



Centerwide System Level Procedure

ISO 9001 - ARC Research Center

Document #:

53.ARC.0004.1

Rev.:

3

Title:

Project Management for the Design, Development, and Maintenance of Software

Page #:

1 of 17

REVISION HISTORY

REV	Description of Change	Author	Effective Date
0	Initial Release	D. Tweten	7/17/98
1	Clarifications based on 7/98 DNV Audit and 6/98 Internal Audit (see DCR 98-028). Major rewrite.	M. Hines	9/25/98
2	Administrative change (DCR 98-057)	R. Serrano	12/18/98
3	Section 6.3.11 delete "Problems requiring corrective action shall be documented in accordance with 53.ARC.0014. For guidance with this requirement see 53.ARC.0004.1.1, Appendix B." Reference Documents add last digits for clarification: NASA-STD-2100-91, NPG 2210.1 (DCR 99-009)	W. Henry	5/18/99

REFERENCE DOCUMENTS

Document Number	Document Title
AHB 5333.1	Ames Handbook: Establishment of Software Assurance Programs
NASA-STD-2100-91	NASA Software Documentation Standard
NPG 2210.1	NASA Procedures and Guidelines: External Release of NASA Software
53.ARC.0000	Ames Research Center Quality Manual, Section 4.4
53.ARC.0003	Acceptance and Amendment of Customer Agreements
53.ARC.0004.1.1	Guidelines for Implementing 53.ARC.0004.1
53.ARC.0004.2	Design and Development of Systems and Hardware
53.ARC.0004.3	Configuration Management
53.ARC.0006	Purchasing
53.ARC.0007	Management of Customer-Supplied Material and Supplies
53.ARC.0009.2	Management and Performance of Research
53.ARC.0009.4	Program and Project Management
53.ARC.0014	Corrective and Preventive Action
53.ARC.0016	Quality Records
53.ARC.0019	Servicing

	Centerwide System Level Procedure ISO 9001 - ARC Research Center	Document #:	Rev.:
		53.ARC.0004.1	3
Title: Project Management for the Design, Development, and Maintenance of Software		Page #: 2 of 17	

Documents referenced in this procedure are applicable to the extent specified herein.

1. Purpose

The purpose of this procedure is to describe the process by which Ames Research Center (ARC) performs project management for the design, development, and maintenance of software.

2. Scope

This procedure applies to ARC organizations whose processes directly affect software products delivered to customers. Note that firmware is both hardware and software. To the extent that it is hardware, it is covered in 53.ARC.0004.2. To the extent that it is software, it is covered in this document. Software produced in support of research, or as part of the research, but not in and of itself a unique deliverable to the customer does not have to be designed and developed in accordance with this procedure. See 53.ARC.0009.2 for requirements governing research software.

The requirement of this procedure may be tailored as appropriate based upon the customer agreement and size, complexity, and cost of a particular design/development effort. Any decision to simplify or modify any of the process steps must be documented and approved in the software project plan. Approved software project plans become the baseline requirements for the software project.

3. Definitions and Acronyms

- | | | |
|-----|----------------------|---|
| 3.1 | Big Bang | Non-structured software development approach in which requirements collection, design, coding, and testing are all done simultaneously |
| 3.2 | Customer | Any organization or individual that enters into a formal agreement with ARC for delivery of ARC products or services |
| 3.3 | Development | All activities to be carried out to create a software product |
| 3.4 | Firmware | Hardware that contains a computer program and data that cannot be changed in its user environment. The computer programs and data contained in the firmware are classified as software. The circuitry containing the computer program and data is classified as hardware. |
| 3.5 | High Risk Software | Software for which in-use failure would directly produce significant risk of death or injury or significant risk of property damage (such as mission loss) more costly than the development of the software itself |
| 3.6 | Low Risk Software | Software for which in-use failure will be difficult to repair or risks significant lost user time or computer time |
| 3.7 | Medium Risk Software | Software for which in-use failure risks significant property damage (such as mission degradation) or significant negative impact to NASA |



Centerwide System Level Procedure

ISO 9001 - ARC Research Center

Document #:

53.ARC.0004.1

Rev.:

3

Title:

Project Management for the Design, Development, and Maintenance of Software

Page #:

