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| ONR Assessment Report  Generic Design Assessment of the Rolls Royce SMR – Step 2 assessment of Safeguards |



ONR Assessment Report

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**Report Title**: Step 2 assessment of Safeguards

**Authored by**: [Redacted]

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# Executive Summary

This report presents the outcomes of my safeguards assessment of the Rolls-Royce Small Modular Reactor (SMR) as part of the Step 2 of the Office for Nuclear regulation (ONR) Generic Design Assessment (GDA). This assessment is based upon the information presented in version 2 of Rolls Royce SMR Limited’s Environmental, Safety, Security and Safeguards (E3S) case chapters and supporting documentation.

ONR’s GDA process calls for a step-wise assessment, which increase in detail as the project progresses. The focus of my assessment in this step was towards the fundamental adequacy of the Rolls-Royce SMR design and safeguards case, and the suitability of the methodologies, approaches, codes, standards and philosophies which form the building blocks for the design and generic safety and security cases.

I targeted my assessment, in accordance with my assessment plan, at the content of most relevance to Safeguards against the expectations of ONR’s Nuclear Material Accountancy, Control, and Safeguards Assessment Principles (ONMACS), Technical Assessment Guides (TAGs) and other guidance which ONR regards as relevant good practice.

I targeted the following aspects in my assessment of the Rolls Royce SMR E3S case:

* Whether the legal requirements for safeguards in the UK, contained within The Nuclear Safeguards (EU Exit) Regulations 2019, are being adequately considered within the design.
* If the design will adequately support ONR as State Regulatory Authority for safeguards in the UK to meet our international safeguards obligations, specifically the UK / IAEA Voluntary Offer Safeguards Agreement and its associated Additional Protocol.

Based upon my assessment, I have concluded the following:

* Rolls Royce SMR Limited has demonstrated a sufficient understanding of both domestic and international regulatory requirements and expectations for safeguarding of nuclear material commensurate with the current status of the design.
* the information that has been submitted to demonstrate an understanding of safeguards by design is consistent with ONRs expectations for the current status of the design. The RP has also engaged with the IAEA as part of the SMR Safeguards by Design task proposal. This further demonstrates that they recognise the importance of safeguards by design and supports the development of safeguards measures as the design matures.
* I am content that sufficient information was provided during Step 2, but further details will be required on the nuclear material accountancy, control and safeguards system as the design matures.

Overall, based on my assessment to date, and subject to the provision and assessment of suitable and sufficient supporting evidence, I have not identified any fundamental safeguards shortfalls that could prevent ONR permissioning the construction of a power station based on the generic Rolls-Royce SMR design.

# List of Abbreviations

AP UK/IAEA Additional Protocol (INFCIRC/951 Add. 1)

BTC Basic Technical Characteristics

CNSS Civil Nuclear Security and Safeguards (ONR)

FSE Fundamental Safeguards Expectation

HOW2 ONR’s Management System Platform

HSE Health and Safety Executive

IAEA International Atomic Energy Agency

INFCIRC IAEA Information Circular

NMACS Nuclear Material Accountancy, Control, and Safeguards

NSR19 Nuclear Safeguards (EU Exit) Regulations 2019

ONMACS ONR Nuclear Material Accountancy, Control and Safeguards Assessment Principles

ONR Office for Nuclear Regulation

QNF Qualifying Nuclear Facility

QNM Qualifying Nuclear Material

RGP Relevant Good Practice

RP Requesting Party

SSC Structure, System and Component

TAG Technical Assessment Guide(s) (ONR)

TSC Technical Support Contractor

VOA UK/IAEA Voluntary Offer Agreement (INFCIRC/951)

