APPENDIX B – REQUESTS FOR ADDITIONAL INFORMATION

RAI-1:

Question:

Section 1 of WCAP-17079-P, "Supplement 3 to BISON Topical Report RPA 90-90-P-A SAFIR Control System Simulator," (hereafter Supplement 3) states:

> *…SAFIR is used in conjunction with BISON to model plant systems important to the balance-of-plant and thereby eliminate Condition 6 of the BISON topical report by demonstrating SAFIR is capable of modeling control systems consistent with the provisions of CENPD-300-P-A, "Reference Safety Report for Boiling Water Reactor Fuel."*

The staff interprets this statement to mean that SAFIR shall model control systems consistent with the provisions of CENPD-300-P-A. Please clarify if the staff interpretation is correct. [A.1]

Response:

The staff interpretation is correct. (RE: CENPD-300-P-A SER dated May 24, 1996 Condition 1: "Acceptability of this topical report is subject to review findings of the other relevant topical reports cited in the topical report, and all conditions set forth therein are applicable to this topical report. Furthermore, acceptability of reload analysis is subject to conditions cited in the methodology topical reports.")

The purpose of WCAP-17079-P, (Supplement 3) is to describe the process that is used to derive a plant control system model using SAFIR.

The intention here is to clarify that the control system model will be developed in the same way as any other plant system important to the balance of plant, and that SAFIR will be used to apply control systems to plant models according to the provisions of the NRC approved topical report methodology, for example, CENPD-300-P-A, Revision 0, "Reference Safety Report for Boiling Water Reactor Reload Fuel."

Further, the addition of new modeling components are internally reviewed and approved in accordance with the Westinghouse Quality Management System and documented according to Westinghouse internal procedures.

The Westinghouse Quality Management System (QMS) has been reviewed and approved by the USNRC and meets all requirements of 10 CFR Part 50, Appendix B as well as ISO-9001. All analysis and internal calculations, or in this case the addition of a new component, must be done in accordance with the Westinghouse QMS. [A.3]

Evaluation:

Section 1 of Supplement 3 states that the SAFIR methodology is capable of modeling control systems consistent with the provisions of CENPD-300-P-A, "Reference Safety Report for Boiling Water Reactor Fuel," [A.10]. The staff requested additional clarification of this statement in RAI-1. The response to RAI-1 confirms the staff's interpretation [A.3]. (NRR question)

Status:

Closed (adequately answered).

RAI-2:

Question:

Supplement 3 describes a process whereby additional components can be added to the litany of SAFIR models. While the steps of verification and validation have been provided in the licensing topical report (LTR), there are not specific acceptance criteria specified. The Standard Review Plan Section 15.0.2 (SRP Section 15.0.2), Subsection II.1.C directs the staff to review code assessment "success criteria." Please provide additional detailed information that describes the process by which a new component model is accepted. [A.1]

Response:

A new component has to have an output signal that may be compared to an analytical solution or the component has to perform the same fundamental mathematical operation as the code compiler. For a new component the uncertainty in output is quantified and is taken into account in the overall model uncertainty following the current methodology in CENPD-300-P-A. [A.3]

Evaluation:

The staff requested additional information regarding success criteria in RAI-2. The response to RAI-2 states that the approved process described by the RSR is used for SAFIR [A.3]. The staff finds this acceptable. (NRR question)

Status:

Closed (adequately answered).

RAI-3:

Question:

The SAFIR control system simulator appears to be best-estimate in nature based on the results of the validation provided in Supplement 3. Condition 6 in the staff's safety evaluation (SE) for BISON LTR (RPA 90-90-P-A) required conservative time-dependent boundary conditions in place of a detailed control system model. SRP Section 15.0.2, Subsection II.1.D directs the staff to review a sample plant uncertainty determination. Please describe how the uncertainties in the SAFIR model are treated in the safety analysis method for anticipated operational occurrences (AOOs). Supplement 3 states that SAFIR is capable of modeling control systems consistent with CENPD-300-P-A. In the response please describe how Section 7.3.3 of CENPD-300-P-A is applied to safety analyses performed using SAFIR with BISON. The response should also give consideration to highly complex control systems whereby biasing particular parameters in a certain direction may not be readily apparent as "conservative." To assist the staff in its understanding of the interface of SAFIR with the reload safety analysis process, please expand the discussion provided for one of the validation cases presented in Supplement 3, or another similar case, to provide a specific example of how the uncertainties are treated. [A.1]

Response:

The purpose of referring to the CENPD-300-P-A is to clarify that the control system model will be developed in the same way as the model of any other plant system important to the transient analysis, and that SAFIR will be used to apply control system inputs to plant models in accordance with the provisions of the NRC approved methodology, for example in the Reference Safety Report (CENPD-300-P-A). Therefore, uncertainties and justification of the models will be treated in the same way as any other plant model that is input to the licensing analysis according to current licensing methodology (see answer to RAI-16, STP Letter # U7-C-STP-NRC-100095, Scott Head to Document Control Desk, May 12, 2010).

In the safety analysis method for AOOs, the model uncertainty is typically accounted for in the form of a [[

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Uncertainties in SAFIR modeling parameters can be estimated from the comparison between SET data and SAFIR simulation of such SETs. The comparison between measurements and code predictions for the relevant modeling parameters yields either the distribution function of differences, or the mean bias and the standard deviation of the bias.

Example: Validation results against the plant data (SET) for the pressure controller of the [[ ]] plant are shown in Figures 6-78 through 6-81 in the topical report. [[

]] Comparison of the model output parameters (BAFR, BATT and APRM-Filter) yields the following probabilistic data:

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It should be noted that the examples in the Validation and Verification (V&V) presented in Supplement 3 were aimed to show the capability of SAFIR to model plant systems and comparisons were made against expected behavior and measurement data. In licensing applications conservative plant responses are modeled by altering the system response in a conservative manner, i.e. changing setpoints or the performance of critical functions in the model.

The control systems required and the complexity of these systems will be determined at the time of the application in connection to a License Amendment Request. Westinghouse will inform the NRC of a new application (for instance application of the methodology to a new plant type) and then an NRC audit would take place at the Westinghouse offices.

Currently, the NRC-approved uncertainty method A from Section 7.3.3 in CENPD-300-P-A is used in licensing applications. [[ ]] SAFIR modeling uncertainties will be addressed consistent with approved methodology for AOO uncertainty evaluation. [A.5]

<u>Evaluation:</u>

The response provided to RAI-3 demonstrates how the RSR uncertainty analysis process is applied for control systems simulated using SAFIR [A.5]. The staff finds that sufficient information has been provided in the response to RAI-3 to illustrate how the RSR uncertainty analysis processes are applied to SAFIR. (NRR question)

<u>Status:</u>

Closed (adequately answered).

RAI-4:

Question:

Provide a summary of the solution technique in SAFIR. Table 3-2 of Supplement 3 provides summaries of the time-dependent output for given pre-defined components. However, it is not clear to the staff if SAFIR numerical transforms specified transfer functions to the time domain or relies on programmed discrete numerical time-dependent responses similar to those provided in the table. Does SAFIR numerically transform the transfer functions and discrete those in time to calculate the time-dependent responses or does SAFIR use the time-dependent functions provided in the table directly? [A.1]

Response:

The time dependent functions as presented in Table 3-2 of Supplement 3 are implemented in SAFIR using discrete numerical representation of the time dependent functions. The output is calculated using an explicit calculation scheme. For example, the transfer function for an Integrator is

G(s)=K*(1/(sTI))

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Evaluation:

The staff requested additional information regarding the solution technique in RAI 4. The response to RAI-4 describes the numerical solution technique [A.4]. The staff finds that the solution technique and model equations have been adequately described in the LTR documentation and RAI-4 response. This information is consistent with the definition of a theory manual provided in SRP Section 15.0.2. (NRR question)

Status:

Closed (adequately answered).

RAI-5:

Question:

SRP Section 15.0.2, Subsection I.1 directs the staff to review the user's manual for transient analysis codes. Provide the SAFIR user's manual. [A.1]

Response:

The SAFIR code is the control system model used within the BISON code, and therefore does not have its own user's manual. The BISON user's manual can be made available for NRC staff review at Westinghouse's Rockville, MD offices. [A.3]

Evaluation:

The response to RAI 5 states that the SAFIR user manual is part of the BISON code documentation and is not maintained separately. The response further states that the documentation has been made available for staff audit [A.3]. The NRR staff and ERI conducted separate audits of the user manual, made available by Westinghouse at their local office and confirmed that it meets the applicable criteria in SRP Section 15.0.2.

These appear to provide adequate documentation of the transfer functions of each component; input and output signals; and input file format specification. However, ERI found that the documentation provides somewhat less in the way of user guidance in terms of selection of parameter values or recommended practice for building a new control system model. Clear and unambiguous user guidance is an important element of good user documentation, according to SRP Section 15.0.2.

The issue of user documentation was discussed with the applicant at the site audit. There, the applicant appeared to concede that the user's manual could be improved in its provision of guidance for users, but stated that Westinghouse gives its new users ample training by means of classes and guidance by experienced users of the code. ERI communicated its view that such information should be formally introduced into the manual in order to better meet the criteria for user's documentation mentioned in the SRP

Status:

Reviewers have identified some areas in which SAFIR user documentation could be improved by Westinghouse, as mentioned in the evaluation above. This has led to some recommendations in the conclusions section of the technical evaluation report, and the RAI can be considered closed.

RAI-6:

Question:

SRP Section 15.0.2, Subsection I.1 directs the staff to review the quality assurance program. Please provide additional details of the quality assurance program under which SAFIR was developed and maintained. Supplement 3, Sections 3, 4, and 5 refer to "Westinghouse standard quality assurance processes." Are these processes equivalent to procedures that have been approved or endorsed by the NRC staff as meeting the requirements of 10 CFR Part 50, Appendix B? In the –A version of the LTR, please add a clarifying statement to the effect that these processes must meet the requirements of 10 CFR Part 50, Appendix B. [A.1]

Response:

All quality assurance processes for code development and maintenance which was recently audited by NRC in connection to the POLCA-T review for Stability and CRDA applications is equivalent to procedures approved under the requirements of 10 CFR Part 50, Appendix B. The –A version of the LTR will be updated to clarify by adding the text which states, "…Westinghouse standard quality assurance processes which meet the requirements of 10 CFR Part 50, Appendix B." [A.3]

Evaluation:

The staff requested additional information regarding the details of the quality assurance process in RAI-6. The response to RAI-6 confirms that the code is maintained under an approved quality assurance process [A.3]. The staff conducted an audit of this process and found it acceptable as part of a separate review. For additional details regarding the staff's review see [A.11]. The staff finds that this information is sufficiently complete to address the procedures and controls under which the code is developed and assessed and the corrective action procedures. (NRR question)

Status:

Closed (adequately answered).

RAI-7:

Question:

Section 3.8 of Supplement 3 provides a specific example for the coupled use of SAFIR and BISON whereby certain outputs and inputs are communicated between the two. How often in terms of transient time steps in the transient code do these two codes interface. For example, is the SAFIR output updated every 10 transient time steps within BISON? For applications to other transient codes besides BISON please describe how an acceptable frequency of communication between the codes is determined and implemented. [A.1]

Response:

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The integration scheme between BISON and SAFIR is as follows.

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A similar process will be analyzed for use with other transient codes during the licensing evaluation of those codes. [A.3]

Evaluation:

The staff requested additional information regarding the coupling between SAFIR and BISON in RAI-7. The staff requested information pertaining to the frequency with which the two codes share information to clarify the information presented in Section 3.9 of Supplement 3. [[

]] Given that the sampling times reflect the condition of the plant control system components, or are set to values consistent with the transient analysis code, the staff finds that the methodology to account for the sampling time is acceptable. (NRR question)

Status:

Closed (adequately answered).

RAI-8:

Question:

Section 3.8 of Supplement 3 provides Table 3-1 that describes the Input/Output signal communication between BISON and SAFIR. The staff understands that SAFIR is compatible with other transient approved transient codes (e.g. POLCA-T). For the use of SAFIR within the context of other NRC-approved methods please describe how an equivalent table is generated. [A.1]

Response:

SAFIR communicates with the transient codes via the input and output signals, but the model of the various control system components are independent of the transient code. The input and output signal connections for other transient codes, such as POLCA-T, work in the same manner as the BISON SAFIR communication. An interface between the codes (in this case POLCA-T and SAFIR) is developed where the signals, such as shown in Table 3-1 of Supplement 3 but not necessarily limited to those listed in the table, are specified and translated into the corresponding POLCA-T signals. Hence, an equivalent table to Table 3-1 is generated by translating the BISON signals into POLCA-T signals. [A.3]

Evaluation:

The response to RAI-8 describes the process for SAFIR to transient code coupling by way of example [A.3]. An interface between alternative transient analysis codes (i.e. POLCA-T) and SAFIR is developed where the signals are specified and translated in the corresponding alternative transient analysis code signals. In effect, an equivalent table to Table 3-1 is generated by translating the BISON signals into the alternative transient analysis code signals. The staff finds that this translation approach is acceptable. (NRR question)

However, see also RAI-17, in which clarification was obtained that Westinghouse will seek approval separately for the use of SAFIR with codes other than BISON via future code-specific licensing submittals. The closure of RAI-8 is not meant to imply that recommendation of such approval is an outcome of the current technical review.

Status:

Closed (adequately answered).

RAI-9:

Question:

Section 3.11 of Supplement 3 states that a signal can only be connected to one single output. There may be measured plant signals for a plant-specific configuration that is used for multiple control system inputs. Please describe how such a configuration is modeled in SAFIR. As appropriate, please provide a specific example to assist the staff in understanding the approach taken. [A.1]

Response:

A SAFIR component calculates an output signal that has to be unique within the SAFIR model, i.e. there may not be two identically named output signals. The signal flow is from an output connection to one or several input connections. An output signal may be connected to several input connections to components as shown in Figure 1 below. A signal may not be calculated by more than one component as shown in Figure 2.

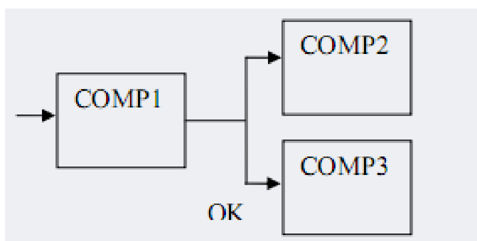

Figure 1 Examples of valid component connection

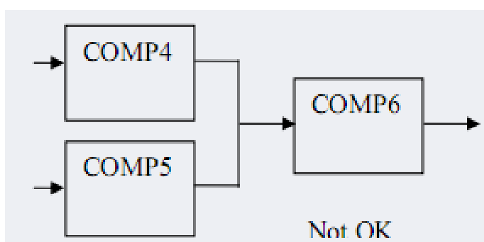

Figure 2 Example of invalid component connection [A.3]

Evaluation:

Section 3.11 specifies the limitations to SAFIR. Three general limitations are listed: (1) a signal can only be connected to one single output, (2) a model must have at least one input signal, and (3) an instance of a component must have a unique name within a model. The staff requested additional information in RAI-9 regarding the first limitation.