3 of 17

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|------|--------------------------|--|
| 3.8 | Negligible Risk Software | Software for which in-use failure risks only minor lost user time or computer time |
| 3.9 | Phase | Defined segment of work |
| 3.10 | Project | Significant activities designated by a Program and characterized as having defined goals, objectives, requirements, Life Cycle Costs, a beginning, and an end |
| 3.11 | Responsible Manager | Person having the responsibility and authority to accomplish/implement a specific activity or process (includes organizational line managers, project managers, etc.) |
| 3.12 | Software | Intellectual creation comprising the programs, procedures, rules, and any associated documentation pertaining to the operation of a computer system. Software exists independent of any medium on which it may reside. |
| 3.13 | Software Assurance | Planned and systematic set of activities that ensure that software processes and products conform to requirements, standards, and procedures. It includes the disciplines of Quality Assurance, Quality Engineering, Verification and Validation, Nonconformance Reporting and Corrective Action, Safety Assurance, and Security Assurance and their applications during a software life cycle |
| 3.14 | Software Life Cycle | Complete, and perhaps repeating, sequence of requirement determination, design, implementation, test, installation, and maintenance of software |
| 3.15 | Software Product | Complete set of computer programs, procedures, and associated documentation and data designated for delivery to a user |
| 3.16 | Software Project Manager | Individual responsible for the administration and technical direction of a software project. Responsibilities typically include planning, organizing, directing, controlling, and managing the software project. |
| 3.17 | Software Project Plan | Document that describes the technical and managerial approach to be followed for a period. The plan typically describes the work to be done, the resources required, the methods to be used, the procedures to be followed, the schedules to be met, and the way the software project is organized. (See NASA-STD-2100 for further details.) |



Centerwide System Level Procedure

ISO 9001 - ARC Research Center

Document #:

53.ARC.0004.1

Rev.:

3

Title:

Project Management for the Design, Development, and Maintenance of Software

Page #:

4 of 17

- 3.18 User Reference Document that explains, in detail, how to use the software. It explains the software's behaviors. Its intended audience is an experienced user of the software.
- 3.19 Validation Process of evaluating software to assure that "the right product has been built." That is, to assure that it meets its functional and performance requirements.
- 3.20 Verification Process that assures that the software has "been built right." That is, to assure that each intermediate product during the life cycle meets its specific requirements.



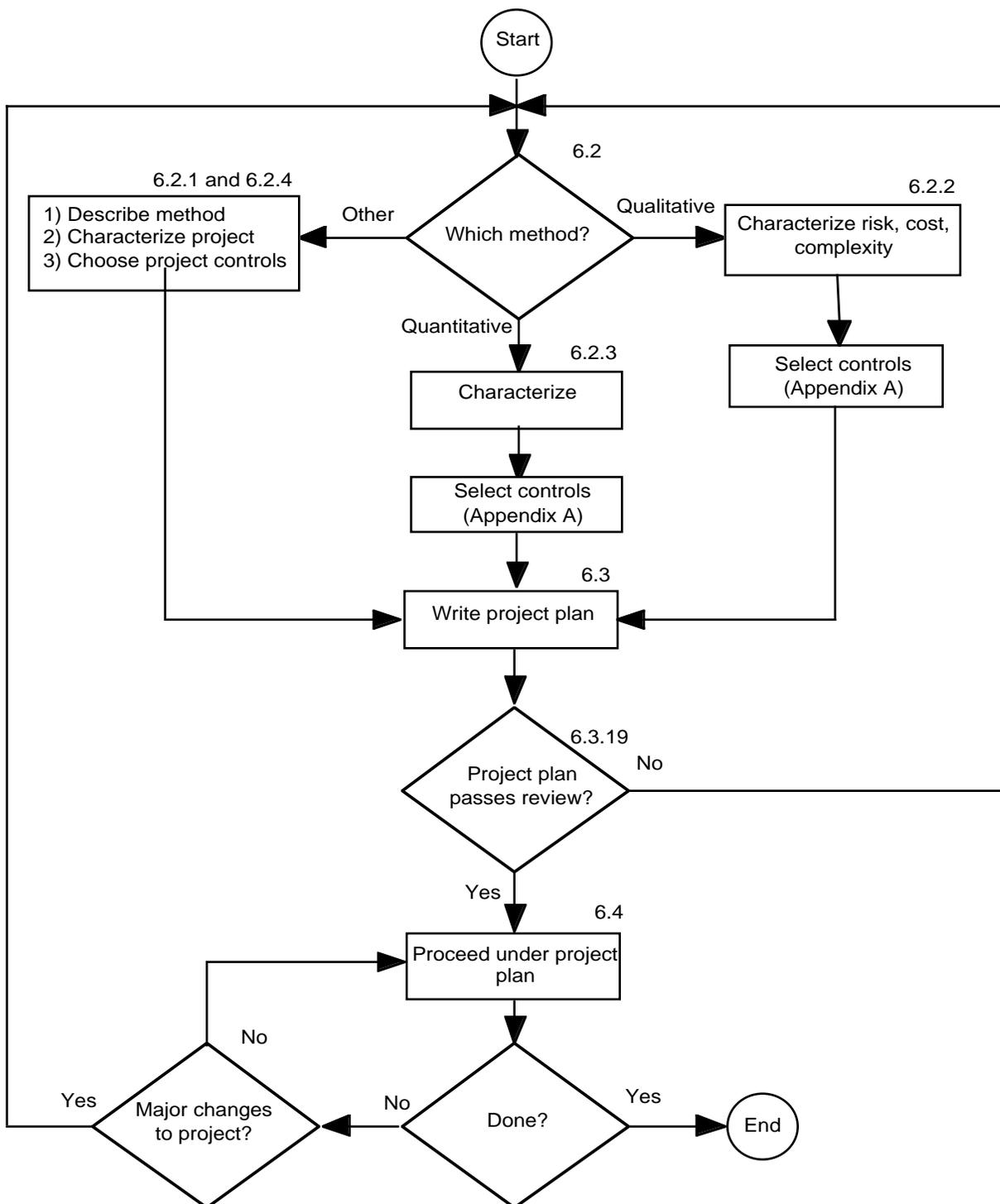
Title:

