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Generic Design Assessment – New Reactors Programme

Assessment of the responses to RI-ABWR-0002 - UK ABWR Probabilistic Safety Analysis: Project Plan and Delivery

Assessment Report ONR-NR-AR-16-091
Revision 0
23 02 2017

EXECUTIVE SUMMARY

This report presents the findings of my assessment of whether the submission provided by Hitachi-GE in response to Regulatory Issue (RI) RI-ABWR-0002, Project Plan and Delivery of the UK ABWR Probabilistic Safety Analysis (PSA) is adequate for ONR to carry out a meaningful assessment in Generic Design Assessment (GDA).

The purpose of this assessment was three-fold;

- To document the assessment which underpins the recommendation made in closing RI-UKABWR-0002, or otherwise;
- To serve as a record of the scope of the assessment undertaken for RI-ABWR-0002, and therefore the boundaries of the judgements made; and
- To identify any areas for follow up which may need to be satisfactorily addressed during the remainder of GDA Step 4, or beyond, as appropriate.

ONR's expectations in the Safety Assessment Principles (SAPs) identify the need for a PSA to be performed as part of the fault analysis and the design development analyses. The *GDA Guidance to Requesting Parties* indicates that the submission for design acceptance should include a full scope PSA and that the PSA should be used to help demonstrate that the design satisfies the as low as reasonable practicable (ALARP) requirement. The *GDA Guidance to Requesting Parties* also indicates that it is expected that the requesting party (RP) provides a PSA at the start of step 3.

Based upon the submissions made by Hitachi-GE during Steps 2 and 3 of the GDA for UK ABWR, ONR judged there to be serious regulatory shortfalls associated with the development of a modern standards full-scope PSA for the UK ABWR, which would be suitable and sufficient for ONR to carry out a meaningful assessment within the project timescales. These had the potential to prevent provision of a Design Acceptance Confirmation (DAC). In line with the guidance to requesting parties, ONR therefore raised RI-ABWR-0002, to make regulatory expectations clear and to ensure that these shortfalls were addressed during GDA.

In response to RI-ABWR-0002 Hitachi-GE has provided a project plan, revised PSA arrangements and extended PSA capability. As a result, Hitachi-GE has delivered a comprehensive UK ABWR PSA submission including consideration of internal events and hazards, for the reactor, spent fuel pool and other facilities for different operating modes. The submission was delivered in a staged manner between September 2015 and December 2016. In addition, responses to Regulatory Queries (RQs) were submitted, providing additional clarification and evidence.

The main conclusions of my assessment are:

- The project plan provided in response to RI-ABWR-0002 is adequate to support Hitachi-GE development of most of the information that I need for Step 4 assessment. Furthermore, the project plan establishes clear PSA objectives, applications and high level requirements that are broadly in line with expectations in the PSA SAPs. Hitachi-GE internal processes have been improved to support the statements in the project plan. For areas that require follow up I have requested additional information as part of my ongoing Step 4 review.
- The extended PSA capability is sufficient to support the development of most of the information that I need for Step 4 assessment. I have identified an item that requires follow-up through the course of my overall Step 4 assessment.
- Hitachi-GE quality assurance (QA) plan and procedures, in particular Hitachi-GE peer review process, is adequate to deliver a submission of sufficient quality to enable a meaningful assessment in Step 4.

- Overall, on the basis of the outcomes of the ongoing Step 4 review, the work submitted by the RP to date is adequate for ONR to carry out a meaningful assessment in GDA.

While I have identified a number of items that require follow-up through the course of my assessment I do not consider any of these to be significant enough to prevent closure of the RI.

To conclude based on my assessment, I am content that Hitachi-GE have provided sufficient information to meet the intent of RI-ABWR-0002 and have addressed the issues which led to it being raised. I am therefore content that the RI has been resolved.

My recommendations are as follows:

- Recommendation 1: RI-ABWR-0002 should be closed.

- Recommendation 2: The items that require follow-up identified in this report should be considered as part of Step 4 GDA of the UK ABWR PSA.

LIST OF ABBREVIATIONS

ABWR	Advanced Boiling Water Reactor
ADS	Automatic Depressurisation System
ALARP	As Low As Reasonably Practicable
ANS	American Nuclear Society
ASME	American Society of Mechanical Engineers
BMS	Business Management System
BOC	Break Outside Containment
CDF	Core Damage Frequency
CST	Condensate Storage Tank
DAC	Design Acceptance Confirmation
DRP	Design Reference Point
ECCS	Emergency Core Cooling System
FLSS	Flooder System of Specific Safety Facility
GEH	GE Hitachi
GDA	Generic Design Assessment
HEPs	Human Error Probabilities
Hitachi-GE	Hitachi GE Nuclear Energy Ltd
HPCF	High Pressure Core Flooder
IAEA	International Atomic Energy Agency
ISLOCA	Intersystem Loss of Coolant Accident
MCT/RIE	Model Changes Tracking/Risk Impact Evaluation
MSQA	Management of Safety and Quality Assurance
NPP	Nuclear Power Plant
ONR	Office for Nuclear Regulation
PQC	Process Quality Control
PRA	Probabilistic Risk Assessment
PSA	Probabilistic Safety Analysis
QA	Quality Assurance

RO	Regulatory Observation
RP	Requesting Party
RPV	Reactor Pressure Vessel
RQ	Regulatory Query
RI	Regulatory Issue
SAP(s)	Safety Assessment Principle(s)
SFP	Spent Fuel Pool
SQEP	Suitably Qualified and Experienced Personnel
SRV	Safety Relief Valve
TAG(s)	Technical Assessment Guide(s)
TSC	Technical Support Contractor
V&V	Verification and Validation
WENRA	Western European Nuclear Regulators' Association

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1 INTRODUCTION

1.1 Background

1. This report presents the findings of my assessment of whether the submission provided by Hitachi-GE (the Requesting Party (RP)) in response to Regulatory Issue (RI) RI-ABWR-0002, Project Plan and Delivery of the UK ABWR (United Kingdom Advanced Boiling Water Reactor) Probabilistic Safety Analysis (Ref. 1) is adequate for ONR to carry out a meaningful assessment in Generic Design Assessment (GDA). Assessment was undertaken in accordance with the requirements of the Office for Nuclear Regulation (ONR) How2 Business Management System (BMS) guide NS-PER-GD-014 (Ref. 2). ONR Safety Assessment Principles (SAP) (Ref. 3), together with supporting Technical Assessment Guides (TAG) (Ref. 4), have been used as the basis for this assessment.

2. ONR's expectations in the SAPs identify the need for a Probabilistic Safety Analysis (PSA) to be performed as part of the fault analysis and the design development analyses. The *GDA Guidance to Requesting Parties* (Ref. 5) indicates that the submission for design acceptance should include a full scope PSA and that the PSA should be used to help show that the design satisfies the as low as reasonable practicable (ALARP) requirement. The *GDA Guidance to Requesting Parties* also indicates that it is expected that the requesting party (RP) provides a PSA at the start of step 3

3. My assessment during Step 2 of GDA of the PSA aspects of the UK ABWR safety submission concluded that the information provided in Step 2 was insufficient to present an overall picture and thus, a reasonable understanding of the UK ABWR risk. In August 2014, ONR raised Regulatory Observation (RO) RO-ABWR-0013 (Ref.6) to state ONR's expectations related to the development and delivery of the PSA for the UK ABWR as part of the GDA submission and to gain early confidence that Hitachi-GE was able to deliver a modern standards full-scope PSA within the GDA timeframes.

4. The UK ABWR PSA for internal events at power was submitted to ONR at the end of December 2014. ONR's Step 3 review identified the need for further work in order to fully meet UK regulatory expectations. The outcomes of the review were captured in a series of related ROs Ref.7 to Ref.12 and Regulatory Queries (RQs) Ref.13 and Ref.14. These ROs and RQs highlighted that the arguments supporting the PSA safety claims did not meet the relevant expectations in ONR's PSA TAG which captures our PSA SAPs and international good practice. On this basis, ONR considered that the PSA submission did not meet the expectations defined in the Step 2 PSA Assessment Report (Ref.15), did not provide a clear understanding of the UK ABWR risk and was not adequate to support the demonstration that the level of risk was ALARP.

5. ONR considers a suitable and sufficient PSA to be an integral aspect of the UK ABWR's safety analysis within GDA. Based upon the submissions made by the RP during Steps 2 and 3, ONR did not have confidence that Hitachi-GE, without further work and changes, would be able to deliver a modern standards full-scope PSA for the UK ABWR, which would be suitable and sufficient for ONR to carry out a meaningful assessment within the project timescales. This was considered a serious regulatory shortfall which ONR, in line with our Guidance to Requesting Parties (paragraphs 159 and 160), escalated to a Regulatory Issue in July 2015.

6. The purpose of this report is therefore three-fold;

   - To document the assessment which underpins the recommendation made in closing RI-UKABWR-0002, or otherwise;
   - To serve as a record of the scope of the assessment undertaken for RI-ABWR-0002, and therefore the boundaries of the judgements made; and

- To identify any associated areas for follow up which may need to be satisfactorily addressed during the remainder of GDA Step 4, or beyond, as appropriate.

1.2 Scope

7. The scope of this report covers the assessment of only those matters identified within the scope of RI-ABWR-0002, as defined within the RI (see Annex 1). Overall, the scope of this report is to support my judgement on whether Hitachi-GE UK ABWR PSA submission is adequate for ONR to carry out a meaningful assessment in GDA. The full scope of the submissions provided in response to this RI have been sampled and assessed in order to make that judgement.

