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LICENSING TOPICAL REPORT

ESBWR I&C SOFTWARE DEVELOPMENT PLAN

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1 Introduction

1.1 Purpose and Scope

This Software Development Plan (referred to as the SDP) specifies the management processes for design and delivery activities for the I&C software and hardware. The scope of this project plan is limited to the activities required to support the delivery of the I&C Controls hardware and software. This SDP specifies the implementation of the design activities outlined in the I&C Software Management Plan (SMP) [2.1.1(3)]*, Software Configuration Management Plan (SCMP) [2.1.2(1)], and Software Verification & Validation Plan (SVVP) [2.1.2(2)]. This SDP is heavily supported by the Project Design Manual (referred to as the PDM) [2.1.1(2)], Project Management Manual (referred to as the PMM) [2.1.1(1)], Project Procedures [2.1.1(4) and (5)], General Procedures [2.1.1(6)], and Software Installation Plan (SIP) [2.1.1(8)].

IEEE Standard 1058.1 specifies a standard for Software Project Management Plans, which includes specification of project organization, project scheduling processes, project risk management processes, and project budgeting processes. These processes are currently addressed for the project in the supporting PDM [2.1.1(2)], PMM [2.1.1(1)], Project Procedures [2.1.1(4) and (5)], and General Procedures [2.1.1(6)] documents. Hence, this SDP references these documents frequently.

1.2 Definitions, Acronyms, and Abbreviations

The PDM, Section 2A [2.1.1(2)], specifies the valid Information Management System (IMS) codes, component function codes (CFCs), equipment/service acronyms, and abbreviations for the Project.

Acronyms and Abbreviations

The following Acronyms and Abbreviations are used in this document:

BRT	Baseline Review Team
CFC	Component Function Code
COL	Construction and Operating License
DCD	Design Control Document
DCIS	Distributed Control & Information Systems
DRF	Design Record File
EOP	Engineering Operating Procedure
ESF	Engineered Safety Feature
GE	General Electric Company
GEEN	GE Energy Nuclear (Previously GENE)
HFE	Human Factors Engineering

* Section numbers referenced in this manner refer to the codes and standards documents listed in the Applicable Documents section (Section 2) of this document.

HSS	Hardware/Software Specification
IMS	Information Management System
IPS	Instrument Performance Specification
MMIS	Man-Machine Interface System
O&MP	Operation & Maintenance Plan (Change Control)
PDM	Project Design Manual
PMM	Project Management Manual
RTIF	Reactor Trip and Isolation Functions
SBD	System Block Diagram
SCMP	Software Configuration Management Plan
SDP	Software Development Plan
SDS	Software Design Specification
SIP	Software Installation Plan
SMP	Software Management Plan
SRE	Software Requirements Engineer
SRP	Standard Review Plan
SSA	Software Safety Analyst
SSLC	Safety System Logic & Control
SSP	Software Safety Plan
SVVP	Software Verification and Validation Plan
V&V	Verification and Validation
VDU	Video Display Unit

Definitions

The following definitions apply throughout this document:

- Baseline** - Items that have been formally reviewed and agreed upon, that thereafter serve as the basis for further development, and that can be changed only through formal change control procedures.

- Baseline Review and Oversight** - A formal review, conducted at the end of each software life cycle phase, and requested by the Responsible Technical Project Engineer (RTPE). The baseline review process is under the control of the Baseline Review Team. The Baseline Review Team (appointed by the BRT Task Lead) performs the review. These reviews confirm adherence to the SMP (this plan), SCMP and SVVP. All Baseline Reviews are performed and documented in accordance with the Software Configuration Management Plan (SCMP).

Oversight including performance indicators is also performed during each software life cycle phase. The RTPE is informed shortly after findings and observations are confirmed. The BRT Task Lead issues an Oversight Report to the RTPE and all direct and indirect project management having a need to know shortly after the end of each software life cycle phase.

- Baseline Review Team** - The BRT is responsible for judging adherence to the process for the work products being base-lined. The members of this team are appointed by the BRT Task Lead. For safety-related software, the team members must not work for the same manager as the person who generated the work to be reviewed.

