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REGULATORY OBSERVATION Resolution Plan

RO Unique No.:	RO-UKHPR1000-0007
RO Title:	Aircraft Impact Safety Case for UK HPR1000
Technical Area(s)	External Hazards
Revision:	Rev 1
Overall RO Closure Date (Planned):	31/05/2021
Linked RQ(s)	RQ-UKHPR1000-0087/RQ-UKHPR1000-0112
Linked RO(s)	---
Related Technical Area(s)	2. Civil Engineering 12. Internal Hazards 18. Security
Other Related Documentation	---

Scope of Work


Background

ONR wrote a letter of UK expectations for aircraft impact on 23 January 2018 and raised two Regulatory Queries (RQs) regarding the protection of UK HPR1000 against aircraft impact. CGN did not provide aircraft load case gap analysis because this letter is classified as both Official-Sensitive (O-S) and containing Sensitive Nuclear Information (SNI) and was not able to be shared with CGN until specific arrangements were in place.

In the subsequent technical Level 4 meetings, ONR considered the responses to RQ-UKHPR1000-0087 questions 1 and 2 did not provide sufficient confidence in the timely delivery and completeness of the planned Aircraft Impact Safety Case and the ability of the UK HPR1000 generic design and analysis to reflect the expectations in the UK context. So, ONR has issued Regulatory Observation RO-UKHPR1000-0007 for the Requesting Party (RP) to clarify their planned approach and delivery strategy to demonstrate a suitable and sufficient safety case for aircraft impact.

ONR's expectation is that the UK HPR1000 Aircraft Impact Safety Case for GDA should provide an adequate demonstration on how overall, relevant risks will be managed and that the external hazards safety case will be complete that could provide the appropriate inputs into civil engineering and other assessments required for UK HPR1000. If potential modifications are considered, they should be appropriately documented within the generic safety case, and done with an understanding of the overall risk balance to demonstrate relevant risks are as low as reasonably practicable (ALARP).

Abbreviations and Acronyms

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ALARP	As Low As Reasonably Practicable
CGN	China General Nuclear Power Corporation
FCG3	Fangchenggang Nuclear Power Plant Unit 3
GDA	Generic Design Assessment
GNS	General Nuclear System Limited
NEI	Nuclear Energy Institute
ONR	Office for Nuclear Regulation
O-S	Official-Sensitive
RGP	Relevant Good Practice
RO	Regulatory Observation
RP	Requesting Party
RQ	Regulatory Query
SNI	Sensitive Nuclear Information
SSC	Structures, Systems and Components
UK	United Kingdom of Great Britain and Northern Ireland
UK HPR1000	The UK Version of the Hua-long Pressurized Reactor

Scope of work


A comparison of aircraft load cases between the expectations in the UK context and the current UK HPR1000 design has been performed by General Nuclear System Limited utilising a UK Supplier. The types of gaps assessed includes types of aircraft, velocity, quantity of fuel, approach angle etc. The main contents of this report are as follows:

- Provide a summary of current UK and International Relevant Good Practice (RGP);
- Review of the UK HPR1000 analysis and design for aircraft impact;
- Provide findings of the gaps and undertake gap analysis.

An *Aircraft Impact Safety Evaluation Methodology Report* has been produced to present the applicable methods of aircraft crash safety evaluation, and guide the production of the *Aircraft Impact Safety Evaluation Report*. The design will be substantiated to demonstrate that the overall risks relevant to aircraft impact will be reduced to ALARP and the external hazards safety case will be complete.

To address this RO, the RP intend to produce ten topic reports; these reports have already been planned as deliverables and a number have already been issued. Revisions are planned to these submitted documents to address comments arising from ONR assessment. Further detail on the topic reports is provided in the deliverable description of this resolution plan:

- Aircraft Impact Gap Analysis Report;
- Aircraft Impact Safety Evaluation Methodology Report;
- Aircraft Impact Load-Time Function Report;
- Basis of Safety Case for Aircraft Impact;
- Basis of Design for Aircraft Impact;
- Aircraft Impact Evaluation Method Statement;

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- Aircraft Impact Evaluation Report;
- Aircraft Impact Dynamic Analysis Report;
- Design Substantiation for Aircraft Impact;
- Aircraft Crash Safety Evaluation Report.