1.3 Methodology

8. The methodology for the assessment follows HOW2 guidance on mechanics of assessment within ONR (Ref. 16). I have sampled the submissions made in response to this RI, to various degrees of breadth and depth. I chose to focus my assessment on those aspects which I judged are important to provide me with confidence that the scope of the PSA and the implementation of the methods and techniques used are adequate to undertake a meaningful assessment in GDA. My sample has also been influenced by the specific weaknesses in the original submissions made by the RP which led to the RI.

9. This assessment is therefore based on the main submissions relating to resolution of RI-ABWR-0002 as well as any further requests for information derived from assessment of those specific deliverables, in particular in responses to a number of RQs raised.

10. Due to the scope and nature of the submissions, it was necessary for Hitachi-GE to update some of the documents throughout the resolution of RI-ABWR-0002. My assessment considers the latest revision of the documents, plus the subsequent RQ responses. Further details of the submissions that formed the basis of this assessment are given in section 3.2 of this report.

11. This assessment allows ONR to judge whether the submissions provided in response to the RI are sufficient to allow it be closed. This is not the same as concluding that all matters associated with the UK ABWR PSA are resolved. Step 4 review of the UK ABWR is ongoing and will be reported separately in Step 4 GDA assessment report. In fact, further work and changes in the PSA submission may be necessary to address the outcomes of this review. Where this assessment recognises that further evidence is required these are specifically identified, such that they can be satisfactorily addressed during the remainder of GDA Step 4, or beyond, as judged appropriate as part of my Step 4 assessment.

2 ASSESSMENT STRATEGY

12. The intended assessment strategy for resolution of RI-ABWR-0002 is set out in this section. This identifies the scope of the assessment and the standards and criteria that have been applied.

2.1 Background to RI-ABWR-0002

13. This section provides a brief overview of the background to RI-ABWR-0002, which provides the context on the detailed assessment scope.

14. The UK ABWR PSA was not submitted to ONR in Step 2 as it was under development. The RP provided a preliminary bounding estimate for the core damage frequency (CDF) for internal events, and internal fire and flooding. The RP also provided the strategy and high level programme to develop a modern-standards, full-scope level 1, level 2 and level 3 PSA during GDA.

15. My Step 2 review concluded that the bounding CDF estimate could result in risk figures that would not meet ONR's expectations for new reactors when compared against the numerical targets in the SAPs. Although the RP indicated that this evaluation was conservative, the analyses provided in Step 2 were simplified and appeared to be incomplete. At this point I did not have sufficient information to properly understand the risk profile for the UK ABWR, as this required a full scope, modern standards PSA.

16. ONR considered this shortfall in the RP's safety case important, and issued RO-ABWR-0013 to request the RP to develop and deliver the UK ABWR PSA in accordance with a detailed programme, which should be reflected in the Project Plan requested in Action 1 of this RO, outlining specific PSA tasks required to be completed and providing clarity on, and timings for, the deliverables (including any required task procedures, task analysis files, models and databases as agreed with ONR). In response to the RO the RP was requested to phase the delivery of the UK ABWR PSA and documentation in a logical manner, in accordance with the Project Plan.

17. The UK ABWR PSA for internal events at power was submitted to ONR at the end of December 2014, in line with the programme provided as part of the response to RO-ABWR-0013. My Step 3 review assessed this PSA and other PSA documentation (e.g. identification and prioritization of hazards for the PSA) with a focus on the arguments supporting the PSA safety claims. My assessment, documented in Ref. 17, identified shortfalls and gaps against regulatory expectations in each technical area of the PSA reviewed.

18. These shortfalls and gaps highlighted that the arguments supporting the PSA safety claims did not meet a significant number of expectations in ONR's PSA TAG which captures ONR's PSA SAPs and international good practice. Therefore the level 1 and level 2 PSA for internal initiating events during operation at power and the screening of hazards for the PSA were considered as not adequate to:

- Support a clear understanding of the UK ABWR risk.
- Support the demonstration that the risk associated with the UK ABWR is ALARP.
- Provide confidence that the design change decision-making process will result in ALARP design solutions.

19. The review also identified issues with the RP PSA capability and the PSA Quality Assurance (QA). Furthermore, the documentation provided in Step 3 was incomplete and not coherently structured. On the basis of the review outcomes, I did not have confidence that Hitachi-GE, without significant improvements, would be able to deliver a modern standards full-scope PSA for the UK ABWR, which was suitable and sufficient for ONR to carry out a meaningful assessment in Step 4, and be able to judge during GDA whether the overall risks from the UKABWR are acceptable. The

general position was that the PSA assessment was not ready to move to the next detailed phase with an examination of the evidence which supports the claims and arguments presented to date. This was considered to be a serious regulatory shortfall and escalated to a Regulatory Issue in July 2015. The PSA schedule was one of the issues that led to Hitachi-GE and the regulators deciding to slightly extend GDA Step 3 to ensure that all topics remained well aligned in the step-wise process.

20. RI-ABWR-0002 is given in Annex 1 and regulatory expectations are explained in section 2.

2.2 Assessment Scope

21. This report presents only the assessment undertaken for resolution of Regulatory Issue RI-ABWR-0002, related to the project plan and delivery of the UK ABWR PSA (Ref. 1). The overall aim of the assessment is to come to a judgement on whether the UK ABWR PSA submission is sufficient for ONR to carry out a meaningful assessment in GDA.

22. RI-ABWR-0002 states ONR's expectations with respect to Hitachi-GE developing and delivering a suitable and sufficient PSA for the UK ABWR fault analysis as part of the GDA submission in order for ONR to undertake a meaningful assessment against regulatory expectations. In particular, Hitachi-GE is required to provide:

- Project plan (Action 1): A project plan that ensures that the PSA's purpose and objectives and hence its scope are clearly understood at the outset of the project. As many of the future applications as possible should be identified, as these will affect the approach to be used in the individual tasks. It should also identify the requisite level of QA, and the various reports and procedures which will be produced during the course of the development of the PSA. It is essential to identify the required documentation at the beginning of the project, and develop it throughout the course of the work, as much more effort would be required to generate the technical documents after the models have been developed.
- Resources (Action 2): The allocation of sufficient Suitably Qualified and Experienced (SQEP) PSA resources required to complete each of the tasks identified in the project plan.
- Quality Assurance (Action 3): The development of the PSA must be based on a secure and traceable process in which all details of the PSA, including explicit and implicit assumptions, modelling techniques. etc., are fully checked, documented and recorded. The purpose of the QA plan and procedures is to ensure that the necessary documentation is developed and the review process for all work products is clearly specified. The QA practices and procedures in use at in the development of the design should be considered when QA is planned for the development of the PSA.
- PSA model and technical documentation (Action 4): PSA model and technical documentation: Comprising the UK ABWR PSA model and all the technical documentation covering the development of each of the tasks and the recording and reporting of the work performed.

23. Annex 1 of this report contains the full text of the Regulatory Issue and Actions. Hitachi-GE have produced a resolution plan which details the methods by which they intended to resolve the RI through identified timescales and deliverables; see Ref. 18.

24. The relevant standards and criteria adopted within this assessment are principally the SAPs (Ref. 3), internal ONR TAGs (Ref. 4) and relevant national and international standards. The key SAPs, relevant TAGs and national and international standards and guidance are detailed within this section.

As described in more detail below, this assessment report therefore does not represent the full judgement on all aspects of the PSA for GDA of UK ABWR. This will be reported in my Step 4 assessment report.

2.3 Assessment Approach

25. The assessment was undertaken by examining the evidence provided by Hitachi-GE in responding to RI-ABWR-0002. This was assessed against the expectations in the RI, SAPs and other guidance considered appropriate. The basis of the assessment undertaken to prepare this report is therefore:

- Submissions made to ONR in accordance with the resolution plan;
- Consideration of RI-ABWR-0002, internal and international standards and guidance;
- Interaction with other relevant technical areas (where appropriate);
- Consideration of relevant outputs from any Technical Support Contractor (TSC) work;
- Raising and issuing of RQs as appropriate, followed by assessment of RP responses; and
- Holding technical meetings to progress the identified lines of enquiry.

2.3.1 Regulatory Queries

26. Regulatory Queries related to the assessment of RI-ABWR-0002 are detailed in Table 1. The responses provided by Hitachi-GE to the RQs were considered as part of this assessment. Commentary on the most important and relevant RQ responses is included in the assessment section later in this report as appropriate. The responses provided further evidence to support resolution of the RI.

2.3.2 Technical Meetings

27. A number of technical meetings with Hitachi-GE were held during assessment of the RI-ABWR-0002 responses, including an inspection of the implementation of PSA processes (RI Action 1 and 3). Overall, the principal focus of these meetings was to discuss progress and responses, to facilitate technical exchanges and to hold discussions with the RP's technical experts on emergent issues.

2.4 Standards and Criteria

28. The goal of this assessment report is to reach an independent and informed judgment on the adequacy of the UK ABWR PSA submission to enable ONR to carry out a meaningful assessment in GDA against the regulatory principles, including the PSA SAPs which are embodied and enlarged on in the TAGs on PSA. The assessment undertaken considers the SAPs and TAGs outlined below.

