Quality Assurance Plan for the

SCALE Computational System

Prepared by

S. M. Bowman

Nuclear Systems Analysis, Design, and Safety (NSADS)
Nuclear Science and Technology Division (NSTD)
Oak Ridge National Laboratory

Date Revised: March 30, 2007

Approvals:

SCALE Project Leader	**Date**
TI Leader, Nuclear Systems Analysis, Design, and Safety	**Date**
Quality Program Manager, NSTD	**Date**

INTRODUCTION

Since 1970 Oak Ridge National Laboratory (ORNL) has been funded to provide the Nuclear Regulatory Commission (NRC) with programming and technical assistance in the analysis of nuclear fuel facility and package (cask) designs. Beginning in 1976, the NRC Office of Nuclear Material Safety and Safeguards (NMSS) began an effort in cooperation with the NRC Office of Research (RES) to fund ORNL to develop an easy-to-use computational system known as SCALE (**S**tandardized **C**omputer **A**nalyses for **L**icensing **E**valuation) that would provide a needed tool for evaluating criticality, shielding, and thermal aspects of nuclear fuel facility and/or spent fuel cask designs. Since inception the system has been expanded to include reactor lattice physics and source terms (radiation spectra, decay heat, nuclide generation/decay, etc.), while the thermal portion of the system has been removed.

The maintenance and development of SCALE is also cosponsored by the Department of Energy (DOE) Packaging Certification Program (PCP) and the DOE Nuclear Criticality Safety Program (NCSP). SCALE has become an increasingly popular computational system and is used around the world in nations with nuclear energy programs. The code system is used by government regulatory agencies and contractors, national laboratories, utilities, nuclear fuel vendors, spent fuel storage and transportation cask vendors, and universities.

SCALE has matured into a modular computational system consisting of easy-to-use control modules that automate standardized analytic sequences capable of performing criticality, source terms, shielding, and reactor physics analyses. The control modules read the user input and generate input files for and call functional modules that actually solve the problems. Standardization is further enhanced by the incorporation of validated data libraries (e.g., material compositions, cross sections, and other nuclear data) which allow easy input (via keywords) and data accessibility.

In July 1980, the initial version of SCALE was made available to the Radiation Safety Information Computational Center (RSICC) at ORNL. This system was packaged and released by RSICC as CCC-288/SCALE 0. Subsequent additions and modifications resulted in the following releases: CCC-424/SCALE 1 in 1981; CCC-450/SCALE 2 in 1983; CCC-466/SCALE 3 in 1985; CCC-545/SCALE 4.0 in 1990; SCALE 4.1 in 1992; SCALE 4.2 in 1994; SCALE 4.3 in 1995; SCALE 4.4 in 1998; SCALE 4.4a in 2000; and CCC-725/SCALE 5 in 2004; and CCC-732/SCALE 5.1 in 2006.

With the release of SCALE 4.0 in 1990, a Quality Assurance (QA) Plan and a Configuration Management Plan were developed and implemented. A verification and validation (V&V) plan was added in 1995. The configuration controlled version of SCALE is maintained and controlled in accordance with these plans by the SCALE staff at ORNL. Newly developed modules and approved revisions or corrections to existing modules are subsequently released to RSICC in updated public versions of the software system. With each release to RSICC, updated documentation is provided as revisions to the SCALE Manual. The documentation 1) describes the problem theory and numerical techniques for solving the problem, 2) provides a discussion on the range of applicability, 3) presents the general program flow, and 4) provides a thorough user input guide and sample problem set.

Throughout the history of the SCALE project there has been a commitment to generate software that is reliable, accurate, and easy to use. Testing and validation have been performed for various modules and data libraries and documented in published reports that are available on the SCALE website. **However, users should independently submit the software to their own testing program prior to use, in accordance with their site or program requirements.**

QUALITY POLICY

In keeping with the UT-Battelle quality policy, as stated in the ORNL Quality Assurance Program Description, the SCALE project team has a goal of providing reliable and defect-free quality products and services to its customers in a timely and cost-effective manner while committing to a continuous quality improvement process that promotes the achievement of excellence.

Recognizing that the responsibility and authority for attainment of quality reside with the line organization, each SCALE team member is responsible for providing work practices, goals, and employee interactions which promote an environment where communication is open, barriers to performance are identified and corrected, and a safer and more productive workplace exists. Each team member has the obligation and organizational freedom to identify and report to management any current or potential deficiency that may have a detrimental effect on quality, safety, cost, or schedule so that appropriate corrective action may be initiated.