In order to de-risk the delivery of these topic reports, regular engagement will be held between the Requesting Party and ONR to provide confidence in the scope and content of the reports which are being produced.

Deliverable Description

RO-UKHPR1000-0007. Action 1 – Aircraft Impact Safety Case Delivery Strategy

The RO action 1 states that:

In response to this Regulatory Observation Action, GNS should:


- *Provide a programme of how GNS intend to deliver both accidental and malicious aircraft impact safety cases, including supporting evidence.*
- *Provide information on how the malicious aircraft impact analysis will be used to support the safety case.*
- *Provide details of how information sharing will be managed between GNS, CGN and UK third party suppliers in order to deliver adequate analysis and optioneering for the Aircraft Impact Safety Case.*

Resolution Plan

a) Programme for Delivering Aircraft Impact Safety Cases

In the design of UK HPR1000, the aircraft impact hazard has been considered during the design development and evolution. A number of topic reports are being produced to make up the aircraft impact safety case:

- Aircraft Impact Safety Evaluation Methodology Report
 - Evaluation Scope
 - Accidental aircraft impact evaluation
 - Evaluation Acceptance Criteria and Assumption
 - Present the evaluation process for the global effect, vibration, local effect, fire and possible explosion
- Aircraft Impact Gap Analysis Report
 - Provide a summary of current UK and International RGP
 - Review of the HPR 1000 analysis and design for aircraft impact
 - Provide findings of the gaps and undertake gap impact analysis
- Aircraft Impact Load-Time Function Report

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- Presents the Aircraft Impact Analysis Load Time Functions
- Aircraft Impact Evaluation Method Statement
 - Present the structural calculation and analysis method of aircraft impact
 - Present the acceptance criteria
- Basis of Safety Case for Aircraft Impact
 - Description of the aircraft impact barriers
 - Codes and Standards
 - Present the safety functional requirements and the engineering requirements
 - Present the documents strategy for the aircraft impact
- Basis of Design for Aircraft Impact
 - Define the load time function after the gap analysis
 - Define the main parameters used in the analysis and design
- Aircraft Impact Evaluation Report
 - Structure analysis and design under aircraft impact
 - Determine the structural reinforcement of the structures
- Design Substantiation for Aircraft Impact
 - Linked to the design basis of safety case report
 - Summary of the substantiation of each sub-claims
- Aircraft Impact Dynamic Analysis Report
 - Present the dynamic analysis process and results
- Aircraft Crash Safety Evaluation Report.
 - Present the evaluation for each aircraft crash effect, including the effects of aircraft crash.
 - Extent of protection, Defence-in-Depth protection measures etc.
 - Update to provide a re-analysis of the design if the initial analysis identifies vulnerabilities that require potential enhancement.

All the documents above are relevant to the malicious aircraft crash safety case. The accidental aircraft crash safety case is presented in *Aircraft Impact Safety Evaluation Methodology Report*, *Basis of Safety Case for Aircraft Impact* and *Aircraft Crash Safety Evaluation Report*.

The documentation hierarchy for the aircraft impact safety case is shown in Figure 1, and the delivery schedule is shown in Appendix A.