2.4.1 Safety Assessment Principles

29. Given the nature and scope of this assessment, the SAPs applied within the assessment are: FA.10 (Need for PSA), FA.11 (Validity), FA.12 (Scope and extent), FA.13 (Adequate representation), FA.14 (Use of PSA).

2.4.2 Technical Assessment Guides

30. The following Technical Assessment Guide have been used as part of this assessment (Ref. 13):

- NS-TAST-GD-030 Revision 6 – PSA

2.4.3 National and International Standards and Guidance

31. My assessment has been principally undertaken against the SAPs.

32. The International Atomic Energy Agency (IAEA) (Ref. 19) and Western European Nuclear Regulators Association (WENRA) standards and guidance (Ref. 20) set expectations for the performance and use of PSA to demonstrate the robustness of designs and are directly applicable to my assessment. The latest Probabilistic Risk Assessment (PRA) standards issued by the American Nuclear Society (ANS/ASME) (Ref. 21) also need to be considered for completeness. The key principles from these standards and guidance are embodied in ONR PSA SAPs and TAGs.

2.5 Use of Technical Support Contractors

33. No TSC support was undertaken to review the responses to RI-ABWR-0002 directly for the purpose of this assessment.

34. However, TSC were engaged to assist with the PSA assessment work throughout GDA. Whilst the TSC have undertaken detailed technical reviews of the UK ABWR PSA in Step 4, this has been done under close direction and supervision by ONR. The TSC have also assisted me in the PSA inspection carried out in March 2016.

35. I have used the outcomes of this work to make a regulatory judgment on the adequacy or otherwise of the UK ABWR PSA submission to enable ONR to carry out a meaningful assessment in GDA.

2.6 Integration with Other Assessment Topics

36. There have been interactions between PSA and the rest of the technical areas as part of the overall assessment of the UK ABWR PSA, which informs my assessment of the response to RI-ABWR-0002. These interactions happened continuously during GDA Step 4, they were two-way, and they were, mostly, of an informal nature. Further information will be presented in my Step 4 report. The interactions with ONR inspector for Management of Safety and Quality Assurance (MSQA) have been of particular benefit for the assessment of RI Actions 1 and 3.

2.7 Out of Scope Items

37. Hitachi-GE identified no items as outside the scope of the response to RI-ABWR-0002, aside from those defined by the RI itself. However, the scope of my assessment as described in Section 2.1, focus on the adequacy of the UK ABWR PSA submission to carry out a meaningful assessment in GDA.

38. This means that the assessment of the adequacy of the UK ABWR PSA, including claims, arguments and evidence, is excluded. The assessment of the evidence that supports the arguments (assessed in Step 3, Ref. 17) that support high level claims (assessed in Step 2, Ref. 15) on how the PSA SAPs are met, have been looked at as part of my overall Step 4 review.

3 REQUESTING PARTY'S SAFETY CASE

3.1 Submissions Provided in Response to the Regulatory Issue

39. This section presents a summary of the RP's submissions in response to RI-ABWR-0002 and the documents submitted by the RP which have formed the basis of my assessment.

40. The aspects covered by the Hitachi-GE submission have been broadly grouped under a number of headings, in line with RI-ABWR-002 Actions, which are summarised in the following paragraphs.

3.1.1 UK ABWR PSA Project Plan (Action 1)

41. In response to RI-ABWR-0002 Action 1, Hitachi-GE established a programme to develop a modern standards full-scope PSA that was subsequently revised in February 2016 to reflect the need for further updates of the internal events PSA and changes in the PSA documentation submission plan.

42. The February 2016 PSA programme (Ref.22) covers reactor and spent fuel pool, internal event at power and shutdown, internal hazard and external hazard PSAs and includes PSA updates to reflect changes in the design reference and regulatory review comments. The PSA programme includes a high level description of processes and procedures and states that the PSA will reflect the design reference. The document indicates that when the level of plant requirements specification limits the detail of the PSA, assumptions will be developed to allow completion of the PSA. Additionally, it is stated that the PSA and risk insights will be used to support the ALARP demonstration and shared with the design teams in accordance with Hitachi-GE's design process.

43. Hitachi-GE has also produced a PSA strategy document (Ref. 23) that identifies the strategy to develop the UK ABWR PSA, including a high level description of the PSA objectives, applications, and requirements of the PSA to meet the intended objectives and applications. A high level definition of the tasks to deliver the PSA tasks and procedures related to the development and applications is also provided. Examples of procedures included are below.

- Hitachi-GE's Process Quality Control (PQC) procedure (Ref. 24) is used to procure the design information that is used to initially develop the PSA and other inputs from the design team.
- Hitachi-GE states that design changes are subsequently communicated to the PSA team via the PQC procedure; then the PSA and assumptions will be updated to reflect design changes.
- Hitachi-GE states that for design changes categorised as requiring to enter the six step process for design change in Step 4 as part of the 'Generic Design Development Control' process (Ref. 25), the PSA is used to support the decision making in design review meetings via the participation of expert(s) having experience or knowledge on PSA. This type of design change, identified by other technical areas but for which the PSA team provide input to support the decision making, is referred in the PSA strategy document as "Design Change Proposal Type 1".
- Hitachi-GE indicates that the 'Generic Design Development Control' process (Ref. 25) have been updated to reflect that Hitachi-GE PSA team can identify design enhancements based on PSA results that will have to go through Hitachi-GE six step process. This type of design change is referred in the PSA strategy document as "Design Change Proposal Type 2".
- A process to capture, track and transfer PSA and assumptions to site specific phase has also been developed by Hitachi-GE (Ref.26).

3.1.2 Allocation of Suitably Qualified and Experienced PSA Resources to Develop the UK ABWR PSA

44. Changes in Hitachi-GE PSA team in response to RI-ABWR-0002 Action 2 are summarised in (Ref. 27). In this document, Hitachi-GE explains the modifications in the PSA team organisation and capability implemented in response to the requirements in the RI. In particular, Hitachi-GE identifies as key changes the appointment of a technical lead with significant international PSA experience, additional support from GE Hitachi (GEH) and internationally experienced technical support contractors.

3.1.3 PSA Quality Assurance Plan and Quality Assurance Procedures

45. In response to RI-ABWR-0002, the RP has put in place new QA arrangements. In particular, a peer review is conducted by external PSA experts. The RP claims that the peer review follows the demands of the US ANS/ASME PRA Standard (Ref. 21). The peer review process and objectives are explained in Ref. 28. In addition, Horizon's PSA analysts carry out another review looking at the PSA from a high-level perspective and then selecting specifics of the PSA to review in more detail. Hitachi-GE provides visibility of the review's scope and outcomes through peer review documents for each technical area of the PSA (examples in Ref.29).

46. Hitachi-GE has also provided a high level description of the PSA quality assurance procedure (Ref.24), as part of Hitachi-GE PQC process. This document includes examples of check sheets or verification plans for different PSA tasks and applications.

3.1.4 PSA Task Analysis Files, Summary Report, Document Database and Task Procedures

47. In response to RI-ABWR-0002, Hitachi-GE have produced a PSA with the following major aspects:

- Internal events at power level 1 (Ref.30) and level 2 PSA (Ref.31).
- Internal events spent fuel pool (SFP) level 1 (Ref.32) and level 2 PSA (Ref.33).
- Internal events shutdown level 1 (Ref.34) and level 2 PSA (Ref.35).
- Fuel route and dropped loads level 1 and level 2 PSA (Ref.36).
- Seismic level 1 and level 2 PSA for the reactor at power and the SFP (Ref.37). A qualitative assessment of the shutdown PSA is also provided
- Hazards prioritisation and hazards PSA (Ref.38)
- Internal fire level 1 and level 2 PSA (Reactor at Power only) (Ref.39).
- Internal flood level 1 and level 2 PSA (Reactor at Power only) (Ref.40).
- Containment performance analysis (Ref.41).
- Consequence analysis for non-reactor faults and success path leading to release (Ref.42).
- A level 3 PSA based on earlier submissions of level 1 and level 2 PSAs was submitted in July 2016 and an update based on recent submissions cited above is expected in early 2017
- PSA summary report providing a collated picture of the global risk calculated by the various elements of the UK ABWR PSA (Ref.43).
- Methodologies have been produced for all the technical areas of the PSA (list provided in Ref.44)
- Task procedures/plans have been produced for the internal events and internal fire and flooding PSAs (list provided in Ref.44).
- A PSA document map (Ref.45)

48. Delivery of the PSA models and documentation noted above has been provided in a staged manner between September 2015 and December 2016. In addition, the internal

events PSA have been revised several times to take into account peer review comments, regulatory review comments and additional design information. The first milestone of the programme was the delivery of the updated level 1 PSA for internal events at power at the end of September 2015. A revised PSA was then submitted in January 2016 and a further revision was developed in June 2016. Further PSA development is expected to address the outcomes of the ongoing ONR assessment, and to include further consideration of hazards during shutdown states and their impact on the SFP.

49. In September 2016, Hitachi-GE also produced a preliminary Topic Report on Use of PSA in ALARP assessment (Ref.46). According to Hitachi-GE this report is to provide evidence from the PSA that the UK ABWR design follows the principles of ALARP and to identify any areas where further risk reduction may be possible as GDA Step 4 activities are completed, or during the detailed design and plant operation which follow the completion of GDA.

4 ONR ASSESSMENT

50. This assessment has been carried out in accordance with HOW2 guide NS-PER-GD-014, “Purpose and Scope of Permissioning” (Ref. 2).