SECTION 1 - PROGRAM

1.1 The SCALE QA Program is based on the applicable requirements of the reference sources listed in paragraph 1.2. QA standards, policies, and procedures which support the SCALE system are drawn from the ORNL Standards Based Management System (SBMS) Subject Areas.

The SCALE QA Plan provides specific guidance to all SCALE project staff as to which QA requirements must be met for SCALE operations, who is responsible for meeting those requirements, and how those requirements are to be accomplished. The functional responsibilities of key personnel are detailed in Attachment A of this document.

The scope of this QA Plan is limited to those activities which maintain the operational integrity of the SCALE configuration controlled version, and verification and validation activities which serve to qualify the SCALE system. This plan does not cover the development and maintenance of the graphical interfaces and visualization/plotting programs that are distributed with SCALE but are not part of the configuration controlled version. The plan does not address application of the system to specific customer requests; applications of SCALE fall under the specific quality requirements of each customer. This QA plan supercedes QAP-X-90-WMRD-029, R3.

SCALE users (e.g., when conducting safety and project analyses) are responsible for ensuring that the SCALE software is both applicable to and sufficient for their specific uses, and for implementation of any additional quality requirements mandated by their sponsors. This QA plan is intended only to ensure that:

- routine maintenance and further enhancement of the SCALE code system is performed in a controlled, documented, and traceable fashion;
- qualified personnel perform the SCALE system maintenance and enhancement;
- changes and enhancements are tested, documented, and implemented in accordance with established procedures;
- necessary verification and validation activities are performed; and
- public releases of the code to users are conducted in accordance with established procedures.

1.2 References:

1.2.1 10 CFR 830 Subpart A, *Quality Assurance Requirements*

1.2.2 ASME NQA-1-1994, *Quality Assurance Requirements for Nuclear Facility Applications, Part 1* (from former NQA-1)

1.2.3 ASME NQA-1-1994, *Quality Assurance Requirements for Nuclear Facility Applications, Part 2* (from former NQA-2) Subpart 2.7

1.2.4 SBMS Quality Assurance Program Description

1.3 The QA Program, as described in this QA Plan, uses a graded approach to apply QA requirements to work activities in order to match QA controls to items and activities consistent with their importance to the achievement of mission objectives: development of defect-free software that has validated performance.

To establish the UT-Battelle Quality Category, the SCALE system was evaluated in accordance with NSTD QA Project Classification guide and determined to be Category II. This category was selected because the activities performed under this QA Plan are limited to maintenance and enhancement of the SCALE code system, and do not apply to tasks performed by users of SCALE for specific sponsors. Category II requires that the activity is evaluated against 10 criteria of 10 CFR 830 Subpart A, *Quality Assurance Requirements*, and UT-Battelle and ORNL Standards Based Management System procedures and QA requirements. The resulting QA plan (this document) must then include those controls necessary to assure reliability and repeatability in SCALE work activities. The sections of this QA plan reflect the results of that evaluation and determination.

1.4 SCALE work activities are accessible (at reasonable times and under the coordination of the Project Leader) during normal working hours for purposes of audit, surveillance, inspection, or visit by authorized representatives of UT-Battelle or SCALE sponsors.

1.5 The Nuclear Systems Analysis, Design, and Safety (NSADS) Group within the Nuclear Science and Technology Division (NSTD) at ORNL provides the staff to support the SCALE computational system. The SCALE system is primarily supported by funding from both NRC and DOE projects, as well as other interim sponsors. This is reflected in the organization chart in Attachment B.

1.6 Quality Assurance (QA) support to SCALE is provided by the NSTD Quality Program Manager. When requested, QA activities are reported to sponsors by the SCALE Project Leader.

1.7 The staff responsibilities for SCALE are as follows:

1.7.1 **Project Leader.** The following responsibilities are delegated to the Project Leader:

- work with NSTD line supervision to prepare budgets, assure that adequate staffing is available, make work assignments, and assure that work is carried out on a timely schedule and within budget;
- review and approve QA and work plans and supporting SCALE procedures;
- report program status on a routine basis;
- authorize the SCALE system baseline;

- approve changes to the baseline; and
- assure the overall quality of the SCALE system.

