Office for Nuclear Regulation Regulatory Research Strategy

2019

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1. Background

1.1. Section 88 of the Energy Act 2013[1] enables ONR to carry out or commission research in connection with its purposes and to publish the results if it considers it appropriate to do so.

1.2. Research plays an important role in our understanding of a wide range of complex, often unique challenges. ONR's research differs from many organisations in that it supports our independent regulatory decision-making and ensures that our regulatory processes remain robust. This needs to be based on an objective, scientific and technical understanding of safety, security and safeguard issues.

1.3. The UK is engaged in the design, construction, operation and decommissioning of a wide range of nuclear facilities across the full spectrum of the nuclear fuel cycle. We base our regulatory decisions on evidence, for which we require expertise across a wide range of specialist topics.

1.4. Where there are unknowns, uncertainties or gaps in our knowledge, we will continue to apply the precautionary principle and be conservative in our decision-making. Similarly, in the absence of robust underpinning information, dutyholders may produce excessively conservative safety cases, which generally result in over-engineered and complex facilities. This often leads to unnecessary delays and cost overruns, including to important risk reduction projects. It could also result in the early closure of vital nuclear facilities, before it is strictly necessary.

1.5. This research strategy document outlines ONR's research objectives, approach to delivery, governance, engagement with national and international stakeholders, and also our plans for measuring the effectiveness of the research we commission. Section 8 of this strategy takes a long-term view of the UK's nuclear landscape, and identifies ONR's strategic regulatory research needs over the period 2020 to 2040.

2. Strategic research objectives

2.1. The main objective of this strategy is to ensure that our Inspectors are able to form their regulatory judgements confidently and effectively using sound, up to date scientific and technical information, to support balanced decisions and avoid over-conservatism and over-optimism.

2.2. We have identified three main drivers to commission research:

- ONR requires independent advice to assist with our decision-making, particularly where the decisions we make might be considered to be contentious.

[1] http://www.legislation.gov.uk/ukpga/2013/32/pdfs/ukpga_20130032_en.pdf

- ONR has identified a knowledge gap which requires research, and has invited the dutyholders concerned to complete the work and share their results. However, they have declined to do so, or declined to do so within acceptable timescales.

- ONR specialists require greater understanding and oversight of developing innovations or emerging subjects, to enable our regulatory decisions to be based on the most up to date information.

3. Overview of approach to delivery

3.1. Our research projects are generally in highly complex and specialised areas. We therefore rely on the expertise of our Specialisms[2] (Professional Leads and Specialist Inspectors acting as Project Officers) to identify and specify our research needs, procure the specialist services required, and drive progress for the successful delivery of work.

3.2. All our research activities are coordinated by our Research Delivery function (RDf) within the Technical Division (TD). The RDf manages our research budget and provides advice and support to our Specialisms and Project Officers, who are accountable for the delivery of the research projects in their individual technical areas.

3.3. As part of the annual planning process, Professional Leads coordinate the identification of topics considered to require research in line with the above strategic research objectives. This coordination role should include discussion with Divisional Delivery Leads to ensure that all necessary research projects are being carried out in a timely manner to support any forthcoming regulatory consideration.

3.4. Research projects are formally proposed through completion of a proposal document submitted to the RDf. These proposals also confirm that the research is consistent with ONR's regulatory purposes under the Energy Act (safety, security, transport, safeguards and conventional health and safety), and identify estimated costs[3] and the dutyholders concerned.

3.5. Examples of research topics which meet our strategic research objectives and support our purposes under the Energy Act include:

- Research which supports our independent decision-making by giving us a diverse view of a subject from the dutyholders.
- Topics which enhance the definition of relevant good practice and thus support reasonable practicability tests.
- Research to test/confirm safety, security and/or safeguards case claims and arguments.

[2] For ONR Technical Specialisms, please refer to http://www.onr.org.uk/research/specialisms.htm
[3] Please also see section 6 on 'Budget / value for money'

- Confirmatory research into the validity of assumptions underpinning safety, security and/or safeguards cases.
- Research to identify where existing models/data may have weaknesses.
- Research into potential safety, security and/or safeguards issues associated with new technologies before their application to new or existing facilities.

3.6. It should be noted that ONR does not commission research either to support the commercial development of nuclear technologies or in areas for which other public bodies have regulatory responsibilities or are responsible for providing authoritative advice; it is confined to the scope of ONR's regulatory vires.