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# Introduction

1. This report presents the outcomes of my safeguards assessment of the Rolls-Royce Small Modular Reactor (SMR) as part of Step 2 of the Office for Nuclear Regulation (ONR) Generic Design Assessment (GDA). This assessment is based upon the information presented in version 2 of Rolls-Royce SMR Limited’s Environmental, Safety, Security and Safeguards (E3S) case chapters (refs [1], [2], [3] and [4]) and supporting documentation.
2. Assessment was undertaken in accordance with the requirements of the Office for Nuclear Regulation (ONR) Management System and follows ONR’s guidance on the mechanics of assessment, NS-TAST-GD-096 (ref. [5]). The ONR Nuclear Material Accountancy, Control, and Safeguards Assessment Principles (ONMACS) (ref. [6]), together with supporting Safeguards’ Technical Assessment Guides (TAGs) (ref. [7]), have been used as the basis for this assessment.
3. This is a Major report (refer to NS-TAST-GD-108 (ref. [8]).
   1. Background
4. The ONR’s GDA process (ref. [9]) calls for a step-wise assessment of the Requesting Party's (RP) submissions with the assessments increasing in detail as the project progresses. Rolls-Royce SMR Limited is the RP for the GDA of the Rolls-Royce SMR design.
5. In April 2022 ONR, together with the Environment Agency and Natural Resources Wales (NRW), began Step 1 of the GDA for the generic Rolls-Royce SMR design. Step 1, which is the preparatory part of the design assessment process and mainly associated with initiation of the project and preparation for technical assessment in later steps, was successfully completed in 12 months.
6. Step 2 commenced in April 2023. This is the first substantive technical assessment step. The focus of ONR’s assessments in this step is towards the fundamental adequacy of the design and safety, security and safeguards cases, and the suitability of the methodologies, approaches, codes, standards and philosophies which form the building blocks for the design and generic cases. The objective is to undertake an assessment of the design against regulatory expectations to identify any fundamental shortfalls that could prevent ONR permissioning the construction of a power station based on the design.
7. Prior to the start of Step 2 I prepared a detailed Assessment Plan for Safeguards (ref. [10]). This has formed the basis of this assessment and was also shared with the RP to maximise openness and transparency.
8. This report is one of a series of Assessments which support ONR’s overall judgements at the end of Step 2 which are recorded in the Step 2 Summary Report (ref. [11]).
   1. Scope
9. The assessment documented in this report is based upon the E3S case for the Rolls-Royce SMR as summarised in the E3S case chapters and supporting documentation.
10. The overall scope of the Rolls-Royce SMR GDA is described in (ref. [12]). Rolls-Royce SMR Limited has indicated that it intends to complete a three step GDA, with the objective of receiving a DAC from ONR and have aligned their GDA scope with this objective. The GDA scope defines the generic plant and layout and includes all systems, structures and components (SSCs) that are identified as being important to safety, security and safeguards, all modes of operation, and all stages of the plant lifecycle.
11. My assessment has considered the following aspects:

* ONR are the State Regulatory Authority (SRA) for safeguards and manage the State System for Accountancy and Control of nuclear material (SSAC) in the UK.
* The legal requirements for safeguards in the UK are contained withinThe Nuclear Safeguards (EU Exit) Regulations 2019 (NSR19) (ref. [13])
* As the SRA ONR are responsible for ensuring the UK complies with its international safeguards obligations including the UK/IAEA (International Atomic Energy Agency) Voluntary Offer Agreement (VOA) (ref. [14]) and the UK/IAEA Additional Protocol (ref. [15])
* My assessment considered if the documentation submitted by Rolls Royce SMR adequately considers ONR’s and international safeguards expectations, and whether there were any reasons the design may not be able to meet these.

