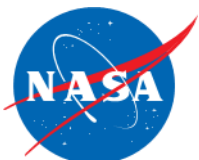**CMMI® Institute**

CAPABILITY COUNTS 2016

Annapolis, MD | May 10th – 11th

Use of the Capability Maturity Model Integration (CMMI®) in software engineering management on NASA missions

Tim Crumbley
NASA
Deputy Manager for Software Engineering Technical Discipline Team

Business Challenge

The importance of software to NASA missions has grown steadily since NASA was formed.

The first spacecraft launched by the United States in 1958 had no software at all, while the Mars Science Laboratory (MSL) launched in 2011 with well over 3 million lines of code.

Contemporary NASA spacecraft have basically become flying computers.

Software percentage of a mission's budget ranges from 5% to 15%, with all missions needing high reliability software delivered on time and on budget.

Flight software is the only items that can be changed or modified after launch

Late or unreliable software threatens the entire mission, potentially causing launch delays and even mission failure.

The result is that NASA is currently one of the 100 largest developers and procurers of software in the world.
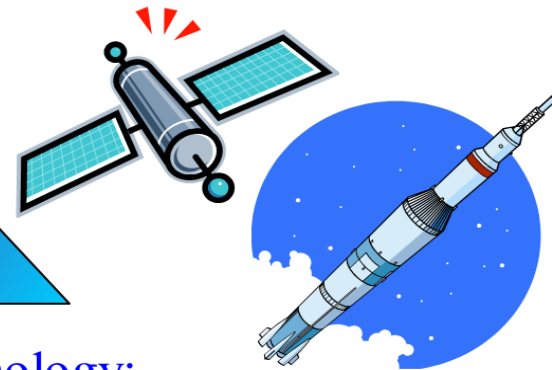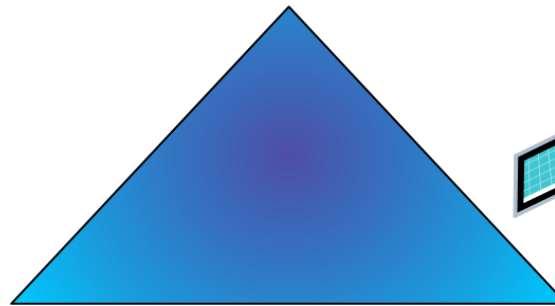
Business Challenge

The Three Elements of Project Success

Process:
a defined method involving steps or operations
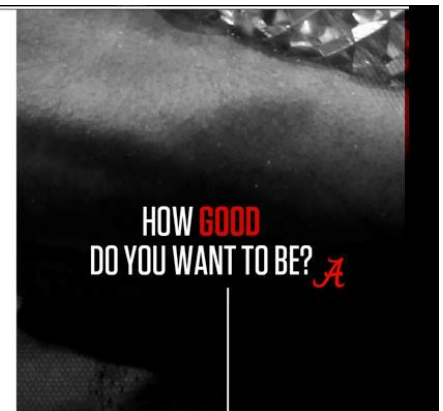
People:
Skills, Training,
Management

Technology:
Application domains, tools,
languages, information,
environments

Improved Process + Competent Workforce + Appropriate Technology
=
Reduced Risk, Higher Productivity, and Better Quality

LEADERSHIP LESSONS FROM ALABAMA FOOTBALL

The challenge for leaders is to examine every area of their organization and identify the processes that are in place.

Ask:

