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George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

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MSFC TECHNICAL STANDARD

MARSHALL SPACE FLIGHT CENTER SOFTWARE ENGINEERING IMPROVEMENT PLAN

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1. SCOPE/PURPOSE

1.1. Introduction

The purpose of this plan is to define the implementation of the Marshall Space Flight Center (MSFC) software development process improvement effort and to document MSFC support of the National Aeronautics and Space Administration (NASA) Software Engineering Initiative Implementation Plan. In compliance with the NASA Engineering and Program/Project Management Policy NPD 7120.4, a major benefit that MSFC derives from the implementation of this initiative is improved software development and acquisition processes enabling MSFC to develop and acquire higher quality software. A major focus of this effort is to improve the processes and practices in use at MSFC by continually measuring the level of process maturity against the Software Engineering Institute's Capability Maturity Model-Integration (CMMI) for development.

In accordance with MWI 7120.4, this document adheres to the mandatory template for a MSFC Technical Standard document. Sections 1 through 3 of the center plan required content as defined in Appendix C of the NASA Software Engineering Initiative Implementation Plan are addressed in Section 1.1, Section 1.2, and Section 1.3 of this plan, respectively.

1.2. Goal

The goal of the NASA Software Engineering Initiative Implementation Plan is to "advance software engineering practices to effectively meet the scientific and technological objectives of NASA." The goal of the MSFC Software Engineering Improvement Plan is to improve the quality of software produced by MSFC, in terms of planning, implementation, testing, and support. These goals are realized by addressing the following areas:

a. Improvement in software engineering processes across MSFC.
b. Improvement in software acquisition processes on MSFC contracts.
c. Collection and use of software metrics in the management of software development projects.
d. Professional development for the MSFC software engineers.
e. Research in software process and product improvement techniques and methods.

1.2.1. Rationale for Implementing this Plan

The highest priority of this plan is to improve NASA's capability to deliver safe, reliable, quality software that meets system and software requirements. Rationale for continuous software engineering improvement includes:

a. Reduction in the risk of mission failure.
b. Reduction in cost and schedule overruns.
c. Fulfillment of mission performance requirements.
d. Provision for uniform procurement policies to ensure quality of software.
e. Ability to deal effectively with the growing scope and complexity of software systems.
   (1) Exponential growth in scope, size, and complexity of software is expected to continue.
      - Ground and flight software represent an ever increasing share of the end-to-end system.
      - Growth stresses our capability to manage and engineer software systems effectively.
   (2) Safety, quality and reliability of software systems are at risk.

1.2.2. Benefits

The primary motivation for implementing this software engineering improvement plan is to assure and improve the quality of software products developed by and/or for MSFC. The following subsections address benefits anticipated for Project Managers/Lead System Engineers/Chief Engineers, MSFC Management, and Software Engineering resulting from the improvement activities.

1.2.2.1. Project Manager/Lead System Engineer/Chief Engineer

a. Identification and recommendation of key software management metrics.
b. Assessment of existing software engineering processes.
c. Access to data from multiple software projects; data can be used as a method of comparison of existing project software metrics and software data.
d. Provision of a common foundation and infrastructure for software process improvement across or within software development organizations.
e. Improvement of the project's ability to manage software activities.
f. Reduction of defects.
g. Reduction of schedule overruns and software costs.
h. Reduction of software development risks.
i. Improvement of software safety and mission success.
j. Reduction of system integration and test risks.
k. Enhancement in the ability to retain and improve software engineering skills.
l. Development of procurement language and contract language to meet the NASA Software Engineering Initiative guidelines for Software Process Improvement on MSFC contracts.

1.2.2.2. MSFC Management

a. All of the benefits listed above for Project Managers/Lead System Engineers/Chief Engineers.

b. Provision of data on the state, status, scope, size and amount of MSFC software development projects.
c. Provision of data to determine strategy and set priorities to address deficiencies.
d. Review of existing technologies for incorporation into existing software processes and products.
e. Identification and conduct of research in software process and product improvement techniques and methods.
f. Support of the MSFC training process to annually prioritize software training needs.
g. Provision of a basis for employee career development planning.