Project Management for the Design, Development, and Maintenance of Software

Page #:

5 of 17

4. Flowchart





Title:

Project Management for the Design, Development, and Maintenance of Software

Page #:

6 of 17

5. Responsibilities

- 5.1 **Responsible Manager** shall:
- appoint software project manager, and
 - approve the software project plan, as appropriate.
- 5.2 **Software Project Manager** shall:
- perform customer coordination,
 - gather, document, and update the requirements,
 - develop and maintain the software project plan,
 - monitor and report on software project status,
 - coordinate the necessary reviews,
 - manage design and development,
 - delegate authority as appropriate, and
 - authorize transition between software life cycle phases.

6. Procedure

- 6.1 Software Project Formulation
- 6.1.1 In all cases when a program/project includes the design and development of software, the responsible ARC organization shall assign a software project manager. If the software project is a Level 2 or Level 3 software project per 53.ARC.0009.4, then the Program Manager shall approve the appointment of the software project manager and the software project plan. A software project may be a software project in its own right or a sub-project of a parent project. When software projects are projects in their own right, sections 6.2 through 6.4 of this procedure shall apply. See 53.ARC.0004.1.1 for further information.
- The software project manager shall determine the level of control and documentation required to meet the needs of the software project. Appendix A contains a suggested checklist for software planning
- 6.1.2 The software planning process commences when a customer makes an inquiry or an invitation to bid for work, which includes the development of software by ARC. When software is identified as being an element of the software project, section 6.3 of this procedure is used to supplement 53.ARC.0009.4 and will be followed to create a software project plan for the software element or elements.
- 6.1.3 The Responsible Manager or the Program/Project Manager shall perform a review of the customer agreement (in accordance with 53.ARC.0003) to ensure that:
- software project requirements are identified,
 - ARC responsibility for subcontracted work is defined,
 - ARC has the capability to meet the customers requirements,
 - intellectual property rights are protected,
 - a problem resolution mechanism is specified, and
 - the terminology and acceptance criteria used are understood by both parties.
- 6.2 Software Project Characterizations



Centerwide System Level Procedure

ISO 9001 - ARC Research Center

Document #:

53.ARC.0004.1

Rev.:

3

Title:

Project Management for the Design, Development, and Maintenance of Software

Page #:

7 of 17

- 6.2.1 The software project manager shall characterize the software project in terms of cost, risk, and complexity and choose appropriate software project controls. The characterization and appropriate software project controls will be recorded in the software project plan. The software project manager may use one of the two methods (Qualitative or Quantitative) explained in sections 6.2.2 and 6.2.3 of this procedure. If a method other than the Qualitative or the Quantitative method is used, the reasons for that choice shall be documented and justified in the software project plan. The method used and the set of software project controls chosen as a result will be documented in the software project plan.
- 6.2.2 When using the Qualitative Method, the software project manager will estimate the software project's characteristic risks, cost, and complexity using Tables 1, 2, and 3.