51. The scope of my assessment is described in section 2, alongside the description of the submissions which formed the basis for that assessment in section 3. The overall scope of this assessment is to provide responses to the following aims:

- To provide the assessment which underpins the judgement made in closing RI -ABWR-0002;
- To serve as a record of the scope of the assessment of RI-ABWR-0002, and therefore the boundaries of the judgements made; and
- To identify any associated items that require follow up as part of my Step 4 assessment.

52. In response to RI-ABWR-0002, Hitachi-GE has established a significantly revised programme, extended their PSA capability and improved the processes to support the development and use of the PSA. The first milestone of the programme was the delivery of the updated level 1 PSA for internal events at power during the extended GDA Step 3 period at the end of September 2015.

53. I reviewed this submission to determine whether it was suitable for ONR to commence Step 4 detailed assessment of the PSA model, data and underlying analyses. My review is documented in Ref. 17. My review highlighted that Hitachi-GE’s improved PSA arrangements and PSA capability had set up the basis to develop and deliver the PSA information that I required for a meaningful assessment during Step 4. I concluded that I was broadly satisfied that the commitment provided by Hitachi-GE in response to RI-ABWR-0002 would address the shortfalls identified in the arguments laid down within Hitachi-GE’s submissions in the PSA topic area. The general position at the end of the extended Step 3 stage was that the PSA topic area was ready to move to the next detailed phase of the assessment with an examination of the evidence which supports the claims and arguments.

54. The sections below describe my assessment of the RI response in Step 4. I have structured my assessment around the responses provided by Hitachi-GE to RI-ABWR-0002 Actions.

4.1 UK ABWR PSA Project Plan (Action 1)

55. RI-ABWR-0002 Action 1 requested Hitachi-GE to provide a project plan to establish the PSA objectives, applications and definition of the requirements of the PSA to fulfil these. The project plan should also include a programme, and identify the various procedures and reports which will be produced or updated during the development of the UK ABWR PSA, for all the PSA tasks and PSA applications.

4.1.1 Assessment

56. My review of the PSA project plan considers the adequacy of the project plan (PSA programme and PSA strategy document) to deliver a PSA that meets ONR’s expectations in the PSA SAPs and TAG outlined in section 2.

57. Hitachi-GE PSA programme was updated in February 2016 to cover most of the areas of the development of a full scope PSA (FA.12). Including:

- Internal events at power level 1and level 2 PSA
- Internal events SFP level 1 and level 2 PSA
- Internal events shutdown level 1 and level 2 PSA.

- Fuel route and dropped loads level 1 and level 2 PSA.
- Seismic level 1 and level 2 PSA.
- Internal fire level 1 and level 2 PSA (reactor at power only)
- Internal flood level 1 and level 2 PSA (reactor at power only)
- Hazards prioritisation and hazards PSA
- Level 3 PSA and consequence analysis

58. I have reviewed whether key PSA tasks, documents and key milestones were identified in the PSA programme and concluded that these are broadly provided (at the high level). However, the programme presented needed to be updated to include the work required to address the outcomes of my regulatory review, ensure the scope of the PSA is complete and adequately reflects the design reference. Furthermore, some aspects of the PSA were revised after February 2016 and the revisions were not included in the programme. Upon ONR request, in December 2016, Hitachi-GE provided a high level PSA programme (Ref. 44) that covers additional work and submissions needed to complete the GDA submission and address regulatory comments.

59. I have reviewed the identified PSA objectives, applications and high level requirements against expectations in the PSA SAPs as defined in section 2.

60. The information provided in the strategy document is broadly aligned with regulatory expectations in the PSA SAPs. However, it is high level and does not include the evidence that I required for my assessment. I have therefore undertaken an inspection of the implementation of key processes outlined in the strategy document that are in place to deliver some of the PSA objectives, applications and requirements. The inspection was carried out in March 2016 and is documented in (Ref. 47). As part of this inspection, I requested Hitachi-GE to provide evidence of the implementation of the following processes:

- Process followed to ensure the PSA reflects the UK ABWR design reference point (DRP). This is identified as a PSA requirement in section 2.3 of the strategy document and is in line with FA.11. The following information was requested from Hitachi-GE during the inspection:

  - Records of design review input (PQC process).
  - Records of how the PSA team share the information to be reviewed with engineering teams.
  - Records of comments from design team on the review of the PSA systems analysis.
  - Records of comments from design team on the review of the PSA assumptions.
  - Records of how changes in the DRP are shared with the PSA team.
  - Process used to evaluate these changes and decide to updated/not the PSA and records.
  - Records of review of assumptions if there has been an update of the DRP

- Process followed to use of the PSA to support the design development. This is identified as a PSA objective in section 2.1 and application in section 2.2 of the strategy document in is line with FA.14. The following information was requested from Hitachi-GE during the inspection:

  - Evidence of the “type 1” review of design changes.
  - Evidence of the “type 2” design change proposed by PSA.

61. The key outcomes of the inspection are reflected below.

62. At the time of the inspection, Hitachi-GE indicated that there were no examples of design change that were not reflected in the January 2016 PSA (which corresponds to

the October 2015 DRP). Hitachi-GE reiterated that they planned to review the PSA and assumptions to reflect future design changes.

63. My inspection identified limitations in the input from Hitachi-GE PSA team to inform the so called “type 1” design changes (see definition in section 3). Hitachi-GE shared four examples regarding the identification of type 2 design changes (see definition in section 3). However, further design changes may be identified as part of the ongoing work that Hitachi-GE is undertaking to use the PSA to demonstrate the risk is ALARP (see section 4.4).

64. During the PSA inspection in March 2016 and follow up interactions, Hitachi-GE also presented examples of the assumptions compiled in the ‘Assumptions List for UK ABWR PSA’ (Ref. 26) which collates the assumptions to be transferred to a future licensee for further sentencing and resolution during the site specific phase. Hitachi-GE confirmed that adequacy of the design assumptions made in the PSA are discussed with the engineering teams. Assumptions related to design enhancements were also shared with the engineering teams during the development of the PSA. The adequacy of the assumptions made will be considered as part of my Step 4 review.

65. Following the inspection and to address the regulatory comments, Hitachi-GE updated further the ‘Generic Design Development Control’ process (Ref. 25), which now requires that Hitachi-GE engineering teams inform the PSA team when a design modification (type 1 design change) is expected to impact the PSA; the updated process states that records of the PSA involvement in the decision making and justification should be kept. As part of my Step 4 assessment I will review the adequacy of the criteria used to involve Hitachi-GE PSA team in the design review process. I have requested further information in RQ-ABWR-1161.

66. This information is also required for the PSA update to reflect design changes. In response to RQ-ABWR-1161, Hitachi-GE provided a document (Ref. 48) to explain the process followed to update the PSA to reflect design changes. At the time of writing this assessment report the new process had not yet been implemented by Hitachi-GE. Hitachi-GE has stated that until the updated process is fully implemented a review of the DRP Annex (Ref. 49) will be used to identify design changes that may need to be reflected in the PSA.

67. Hitachi-GE indicated that a categorisation to determine whether the PSA needs to be updated has already been applied to all modification identified in the ‘DRP Annex’ and will be applied to all modifications going forward. A record of the categorisation is kept in Hitachi-GE ‘Model Changes Tracking/Risk Impact Evaluation’ (MCT/RIE) database. An extract of this database was shared with ONR in December 2016 (Ref. 50). Hitachi-GE has indicated that most of the design changes reviewed have a low impact in the PSA results and an update is not required in GDA. Instead, a commitment log for beyond GDA PSA development, consisting of open items in the assumption list, open items related to regulatory questions and the MCT/RIE database has been created by Hitachi-GE. My review of Ref. 48 and MCT/RIE have identified aspects of the categorisation process that will require follow up during my Step 4 review (see below).

68. I have also raised RQ-ABWR-1119 to seek further information regarding the use of the PSA to support the selection of safety function categories or the safety class of structures, systems and components. This is identified in the strategy document as PSA application. The response to this RQ will be considered jointly with ONR fault studies inspector and will be reported as needed in Step 4 reports.

69. Through the development of the UK ABWR PSA, Hitachi-GE has indicated that a number of requirements for the detailed design are being identified for aspects of the UK ABWR found to be risk significant. RQ-ABWR-1119 requests information regarding the process followed to capture these requirements and the interface of the PSA with the detailed design. I will review this information as part of my Step 4 review.

4.1.2 Strengths

70. Hitachi-GE has established and implemented a programme to deliver most of the areas of a full scope PSA (see Action 4). The PSA objectives and applications are clear in the PSA strategy document at the high level and overall align with regulatory expectations.

71. Hitachi-GE has developed a number of processes to enable delivery of the PSA objectives and applications outlined in the strategy document in terms of:

- Development of a PSA that reflects the UK ABWR design by the use of PQC process to obtain initial input from the design teams; and the review and categorisation of design changes that need to be reflected in the PSA or captured in the commitment log for future PSA updates beyond GDA, through the PSA maintenance process.
- Use of the UK ABWR PSA to inform the design development through Hitachi-GE revised Generic Design Development Control process.
- Capture design (and other) assumptions and transfer them to site specific stage in cases where there is no sufficient information in GDA through a formal process.

4.1.3 Items that Require Follow-up

72. My review has identified the following items that require follow up in GDA. I will consider these matters in my Step 4 review.