The Project Leader has the authority and responsibility to request that work be stopped where quality or safety requirements are not being met, and to contact the appropriate level of management to obtain remedial actions to resolve problems. For subtasks within SCALE which have assigned task leaders, the Project Leader delegates authority to those task leaders as appropriate, while retaining responsibility for the SCALE system.

1.7.2 **Quality Program Manager.** The Quality Program Manager reports functionally to the NSTD Director and administratively to the NSTD Nuclear Research Support Group Leader. The Quality Program Manager supports the NSTD Director in assuring that an appropriate QA program is implemented for SCALE by:

- evaluating the SCALE project with the Project Leader to determine applicable QA requirements,
- assisting the Project Leader in preparing a QA Plan which identifies quality assurance controls appropriate to the work,
- approving the QA Plan and revisions thereto,
- interfacing with other ORNL divisions and UT-Battelle organizations on quality-related matters, and
- conducting surveillance on behalf of the NSTD Director to verify compliance with established requirements.

The Quality Program Manager has the authority, independence, and organizational freedom to identify quality-related problems, initiate and evaluate solutions to those problems, and to verify implementation of solutions. The Quality Program Manager has the authority and responsibility to request that work be stopped where quality requirements are not being met, and to contact the appropriate level of management to obtain remedial actions to resolve quality problems. The Quality Program Manager reports at the same organizational level as the highest line manager directly responsible for performing quality-related activities. This structure avoids any compromise of quality due to requirements such as cost and schedule.

1.7.3 **Support Staff.** The support staff includes the Software Quality Assurance (SQA) Coordinator, Technical Analysts and Aides, Code Managers, and Task Team Leaders. The staff is responsible for conducting work in accordance with this QA Plan and procedures, and with SCALE technical and administrative procedures.

SECTION 2 - PERSONNEL TRAINING AND QUALIFICATION

2.1 SCALE management and support staff are qualified by experience, education, training and position to perform their assigned responsibilities. The qualifications of each person are documented on Biographical History sheets which are maintained in the SCALE QA records system.

Identification of training appropriate to assure that staff proficiency is adequately maintained is a joint responsibility of the SCALE Project Leader and each staff member. The SCALE Project Leader has an additional responsibility to assist the staff in obtaining necessary UT-Battelle training, attendance at pertinent technical conferences where professional training is provided, and

any needed task-specific training. Records of task-specific training are maintained by the SQA Coordinator.

2.2 Training and qualification of QA audit personnel are completed in accordance with the requirements of procedure QSSD-QMS-001, *Qualifying Auditors and Certifying Lead Auditors*.

SECTION 3 - QUALITY IMPROVEMENT

3.1 Improvement of the SCALE system is an ongoing process which is controlled through the Configuration Management Plan as addressed in Section 6 of this QA Plan and described in detail in the SCALE Configuration Management Plan and supporting procedures. Changes to the SCALE system are evaluated, tested and approved prior to incorporation into the configuration controlled version of SCALE.

3.2 Significant conditions adverse to quality are identified and corrective action taken to avoid repetition of problems. Procedures for ORNL Performance Based Management System are used for identifying, reporting, and correcting quality problems. The SCALE code system is controlled and documented through the Configuration Management Plan, SCALE-CMP-001.

3.3 Corrective actions resulting from surveillance and audit or other assessment activity are tracked by the NSTD Quality Program Manager.

3.4 Should any reportable occurrences (DOE Manual M231.1-2) be identified, they will be reported and tracked in accordance with the most current ORNL SBMS procedure for occurrence reporting.

SECTION 4 - DOCUMENTS AND RECORDS

4.1 The documents requiring control on the SCALE project are:

4.1.1 ORNL/TM-2005/39: the set of operating manuals containing instructions for using the SCALE system software - a master set is controlled by the SCALE Project Leader under the SCALE configuration management system. Uncontrolled copies of the operating manuals are issued to external users by RSICC as part of distribution of the SCALE code system.

4.1.2 SCALE-QAP-005: SCALE Quality Assurance Plan - controlled by the SCALE Project Leader and issued to a controlled distribution that includes SCALE support staff.

4.1.3 SCALE-CMP-001: SCALE Configuration Management Plan (plus supporting CM procedures) - controlled by the SCALE Project Leader and issued to a controlled distribution that includes SCALE support staff.