- Baseline Review Team Task Lead** - The person responsible for organizing the baseline review process. This person is appointed by the SPE Task Lead.

- Design Record File** - A formal controlled information record under the GEEN procedures for in-progress and completed engineering work which is retained and from which work can be retrieved.

- Design Reviews** - Formal, design adequacy evaluations which are performed by knowledgeable persons other than those directly responsible and accountable for the design in accordance with GEEN EOP 40-7.00 [2.1.2(6b)]. Design reviews are used to verify that product designs meet functional, contractual, safety, regulatory, industry codes and standards, and company requirements.
- Quality Class N** - Project non safety-related classification {see Project Quality Assurance Plan}.
- Quality Class Q** - Project safety-related classification {see Project Quality Assurance Plan}.
- Software Life Cycle Phase** - The Software Life Cycle is the period of time that begins when a software product is conceived and ends when the software is no longer available for use. The I&C software lifecycle is divided into eight phases: Planning, Requirements, Design, Implementation, Integration, Validation, Installation, Operation & Maintenance. (See the SMP for more explanation.)
- Verification and Validation** - The V&V activities performed by the responsible design organization in accordance with GEEN EOPs 40-7.00 (Design Reviews) [2.1.2(6b)] or 42-6.00 (Independent Design Verification) [2.1.2(6c)] or equivalent to ensure the quality of the design process and the associated documents produced.

2 Applicable Documents

2.1 Supporting and Supplemental Documents

2.1.1 Supporting Documents

The following supporting documents are used as the controlling documents in the production of this plan:

Document Title	Document Number
1. Project Management Manual (PMM)	NEDO-33216
2. Project Design Manual (PDM)	
3. Software Management Plan	NEDO-33226
4. Project Procedure, Progress Reports	
5. Project Procedure, Integrated Schedule	
6. Procedure for Change Control Board Submittals	
7. Composite Specification (26A007)	A11-5299
8. Software Installation Plan	NEDO-33247

2.1.2 Supplemental Documents

The following supplemental documents are used in conjunction with this document:

Document Title	Document Number
1. Software Configuration Management Plan	NEDO-33227
2. Software Verification and Validation Plan	NEDO-33228
3. Software Installation Plan	NEDO-33231
4. Software Safety Plan	NEDO-33230
5. GEEN Engineering Operation Procedures	NEDE-21109
a. EOP 25-5.00 Work Planning and Scheduling	
b. EOP 40-7.00 Design Reviews	
c. EOP 42-6.00 Independent Design Verification	
7. Man-Machine Interface System and HFE Design Implementation Plan (MMIS/HFE IP)	NEDO-33217
8. NP 2010 COL Demonstration Project Quality Assurance Program	NEDO-33181

2.2 Codes and Standards

The following codes and standards are applicable to the Software Development Plan to the extent specified herein. The applicable date/revision of the code or standard is specified in the Composite Specification [2.1.1(7)].

2.2.1 Institute of Electrical and Electronic Engineers (IEEE) Standards

1. IEEE 1058.1, IEEE Standard for Software Project Management Plans
2. IEEE 1074-1997, IEEE Standard for Developing Software Life Cycle Processes

2.2.2 Others

1. None

2.3 U.S. Nuclear Regulatory Commission (NRC) Regulatory Guides (Reg Guide)

1. R.G. 1.173-1997, Developing Software Life Cycle Processes for Digital Computer Software Used in Safety Systems of Nuclear Power Plants

2.4 NUREG

1. NUREG/CR-6101-1993, Software Reliability and Safety in Nuclear Reactor Protection Systems
2. NUREG-0800, Chapter 7, Branch Technical Position HICB-14, for Software Safety Plans

3 Project Organization

3.1 Project Deliverables

The deliverables consist of hardware, software, and supporting specifications, analyses, and reports. The work packages, specifications, analyses, and reports to be delivered are defined in Section 6 of this plan.

The hardware and software will be produced in accordance with the target schedule milestones specified in the Integrated Project Schedule produced per Project Procedure [2.1.1(5)]. GEEN staff will revise the target schedule milestone to match any updates to the Integrated Project Schedule. The Project Procedure, Progress Reports [2.1.1(4)] specifies the requirements for developing progress reports to ensure timely and appropriate reporting of project status and progress.