The response to RAI-9 states that the signal flow is from an output connection to one or several input connections. The uniqueness of the output signal is maintained if the output signal is connected in this way. A connection of more than one component to a single input connection would destroy the uniqueness of the input signal [A.3].

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The staff finds this description of how configurations, that utilize a single input signal for several control systems in SAFIR, is acceptable. (NRR question)

Status:

Closed (adequately answered).

RAI-10:

Question:

Section 3.11 states that all instances of a component must have a unique name within a model. How many characters are allotted to name a component within a model? If such a character limit exists, does it pose a challenge in terms of simulating a sufficient number of components within a detailed transient analysis model? [A.1]

Response:

A component may be named using any combination of characters; the current limit is 72 characters and doesn't pose any limitations in terms of simulating a sufficient number of components. Therefore there is no challenge to simulating the number of components within a detailed transient analysis model. [A.2]

Evaluation:

The staff requested that Westinghouse describe how configurations that utilize a single input signal for several control systems are modeled in SAFIR. The staff requested additional information regarding the third limitation in RAI-10. The staff requested that Westinghouse specify the limit to the number of component names that may be input in a model as to clarify if this limitation presents a secondary limitation on the number of components that may be modeled within a single control system model.

The response to RAI-10 states that a component may be named using any combination of 72 characters [A.3]. This allows for 72! (72 factorial) names and the staff finds this more than adequate. (NRR question)

Status:

Closed (adequately answered).

RAI-11:

Question:

Section 3.8 of Supplement 3 states that new input or output connectors may be added to the code using the standard code update procedures. Section 4.1 of Supplement 3 includes similar language for the addition of a new component. The staff requires clarification of this statement. First, do the referenced code update procedures meet the requirements of 10 CFR Part 50, Appendix B in terms of quality assurance? Second, please provide some details regarding the type of documentation required to implement a new connector and/or component and verify that this documentation is maintained in an auditable manner. [A.1]

Response:

Westinghouse software is developed and maintained in accordance with the Westinghouse Quality Management System (QMS). The QMS meets the applicable requirements of the United States Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Appendix B and ASME NQA-1-1994 Edition, Part 1, Supplement 11S-2 and Part II, Subpart 2.7.

The Westinghouse Quality Management System (QMS) has been reviewed and approved by the NRC and meets all requirements of 10 CFR Part 50, Appendix B as well as ISO-9001. All analysis and internal calculations, or in this case the addition of a new input or output connectors, must be done in accordance with the Westinghouse QMS. [A.3]

Evaluation:

According to the response to RAI-11, Westinghouse software is developed and maintained in accordance with the Westinghouse Quality Management System (QMS) [A.3]. The QMS meets the applicable requirements of the United States United States Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Appendix B and ASME NQA-1-1994 Edition, Part 1 Supplement 11S-2 and Part II, Subpart 2.7. The Westinghouse Quality Management System (QMS) has been reviewed and approved by the NRC; and meets all requirements of 10 CFR Part 50, Appendix B as well as ISO-9001. All analysis and internal calculations, or in the case of the addition of a new input or output connectors, must be done in accordance with the Westinghouse QMS. The staff finds this approach acceptable. (NRR question)

Status:

Closed (adequately answered).

RAI-12:

Question:

When new components are developed, must the transfer functions have analytical solutions? Section 4.1 of Supplement 3 states that any components added to SAFIR in the future must consist of a simple transfer function. Please describe more specifically what is meant by the term "simple". [A.1]

Response:

Westinghouse will, if needed, incorporate new components that can be verified based on an analytical solution. New components that perform a mathematical operation can also be added to SAFIR based on mathematical functions provided by the code compiler. An example is the logarithmic function.

Transfer functions are not required to have analytical solutions. [[

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The process by which a new component will be verified is governed by the Westinghouse Quality Management System (QMS). [A.2]

Evaluation:

According to the response to RAI-12 [[

]] The staff finds the clarification acceptable. (NRR question)

Status:

Closed (adequately answered).

RAI-13:

Question:

Section 4 of Supplement 3 refers to "empirical" component models that are essentially tuned to plant data. When such models are developed for inclusion in SAFIR, please describe how the addition is consistent with the requirement that the transfer function be "simple."

Additionally, when empirical models are developed, it is likely that such models would be tuned to plant data over a specific range of plant or control system conditions. Please specify how the assumptions, validation range, and limitations of an empirical component model are documented. Additionally, please describe how these aspects of the empirical component model are tracked in the Westinghouse safety analysis process to ensure that the model is implemented appropriately for the transient analyses. [A.1]

Response:

Westinghouse will, if needed, incorporate new components [[ ]] according to the answer to RAI-12. New components that cannot be classified as simple will be treated as a complex component. Examples are a fuzzy controller or an empirical component. The assumptions, validation range, and limitations of such a component depend on the nature of the function. The verification and validation process including documentation for such component is identical to the process to verify and validate a SAFIR model as described in Section 5 of Supplement 3. [A.2]

Evaluation:

According to the response to RAI-13, Westinghouse will, if necessary, incorporate new components [[

]] The assumptions, validation range, and limitations of such a component depend on the nature of the function. The verification and validation process, including documentation for such components is identical to the process to verify and validate a SAFIR model as described in Section 5 of Supplement 3. The staff finds this acceptable. (NRR question)

Status:

Closed (adequately answered).

RAI-14:

Question:

On a plant-specific basis, when new component models are employed in the safety analysis, please confirm that the Westinghouse Reload Safety Evaluation provides sufficient information, either directly or by reference, for the licensee to independently verify that the new component model was developed and implemented consistent with the process described in the LTR and quality assurance procedures that comply with the requirements of 10 CFR Part 50, Appendix B. Please provide a statement in the –A version of Supplement 3 to this effect. [A.1]

Response:

The Westinghouse Reload Safety Evaluation is presented in WCAP-9272-P-A, and is applicable to pressurized water reactors. For boiling water reactors the reload specific safety methodology is described in CENPD-300-P-A. In CENPD-300-P-A there is an example of a reload safety analysis for a plant specific basis called the Reload Safety Analysis Summary Report. The Reload Safety Analysis Summary Report does not address the addition of new control system components as this is below the level of detail that is described. The addition of new components is internally reviewed and approved in accordance with the Westinghouse Quality Management System.

The Westinghouse Quality Management System (QMS) has been reviewed and approved by the USNRC (WCAP-12308). The Westinghouse QMS meets all requirements of 10 CFR Part 50, Appendix B as well as ISO-9001. All analysis and internal calculations, or in this case the addition of a new component, must be done in accordance with the Westinghouse QMS. [A.2]

Evaluation:

RAI-14 the staff requested that Westinghouse confirm that cycle-specific reload safety analyses include sufficient information for licensees to verify that component models included in SAFIR have adhered to the approved V&V process.

The response to RAI-14 clarifies that the Reload Safety Analysis Summary Report, WCAP-9272-P-A for PWRs and CENPD-300-P-A for BWRS, does not contain the level of detail that is necessary to address the addition of new control system components. However, the addition of new components is reviewed and approved in accordance with the Westinghouse Quality Management System [A.2]. The staff has approved the QMS and finds this adequate. (NRR question)

Status:

Closed (adequately answered).

RAI-15:

Question:

NUREG-0800, Section 15.0.2, Subsection II.1 requires that "[t] the submittal must identify the specific accident scenarios and plant configurations for which the codes will be used. The evaluation model documentation must be scrutable, complete, unambiguous, accurate, and reasonably self-contained."

WCAP-17079-P states that "SAFIR is capable of modeling control systems consistent with the provisions of CENPD-300-P-A" and also states "SAFIR is capable of modeling various types of transients which include, but not limited to, Load Rejection, Turbine Trip, Core Power or Pressure changes, and valve failures."

CENPD-300-P-A states in Table 1-1 that BISON is used in the Westinghouse reload methodology to analyze AOO fast transients. Section 7.4 of the same document lists the fast transients as:

- Generator Load Rejection Without Bypass
- Turbine Trip Without Bypass
- Feedwater Controller Failure - Maximum Demand
- Pressure Regulator Failure - Closed (BWR/6 only).

The material in WCAP-17079-P does not satisfy the requirements. First it addresses SAFIR and not the subject of the WCAP-17079-P – the evaluation model comprising BISON coupled with SAFIR (i.e., BISON-SAFIR). Secondly, it suggests an open-ended application rather than specifying the limits of applicability called for in the requirement.

State whether the set of transient events for which BISON-SAFIR will be used is the same as that defined in CENPD-300-P-A. If there are any additional transient events for which BISON-SAFIR is intended to be used beyond the set originally defined for BISON, and then describe in accordance with the requirement the additional transients events for which BISON-SAFIR will be used. [A.1]

Response:

The objective of the SAFIR Licensing Topical Report is to obtain generic NRC approval for the process to develop control system models for licensing applications. The specific transient analysis methodology has been independently submitted to the NRC for review and approval and is not considered a part of the approval of the SAFIR.

Westinghouse currently simulates the effects of control systems by conservative time-dependent boundary conditions. Conservative control system models can also be developed by using SAFIR. Please see answer to RAI-16.

The intention of WCAP-17079-P is to replace the method of modeling boundary conditions in NRC approved transient methods such as BISON, with a more flexible and robust method using SAFIR code. SAFIR will be used in conjunction with transient analysis codes approved by the

NRC, such as the currently approved BISON, or with POLCA-T (once reviewed and approved by the NRC for transient analysis). The combined codes (for example BISON-SAFIR), will be used with NRC approved analysis methodologies, such as the AOO's described in chapter 5 of CENPD-300-P-A, for performing plant specific transient licensing evaluations.

The quoted statement in WCAP-17079-P, "SAFIR is capable of modeling various types of transients which include, but is not limited to, Load Rejection, Turbine Trip, Core Power or Pressure changes, and valve failures." is an incorrect statement as SAFIR does not model transients. It will be modified in the final version of the topical report to state: "SAFIR is capable of modeling time-dependent boundary conditions for various types of transients which include, but are not limited to, Load Rejection, Turbine Trip, Core Power or Pressure changes, and valve failures."

The following is an illustrative example of the application of the approved BISON methods in conjunction with the SAFIR control system methods for an ABWR plant. The transient event failure in the feedwater controller requesting maximum feedwater flow is simulated below. [[

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A brief description of SAFIR models used during an example transient (Feedwater Controller Failure – FWCF) and the main connections between models is presented in Figure 1. The analysis results, as calculated in BISON, shown in Figures 2 through 7, demonstrate the capability of BISON-SAFIR methods to determine a transient scenario.

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The example case is initiated by limiting the output signal from the feedwater controller to maximum demand at time equal to 1 second, see Figure 2. The disturbance is applied to the feedwater controller (SAFIR) that calculates the feedwater flow to be used by BISON.

Figure 3 illustrates the behavior of the recirculation pump operation and flow characteristics during the transient. [[

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Figure 4 shows an increase in feedwater flow will also raise the water level and reduce the temperature of the coolant flow (sub-cooling) in the BISON RPV model.

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Evaluation:

Inadequate. The RAI asked STP to identify specific accident scenarios and plant configurations for which BISON-SAFIR will be used. STP responded with some details regarding a transient previously analyzed, but did not provide the information requested. The information provided by STP is non-responsive to the request.

Follow-up Question:

Since the topical report WCAP-17079-P is being reviewed using the standards described in NUREG-0800, (SRP) Section 15.0.2, "Review of Transient and Accident Analysis Methods", the subject of which is a transient evaluation model rather than an individual computer code, approval cannot be granted to SAFIR generically but only to an appropriately documented evaluation model employing SAFIR (e.g., BISON, SAFIR, and any other codes or procedures necessary to perform the complete analysis).

Among the other requirements of NUREG-0800, Section 15.0.2, Subsection II.1 requires that

> *[t]he submittal must identify the specific accident scenarios and plant configurations for which the codes will be used. The evaluation model documentation must be scrutable, complete, unambiguous, accurate, and reasonably self-contained.*

WCAP-17079-P states that

> *"SAFIR is capable of modeling control systems consistent with the provisions of CENPD-300-P-A" and also states "SAFIR is capable of modeling various types of transients which include, but not limited to, Load Rejection, Turbine Trip, Core Power or Pressure changes, and valve failures."*

CENPD-300-P-A states in Table 1-1 that BISON is used in the Westinghouse reload methodology to analyze AOO fast transients. Section 7.4 of the same document lists the fast transients as:

a) Generator Load Rejection Without Bypass
b) Turbine Trip Without Bypass
c) Feedwater Controller Failure - Maximum Demand
d) Pressure Regulator Failure - Closed (BWR/6 only)

The material in WCAP-17079-P does not satisfy the requirements. First it addresses SAFIR and not the subject of the WCAP-17079-P – the evaluation model comprising BISON coupled with SAFIR (i.e., BISON-SAFIR). Secondly, it suggests an open-ended application rather than specifying the limits of applicability called for in the requirement. The response to RAI-15 neither identified a list of specific accident scenarios nor confirmed that the original scenario list described in CENPD-300-P-A would remain unaffected by the addition of SAFIR to the evaluation model.

State the set of transient events for which BISON-SAFIR will be used. [A.6]

<u>Follow-up Response:</u>

The original scenario events as described in CENPD-300-P-A are unchanged with the addition of WCAP-17079-P. The events in Section 7.4 of CENPD-300-P-A are:

a) Generator Load Rejection Without Bypass
b) Turbine Trip Without Bypass
c) Feedwater Controller Failure – Maximum Demand
d) Pressure Regulator Failure – Closed (BWR/6 only)

These events will continue to be evaluated as outlined within CENPD-300-P-A. [A.8]

<u>Follow-up Evaluation:</u>

This response is considered acceptable.

<u>Status:</u>

Closed (adequately answered).

RAI-16:

Question:

NUREG-0800, Section 15.0.2, Subsection II.1 requires that the documentation include "[a]n overview of the evaluation model", "[a] complete description of the accident scenario", "and [a] complete description of the code assessment", and "[a] determination of the code uncertainty".

WCAP-17079-P does not clearly present the evaluation model. It does not relate the SAFIR control system models to a description of the accident scenarios (see RAI 15). It does not present a code assessment in terms of the union of BISON-SAFIR. It does not address any changes to the uncertainty from having introduced SAFIR into BISON.

a) Provide an overview of the evaluation model, a complete description of the accident scenario(s), a complete description of the code assessment, and a determination of the code uncertainty. Identify in each response the contributions to changes that are introduced by incorporating SAFIR into BISON. If any of these items are unchanged from previous submittals then so state in the response and refer to the location of these items in such submittals.

b) Specify all of the individual ABWR structures, systems and components (SSCs) that will be modeled using BISON-SAFIR. (Note: SSCs refers to ABWR systems as defined in the DCD (e.g., Reactor Protection System (RPS), Steam Bypass and Pressure Control System (SB&PCS), Rod Control and Information System (RCIS), etc.) as well as to other ABWR elements that are not referred to as systems (e.g., RIPs, diesel/generators, combustion turbine generator, motor-generator set, etc.)). [A.1]

Response:

a) The SAFIR LTR addresses only the process that is used to verify and validate SAFIR generated control systems and logical functions to be used as input for the transient analysis and provides the information requested by the NRC in a SER condition to the BISON LTRs for modeling control systems for licensing purposes. The lack of this information resulted in the mentioned SER limitation in the BISON LTR to the use of control system models for licensing applications.