- Evidence of the implementation of Hitachi-GE process to maintain and update the PSA regarding the review of design changes have been shared with ONR. However, the information provided is high level. In addition, further information is needed to support the justification of the criteria to categorise modifications and how the cumulative impact on the risk of several modifications is considered. Further information will be provided by Hitachi-GE in response to RQ-ABWR-1161 and I will follow up as needed as part of my Step 4 review.
- There is a lack of clarity regarding the criteria used by Hitachi-GE to decide when the design review process for a design change will consider input from the PSA. I expect that the work that Hitachi-GE is undertaking as part of the ALARP demonstration (see section 4.4) will provide further evidence that the PSA has been used to support the design in GDA. I will review this work as part of my Step 4 assessment.

4.1.4 Conclusions

73. Based on the outcome of my assessment, I have concluded that the project plan provided in response to RI-ABWR-0002 is adequate to support the development by Hitachi-GE of most of the information that I need for Step 4 assessment. Furthermore, most of the PSA submission has already been shared with ONR. In addition, the project plan establishes key PSA objectives, applications and high level requirements that are broadly in line with expectations in the PSA SAPs. Hitachi-GE has reviewed their internal processes to support the statements in the project plan. The documentation of these processes is high level and I have requested additional information as part of my ongoing Step 4 review.

4.2 Allocation of Suitably Qualified and Experienced PSA Resources to Develop the UK ABWR PSA (Action 2)

74. RI-ABWR-0002 Action 2 requested Hitachi-GE to provide information on the resources allocated to develop the UK ABWR PSA in terms of manpower and qualifications and

experience (Hitachi-GE staff and, if relevant, technical support contractors) required to complete each of the PSA tasks identified in Action 1.

4.2.1 Assessment

75. My assessment of this RI action focus in the suitability of PSA capability within Hitachi-GE to deliver the PSA as outlined in the project plan.

76. I have reviewed the information provided by Hitachi-GE in response to this RI action and consider it to lack sufficient detail. For example, there is limited clarity regarding what resources are available to complete each PSA task and what specific PSA tasks require involvement of other technical areas.

77. On the other hand, Hitachi-GE has provided evidence of the PSA capability through the delivery of the PSA and engagement with ONR. This technical capability is in evidence during meetings in Hitachi-GE's interactions with ONR's PSA team. As explained in Ref. 27 (and confirmed during my engagement with Hitachi-GE) the RP PSA resources have been extended significantly. This has included international expert support, leading some aspects of the PSA development or undertaking a peer of Hitachi-GE work (see section 4.3). In my opinion, this approach has greatly contributed to developing further Hitachi-GE expertise in PSA. For example, there have been improvements in the PSA submission and technical interactions of my review team with Hitachi-GE in Step 4 (Ref. 51 and 47). This provides me with confidence that sufficient SQEP resources were available to support the PSA submission delivery.

78. I therefore consider the outcomes of my review related to Ref. 27 are minor documentation issues and no further follow up in GDA is needed.

4.2.2 Strengths

79. Hitachi-GE has significantly increased their PSA capability during GDA. This has resulted in the timely submission of most of the information required for GDA assessment and a Hitachi-GE grown capability in the area of PSA.

4.2.3 Items that Require Follow-up

80. There is outstanding work in some areas of the PSA that Hitachi-GE needs to undertake in GDA. In particular the refinement of the internal fire and flooding PSA (see section 4.4). The timescales proposed for the development of some of this work are too late in Step 4. In order to deliver this work earlier, Hitachi-GE should look at different options including extending further their PSA resources. I will follow up this issue as part of my overall Step 4 assessment.

4.2.4 Conclusion

81. In conclusion, Hitachi-GE has already submitted most of the information that I require for Step 4 review. In addition, my engagement with Hitachi-GE in Step 4 has provided me with confidence that Hitachi-GE have a good technical knowledge and sufficient PSA resources. I therefore consider that response to RI-ABWR-0002 Action 2 is adequate to support the development of most of the information that I need for Step 4 assessment.

4.3 PSA Quality Assurance Plan and Quality Assurance Procedures (Action 3)

82. RI-ABWR-0002 Action 3 requested Hitachi-GE to provide the UK ABWR PSA QA plan and procedures, including the requisite level of QA for each PSA task and PSA tasks that require involvement of other departments.

4.3.1 Assessment

83. The main focus of my review is to consider whether Hitachi-GE has established adequate QA plan and process to deliver the quality in the submission that I need to undertake a meaningful Step 4 review. In my review I have considered ONR expectations in the PSA TAG and relevant good practice and in particular IAEA guidance (Ref.19).

84. Hitachi-GE peer review process is documented in Ref. 28. Hitachi-GE has produced a peer review report for each technical area of the PSA that is available for ONR review if requested. As part of my review at the end of the extended period in Step 3 (Ref.17), I had considered peer review comments and resolution for the September 2015 PSA. My review concluded that the peer review process appeared to be key for Hitachi-GE to deliver modern standards PSA and needed to continue through GDA. From the documents provided at that stage, ONR inferred that the peer reviews had been carried out in very short timescales, sometimes with limitations on the documentation available at the time of the review. I have continued to monitor the development of the PSA peer reviews and considered peer review outcomes as part of my Step 4 assessment. On this basis I have confirmed that the conclusion of my Step 3 review remain valid.

85. In some areas of the PSA, there are outstanding peer review comments. In principle, Hitachi-GE is committed to address all the peer review comments in GDA or include them in the commitment log for future work that the future licensee will have to undertake beyond GDA. The adequacy of the sentencing of commitments has not been considered as part of this assessment report as it will be implicitly captured by my Step 4 review. I will request further clarity on which are the peer review comments still outstanding after the PSA update in June 2016 (and documentation update expected in 2017) and how they will be followed up by Hitachi-GE.

86. In addition, upon ONR request, Hitachi-GE documentation of the changes of the PSA updated in June 2016 has been provided in response to RQ-ABWR-1077. As part of my Step 4 review I will implicitly consider the adequacy of the PSA change control documentation.

87. As part of this assessment, I have reviewed Hitachi-GE QA procedure and examples of verification check lists provided in Ref. 24. As part of my review, I undertook an inspection of the implementation of this process in March 2016 (Ref. 47). I requested the following information to Hitachi-GE during the inspection:

- Records of verification work associated to internal events and seismic PSA (verification plan and records for Ref.52, Ref.53 and 54).
- Improvements made in the verification check sheets as corrective actions of errors identified in the PSA in Step 3 and 4.
- Records of the process followed by Hitachi-GE when errors in the documentation already submitted to ONR were identified internally or by the regulator.

88. A number of QA issues have been identified by Hitachi-GE or ONR in several PSA submissions in Step 4 (e.g. RQ-ABWR-0761, RQ-ABWR-0774). Hitachi-GE has a process that enables the identification of corrective actions which was discussed during the PSA inspection in March 2016. However, it is unclear if the lessons learned from Hitachi-GE's investigation of the root cause of the errors are used to seek holistic improvements in the QA of the PSA. In addition, my review of Hitachi-GE QA

documents and records against relevant good practice has identified that there could be improvements in the verification plans to make them more detailed.

89. During the inspection in March 2016, my team also reviewed UK ABWR Verification and Validation (V&V) testing that was performed for the PSA software. My team concluded that the V&V methodology, testing, and results were appropriate. A few minor comments were identified. However, it was judged by the technical experts in my team that the comments would not invalidate the intent and conclusions of the V&V tests and results. The comments were shared with Hitachi-GE in RQ-ABWR-0817 which response has been reviewed by my team and considered adequate.

90. My review of QA records did not cover the internal hazards PSA submitted to ONR in September 2016. This review will be part of my Step 4 assessment (RQ-ABWR-1183).

4.3.2 Strengths

91. Hitachi-GE has established a peer review process that is fully traceable and involves international PSA experts.

4.3.3 Items that Require Follow-up

92. My review has identified the following items that require follow up in GDA. I will consider these matters in my Step 4 review.

- If the RP PSA QA plan and processes is to be used by future licensees, improvements should be considered taking into account lessons learned during GDA and the peer review process.
- There is lack of clarity regarding what are the outstanding peer review comments and how they will be addressed in the future.

4.3.4 Conclusion

93. Based on the outcome of my assessment, I have concluded that Hitachi-GE QA plan and procedures, in particular the peer review process, is adequate to deliver a submission of sufficient quality to enable a meaningful assessment in Step 4. I have identified some specific aspects of the QA process that require follow up as part of my Step 4 review.

4.4 PSA Task Analysis Files, Summary Report, Document Database and Task Procedures (Action 4)

94. RI-ABWR-0002 Action 4 requested Hitachi-GE to provide a modern-standards full-scope PSA fully documented, including:

- individual reports for each of the UK ABWR PSA tasks (or sub-tasks, when appropriate, e.g., individual systems);
- a UK ABWR PSA summary report;
- the UK ABWR PSA computer model (including input parameter data bases, result files, etc.);
- the complete task files, including relevant references, should be made available to ONR upon request;
- an updated Document Database in line with the relevant expectation in RO-ABWR-0013.A6 and regulatory feedback given in Ref. 7 to Ref 14, assessments reports and formal engagements; and

- updated Task Procedures in line with the relevant expectations in RO-ABWR-0013.A4 and regulatory feedback given in Ref. 7 to Ref 14, assessments reports and formal engagements.

95. ONR expectation is that the full scope PSA and documentation should meet the regulatory expectations set out in the RI and the regulatory feedback given in Ref. 7 to Ref 14, assessments reports and formal engagements.

