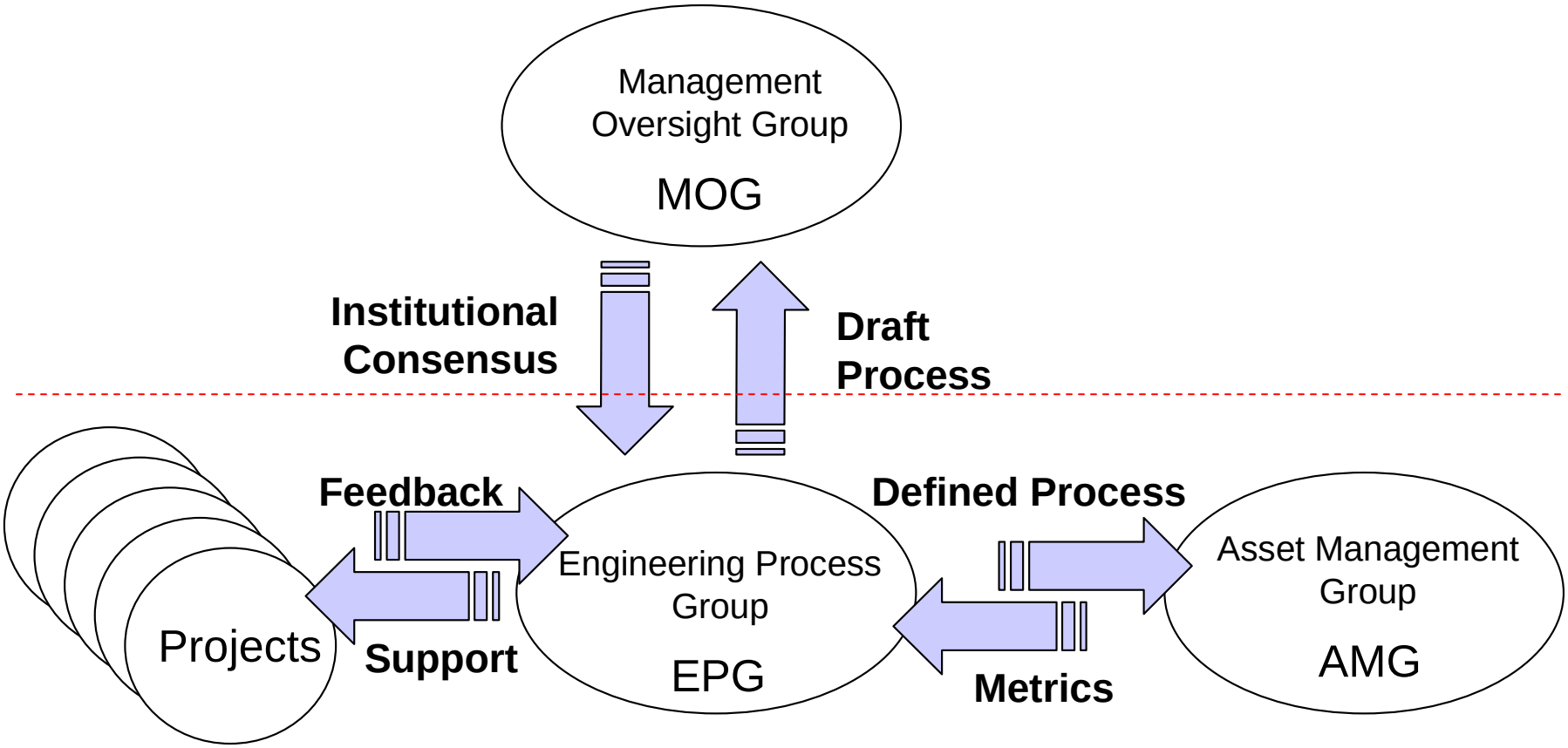
Promoted by the agency Software Working Group (SWG)

- Software Initiative being implemented across agency
- CMM and CMMI-SW programs at all Centers

Studied by the agency Systems Engineering Working Group (SEWG)

- Assessment data from GSFC will be evaluated by the SEWG to determine if CMMI is appropriate for Systems Engineering implementation agency-wide.