3.7. Our management processes require our Specialist Inspectors to test their research proposals against our strategic research objectives, to determine whether they qualify for inclusion on our Research Register. Proposals are reviewed for acceptance by the relevant Professional Leads in consultation with the relevant Divisional Delivery Leads, and are approved by the Research Delivery Lead (RDL). This process filters out projects that do not adequately support ONR's strategic research objectives or purposes under the Energy Act 2013, or projects which are judged to represent poor value for money. By submitting and gaining approval for a proposed research project, Project Officers and Professional Leads are committing to manage its delivery, ensuring that they plan sufficient resource and follow all relevant ONR processes, including those related to contract management.

3.8. If for any reason an ongoing research project fails to meet ONR's strategic research objectives and purposes, or we are not provided with assurance about the status of a contract in terms of progress towards delivering the required work to the agreed quality within agreed timescales and costs, ONR may terminate the research project. This will be stipulated in our contractual documentation.

4. Governance, Openness and Transparency

4.1. Given our powers under the Energy Act 2013 to carry out or commission research in connection with our purposes and to recharge all related costs to the dutyholders, it is imperative that ONR should maintain the highest standards with respect to HM Treasury's expectations of public bodies in relation to value for money.

4.2. Rigorous governance arrangements have therefore been put in place to provide oversight of the management of our Research. 'Regulatory Research' is a standing agenda item at our monthly TD Board meetings, where the delivery of objectives, expenditure, milestones and risks are reported and challenged where appropriate by Divisional Board members. In addition, we propose to strengthen the way in which we measure our research

effectiveness. This will also be reported to these meetings to demonstrate that the work is providing appropriate levels of benefit to the organisation[4].

4.3. Alongside the TD Board, we report to various other governance and advisory groups such as the Regulatory Leadership Team (RLT), the ONR Board and the Chief Nuclear Inspector's Independent Advisory Panel (IAP). These governance arrangements provide senior stakeholders with appropriate oversight of our arrangements and delivery[5].

4.4. To increase our confidence in specific areas judged to be contentious or of high monetary value, we commission ad hoc independent Assurance Reviews, typically delivered by the TD's Regulatory Oversight function, or by ONR's Regulatory Assurance function. Our two most recent reviews (2016 and 2018) demonstrated the effectiveness and value of such an approach. These supported our approach to delivery and value for money, whilst recommending a strengthening of our Research management processes and improved visibility of our overarching graphite strategy. Both of these have now been addressed.

4.5. In ONR's Regulatory Strategy 2015 – 2020, we outline our *"vision to be an exemplary regulator that inspires respect, trust and confidence"*, with one of our Strategic Themes specifically focused on *"inspiring a climate of stakeholder respect, trust and confidence"*. Openness and transparency is at the heart of how the Research Delivery function is governed, with a presumption of disclosure of information on our activities, and to be fully accountable for everything that we do.

4.6. We will continue to publish an Annual Research Report (ARR), which will form part of the Chief Nuclear Inspector's Report on the state of safety, security and safeguards in GB's nuclear industry. This ARR will summarise the work completed in the year, and will supplement the quarterly research delivery reports[6], which report and monitor the progress of individual projects. Subject to commercial confidentiality and security restrictions, we publish the final outputs and reports from all research work that ONR commissions.

5. Stakeholder Engagement and Collaboration

5.1. Given the cross-cutting nature of research and the many interested parties within and outside ONR, we actively engage with a wide range of national and international stakeholders.

Engagement with Dutyholders

5.2. Our Specialist Inspectors routinely engage on technical matters with their dutyholder counterparts in working level discipline-specific meetings. These meetings provide opportunities to discuss extant and emerging safety,

[4] See section 'Effectiveness of our Research' for further information
[5] See section 'Stakeholder Engagement and Collaboration' for further information
[6] Quarterly Research reports can be accessed via http://www.onr.org.uk/research/regulatory-research-register.htm

security and safeguards cases, underpinning arguments, the use of emerging technologies and innovation. It is often information gained from these engagements and our assessment of documentation which helps our Specialist Inspectors to identify topics in need of potential research.

5.3. These working level meetings also enable our Specialist Inspectors to discuss and review dutyholders' research programmes. This ensures that ONR does not initiate and duplicate research in areas which are already covered by the industry, except in circumstances where our aim is to obtain independent underpinning information.