1.2.2.3. Software Engineering

The Software Engineering Institute's Software CMMI serves as a guide for the supporting infrastructure and the standard software best practices upon which to base the improvement activities. The standard software best practice areas in which to focus improvement activities include as appropriate:

a. Requirements Management
b. Requirements Development
c. Project Planning
d. Project Monitoring and Control
e. Supplier Agreement Management
f. Process and Product Quality Assurance
g. Software Configuration Management
h. Risk Management
i. Measurement and Analysis
j. Organizational Process Focus
k. Organizational Process Definition
l. Organizational Training
m. Integrated Project Management
n. Technical Solution
o. Product Integration
p. Verification
q. Validation
r. Decision Analysis and Resolution.

1.2.3. Challenges

The following areas have been identified as challenges to the implementation of this software engineering process improvement plan:

a. Maintaining management commitment.
b. Maintaining resources and adequate skills.
c. Coordinating activities across organizational elements.

d. Organizational acceptance of standard processes.
e. Inordinate focus on achieving specific CMMI Level versus effecting true technical capability improvement.
f. Determining a realistic time frame to achieve improvement goals.

1.2.4. FY02 Accomplishments

The following list is a set of the primary objectives accomplished in FY02. The main objective in FY02 was to establish a baseline on which to improve.

a. Surveyed the state of software at MSFC.
    (1) Collected data on each project and on process improvement activities.
    (2) Reviewed existing contracts and in-house development organizations that include software development.
    (3) Determined deficiencies with respect to meeting the intent of the software CMM Level 2 and 3 key practice areas.
    (4) Identified best practices.
    (5) Identified formality of software Verification and Validation (V&V) and software Independent Verification and Validation (IV&V) required.
b. Provided the MSFC software survey and data to Goddard Space Flight Center to serve as a pilot for the Agency Level Software Characteristics.
c. Supported the development of Agency policy, standards, and guidebooks on NASA software.
d. Attended Software Process Improvement courses provided through Headquarters training and software practitioner training courses provided through the MSFC Training Organization.
e. Conducted software research activities in the areas of coding standards, code analysis, computing algorithms for engine control, and space activity scheduling algorithms.
f. Provided annual report to the NASA Software Working Group.

1.2.5. FY03 Accomplishments

The following list is a set of objectives accomplished in FY03. The main objective in FY03 was to improve MSFC software engineering capabilities.

a. Maintained the survey of the state of software at MSFC.
b. For in-house software development organizations:
    (1) Determined deficiencies with respect to meeting the intent of the software CMM Level 2 and 3 key practice areas.
    (2) Determined strategy and set priorities to address software engineering deficiencies.
    (3) Flight Software Group underwent a Software Capability Evaluation and achieved a CMM Level 3 rating.
c. Supported the development of Agency policy, standards, metrics, and guidebooks

on NASA software.

d. Initiated work on a MSFC Software web page to contain or reference software processes, documentation, best practices, policies, standards, guidelines and other software resource information.
e. Attended Software Process Improvement courses provided through Headquarters training and software practitioner training courses provided through the MSFC Training Organization.
f. Presented annual status to the NASA Software Working Group.

1.2.6. FY04/FY05 Accomplishments

The following list is a set of objectives accomplished in FY04/FY05. A main objective for FY04/FY05 was to improve MSFC software acquisition practices and insight practices.

a. Transitioned from Software CMM to CMMI for software as a guide for software improvement activities.
b. Supported development and roll-out of NPR 7150.2, NASA Software Engineering Requirements.
c. Supported the development of Agency policy, standards, and metrics on NASA software.
d. Updated organizational documentation to maintain compliance with the NASA software policies and standards.
e. Developed and maintained Flight Software Branch's electronic Process Asset Library to contain software processes, documentation, best practices, policies, standards, guidelines and other software resource information.
f. Improved the MSFC software metric collection capabilities.
g. Supported software research infusion subgroup, metrics subgroup, and training subgroup of the NASA Software Working Group.
h. Provided input to the MSFC training process to annually prioritize software training needs.
i. Supported the NASA System Engineering improvement activities through coordination with the NASA System Engineering Working Group.
j. Provided reports to the NASA Office of Chief Engineer and to the NASA Software Working Group.
k. Developed and populated an Agency Software Process Asset Library website containing software processes, documentation, best practices, policies, standards, guidelines and other software resource information from across the Agency.

