QUALITY ASSURANCE PLAN

FOR THE

SCALE COMPUTATIONAL SYSTEM

DOCUMENT NO. SCALE-QAP-005, Rev. 1

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APPROVALS:

SCALE Project Leader	**Date**
Group Leader, Nuclear Analysis Methods and Applications	**Date**
Quality Program Manager, NSTD	**Date**

INTRODUCTION

Since 1970 the Nuclear Analysis Methods and Applications (NAMA) Group of the Nuclear Science and Technology Division (NSTD) at 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 to develop an easy-to-use computational system that would provide a needed tool for evaluating the criticality, shielding, and thermal aspects of nuclear fuel facility and/or spent fuel cask designs. A program was thus begun to develop the SCALE (**S**tandardized **C**omputer **A**nalyses for **L**icensing **E**valuation) software system, a modular computational system consisting of easy-to-use control modules that automate and standardize analytic sequences capable of adequately solving problems pertinent to the needs of NRC/NMSS. Well-established computer programs were used to form the functional modules that actually solve the problems. The analysis sequences are driven by control modules that automate the necessary data processing (e.g., cross-section preparation), generate the input to the functional modules, initiate module execution in proper sequence, and perform any needed post-processing of the analytic results. Input to a control module is in the form of easily visualized engineering parameters and keywords. Standardization is further enhanced by the incorporation of a host of validated data libraries (e.g., material compositions, physical properties, and cross sections) which allow easy input (via keywords) and data accessibility.

In July 1980, a limited 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; and SCALE 4.4a in 2000.

Since its initial release, SCALE has become an increasingly popular computational system. The system is used by the NRC staff, numerous government contractors and national laboratories, utilities, nuclear fuel vendors, spent fuel storage and transportation cask vendors, and universities. As popularity increased, the demand to install SCALE on various computer platforms increased. Thus, in 1987 the Department of Energy (DOE) Packaging Certification Branch began funding ORNL to convert SCALE (which was developed for an IBM mainframe computing environment) to FORTRAN 77 and ensure its operation on Cray computing systems. New and old modules were converted and the system was tested on both the Cray (under a CTSS operating system) and IBM machines. This effort was completed in 1989.

Also, in late 1988, the DOE Office of Civilian Radioactive Waste Management (OCRWM) funded ORNL to ensure that an adequate quality assurance program was in place to meet the requirements of the Cask System Development Program. Thus, with the release of SCALE-4, a Quality Assurance (QA) Plan and a Configuration Management Plan were developed and implemented. The configuration controlled version of SCALE is maintained and controlled in accordance with these plans by the NAMA staff at ORNL. This enhanced level of control began with the SCALE-4 initial baseline configuration (released by RSICC as CCC-545/SCALE-4.0). Newly developed modules and approved revisions or corrections to existing modules are subsequently released to RSICC to form an updated public version of the software system.

Maintenance and enhancement of SCALE continues to be co-funded by departments of both the NRC and the DOE.

With each release to RSICC, new and/or updated documentation is also provided as revisions to the NRC-published SCALE Manual, NUREG/CR-0200. Self-contained and thorough documentation of the control modules, functional modules, and data bases has been invaluable in making SCALE understandable to the user. The documentation has been aimed at 1) describing the problem theory and numerical techniques for solving the problem, 2) providing a discussion on the range of applicability, 3) presenting the general program flow, and 4) providing 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, correct, and easy to use. The use of well-established codes and data libraries that have a wide range of applicability and a proven record of reliable performance has decreased the amount of code testing and validation required. Although the initial baseline configuration for SCALE-4.0 was considered to be a validated and verified code system based on the established experience with the SCALE system and the individual functional modules and libraries, additional validation and verification activities are planned, conducted, and documented to further assure the quality of the SCALE system. The major analysis modules and libraries implemented in SCALE 4.0 had been used for production analyses for the past 10 to 25 years. This broad and ever-increasing user experience with the system, combined with numerous validation tasks performed throughout its life cycle, serve as confirmation of the adequacy of the SCALE software system. **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 in the workplace and while maintaining the safety of all personnel, the public, and the environment.

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 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. 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.

1.2 References:

1.2.1 DOE Order 5700.6C, *Quality Assurance*

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 safety, waste isolation, and the achievement of mission objectives.

To establish the UT-Battelle Quality Category, the SCALE system was evaluated in accordance with NSTD QA Project Classification guide and determined to be a 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 DOE Order 5700.6C, *Quality Assurance*, 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.