Delivery processes for all equipment and documents are specified in the PDM [2.1.1(2)] and PMM [2.1.1(1)].

3.2 Evolution of Software Development Project Plan

All changes to this SDP will be processed under the configuration management requirements of the Composite Specification [2.1.1(7)] and the Procedure for Change Control Board Submittals [2.1.1(6)].

3.3 Process Model

The SMP [2.1.1(3)] specifies the process used to develop all I&C equipment, and the required approvals and reviews. The SMP [2.1.1(3)] figure 3 shows a graphical representation of this process.

Project Procedure, Progress Reports [2.1.1(4)] specifies the requirements for developing progress reports to ensure timely and appropriate reporting of project status and progress.

3.4 Organizational Structure

The PMM [2.1.1(1)] specifies the Project Organization for the project. The SMP [2.1.1(3)] specifies the organizational structure for all I&C development groups.

Responsible Verifiers will perform V&V as specified in the SVVP [2.1.2(2)]. For safety-related software, the team members must not work for the same manager as the person who generated the work to be reviewed.

3.5 Organizational Boundaries and Interfaces

The PMM [2.1.1(1)] specifies overall organizational boundaries. The SMP [2.1.1(3)], the SCMP [2.1.2(1)], and the SVVP [2.1.2(2)] specify organizational responsibilities for all Software Development for the I&C Controls equipment, including the requirements for V&V, by Responsible Verifiers.

3.6 Organizational Resources

Budget: The financial resources necessary to carry out the work in the SCMP is proprietary data, maintained by the senior manager(s) responsible for the personnel assigned to their area of responsibility.

Methods/Tools: The methods, tools, and techniques used in the design and development of I&C Controls equipment are specified in SMP [2.1.1(3)], SCMP [2.1.2(1)], SVVP [2.1.2(2)], and SSP [2.1.2(4)].

Personnel: The proprietary Staffing Plan defines the personnel resources, qualification, and training required to carry out the work defined in the SDP (this plan).

Standards: The primary international, national, industry, and company standards and guidelines to be followed in the work defined in the SMP [2.1.1(3)] is identified in Supporting and Supplemental Documents section of this SDP.

3.7 Project Responsibilities

The primary duties of the organization covered by the SMP [2.1.1(3)], and of individuals within the organization are defined below. This section of the SDP defines the Manager/Technical Leads of Control/Electrical Systems and Configuration Management responsibilities.

1. Manager/Technical Lead, Control/Electrical Systems

Responsible for directing all activities under this Project Plan. Responsible for all cost/schedule commitments associated with activities under this Project Plan.

2. **Manager/Technical Lead, Configuration Management**

Responsible for providing configuration control over documents, acquired software (e.g., tools used to develop final software) and software produced under this plan.

4 Managerial Process

4.1 Management Objectives and Priorities

The objective for the project management is to coordinate the development and realization efforts of project deliverables.

Managerial decisions shall be made using the following levels of priority, where 1 represents the highest level of priority.

1. Safety
2. Requirements
3. Schedule
4. Budget

The PMM [2.1.1(1)] defines the processes for establishing management objectives and priorities on the project. Project planning, project controls, project scheduling, project cost monitoring, and project progress reporting will be conducted in accordance with the PMM requirements.

Project Procedure [2.1.1(5)] specifies the process for the overall project schedule to be utilized across Project Team members (Customer, GE, A/E(s), Vendors). This schedule will be the source for reports for organizations with differing responsibilities and provides a common framework for analysis of overall schedule performance throughout the project.

Project Procedure, Progress Reports [2.1.1(4)] specifies the requirements for developing progress reports to ensure timely and appropriate reporting of project status and progress.

The SMP [2.1.1(3)] defines the process for software development, including the application of support software, software tools, third-party software, and previously developed software used in the development of the I&C Controls software.

4.2 Assumptions, Dependencies, and Constraints

The following assumptions apply to the work performed under this SDP:

1. The scope does not rely on assumptions that constitute a calculated risk to safety. The core of the development process and the majority of the development tools have been used earlier. The technology is proven in identical or similar applications.