1.2.7. FY06/FY07/FY08 Accomplishments

The following list is the set of objectives accomplished in FY06/FY07/FY08. A main objective for FY06/07 was to improve the MSFC software products and processes in compliance with the NPR 7150.2 NASA Software Engineering Requirements and the software CMMI level 3. A main objective of FY08 was to broaden the scope of center software improvement activities to include the Avionics and Software Ground Systems Test Branch within the Flight and Ground Software Division of the Engineering Directorate.

a. Updated the organizational software policies and processes to comply with appropriate CMMI best practices.
b. Applied NPR 7150.2 and software policies and processes to Ares software.
c. Hosted the October 2006 face-to-face meeting of the NASA Software Working Group.
d. Expanded the scope of the EI Flight Software Branch processes to include the EV Flight Software Branch within the Engineering Directorate. (FY07)
e. Conducted CMMI workshops and appraisals.
f. Achieved a CMMI Maturity Level 3 rating for the Flight Software Branches (Software Systems Engineering Branch and Software Development Branch). (FY07)
g. Populated and maintained the Agency NASA Software Process Asset Library.
h. Defined the initial design of a MSFC web-based Process Asset Library. (FY08)
i. Began working with the Avionics and Software Ground Systems Test Branch toward CMMI maturity level 2. (FY08)
j. Conducted an informal CMMI assessment of the Avionics and Software Ground Systems Test Branch. (FY08)
k. Collected and analyzed software metrics for Center projects.
l. Supported the development of Agency policy, standards, metrics, and guidebooks on software.
m. Provided software engineering training and attended software conferences.
n. Supported the NASA System Engineering improvement activities through coordination with the NASA System Engineering Working Group.
o. Provided reports to the NASA Office of Chief Engineer and to the NASA Software Working Group.

1.2.8. FY09/FY10 Objectives

The following list is the set of objectives for FY09/FY10. A primary objective is to renew the CMMI Maturity Level 3 rating for the flight software branches (Software Systems Engineering Branch and Software Development Branch) and to attain a CMMI Level 2 rating for the Avionics and Software Ground Systems Test Branch of the Engineering Directorate.

a. Maintain and improve CMMI level 3 practices for the flight software branches.
b. Apply NPR 7150.2 and software policies and processes to Ares software.
c. Maintain the organizational software policies and processes to be compliant with appropriate CMMI best practices.
d. Continue working with the Avionics and Software Ground Systems Test Branch toward CMMI level 2.
e. Conduct CMMI class B appraisal of the Avionics and Software Ground Systems Test Branch for Level 2 process areas to determine readiness for Standard CMMI Appraisal Method for Process Improvement (SCAMPI) A appraisal.
f. Conduct SCAMPI A appraisals of the Avionics and Software Ground Systems Test Branch for Level 2 process areas.
g. Conduct CMMI Level 3 class B appraisal of the flight software branches.
h. Conduct CMMI SCAMPI A appraisal (re-assessment) of the flight software branches for Level 3 process areas in order to maintain the Maturity Level 3 rating achieved in FY07 (SEI requirement).
i. Populate and maintain the Agency NASA Software Process Asset Library.
j. Populate and maintain the MSFC web-based software Process Asset Library.
k. Collect and analyze software metrics for Center projects.
l. Support the development of Agency software policies, standards, metrics, and guidebooks.
m. Provide software engineering training and attend software conferences.
n. Support the NASA System Engineering improvement activities through coordination with the NASA System Engineering Working Group.
o. Determine the benefits and approach toward CMMI higher maturity levels (4/5).
p. Provide reports to the NASA Office of Chief Engineer and to the NASA Software Working Group.