4.4.1 Assessment

96. The main focus of my review is to evaluate whether the UK ABWR PSA submission provided in response to Action 4 is adequate to carry out a meaningful assessment in GDA.

97. For this purpose, I have considered the completeness of the scope of the overall UK ABWR PSA submission against ONR expectations identified in SAP FA.12. The full list of Step 4 deliverables is in Ref. 44. It is important to note that my review has not considered the technical contents of the specific topic reports as this will be covered by my Step 4 assessment. This assessment therefore remains high level and focussed on the submission list.

98. I have also considered whether the detail and quality of Hitachi-GE submission is sufficient to undertake my Step 4 review against SAP FA.13. I have based my judgement on the outcomes of my ongoing Step 4 review that were available at the time of writing this report. My team has completed most of the review of the January 2016 internal events PSA and prioritisation of hazards. ONR's PSA team has also reviewed the information presented in the Containment Performance Analysis submission.

99. Overall, my review has identified issues in all the technical areas of the PSA of different level of importance.

100. There are a number of ROs 40, 41, 42, 48 and 53 actions that were open at the time of writing this assessment report. ONR assessment of the response to these submissions is ongoing and in some cases additional information has been requested in RQs.

101. However, Hitachi-GE has proposed a programme to address most of the remaining issues identified by my ongoing review in 2017. Most of these issues can be addressed through a documentation update to provide additional clarifications and evidence. In addition, there is further refinement work needed on the internal fire and flood PSA that Hitachi-GE has committed to undertake in GDA. The technical adequacy of the submissions will be considered by my Step 4 assessment. There are a more limited number of issues not covered by Hitachi-GE programme that requires follow up through new RQs.

102. The issues identified by my review that could potentially impact the ability to complete Step 4 assessment are the specificity of the containment performance analysis and its adequacy to provide best estimate information to support the PSA, and the adequacy of the demonstration that the risks are ALARP.

103. RO-ABWR-0046 covers the outstanding issues related to the containment performance analysis identified by my review. Hitachi-GE has submitted a containment performance analysis document which they believe to be sufficiently specific to the UK ABWR design. However, my review of this document has identified that some analyses presented make use of data previously evaluated for Mark-II BWR and Japanese ABWR containments. In particular, the failure criteria adopted to construct the containment limiting pressure-temperature curves presented for the UK reinforced concrete containment vessels metallic components make use of data from Mark-II BWR. Comparison between the two containment designs highlights what appear to be big differences and as such ONR required Hitachi-GE to provide adequate justification

that their analysis is applicable to the UK ABWR. In addition, the analysis presented to evaluate the containment's performance is not best estimate and include different degrees of conservatism normally included for substantiating the design integrity. I have raised RQ-ABWR-1235 to follow up the shortfalls identified by my review and request additional information to understand their risk significance. Hitachi-GE has indicated that the response to this RQ will provide a review of the containment capacity at the majority of failure locations using UK ABWR design information which should address ONR concerns relating the use of Mark II and Japanese ABWR information. I will assess this information as part of my Step 4 review.

104. ONR has raised RO-ABWR-0076 (Ref.55) which will enable the regulatory follow up of the work required as part of the ALARP demonstration. I will seek early confidence that Hitachi-GE response to RO-ABWR-0076 will meet regulatory expectations, by reviewing the resolution plan.

105. Other less important but potentially risk significant issues related to the internal events PSA at power for the reactor are summarised in Ref.56 as an example; additional information has been requested through RQs. Overall, these are not systematic errors and therefore do not prevent my ability to undertake a meaningful assessment.

106. The shortfalls identified by my assessment are related to specific areas of the PSA and are captured under ROs (or RQs) which will be considered in my Step 4 review; I therefore consider they do no need to be fully addressed in order for this RI to be closed.

107. The PSA summary report was submitted too late to be considered in this report but it will be part of my assessment in early 2017. There is no new information presented in this report. I therefore do not expect to identify additional shortfalls that can have an impact on my ability to undertake a meaningful assessment in GDA.

4.4.2 Strengths

108. The scope of Hitachi-GE Step 4 submission in response to this RI is comprehensive. This includes the UK ABWR internal events PSA for the reactor at power and shutdown operating modes, fuel route operations, spent fuel pool and consideration of other non-reactor facilities. The PSA also covers internal fire and flooding for the reactor at power, seismic events for the reactor and the spent fuel pool; pseudo quantitative analysis have been/will be developed in GDA to assess the risk of the reactor shutdown operating states and SFP due to internal fire, flooding and seismic events.

109. A prioritisation of hazards has been developed for the reactor and non-reactor facilities, including consideration of combination of hazards; when hazards are considered important in terms of risk, more detailed studies are provided. Sensitivity analysis were undertaken to investigate the risk impact of external flooding and biological fouling events.

110. The PSA has in general covered level 1, level 2 and level 3. Consequence analyses are also developed for non-core damage sequences leading to a release.

4.4.3 Items that Require Follow-up

111. In addition to the information that Hitachi-GE has committed to deliver in 2017 in response to my review comments, Hitachi-GE has identified the need to provide further updates of the PSA summary report and the document map at the end of GDA. This work has been included in Hitachi-GE programme and will be considered as part of my Step 4 review. I therefore have not captured this as an area that requires follow up.

4.4.4 Conclusion

112. Overall, on the basis of the outcomes of the ongoing review, the work submitted by the RP up to date is adequate for ONR to carry out a meaningful assessment in GDA. Further work will be required in Step 4 to address my review outcomes. I consider this to be normal business as part of my Step 4 review. There are some potentially significant issues related to the demonstration of ALARP and the Containment Performance Analysis that are captured by Regulatory Observations and will be considered as part of my Step 4 assessment.

4.5 Comparison with Standards, Guidance and Relevant Good Practice

113. In section 2 I have listed the standards and criteria I have used during my assessment to judge whether the UK ABWR PSA submission is sufficient for ONR to carry out a meaningful assessment in GDA. My overall conclusions in this regard can be summarised as follows:

- The PSA objectives and applications have been identified at the high level and are adequate for ONR to carry out a meaningful assessment in Step 4 against regulatory expectations in SAPs FA.10, FA.11 and FA.14, the PSA TAG and relevant good practice.
- The quality of the submission is sufficient to enable ONR to carry out a meaningful assessment in Step 4 against SAP FA.13, the PSA TAG and relevant good practice.
- The scope of the UK ABWR PSA submission is adequate for ONR to carry out a meaningful assessment in Step 4 against ONR expectations in SAP FA.12, the PSA TAG and relevant good practice.

4.6 Items that Require Follow-up

114. On the basis of my assessment I have identified areas to follow up as part of my Step 4 review. These are given in Annex 2. The follow up of these aspects of Hitachi-GE submission will be reported in my Step 4 assessment report. I do not consider that any of these items prevents my ability to undertake a meaningful assessment in GDA and therefore resolution of RI-ABWR-0002.

4.7 ONR Assessment Rating

115. An ONR assessment rating is normally applied to licensee safety justifications which support ONR permissioning decisions and is therefore not applicable for GDA reports.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

116. This report presents the findings of my assessment of whether the submission provided by Hitachi-GE in response to Regulatory Issue RI-ABWR-0002, Project Plan and Delivery of the UK ABWR PSA (Ref. 1) is adequate for ONR to carry out a meaningful assessment in GDA.

117. The purpose of this assessment was three-fold;

- To document the assessment which underpins the recommendation made in closing RI-UKABWR-0002, or otherwise;
- To serve as a record of the scope of the assessment undertaken for RI-ABWR-0002, and therefore the boundaries of the judgements made; and
- To identify any areas for follow up which may need to be satisfactorily addressed during the remainder of GDA Step 4, or beyond, as appropriate.

118. In response to RI-ABWR-0002 Hitachi-GE has provided a project plan, revised PSA arrangements and extended PSA capability. As a result Hitachi-GE has delivered a comprehensive UK ABWR PSA submission including consideration of internal events and hazards, for the reactor, spent fuel pool and other facilities for different operating modes.

119. The main conclusions of my assessment are:

- The project plan provided in response to RI-ABWR-0002 is adequate to support Hitachi-GE development of most of the information that I need for Step 4 assessment. Furthermore, the project plan establishes clear PSA objectives, applications and high level requirements that are broadly in line with expectations in the PSA SAPs. Hitachi-GE internal processes have been improved to support the statements in the project plan. For areas that require follow up I have requested additional information as part of my ongoing Step 4 review.
- The extended PSA capability put in place in response to RI-ABWR-0002 Action 2 is sufficient to support the development of most of the information that I need for Step 4 assessment. I have identified an item that requires follow-up through the course of my overall Step 4 assessment.
- Hitachi-GE QA plan and procedures, in particular the peer review process, is adequate to deliver a submission of sufficient quality to enable a meaningful assessment in Step 4.
- Overall, on the basis of the outcomes of the ongoing Step 4 review, the work submitted by the RP up to date is adequate for ONR to carry out a meaningful assessment in GDA.

120. While I have identified a number of items that require follow-up through the course of my assessment I do not consider any of these to be significant enough to prevent closure of the RI.

121. To conclude based on my assessment, I am content that Hitachi-GE have provided sufficient to meet the intent of RI-ABWR-0002 and have addressed the issues which led to it being raised. I am therefore content that the RI has been resolved.

5.2 Recommendations

122. My recommendations are as follows.

- Recommendation 1: RI-ABWR-0002 should be closed.