   The methodology for transient analysis itself is described in the transient analysis code LTRs (RPA 90-90-P-A and later supplements for BISON or WCAP-16747-P for POLCA-T) and in Reference Safety Report CENPD-300-P-A, Section 7, Appendices D and E including uncertainties to be applied. Today Westinghouse simulates the effects of control systems by conservative time-dependent boundary conditions. In the same way conservative control systems models can be developed by using SAFIR.

   Uncertainties and justification of these models will be treated in the same way as any other plant model that is input to the licensing analysis according to current licensing methodology.

   The objectives of the SAFIR LTR are to obtain generic NRC approval for the process to develop control systems models for licensing applications. The specific transient analysis methodology has been independently submitted to the NRC for review and approval and is not considered a part of the approval of the SAFIR LTR.

It should be noted that at the time of the BISON LTR submittals the RG 1.203 was not published yet and therefore the recommendations of the RG were not strictly applied in the development of LTR submitted before 2007. A more up to date description of the transient evaluation model is being included by Westinghouse in the recent applications for POLCA-T and ABWR related LTRs.

b) The control systems required for an application will be determined according to the methodology described in the Reference Safety Report (RSR, CENPD-300-P-A) at the time of the application in connection with a specific License Amendment Request. The SAFIR LTR examples of the ABWR control systems and logical functions are included to demonstrate applicability to the ABWR plant design. Due to the plant design similarities, both Hamaoka 5 and [[ ]] are considered technically relevant examples of applicability to ABWR.

Examples of the ABWR SAFIR control system modeling is presented in Section 6.2 of the subject LTR. When new control system and logical functions are required, new control system and logical functions will be developed in accordance with the process and documentation requirements specified in the SAFIR LTR and the conditions imposed in the independently submitted transient analysis methodology. [A.4]

<u>Evaluation:</u>

ERI has been tasked to review the LTR against SRP Section 15.0.2. This is logical because the subject report is clearly used in transient and accident analysis for licensing purposes. Such a review entails review of evaluation model (EM - in this case BISON-SAFIR). The review may use a graded approach in the case of “small changes.” However, even if this is termed a small change it must be considered against the four (4) criteria in Section III.6 of 15.0.2 to determine the extent: novelty, complexity, degree of conservatism, and extent of reanalysis. Once the extent is established by the reviewer the attributes of the application reviewed are still the same (e.g. documentation, validation, uncertainty analysis, etc.); it is only the extent of the review that is potentially reduced.

STP’s response to parts (a) does not provide sufficient information to permit a review of the LTR against SRP Section 15.0.2.

STP’s response to parts (b) does not provide sufficient information to determine what ABWR SSCs will be modeled in BISON-SAFIR.

Thus we are unable to determine whether the EM is sufficiently equipped to support the STP fuel amendment.

While it is possible that this issue may be resolved in the detailed documentation of a BISON-SAFIR example, as promised by STP to address other questions, the review of BISON-SAFIR requires a review of the EM under SRP Section 15.0.2. Therefore, a follow-up question may become necessary depending on the content of this future response.

Follow-up Action:

RAI-16S001 and the response is given in the letter dated December 6, 2011 (U7-C-STP-NRC-100251 (A..9)

Follow-up Evaluation:

The STP/Westinghouse response based on the discussion of this RAI was comprehensive and was accomplished by presenting the analysis of two transient scenarios (i.e., Load Rejection Without Bypass and Feedwater Controller Failure). The first of these two scenarios employed SAFIR to model the generation of signals related to TCV closure, scram, RIP trip, control rod insertion, and SRV opening. The second scenario also featured use of SAFIR functionality to model feedwater addition through the use of a tabular function. The audit team was able to view sections of the SAFIR code input pertaining to these modeled systems and how they were interfaced with BISON system variables. Presentation of the results by Westinghouse walked the audit team through the event progression, verifying that the response of SAFIR models and overall system behavior was in accordance with expectations. It is the view of the auditors that the STP/Westinghouse presentations adequately addressed the concerns that prompted part (a) of RAI-16. For the reasons explained above, part (b) of this RAI can be considered adequately addressed in view of the applicant's response to RAI-36S01.

Status:

Closed (adequately addressed by the answers to this question and to RAI-36S01).

RAI-17:

Question:

The last paragraph of WCAP-17079-P, Section 2.2 states "In this case BISON is the transient code interacting with SAFIR, but other dynamic BWR codes that are approved for application by the NRC may be used provided the model development and verification and validation process is followed."

How would the approval of SAFIR by NRC for use with BISON impact the intended applications of SAFIR coupled with other dynamic BWR codes? Specifically, do you plan to submit for NRC review, the technical basis for application of SAFIR with other dynamic BWR codes? Please elaborate and identify the candidate codes. [A.1]

Response:

The SAFIR code is developed as a generic tool and Westinghouse intends to use it for modeling control system and logical functions coupled to other dynamic codes that are approved by the NRC. SAFIR will be shown in future licensing submittals for the appropriate code to correctly interact with transient codes as defined in RAI-8.

One code we plan to submit for application with SAFIR is POLCA-T. The POLCA-T LTR Appendix C, planned for submittal in September of 2010, will include a description of connection between SAFIR and POLCA-T and will refer to BISON Supplement 3 for the description of SAFIR. Any additional codes in the future would be submitted for NRC approval. [A.3]

Evaluation:

The response states that SAFIR application to other codes would be addressed in future submittals. This appears to agree with the understanding that the current LTR only seeks approval for use of SAFIR with BISON. Therefore, at this time additional documentation pertaining to other computer codes would not be required. However, this also means that the evaluation of SAFIR will be performed with respect to the use of SAFIR with the BISON computer code only, and this evaluation should not be construed to apply to SAFIR use with any other computer codes beyond those previously identified in the staff's Final Safety Evaluation (ML100780156) for WCAP-16747-P, "POLCA-T System Analysis Code with Three Dimensional Core Model". [A.5]

Status:

Closed (adequately answered).

RAI-18:

<u>Question:</u>

Section 15.0, Subsection I.6.C of NUREG-0800 states that the reviewer should ensure "that the applicant has discussed the evaluation model used and any simplifications or approximations introduced to perform the analyses and identified digital computer codes used in the analysis. If the analysis uses more than one computer code, the applicant should describe the method used to connect the codes." SRP Section 15.0 I.6.C (i) also states that "(i)f the analysis uses more than one computer code, the applicant should describe the method used to connect the codes."

Westinghouse has stated in WCAP-17079-P that "SAFIR is a code package containing a selection of standard control components and logical functions that can be coupled for use with any transient code." Furthermore, "SAFIR is a stand-alone modeling tool for simulation of plant systems, including control systems, in conjunction with approved transient modeling codes such as BISON."

a) Describe the method used to connect BISON and SAFIR. In this regard, describe whether this new connection removed any previous functionality of BISON. Section 3.8 of WCAP-17079-P only describes input and output signals shared between the codes.

b) Originally BISON, along with the hot channel analysis code SLAVE, were approved for licensing of reload transients used in fuel reload analysis. Describe how SAFIR affects the hot channel analysis performed using BISON-SLAVE. Describe any input and output signals shared directly between SLAVE and SAFIR.

c) Demonstrate that the introduction of the SAFIR capability has not changed the previously approved performance capability of BISON-SLAVE (i.e., that an input to BISON-SAFIR that uses no SAFIR components performs identically to the same input to the previously approved BISON code).

d) ABWR systems will employ a variety of digital systems to monitor and actuate safety SSCs. These digital systems operate in a certain time domain or frequency. Does SAFIR operate in the time domain or frequency domain (given that transfer functions in the frequency domain are also listed in Table 3-2 of WCAP-17079-P)? Describe how the BISON-SAFIR time or frequency domain relationship is selected to replicate the performance of the real system. Describe testing performed under the Westinghouse Quality Assurance Program (WQAP) to demonstrate the appropriateness of this relationship.

e) WCAP-17079-P does not describe or document the use of SAFIR to model a safety system. However, such safety systems were modeled in previous submittals relating to BISON.

   For each ABWR safety system that is intended to be modeled using the newly integrated SAFIR capability, demonstrate that the chosen modeling method provides acceptable performance in BISON-SAFIR.

f) Section 7 of RPA 90-90-P-A provides a description of the transient time-step advancement algorithm of BISON. Describe how the calculations performed by SAFIR fit into this algorithm when the code is coupled with BISON.

g) Section 3.11 of RPA 90-90-P-A discusses the numerical solution procedure for steady-state calculations in BISON, while Section 3.7 of WCAP-17079-P describes SAFIR signal initialization. The concern exists that the steady-state solution prescribed to SAFIR at the start of the transient calculation may not be consistent with the actual BISON steady-state result. Describe whether and how the incorporation of SAFIR alters the numerical solution procedure for steady-state calculations in the combined BISON-SAFIR. In particular, demonstrate how consistent and correct steady-state values are obtained for the state variables shared between BISON and SAFIR.

h) The comments column to Table 3-1 of WCAP-17079-P indicates that the values of certain parameters (e.g., recirculation pump speed, feedwater temperature, etc.) cannot be set in steady-state. In light of the issues discussed in RAI18 (g), elaborate upon how the initial values for these parameters are established.

i) Section 3.9 of WCAP-17079 provides some limitations on the SAFIR sampling time (TS) size for simulated digital and analog systems:

- *For a digital control system the requirement on individual component sampling time shall be that of the real plant component.*

- *For an analog control system the sampling time shall not be longer than the transient code time step.*

Furthermore, in Table 3-1 of WCAP-17079, transient code (i.e., BISON) time step size is not explicitly listed as part of the BISON output signal set in the BISON-SAFIR interface.

i. SAFIR components may be used to model plant elements that are not control systems, whether of a digital or analog type (e.g., the mechanical model of turbine angular velocity as a function of steam flow rate, as described in the example of Section 6.1 in WCAP-17079). The excerpt quoted above does not cover how sampling time is determined for such systems. What limitations or guidelines govern SAFIR sampling time selection for such components?

ii. Describe in fuller detail how the SAFIR sampling time for digital and analog components is selected when the code is coupled with BISON. Does SAFIR obtain its sampling time from BISON, or is it input separately by the user? Do changes during a calculation in BISON's time-step size affect the SAFIR's sampling time, or vice-versa?

iii. Are the BISON time step size and SAFIR sampling time forced to be identical, or are they independent? If independent, describe how interface variable values are obtained, given that one code may demand the value of a variable at a point in problem time that is not necessarily defined by the other code (without means such as interpolation).

iv. Since the sampling time for simulated digital components (as described above) appears to be fixed by the design properties of the real components, does this place new constraints upon the BISON time step size in modeling ABWR digital systems with the combined BISON-SAFIR? If there are such new time step constraints, describe their impact upon BISON-SAFIR results and demonstrate that the results are not adversely affected as compared with a comparable calculation not using SAFIR.

v. In an algorithm for the solution of a system of time-discrete differential equations, the accuracy of the calculated results generally increases with decreasing time step size. Of the ABWR digital systems to be modeled using SAFIR, demonstrate that the real component sampling period (which, according to the above, must be identical to the SAFIR sampling time) is not so large as to significantly degrade the accuracy of the BISON-SAFIR solution as compared with a comparable calculation performed without SAFIR; or, if there is any loss of accuracy due to digital systems sampling time in SAFIR, justify the impact of this factor upon the validity of the coupled code's results.

j) If invalid values of input variables were to be passed through an interface between two codes, then, absent explicit error-checking at the interface, validity of the results could not be assured, and the fault would not necessarily be obvious from analysis of the results. (For example, if the value of an input signal obtained from BISON were to fall outside the range of an input table of a PROF component in SAFIR). Describe any input variable error-checking performed at the BISON-SAFIR interface to prevent this type of fault, or any input signal domain error checking performed in SAFIR that might render them inapplicable.

k) One of the requirements in Section 4.4.1.2 states "There is an input that determines the time constant for integration. This time constant may not be smaller than TS, or, or it will automatically be set equal to TS." This is an inappropriate assumption. The time constant for integral controller is an inherent property of the controller; therefore, arbitrary resetting this time to the integration time-step in non-physical/incorrect. Please elaborate. [A.1]

<u>Response:</u>

a) [[

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b) The SLAVE code is a Westinghouse method to determine transient response within a single fuel bundle. The code is typically used to predict the transient response of the hot fuel bundle and compare it to the thermal limits such as Critical Power Ratio and Linear Heat Generation Rate. The BISON code is used to simulate the global core response and consists of various types of plant systems models for simulating transients. [[

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c) [[

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d) SAFIR operates only in the time domain and the implemented transforms from Table 3-2 in Supplement 3 are the discrete formulation. Laplace transformations are only provided as additional information with the intention to make it easier to recognize the desired functionality.

e) The introduction of SAFIR facilitates the modeling of measurement systems and trip limits that are otherwise given as input to BISON, as described in answer to RAI-20. BISON safety systems, such as the control rod insertion model, are not affected by SAFIR: see RAI-21 (STP Letter # U7-C-STP-NRC-100089, Scott Head to Document Control Desk, Mary 12, 2010).

f) The BISON time-step advancement algorithm is unaffected by the introduction of SAFIR capabilities in BISON. The BISON code advances in time using the integration method as described in Section 7 of RPA 90-90-P-A. The integration scheme between BISON and SAFIR is explained in the answer to RAI-7 (STP Letter # U7-C-STP-NRC-100089, Scott Head to Document Control Desk, May 12, 2010).

g-h) [[

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i)

i. [[

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ii. Digital components are simulated by the user supplied sampling time of the real component as input to each SAFIR component. SAFIR components without an assigned sampling time will use the transient code time step size as sampling time. Simulation of analog functions may be performed either by using SAFIR components without any specified sampling time and updated at each timestep or by a sampling time shorter than the timestep specified for the transient code. The integration scheme and the update of SAFIR components are described in the answer to RAI-7.

iii. [[

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iv. The use of SAFIR to generate transient boundary conditions introduces no new time step constraints upon the BISON time step size.

v. The SAFIR code does not involve any advanced functions that restrict the time step or the sampling time due to numerical reasons. The code does not solve any equations using an iterative calculation method. The transfer functions are implemented using an explicit calculation scheme where the output is calculated using the input and the old states without iteration. Note that the code also restricts the use of time constants that are not valid for certain components. As an example, the integrator is not allowed to have an integration time constant smaller than the components sampling time. Consequently, the accuracy of the components, evaluated using time-discrete differential equations, does not depend on the real digital components sampling time.

j) See RAI-30. The response to RAI-30 was provided in STP Letter # U7-C-STP-NRC-100089, Scott Head to Document Control Desk, May 12, 2010.

k) [[

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Evaluation:

The responses to RAI-18(a), (b), (g), (h), (j), and (k) are acceptable.