Table 1: Software Project Risk Classifications	
Classification	Characteristics
High Risk	In-use software failure would directly produce significant risk of death or injury or significant risk of property damage (such as mission loss) more costly than the development of the software itself.
Medium Risk	In-use software failure risks significant property damage (such as mission degradation) or significant negative impact upon NASA.
Low Risk	In-use software failure risks significant lost user time or computer time, or the software will be difficult to repair.
Negligible Risk	In-use software failure risks only minor lost user time or computer time. The source code will be available to its users. The software will be used mainly by developer(s).

Table 2: Software Project Cost Classifications	
Classification	Characteristics
Extremely High Cost	The software project budget requires higher than Center Director approval.
Very High Cost	The software project budget requires Center Director approval.
High Cost	The software project budget requires Directorate approval.
Medium Cost	The software project budget requires Division Chief approval.
Low Cost	The software project budget requires approval by a responsible manager below Division Chief.
Very Low Cost	The software project budget can be approved by the software project manager.

Table 3: Organizational Complexity Classifications	
Classification	Characteristics
Very Complex	The software project involves personnel from several organizations or personnel at several locations.
Complex	The software project involves personnel from no more than two organizations at no more than two locations.
Simple	The software project involves only a single organization at a single location.

- 6.2.3 When using the Quantitative Method, the software project manager will estimate the characteristic risks of the software project using the Software Project Risk Assessment Form (see Appendix B). The software characterization should be independent of any parent software project characterization. The Software Project Risk Assessment Form yields a



Title:

Project Management for the Design, Development, and Maintenance of Software

Page #:

8 of 17

software project risk score that is used to determine the software category as shown in Table 4. The completed Software Project Risk Assessment Form will be attached to the software project plan.

Table 4: Software Category

Software Project Risk Score	Software Project Category
Less than 41	Negligible Risk (very small software project)
42 – 100	Low Risk (small software project)
101 – 154	Medium Risk (medium software project)
Greater than 154	High Risk (large software project)

6.2.4 Based on the results of the Qualitative or Quantitative method, the software project manager will select the most appropriate level of control which may be a different level of control (e.g., different from the parent project) by recording justification in the software project plan and obtaining customer agreement. The types and extent of software project controls will be documented in the software project (guidance on suggested levels of control can be found in 53.ARC.0004.1.1, Appendix A).

6.2.5 The results of software project characterization and production of the software project plan (see 6.3) shall result in defining how:

- Design-input requirements are identified, documented, and reviewed for adequacy,
- Incomplete, ambiguous, or conflicting requirements are resolved,
- Design outputs are documented and verified against design-input requirements,
- Design-output documents shall be reviewed and approved before release,
- Design verification shall be performed and documented (in accordance with 53.ARC.0016), and
- Design validation shall be performed to ensure the software product meets customer requirements.

6.3 Software Project Planning

The software project manager shall produce a software project plan that contains all management and quality planning information for the software project. Quality planning includes the identification and acquisition of any controls, processes, equipment, resources, and skills that may be needed to achieve the required quality of deliverable software. The software project manager shall use ARC Quality System processes (e.g., procedures and work instructions) in the design, development, replication, and delivery of software products.

6.3.1 The software project plan will be a controlled in accordance with 53.ARC.0004.3. The software project plan may be a complete plan or a section within a higher level plan (i.e., project/program plan).

6.3.2 The software project plan shall define the organizational and technical interfaces between groups that provide inputs into the design process.

6.3.3 The software project plan shall also describe the software project objectives and deliverables, describe the approach to the software development, identify the individuals responsible for each role (such as software developer, software assurance, software librarian), describe the



outputs to be produced, detail the specific design review and design verification quality records to be kept, and reference the procedures to be followed. The plan shall require that identified Quality Records be controlled in accordance with 53. ARC.00016.

