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MSFC-PLAN-3204
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George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

EI32

MULTIPROGRAM/PROJECT COMMON-USE DOCUMENT

MARSHALL SPACE FLIGHT CENTER SOFTWARE ENGINEERING IMPROVEMENT PLAN

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DOCUMENT HISTORY LOG

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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 how MSFC supports the National Aeronautics and Space Administration (NASA) Software Engineering Initiative Implementation Plan. In compliance with the NASA Software Policies NPD 2820.1, 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 our level of maturity against the Software Engineering Institute's Capability Maturity Model/ Capability Maturity Model-Integrated (CMM/CMMI).

In accordance with MWI 7120.4, this document adheres to the mandatory template for a Multiprogram/Project Common-Use 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, both in terms of planning and implementation. 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.

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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 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. Provision of a common foundation and infrastructure for software process improvement across or within software development organizations.

e. Review of existing technologies for incorporation into existing software process and products.

f. Identification and conduct of research in software process and product improvement techniques and methods.

g. Support of the Employee and Organizational Development Department training process to annually prioritize software training needs.

h. Provision of a basis for employee career development planning.

1.2.2.3 Software Engineering

The Software Engineering Institute's Software CMM/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 to focus improvement activities include as appropriate:

a. Requirements Management
b. Software Project Planning
c. Software Project Tracking and Oversight
d. Supplier Agreement Management
e. Software Quality Assurance
f. Software Configuration Management
g. Risk Management
h. Measurement Analysis
i. Organization Process Focus
j. Organization Process Definition
k. Training
l. Integrated Software Management
m. Software Product Engineering
n. Intergroup Coordination
o. Peer Reviews.

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.

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    e. Inordinate focus on achieving specific CMM/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.

 g. Presented annual status to the NASA Software Working Group.

1.2.6. Primary Objectives in FY04/FY05

The following list is a set of objectives for FY04/05. A main objective for FY04/05 is to improve MSFC software acquisition practices and insight practices. Section 5 correlates the MSFC FY04/05 objectives and the associated products to the Strategy Areas of the NASA Software Engineering Initiative.

 a. Transition from Software CMM to CMMI for software as a guide for software improvement activities.

 b. For software development projects:
  (1) Determine deficiencies perceived by project management.
  (2) Determine strategy and set priorities to address software engineering deficiencies.

 c. Improve software acquisition practices.

 d. Improve software insight practices (technical monitoring of contractor-developed software).

 e. Support the development of Agency policy, standards, metrics, and guidebooks on NASA software.

 f. Update organizational documentation to maintain compliance with the NASA Software Policies and the Software Safety NASA Technical Standard.

 g. Develop and maintain a Process Asset Library to contain or reference software processes, documentation, best practices, policies, standards, guidelines and other software resource information.

 h. Improve MSFC software metric collection capabilities.

 i. Accommodate software research infusion into MSFC projects.

 j. Provide input to the Employee and Organizational Development Department training process to annually prioritize software training needs.

 k. Support NASA System Engineering improvement activities through coordination with the NASA System Engineering Working Group.

 l. Provide reports to the NASA Office of Chief Engineer and to the NASA Software Working Group.

 m. Revise MSFC-PLAN-3204 for FY06/07.

1.3 Scope

The scope of this plan applies to MSFC organizations responsible for developing, managing, and/or acquiring flight software and mission ground support software. The

application of software engineering improvement activities as measured against the CMM/CMMI to other categories of software, including institutional software, is determined by the responsible project.

1.3.1 Organizational Elements Involved

This plan applies to all MSFC organizations responsible for developing, managing, and/or acquiring flight software and mission ground support software for projects under NPR 7120.5.

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

As of FY03, the Flight Software Branch within the Instrument & Payload Systems Department of the Engineering Directorate has achieved a Software CMM Level 3 rating. Other organizations including the Mission Operations Laboratory are in the initial stages of process improvement based upon the Software CMM.

1.3.2 Criteria

It is MSFC's goal that organizations that develop flight software and mission ground support software show software improvement progress over time, as measured against CMM/CMMI Level 3.

2. APPLICABLE DOCUMENTS

a. MWI 7120.4, Documentation Preparation, Programs/Projects
b. NASA Software Engineering Initiative Implementation Plan
c. NASA-STD-1819.13, Software Safety NASA Technical Standard
d. NPD 2820.1, NASA Software Policies
e. NPR 7120.5, NASA Program and Project Management Processes and Requirements

3. DEFINITIONS/ACRONYMS

3.1 Definitions

The following definitions are applicable for this plan.

3.1.1 <u>Flight Software</u>

Flight Software is defined as software for flight spacecraft or payload applications.

3.1.2 **Mission Ground Support Software**

Mission Ground Support Software is defined as software that operates on the ground in preparation for, or in direct support of, space flight missions.

3.1.3 **Institutional Software**

Institutional software is defined as commercially available office automation software, financial software, and business software.

3.2 **Acronyms/Abbreviations**

CMM	Capability Maturity Model
CMMI	Capability Maturity Model-Integrated
CS	Civil Service
DRD	Data Requirements Description
EI32	Flight Software Branch
FTE	Full-time Equivalent
FY	Fiscal Year
G&A	General and Administrative
IV&V	Independent Verification and Validation
K	Thousands
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
POP	Program Operating Plan
RY	Real Year
SEPG	Software Engineering Process Group
V&V	Verification and Validation
WBS	Work Breakdown Structure
WYE	Work Year Equivalent

4. **OWNERSHIP**

The MSFC Software Initiative Project is the Center focal point for implementing and monitoring progress with respect to this plan.