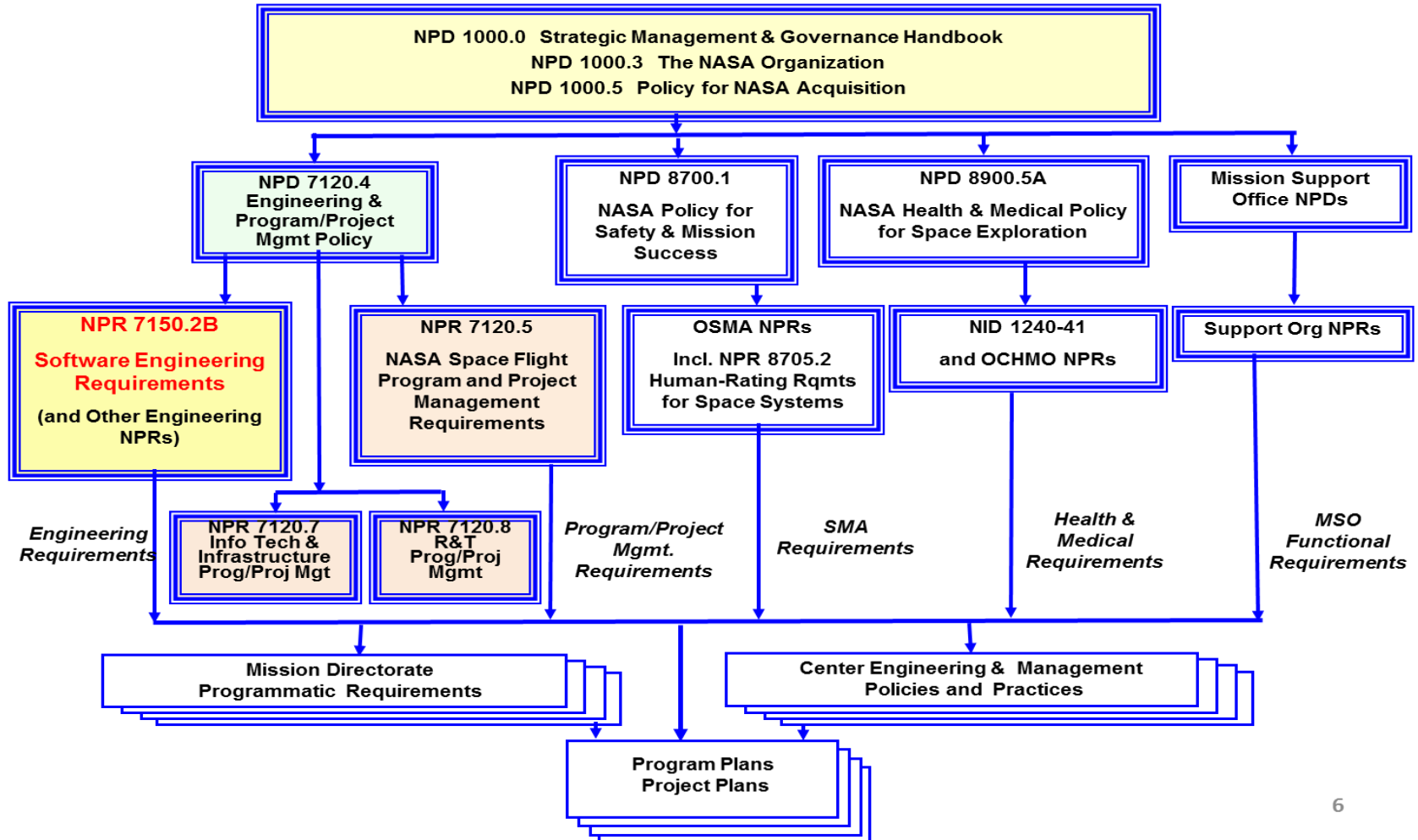- Does the right process or procedure exist?
- Is the process effective? How do you know?
- Do staff members know the outcome of the procedure?
- Does everyone know the "why" of the process?
- How and when is the process evaluated?
- Does everyone know how they fit into the process and what to do?
- Are staff members held accountable to the process?
- What is the process to fix an ineffective process?

The Plan

NASA Governing Documents

The diagram shows NASA governing documents hierarchy:

- **NPD 1000.0** Strategic Management & Governance Handbook
  NPD 1000.3 The NASA Organization
  NPD 1000.5 Policy for NASA Acquisition

Branching to:
- **NPD 7120.4** Engineering & Program/Project Mgmt Policy
- **NPD 8700.1** NASA Policy for Safety & Mission Success
- **NPD 8900.5A** NASA Health & Medical Policy for Space Exploration
- **Mission Support Office NPDs**

Second level:
- **NPR 7150.2B** Software Engineering Requirements (and Other Engineering NPRs)
- **NPR 7120.5** NASA Space Flight Program and Project Management Requirements
- **OSMA NPRs** Incl. NPR 8705.2 Human-Rating Rqmts for Space Systems
- **NID 1240-41** and OCHMO NPRs
- **Support Org NPRs**

Third level:
- **NPR 7120.7** Info Tech & Infrastructure Prog/Proj Mgt
- **NPR 7120.8** R&T Prog/Proj Mgmt

Labels:
- *Engineering Requirements*
- *Program/Project Mgmt. Requirements*
- *SMA Requirements*
- *Health & Medical Requirements*
- *MSO Functional Requirements*