# Assessment standards and interfaces

1. For ONR, the primary goal of the GDA Step 2 assessment is to reach an independent and informed judgment on the adequacy of a safety, security and safeguards case for the reactor technology being assessed.
2. ONR has a range of internal guidance to enable Inspectors to undertake a proportionate and consistent assessment of such cases. This section identifies the standards which have been considered in this assessment.
3. This section also identifies the key interfaces with other technical topic areas.
   1. Standards
4. The ONR Nuclear Material Accountancy, Control, and Safeguards Assessment Principles (ONMACS) (ref. [6]) constitute the regulatory principles against which the RP’s case is judged alongside the regulatory requirements in NSR19. Consequently, the ONMACS and NSR19 are the basis for ONR’s assessment and have therefore been used for the Step 2 assessment of the Rolls-Royce SMR.
5. The IAEA Nuclear Energy Series includes standards on safeguards by design. These standards provide a framework of fundamental principles for safeguards by design including NP-T-2.9 International Safeguards in the Design of Reactors (ref. [16]) and NP-T-2.8 International Safeguards in Nuclear Facility Design and construction (ref. [17]). The IAEA Safety Reports Series No. 123 Applicability of IAEA Safety Standards to Non-Water Cooled Reactors and Small Modular Reactors (ref. [18]) is also applicable.
6. The relevant ONMACS are embodied and expanded on in the safeguards Technical Assessment Guides (TAGs) (ref. [33]) specifically SG-TAST-GD-001 Safeguards TAG issue 4 and SG-TAST-GD-002 Safeguards Nuclear Material Accountancy TAG Issue 2. The TAGs provide the principals used as the basis for consideration of safeguards aspects in practice.
   * 1. NSR19 and ONR Nuclear Material Accountancy, Control, and Safeguards Assessment Principles (ONMACS)
7. The key section of NSR19 considered as part of my assessment is Schedule 1 Part 1, Questionnaire I-A Reactors. This template was agreed to be utilised by the RP at the start of the Step 2 Assessment as it captures the safeguards-relevant technical detail of the key areas for where the QNM will be processed and stored in the reactor, the locations where QNM will be held, the key measurement points and how the QNM will be accounted for and controlled.
8. The key ONMACS Fundamental Safeguards Expectation (FSE) applied within my assessment is FSE 7 Nuclear Material Tracking. This FSE details ONRs regulatory expectations for the NMACS system and was used as a basis to support my assessment.
9. A list of the ONMACS FSEs used in this assessment is recorded in Appendix 1.
   * 1. Technical Assessment Guides (TAGs)
10. The following TAGs have been used as part of this assessment:

* NS-TAST-GD-096 - Guidance on Mechanics of Assessment (ref. [5]).
* SG-TAST-GD-001 – Safeguards Technical Assessment Guidance (ref. [7]).
* SG-TAST-GD-002 – Safeguards Nuclear Material Accountancy Technical Assessment Guidance (ref. [7]).
  + 1. National and international standards and guidance

1. The following international standards and guidance have been used as part of this assessment:

* IAEA, NP-T-2.9 International Safeguards in the Design of Reactors (ref. [16]).
* IAEA, NP-T-2.8 International Safeguards in Nuclear Facility Design and construction (ref. [17]).
* The IAEA Safety Reports Series No. 123 Applicability of IAEA Safety Standards to Non-Water Cooled Reactors and Small Modular Reactors (ref. [18]).
  1. Integration with other assessment topics

1. I have worked closely with other topics as part of my Safeguards assessment. These interactions are key to the success of GDA to prevent or mitigate any gaps, duplications or inconsistencies in ONR’s assessment.
2. The key interactions with other topic areas were:

* Fuel and Core. This interaction supported the understanding of the qualifying nuclear material (QNM) that will be processed and stored in the reactor and the locations where QNM will be held.
  1. Use of technical support contractors

1. During Step 2 I have not engaged Technical Support Contractors (TSCs) to support my assessment of the safeguards aspects of the Rolls-Royce SMR.