RAI-18(c) asked STP to demonstrate that the evaluation model using BISON-SAFIR reproduces acceptable results compared to the evaluation model used with BISON-SLAVE using similar input. Instead of answering the question, STP explained the separation of SLAVE and SAFIR. The information provided is non-responsive to the request.

RAI-18(d) requested information pertaining to the ability of SAFIR to model real ABWR system performance of SSCs. STP responded by describing operation of SAFIR [[ ]] The information provided is non-responsive to the request.

RAI-18(e) pointed out that WCAP-17079-P does not describe the use of SAFIR to model a safety system and that previous submittals did. The RAI then requested that "for each ABWR safety system that is intended to be modeled using the newly integrated SAFIR capability, demonstrate that the chosen modeling method provides acceptable performance in BISON-SAFIR." STP responded with a reference to RAI 20 and RAI 21. The information provided is non-responsive to the request.

RAI-18(f) and (i) asked for further details on the transient timestep control algorithm used when BISON and SAFIR are used in conjunction with one another. STP answers with new information as well as references to the previous response to RAI-7 and to RPA 90-90-P-A. These responses largely address the concerns in the RAIs. However, the independence of BISON and SAFIR timestep selection raises some minor question concerning how interface variables are obtained when timesteps may be "staggered" (i.e., timestep boundaries are not synchronous in the two codes). This requires a follow-up RAI.

Follow-up Action:

c) In continuing discussion on this part of the question, it was decided to make it a subject of the site audit. STP/Westinghouse addressed this item during the audit by presenting results from several variants of BISON-SAFIR simulation of the Peach Bottom Turbine Trip transient. In these variants several functions were simulated alternatively using either BISON models or SAFIR models. Comparisons of the results provided confidence that the introduction of SAFIR functionality has not by itself changed the underlying behavior of the BISON code, and also that the SAFIR modeling of simple systems demonstrated in this example (i.e., scram signal generation and control rod insertion) yield results nearly identical to results using solely BISON.

d,e) The response to RAI-36S01 resulted in a list of top-level systems (rather than individual SSCs) to be modeled using SAFIR, which was considered to be an adequate response. Presentations made at the site audit demonstrated that SAFIR models of these systems yielded adequate results compared to other code results and/or expected plant response.

This is considered by the reviewers to satisfy the intent of these parts of the original RAI-18(d,e).

f,i) Regarding the staggering of timesteps, Westinghouse revealed how the old and new data are obtained in signals transmitted from BISON to SAFIR across the data interface. SAFIR uses the current state of the interface variables calculated by the transient code. To determine the values of the interface variables in between two adjacent BISON timesteps, interpolation is used. This is considered an acceptable answer to the one concern remaining in these parts of the original RAI-18(f,i). [A.7]

<u>Follow-up Evaluation:</u>

The applicant's RAI response (to this question as well as to RAI-36S01), together with the information obtained at the site audit, are considered to form an acceptable response to all parts of the question.

<u>Status:</u>

Closed (adequately addressed).

RAI-19:

Question:

The previously approved BISON code (RPA 90-90-P-A and CENPD-292-P-A) contains the following component/system models:

a) Reactor Internal Pump model,

b) Steam Line model (RPA 90-90-P-A) or PARA Steam Line model (CENPD-292-P-A),

c) Trip System model,

d) Reactor Scram model,

e) Turbine and Generator model,

f) Feedwater System model, and

g) Relief and Safety Valve model.

Describe which aspects of the above models are affected by the introduction of SAFIR code. Provide a summary table explaining modifications to the originally approved BISON models (similar to Table 2-1 of CENPD-292-P-A).

Where BISON-SAFIR code models for these components/systems are different from the previously approved BISON models, provide documentation of the qualification analysis, uncertainty analysis, and applicability range for the new BISON-SAFIR models, or establish that the new models yield results not significantly different from those of the approved BISON models. [A.1]

Response:

Figure 1 of the response to RAI-15 shows a description of an ABWR model and the interaction of SAFIR with BISON. RAI-15 (Figures 3, 5 and 6) shows examples of BISON responses (recirculation pump speed, steam line flow, and control rod insertion) with SAFIR calculated boundary conditions.

SAFIR provides the boundary conditions for BISON models but does not interact with the numerical solution of any of these BISON models approved in RPA 90-90-P-A and CENPD-292-P-A. As described in RAI-15 and RAI-20, BISON calculations are done outside of SAFIR. Start and stop signals may also be generated by SAFIR and transmitted to BISON. Again BISON approved models will not be changed from the originally approved documents and are not affected by the introduction of SAFIR. [A.5]

Evaluation:

The RAI requested the applicant to describe the aspects of various BISON models affected by the introduction of SAFIR. The response states that only the boundary conditions to the BISON models are provided by SAFIR and SAFIR does not interact with the numerical solution of BISON models. However, the RAI also requested a tabular summary of the changes to the identified BISON models. The response failed to explain how the boundary conditions modeled using SAFIR compares with the original BISON modeling approach.

Furthermore, from the explanation provided in a response to RAI-15, it appears that SAFIR is not only used to provide boundary conditions (such as tabulated time dependant function), but that there is time-dependent feedback between the internal state variables used by BISON and by SAFIR. Therefore, the RAI response statement that SAFIR does not interact with the numerical solutions of the BISON model is not correct. This requires a follow-up RAI.

Follow-up Action:

RAI-19S001 and the response is given in the letter dated December 6, 2011 (U7-C-STP-NRC-100251 (A.9)

Follow-up Evaluation:

The information provided in response to the original and follow-up RAIs (including the sample calculations included in the response to follow-up RAI-16S001) by STP is considered sufficient to address the concerns prompting the question.

Status:

Closed (adequately addressed by alternate means).

RAI-20:

Question:

The existing reactor protection system in the BISON code provides for modeling of reactor trip due to:

a) High neutron flux,
b) High steam dome pressure,
c) Low core flow rate,
d) High or low reactor water level, and
e) Low reactor pressure.

Identify and describe the input models for any of these trips that may be modeled using the new SAFIR capability of the BISON-SAFIR code. Include a description of the signals at the BISON-SAFIR interface that are used in modeling these trips. [A.1]

Response:

Figure 1 below shows the process by which BISON interfaces with SAFIR to model a reactor trip. This is an example intended to describe the process, but the information that is passed from BISON to SAFIR is dependent on the situation. [[

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The process would not change the transient analysis performed by BISON and thus not impact any safety analysis results calculated within BISON. SAFIR would act as a logical component to determine if plant conditions exceed any boundary conditions which would trigger a reactor scram and communicate those results to BISON.

Figure 6 from RAI-15 shows the BISON control rod model response to a scram signal generated by SAFIR.

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[[ ]]

Evaluation:

The response to the RAI describes the process used to model the Reactor trip using BISON-SAFIR interface. This explanation is considered adequate.

Status:

Closed (adequately answered).

RAI-21:

Question:

The existing reactor scram model in the BISON code simulates control rod insertion using one of the following two methods:

- A user-supplied input table for control rod position versus time, or
- The built-in model for the hydraulic insertion of control rods.

a) The ABWR control rod drive system includes a Fine Motion Control Rod Drive (FMCRD) mechanism. State whether the FMCRD is modeled in SAFIR for the set of scenarios that will be analyzed using BISON-SAFIR, and, if so, then describe its input model (e.g., control mechanism, actuator, etc.).

b) Scram signal is described as being both an input and an output from BISON, in Table 3-1 of WCAP-17079-P. Explain the meaning of this description, and elaborate upon how scram signal is calculated in the combined BISON-SAFIR. [A.1]

Response:

The ABWR Fine Motion Control Rod Drive Run-in mechanism is modeled using a user-supplied input table for control rod positions versus time. The FMCRD Run-in can be activated by setting an explicit time for activation or when SAFIR determines that the activation setpoints are exceeded for a plant parameter as applicable.

a) Below is an overview of a typical transient scenario when SAFIR is used to model the logics for FMCRD Run-in activation.

- BISON supplies SAFIR with current plant conditions (Average Power Range Monitor, Steam dome pressure etc)

- SAFIR compares the data against specified setpoints and determines if any setpoints are exceeded.

- If the FMCRD Run-in setpoint is exceeded, then SAFIR sends a signal to BISON to start the control rod insertion using the user-supplied table for control rod positions versus time. The control rod motion, such as FMCRD, is only modeled in BISON but can be activated by SAFIR or BISON

b) The scram signal (a Boolean function) is calculated by comparing the value of a certain parameter associated with the scram (pressure, APRM, etc) to the specified setpoint and can be calculated by either SAFIR or BISON. In the example above, SAFIR generates a signal that is transferred to the BISON Boolean scram signal to activate the BISON control rod insertion model.

As described in RPA 90-90-P-A, the BISON code itself has the capability to model a simple reactor protection system to determine when the APRM or steam dome pressure, for example, exceeds specific setpoints.

In this latter case, the BISON Boolean scram signal is set by BISON when a reactor trip limit is reached. This Boolean scram signal from BISON can be used as an input to SAFIR to activate other plant features such as runback of Reactor Internal Pumps or Feedwater pumps. The connection referred to in Table 3-1 in Supplement 3 regarding scram is actually two parallel signals, one signal generated by SAFIR and transferred to BISON in order to activate the control rod insertion model and one signal generated by BISON at the activation of the control rod insertion model that may be used by SAFIR. [A.3]

Evaluation:

The response states that FMCRD run-in will be via a user-supplied input table of rod position versus time. This is reasonable and requires no further investigation. The response furthermore clarifies the meaning of scram signal as both input and output that satisfies the question raised as part of this RAI. [A.5]

Status:

Closed (adequately answered).

RAI-22:

Question:

With reference to the response to RAI-15 regarding accident events to be analyzed using BISON-SAFIR:

a) Describe the uncertainty bounds of individual physical models determined by testing to satisfy NUREG-0800, Section 15.0.2, Subsection II.4.

b) Describe the integral effects testing and demonstrate that the interactions between different physical phenomena and reactor coolant system components and subsystems modeled in BISON-SAFIR are identified and predicted correctly, in order to satisfy NUREG-0800, Section 15.0.2, Subsection II.4.

c) Describe the separate effects testing for input models of individual systems modeled for ABWR, or other equivalent testing to determine that there are no compensating errors in the integral effects testing ((b), above). [A.1]

Response:

The control system modeling required for an application and the uncertainty bounds associated with the model will be determined in connection with a plant-specific License Amendment Request in accordance with the methodology described in the Reference Safety Report (RSR per CENPD-300-P-A). See the answers to RAI-16 and RAI-45. The response to RAI-45 was submitted in STP Letter # U7-C-STP-NRC-100089, Scott Head to DCD, 5/12/2010.

The basis for the SAFIR models will be provided in the appropriate site specific document. [A.5]

Evaluation:

The RAI requested descriptions of a) uncertainty analysis, b) integral effects tests and c) separate effects tests. STP responded that such information would be in future submittals. The information provided is non-responsive to the request.

Follow-up Action:

Following discussions among NRC, ERI, and the applicant via conference call, it was agreed that various aspects of the new BISON-SAFIR evaluation model would be demonstrated at the site audit via presentation of detailed example models and calculations. These cases were supplemented by comparisons with BISON calculations (without SAFIR) or to other older calculation results, thus adding to the assessment base already present in the topical report comparing SAFIR results against plant data. These demonstrations are considered to form an acceptable response to RAI-22(b,c). [A.7]

Discussions with the applicant also made clear that no physical models in BISON had changed through the introduction of SAFIR. Aspects of uncertainty analysis as pertain to SAFIR itself were questioned and answered adequately by RAI-3, and therefore it was determined that RAI-22(a) required no further response.

Follow-up Evaluation:

Example calculations presented at the audit were judged an acceptable response to the intent of parts (b) and (c) of the original RAI, whereas discussions determined that no further response to part (a) would be necessary, particularly in view of the response to RAI-3.

Status:

Closed (adequately addressed by alternate means).

RAI-23:

Question:

The existing recirculation pump model in the BISON code has been approved with the following SER limitations as stated in RPA 90-90-P-A:

- *We require justification for use of the recirculation pump model when transients are in other than the first quadrants of the Karman-Knapp diagram.*

- *We require justification for use of the recirculation pump model when two-phase flow conditions are calculated.*

Section 3.8, Table 3-1 of WCAP-17079-P indicates that the recirculation pump speeds are output by SAFIR as well as by BISON (i.e., it is listed as both an input to and an output from BISON).

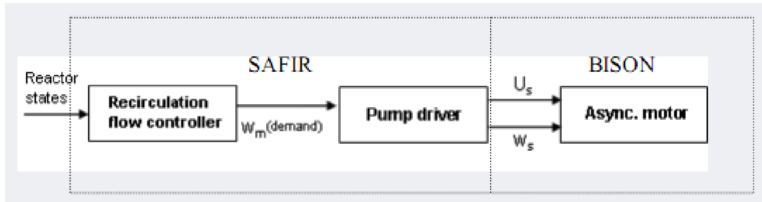
a) Explain how ABWR reactor internal recirculation pumps are modeled in BISON-SAFIR, including how the pump speeds can be both an input to and an output from BISON, as described in Table 3-1 of WCAP-17079-P.
b) Provide a qualification analysis, uncertainty analysis, and range of validity demonstrating applicability of the BISON-SAFIR model of the ABWR reactor internal recirculation pumps. [A.1]

Response:

a) The use of SAFIR for controlling the recirculation pumps does not change the BISON recirculation pump model approved by the NRC and described in RPA 90-90-P-A. The SAFIR code determines the pump speed demand (Wm) by using various plant parameters, which is then transferred to a pump driver that feeds the BISON asynchronous motor model with a frequency (Us) and a voltage (Ws) as shown in Figure 1 below. The asynchronous motor uses this information to calculate a pump speed which is the input to the BISON recirculation pump model. The BISON code calculates the pump head and pump torque given the pump speed, in accordance with methods as described in RPA 90-90-P-A. Since SAFIR can be used to control the recirculation pumps, the pump speed can be both an input and an output to the model if the pumps are in speed control mode. If the pumps are in speed control mode, the pump controller uses the current pump speed to calculate the error in pump speed (pump demand minus the current pump speed) to determine the means to maintain a constant pump speed.