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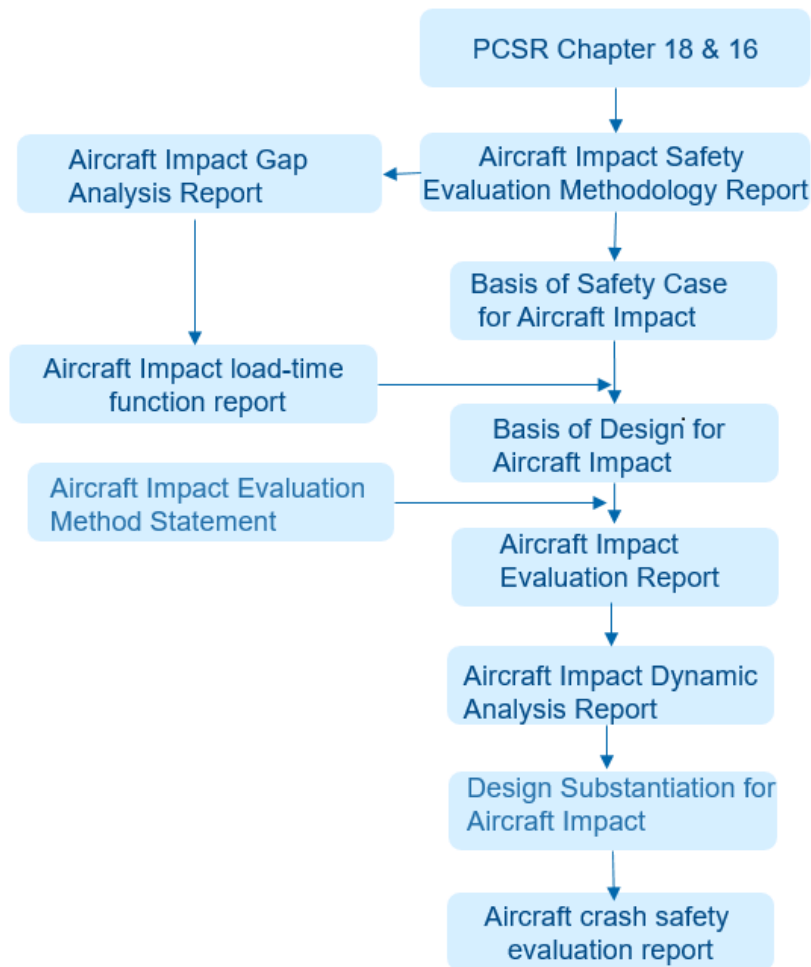



Figure 1 Documentation Hierarchy for Aircraft Impact Safety Case

b) The Malicious Aircraft Impact Analysis to be used to Support the Safety Case

The ONR expectations summarised in the Letter of UK expectations for aircraft impact will be closely reviewed. Specifically,

- 1) For each sub-category, a single most appropriate and representative aircraft type will be selected.
- 2) Based on previous UK practices, international RGPs and statistical information on UK airspace. The selected aircraft will be based on realistic aircraft parameters (fuel, speed, angle and payload), instead of the maximum possible.
- 3) For the assessment of the effects from aircraft impact, the load-time function analysis method is adopted.
- 4) The codes for the analysis and design against aircraft impact will be based on NEI 07-13 (Ref. [1]). Further study will be conducted for the new published IAEA Safety Reports 86 (Ref. [2]), 87 (Ref. [3]) and 88 (Ref. [4]).

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- 5) Output from the analysis will include the structural demand to be used for structural design and impact induced global effects, vibration, local effects and fire will be taken into consideration.
- 6) In addition, considering that malicious aircraft impact is a beyond design basis case, best estimate material properties as well as allowing for some level of damage is adopted, but without compromising the safety case claims. This ensures the design is not overly conservative.

UK 3rd Party technical support will be utilised due to the extent of UK context for this topic and to utilise state-of-the-art analysis techniques.

c) Information Sharing Management

As the ONR's Aircraft Impact Expectations letter is marked as Official Sensitive and SNI, information shall be handled in accordance with General Nuclear System Limited procedures (HPR-GDA-PROC-0113 International Information Sharing, HPR-GDA-PROC-0031 Identifying And Handling Protectively Marked Information, HPR-GDA-PROC-0035 Personnel Security & Vetting of Staff & Contractors, and HPR-GDA-PROC-0036 3rd Party Contracts Involving Regulatory and SNI Information). In addition technical sharing of information shall be in compliance with the General Nuclear System Limited procedure 'HPR-GDA-PROC-0028 Control of Service Provider Technical Work'.