- Recommendation 2: The Items that require follow-up identified in this report should be considered as part of Step 4 GDA of the UK ABWR PSA.

6 REFERENCES

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6. UK ABWR PSA Project Plan and Delivery. RO-ABWR-013, Revision 0, August 2014. TRIM 2014/241720.

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13. UK ABWR Level 1 PSA Accident Sequences Analyses and Success Criteria. RQ-AWBR-0559, Revision 0. June 2015. TRIM 2015/238694.

14. UK ABWR PSA Quantification, Identification of Assumptions, Uncertainty and Sensitivity Analyses, Interpretation of Results and Use of the PSA. RQ-ABWR-0560, Revision 0. June 2015. TRIM 2015/238693.

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- Development and Application of Level 1 Probabilistic Safety Assessment for Nuclear Power Plants Safety Standard. Specific Safety Guide SSG-3, 2010.
- Development and Application of Level 2 Probabilistic Safety Assessment for Nuclear Power Plants Safety Standard. Specific Safety Guide SSG-4, 2010.
- Living Probabilistic Safety Assessment (LPSA). IAEA-TECDOC-1106, 1999.
- A Framework for a QA programme for PSA. IAEA-TECDOC-1101, 1999.

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- Assumption List for UK ABWR PSA. GA91-9201-0003-00937-AE-GD-0521, Revision 2, September 2016. TRIM 2016/362598.
- Assumption List for UK ABWR PSA. GA91-9201-0003-00937-AE-GD-0521, Revision 1, February 2016. TRIM 2016/52658.
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- PSA Document Map. GA91-9201-0003-00605 - AE-GD-0356, Revision 3, September 2016. TRIM 2016/360867.
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- Topic Report on Internal Event at Power Level 1 PSA. GA91-9201-0001-00102 - AE-GD-0257- AE-GD-0257, Revision 3, January 2016. TRIM 2016/22862.
- Topic Report on Internal Event at Power Level 2 PSA. GA91-9201-0001-00103 - AE-GD-0258, Revision 2, January 2016. TRIM 2016/35015.

53. Dependency Notebook for UK ABWR PSA. GA91-9201-0003-00910 - AE-GD-0526, Revision 2, January 2016. TRIM 2016/22795.

54. The following PSA submissions:

- Seismic Equipment List for UK ABWR Seismic PSA. GA91-9201-0003-01106 - AE-GD-0609, Revision 0, January 2016

- Treatment of Seismic Category 3 SSCs (Response to RQ-ABWR-0672). GA91-9201-0003-01109 - AE-GD-0623, Revision 0, January 2016. TRIM 2012/12172.

55. PSA ALARP Demonstration and Optioneering. RO-ABWR-0076, Revision 0, November 2016. TRIM 2016/462941.

56. Examples of Outstanding Issues - Internal Events PSA Reactor at Power. 22 December 2016. TRIM 2017/58895

Table 1

Regulatory Queries related to this assessment

RQ Number	RQ Title	Response TRIM Ref
RQ-ABWR-0597	Impact of Second Package of UK ABWR Major Design Change Proposals	2015/368969
RQ-ABWR-0761	UK ABWR GDA Step 4 – PSA Workshop March 2016 - Errors in Dependency Notebook GA91-9201-0003-00910 Rev. 2	2016/112191
RQ-ABWR-0774	UK ABWR GDA Step 4 Seismic Equipment List Rev 2	2016/134768
RQ-ABWR-0817	Review of UK ABWR PSA Software Verification and Validation Forms	2016/228481
RQ-ABWR-0834	UK ABWR PSA – Error in the Application of the Mutually Exclusive File	2016/220470
RQ-ABWR-1077	PSA Comparison	2016/470486
RQ-ABWR-1119	UK ABWR PSA Applications - Classification of Systems Structures and Components	2016/463726
RQ-ABWR-1161	PSA Design Reference	2016/483209 2016/471806 2016/504261
RQ-ABWR-1183	Fire PSA Database	2016/504822
RQ-ABWR-1185	Interface of PSA with detailed design	2016/501423

Annex 1

RI-ABWR-0002 - UK ABWR Probabilistic Safety Analysis: Project Plan and Delivery

To Be Determined By The Hitachi-GE Resolution Plan. **REGULATORY ISSUE**	
REGULATOR TO COMPLETE	
RI unique no.:	RI-ABWR-0002
Date sent:	3rd July 2015
Acknowledgement required by:	10th July 2015
Agreement of Resolution Plan Required by:	*To Be Determined By The Hitachi-GE Resolution Plan.*
Resolution of Regulatory Issue required by:	*To Be Determined By The Hitachi-GE Resolution Plan.*
TRIM Ref.:	2015/248197
Related RQ / RI No. and TRIM Ref. (if any)**:**	
From (Inspector / Regulator)**:**	[redacted]
Approved by:	[redacted]
Issue title:	UK ABWR Probabilistic Safety Analysis: Project Plan and Delivery
Technical area(s) 4. PSA	**Related technical area(s)** 1. Internal Hazards 2. Civil Engineering 5. Fault Studies 6. Control & Instrumentation 10. Radiation Protection & (Level 3 PSA) 13. Human Factors 14. MoS & QA

Regulatory Issue

SUMMARY

The objective of this Regulatory Issue (RI) is to state ONR's expectations with respect to Hitachi-GE developing and delivering a suitable and sufficient Probabilistic Safety Analysis (PSA) for the UK ABWR fault analysis as part of the GDA submission.

A suitable and sufficient scope PSA for GDA developed in line with UK requirements is required, in order for ONR to undertake a meaningful assessment against regulatory expectations, including:

- SAP FA.10 (Need for PSA): *"Suitable and sufficient PSA should be developed as part of the fault analysis and design development and analyses …The PSA should assist the designers in achieving a balanced and optimised design…The PSA should enable a judgement to be made of the acceptability or otherwise of the overall risks against Numerical Targets 5 to 9 and should help to demonstrate that the risks are, and remain,* as low as reasonable practicable (ALARP)*…"*
- SAP FA.11 (Validity): *"The PSA should reflect the current design and operation of the facility."*
- SAP FA.12 (Scope and extent): *"The PSA should cover all significant sources of radioactivity, all permitted operating states and all relevant initiating faults."*
- SAP FA.13 (Adequate representation): *"The PSA model should provide an adequate representation of the facility".*
- SAP FA.14 (Use of PSA): *"The PSA should be used to inform the design process".* As noted above the PSA should be used to support the demonstration that risks are tolerable and ALARP."

In addition to SAPs FA.10 to 14, the regulatory expectations on PSA are summarised in SAPs Targets 7 to 9 and ONR's PSA Technical Assessment Guide (TAG) (Ref.2).

The GDA Guidance to Requesting Parties (Ref.1) indicates that the submission for design acceptance should include a full scope Level 1 and Level 2 PSA and that the PSA should be used to help show that the design

satisfies the ALARP requirement. The GDA Guidance to Requesting Parties also indicates that it is expected that at the start of Step 3 the Requesting Party (RP) provide a PSA.

BACKGROUND

ONR's assessment during Step 2 of GDA of the PSA aspects of the UK ABWR safety submission concluded that the information provided in Step 2 was insufficient to present an overall picture and thus, a reasonable understanding of the UK ABWR risk. Hitachi-GE indicated its intention to develop, within GDA timescales, a modern standards full-scope PSA to demonstrate that the risk associated with the UK ABWR is ALARP and to support the design change decision-making process. In this regard, Hitachi-GE submitted, in GDA Step 2, a high level plan to develop the UK ABWR PSA; according to this plan the Level 1 and Level 2 PSA for internal initiating events during operation at power would be submitted at the end of 2014. The remaining parts of the PSA would follow later in GDA in a staggered approach, including delivery of the hazards PSA in Step 4.

In the Step 2 PSA Assessment Report (Ref.3) paragraph 132 ONR highlighted;

"The timely delivery by the RP of the level 1 and level 2 PSA for internal initiating events during operation at power (proposed for December 2014), and the quality of this part of the PSA, will be key to providing me with confidence of the RP's ability to deliver a full scope PSA which:

- *Meets ONR's expectations.*
- *Provides a clear understanding of the UK ABWR risk.*
- *Supports the demonstration that the level of risk is ALARP.*

Should the RP not deliver the analyses as per the programme, or the quality be lacking, ONR has additional regulatory options."

In August 2014 ONR raised RO-ABWR-0013 (Ref.4) to state ONR's expectations related to the development and delivery of the PSA for the UK ABWR as part of the GDA submission and to gain early confidence that Hitachi-GE was able to deliver a modern standards full-scope PSA within the GDA timeframes.

The UK ABWR PSA for internal events at power was submitted to ONR at the end of December 2014, on time in line with the programme provided as part of the response to RO-ABWR-0013. ONR's Step 3 review assessed this PSA and other PSA documentation with a focus on the arguments supporting the PSA safety claims, these are interpreted by ONR as being:

- The PSA methods and techniques (and task procedures provided in response to RO-ABWR-0013) and their application in practice against ONR's SAPs, PSA TAG and international good practice.
- The basis and the scope of the UK ABWR PSA against the regulatory expectation that it should cover all the relevant sources of radioactivity, all relevant initiating events, and all operation modes.
- The processes used to support the development of the UK ABWR PSA and PSA applications and justification that these processes and their implementation by the RP meet modern standards and international good practice.