# Requesting party’s submission

1. Rolls-Royce SMR Limited submitted a series of E3S chapters, or summary reports, and other supporting references, which outline the E3S case for the generic Rolls-Royce SMR design. This section presents a summary of the RP’s safeguards case. It also identifies the documents submitted by the RP which have formed the basis of my safeguards assessment of the Rolls-Royce SMR.
   1. Summary of the Rolls-Royce SMR design
2. The generic Rolls-Royce SMR design is a three loop Pressurised Water Reactor (PWR) with a target electrical power output of 470 MWe (from a thermal power of 1,358 MWth) and a design life of 60 years for non-replaceable components.
3. The Rolls-Royce SMR design has been developed by the RP based upon well-established PWR technology, in use all over the world. Innovation comes in the form of its modular approach to construction which would see the majority of the power station built in factory conditions and assembled on site.
4. The reactor itself is of a typical PWR design, including a steel Reactor Pressure Vessel (RPV) holding fuel assemblies, Steam Generators (SG), Reactor Coolant Pumps (RCP) and piping, all held within a steel containment vessel. The reactor is equipped with a number of supporting systems for normal operations and a range of safety measures are present in the design to provide cooling, control criticality and contain radioactivity under fault conditions. Passive safety features are preferred to active components, reflecting the RP’s design philosophy.
5. From a safeguards perspective, the key design aspects are the size of the facility and the impact this may have on the size of the fuel and the fuel route. This includes the receipt of fuel, movement of the fuel into the reactor and storage of spent fuel, i.e. where the QNM will be stored and how it will be controlled and safeguarded.
   1. E3S case approach and structure
6. Rolls-Royce SMR Limited has chosen to develop its cases in a holistic manner, as an Environment, Safety, Security and Safeguards (E3S) case. The overall objective for the E3S case is to demonstrate that the design will ‘protect people and the environment from harm’.
7. This means that, although the case made for each of the E3S purposes (i.e. environment, safety, security and safeguards) will inevitably be different at the top level, it will draw upon common evidence outputs (as well as other non-common outputs) to substantiate each of the purposes. This is claimed to offer benefits in terms of clarity, integration and understanding impacts from any changes to the case.
8. The E3S case is being developed using a three tier hierarchy and incorporating a Claim, Argument and Evidence (CAE) structure with the highest-level claims being derived from the RP’s own E3S principles. The highest level of the three tiers is the RP’s Tier 1 E3S chapters, with the lower tiers providing more detailed arguments and evidence. This is illustrated in Figure 1.

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**Figure 1: Claim, Argument and Evidence (CAE) structure within the E3S hierarchy** (ref. [1])

1. The structure of the E3S case largely aligns with the IAEA guidance for safety cases, SSG-61 (ref. [19]), supplemented to include UK specific expectations and expanded to include the other E3S purposes.
   1. Summary of the requesting party’s E3S case for Safeguards
2. The aspects covered by the Rolls-Royce SMR safety case in the area of safeguards can be broadly grouped under three headings which are summarised as followed:
   * 1. Safeguards domestic regulatory requirements and regulatory expectations
3. The RP claim they understand the domestic regulatory requirements and ONR’s regulatory expectations are contained within the ONMACS. The RP recognises that the duty holder/operator will be legally required to comply with NSR19 and have identified two commitments on the future Duty Holder/Licensee C33.1 and C33.2.
4. The RP has submitted the Basic Technical Characteristics (BTC) document in the form of NSR19 Schedule 1, Part 1, I-A Reactors to demonstrate their understanding of the QNM to be stored and processed in the facility.
   * 1. International safeguards obligations
5. The RP claim they understand the legal basis of the IAEA in international safeguards and the requirements for the UK as a State to provide facility information to the IAEA.
   * 1. Safeguards by design
6. The RP claim that safeguards requirements have been reflected in the Rolls Royce design from the IAEA Safeguards by Design guidance.
   1. Basis of assessment: requesting party’s documentation
7. The principal documents that have formed the basis of my safeguards assessment of the E3S case are:

* E3S Case Chapter 33 Safeguards, SMR0004293 (ref. [4]).

This document is used by the RP to demonstrate their understanding of both the UK and international safeguards expectations. It is also used by the RP to demonstrate that the Rolls Royce SMR design can facilitate these expectations.

* E3S Basic Technical Characteristics: Safeguards, SMR0004750 (ref. [20])

This document details information including facility description along with the form, quantity, location and flow of QNM. This document enables ONR to understand the safeguards-relevant characteristics of the facility design and to assess if the RP has adequately considered ONRs and international safeguards expectations. This document will be used by the IAEA to design a facility safeguards approach if IAEA safeguards measures are to be applied to the facility (this will depend on the country where the facility is to be constructed and operated).