   Moreover, the recirculation core flow is one of the user inputs to BISON to solve the BISON steady state. When the steady state is solved, BISON determines a pump speed that matches the recirculation core flow and the pump head in accordance to the methods as described in RPA 90-90-P-A. Hence, the BISON determined pump speed can be transferred to SAFIR to initialize models such as Recirculation Flow Controller to a state that corresponds to the calculated steady state pump speed.

b) The usage of SAFIR for controlling the recirculation pumps does not pose any changes to the BISON recirculation pump model licensed by the NRC as described in RPA 90-90-P-A since the recirculation pumps are not modeled with SAFIR. Therefore SAFIR does not introduce any further uncertainties in the recirculation pump model.



RAI 23, Figure 1 Block schedule of the SAFIR-BISON interface for the pump model [A.2]

Initial Evaluation:

Partially Inadequate. The response to the RAI clarifies adequately the meaning of internal recirculation pump speed as both an input and an output. Furthermore, the response states that SAFIR is only used for calculating transient pump speed demand, which is transferred to the BISON recirculation pump model for calculating pump speed, flow, etc. The BISON recirculation pump model was previously approved by NRC as part of RPA 90-90-P-A for application to BWR. However, no evidence has been provided that the BISON recirculation pump model is qualified for simulation of ABWR internal recirculation pumps. While it is possible that this issue may be resolved in the detailed documentation of a BISON-SAFIR example, as promised by STP to address other questions, a follow-up RAI may be called for to request experimental qualification analyses demonstrating the applicability of BISON models to the ABWR internal recirculation pumps over the range of conditions needed for transient analysis.

Follow-up Action and Resolution:

Discussions between ERI and NRC staff on this issue, together with informal discussions with STP and Westinghouse via conference calls, resulted in our understanding that issues of verification and validation of code performance for ABWR reactor internal pumps do not lie within the scope of Supplement 3, and that future licensing submittals would address such features of plant-specific modeling. From what is presented in the current submittal, we can find no cause to doubt that SAFIR is capable of modeling control systems required for transient calculations featuring an ABWR reactor internal pump. Furthermore, during the process of RAI resolution for Supplement 3, we also learned that BISON Supplement 4 [A.9] (under technical review by NRC and ERI as of this writing) addresses in more specific detail the validation of an asynchronous pump motor model against ABWR data, and therefore it is unnecessary to address the issue as part of the current review.

In result, those parts of RAI-23 not adequately addressed in the applicant's response were found not worthy of a follow-up question or audit issue, and the issues raised by the RAI can be considered closed.

Status:

Closed (partially answered, and the remainder re-evaluated as outside of the scope of the current review).

RAI-24:

Question:

The previously approved steam line model (described in RPA 90-90-P-A) or PARA steam line model (described in CENPD-292-P-A) calculates the mass flow and pressure for each of the modeled steam line assuming isentropic behavior of the steam. Furthermore, the PARA steam line model includes models for flow control valves (Main steam line isolation valve (MSIV), turbine bypass valve, and turbine stop valve), safety/relief valves, and the turbine assembly. The valves are modeled using user-specified tables representing changes in valve stem position, valve flow area, or valve flow rate with time. The SER limitation on this model as documented in CENPD-292-P-A states that:

> *With use of the PARA steamline model, the user has flexibility of modeling valves and control system functions through the use of user supplied table and control systems. Modeling of these systems greatly affects the amount of conservatism in the transient outcome in certain event analysis. Therefore as required in the original SER for BISON, ABB/CE is required to provide justification for these user controlled items, which include valve performance, to assure conservatism in licensing applications.*

Table 3-1 in Section 3.8 and Sections 5 and 6 of WCAP-17079-P indicate that SAFIR is used for modeling MSIV, turbine bypass valve, turbine stop valve, and safety/relief valves.

a) Confirm that SAFIR models for these components are in compliance with above noted SER limitation.

b) Explain how the flow rates in flow controlled steam line valves can be both an input to and an output from BISON, as described in Table 3-1 of WCAP-17079-P. [A.1]

Response:

a) The above SER limitation is based on the original SER for BISON. This limitation will be removed with the approval of WCAP-17079-P. The SAFIR models approved by WCAP-17079 P will also meet the requirements for the above SER limitation as documented in CENPD-292 P-A.

b) Output signals from the steam line model are pressure and flow from each junction within the steamline model. The flow from the steamline is controlled by one or several valves and the valve position may be altered by signals where the signals describe the relative change of flow compared to the stationary solution. [A.2]

Initial Evaluation:

Partially Inadequate. The response to item (a) of the RAI states that STP seeks to remove the original SER limitation for the steam line model as documented in CENPD-292-P-A.

However, the RAI remains not fully answered in that STP should provide documentation supporting the basis for this removal. While it is possible that this issue may be resolved in the detailed documentation of a BISON-SAFIR example, as promised by STP to address other questions, a follow-up RAI may be called for to request details of the BISON-SAFIR ABWR steam line model and demonstration that the model accurately reproduces the real system's behavior or bounds it conservatively.

The response by STP furthermore clarifies the meaning of flow rates as both inputs and outputs that resolves part (b) of the RAI.

Follow-up Question:

The previously approved steam line model (described in RPA 90-90-P-A) or PARA steam line model (described in CENPD-292-P-A) calculates the mass flow and pressure for each of the modeled steam line [[ ]] Furthermore, the PARA steam line model includes models for flow control valves (Main steam line isolation valve (MSIV), turbine bypass valve, and turbine stop valve), safety/relief valves, and the turbine assembly. The valves are modeled using user-specified tables representing changes in valve stem position, valve flow area, or valve flow rate with time. The SER limitation on this model as documented in CENPD-292-P-A states that:

> *With use of the PARA steamline model, the user has flexibility of modeling valves and control system functions through the use of user supplied table and control systems. Modeling of these systems greatly affects the amount of conservatism in the transient outcome in certain event analysis. Therefore as required in the original SER for BISON, ABB/CE is required to provide justification for these user controlled items, which include valve performance, to assure conservatism in licensing applications.*

Table 3-1 in Section 3.8 and Sections 5 and 6 of WCAP-17079-P indicate that SAFIR is used for modeling MSIV, turbine bypass valve, turbine stop valve, and safety/relief valves.

In RAI-24(a), STP had been requested to confirm whether SAFIR models for these components are in compliance with the above-noted SER limitation. STP responded in U7-C-STP-NRC-100078 that the limitation would be removed with the approval of WCAP-17079-P. However, neither the submittal nor the RAI response provided adequate documentation of the basis for the removal of the limitation. Therefore:

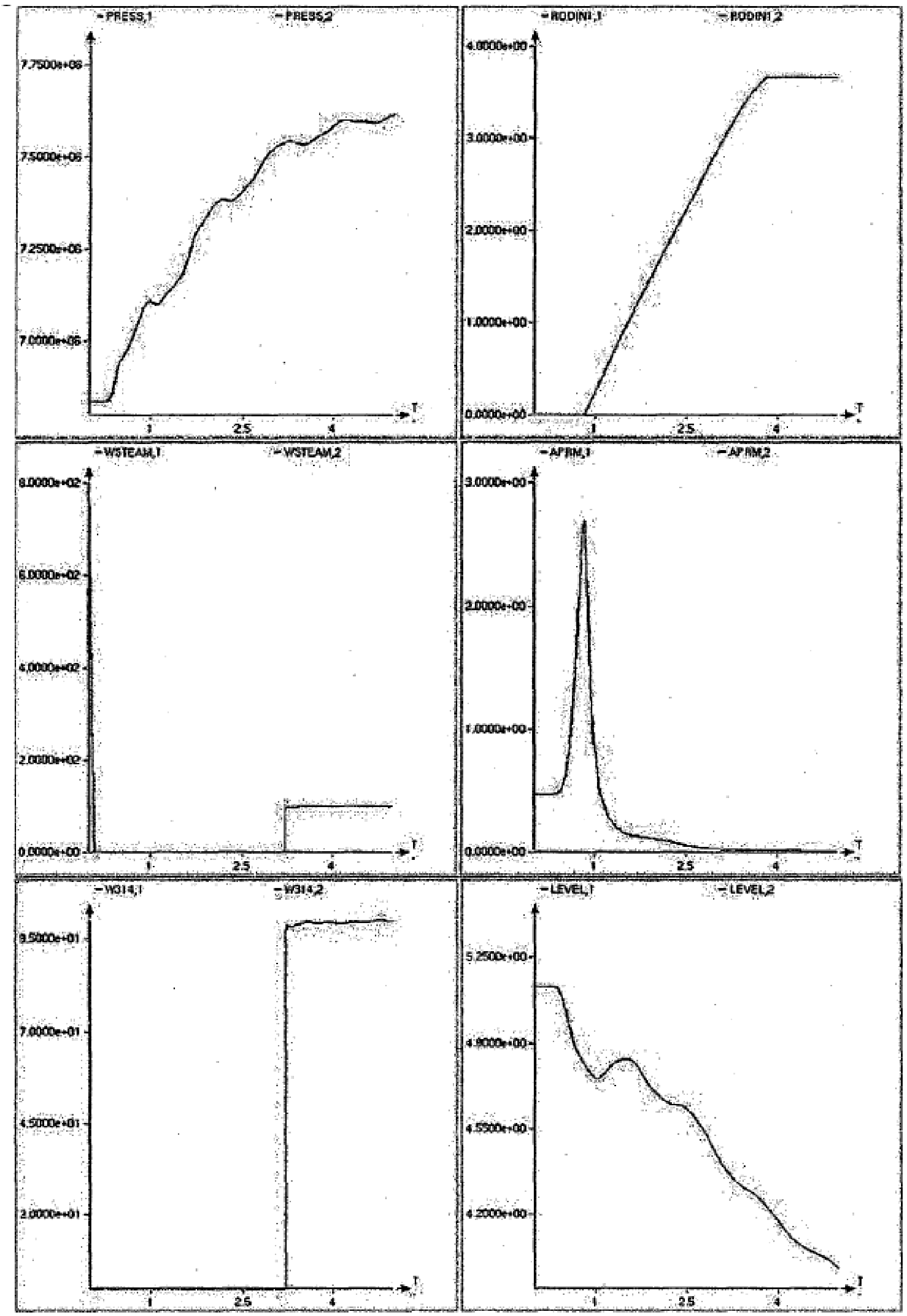
- Provide documentation of the basis for removal of the limitation regarding the steam line or PARA steam line model.

- Provide details of the ABWR steam line model as implemented in BISON-SAFIR and demonstrate by means of the results of an appropriate calculation that the model accurately reproduces the real system's behavior or bounds it conservatively. [A.6]

Follow-up Response:

a) The removal of the PARA steam line model SER limitation is not a subject of WCAP-17079-P. After examining the PARA steam line model it was determined to maintain this restriction. Hence, when SAFIR is used in conjunction with a PARA steam line model, valve performance will be modeled in compliance with the PARA SER limitation for US NRC approved fast transient or ATWS methodology. Figure 24a-1 shows the response of the steam dome pressure (PRESS), length of control rod insertion (RODIN), steam flow (WSTEAM), and average power range monitor (APRM) during the transient. These two cases can be seen in Figure 24a-1, the addition of SAFIR to the PARA model does not alter the ability to comply with the SER limitation from CENPD-292-P-A. Conservative modeling is still maintained with the implementation of SAFIR.

[Figure 24a-1]


PRESS,1
PRESS,2
7.7500e+06
7.5000e+06
7.2500e+06
7.0000e+06
RODIN1,1
RODIN1,2
4.0000e+00
3.0000e+00
2.0000e+00
1.0000e+00
0.0000e+00
WSTEAM,1
WSTEAM,2
8.0000e+02
6.0000e+02
4.0000e+02
2.0000e+02
0.0000e+00
APRM,1
APRM,2
3.0000e+00
2.0000e+00
1.0000e+00
0.0000e+00
W314,1
W314,2
9.5000e+01
7.0000e+01
4.5000e+01
2.0000e+01
LEVEL,1
LEVEL,2
5.2500e+00
4.9000e+00
4.5500e+00
4.2000e+00
1
2.5
4
T

b) As demonstrated in part (a) of this response, SAFIR will continue to conservatively bound the control system models in the PARA steam line model. [A.9]

Sample calculation results provided in response to the follow-up RAI adequately demonstrate that the results of the new BISON-SAFIR evaluation model accurately or conservatively bound those of the old BISON evaluation model with respect to the steam line. Together with other examples exercising features of the steam line model, this was considered to adequately address the concerns in the original and follow-up RAIs, and they can be considered closed. (based on [A.7])

<u>Status:</u>

Closed (adequately addressed).

RAI-25:

Question:

The description of the BISON turbine and generator model in Section 8.3 of RPA 90-90-P-A is very limited. Furthermore, the turbine assembly model presented in CENPD-292-P-A was not approved by NRC due to lack of proper qualification:

> *ABB stated that the turbine assembly model will not be used, thus this model was not qualified in this review. The use of the turbine assembly model is restricted until qualified.*

A model of the turbine and generator of a BWR is described in Section 6.1 of WCAP-17079-P as an example of SAFIR model verification and validation. State whether, in the BISON-SAFIR evaluation model (as possibly distinct from the model verification and validation example presented in Section 6.1), the new SAFIR capability will be used to model the turbine and generator for ABWR. If so, then:

- How does the model of the ABWR turbine and generator in BISON-SAFIR (as presented in Section 6.1 of WCAP-17079-P) differ from the previous model of these components in BISON? Include details of the mathematical models (i.e., all equations and associated inputs) for elements including angular momentum equation for turbine speed; relationship between turbine speed and generator power; representation of valve characteristics; valve actuator dynamics; and specific set points, deadbands, and hysteresis values.

- What is meant in Section 6.1.4.6 of WCAP-17079-P by the “Balance of Plant Model”? Provide details of the built-in BOP model.

- For Figures 6-82, 6-84, and to a lesser extent 6-85 of WCAP-17079-P, provide the basis for inconsistencies in measured and calculated values at time zero (i.e., steady-state). This is related to RAI 18(g) above.

- Provide a qualification analysis, uncertainty analysis, and range of validity demonstrating applicability of the BISON-SAFIR model of the ABWR turbine and generator. [A.1]

Response:

a) There has been no need for modeling the turbine and generator for ABWR.

b) What is meant by “Balance of Plant model” is the built-in plant models developed for Nordic BWR plants. Such models consist of models such as the turbine controller and turbine model for which the comparison in Section 6.1.4.6 is made. This comparison is only made to show an example of the verification and validation process and not to license the model.

c) The signal in the turbine controller prior to a split on individual valve signals is presented in Figure 6-81 in Supplement 3 where the observed deviation is small. The observed differences at time zero are due to a deviation in valve characteristics in the plant turbine controller and the SAFIR turbine controller at the time for the load rejection test.

Westinghouse did not have detailed information about the controller. In the Figures 6-83 and 6-84 in Supplement 3 the plots of calculated position was switched and the corrected figures are presented below. The figures in Supplement 3 will be corrected in the final approved version.