4.1.4 SCALE-CCV-001: Verification and Validation Plan for the SCALE Computational System Codes - controlled by the SCALE Project Leader and issued to a controlled distribution that includes SCALE support staff.

Instructions and procedures, such as those developed to support the SCALE Configuration Management Plan, are prepared, reviewed and approved by the SCALE Project Leader, or a designated alternate, in accordance with the NSTD Records Management Plan.

The SCALE Project Leader will make decisions on any additional documents which are recommended for control and will assign responsibility for control of documents to SCALE staff, as necessary.

4.2 SCALE project QA records are identified and maintained in accordance with the NSTD Records Management Plan. The record categories determined by the SCALE Project Leader to be appropriate to the SCALE system are identified in Attachment C of this QA Plan. The SCALE Project Leader is responsible for identification of completed records and forwarding them to the assigned records custodian for entry into the master and duplicate files. In addition, SCALE QA records are indexed within each category list in Attachment C.

SECTION 5 - WORK PROCESSES

5.1 The SCALE system is applied extensively by the NSTD technical staff to the analytical problems of various customers (DOE, NRC, internal, etc.). That work is conducted in accordance with the technical and quality requirements of each customer, and is not addressed in this QA Plan.

The work processes falling under this QA Plan are the operations performed to maintain the configuration controlled version of SCALE, and to conduct verification and validation (V&V) of SCALE system modules. Maintenance of the SCALE system is performed in accordance with the SCALE Configuration Management Plan.

5.2 Modifications (enhancement, error correction, etc.) to the SCALE system are performed by technical staff and are controlled in accordance with the SCALE Configuration Management documentation (Section 6). Documentation resulting from configuration changes is tracked by the SCALE SQA Coordinator and entered into the SCALE QA records system.

5.3 V&V of the SCALE system is specifically addressed in Section 6 of this QA Plan.

5.4 The handling, storage, and shipping of SCALE software and supporting documentation to users is performed by RSICC, which is the DOE software distribution center. The approved SCALE baseline version and accompanying documentation are delivered to RSICC to prepare code packages for external distribution. The software and documentation packages are handled, stored, and shipped according to RSICC operating procedures. SCALE users are notified that they are responsible for their specific uses of the SCALE system.

SECTION 6 - DESIGN

This QA criterion is not generally applicable to SCALE activities since design work is not being performed by SCALE staff. However, design type activities, such as establishing a software configuration management system, performing technical reviews, and verifying and validating the SCALE system modules on an incremental basis are performed. The controls on those activities are addressed in this section as follows.

6.1 The SCALE system (hardware, software and documentation) is under control of a configuration management system as described in SCALE-CMP-001, *Configuration Management Plan for the SCALE Code System*, plus supporting configuration management procedures.

In accordance with the Configuration Management Plan and procedures, modifications or additions to the SCALE system must be submitted to the Project Leader for authorization to proceed. Changes must be tested and documented, and approved by the Project Leader prior to incorporation into the pertinent SCALE code module.

For major system modifications, or for a new code or data library, verification and/or validation will be performed using a graded approach based on the complexity of the modifications or additions and will be at a level determined to be appropriate by the Project Leader. Results of all verification or validation activities will be documented in a report that will be reviewed for technical adequacy and appropriateness by at least one independent reviewer with the required qualifications as assessed by the Project Leader.

6.2 In addition, SCALE project management uses the following communication tools to notify users of changes to the SCALE system. E-mail notices are sent to local ORNL users whenever a change has been implemented in the configuration controlled version of SCALE. Interim change orders (ICOs) are sent to RSICC on a quarterly basis to notify them of all changes that have been implemented. External users of the SCALE system are notified of corrections and updates via e-mail notices and/or the SCALE Newsletter as deemed appropriate by the Project Leader. The Project Leader decides when sufficient changes have been made to issue a new version of SCALE. At the Project Leader's discretion, important changes may be made available to external users before a new version of SCALE is issued. These changes will be posted as updates on the SCALE website.

SECTION 7 - PROCUREMENT

This QA criterion is not applicable to SCALE activities since no hardware, software, or services are being procured. Should this change, the applicable ORNL procurement procedures shall be invoked and implemented.

SECTION 8 - INSPECTION AND ACCEPTANCE TESTING

Specific evaluation and acceptance tests shall be designated for other than off-the-shelf items or software that are obtained from sources outside of ORNL for use in Category I or Category II activities. Results of such tests will be documented and kept with the project file relating to the software.