5.4. The working level meetings also enable our Specialist Inspectors to share with their dutyholder counterparts where we have identified an apparent need to commission research. In all circumstances (except those where our aim is to obtain independent information), we consult the relevant dutyholders and provide them with the opportunity to undertake the research themselves. If they decline to do so within acceptable timescales and we remain confident of the value of the proposed research, we will commission the research ourselves. We will then use our powers under the Energy Act 2013 to recover the funding from the appropriate dutyholders through ONR's regulatory charging regime.

5.5. At a more strategic level, our RDf holds annual meetings with the dutyholders' research coordination teams to discuss our respective research plans in a spirit of openness and transparency. These meetings have proved effective in ensuring that dutyholder research managers gain a working understanding of our current and proposed research portfolios, of our robust governance arrangements, and of our efforts to achieve value for money and prevent duplication.

5.6. During our interactions, we ensure that dutyholders understand that the research we propose is to support our regulatory purposes. It is not intended to displace research projects identified by dutyholders as necessary to further underpin their safety, security or safeguards cases.

Engagement with other National Regulators

5.7. In regulating the UK nuclear industry, we collaborate where possible with other regulators such as the environment agencies (Environment Agency (EA), Scottish Environment Protection Agency (SEPA), Natural Resources Wales (NRW)). We have similar requirements to understand the technical underpinning of safety or environmental cases, and to keep abreast of developing and emerging technologies. We share the same desire to promote innovation in the nuclear industry, principally in areas where innovation could be used to benefit the decommissioning of hazardous facilities by making it safer, more efficient and with reduced environmental impact.

5.8. Our Research function meets annually with the EA's research team, to compare our approach to research, our portfolio of research projects, and areas of mutual interest. Our engagement with the EA provides us with the

right level of awareness of research programmes across the environment agencies, and avoids duplication of research projects.

Wider Research Landscape

5.9. We seek to avoid working in isolation and to maintain a good level of awareness of the wider research landscape in the UK. ONR's Research Delivery Lead is a standing member of the Nuclear Decommissioning Authority Research Board (NDA RB)[7] - an independent advisory board promoting strategic coordination between relevant research bodies across the UK. The EA and SEPA are also members of the NDA RB, which further enhances our common regulatory understanding of the research landscape.

5.10. Recognising that the nuclear landscape in the UK is changing, ONR should also seek to influence national and international research institutions and organisations to conduct research in areas which we consider to be priorities.

5.11. At a UK strategic level, our RDL participates as an 'Observer' in the Nuclear Innovation and Research Advisory Board (NIRAB)[8], set up to provide independent, expert advice to Government on nuclear research and innovation. The Observer status has been selected to balance the need for ONR to remain suitably informed of developments in the UK nuclear research landscape, whilst maintaining our regulatory independence and avoiding conflicts of interest. In addition to our Observer participation at board meetings, we also have the option to observe, and possibly influence, several of the underpinning working groups, which focus on innovation.

5.12. ONR also routinely collaborates with various national and international specialised organisations, universities, research councils[9], institutes and contractors, which helps to ensure our research portfolio is well focused and informed. This requires our specialists to track and participate in ongoing committees[10] and working groups across the industry to remain up to date with latest developments and innovation.

International Engagement

5.13. Learning from others is a key aspect of the way we work, as it allows us the opportunity to observe and understand how other organisations operate, and to capture essential learning points. We have longstanding and well-established working relationships with a number of international nuclear regulators, with formal arrangements in place for cooperation and the exchange of information.

5.14. Amongst these, our longstanding working relationship with the French Autorité de Sûreté Nucléaire (ASN) has been formalised through the recent renewal of the 'Arrangement for Cooperation and Exchange of Information'[11].

[7] https://www.gov.uk/government/organisations/nuclear-decommissioning-authority/about/research#nda-research-board
[8] http://www.nirab.org.uk/
[9] Including the Engineering and Physical Sciences Research Council (EPSRC), and the National Research Council (NRC)
[10] Including at OECD NEA (Organisation for Cooperation and Development, Nuclear Energy Agency)
[11] http://www.onr.org.uk/documents/2018/onr-asn-information-exchange.pdf

This arrangement specifically includes *"safety-related research in connection with licensing and regulatory control of nuclear installations"*.

5.15. In the context of this arrangement, secondments of two to three years are routinely organised between ASN and ONR. In the past these have facilitated the identification of areas of common interest, and enabled collaboration in key areas such as decommissioning of legacy facilities. We aim to continue working with our secondees to further improve our understanding of topics of mutual interest, including research programmes.