[[

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[[ ]]

[[

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[[ ]]

d) There is no turbine or generator model in the present ABWR SAFIR model. [A.4]

Evaluation:

The STP response clarifies that SAFIR has not yet been used to model the ABWR turbine and generator, and that they were present in the submittal merely as an example of the verification and validation process. This satisfies the concerns raised in part (a) of the RAI. Part (b) of the RAI was answered adequately by clarifying the definition of "balance of plant".

[[

]] plus an inadvertent transposition of two graphs, which will be corrected in the final version of the LTR.

<u>Status:</u>

Closed (adequately answered).

RAI-26:

Question:

The previous model of the Feedwater System in the BISON code solves the momentum balance equation for the feedwater and condensate system. The model describes the condensate and feedwater lines with respect to pressure losses, the feedwater and condensate pumps, and the control valves.

WCAP-17079-P does not clearly describe the implementation of the Feedwater System model in BISON-SAFIR. Table 3-1 in Section 3.8 of WCAP-17079-P indicates that the feedwater temperature and flow rate are input signals to BISON from SAFIR code.

- Describe how the momentum balances equation for the feedwater and condensate system is solved using the SAFIR code.

- Explain how feedwater temperature and flow rate can be both inputs to and outputs from BISON, as described in Table 3-1 of WCAP-17079-P. [A.1]

Response:

a) The feedwater model described in RPA 90-90-P-A is unaffected by the introduction of SAFIR. SAFIR does not solve the momentum balances equations for the feedwater and condensate system (only BISON does).

b) BISON finds the steady-state solution before a transient is initiated. To find the steady state solution in BISON, the global reactor energy balance is used to calculate the stationary feedwater flow based on the thermal power and the associated feedwater temperature. The feedwater temperature (or enthalpy) is user specified as described in RPA 90-90-P-A. For the steady state solution it is assumed that the steam flow equals the feedwater flow to maintain the global reactor mass balance. For details please refer to RPA 90-90-P-A

One instance SAFIR may be used is to simulate the feedwater system response to a feedwater pump runout or a feedwater controller failure. The feedwater system response can also be given as input to BISON as boundary conditions for the system without using SAFIR.

In the case that SAFIR is used to simulate the feedwater system response, the steady state feedwater temperature and flow rate (output from BISON) are used to initialize SAFIR's feedwater model (input to SAFIR). SAFIR calculates the system response to the feedwater controller failure for example, and after this time in the sequence of events, the feedwater temperature and flow rate are provided to BISON (input to BISON) from SAFIR (output from SAFIR). BISON no longer calculates either the feedwater flow or temperature and relies on SAFIR to supply those two boundary conditions to BISON transient simulation. [A.3]

Evaluation:

Partially Adequate. In the response to part (a) of the RAI, it is stated that SAFIR does not solve the momentum equation for feedwater, which will be handled as before by BISON. However, in the response to part (b) of the RAI, the applicant states that, "one instance SAFIR may be used is to simulate the feedwater system response to a feedwater pump runout or a feedwater controller failure". In this case, SAFIR will calculate the feedwater flow rate and temperature. This application of SAFIR to model the feedwater system response is not described in WCAP-17079-P. While it is possible that this issue may be resolved in the detailed documentation of a BISON-SAFIR example, as promised by STP to address other questions, a follow-up question may be in order to ask for a list of all instances under which feedwater response would be calculated by SAFIR instead of by BISON, documentation of the models by which this response would be calculated, and a qualification analysis showing that SAFIR is adequate for calculating feedwater response within the range of accident scenarios considered.

The meaning of feedwater temperature and flow rate as both inputs and outputs was clarified adequately in part (b) of the RAI response (i.e., BISON provides steady-state values to SAFIR, which then calculates the transient values of those variables).

Follow-up Action:

During an informal conference call among NRC, ERI, and the applicant, it was agreed that the issue raised in the initial response, regarding situations in which SAFIR would be used to simulate feedwater system response, would be addressed during the site audit. No follow-up RAI was prepared. At the site audit, one detailed calculation example exercised SAFIR-modeled features of the feedwater control system. In this demonstration it was made clear that concerns about SAFIR replacing original BISON models for momentum conservation in the feed water system were unfounded, and therefore that the RAI can be closed. [A.7]

Status:

Closed (adequately addressed).

RAI-27:

Question:

RPA 90-90-P-A includes some statements and qualifications about the numerical stability of BISON with respect to certain input parameters and time step sizes. For example:

> *A large value of R [in Equation 3.4.3.18, describing bulk fluid evaporation] would give near complete thermal equilibrium, but stability considerations for the numerical integration method prevent the use of unlimited large values of R for reasonable time step values.*

and

> *For low void fractions rapid condensation may cause instability in the numerical time integration of the local mass balance equations.*

and

> *Numerical stability of the solution method is still limited by a material transport Courant limit...*

When the BISON equation set is coupled with equations in SAFIR that incorporate feedback from the control systems, it is possible that the stability limits of the coupled code could be adversely affected. Demonstrate that the ABWR models used with BISON-SAFIR do not have significantly more stringent stability limits, or that any such limits would not be of practical importance for the scenarios to be run using the ABWR model under BISON-SAFIR. [A.1]

Response:

The use of SAFIR as a method to calculate dynamic boundary conditions to BISON does not affect the numerical stability limits in BISON. SAFIR calculates new boundary conditions to BISON to be used in the next time step. There is no iteration between BISON and SAFIR during a single time step and therefore the introduction of SAFIR does not affect the numerical stability limits in BISON. The BISON equation set is not coupled to SAFIR, the only communication is by boundary conditions as described in Table 3-1 in Supplement 3. [A.3]

Evaluation:

The response states that the BISON and SAFIR parts of the system solution are completely separated at the interface, with all BISON calculations for one timestep being performed first for one timestep before all of the SAFIR components are updated. If understood correctly, this would eliminate concerns over effects on numerical stability that prompted the RAI. However, a judgment upon the adequacy of this response is withheld until the response to RAI-18 is available.

This is because we still do not clearly understand some aspects of how timestep size and synchronization are managed in SAFIR, subjects which make up a primary portion of RAI-18. Depending on the content of this future RAI response, a follow-up may be called for.

Follow-up Action:

It was initially determined that evaluation of the response to this RAI would depend on the answers to a number of others, for example RAI-28. Responses to RAI-28 necessitated a site audit item, and the applicant explained the timestep advancement and coordination scheme in more detail at the audit. [[

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Status:

Closed (adequately addressed).

RAI-28:

Question:

The SAFIR general model description and limitations in WCAP-17079 appear to permit feedback in an input model (i.e., it is possible to construct a closed circular path from an input signal back to itself entirely within SAFIR). Does the SAFIR model used for ABWR contain any such closed loops? If so, describe how a SAFIR solution is obtained for a sampling time interval, given the existence of such feedback loops, and justify its correctness. (For example, consider the hypothetical situation where output from SAFIR component “A” is an input to component “B”, and the output from “B” feeds back into “A”. If this were simply evaluated once in either order, the outputs of “A” and “B” may be inconsistent since one output changes after the other has been evaluated.) (e.g., does SAFIR iterate within one sampling time interval until a stable solution is obtained for all components? Does it simply evaluate each component once in some fixed order regardless of the existence of feedback loops, resulting in a possibly inconsistent solution?) [A.1]

Response:

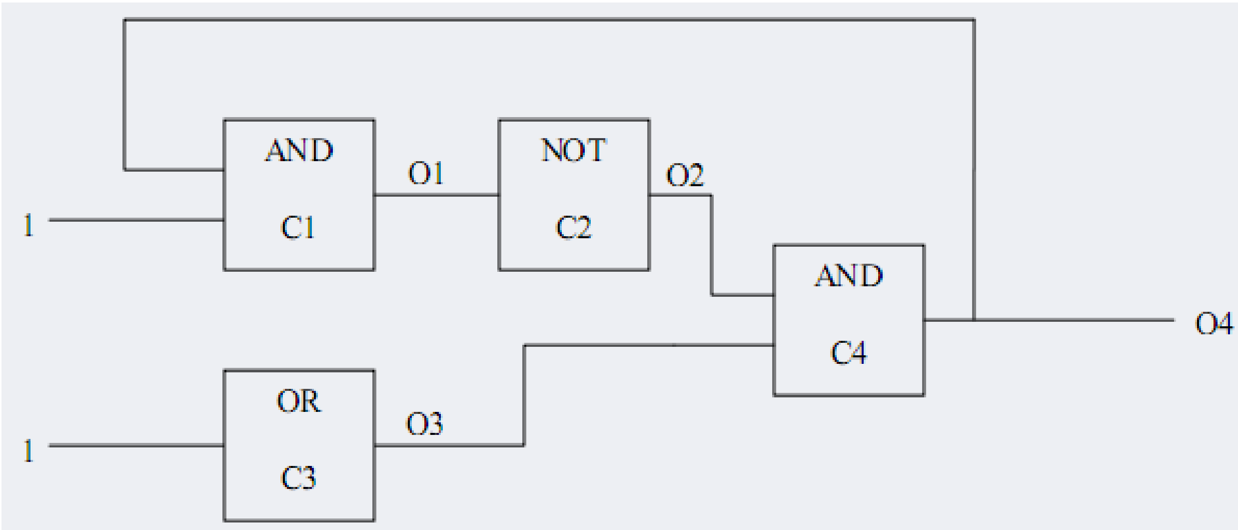
SAFIR permits feedback such as constructing a closed circular loop from an input signal back to itself. This feature can be used in many applications such as in controllers to feed back the output signal to the input signal. Figure 6-90 in Supplement 3 is an example on a model where such feedback is used in the SAFIR model for the ABWR.

SAFIR uses an explicit calculation scheme and does not iterate to get a stable solution except for the steady state iteration. Instead, the user supplied order of the components matters. The component that is first in order is evaluated first and then the second component and so on. Note that the component will only be updated if its sample time permits it.

An illustrative example is provided in Figure 1 below for a feedback loop. The components are supplied in the order of C1, C2, C3 and C4 and the outputs are named O1, O2, O3 and O4. The output (O4) from component C4 is feed back to component C1 and is assumed to be initialized to 1 for the steady state iteration. Furthermore, the components are assumed to have the same sampling time. The output signal O4 for each time step is shown in Table 1. As can be seen in the table, the output signal is assigned the values 0 and 1 every second time step. Note that if an iterative solution technique is used, the output signal would never converge despite the fact that the model as shown below is a valid one.

RAI 28, Table 1 Output signals from the feedback model

Sampling time #	O1	O2	O3	O4
1	0	1	1	1
2	1	0	1	0
3	0	1	1	1
4	1	0	1	0
5	0	1	1	1



RAI 28, Figure 2 Example of a feedback model [A.2]

Evaluation:

Requires other RAI responses to fully evaluate. According to the RAI response, components are updated only once per time interval (TS) and always in the order that they were listed in the input model. Thus, the time required to trace around a feedback loop in SAFIR will equal one or more integral multiples of TS, depending on the order of components. This may or may not be accurate (only incidentally?) with respect to the system being simulated. On the other hand, in the case of analog control systems, the time to trace around a loop in SAFIR would almost certainly not be physically accurate, because it depends on a value of TS that has no physical correspondence to the physical system. Note that the input order of components may be constrained by other considerations, such as the desired order for update of other feedback loops or linear chains. The order-of-components issue may affect other parts of the model, too, besides feedback loops (i.e., input order must be ensured to match the order of updating in the actual system being simulated). However, a judgment upon the adequacy of this response is withheld until the response to RAI-18 is available. This is because we still do not clearly understand some aspects of how timestep size and synchronization are managed in SAFIR, subjects which make up a primary portion of RAI-18. Depending on the content of this future RAI response, a follow-up may be called for.

Follow-up Action:

The full evaluation of this RAI became dependent on the resolution of RAI-18, for more detail on which see the relevant part of this Appendix. RAI-18 was eventually resolved to the reviewers' satisfaction through discussions made at the site audit, although no formal follow-up question to either RAI-18 or RAI-28 was ever sent to the applicant.

Status:

Closed (adequately addressed via discussions made at the site audit).

RAI-29:

Question:

Is the BISON-SAFIR model for ABWR nodalized in such a way that system quantities measured by modeled instrumentation are located exactly at BISON region/sub-region centers or edges? If not, then describe how quantities needed for SAFIR input signals are obtained (e.g., interpolation or approximation) given that the instrument locations and state variable locations may not coincide. Describe the impact any such approximations may have upon BISON-SAFIR results. [A.1]

Response:

SAFIR will be able to provide delays and response time for measured signals based on physical parameter values simulated by BISON. The most common modeled instrumentation are steam dome pressure, turbine inlet pressure, Reactor Pressure Vessel(RPV) water level, steam flow and recirculation flow.

Steam dome pressure, turbine inlet pressure, steam flow and recirculation flow are calculated by BISON at a node boundary and no interpolation is needed.

The RPV water level is obtained based on the pressure difference of two nozzles. To obtain the pressure at a nozzles location, BISON performs a linear interpolation of the pressure from the two adjacent nodes. Assuming nozzle *x* is situated at height h_x between node *n* and *n+1* at height h_n and h_{n+1}, all defined from an arbitrary reference level, the pressure at nozzle *x* can be written as

$$p(x) = p(n) + \frac{p(n+1) - p(n)}{h_{n+1} - h_n}\left(h_x - h_n\right)$$

The calculated nozzle pressure is provided to SAFIR as input. To obtain the measured water level, a model of level measurement system based on the SAFIR components can be built.

The impact of the above described interpolation is evaluated at the first time application for a specific model. This is normally done by studying the impact of the BISON nodalization on the model output. The level measurement model is thereafter tuned to conservatively predict the BISON calculated water level. [A.3]

Evaluation:

The description of simulated instrumentation variable interpolation is considered to be adequate, and the study of its impact through nodalization sensitivities satisfies the concern raised in the RAI.

<u>Status:</u>

Closed (adequately answered).

RAI-30:

Question:

Does the SAFIR code contain checking for run-time errors such as domain errors, division by zero, array out-of-bounds, etc.? Will the code stop or print warning messages for all such errors? [A.1]

Response:

The error handling of invalid values occurs at several levels in SAFIR and in BISON. Array out-of-bounds are checked during input reading, where the code will stop and notify the user when arrays are out of bounds.

Additional checks are performed during the initialization part of SAFIR. The code verifies that the implemented SAFIR models are complete in terms of input and output signals, and that all used components are defined. The code will abort execution if a component description is missing or if a signal is generated by more than one component. Warnings will be issued if input values are missing or if a stationary solution is not obtained; unknown states will be set to zero.

During run-time, out of range error checking is performed on a SAFIR component. The error handling in BISON is very rigorous and numerous checks are also performed. So the error-handling is a two sided check to assure adequate error-handling in case of invalid values are passed to SAFIR from BISON.