2. Project Team members perform all work in accordance with an agreed upon Integrated Project Schedule, approved by the Project Team management, and in accordance with the Project Procedure [2.1.1(5)].
3. All work performed by GE will be performed in accordance with the requirements of the NP-2010 COL Demonstration Project Quality Assurance Plan or equivalent.
4. Work will be performed in accordance with the Project codes and standards defined in the composite specification. Any request to utilize later versions of these codes and standards, or application of new codes and standards on the project, will be treated as a formal contract change.
5. Work will be performed based upon the requirements of the PMM [2.1.1(1)], PDM [2.1.1(2)], and PROJECT PROCEDURES in effect.
6. The software development process in the SMP [2.1.1 (3)] requires that the software safety analyses be completed as part of phase specific documentation and verified in accordance with the Software Safety Plan (SSP).

4.3 Risk Management

The risk management for the software development project is based on the following fundamental principles:

1. Minimize exposure to known risks
2. Detect a materialized unknown risk as soon as reasonably possible
3. Mitigate risk impact promptly

Specific Software Work Packages should identify and assess the risk factors associated with product engineering, development environment, and program constraints. It should describe contingency and mitigation plans for each associated risk. Risk factors to consider should include;

- 1) system risks,
- 2) mechanical/electrical hardware integration,
- 3) risks due to size and complexity of the product,
- 4) the use of pre-developed software,
- 5) cost and schedule,
- 6) technological risk, and

- 7) risks from program interfaces (maintenance, user, associate contractors, subcontractors, Customer, etc.).

The plan should identify key design and implementation issues, and the preliminary studies, simulation modeling, and prototyping required to resolve them.

4.3.1 Minimized Risks

The following risks have been identified and taken into consideration during the development of the software planning documents (SMP, SCMP, SVVP and this SDP).

1. The process is defined and documented but not followed
2. The process is too complex to understand
3. The process is defined and documented but deficient

The software planning documents have adopted proven processes to mitigate these risks.

4.3.2 Prioritized Risks

The following risks have been identified to require strengthened attention throughout the project.

1. Deficient development process
2. Insufficient engineering capacity
3. Insufficient or inadequate Independent Verification and Validation capacity
4. Insufficient Software Safety Analysis capacity
5. Insufficient communication among organizational units and individuals at all levels in the Project Organization, including Customer and vendors.
6. Misinterpretation of the unproved licensing basis

Failure to detect a single materialized risk of 1 - 5 may have an impact on safety. Failure to detect materialization of multiple of these risks simultaneously has an impact on safety.

Materialization of risk 6 has a significant impact on schedule and budget.

4.3.3 Risk Monitoring

Bi-Weekly GEEN staff meetings shall be held to facilitate early detection of impact from materialized risks.

At a minimum, both the Software Safety Analyst and the Software Requirements Engineer, or their representative(s), shall attend the Baseline Review Meetings and be alert for any impacts from the prioritized risks. A process performance evaluation shall be performed for each baseline review to detect deficiencies. Any sign of deficiency shall be addressed immediately and corrective actions shall be taken.

4.3.4 Reporting Risks

The PMM [2.1.1(1)] specifies the process for detecting issues representing a threat to the project budget and or the Integrated Project Schedule. Major project issues, representing risks to project budget or schedule, are reported to the Customer through a monthly project progress report prepared by GEEN for the Customer in accordance with the requirements of the NP-2010 COL Demonstration Project Quality Assurance Plan. Monthly project management meetings are held with the Customer to address major project issues.

The monthly meetings shall discuss progress on active tasks. In order to avoid discussion of proprietary data, tasks may be presented as percent complete of budget and schedule. The GEEN estimates to complete shall be revised for these meetings and shall reflect current status. The Customer shall be provided with electronic files, with sufficient level of detail for the Customer to review progress at least down to the system level.

The Project Procedure, Progress Reports [2.1.1(4)] specifies the requirements for developing progress reports to ensure timely and appropriate reporting of project status and progress.