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
- public releases of the code to users are conducted in accordance with established procedures

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 Analysis Methods and Applications (NAMA) Group within ORNL provides the staff to support the SCALE computational system. The SCALE system is supported by funding from both NRC and DOE projects, as well as other occasional sponsors. This is reflected in the organization chart in Attachment B.

1.6 Quality Assurance (QA) support to SCALE is provided by the Nuclear Science and Technology Division (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:

- preparing budgets,
- reviewing and approving QA and work plans, and supporting SCALE procedures,
- assuring that work is carried out on a timely schedule and within budget,
- assuring that adequate staffing is available,
- making work assignments,
- reporting program status on a routine basis,

- authorizing the SCALE system baseline,
- approving changes, and
- assuring the overall quality of the SCALE system.

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 **QA Coordinator** The QA Coordinator reports functionally to the NSTD Director and administratively to the NSTD Nuclear Research Support Group Leader. The QA Coordinator 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 QA Coordinator 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 QA Coordinator 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 QA Coordinator 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 Coordinator, Technical Analysts and Aides, Code Managers, and Task Team Leaders. The staff is responsible to the Project Leader for performance of the work directed by the Project Leader; and for assuring that work is conducted 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, relative to SCALE operations, is 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, and any needed task-specific training. Records of task-specific training are maintained by the Software Coordinator.

2.2 Training and qualification of QA audit personnel are completed in accordance with the requirements of procedure ORNL-OQS-P02, *Qualification of Technical Audit Personnel*.

SECTION 3 - QUALITY IMPROVEMENT

3.1 Improvement of the SCALE system is an ongoing process which is controlled through the Configuration Management program 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 QA Coordinator.

3.4 Should any reportable occurrences (DOE Order 232.1) be identified, they will be reported and tracked in accordance with ORNL-OR-P01, ORNL Occurrence Notification and Reporting.

SECTION 4 - DOCUMENTS AND RECORDS

4.1 The documents requiring control on the SCALE project are:

4.1.1 NUREG/CR-0200: 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.

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.

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.

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 into a database maintained within the SCALE Configuration Management system.

SECTION 5 - WORK PROCESSES

5.1 The SCALE system is applied extensively by the NAMA 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 documentation. The SCALE V&V Plan and subsequent reports will be developed and implemented in accordance with ORNL software requirements, and will be reviewed and approved prior to use. Plans and reports (as well as configuration management documentation) are entered into the SCALE QA records system.

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 (See Section 6). Documentation resulting from configuration changes is tracked by the SCALE Software 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 at ORNL. 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 criteria 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 in accordance with a plan (approved by the Project Leader) which meets the requirements of the SCALE System V&V Plan. The specific verification and/or validation plan will be 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 which will then be reviewed for technical adequacy and appropriateness

by at least one independent reviewer within NAMA who is qualified and acceptable to 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 via the SCALE Newsletter, which is issued semiannually. 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 criteria is not applicable to SCALE activities since no hardware, software, or services are being procured. Should this change, the NSTD procedure on Procurement of Items & Services 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 during verification and validation of the system modules. Ongoing system corrections and improvements are handled under SCALE-CMP-001. Module and system V&V are handled under the SCALE V&V Plan.

SECTION 9 - MANAGEMENT ASSESSMENT

9.1 The SCALE Project Manager assures that sufficient assessments are conducted within NAMA to confirm that the SCALE QA program is adequate and implemented, and that any problems found 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 NAMA 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 ORNL-OQS-P02. 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.