- 6.3.4 The software project manager shall define how the requirements for quality will be met. This quality planning shall be consistent with all other program/project constraints and AHB 5333.1. The results of this planning shall be documented in the software project plan.
- 6.3.5 The software project manager shall identify and plan the design, development, replication, delivery, and servicing (per customer agreements) processes that directly affect quality. The software project plan will describe how these processes will be carried out under controlled conditions.
- 6.3.6 Based upon the software project's development approach, risk, cost, and complexity, the software project manager shall choose the appropriate approaches, methods, techniques, tools, etc. for each of the items addressed in sections 6.3.8 through 6.3.19 of this procedure. These choices will be recorded in the software project plan. Additionally, the software project plan will state the criteria for software project closure and the planned manner of software project closure. The approved software project plan establishes the baseline requirements for the software project.
- 6.3.7 The software project manager will baseline the software project, make available the authorized software project plan to all members of the development effort, and issue detailed plans and tasks to individuals as appropriate.
- 6.3.8 Development Approach
 - 6.3.8.1 The software project manager shall choose the most appropriate life cycle model, techniques, tools, and methods. The life cycle model, techniques, and methods may be modified during the life of the software project, and modifications will be incorporated into a new issue of the software project plan. Life cycle models include Rapid Prototyping, Single-Release Life Cycle, Multiple-Release Life Cycle, and Big Bang. Each model is appropriate for certain software projects. For further guidance see 53.ARC.0004.1.1.
 - 6.3.8.2 These are not the only possible development approaches. The approach chosen by the software project manager shall be explained in the software project plan.
- 6.3.9 Documentation
 - 6.3.9.1 Software project documentation shall include at least a software project plan, a Requirements Document, a User Reference, a Design Document, and a Test Plan. In addition, the software



project manager will choose an appropriate level of documentation. Guidance on this can be found in 53.ARC.0004.1.1. The choice will be described and justified in the software project plan. Other approaches and plans that should be considered include:

- configuration management and change control,
- verification and validation (including reviews),
- software assurance (including reviews of all phase products), and
- software audits.

6.3.9.2 Any software project plan section may consist of a reference to a separate document. For purposes of review, approval, and configuration control, the main software project plan and all such referenced documents will be treated as a single document.

6.3.9.3 The software project manager will select the procedures and local control documents (such as coding standards, change control procedures, etc.) to be followed by the software project.

6.3.9.4 After the initial approval and release of the software project documentation, successive issues shall be managed in accordance with 53.ARC.0004.3.

6.3.10 Software Configuration Control

The software project manager shall choose appropriate methods of configuration control. Software Configuration Management shall be performed per 53.ARC.0004.3. For guidance with this requirement see 53.ARC.0004.1.1.

6.3.11 Change Request Tracking

The software project manager will choose appropriate methods of problem and change request tracking. The methods of problem and change request tracking will be described in the software project plan.

6.3.12 Software Project Metrics

The software project manager will choose an appropriate set of metrics. For guidance with this requirement see 53.ARC.0004.1.1. The choice will be described in the software project plan.

6.3.13 Software Reuse

All re-used software will meet the same requirements as software original to the software project. If necessary, appropriate software project controls will be applied retroactively.

6.3.14 Field-testing

When the software is to be tested under field conditions, the software project manager shall record in the Test Plan how field-testing is to be carried out. The plan should address the specific features to be tested, the responsibilities for evaluating the test, problem reporting, and resolution, and the restoration of the user's environment after test.

	<p align="center">Centerwide System Level Procedure ISO 9001 - ARC Research Center</p>	<p>Document #: 53.ARC.0004.1</p>	<p>Rev.: 3</p>
<p>Title: Project Management for the Design, Development, and Maintenance of Software</p>		<p>Page #: 11 of 17</p>	

6.3.15 Replication, Delivery, and Installation

For software that is to be delivered to the customer, the software project manager shall document in the software project plan the mechanisms for replication, delivery, and installation. The plan should address or describe:

- the number of copies, including the type, format, and version of media to be delivered,
- the documentation to be delivered,
- copyright and licensing agreements,
- custody of the master and backup copies,
- the period of obligation of ARC to supply copies of the software,
- the method of verifying the correctness and completeness of delivered software copies, and
- the roles, responsibilities, and obligations of ARC and purchaser, including the installation schedule, access to purchaser's facilities, personnel and equipment, and validation and authorization of installation.