Division by zero applies for the DIV component and is treated as a domain error whereas the user will be notified about division by zero, output will be set to largest allowed number. Moreover, checks are also performed for components such as INT, PI, etc. in order to prevent division by zero while evaluating the expressions as presented in Table 3-2 of Supplement 3. [A.3]

Evaluation:

The description in the response of run-time error checking in BISON-SAFIR is adequate and satisfies the concern that there should be no cases of un-caught errors in SAFIR.

Status:

Closed (adequately addressed).

RAI-31:

<u>Question:</u>

One element commonly found in computational models of control systems is the ability to latch an output signal (i.e., to fix an output signal once certain conditions are met, such as activation of scram, irrespective of later changes to the input signals). Is any such capability necessary in modeling ABWR systems using SAFIR? If so, how will the "latched" outputs be modeled (e.g., through use of GVB component)? [A.1]

<u>Response:</u>

Latched output signals can be modeled using various components and techniques. An example is to use the Set and Reset switch where the Reset input is kept to zero. Hence, the output can never be changed, as the reset is set to zero, after the Set input has been set. Reactor protection systems and ATWS logics are two typical examples where latched output signals are used where the output signals are irrespective of later changes to the input signals. [A.2]

<u>Evaluation:</u>

The description in the response of how latched signals would be simulated is considered adequate.

<u>Status:</u>

Closed (adequately answered).

RAI-32:

Question:

Among the available SAFIR components described in WCAP-17079-P, Table 3-2 are ones labeled as PIP (Proportional Integrating Proportional) and PDP (Proportional Derivating Proportional). Are PIP and/or PDP controllers used in the SAFIR input model for ABWR? If so, then:

- Are PIP and PDP controllers used in the SAFIR model of ABWR? If so, then provide a reference on the technical basis (i.e., theory) and application of these controller types.
- Why does the SAFIR component list (i.e., Table 3-2 of WCAP-17079-P) not include a standard PID (Proportional-Integral-Derivative) controller? A re any PID controllers present in ABWR systems to be modeled using SAFIR? If so, then describe how they would be modeled in SAFIR. [A.1]

Response:

The PIP and PDP controllers are standard lead and lag filters as described by the transfer function in Table 3-2 of Supplement 3. These controllers are used in the SAFIR control systems for ABWR.

The PID controller was not part of the selection of components during the development of SAFIR (based on a predecessors to the current Westinghouse Advant Controller family), and there has not been any request or need for a PID controller in any of the SAFIR models built as today. If a need for a PID function arises, the PID controller can be composed by combining the INT, AMP and DERIV components in SAFIR as shown in Figure 1.

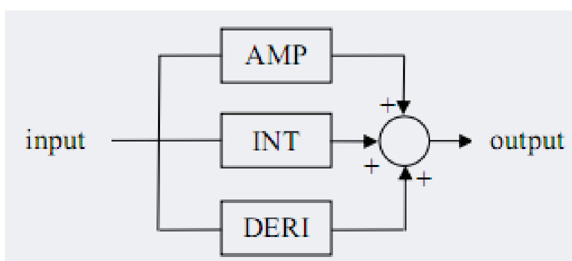


Figure 1 PID controller composed of SAFIR AMP, INT and DERIV [A.3]

Evaluation:

The first part of the response by STP describes the two controller models as standard lead and lag filters given by the appropriate transfer functions. The second part of the response describes how a PID controller would be modeled using current SAFIR functionality, even though it is not required for modeling the ABWR. This part of the response is considered adequate.

Status:

Closed (adequately answered).

RAI-33:

Question:

SAFIR provides several components for modeling random numbers (UNI, NORM, PRBS), as described in Table 3-2 of WCAP-17079-P. Are any of these random number components used in the SAFIR model of ABWR? If so, then:

- Are the random numbers generated by these components pseudo-random, such that they are reproducible from one calculation to another (given the same input random number seed)?
- Suppose a SAFIR input model includes one or more random number components, and the calculation yields a certain time-dependent random number vector for each. If this input model were to be later augmented with an additional random number component, and the same random number seed used, would the previous random number components generate the same random vectors as before (i.e., previously present random elements remain reproducible and independent of new random elements)? [A.1]

Response:

The random number generators have been found to be unnecessary for modeling of the ABWR plant as of today. The random number generators are pseudo-random numbers and the results are therefore re-producible. Each pseudo-random number generator works independent of one another and thus, adding more random number components does not affect the number sequences generated by the previous ones. [A.2]

Evaluation:

The independence of random number seeds for random number components in SAFIR satisfies the concern that prompted the RAI.

Status:

Closed (adequately answered/addressed, given that the random number components are stated to be unnecessary for plant modeling).

RAI-34:

Question:

The list of SAFIR components described in WCAP-17079, Section 3.10 does not include ones to facilitate calculation of a number of basic mathematical functions, such as logarithms (OUT(t) = LOG(IN(t))) or exponentiation (OUT(t) = IN(t) ** C1, for C1 not equal to 0.5 (SQRT)). Are any such mathematical functions necessary for modeling of ABWR systems in SAFIR? If so, describe how these would be modeled (e.g., user-input table lookup). [A.1]

Response:

None of these functions are needed in the current ABWR modeling as today. If new functionality is required in SAFIR to model a certain system Westinghouse can either follow the processes as described in the answers to RAI-12 and RAI-13, or model an equivalent functionality by usage of the existing basic components within SAFIR. Two examples of the latter could be a piece-wise linear function or a Taylor expansion. [A.2]

Evaluation:

The response states that the mathematical functions described in the RAI are not used in modeling the ABWR and describes methods for approximating them using current SAFIR functionality if they are required later. This is considered adequate.

Status:

Closed (adequately answered).

RAI-35:

Question:

WCAP-17079-P presents simulation of Hamaoka-5 startup tests with the BISON-SAFIR codes in Section 6.2.2. Describe the BISON-SAFIR nodalization used for this simulation and the components/system/signals simulated using the BISON code. [A.1]

Response:

The SAFIR models needed to simulate the Hamaoka-5 startup test as presented in Supplement 3 and the interacting signals between BISON and SAFIR are shown in Table 1.

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Evaluation:

The response to the RAI fails to provide the requested BISON-SAFIR nodalization for Hamaoka-5; therefore is considered inadequate. However, it is understood that STP intends to address some currently outstanding RAIs in the form of documentation of a BISON-SAFIR example calculation for ABWR. This may address the concerns raised in RAI-35 and render more information on the Hamaoka-5 example unnecessary, so depending on the schedule it may be advised to wait for this response before formulating a follow-up.

Follow-up Action:

The example calculations presented at the site audit, alluded to above under “Evaluation”, were deemed sufficient to address the concerns that prompted the request for more information on the Hamaoka-5 example included in the topical report. [A.7]

Status:

Closed (reviewers’ concerns adequately addressed by alternative means).

RAI-36:

Question:

WCAP-17079-P states in Section 3.10 that the "the available verified and validated basic components are listed in Table 3-2."

- For each SSC identified in RAI-16(b), state whether non-SAFIR capabilities in BISON are being used to provide representation of that SSC.
- For each SSC identified in response to RAI-16(b) that will be modeled using BISON-SAFIR, state whether the components listed in Table 3-2 are sufficient to build the applicable models with BISON-SAFIR. If not, provide a supplement to Table 3-2 listing all required components. [A.1]

Response:

- The control systems required for an application will be determined according to the methodology described in the Reference Safety Report (RSR, CENPD-300-P-A) at the time of the application in connection with a Licensing Amendment Request. See the answer to RAI-16 (Letter U7-C-STP-NRC-100095). Examples of SSCs that use a combination of BISON built-in functions and SAFIR models are Rod Control and Information System (RCIS), Steam Bypass and Pressure Control System (SB&PCS), Safety Relief Valve (SRV) and Reactor Internal Pumps (RIPs).
- Westinghouse believes that the SAFIR components listed in Table 3-2 of Supplement 3 are sufficient to build an applicable ABWR model that can be used for licensing analysis of the transients as defined in the DCD. [A.3]

Evaluation:

Inadequate. The response to RAI-16 has been evaluated and found to be inadequate. The response to part (a) of this RAI does not alter that evaluation. STP has not described the specific SSCs to be modeled using SAFIR to support the fuel amendment. STP is confident that current SAFIR capability is sufficient to model all SSCs that would be required for application to ABWR transient analysis without identifying these SSCs. Because it fails to list all SSCs to be modeled and the specific capability of SAFIR to model them, and instead only presents four examples, the information supplied in the response to RAI-36 is insufficient to permit a review of the related material, and a follow-up RAI may be required pending the content of answers to yet outstanding RAIs and the detailed documentation of a BISON-SAFIR example that has been promised by STP.

Follow-up Question:

WCAP-17079-P states in Section 3.10 that the "the available verified and validated basic components are listed in Table 3-2."

STP had been requested in RAI-36 to provide a list of those top-level systems that will be modeled using the newly integrated SAFIR capability in the evaluation model, and to state whether the toolbox of presently available SAFIR components as described in the LTR is sufficient to build models of those systems. STP's response consisted only of four examples of systems that may be modeled using SAFIR. However, in order to perform an adequate review of the adequacy of the new evaluation model employing SAFIR, we require a comprehensive list of such systems in order to properly establish its scope of applicability. Therefore:

- For each individual system identified in RAI-16S01, state whether SAFIR and/or non-SAFIR capabilities in BISON are being used (either wholly or in part) to provide representation of that system.

- For each system identified in response to RAI-16S01 that will be modeled using BISON-SAFIR, state whether the components listed in Table 3-2 are sufficient to build the applicable models with BISON-SAFIR. If not, provide a supplement to Table 3-2 listing all required components. [A.6]

Follow-up Response:

- SAFIR will be used to support the modeling of the following top level ABWR systems:

    - Pressure Controller
    - Feedwater Controller
    - Recirculation Flow Controller
    - Reactor Protection System
    - High Pressure Core Flooder
    - Core Flow Measurement System
    - Water Level Measurement System
    - Adjustable Speed Drive

  Each of the listed systems will be represented by both SAFIR and non-SAFIR BISON capabilities. The systems will represent the top level plant models described in the DCD.

- WCAP-17079-P, Table 3-2 contains components sufficient to build models of all of the ABWR systems listed in part a) of this response. [A.8]

Follow-up Evaluation:

The RAI asked STP to identify top-level plant systems that would be modeled in SAFIR for use with the BISON-SAFIR transient analysis methodology, and to verify that the set of SAFIR components discussed in WCAP-17079P would be sufficient for modeling these systems. Westinghouse responded with a list of eight top-level systems and verified that these could all be modeled using the documented SAFIR component set. Note that this list of top-level systems is identical to that provided during the September 2, 2010 site audit.

We find this response adequate, as it sufficiently describes the range of SAFIR application and gives rise to no significant concerns about the modeling of the systems in the list.

<u>Status:</u>

Closed (adequately answered).

RAI-37:

Question:

WCAP-17079-P provides the Westinghouse definitions of validation and verification in Sections 4.2 and 4.3.

a) Identify the extent to which the Westinghouse definitions comply with any national standards.

b) Identify on the list provided in response to RAI-16(b) which means (validation or verification) is used to assure the performance of each component listed.

c) In Section 1, the statement is made that "(t)he Westinghouse definition of validation is to show the behavior compared with reference data like e.g., measurement data." In Section 4.3 the statement is made: "validation will be performed using comparisons to measurement data." In Section 5.4 the statement is different: "Validation of models is performed against available data and code to code comparison". Describe consistently and completely what "Validation" is within the Westinghouse QAP. Identify changes that need to be made to the submittal to implement this consistent understanding of the process intended. [A.1]

Response:

a) Consistent with SRP Section 15.0.2 which states that the code must be maintained under a quality assurance program that meets the requirements of 10 CFR Part 50, Appendix B, control system models derived using SAFIR will be developed and implemented in accordance with the Westinghouse Quality Management System (QMS) program. The Westinghouse QMS program describes computer software related requirements that include documentation of software requirements, computer software design, verification and validation (testing), configuration control, and error reporting and resolution. The Westinghouse QMS has been reviewed and approved by the NRC and meets all requirements of 10 CFR Part 50, Appendix B as well as ISO-9001.

b) As described in the response to RAI-16 (Letter U7-C-STP-NRC-100095), the scope of the LTR is to provide a description of the process used to develop and verify models of plant control systems used for transient analysis, rather than to provide a complete list of systems and components required for a specific application. The control system modeling required for an application will be determined at the time of the application and in connection to a plant specific License Amendment Request according to the methodology described in the Reference Safety Report (RSR per CENPD-300-P-A).

c) The definitions for validation and verification provided in the LTR are consistent with the requirements for computer software development described in Section 4.2 of the Westinghouse QMS. Functional requirements, design documents, test requirements, and test results are verified in accordance with written procedures.

   Verification is performed at the completion of each phase to ensure that the output of a given phase fulfills the requirements established by previous phases. Validation is performed upon completion of software development to ensure that the code satisfies all identified requirements and produces correct results. [A.3]

Evaluation:

Partially Inadequate. The response to RAI-37(a) has been evaluated. It provides a general quality assurance response without addressing the question posed (i.e., whether or not the Westinghouse definitions for validation and verification comply with any national standards). Although the response to part (a) is inadequate for the reason stated above, the fact that Westinghouse QMS has been previously approved by NRC may mean that no follow-up would be required (at NRC's discretion). Since the response to RAI-16(b) was inadequate (i.e., it failed to document BISON-SAFIR as a change to an existing evaluation model that permits review under the guidelines of SRP Section 15.0.2), the response to RAI-37(b) which relies upon it is also inadequate. The information supplied in the response to RAI-37(a) and (b) is insufficient to permit review of the related material. As such, it may require a follow-up RAI pending the content of answers to yet outstanding RAIs and the detailed documentation of a BISON-SAFIR example that has been promised by STP. The response to RAI-16(c) is adequate.

Follow-up Action:

Upon further discussion between NRC and ERI, and in conjunction with evaluation of the responses to other RAIs, it was agreed that adherence to Westinghouse QMS would satisfy the criteria for quality assurance from the SRP that prompted part (a) of this question, as it had been reviewed and approved by NRC separately. Furthermore, with regard to the answer to part (b) of the question, presentations for several sample calculations demonstrated verification and validation for some top-level systems (e.g., steam line, reactor protection system, RIP trip, control rod insertion, and feed water controller) satisfied reviewers' concerns about how specific model verification and validation is performed for BISON-SAFIR. [A.7]

Status:

Closed (adequately addressed).