Testing of the various SCALE system modules occurs as part of the configuration management activities. Ongoing system corrections, improvements, and testing are handled under SCALE-CMP-001.

SECTION 9 - MANAGEMENT ASSESSMENT

9.1 The SCALE Project Manager assures that sufficient internal assessments are conducted to confirm that the SCALE QA Plan is adequately implemented, and that any identified problems are corrected. The SCALE system is routinely assessed by the code managers and analysts as a byproduct of conducting analyses for customers.

9.2 Configuration assessments of the SCALE configuration management system are periodically conducted in accordance with SCALE-CMP-001, SCALE Configuration Management Plan. These

assessments are conducted by technically qualified SCALE staff, the results are reported, and corrective actions are taken when necessary.

9.3 Follow-up action is taken by SCALE project management, when necessary, based on the results of management assessments. Corrective actions resulting from such assessments are documented, tracked, completed and verified in accordance with Section 3 of this QA Plan.

SECTION 10 - INDEPENDENT ASSESSMENT

10.1 Assessments conducted within NSTD but outside the SCALE Project Team fall into the independent assessment category. These may be conducted by NSTD senior management, the NSTD Quality Program Manager, or by other qualified staff with concurrence from NSTD management. ORNL requires that QA audits and surveillances will be performed in accordance with established procedures. Personnel leading QA audits are certified by UT-Battelle as described in procedure QSSD-QMS-001. QA audits are planned and scheduled to verify compliance with all aspects of the QA program and to determine the effectiveness of the QA program. Independent assessment activities are scheduled at least once every three years for this project and are coordinated and tracked by the NSTD Self-Assessment Program Manager.

10.2 Assessments conducted by organizations external to the NSTD also fall into the independent assessment category. These may be scheduled and conducted by such organizations as: ORNL Quality Services Division, Department of Energy, Nuclear Regulatory Commission, and other sponsors of work activities. Such assessments are coordinated, scheduled, conducted and reported by the assessing organization.

10.3 Follow-up action is taken by SCALE project management, when necessary, based on the results of independent assessments. Corrective actions resulting from such assessments are documented, tracked, completed and verified in accordance with Section 3 of this QA Plan.