6.3.16 Sustaining Engineering (i.e., maintenance or servicing of software)

When required by customer agreement, servicing shall be performed in accordance with 53.ARC.0019 and documented in the software project plan. This documentation will include addressing the duration, responsibilities, organization, and controls used to deliver the service to the customer. This section should include a description of how the following are to be managed:

- problem resolution, interface modifications, and functional changes,
- problem status records,
- identification of organizations responsible for problem resolution,
- priorities for corrective actions,
- change implementation, impact analysis, regression testing, and change recording,
- the mechanism and timing for releasing changes,
- the methods by which changes are confirmed by the user,
- provisions for technical and telephone support, and
- backup, restoration, and recovery arrangements.

6.3.17 Software Purchasing

The software project manager shall determine whether the software project involves acquisition of development services software. On Medium Risk or High Risk software projects, for software developed under contract (i.e., procured per 53.ARC.0006), the software project plan will address:

- criteria and methods of selection,
- performance assessment of suppliers,
- schedule for joint reviews with suppliers,
- methods for review of the status of deliverables,
- verification and validation requirements,
- how products are tested for fitness of purpose,
- how nonconformances will be handled, and
- how acceptance is to be achieved.



Centerwide System Level Procedure

ISO 9001 - ARC Research Center

Document #: **53.ARC.0004.1**

Rev.: **3**

Title:

Project Management for the Design, Development, and Maintenance of Software

Page #:

12 of 17

6.3.18 Release of NASA Software

The software project manager shall release software in accordance with NPG 2210 and requirements in customer agreements. The manner in which software is to be released for use will be documented in the software project plan.

6.3.19 Reviews

The software project plan shall specify an appropriate sequence of reviews. There will be a software project plan review. This review will be completed and result in a software project plan approved by the Responsible Manager prior to the start of the software project. In addition, a requirements review must be completed and approved by the customer prior to the start of design or coding. The software project manager shall ensure that the appropriate functions or organizations are invited to the review. Results of these reviews will be documented and maintained as Quality Records per 53.ARC.0016. For guidance with this requirement see 53.ARC.0004.1.1.

6.3.20 Customer-Supplied Product

If customer-supplied software is to be incorporated into the deliverable software, then the software project plan shall address how this software is to be controlled in accordance with 53.ARC.0007.

6.4 Software Project Execution

6.4.1 This phase starts with the allocation of the software project tasks and proceeds to the achievement of software project deliverables accepted by the customer. This phase shall be executed in accordance with the software project plan.

6.4.2 The software project plan will be periodically reviewed by the software project manager and revised and re-issued as necessary. Sections 6.1 through 6.3 of this procedure shall be reiterated in order to revise and update the software project plan.

6.4.3 For Medium Risk and High Risk software projects, metrics will be collected and reported at the end of each defined life cycle phase or every six months, whichever comes first. Guidance on suitable metrics can be found in 53.ARC.0004.1.1, Appendix B.

7. Metrics

There are no metrics required for this document.

8. Quality Records

The following Quality Records shall be generated and managed in accordance with 53.ARC.0016.

Required Record	Custodian
Design Review (includes list of attendees, items reviewed and	Software Project Manager



Centerwide System Level Procedure

ISO 9001 - ARC Research Center

Document #:

53.ARC.0004.1

Rev.:

3

Title:

Project Management for the Design, Development, and Maintenance of Software

Page #:

13 of 17

approved, and action items)	
Design Verification (includes inspection or test results, or test reports, or project memo)	Software Project Manager

9. Form(s)

Forms required for this document:

Form Number	Title
(see Appendix B)	Software Project Risk Assessment



Centerwide System Level Procedure

ISO 9001 - ARC Research Center

Document #:

53.ARC.0004.1

Rev.:

3

Title:

Project Management for the Design, Development, and Maintenance of Software

Page #:

14 of 17

Appendix A: Software Planning Checklist

The following checklist is a quick reference to planning and writing the software project plan. The step numbers in the first column are sections in this document.