An electronic document transfer system (DTS) is in place between General Nuclear System Limited, CGN and 3rd party suppliers to share relevant project documentation as required. For SNI, separate and appropriate encryption measures are adopted to transfer applicable information. From a practical point of view, 3rd party suppliers will also have access to attend General Nuclear System Limited offices in UK and required CGN offices in China to directly liaise with required General Nuclear System Limited and CGN staff and access any specifically restricted documentation that they have appropriate clearance to view.

RO-UKHPR1000-0007.Action 2–Design Optimisation in Response to Aircraft Impact

The RO action states that:


In response to this Regulatory Observation Action, GNS should:

- *Provide details of how GNS will ensure UK HPR1000 meets UK expectations given that it may require modification to the reference plant design in response to the analysis.*
- *Provide details of the process by which any potential modifications would be identified and optioneered, including any information sharing between UK third party suppliers, GNS and CGN.*

Resolution Plan

a) Detailed Modification to Address the Identified Gaps

After the results from Aircraft Impact Gap Analysis Report are received, the design of UK HPR1000 for aircraft impact may be modified if shortfalls are identified. The codes and standards will be taken

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from RGPs and the types of aircraft and parameters will meet the UK expectations. The detailed modification process will follow the established Guidance for Optioneering (Ref. [5]), which includes optioneering, decision-making, ALARP justification and implementation. The modification design will follow the Modification Categorisation Procedure (Ref. [6]) and Modification Control Procedure (Ref. [7]).

b) Potential Modifications Identification and Optioneering

Potential modifications will be identified through the following three ways:

1) Types and Parameters of Aircraft

Types and parameters of aircraft are different with the FCG3 design, which can be identified as the potential modifications.

2) Codes and Standards used for Evaluation of Aircraft Impact

The main codes and standards used for aircraft impact analysis of FCG3 are based on NEI 07-13 (Ref. [1]). In addition, IAEA reports (Ref. [2], Ref. [3] and Ref. [4]) may be reviewed and further analysis will be conducted if necessary. Potential modification may be identified in the analysis.

3) Methods used for evaluation of Aircraft Impact

In the evaluation of aircraft impact, best estimate values will be used as it is a beyond design basis event. New models of buildings will be built.

All potential modifications will be optioneered with RGP where applicable in the supporting evidence deliverables in Action 1 a). In addition, the types and parameters of aircraft impact chosen will be based on the research of inventory of aircraft in UK.

c) Sensitive Information Sharing


As clarified in the response of Action 1 c), a suite of relevant General Nuclear System Limited procedures shall apply to specifying technical support work and sharing of information. Where any security classified information is generated or required the applicable procedures shall apply to ensure control of documentation and information associated with the tasks. The DTS system is in place for sharing of information between CGN, General Nuclear System Limited and 3rd party suppliers with additional controls and separate systems for sharing of Official-Sensitive and SNI information where required.

RO-UKHPR1000-0007.Action 3 – Provision of Aircraft Impact Safety Case

The RO action states that:

In response to this Regulatory Observation Action, GNS should:

- *Provide the aircraft impact safety case for UK HPR1000.*
- *Provide evidence that the UK HPR1000 design is optimised against the UK context for the aircraft*

 CGN EDF General Nuclear System	REGULATORY OBSERVATION RESOLUTION PLAN RO-UKHPR1000-0007	Rev.: 1	Page: 8 / 10
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impact safety case.