4.4 Monitoring and Controlling Mechanisms

Bi-weekly meetings shall be held to monitor and control the project. The Control/Electrical Manager shall call the meeting and attendance is mandatory for the functions listed in Section 3.4 as well as SSA and software requirements representatives.

External vendors shall submit Progress Reports to facilitate project monitoring, including electronic updates of their current status to update the integrated project schedule. Internal vendors shall be monitored by use of established GEEN reporting procedures.

Project Procedure, Progress Reports [2.1.1(4)] specifies the requirements for developing progress reports to ensure timely and appropriate reporting of project status and progress.

The PMM [2.1.1(1)] specifies the project planning, control, and report mechanisms, including:

1. Project Planning and Control Documents (Section 2.1)
2. Project Schedule (Sections 2.2.2 and 2.3)
3. Project Cost Reporting (Sections 2.2.3 and 2.4)
4. Codes and Standards Database (Section 2.2.7)
5. Project Progress Reporting (Section 2.5)

Design Control processes are specified in Section 4 of the PMM [2.1.1(1)].

4.5 Staffing Plan

The SMP [2.1.1(3)] summarizes the responsibilities for each member of the software development team. Detailed responsibilities are specified in the staffing plan.

The design team shall be composed of experienced individuals whose collective expertise covers a broad range of disciplines relevant to the design and implementation process. These disciplines shall include technical project management, systems engineering, nuclear engineering, electrical engineering, nuclear software systems design and development engineering, and control and instrument engineering. Table 2A in the MMIS and HFE Review Implementation Plan [2.1.2(7)] defines the acceptance criteria for the required skill levels for these disciplines.

Staffing plans shall be established for each work package according to EOP 25-5.00 [2.1.2(6a)]. Due to the very sensitive nature of the information, these plans will be retained as GE Company Private information in Project Files for the duration of the project.

Methods for obtaining, training, and retraining are defined in internal GE human resource policies.

5 Technical Process

5.1 Methods, Tools and Techniques

The methods, tools, and techniques used in the design and development of I&C Controls equipment are specified in the SMP [2.1.1(3)], SCMP [2.1.2(1)], SVVP [2.1.2(2)], and SSP [2.1.2(4)] as follows:

1. The SMP specifies the following:
 - a. The methods, tools, standards, and procedures to be used for each engineering process step. Methods and resources that are system specific are documented in the DRF.
 - b. The Software Conventions and Guidelines document which will contain required conventions and guidelines for software programming (i.e., specifies the software programming languages used). Software based products, development methodology(s), and programming language(s) are defined separately for each system or logical group of systems. Optimal choice of such techniques is made after the defining the hardware and software content of each system, and allows for potential advances in technology to be included in the choice of such techniques.
2. The SVVP specifies the methods and tools used in performing V&V.
3. The SCMP specifies:
 - a. The configuration control tools and methodologies
 - b. The configuration control process
 - c. The configuration change control process
 - d. The record collection and retention method
4. The Software Safety Plan specifies the management of software safety activities and safety analyses to be performed and documented.

5.2 Software Documentation

The SMP [2.1.1(3)] defines the documentation to be produced in each engineering work package and the requirements to be met in each applicable engineering document.

The SCMP [2.1.2(1)] specifies the configuration control activities, baseline review activities, document naming conventions, configuration management methods, tools, resources, and configuration management responsibilities.

SVVP [2.1.2(2)] specifies the Internal V&V methods, tools, and activities.

5.3 Project Support Functions

The PDM [2.1.1(2)] and PMM [2.1.1(1)] specify the project support functions.

Project level Configuration Management Activities are specified in the Composite Specification [2.1.1(7)] and Software Configuration Management Plan [2.1.2(1)]

The SVVP [2.1.2(2)] specifies the software V&V activities

PMM [2.1.1(1)] Sections 2.3 and 2.4 specify the project scheduling and budgeting processes.