ONR's Step 3 review (reported to Hitachi-GE between February 2015 and May 2015) identified the need for further work in order to fully meet UK regulatory expectations. The outcomes of the review are captured in a series of related Regulatory Observations (ROs) Ref.5 to Ref.10, Regulatory Queries (RQs) Ref.11 and Ref.12 and other regulatory feedback provided during formal engagements or in assessment reports:

- RO-ABWR-0040 and RO-ABWR-0041 (Identification and prioritization of hazards for the PSA) .
- RO-ABWR-0042 (Identification of internal initiating events at power).
- RO-ABWR-0046 (Containment performance analyses).
- RO-ABWR-0048 (Level 2 PSA for internal initiating events at power).
- RO-ABWR-0053 (System analyses).
- Regulatory feedback provided on data analyses.
- RQ-AWBR-0559 (Accident Sequences Analyses and Success Criteria).
- RQ-ABWR-0560 (PSA Quantification, Identification of Assumptions, Uncertainty and Sensitivity Analyses, Interpretation of Results and Use of the PSA).
- Regulatory feedback regarding response to RO-ABWR-0013 provided in formal engagements (e.g. limitations regarding Hitachi-GE allocation of PSA resources and internal review process).

These ROs, RQs and feedback highlight that the arguments supporting the PSA safety claims do not meet the

relevant expectations in ONR's PSA TAG which captures our PSA SAPs and international good practice. On this basis, it was considered that the PSA submission did not meet the expectations defined in the Step 2 PSA Assessment Report (Ref.3) such as paragraph 132 (see above).

The regulators consider a suitable and sufficient PSA to be an integral aspect of the UK ABWR's safety analysis within GDA. Overall, the UK ABWR PSA information received so far does not provide ONR with confidence that Hitachi-GE, without further work and changes, will be able to deliver a modern standards full-scope PSA for the UK ABWR, which is suitable and sufficient for ONR to carry out a meaningful assessment within the project timescales. This is considered a serious regulatory shortfall which ONR, in line with our Guidance to Requesting Parties (paragraphs 159 and 160), are now escalating to a Regulatory Issue.

REGULATORY EXPECTATIONS

The regulatory expectations are the same as those defined under RO-ABWR-00013 (Ref.3). Overall, ONR expects Hitachi-GE to provide:

- **Project plan**: A project plan that ensures that the PSA's purpose and objectives and hence its scope are clearly understood at the outset of the project. As many of the future applications as possible should be identified, as these will affect the approach to be used in the individual tasks. It should also identify the requisite level of QA, and the various reports and procedures which will be produced during the course of the development of the PSA. It is essential to identify the required documentation at the beginning of the project, and develop it throughout the course of the work, as much more effort would be required to generate the technical documents after the models have been developed.
- **Resources:** The allocation of sufficient Suitably Qualified and Experienced PSA resources required to complete each of the PSA tasks identified in the project plan.
- **Quality Assurance:** The development of the PSA must be based on a secure and traceable process in which all details of the PSA, including explicit and implicit assumptions, modelling techniques. etc., are fully checked, documented and recorded. The purpose of the QA plan and procedures is to ensure that the necessary documentation is developed and the review process for all work products is clearly specified. The QA practices and procedures in use at in the development of the design should be considered when QA is planned for the development of the PSA.
- **PSA model and technical documentation**: Comprising the UK ABWR PSA model and all the technical documentation covering the development of each of the tasks and the recording and reporting of the work performed.

ONR's expectation is that the UK ABWR PSA is updated as necessary to address the shortfalls identified in Step 3 (regulatory feedback given in Ref. 5 to Ref 12, assessments reports and formal engagements) and ONR's expectations in relevant sections of the SAPs and the PSA TAG.

REFERENCES

1. New nuclear reactors: Generic Design Assessment Guidance to Requesting Parties, ONR-GDA-GD-001 Revision 1, August 2014. www.onr.org.uk/new-reactors/ngn03.pdf
2. Technical Assessment Guides. Probabilistic Safety Analysis NS-TAST-GD-030 Revision 4 ONR June 2016.
3. Assessment Report ONR-GDA.-AR-14-003. Step 2 Assessment of the Probabilistic Safety Analysis (PSA) and Severe Accident Analysis (SAA) of Hitachi-GE's UK Advanced Boiling Water Reactor (UK ABWR). Revision 0. 28 August 2014.
4. RO-ABWR-013. UK ABWR PSA Project Plan and Delivery. TRIM 2015/241720.
5. RO-ABWR-040. UK ABWR Probabilistic Safety Analysis: Identification of Applicable Internal Hazards. TRIM 2015/60355.
6. RO-ABWR-041. UK ABWR Probabilistic Safety Analysis: Identification of Applicable External Hazards. TRIM 2015/30525.
7. RO-ABWR-0042. Probabilistic Safety Analysis (PSA) internal initiating events at power. TRIM 2015/99947.
8. RO-ABWR-0046. Containment Performance Analyses. TRIM 2015/79125.
9. RO-ABWR-0048. Level 2 PSA methodology. TRIM 2015/136397.
10. RO-ABWR-0053. UK ABWR Probabilistic Safety Analysis (PSA) – level 1 and level 2 PSA for internal events during operation at power - System Analyses. TRIM 2015/155573
11. RQ-AWBR-0559 UK ABWR Level 1 PSA Accident Sequences Analyses and Success Criteria

12. RQ-ABWR-0560 UK ABWR PSA Quantification, Identification of Assumptions, Uncertainty and Sensitivity Analyses, Interpretation of Results and Use of the PSA

Regulatory Issue Actions

RI-ABWR-002.A1: UK ABWR PSA Project Plan

The scope of this action is similar to that defined under RO-ABWR-0013.A1.

Hitachi-GE is requested to provide the UK ABWR project plan. This should include the following:

- A complete list of the PSA objectives, applications and definition of the requirements of the PSA to fulfil these.
- Definition of the PSA tasks required to be completed during GDA (including the tasks already completed or on-going).
- Identification of the various procedures and reports which will be produced or updated during the development of the UK ABWR PSA, for all the PSA tasks and PSA applications.
- A detailed work programme including all planned deliverables. This programme should propose a resolution to the regulatory feedback given in Ref. 5 to Ref 12, assessments reports and formal engagements and meet the regulatory expectations set out in the RI.

Resolution required by: *To be determined by the Hitachi-GE Resolution Plan*

RI-ABWR-002.A2: Allocation of Suitably Qualified and Experienced PSA Resources to Develop the UK ABWR PSA

The scope of this action is the same as that defined under RO-ABWR-0013.A2.

The response to this Action should:

- meet the regulatory expectation defined in this RI;
- address the relevant regulatory expectations of RO-ABWR-0013.A2; and
- address the regulatory feedback given in Ref. 5 to Ref 12, assessments reports and formal engagements.

Resolution required by: *To be determined by the Hitachi-GE Resolution Plan.*

RI-ABWR-002.A3 : PSA Quality Assurance Plan and Quality Assurance Procedures

The scope of this action is the same as that defined under RO-ABWR-0013.A3.

The response to this Action should:

- meet the regulatory expectation defined in this RI.
- address the relevant regulatory expectations of RO-ABWR-0013.A3, and
- address the regulatory feedback given in Ref. 5 to Ref 12, assessments reports and formal engagements.

Resolution required by: *To be determined by the Hitachi-GE Resolution Plan.*

RI-ABWR-002.A4: PSA Task Analysis Files, Summary Report, Document Database and Task Procedures.

The scope of this action is similar to that defined under RO-ABWR-0013.A4, RO-ABWR-0013.A5 and RO-

ABWR-0013.A6.

Hitachi-GE is requested to provide a modern-standards full-scope PSA fully documented, including:

- individual reports for each of the UK ABWR PSA tasks (or sub-tasks, when appropriate, e.g., individual systems);
- a UK ABWR PSA summary report;
- the UK ABWR PSA computer model (including input parameter data bases, result files, etc.);
- the complete task files, including relevant references, should be made available to ONR upon request;
- an updated Document Database in line with the relevant expectation in RO-ABWR-0013.A6 and regulatory feedback given in Ref. 5 to Ref 12, assessments reports and formal engagements; and
- updated Task Procedures in line with the relevant expectations in RO-ABWR-0013.A4 and regulatory feedback given in Ref. 5 to Ref 12, assessments reports and formal engagements.

The full scope PSA and documentation should meet the regulatory expectations set out in the RI and the regulatory feedback given in Ref. 5 to Ref 12, assessments reports and formal engagements.

Resolution required by: *To be determined by the work programme provided in response to action A1.*

REQUESTING PARTY TO COMPLETE	
Actual Acknowledgement date:	
RP stated Resolution Plan agreement date:	

Annex 2

Items that Require Follow-up

Number	Description
1	PSA maintenance process: there is a need for further information to support the justification of Hitachi-GE criteria to categorise modifications and how the cumulative impact on the risk of several modifications is considered.
2	There is a lack of clarity regarding the criteria used by Hitachi-GE to decide when the design review process for a design change will consider input from the PSA.
3	There is outstanding work in some areas of the PSA that Hitachi-GE needs to undertake in GDA. The timescales proposed for the development of some of this work is too late in Step 4. In order to deliver this work earlier, Hitachi-GE should look at different options including extending their PSA resources.
4	If the RP PSA QA processes and plan is to be used by future licensees, they should be improved with lessons learned during GDA and the peer review process.
5	There is lack of clarity regarding outstanding peer review comments and how they will be addressed in the future.