# ONR assessment

* 1. Assessment strategy

1. In line with the objectives for Step 2, I undertook a broad review of the highest level, fundamental claims and supporting arguments with limited in-depth sampling. I also undertook a review of the design and the DRP1 design [21] is consistent with the design that I have assessed in Step 2.
   1. Assessment
      1. Safeguards domestic regulatory requirements and regulatory expectations
2. In the E3S Chapter 33 Safeguards, the RP demonstrates an understanding of the UK Legal Basis for safeguards; that NSR19 contains the regulatory requirements and the regulatory expectations are detailed in the ONMACS.
3. The RP identifies that NSR19 places a number of duties on Dutyholders/Licensees including to establish, implement and maintain a system of accountancy and control of qualifying nuclear material (QNM) in each QNF qualifying nuclear facility. The RP has captured the below high level commitments:

Commitment on Future Dutyholder/Licensee C33.1: The future Dutyholder/Licensee shall put into place an adequate Nuclear Material Accountancy and Control System (NMACS) for Safeguards.

Commitment on Future Dutyholder/Licensee C33.2: The future Dutyholder/Licensee shall establish, implement, and maintain an accountancy and control system of QNM in each QNF, to enable provision of reporting requirements under NSR19.

1. In my opinion it is correct that these commitments are placed on the future Dutyholder/Licensee however I judge that the NMACS system should be considered as part of the generic design. The RP should consider the system they intend the duty holder/licensee to utilise to account and control for QNM and the reporting structure for submitting the required safeguards accounting reports.
2. I consider that adequate information has been provided for NMACS systems as part of the Step 2 assessment, however further detailed follow up will be required in Step 3.
3. In the E3S Basic Technical Characteristics (BTC): Safeguards document the RP has correctly utilised Questionnaire 1A Reactors from Part 1, Schedule 1 of NSR19 (Required by NSR19 Regulation 3). I consider that the BTC contains adequate safeguards-relevant information for the current status of the Rolls Royce SMR design including details at a high level on:

* The storage area for incoming QNM.
* Reactor area for details on refuelling.
* Storage area for outgoing QNM.
* Description of QNM and the flow of QNM.