Bottom level:
- **Mission Directorate Programmatic Requirements**
- **Center Engineering & Management Policies and Practices**
- **Program Plans Project Plans**

The Plan

The project manager shall acquire, develop, and maintain software from an organization with a non-expired CMMI-DEV rating as measured by a CMMI Institute authorized or certified lead appraiser as follows: [SWE-032]

a. **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 3 process areas for software.

b. **For Class B software** (except Class B software on NASA Class D payloads, as defined in NPR 8705.4): CMMI-DEV Maturity Level 2 Rating or higher for software, or **CMMI-DEV Capability Level 2 Rating** or higher for software in the following process areas:

(1) Requirements Management.
(2) Configuration Management.
(3) Process and Product Quality Assurance.
(4) Measurement and Analysis.
(5) Project Planning.
(6) Project Monitoring and Control.
(7) Supplier Agreement Management (if applicable).

Class A	Human-Rated Space Software Systems (e.g. SLS, MPCV, GSDO)
Class B	Non-Human Space-Rated Software Systems or Large-Scale Aeronautics Vehicles (e.g. JWST, MARS 2020, Kepler, SSP, LADEE, etc.)
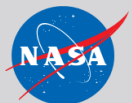
Why has NASA Management directed the use of CMMI® standards?

The CMMI requirement is a qualifying requirement. The requirement is included to make sure NASA projects are supported by software development organization(s) having the necessary skills and processes in place to produce reliable products within cost and schedule estimates.

It is a benchmarking tool widely used by industry and government, both in the US and abroad

It acts as a roadmap for process improvement

It provides criteria for reviews and appraisals

It provides a reference point to establish present state of processes

It can help the government compare the maturity of one offerer (or supplier) to another

It addresses practices that are the framework for process improvement

It is not prescriptive; it does not tell an organization how to improve
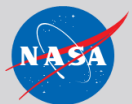
NASA Timeline 2000 – 2015
NASA Software Engineering Initiative – CMM and CMMI Activities

Results

CMMI Level 3

| MSFC JPL | LaRC | LaRC | MSFC (FSW) JPL | LaRC (FSSB) LaRC (SDAB) | JSC | MSFC (FSW) JPL | JSC KSC |

CMMI Level 2

| MSFC | GSFC LaRC | GSFC LaRC | JSC KSC LaRC | MSFC (GND) ARC GRC | GSFC GSFC (ACQ) | MSFC (Grnd) ARC GRC | GSFC LaRC | LaRC |

CMM Level 3

| MSFC ARC* | JSC |

Affordability from a Level 1 Software Organization:
7 to 8% increase in Software Productivity for CMMI Level 2
15% increase in Software Productivity for CMMI Level 3

CMM Level 2

| MSFC | JSC | LaRC JPL ARC | GRC JPL | JPL JSC |

| 2000 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |

Software Working Group Charter

Started: NASA SW Eng Improvement Initiative

Signed: NASA Software Procedural Requirement NPR 7150.2 (2004)

CMMI Requirement for Class A and B software

CMMI Level 2 or CMM Level 3

In 2004 timeframe 5 of the 10 NASA Centers had experience using the CMM model

Signed: NASA Software Procedural Requirement NPR 7150.2A (2009)

CMMI Requirement for Class A and B software

Class A - CMMI Level 3
Class B - CMMI Level 2

By the 2009 timeframe 8 of 10 NASA Centers have experience using the CMMI model

Signed: NASA Software Procedural Requirement NPR 7150.2B (2014)

CMMI Requirement for Class A and B software

Class A - CMMI Level 3
Class B - CMMI Level 2

CMM/CMMI Appraisals & Consultations at NASA Centers

Software Engineering Training and SEI Training at NASA Centers

Lessons Learned

Benefits of using CMMI include:

– Reduced risk of software failure - Increasing mission safety,

– Improved the accuracy of schedule and cost estimates by requiring the use of historical data and repeatable methods

– Helped NASA become a smarter buyer of contracted out software,

– Increased quality by finding and removing more defects earlier,

– Improved the potential for reuse of tools and products across multiple projects,

– Increased ability to meet the challenges of evolving software technology,

– Improved Software development planning across the Agency,

– Improved NASA contractor community with respect to software engineering,

– Lowered the software development cost, improves productivity

– Improved employee morale,

– Improved customer satisfaction,

– Improved NASA and Contractor community knowledge and skills,

– Provided NASA a solid foundation and structure for developing software in a disciplined manner.