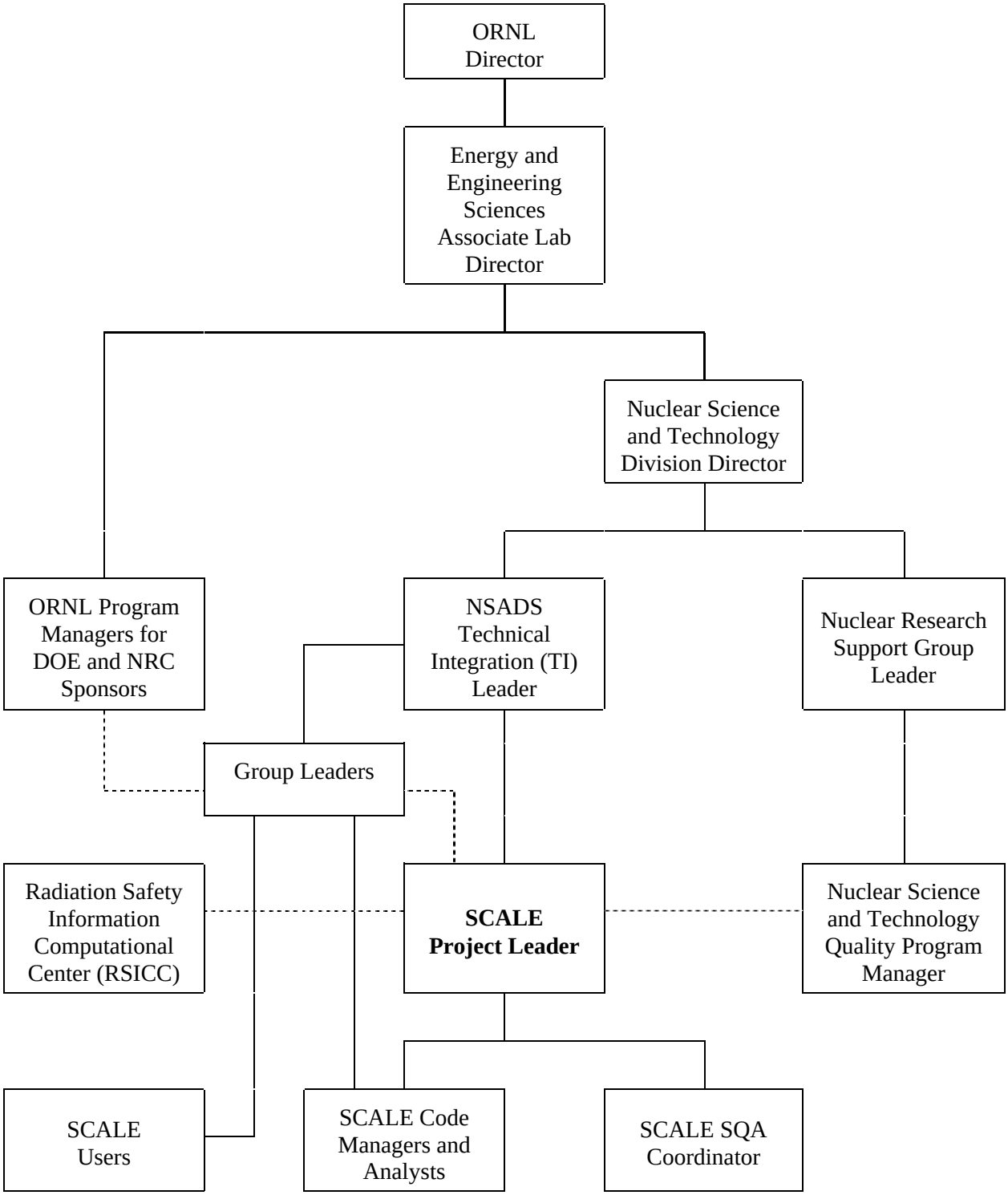
ATTACHMENT A

FUNCTIONAL RESPONSIBILITY MATRIX

P = Prepare/Perform A = Approve I = Input R = Review S = Surveillance D = Distribute **Documents/Actions**	**Project Leader**	**Code Managers and Analysts**	**SQA Coordinator**	**Quality Program Manager**	**RSICC**
QA Plan	P, A, D		I, R	P, A	
Configuration Mgmt. Plan and Procedures	P, A, D	I, R	I, R	R, A	
V&V Plan	P, A	I, R		R, A	
QA Records	A		P	S	
SCALE Documentation	R, A	I, P ,R	R	S	D
SCALE Code	A	I, P ,R			D
Technical Reviews	P	P		S	
Code Design Requirements	I, R, A	I, P		S	
Configuration Control List	R, A		P	S	
Software Archive			P	S	
Software Changes	R, A	P, R	P	S	
Change Documents	R, A	P, R	P	S	
Biographical Sheets	R	P	P		
Newsletter	I, R, D	I	P		

ATTACHMENT B

SCALE SYSTEM ORGANIZATION



ATTACHMENT C

QA RECORDS CATEGORY LIST

QA Records		Retention Period [1]	Master File Point	Duplicate File Point [2]
Abbreviation	**Category**			
AU	Audit/Surveillance Reports	L	5700, H330	DMC
BHS	Biographical History Sheets	L	5700, H330	DMC
CA	Corrective Action Reports	L	5700, H330	DMC
CCL	Configuration Control List	L	5700, H330	DMC
CCV	Computer Code Verification/Validation Documentation: Sample Problem Verifications, V&V Plans and Reports	L	5700, H330	DMC
CMP	Configuration Management Plan and Procedures	L	5700, H330	DMC
CODE	SCALE Computer Code	L	5700, H330	RSICC
CSDC	SCALE Code Documentation	L	5700, H330	RSICC
DIST	Document Distribution and Control	L	5700, H330	DMC
ICO	Interim Change Orders	L	5700, H330	DMC
QAP	SCALE QA Plan	L	5700, H330	DMC
BRR	Baseline Revision Report	L	5700, H330	DMC
CDR	Code Design Requirements	L	5700, H330	DMC
DRR	Dataset Revision Report	L	5700, H330	DMC
MRR	Module Revision Report	L	5700, H330	DMC
SDR	Software Discrepancy Report	L	5700, H330	DMC
TRF	Technical Review Form	L	5700, H330	DMC
TRA	Training Records	L	5700, H330	DMC

[1] **L** - Lifetime (Determined by records turnover schedule); **N** - Non-permanent

[2] **DMC** (NSTD Document Management Center)
RSICC