5.16. Like us, ASN recognises that regulatory decision-making relies particularly on robust technical expertise. Through its Scientific Committee[12], ASN is taking a long-term strategic view of its research requirements. Recognising that 'long-term strategic research' is an area where we could learn from ASN, a maned individual who represents the RDL has been formally appointed as a member of ASN's Scientific Committee.

5.17. Finally and on a less strategic level, a named individual who represents the RDL has been formally appointed as a member of one of ASN's Advisory Committees (GPU[13]), which provides an independent review of assessment reports related to the French nuclear fuel cycle. Through our participation, we aim to identify and bring back to the UK any learning points and good practices, including those related to the way in which research is used to underpin safety arguments presented in safety cases.

Internal Engagement

5.18. Our Research function is occasionally invited to present matters of topical interest to the Chief Nuclear Inspector's (CNI's) Independent Advisory Panel (IAP)[14], established to provide independent strategic technical advice to ONR on a wide range of nuclear safety, security and safeguards related topics.

5.19. In late 2018, the IAP provided helpful advice to guide us in our development of measures to evaluate the effectiveness of our research projects. We are currently following up on contacts provided by IAP members, and learning from ideas and principles which are at the very early stages of development, working with UK research institutions such as the National Nuclear Laboratory (NNL)[15] and the Dalton Nuclear Institute (DNI)[16].

5.20. The IAP also provided support to our objective of enhancing our consideration of long-term strategic research, which we propose to develop via our arrangements for cooperation with ASN.

[12] http://www.french-nuclear-safety.fr/ASN/Technical-support/ASN-s-Scientific-Committee
[13] http://www.french-nuclear-safety.fr/ASN/Technical-support/The-Advisory-Committees
[14] http://news.onr.org.uk/2013/05/chief-nuclear-inspector-advisory-panel-cniap/
[15] http://www.nnl.co.uk/
[16] http://www.dalton.manchester.ac.uk/

6. Budget / Value for Money

6.1. We have made tangible progress in recent years at improving the delivery and financial control of our research portfolio. We work closely with others, and manage the considerable uncertainty by applying weighting factors to individual projects. We have also strengthened our engagement with ONR's Specialisms and our Procurement team, to maintain the emphasis on delivery and cost effectiveness.

6.2. We intend to further tighten our proposed budget, so it reflects past experience of delivery. We will continue to actively emphasise project delivery, and collaborate with our Finance team to ensure that the most up to date financial information is entered into ONR's Management Accounts.

6.3. 'Value for money' is and will remain a fundamental consideration in the management of our research portfolio, especially since we recover the costs of research directly from dutyholders as a pass-through cost through our regulatory charging regime.

6.4. We will continue to seek and gain maximum value from our research activities by partnering with other national[17] and international[18] research institutions, and joining existing national and international research projects. This provides, through a modest annual contribution, UK access to the results of multi-million pound, cutting edge research, helping to support our assessment activities.

6.5. This allows ONR to achieve a high degree of leverage on its investment in research, benefit from economies of scale and access research performed by international teams of experts whilst complying with the National Audit Office's 'value for money principles'. In cases where ONR commissions the research, work is awarded on a competitive tender basis against a detailed specification. The research is progressed through ONR's technical support framework as appropriate.

6.6. Avoiding duplication of research projects is also a reputationally important factor in helping us to achieve value for money. This is why we will continue to proactively coordinate with industry and also at a wider national level with other research related organisations[19], sharing our regulatory research register to minimise duplication and overlap, but recognising that at times ONR will require a fully independent view of a topic to guide and inform regulatory decisions.

7. Effectiveness of our Research

7.1. In commissioning research, our intention is always to ensure that the projects we select make a proportionate and beneficial impact on our regulatory

[17] e.g. the National Nuclear Laboratory
[18] e.g. the OECD NEA (https://www.oecd-nea.org/)
[19] Refer to Section 5 – Stakeholder Engagement and Collaboration

activities. The impact of research is generally wide-ranging, which makes it impractical to translate it into purely monetary or financial indicators. Our research is driven by the need to gain independent advice for ONR to make well informed regulatory decisions, increasing ONR's stock of knowledge, training and developing skilled people, and collaborating with other specialised institutions to share information.

7.2. ONR Board Members consistently seek to obtain assurances regarding our delivery and the value of our research activities. 'Demonstrating the value of research' is indeed a common but highly complex and challenging question to answer, which many research institutions are currently attempting to address.