1.3. Scope

NPR 7150.2 NASA Software Engineering Requirements applies to all software development projects at MSFC. The scope of MSFC's on-going software engineering improvement as measured against the CMMI applies to MSFC's Flight and Ground Software Division that develops class A, B, and C software as defined by NPR 7150.2 and to the Mission Systems Assurance and Technical Support Department that performs associated software assurance activities. The application of software engineering improvement activities as measured against the CMMI to other software development organizations would be determined by the responsible project or organization.

1.3.1. Organizational Elements Involved

As of FY09, software engineering improvement as measured against the CMMI applies to the Software Systems Engineering Branch, the Software Development Branch, and the Avionics and Software Ground Systems Test Branch within Engineering Directorate's Flight and Ground Software Division. In addition, the Software Assurance Team within the Safety and Mission Assurance Directorate's Mission Systems Assurance and Technical Support Department provides process and product quality assurance.

The approach for phasing in software engineering improvements is via organizational phasing. Improvement activities are typically managed at the Branch or Division level.

As of FY09, the flight software branches within the Flight and Ground Software Division (Software Systems Engineering Branch and Software Development Branch) have achieved a CMMI Maturity Level 3 rating.

MSFC primary and alternate representatives to the NASA Software Working Group are from the Flight and Ground Software Division. Software assurance representatives are from the Software Assurance Team within the Safety and Mission Assurance Directorate's Mission Systems Assurance and Technical Support Department. These representatives typically compile the annual software inventory input to Headquarters from MSFC.

1.3.2. Criteria

CMMI is the criteria used for measuring software improvement progress over time.

2. APPLICABLE DOCUMENTS

a. MWI 7120.4, Documentation Preparation, Programs/Projects
b. NPR 7150.2, NASA Software Engineering Requirements
c. NASA Software Engineering Initiative Implementation Plan
d. NPD 7120.4, NASA Engineering and Program/Project Management Policy

3. DEFINITIONS/ACRONYMS

3.1. Definitions

The following definitions are applicable for this plan.

3.1.1. Class A: Human Rated Space Software Systems

Class A software is defined in NPR 7150.2 NASA Software Engineering Requirements, Appendix E Software Classifications.

3.1.2. Class B: Non-Human Space Rated Software Systems or Large Scale Aeronautics Vehicles

Class B software is defined in NPR 7150.2 NASA Software Engineering Requirements, Appendix E Software Classifications.

3.1.3. Class C: Mission Support Software or Aeronautic Vehicles, or Major Engineering/Research Facility software

Class C software is defined in NPR 7150.2 NASA Software Engineering Requirements, Appendix E Software Classifications.

3.2. Acronyms/Abbreviations

CMM	Capability Maturity Model
CMMI	Capability Maturity Model Integration
DRD	Data Requirements Description
FY	Fiscal Year
IV&V	Independent Verification and Validation
MSFC	Marshall Space Flight Center
MSG	Management Support Group
MWI	Marshall Work Instruction
NASA	National Aeronautics and Space Administration
NPD	NASA Policy Directive
NPR	NASA Procedural Requirements
PAL	Process Asset Library
SCAMPI	Standard CMMI Appraisal Method for Process Improvement
SEPG	Software Engineering Process Group
SPI	Software Process Improvement
V&V	Verification and Validation

4. OWNERSHIP

The MSFC Software Process Improvement (SPI) Initiative project is the Center focal point for implementing and monitoring progress with respect to this plan.

The SPI Initiative Management Steering Group is responsible for managing the SPI Initiative project. The steering group is comprised of management within the Flight and Ground Software Division and the Mission Systems Assurance and Technical Support Department. The steering group assigns responsibility and provides resources for the SPI Initiative activities; reviews activities, status, and results of the initiative; and resolves issues as necessary.

The chair of the SPI Initiative Management Steering Group serves as the Center Software Engineering Process Champion.

The Software Engineering Process Group (SEPG) is comprised of members of the Flight and Ground Software Division and Safety and Mission Assurance. The chair of the SEPG serves as the SPI Initiative project lead.

5. STRATEGIES AND OBJECTIVES

This section correlates the MSFC FY09/FY10 objectives and products to the Strategy Areas of the NASA Software Engineering Initiative.