1. The key measurement points and the material balance area structure have been considered by the RP. I would expect further clarity and detail would be required to be provided as the design of the Rolls Royce SMR develops.
2. I judge that, based on the status of the Rolls Royce design, the information captured in the BTC is adequate however further detail will be sought as the design develops and through the Step 3 Assessment process.
3. In my opinion, the information that has been submitted for safeguards Domestic Regulatory Requirements and Regulatory Expectations is consistent with UK regulatory requirements and expectations for the current status of the design, and should enable the RP to further develop the generic Rolls-Royce SMR design and associated E3S case evidence. I consider that, based on the sample evidence assessed in this section, I have not identified any fundamental safeguards shortfalls that could prevent ONR permissioning the construction of a power station based on the generic Rolls-Royce SMR design
   * 1. International safeguards obligations
4. In the E3S Chapter 33 Safeguards, the RP demonstrates an understanding of the UKs international safeguards obligations under the UK/IAEA VOA (ref. [14]). The RP also demonstrates an understanding that, in the UK, parts of NSR19 are prescriptive and enable the UK to fulfil its international obligations.
5. The RP demonstrates an understanding of the IAEA standards on the fundamental principles for safeguards by Design including those contained in NP-T-2.9 International Safeguards in the Design of Reactors (ref. [16]) and NP-T-2.8 International Safeguards in Nuclear Facility Design and construction (ref. [17]), and The IAEA Safety Reports Series No. 123 Applicability of IAEA Safety Standards to Non-Water Cooled Reactors and Small Modular Reactors (ref. [18]). This will be covered further in section 4.2.3 Safeguards by Design.
6. In my opinion, the information that has been submitted to demonstrate an understanding of International Safeguards Obligations is consistent with ONRs expectations for the current status of the design and should enable the RP to further develop the generic Rolls-Royce SMR design and associated E3S case evidence. I consider that, based on the sampled evidence assessed in this section, I have not identified any fundamental safeguards shortfalls that could prevent ONR permissioning the construction of a power station based on the generic Rolls-Royce SMR design.
   * 1. Safeguards by design
7. In the E3S Chapter 33 Safeguards, the RP demonstrates an understanding of the fundamental principles for Safeguards by Design including those contained in the IAEA guidance as detailed in paragraph [51] above.
8. Section 33.2 of the E3S Chapter 33 Safeguards contains details of the safeguards requirements that the RP has reflected in the Rolls Royce SMR design, this includes the proposed flow of QNM through the Rolls Royce SMR design and examples of key measurement points. As the Rolls Royce SMR design is similar to a Generation III pressure water reactor design, it is not expected that there will be any fundamental issues with the design from a safeguards perspective. The RP recognises that the key aspects that make this design different are the size of the facility and the impact this may have on the size of the fuel and the fuel route. The RP has considered these factors as part of the design and this is evidenced in the documentation submitted.
9. The RP has entered into the IAEA UK Member States Programme Project Task 18/CCA-002:Safeguards by Design for Small Modular Reactors. The goal of the IAEA Project Task is to identify the key technical challenges for safeguards implementation involving SMRs, and steps that can be taken to support incorporating safeguards by design principles into SMR designs. ONR will be included in all engagements as the IAEA Project Task progresses (expected duration is 24 months). I judge that this demonstrates an adequate understanding of the safeguards by design process and an appreciation that further work is required between vendors and the IAEA to support international safeguards guidance and policy in this area. Further detail will be sought as the design develops and through the Step 3 Assessment process.
10. In my opinion, the information that has been submitted to demonstrate an understanding of safeguards by design is consistent with ONRs expectations for the current status of the design and should enable the RP to further develop the generic Rolls-Royce SMR design and associated E3S case evidence. I consider that, based on the sample evidence assessed in this section, I have not identified any fundamental safeguards shortfalls that could prevent ONR permissioning the construction of a power station based on the generic Rolls-Royce SMR design.

# Conclusions

* 1. Conclusions

1. This report presents the Step 2 safeguards assessment for the GDA of the Rolls-Royce SMR design. The focus of my assessment in this Step was towards the fundamental adequacy of the design and safeguards case. I have assessed the Tier 1 E3S chapters and relevant supporting documentation provided by Rolls-Royce SMR Limited to form my judgements. I targeted my assessment, in accordance with my assessment plan (ref. [10]), at the content of most relevance to safeguards against NSR19 and the expectations of ONR’s ONMACS, TAGs and other guidance which ONR regards as relevant good practice.
2. Based upon my assessment, I have concluded the following:

* the RP has demonstrated a sufficient understanding of both domestic and international regulatory requirements and expectations for safeguarding of nuclear material commensurate with the current status of the design.
* the information that has been submitted to demonstrate an understanding of safeguards by design is consistent with ONRs expectations for the current status of the design. The RP has also engaged with the IAEA as part of the SMR Safeguards by Design task proposal (see paragraph 55). This further demonstrates that they recognise the importance of safeguards by design and supports the development of safeguards measures as the design matures.
* I am content that sufficient information was provided during Step 2, but further details will be required on the NMACS systems and BTC as the design matures.

1. Overall, based on my assessment to date, and subject to the provision and assessment of suitable and sufficient supporting evidence, I have not identified any fundamental safeguards shortfalls that could prevent ONR permissioning the construction of a power station based on the generic Rolls-Royce SMR design.
   1. Recommendations
2. My recommendations are as follows:

* Recommendation 1: ONR should consider the outcomes from my assessment as part of the decision to progress to Step 3 of GDA for the generic Rolls-Royce SMR design.

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# Appendix 1 – Relevant ONMACS Fundamental Safeguards Expectation (FSE) considered during the assessment

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| FSE No. | FSE Title |
| FSE 7 | Nuclear Material Tracking |