7.3. For a number of years, our management processes have included a final 'close-out' step to evaluate the impact of our research projects, and the extent to which they have been successful in providing the underpinning information originally sought. Examples of fundamental questions we ask on completion of a project are:

- Did we receive appropriate answers to the questions we set out in the research specification?
- Has it helped us in our regulatory activities and our decision-making?
- Have we made effective use of the results?
- To what extent did the research represent value for money?
- What lessons should we learn from the research contract, in terms of specification, execution and delivery, selection of contractor, cost and scope control, etc.?

7.4. Our current project evaluation process relies solely on feedback by the Project Officer. However, we recognise that there is scope to strengthen the evaluation process by extending the feedback to include stakeholders who have not been directly involved in the specification and delivery of the project, and are therefore able to provide an independent assessment.

7.5. We have met with UK research institutions such as National Nuclear Laboratory (NNL) and the Dalton Institute (DI) to learn how they address the challenge of developing a meaningful measure of effectiveness. Although these institutions are themselves learning, a common theme emerging from our benchmarking is that qualitative evaluations of effectiveness of research are far more helpful than quantitative assessments. It has been found that the figures in quantitative assessments are difficult to substantiate, which reduces their credibility and leaves them open to challenge.

7.6. To evaluate the effectiveness of our research, we propose are developing our own qualitative approach, by engaging on a number of fundamental questions (ref. 7.3) with a wide body of stakeholders including:

- the dutyholders who provided the funding;
- the ONR Specialisms and Divisions which commission the research and make use of the findings; and
- the organisations which performed the research.

7.7. We will review and collate the wide-ranging feedback gained from these engagements annually into a concise qualitative narrative, explaining main conclusions and learning points. Our work in this area will be further informed by our discussions with NNL and the DI.

8. Near, Medium and Long term Outlook

8.1. We rely on the expertise of our Specialisms and Professional Leads to identify and specify our research needs for the future. In considering our strategic research needs over the coming years, the RDf has actively engaged with ONR Divisions and Specialisms to identify significant upcoming UK nuclear challenges in line with ONR's five key regulatory purposes under the Energy Act (safety, security, transport, safeguards and conventional health and safety).

8.2. The time frame we have considered for identifying the most significant nuclear challenges facing the UK and our corresponding strategic research needs covers the near, medium and long-term future. Appendix A presents the detail in tranches of five years to 2040, and aligns the research needs to ONR Divisions, or Specialisms where topics are cross-cutting.

8.3. For convenience, the table below provides a high level summary of the more detailed information available in appendix A.

- Column 1 lists key 'Areas of Interest', which we have identified as major UK challenges with corresponding ONR Research needs.
- Column 2 'Driver for Research' identifies which of ONR's Strategic Research Objectives (ref. section 2) acts as a driver for ONR to commission research, i.e. Independence, Knowledge gap, Innovation.
- Column 3 indicates whether the 'area of interest' is already included in our current research programme.
- Column 4 considers whether our current research programme meets our short, medium and long-term needs, and whether updates / amendments are required to keep up with developments.

Summary table of areas of research			
1. Area of interest	**2. Driver for research**	**3. Currently covered by existing research**	**4. Changes proposed to research programme**
1. Graphite	• Independence • Knowledge gap • Innovation	Yes	No changes required in the short term, but longer term need to consider graphite disposal.
2. Ageing Management/ Asset Management	• Independence • Knowledge gap • Innovation	Yes	During future planning rounds, we will emphasise the importance of this area with Professional Leads to ensure that it continues to be adequately covered.