5.1 Support of NASA Software Engineering Initiative Strategy 1: Implement a continuous software process and product improvement program across NASA and its contract community

Table I addresses Software Process Improvement across MSFC and on applicable MSFC contracts. Table II addresses software metric activities.

Table I Software Process Improvement across MSFC and on Applicable MSFC Contracts

Initiative	Responsibility	Metric/Product
Maintain this multi-year Center-level implementation plan for advancing software engineering practices.	SPI Initiative Management Steering Group	MSFC status reports on the MSFC Software Engineering Improvement Plan to the NASA Office of Chief Engineer and to the NASA Software Working Group; Revisions to MSFC-PLAN-3204.

Initiative	Responsibility	Metric/Product
Use software CMMI as a benchmark to measure process improvement within applicable software development organizations. - Conduct CMMI workshops and appraisals. - Provide process training for Ares project and flight software organizations. - Maintain and improve processes and documentation for CMMI level 3 process areas. - Work with the Avionics and Software Ground Systems Test Branch toward CMMI level 2. - Conduct CMMI assessments of the Avionics and Software Ground Systems Test Branch for CMMI level 2 process areas. - Conduct CMMI assessments of the flight software branches for CMMI level 3 process areas. - Determine the progression approach toward CMMI level 4/5. -	SEPG; MSFC software development and assurance organizations	Organizational Software Process Improvement Plan(s) Gap assessment of meeting CMMI process areas CMMI appraisals Updated organizational work instructions
Apply NPR 7150.2 and software policies and processes to Ares software. Changes resulting from updates to agency software requirements and policy are negotiated with the affected elements for implementation approach.	SEPG; MSFC software development and assurance organizations; project office	Updated work instructions; updated NPR 7150.2 Compliance Matrix in project software plans
Improve software acquisition practices.	MSFC software development organizations and MSFC Procurement Office	New or updated DRDs provided to the Marshall Data Requirements Management System; software statement of work template
Improve software insight practices (technical monitoring of contractor-developed software).	MSFC software development organizations	Updated organizational work instructions
Support the development of Agency policy, standards, requirements, and guidebooks on NASA software.	MSFC representatives to NASA Software	Input to NPRs, NPDs, and NASA standards.

Initiative	Responsibility	Metric/Product
	Working Group	
Update organizational documentation to maintain compliance with NASA software policies and requirements.	SEPG; MSFC software development and assurance organizations	Updated organizational work instructions; NPR 7150.2 Compliance Matrix in project software plans
Populate and maintain the Agency Software Process Asset Library.	Software Systems Engineering Branch	Process Asset Library to contain or reference software processes, documentation, best practices, policies, standards, guidelines and other software resource information from across the Agency.
Support the NASA System Engineering improvement activities through coordination with the NASA System Engineering Working Group.	MSFC representatives to NASA Software Working Group	Participation in MSFC System Engineering Working Group; Face-to-face meetings of the NASA Software Working Group and the NASA System Engineering Working Group

Table II Software Metrics

Initiative	Responsibility	Metric/Product
Support NASA agency software metric activities.	MSFC representatives to NASA Software Working Group	MSFC software survey data which served as agency pilot; input to agency software metric guidelines/requirements
Improve MSFC software metric collection capabilities	SEPG	Revised organizational work instruction; monthly project and organizational software metrics
Track and maintain software metrics for software projects.	SEPG	Monthly Software Metric Report; DRD located on the Marshall Data Requirements Management System

5.2 Support of NASA Software Engineering Initiative Strategy 2: Improve safety, reliability and quality of software products through the integration of sound software engineering principles and standards

Table III addresses support of Strategy 2.

Table III Support of NASA Software Initiative Strategy 2

Initiative	Responsibility	Metric/Product
Inventory all MSFC programs and identify software Independent Verification and Validation (IV&V) ranking.	Engineering Directorate	Ranked list of MSFC projects for software IV&V
Support the development of Agency policy, standards and guidebooks on safety, reliability, and quality of NASA software.	MSFC representatives to NASA Software Working Group	Input to agency policy, standards and guidebooks on safety, reliability, and quality of NASA software.
Update organizational documentation to maintain compliance with NASA software assurance policy, standards, and guidelines.	SEPG; MSFC software development and software assurance organizations	Updated organizational work instructions

5.3 Support of NASA Software Engineering Initiative Strategy 3: Improve software engineering through research

Table IV addresses support of Strategy 3.