This initiative is supported by the MSFC Software Working Group. The MSFC Software Working Group serves as the Center Software Engineering Process Group (SEPG) and is composed of representatives from the following MSFC Directorates and Offices:

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a. Office of Center Operations
b. Office of Human Capital
c. Engineering Directorate
d. Space Systems Programs/Projects Office
e. Shuttle Propulsion Office
f. Safety and Mission Assurance Directorate
g. Office of the Chief Financial Officer
h. Science and Technology Directorate
i. Space Transportation Programs/Projects Office
j. Systems Management Office.

This broad representation across Center organizations allows the plan to be effectively communicated and aligned with the appropriate Center organizations.

The chair of the MSFC Software Working Group serves as the Center Software Engineering Process Champion.

The Center Director or his designee(s) along with organizational line management provide the Management Support Group (MSG) function.

Additional SEPGs and MSGs exist for software engineering improvement activities managed at the branch or other organizational level.

5. STRATEGIES AND OBJECTIVES

This section correlates the MSFC FY04/05 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.	Flight Software Branch	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.
Use software CMM or CMMI as a benchmark to measure process improvement within applicable software development organizations. - Determine deficiencies perceived by project management. - Perform gap assessment of meeting CMMI Level 3 process areas - Determine strategy and set priorities to address software engineering deficiencies. - Build upon best practices and pilot solutions - Revise organizational approach as necessary.	MSFC Project Offices that have flight or mission ground support software development Line Organization that is responsible for the software development activity	Organizational Software Process Improvement Plan(s) Gap assessment of meeting CMMI process areas CMM/CMMI assessments Updated organizational work instructions
Improve software acquisition practices.	Flight Software Branchand 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).	Flight Software Branch	Updated organizational work instructions
Support the development of Agency policy, standards, requirements, and guidebooks on NASA software.	Flight Software Branch	Input to NPRs, NPDs, and NASA standards.
Update organizational documentation to maintain compliance with NASA software policies and requirements.	Flight Software Branch	Updated organizational work instructions
Develop/maintain a Process Asset Library.	Flight Software Branch	Process Asset Library to contain or reference software processes, documentation, best

		practices, policies, standards, guidelines and other software resource information

Table II Software Metrics

Initiative	Responsibility	Metric/Product
Support NASA agency software metric activities.	Flight Software Branch	MSFC software survey data which served as agency pilot; input to agency software metric guidelines/requirements
Improve MSFC software metric collection capabilities	Flight Software Branch	Revised organizational work instruction; monthly project and organizational software metrics
Recommend a core set of software metrics for flight or mission ground support projects, as appropriate.	Flight Software Branch	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.	Safety and Mission Assurance Directorate, System Management Office, Flight Software Branch	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.	Safety and Mission Assurance Directorate	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.	Safety and Mission Assurance Directorate; Flight Software Branch	Updated organizational work instructions

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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
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.

Table V Professional Development for the MSFC Software Staff

Initiative	Responsibility	Metric/Product
Support the Employee and Organizational Development Department training process to annually prioritize training needs.	MSFC software development 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 representative to the NASA Software Working Group	Training needs input to NASA headquarters

6. SCHEDULE

The following schedule applies to objectives for FY04/05:

On-going	Support the development of Agency policy, standards, metrics, and guidebooks on NASA software
On-going	Software research infusion
On-going	Improvements in MSFC software metrics
Q4 FY04	Improve MSFC software acquisition practices and insight practices. Provide software DRDs to the Marshall Data Requirements Management System. Generate a software statement of work template.
Q4 FY04	Provide Software Engineering Training (Plan in place for FY04; Q4 FY04 for FY05 plan)
Q4 FY04	Determine software engineering deficiencies perceived by project management
Q2 FY05	Determine strategy and set priorities to address software engineering deficiencies
Q2FY05	Update center documentation to maintain compliance with the NASA Software Policies and the Software Safety NASA Technical Standard
Q1 FY05	Develop and maintain a Process Asset Library to contain or reference software processes, documentation, best practices, policies, standards, guidelines and other software resource information
Q4 FY05	Gap assessment between CMM and CMMI; CMMI Level 3 assessment
Q1 FY05	Support NASA System Engineering improvement activities through coordination with the NASA System Engineering Working Group
Quarterly or as required	Reports to the NASA Office of Chief Engineer and to the NASA Software Working Group
Q4 FY05	Revise MSFC-PLAN-3204 for FY06/07

6.1 Resources

Table VI summarizes the manpower requirements for this plan and includes the MSFC full cost resource requirements as defined in the MSFC POP.

Procurement cost through FY10 reflects planning guidelines provided by the NASA Office of Chief Engineer.

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

FTE's identified in this plan are 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.

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Table VI MSFC Software Engineering Improvement Plan Resources

WBS 62-103-06-30	FY04	FY05	FY06	FY07	FY08	FY09	FY10	TOTAL
POP-04 Estimate, RY $K	**$1,095**	**$1,311**	**$1,217**	**$1,251**	**$1,076**	**$1,140**	**$1,176**	**$8,267**
Personnel	286	323	334	349	243	251	264	**$2,051**
Travel	19	20	20	20	20	20	20	**$139**
Procurement	381	400	400	400	400	400	400	**$2,781**
Center G&A	257	247	290	303	269	314	330	**$2,010**
Service Pool	153	321	172	179	143	155	163	**$1,286**
Workforce								
Direct CS FTEs	3	3	3	3	2	2	2	
On-Site Direct Contractor WYEs	2	2	2	2	2	2	2	
Center G&A CS FTEs	0	0	0	0	0	0	0	
On-Site Center G&A Contractor WYEs	1	1	1	1	1	1	1	
Service Pool CS FTEs	0	0	0	0	0	0	0	
On-Site Service Pool Contractor WYEs	0	0	0	0	0	0	0	

7. RECORDS

None

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