Infrastructure



MOG

- Provide oversight and direction to the EPG and AMG and assist in establishing priorities
- Work with the EPG in communicating process issues and industry practices to GSFC senior management
- Represent their constituent organizations in reaching consensus on GSFC institutional software policies and standards for both in-house and contractor-supplied software
- Review and concur on all GSFC software and system policies and guidelines prior to final publication

EPG

For the pilots and during the rollout to other GSFC entities the EPG will:

- ✓ Lead the continuous definition, maintenance and improvement of software process policies procedures and best practices including the development and maintenance of the GSFC software development process improvement plan
- ✓ Facilitate software process assessments
- ✓ Arrange for and support training and continuing education related to process improvements for engineers, line managers, project management, and GSFC senior management
- ✓ Define and maintain metrics to track, monitor, and assess the status of focused improvement efforts and pilot studies
- ✓ Provide status information and evaluations of the improvement activities to all levels of management
- ✓ Lead the institutional response, where appropriate, to software/systems-related Nonconformance Reports
- ✓ Maintain a collaborative working relationship with practicing software/systems engineers to obtain, plan, and install new practices and technologies
- ✓ Provide software engineering consultation to development projects and management

AMG

- Develop and maintain the GSFC “Develop Software and Systems Products” web site which includes the software development process improvement library,
- Develop and maintain a database of GSFC software process and product metrics,
- Act as the clearinghouse for software metrics reported to NASA HQ,
- Develop insights into the metrics sources that will enhance the consistency and effectiveness of interpretation,
- Maintain a database of GSFC software product characteristics in order to understand process metrics, encourage software reuse, and assist in identifying special expertise, and
- Establish and manage a service that provides software engineering tools to projects in cases where a single GSFC vendor interface and institutional supplier is appropriate.

CMMI and ISO

- **ISO is a standard, CMMI is a model**
- **ISO is broad- focusing on more aspects of the business. Initially for manufacturing**
- **CMMI is "deep"- provides more in-depth guidance in more focused areas (Software/Systems Engineering/Software Acquisition-SW/SE/SA)**
- **Both tell you "what" to do, but not "how" to do it**
- **But CMMI tells you what "expected" practices are for a capable, mature organization**
- **CMMI provides much more detail for guidance than ISO by including an extensive set of "best practices", developed in collaboration with industry/gov/SEI**

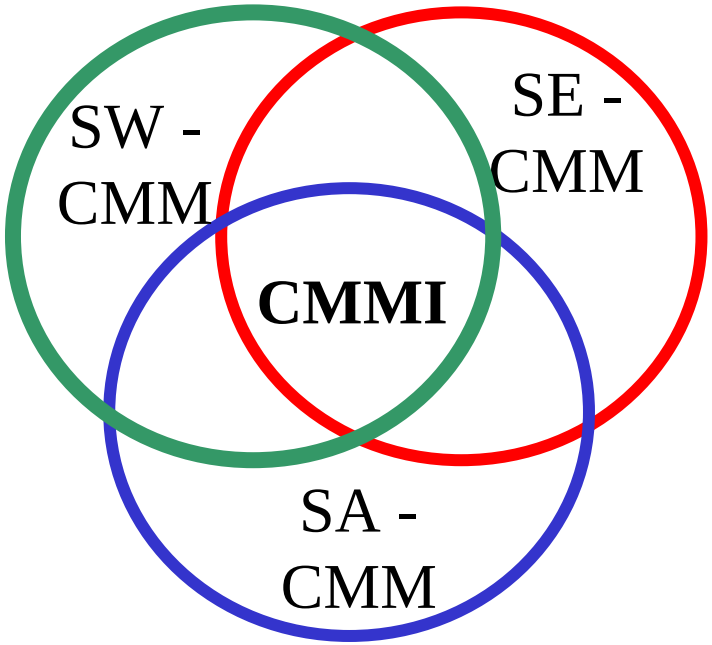
  -CMMI provides much better measure of quality of processes; ISO focuses more on having processes

  -CMMI puts more emphasis on continuous improvement

  -CMMI allows you to focus on one or a few process areas for improvement (It's a model, not a standard, like ISO) --Can rate just one area in CMMI

  -CMMI and ISO are not in conflict: ISO helps satisfy CMMI capabilities; CMMI more rigorous

Capability Maturity Model Integrated (CMMI)-Staged



Level	Process Areas
5 Optimizing	Organization innovation and deployment Causal analysis and resolution
4 Quantitatively Managed	Organizational process performance Quantitative project management
3 Defined	**Requirements development** **Technical solution** **Product integration** **Verification** **Validation** **Organizational process focus** **Organizational process definition** **Organizational training** **Integrated project management** **Risk management** **Decision analysis and resolution** **Integrated Supplier Management** **Integrated Teaming**
2 Managed	**Requirements management** **Project planning** **Project monitoring and control** **Configuration Management** **Supplier agreement management** **Measurement and analysis** **Product & Process Quality Assurance**
1 Initial	