Table IV Conduct Research in Software Process and Product Improvement Techniques and Methods

Initiative	Responsibility	Metric/Product
Identify and conduct research in software process and product improvement techniques and methods.	MSFC software development organizations	Research proposals; Monthly status for research projects
Review existing or new technologies for incorporation into software process and products.	SEPG and MSFC software development organizations	Software tool survey; assessment of technology products; use of model-based design for Ares flight software; use of code analysis tools
Support transfer of new software methods/tools into NASA practice.	Technology Transfer organization	Software release documentation

5.4 Support of NASA Software Engineering Initiative Strategy 4: Attract and retain software engineers and improve their knowledge and skills

Table V addresses professional development for the MSFC software staff. Organizational software engineering training plans serve as implementation of the NPR 7150.2 center training plan requirement.

Table V Professional Development for the MSFC Software Staff

Initiative	Responsibility	Metric/Product
Support the MSFC training process to annually prioritize training/conference needs.	MSFC software development and software assurance organizations	Training needs input to MSFC training organization; organizational software engineering training plan
Support the NASA headquarters training process to annually prioritize training needs.	MSFC representatives to the NASA Software Working Group	Training needs input to NASA headquarters
Provide software engineering training and enable software conference attendance.	MSFC training organization	Record of training
Support career development model for software engineering.	MSFC representative to the NASA Software Working Group	Course of study for software engineering career path

6. SCHEDULE

The following schedule applies to objectives for FY09/FY10:

On-going	Support the development of Agency policy, standards, metrics, and guidebooks on NASA software
On-going	Update center documentation to maintain compliance with NASA software policies and requirements
On-going	Software research infusion
On-going	Collect and improve the MSFC software metrics
On-going	Populate and maintain the Agency Software Process Asset Library (PAL)
On-going	Populate and maintain the MSFC web-based PAL to contain or reference software processes, documentation, best practices, policies, standards, guidelines and other software resource information
On-going	Improve the MSFC software acquisition practices and insight practices
On-going	Coordinate with the NASA System Engineering Working Group
On-going	Provide Software Engineering Training
Q1 FY09	Conduct CMMI level 2 Class B appraisal for the Avionics and Software Ground Systems Test Branch
Q4 FY09	Conduct CMMI level 2 SCAMPI A appraisal for the Avionics and Software Ground Systems Test Branch
Q2 FY10	Conduct CMMI level 3 Class B appraisal for flight software branches
Q3 FY10	Conduct CMMI level 2 SCAMPI A appraisal for the Avionics and Software Ground Systems Test Branch
Q4 FY10	Conduct CMMI level 3 SCAMPI A appraisal for flight software branches
Q4 FY10	Revise MSFC-PLAN-3204 for FY11/FY12
As required	Report to the NASA Office of Chief Engineer and to the NASA Software Working Group

6.1 Resources

Manpower requirements for this plan are contained in the Program Planning, Budgeting, and Execution documents.

Budget inputs for procurement, personnel, and travel reflect planning guidelines provided by the NASA Office of Chief Engineer for the NASA Software Engineering Initiative.

Procurement cost covers contractor and other software process improvement support functions such as consulting, training, and tools.

Manpower funded by the NASA Software Engineering Initiative is in support of coordinating, implementing, and maintaining this plan. Manpower to implement software process improvement, metric reporting, or incorporation of new technologies for

a specific project, is included within the project's continuous process improvement activities.

7. RECORDS

Records generated from execution of the software engineering improvement plan are maintained within the responsible organization in accordance with associated Records Plans.

Although not a repository for formal records, the NASA Software PAL is located at http://swpal.nasa.gov/ and provides a means for sharing of assets among NASA centers. The MSFC web-based PAL is located at http://spi.msfc.nasa.gov/. This site contains or references software processes, documentation, best practices, policies, standards, guidelines and other software resource information.