**Technical Support – Work Order Specification**

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| **Title: Provision of information to underpin the UK nuclear design basis criterion for naturally occurring external hazards** |
| 1. Background to the project   Nuclear site licensees are responsible for managing the risks of their operations, and for undertaking the research necessary to identify and reduce those risks. However, the Energy Act 2013 enables ONR to carry out or commission research in connection with improving its regulatory processes and minimising nuclear risks. This work order specification details such a requirement for ONR research in relation to the design basis criterion for naturally occurring external hazards affecting nuclear safety.  The ONR Safety Assessment Principles (SAPs) define external hazards as those natural or man-made hazards to a site and its facilities that originate externally to both the site and its processes. Important external hazards to nuclear facilities typically include earthquake, tsunami, high wind, flooding, extreme ambient temperature, and aircraft crash. Extensive guidance on external hazards in relation to nuclear regulation and safety is contained in Technical Assessment Guide (TAG) 13.  The design basis criterion for naturally occurring external hazards is defined in the SAPs in terms of an exceedance frequency of 10-4 per year, conservatively evaluated. The design basis criterion effectively determines the hazard severity level to which Systems Structures and Components (SSCs) need to be designed to withstand. It is expected that this design basis criterion, together with suitable beyond design basis design provisions will facilitate plant designs that:   * ensure risks are as low as reasonably practicable (ALARP) * meet nuclear risk targets (SAP NT.1) * have a balanced risk profile (i.e. no one type of fault or hazard should have a disproportionate contribution to the total nuclear risk).   Given advances in nuclear technology and the continual drive to reduce risks from plant faults and hazards to as low as reasonably practicable, this project seeks to provide evidence to underpin the design basis criterion for naturally occurring external hazards. |
| 1. SCOPE OF THE SERVICES REQUIRED   In line with international good practice, ONR expects nuclear licensees to carry out fault analysis comprising suitable and sufficient design basis analysis (DBA), probabilistic safety analysis (PSA) and severe accident analysis (SAA) to demonstrate that risks are ALARP. DBA is generally considered to be deterministic in nature, in that the nuclear risks are not explicitly evaluated. Conservative design, good operational practice and adequate maintenance and testing should minimise the likelihood of faults and ensure adequate protection against external hazards. Whilst DBA does not include explicit risk evaluation, with regard to external hazards, the application of DBA requires an external hazards design basis criterion to be defined. ONR has defined this criterion for naturally occurring external hazards to be those having an exceedance frequency of 10-4 per year, conservatively estimated.  The design basis criterion can be difficult to apply in practice since the low exceedance frequency generally leads to a scarcity of data on which to evaluate the frequency. Statistical methods such as extreme value analysis are often employed. ONR has taken the approach that in order to account for the resultant uncertainty, the hazard analysis should be conservatively based. However, in practice, the application of this strategy can be problematic since the level of conservatism necessary is difficult to define as it may depend on the availability of data, the nature or shape of the hazard curve, and the actual plant specifics.  An important attribute of naturally occurring external hazards is that they are generally characterised by hazard curves, which describe their expected severity as a function of exceedance frequency. Therefore, for a design basis at a given exceedance frequency there will be a range of hazard severities that are within the design basis but there will also be some that are more severe than the design basis. This means that beyond design basis evaluation is necessary to ensure that there is an absence of cliff edge effects just beyond the design basis. Furthermore there is an undefined element of risk arising from hazard severity considerably beyond the design basis. This makes evaluating the risk from hazards beyond the design basis complicated and it is difficult to determine how far beyond the design basis DBA should be extended to ensure the absence of cliff edge effects and that the risks are ALARP.  The scope of work for this project includes a comparison of the UK external hazards design basis criterion with international practices and a quantitative investigation into the potential risk resulting from selected key hazards exceeding the design basis criterion. It should provide information on the amount of conservatism that is appropriate within the design basis definition. The eventual objective of the work is to identify a method, or methods to substantiate an appropriate design basis criterion for naturally occurring external hazards, and the level of conservatism required within the design basis. Since the actual method or tools required are not yet defined, the scope is limited to investigation of the feasibility of achieving the objective, and identification of the appropriate methods and resource requirements. The scope can be broken down into three parts which are detailed below.  **Comparison of the UK external hazards criteria for external hazards with international practices**  The first objective is to compare the UK design basis criterion for naturally occurring external hazards with other practices (both in terms of adopting a probabilistic approach rather than deterministic, and in terms of the value of the probabilistic criterion itself - 10-4 per year). For example for seismic hazard analysis, US guide RG1.208 advocates using a performance based approach and selecting an appropriate fraction between the 10-4 and 10-5 mean hazard curves, rather than a single conservatively estimated curve. Other countries, particularly where earthquakes are more frequent or severe than in the UK, may elect to design to a given deterministic event. Even though the UK may be relatively seismically inactive, the current design basis criterion may lead to relatively stringent design conditions, ironically, partly driven by the uncertainty resulting from scarcity of severe earthquake data and the requirement to ensure a conservative evaluation.  This situation may also be applicable to other hazards. It may be possible to define deterministic scenarios involving multiple hazards, rather than a probabilistic criterion for each hazard or combination explicitly. This approach could be used to define storm hazard conditions for example. The scope of work should therefore consider the approach adopted by other countries for various naturally occurring hazards and the potential suitability within the UK given the UK hazard propensity and the nuclear regulatory regime. The scope should include consideration of whether the UK regulatory approach results in more or less onerous design requirements than in other countries.  In practice, this task is substantially simplified by the issue in April 2019 of NEA/CSNI/R(2018)7 “Examination of Approaches for Screening External Hazards for Nuclear Power Plants”, which provides most of the required information. Hence this task requires a review of NEA/CSNI/R(2018)7 leading to a summary of the salient points in accordance with the objective stated above.  **Investigation into the relative risk contribution from design basis, beyond design basis and very low frequency naturally occurring external hazards**  Naturally occurring external hazards are generally characterised by hazard curves, which include hazard severities corresponding to exceedance frequencies beyond the design basis (10-4 p.a.). The purpose of this work is to establish the risk contributions for selected hazards at severities ranging from within the design basis, around the design basis and extending to very low frequencies. In order to provide quantitative assessment, it is expected that this may involve convolution of selected hazard curves with SSC fragility data. It is anticipated that a few important hazards could be considered for study, together with typical fragility information for nuclear facilities. An important aspect in the selection of relevant hazards is to identify which hazards are likely to present the bounding or limiting cases in terms of both design basis and beyond design basis withstand capability. The study should identify which hazards are likely to have the greatest beyond design basis risk contribution. For example, some meteorological hazards are limited by physical constraints, such as the amount of energy held in the atmosphere, whereas other hazards may not be physically limited, at least as far as practical provision of engineered protection is concerned. The scope of this work does not however involve detailed calculation of hazard curves associated with, for example, meteorological hazards. It is envisaged that the contractor should use information that they consider reasonably represents typical UK conditions.  **(For information only) Investigation of the sensitivity of risk to the design basis criterion and degree of conservatism.**  Following completion of the second task specified above, ONR may wish to commission a third task investigating the sensitivity of risk to the design basis criterion and degree of conservatism (depending on the output of the first two tasks). If this third task is required, it will be described in a separate scoping document. Bidders should not provide a separate costing for the third task at this stage.  **Project tasks**  Specific tasks for the project:  **Task 1** Review of NEA/CSNI/R(2018)7 to compare UK and international guidance and practice for external hazard design basis criteria as described in paragraphs 2.5 and 2.6.  Assume:   * + One project kick off meeting with ONR project officer in ONR offices, Bootle   + One progress meeting with ONR project officer in ONR offices or contractor premises to discuss findings.   **Task 2** Investigate the relative risk contribution from beyond design basis and very low frequency parts of hazard curves for naturally occurring external hazards.   * Investigate the relative risk contribution arising from the design basis (10-4 per year) elements and beyond design basis elements of hazard curves describing naturally occurring external hazards, as described in paragraphs 2.7 and 2.8. * Select up to three significant naturally occurring hazards for this study.   Assume:   * + One meeting to discuss overall approach with ONR project officer in ONR offices (may be combined with kick off meeting for task 1)   + Two progress meetings at ONR offices or contractor premises.   Deliverables   * Report for tasks 1 and 2 describing the scope of work undertaken, the methodology and findings and any recommendations. |
| 1. OBJECTIVES  * Compare the UK design basis criterion for naturally occurring external hazards with international practice. * Investigate the relative risk contribution from key design basis, beyond design basis and very low frequency naturally occurring external hazards. |
| **TECHNICAL RESPONSE** |
| 1. Response   The Technical Response should demonstrate a clear understanding of the work required.  Please provide a description of how you will deliver the scope of work (methodology) and the proposed delivery team you will use, clearly signposting to relevant sections within your Capability Prospectus where appropriate/relevant.  The response must include:   * a description of proposed deliverables and/or outputs * an outline of anticipated engagement (project meetings & management) * details of proposed cost and associated effort assumptions * a project delivery plan showing activities and milestones * a planned invoice schedule * details of any assumptions or constraints |