Step	Action	Reference, Procedure, or Comments
6.1	Customer requests software Perform contract review	53.ARC.0003
6.2	Software project manager characterizes the software project via Qualitative Method or Quantitative Method Software project manager selects the most appropriate level of control (Negligible, Low, Medium, or High Risk)	Appendix B Tables 1–4
6.3	Software project manager evaluates software project objectives and deliverables	
6.3.3	Software project manager develops a software project plan Write, review, and authorize the software project plan	Establish as appropriate: <ul style="list-style-type: none"> • work breakdown structure • schedule • documentation (6.3.9) • software project deliverables • software project monitoring process • method for handling complaints • problem and change request tracking (6.3.11) • metrics (6.3.12) Distribute approved plan to software project members
6.3.8	Determine the life cycle phases, the development approach, and the software development technical procedures	Configuration control (6.3.10) Verification, validation, and test AHB 5333.1 Methods and tools Technical procedures
6.3.15	Replication, delivery, and installation	
6.3.16	Sustaining Engineering	Determine the need for support or servicing of software after delivery. Develop Software Maintenance Plan if required.
6.3.17	Software Purchasing: determine the purchasing requirement(s) and management of suppliers	53.ARC.0006
6.3.18	Software Release: determine the requirements for releasing software project software to customers outside of NASA	NPG 2210
6.3.19	Software Reviews: determine the appropriate sequence of independent reviews	AHB 5333.1
6.4	Execute and deliver against the plan Review and re-issue plan as appropriate	



Centerwide System Level Procedure

ISO 9001 - ARC Research Center

Document #:

53.ARC.0004.1

Rev.:

3

Title:

Project Management for the Design, Development, and Maintenance of Software

Page #:

15 of 17

Appendix B: Software Project Risk Assessment Form

FACTORS	RISK ASSESSMENT FOR					WEIGHTING FACTOR		SIZE SCORE (AXB)
	SOFTWARE PROJECT:					A**	B	
	1	2	4	8	16			
<i>Resources – Total software project cost in 1998 dollars</i>	Less than \$50k	\$ 50K to \$100K	\$100K to \$500K	\$500K to \$1000K	More than \$1000k		x 3	
Software project team membership	Up to 2 people, all ARC	Up to 5 people, all ARC	Up to 10 all ARC or with external support	Up to 20 all ARC or with external support	More than 20 all ARC or with external support		x 2	
External Contractors	None	New supplier, tightly defined contracts	Suppliers with some development work	Suppliers with major development work	Suppliers with development work critical to software project success		x 2	
<i>Organizational Complexity – Software Project Diversity</i>	ARC Center only	ARC and another NASA center	ARC and 2 or more NASA centers	ARC and another gov't agency	ARC and another gov't agency		x 1	
Software Project Schedule	No time pressure	Easy calendar deadlines	Difficult calendar deadlines	"Time is of the essence"	N/A		x 2	
Software Project Location	One site	Up to three sites	More than three sites	N/A	N/A		x 2	
Staff Competence	Fully qualified team		Half of the team qualified		Experienced staff not available		x 2	
<i>Technical Complexity - Test Risk</i>	No product test		Standard tests		Major risk of test failure		x 3	

**Value is either 1, 2, 4, 8, or 16 depending upon the risk associated with the software project



Centerwide System Level Procedure

ISO 9001 - ARC Research Center

Document #: **53.ARC.0004.1**

Rev.: **3**

Title: **Project Management for the Design, Development, and Maintenance of Software**

Page #: **16 of 17**

Appendix B: Software Project Risk Assessment Form continued

FACTORS	RISK ASSESSMENT FOR SOFTWARE PROJECT:					WEIGHTING FACTOR		SIZE SCORE (AXB)
	1	2	4	8	16	A**	B	
	Degree of innovation	Well proven		Proven but new to ARC		Pioneering		
Interdependencies of deliverables	Simple stand-alone			Highly integrated	Not available		x 2	
Requirements clarity	Clear objectives, no unknowns	Clear objectives and check points, few unknowns		Preliminary objectives with well-defined check points	Fast tracking on preliminary objectives		x 2	
Size of program	Less than 50K LOC		50K to 500K LOC		Greater than 500K LOC		x 2	
<i>Impact of failure - Human risk*</i>	Minor injury		Severe injury		Death or disability		x 3	
Visibility	ARC only		NASA		World wide		x 1	
* Note: If there is no human risk, then a value of zero (0) is used here.						Software Project Risk Score:		

** Value is either 1, 2, 4, 8, or 16 depending upon the risk associated with the software project