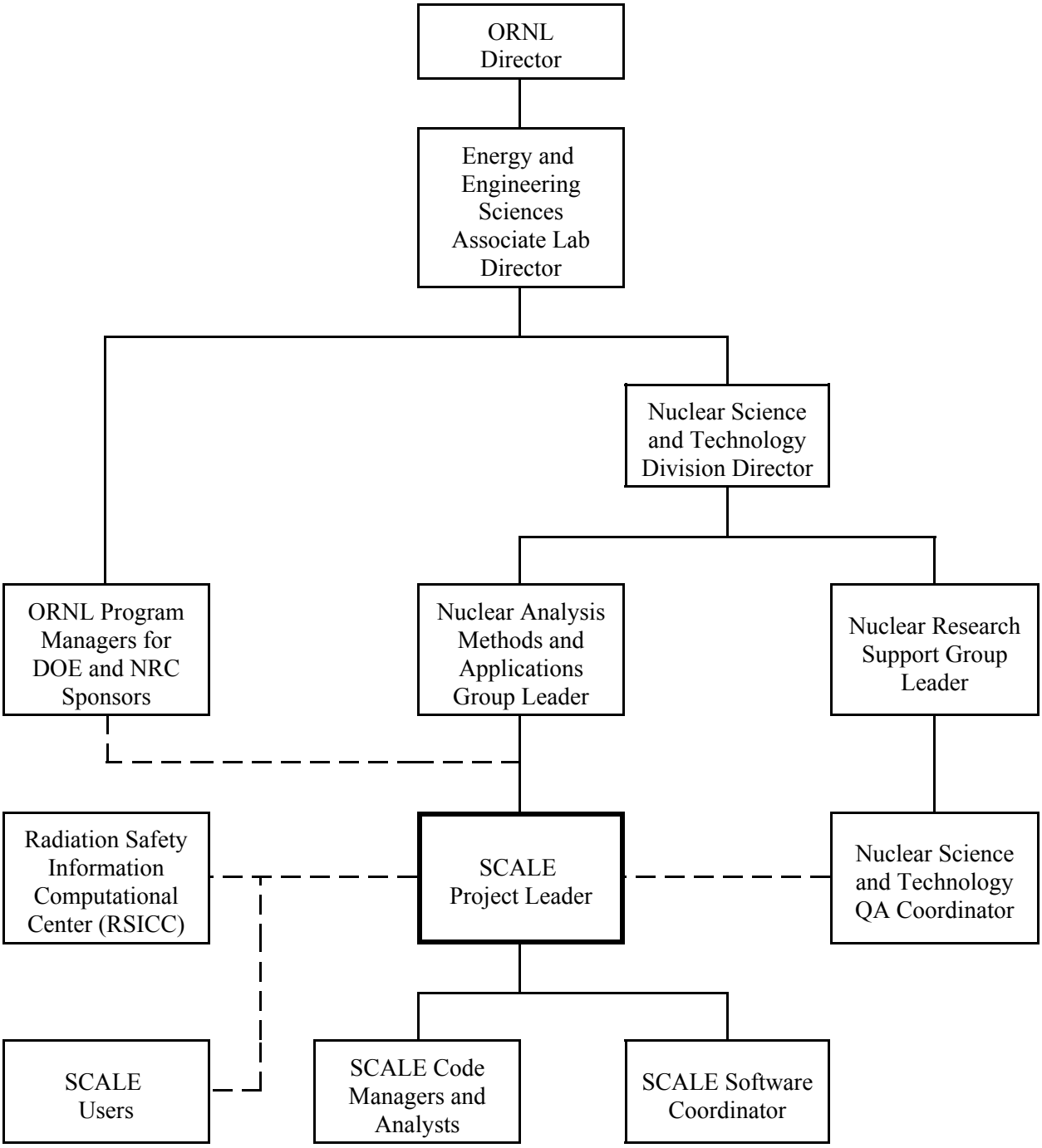
ATTACHMENT A

FUNCTIONAL RESPONSIBILITY MATRIX

P = Prepare/Perform A = Approve I = Input R = Review S = Surveillance D = Distribute **Documents/Actions**	**Project Leader**	**Code Managers and Analysts**	**Software Coordinator**	**QA Coordinator**	**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	6011, RM203	DMC
BHS	Biographical History Sheets	L	6011, RM203	DMC
CA	Corrective Action Reports	L	6011, RM203	DMC
CCL	Configuration Control List	L	6011, RM203	DMC
CCV	Computer Code Verification/Validation Documentation: Sample Problem Verifications, V&V Plans and Reports	L	6011, RM203	DMC
CMP	Configuration Management Plan and Procedures	L	6011, RM203	DMC
CODE	SCALE Computer Code	L	6011, RM203	RSICC
CSDC	SCALE Code Documentation	L	6011, RM203	RSICC
DIST	Document Distribution and Control	L	6011, RM203	DMC
ICO	Interim Change Orders	L	6011, RM203	DMC
QAP	SCALE QA Plan	L	6011, RM203	DMC
BRR	Baseline Revision Report	L	6011, RM203	DMC
CDR	Code Design Requirements	L	6011, RM203	DMC
DRR	Dataset Revision Report	L	6011, RM203	DMC
MRR	Module Revision Report	L	6011, RM203	DMC
SDR	Software Discrepancy Report	L	6011, RM203	DMC
TRF	Technical Review Form	L	6011, RM203	DMC
TRA	Training Records	L	6011, RM203	DMC

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

[2] **DMC** (NSTD Document Management Center)
RSICC (located in Building 6025)