RAI-38:

Question:

In 10 CFR Part 50, Appendix B, Criteria III on Design Control, Criteria IV on Procurement Document Control, on Criteria VII Control of Purchased Material, Equipment, and Services, Criteria XVI on Corrective Action requirements have been established that would pertain to SAFIR.

a) Describe the organization from which SAFIR originated and the design interfaces established to facilitate using SAFIR in conjunction with to BISON.

b) If SAFIR was acquired as a commercial product, describe any processes used to bring it under the WQAP.

c) Describe the receipt inspection process employed to ensure that the SAFIR technology brought under the WQAP was in conformance with the procurement documents.

d) Describe any internal, external, or shared internal/external processes employed for the collection, evaluation, reporting and documenting of reported, suspected or actual conditions adverse to quality.

e) Describe processes and procedures employed to ensure that any conditions adverse to quality are reported in a timely manner to those affected including the means for informing licensees. [A.1]

Response:

a,b,c) SAFIR is an internally developed Westinghouse code and therefore receipt inspections are not required. SAFIR was developed under the approved quality assurance program and has been updated in compliance with Westinghouse Quality Management System (QMS) policies and procedures. Therefore, these sections of the RAI are not applicable.

d,e) The process and procedures employed to document and report conditions adverse to quality and the means of informing licensees are governed by the Westinghouse QMS program. [A.3]

Evaluation:

As the response states that the SAFIR code was developed internally by Westinghouse, no further information is required concerning parts (a) through (c). Parts (d) and (e) of the response refer to the Westinghouse QMS program, which is considered to be an adequate response.

Status:

Closed (adequately answered).

RAI-39:

Question:

For the INT, PI, and PIP components in Table 3-2 and PI component used in Section 4.4 for Verification Example, there is lack of discussion on how to accommodate the integral windup. The applicant is requested to address this issue in the topical report. [A.1]

Response:

Integral windup is an issue for the INT and PI components; not for the PIP and PDP components as these are filter functions that provide lead and lag abilities to the modeled system without any internal integral function. The method used within SAFIR to address integral windup is to initialize the components with desired values. This requires that the input and output signals are known during the stationary solution in SAFIR for INT and PI components. As stated in Section 3.7 of Supplement 3 all components that contain historical information require initialization to calculate the steady-state conditions. The technique used within SAFIR assigns a starting value for selected output signals so the historical value for the component can be calculated provided that the input signals to the component are known. In the case of INT and PI, the internal integral of the component will be assigned an initial value. Another design method used during modeling to deal with integral windup is to use the balancing (tracking) functionality with bumpless return to normal function in order to ensure correct initial conditions for the internal integral when the component is to be engaged. [A.3]

Evaluation:

This response is considered adequate. However, a follow-up question was submitted asking the applicant to revise the topical report to include this information.

Follow-up Question:

The response is acceptable, revise the LTR to reflect the RAI response. [A.6]

Follow-up Response:

The Licensing Topical Report will be updated 90 days following issuance of the Safety Evaluation Report and submitted to the NRC. [A.8]

Follow-up Evaluation:

This response is considered adequate.

Status:

Closed (adequately answered).

RAI-40:

Question:

Table 3-2 just includes basic components. Some components used in Section 6 for the model verification and validation are not included in Table 3-2. The applicant is requested to submit for review a complete list of components and as-built macros to be used for the SAFIR control system simulation. [A.1]

Response:

The identified missing components in Section 6 of Supplement 3 are two macro functions. The first missing function is to resemble a type component in the plant valve controller; the name of this type component is VICKI (see Figure 1).

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The second missing function is a multiplexer with 3 addresses shown in Figure 2. The macro of a multiplexer is an example of the option to create additional user built functions to SAFIR using the basic components from Table 3-2 in Supplement 3. This multiplexer is used in Section 6 of Supplement 3 to simulate different behaviors of a valve. The default mode is address 3 where the turbine controller output is used to calculate the valve position. Address 2 is a user controlled mode and the valve position is determined by a user provided function. Address 1 is used to freeze the valve position at user specified time, i.e. to be able to simulate a stuck valve or a valve that cease to function.

These components were created with SAFIR and show the ability of the code to use basic components to create macro function.

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Evaluation:

The first response to this RAI was found not fully adequate, and a follow-up question was subsequently submitted to the applicant.

Follow-up Question:

WCAP-17079P, Revision 0, Table 3-2 just includes basic components. Some components used in section 6 for the model verification and validation are not included in Table 3-2. The applicant is requested to submit for review a complete list of components and as-built macros to be used for the SAFIR control systems. [A.6]

Follow-up Response:

There were two components in Section 6 of Supplement 3 missing from Table 3-2. These two components are macro functions that are described in response to RAI-40. These macro components were created using components found in Table 3-2. [A.8]

Follow-up Evaluation:

This response is considered adequate.

Status:

Closed (adequately answered).

RAI-41:

Question:

Section 3.1 in the SAFIR Topical Report states that the SAFIR code can be used to simulate most types of control systems or logical functions. The applicant is requested to list the control systems or logical functions which cannot be simulated by the SAFIR. [A.1]

Response:

SAFIR is able to model any control system that may be described by a combination of the basic components available within SAFIR. If new components are required to model a certain control- or logical system, Westinghouse will follow the process as described in the answers to RAI-12 and RAI-13 (Letter U7-C-STP-NRC-100078) depending on the nature of the new component.

Westinghouse has no knowledge of any control systems in the ABWR plant that cannot be modeled using SAFIR. [A.3]

Evaluation:

This response was found partially adequate, as it led to a follow-up question concerning the use of macro functions in the verification and validation examples included in the topical report.

Follow-up Question:

WCAP-17079P, Revision 0, Table 3-2 just includes basic components. Some components used in Section 6 for the model verification and validation are not included in Table 3-2. The applicant is requested to submit for review a complete list of components and as-built macros to be used for the SAFIR control systems. [A.6]

Follow-up Response:

There were two components in Section 6 of Supplement 3 missing from Table 3-2. These two components are macro functions that are described in response to RAI-40. These macro components were created using components found in Table 3-2. [A.8]

Follow-up Evaluation:

This response is considered adequate.

Status:

Closed (adequately answered).

RAI-42:

Question:

Section 2.2 in the SAFIR Topical Report states that the SAFIR code is a generic tool which can be used with any type of simulation code for any type of plant. The applicant is requested to provide evidences or facts to support this kind of statement, otherwise, it's recommended to modify this statement because there are compatible issues between the SAFIR simulation system and other simulation codes which need to be addressed and tested. [A.1]

Response:

This statement will be modified in the final version of the subject LTR WCAP 17079-P-A to: "..the SAFIR code is a generic tool which can be used with an NRC approved transient code with an NRC approved interface to SAFIR for plant and transient types that the approved NRC code is approved for."

New transient codes will be validated to be used with SAFIR as described in RAI-8. [A.3]

Evaluation:

This response is considered adequate.

Status:

Closed (adequately answered).

RAI-42, Revision 1:

Question:

Section 2.2 in the SAFIR Topical Report states that the SAFIR code is a generic tool which can be used with any type of simulation code for any type of plant. The applicant is requested to provide evidence or facts to support this kind of statement, otherwise it is recommended to modify this statement because there are compatible issues between the SAFIR simulation system and other simulation codes which need to be addressed and tested.

Response to RAI-42, Revision 1:

In the approved version of the SAFIR topical, the following changes will be made (identified by underlined text):

The last paragraph of Section 1 currently reads:

> "The main purpose of this amendment is to license the SAFIR code and the process that uses the SAFIR code to develop, verify, and validate control systems in combination with licensed transient codes."

This paragraph will be updated in the approved version of the report to read:

> "The main purpose of this amendment is to license the SAFIR code and the process that uses the SAFIR code to develop, verify and validate control systems in combination with the licensed BISON transient analysis code."

Additionally, the last paragraph of Section 2.2, which currently reads:

> "In this report, however, only application to BWRs is shown. In this case BISON is the transient code interacting with SAFIR, but other dynamic BWR codes that are approved for the application by the NRC may be used provided the model development and the verification and validation process is followed."

This will be changed in the approved version of the topical so that it reads:

"In this report, however, only application to BWRs is shown. In this case BISON is the transient code interacting with SAFIR, but other dynamic BWR codes may be used as described in other licensing topical reports and subject to NRC approval on a code-by-code basis." (A-12)

Evaluation:

The response is considered adequate

Status:

Closed (adequately answered).

RAI-43:

Question:

Section 6.1.2.5 in the SAFIR Topical Report states that only the 5 initial verification cases are presented in the report. The applicant is requested to provide reasons why the other four verification cases are not provided. [A.1]

Response:

The purpose of Section 6.1 is to give some illustrative examples of the SAFIR model development process. The cases not presented do not provide any additional information on the model development process beyond the 5 cases presented. [A.3]

Evaluation:

This response is considered adequate.

Status:

Closed (adequately answered).

RAI-44:

Question:

Section 6 in the SAFIR Topical Report states that simplified models are used in the SAFIR simulation system. The applicant is requested to provide criteria in the topical report on how the simplification is made in the SAFIR simulation system. [A.1]

Response:

Models are normally simplified when adding complexity does not improve the system response or when parts of the systems can be replaced by boundary conditions that adequately produce the expected system response.

The simplifications addressed in Section 6 concern the modeling of the turbine controller and the response from the turbine and generator. One simplification of the turbine controller concerns the turbine speed and power controllers that are not used at full load. The impact from the speed- and power controller is only felt during a load rejection and the controllers are replaced by boundary values. The purpose of the turbine model is to describe turbine speed change during a load rejection, used by the turbine protection system and to estimate generator power. The turbine model is developed such that the turbine speed change at load rejection can be described. The model is validated vs. measurements and the results presented in Figure 5-125 are within desired accuracy. The BOP models refer to Structure System and Components (SSCs) modeling within BISON for BWR plants built in Sweden and Finland. The BISON built-in SSC model (BOP) of the turbine has a larger resolution than the later SAFIR model, especially concerning the heat-balance in the turbine. It was decided during the requirements phase of the model development of a new SSC model for the [[ ]] that there was not a need for a detailed description of the turbine. [A.4]

Evaluation:

This response is considered adequate.

Status:

Closed (adequately answered).

RAI-45:

Question:

Section 1 in the SAFIR Topical Report states that the SAFIR is used in conjunction with BISON to model plant systems important to the balance-of-plant. The applicant is requested to provide a generic list of plant systems important to the BOP and their corresponding verification and validation should be presented as well in the topical report. [A.1]

Response:

This statement will be modified in the final version of the subject LTR WCAP 17079-P-A to: "SAFIR is used in conjunction with BISON to model plant systems, structures and components (SSCs) required for a specific application."

The determination of the control system modeling required for an application will be determined at the time of the application and in connection to a plant specific License Amendment Request according to the methodology described in the Reference Safety Report (RSR per CENPD-300-P-A), also see the answer to RAI-16 (Letter U7-C-STP-NRC-100095).

The scope of the topical report is to provide a description of the process to develop and verify models of control systems, and not a complete list of systems required for a certain application. [A.3]

Evaluation:

This response is considered adequate.

Status:

Closed (adequately answered).

References:

A.1 Letter from U.S. NRC to STPNOC, "Request for Additional Information Re: South Texas Project Nuclear Operating Company Topical Report (TR) WCAP-17079-P, Revision 0, Supplement 3 to BISON Topical Report RPA 90-90-P-A: SAFIR Control System Simulator,", ML100710322, March 12, 2010.

A.2 Letter from STPNOC to U.S. NRC, "South Texas Project, Units 3 and 4, Response to Request for Additional Information 10, 12, 13, 14, 23, 24, 28, 31, 33, 34 and 15.06.05-1," South Texas Project Units 3 and 4, Docket No. PROJ0772, U7-C-STP-NRC-100078, ML101090145, April 13, 2010.

A.3 Letter from STPNOC to U.S. NRC, "South Texas Project, Units 3 and 4, Response to Requests for Additional Information, RAI-1, RAI-2, RAI-5 , RAI-6 , RAI-7, RAI-8, RAI-9, RAI-11, RAI-17, RAI-21, RAI-26, RAI-27, RAI-29, RAI-30, RAI-32, RAI-36, RAI-37, RAI-38, RAI-39, RAI-41, RAI-42, RAI-43 and RAI-45," South Texas Project Units 3 and 4, Docket No. PROJ0772, U7-C-STP-NRC-100089, ML101380351, May 12, 2010.

A.4 Letter from STPNOC to U.S. NRC, "South Texas Project, Units 3 and 4, Response to Request for Additional Information, RAI-4, RAI-16, RAI-25, RAI-35, RAI-40, and RAI-44," South Texas Project Units 3 and 4, Docket No. PROJ0772, U7-C-STP-NRC-100095, ML101380349, May 12, 2010.

A.5 Letter from STPNOC to U.S. NRC, "South Texas Project, Unit 3 & 4 - Response to Request for Additional Information, RAI-3, RAI-19, RAI-15, RAI-20, RAI-18, RAI-22," South Texas Project Units 3 and 4, Docket No. PROJ0772, U7-C-STP-NRC-100127, ML101620286, June 8, 2010.

A.6 Letter from U.S. NRC to STPNOC, "South Texas Project, Units 3 & 4, Request for Additional Information re: Topical Report (TR) WCAP-17079P, Revision 0, Supplement 3 to Bison Topical Report RPA 90-90-P-A SAFIR Control System Simulator (TAC No. RG0012)," United States Nuclear Regulatory Commission, ML102370949, August 24, 2010.

A.7 U.S. NRC, "Regulatory Audit Summary of South Texas Project Nuclear Operating Company Topical Report WCAP-17079P, Revision 0, Supplement 3 to Bison Topical Report RPA 90-90-P-A SAFIR Control System Simulator," United States Nuclear Regulatory Commission, ML102730292, October 14, 2010.

A.8 Letter from STPNOC to U.S. NRC, RAI-15S01, RAI-36S01, RAI-39S01, RAI-40S01, RAI-41S01, "South Texas Project, Units 3 and 4 - Response to Request for Additional Information," South Texas Project Units 3 and 4, Docket No. PROJ0772, U7-C-STP-NRC-100221, ML102850213, October 6, 2010.

A.9 Letter from STPNOC to U.S. NRC, RAI-16S001, RAI-19S001, RAI-24S001, "South Texas Project, Units 3 and 4 - Response to Request for Additional Information," South Texas Project Units 3 and 4, Docket No. PROJ0772, U7-C-STP-NRC-100251, ML110060380, December 6, 2010.

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A.10 L. Olsson and Henrik Björke, “Supplement 4 to BISON Topical Report RPA 90-90-P-A,” WCAP-17202-P, Revision 0, Westinghouse Electric Company LLC, June 2010.

A.11 ABB Combustion Engineering Nuclear Operations, “Reference Safety Report for Boiling Water Reactor Reload Fuel,” CENPD-300-P-A, ML072250429, July 1996.

A.12 Revised Final Safety Evaluation by the Office of Nuclear Reactor Regulation for Westinghouse Electric Company Topical Report WCAP-16747-P, “POLCA-T: System Analysis Code with Three-Dimensional Code Model,” TAC No. MD5258, ML101460445, June 1, 2010.

A.13 Letter from NINA to U.S. NRC, RAI-42, Rev.1, “South Texas Project, Units 3 and 4 - Response to Request for Additional Information,” South Texas Project Units 3 and 4, Docket No. PROJ0772, U7-C-STP-NRC-110086, ML11178A108.