6 Work Packages, Schedule, Metrics, and Budget

6.1 Work Packages and Schedule

Work packages for the I&C Controls consists of two types:

1. Generic Work Packages, which are not system specific
2. System Specific Work Packages

The project schedule will specify the planned target schedule dates for producing work packages. Target schedule dates shall be assigned for the completion of each software life-cycle phase. Time and individual tasks shall be allocated for all work activities associated with the life-cycle phase, including engineering, reviews, and verifications as well as realistic margin to allow for recovery from unanticipated problems. PMM [2.1.1(1)] Sections 2.3 and 2.4 provide the details for the project scheduling and budgeting processes.

The Manager and the Engineer responsible for the work package shall develop a detailed Work Plan for each work package, in accordance with the requirements provided in GEEN EOP 25-5.00 [2.1.2(6a)].

6.2 Software and Process Metrics

The current state of the art in software metrics does not suggest a set of software metrics that should be implemented by this project. GEEN management intends to use current state-of-the-art equipment and development practices, which mandates that specific metrics not be chosen in these plans. Early in the Planning Phase, GEEN management, staff, and industry experts shall develop a generic set of indicators, otherwise known as metrics, to measure the ongoing technical success or failure of each software life-cycle phase. System-specific work packages will then make use of these metrics, and update the metrics in a timely manner. GEEN management will evaluate each work package separately, as well as the integrated, overall

I&C Controls development project, which will be considered with the progress monitoring for the IPS. GEEN management may determine that a graded approach for metrics is appropriate, and thus assign minimum and maximum acceptance criteria based on the overall safety and quality goals commensurate with the package.

Schedules for these work packages are not included in this document. GEEN management and staff will establish schedules for these work packages during the project scheduling activity for that phase.

6.3 Schedule Estimates and Tracking

Any cost, budget, and resource estimates made to vague specifications will never be correct or add value to planning. The more time given to the planning of detailed and accurate schedules, the better the estimation will be and the more value it will provide. Two methods of estimating person-hour requirements for software are:

1. Cost per function point and,
2. Cost per line of code.

The key to estimating function points or cost per line of code ultimately will come down to the quality and accuracy of the estimate of the size and complexity of the function point or the module to be coded. This requires good specifications, specification of requirements, and decomposition of requirements into manageable sized function points of functions to code.

GEEN management and staff will provide initial estimates for all software life-cycle phases, (e.g. requirement definition, design, coding, testing, etc.). Throughout the project, GEEN management and staff will re-adjust the estimates to eliminate the uncertainties from the original estimate.

For both methods, the estimates have no value unless GEEN management tracks the actual data required to design and develop each work package. Then, GEEN management can compare the actual resource requirements to the estimated values, and make appropriate adjustments in resource allocations.

The basic equation for estimation is the similar in both cases:

$$\text{Development Time} = (\text{Number of Function Points}) \times (\text{Time per Function Point})$$

Or

$$\text{Development Time} = (\text{Program Size in Lines of Code}) \times (\text{Time per Line of code})$$

Without good initial input data, neither of these techniques will generate accurate estimations, which can be another risk to the schedule and ultimately the cost of the project.

Specific work packages should use data collected from previous projects to accurately compute the development time and adequately and accurately plan schedules and budgets.

Work packages shall define the output documents to be developed for each of the following life-cycle phases, in accordance with the requirements of the software plans:

- **Planning Phase**
- **Requirements Phase**
- **Design Phase**
- **Implementation Phase**
- **Integration Phase**
- **Validation Phase**
- **Installation Phase**
- **Operation and Maintenance Phase**

6.4 Dependencies

The SDP (this plan) Section 6.1 and SMP [2.1.1(3)] Figure 2 specify the methods used to develop work packages.

The Integrated Project Schedule by the Project Procedure [2.1.1(5)] defines all dependencies to interfacing organizations. Dependencies between work elements are defined and tracked using the scheduling methods defined in the Project Procedure [2.1.1(5)] and the PMM [2.1.1(1)].

6.5 Resource Requirements

The SMP [2.1.1(3)] specifies the organizational responsibilities for each member of the project team serving in a lead capacity.

The PMM [2.1.1(1)] Project Schedule and Project Cost Reporting processes define how start times, duration, and manpower loading across time are to be generated.

6.6 Budget and Resource Allocation

The PMM [2.1.1(1)] specifies the project scheduling and budgeting processes.