Resolution Plan

a) Aircraft Impact Safety Case

The safety case of aircraft impact will be complete when the evaluation reports are finished. All the deliverables have been given in the response of Action 1 a).

b) The Evidence of Aircraft Impact Safety Case

The evaluation reports listed as follows contain the evidence for the aircraft impact safety case:

- Basis of Design for Aircraft Impact;
- Aircraft Impact Evaluation Report;
- Design Substantiation for Aircraft Impact;
- Aircraft Impact Dynamic Analysis Report;
- Aircraft Crash Safety Evaluation Report.

In these evaluation reports, the best estimate methods and international RGP will be used to evaluate the aircraft impact. All these optimised aspects can provide detailed evidence for the aircraft impact safety case. The anticipated timescale to publish these documents is given in Appendix A.

Impact on the GDA Submissions

The updated information will be incorporated into PCSR Chapter 16 and 18 Version 2 submitted in Step 4.

Supporting references in the Appendix A are already planned submissions. The scope of these deliverables has been amended to incorporate responses to this RO.

Timetable and Milestone Programme Leading to the Deliverables

See attached Gantt Chart in APPENDIX A.

Reference

- [1] NEI, Methodology for Performing Aircraft Impact Assessments for New Plant Designs, NEI 07-13, 2011.
- [2] IAEA, Safety Aspects of Nuclear Power Plants in Human Induced External Events: General Considerations, No.86, 2017.
- [3] IAEA, Safety Aspects of Nuclear Power Plants in Human Induced External Events: Assessment

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of Structures, No.87, 2018.

- [4] IAEA, Safety Aspects of Nuclear Power Plants in Human Induced External Events: Margin Assessment, No.88, 2017.
- [5] General Nuclear System Limited, Guidance for Optioneering, HPR/GDA/REPO/0080, Rev. 0, 2019
- [6] General Nuclear System Limited, UK HPR1000 Modification Categorisation Procedure, HPR/GDA/PROC/0033, Rev 0, 2019.
- [7] General Nuclear System Limited, UK HPR1000 Modification Control Procedure, HPR/GDA/PROC/0053, Rev 01, 2019.

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APPENDIX A RO-UKHPR1000-0007 Gantt Chart

Task and Schedule	2019						2020												2021					
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	
1 Aircraft Impact Safety Evaluation Methodology Report (Issued)	▲																							
2 Aircraft Impact Safety Evaluation Methodology Report (Update Planned)									▲															
3 Aircraft Impact Gap Analysis Report (Issued)			▲																					
4 Aircraft Impact Gap Analysis Report (Update Planned)						▲																		
5 Aircraft Impact Load-Time Function Report (Issued)				▲																				
6 Aircraft Impact Load-Time Function Report (Updated Planned)									▲															
7 Basis of Safety Case for Aircraft Impact (Issued)	▲																							
8 Basis of Safety Case for Aircraft Impact (Update Planned)									▲															
9 Basis of Design for Aircraft Impact (Issued)	▲																							
10 Basis of Design for Aircraft Impact (Update Planned)									▲															
11 Aircraft Impact Evaluation Method Statement (Issued)	▲																							
12 Aircraft Impact Evaluation Method Statement (Update Planned)										▲														
13 Development of Deliverable - Aircraft Impact Evaluation Report																								
14 Submission of Deliverable - Aircraft Impact Evaluation Report																								
15 Development of Deliverable - Aircraft Impact Dynamic Analysis Report																								
16 Submission of Deliverable - Aircraft Impact Dynamic Analysis Report																								
17 Development of Deliverable - Design Substantiation Report for Aircraft Impact																								
18 Submission of Deliverable - Design Substantiation Report for Aircraft Impact																								
19 Development of Deliverable - Aircraft Crash Safety Evaluation Report																								
20 Submission of Deliverable - Aircraft Crash Safety Evaluation Report																								
21 Development of Deliverable - Aircraft Crash Safety Evaluation Report																								
22 Submission of Deliverable - Aircraft Crash Safety Evaluation Report																								
Assessment																								
23 Regulatory Assessment																								
24 Target RO Close Date																								▲