3. Beyond Design Life Substantiation	• Knowledge gap • Innovation	Yes	This is a phased programme of work over a long period of time, using the output/results from previous phases to inform future work.
4. Climate Change	• Knowledge gap	Yes	During future planning rounds, we will emphasise the importance of this area with Professional Leads to ensure this continues to be adequately covered.
5. Digital systems, incl. robotics/ artificial intelligence and drones	• Knowledge gap • Innovation	Yes	Active ONR engagement in national and international fora (CINIF, IAEA, OECD, etc.). This will be maintained to ensure consistency of ONR regulatory approach on developing standards.
6. Geological Disposal Facility (GDF)	• Independence • Knowledge gap • Innovation	Yes	Minimal research is being performed at this stage, due to the requirement for further clarity from the UK Government on siting and technologies from Radioactive Waste Management (RWM). We recognise there will be a need for ONR research in this area once the position becomes clear. We currently attend national fora on waste strategy to maintain a watching brief on UK and international developments in this area.
7. New Reactors, incl. Innovation	• Independence • Knowledge gap • Innovation	Yes	Minimal research is being performed at this stage, due to the requirement for further clarity from BEIS for both Small and Advanced Modular Reactor (SMR & AMR) technologies. We recognise there will be a need for ONR research in this area once the position becomes clear.
8. Cyber Security	• Knowledge gap • Innovation	Partially	Owing to the ongoing development of outcome focused regulation in the security sphere, the exact nature of any cyber security research requirements will only become clear as the duty holders' security plans are assessed, potentially revealing areas where improved understanding would bolster confidence in claims and arguments. There are already areas of joint safety and cyber security consideration, including the implications of increasingly smart/digitised industrial control systems and implications of emergent technology to automate decision making. These areas are suitable for collaborative working on research to ensure both safety and security issues are addressed.

9. Physical Security Protective Measures	• Knowledge gap	Partially	Owing to the ongoing development of outcome focused regulation in the security sphere, the exact nature of any physical security research requirements will only become clear as the duty holders' security plans are assessed, potentially revealing areas where improved understanding would bolster confidence in claims and arguments. Currently, testing of Physical Security Protective Measures has up to now been performed by the Centre for Applied Science and Technology (CAST), driven by UKs requirements to protect critical national infrastructure. Testing is in the process of being transferred to the Defence Science and Technical Laboratory (DSTL) after which ONR will review the need for any complementary physical protection research. There are already areas of safety research such as long term plutonium disposition, where collaborative working within ONR is suitable to ensure both safety and security issues are addressed.

8.4. On the basis of this summary table, we are able to draw a number of conclusions:

- Comparing our research needs against our extant research register, ONR is currently performing the research required at this early stage of the 2020 – 2040 timeline considered in this strategy. No gaps have been identified between short-term research needs and our current programme of research.

- Most 'areas of interest' will continue to evolve over time. For example, we will continue to require highly specialised information on the ageing of graphite cores to support our independent decision-making in the last few years of operation of the fleet of Advanced Gas-cooled Reactors. We recognise however that there is a long term need for us to provide independent regulatory decision-making for the decommissioning and ultimate disposal of graphite.

- Although our current register includes research in areas such as 'Ageing Management', 'Beyond Design Life Substantiation', 'Climate Change', 'Robotics and Artificial Intelligence', we recognise that these are developing topics. Our proposed course of action is to emphasise their importance with Professional Leads, to ensure that they continue to be adequately covered during future planning rounds.

- The 'Geological Disposal Facility' and 'Innovation in New Reactors' are areas where minimal research is being performed at this early stage. Although we recognise that significant future research will be required to support our independent decision-making, we are highly dependent on UK Government Policy and will only be able to define our research needs when the UK position becomes clear. We currently attend

national fora and maintain a watching brief on UK and international developments in these areas.

- Physical and Cyber Security are areas which have not previously been included on our research register. We are currently engaging with our Security Division to understand their needs around the introduction of outcome focused regulation and whether research projects should be considered for future financial years. ONR will continue to support the UK Government's commitment to openness and transparency by publishing the results of its research, except in circumstances where national security may be compromised.

Office for Nuclear Regulation

Appendix A

Regulatory Research - Strategic Long-Term Planning				
Division Specific	**2020-2025**	**2025-2030**	**2030-2035**	**2035-2040**
Operating Facilities	Graphite. ONR aims to base the level of research for the remaining life of the reactors on our current understanding of the degradation mechanisms in the reactor cores, whilst ensuring sufficient resilience in the external research teams to allow for any unexpected problems as reactors get closer to end of generation.			
	End of life reactors + issues with disposal			
New Reactors (incl. Innovation)	SMRs and in particular AMRs are expected to provide a number of new regulatory challenges that may need to be addressed through research but these are identified in Specialisms below. The safety and security implications of the application of artificial intelligence is also expected to require research but again this has been identified in the EC&I area below.			
DFW	GDF			
	Transport Chemistry			
Sellafield	Raw waste storage			
	Plutonium Strategy			
	Longer-term storage of submarine and reactor fuels			
Defence	Submarine decommissioning			
	Long-term storage of RPV			
Technical	Transport			
Security	Cyber and Physical Security			
Safeguards	The UK Government has funded a programme of safeguards-related R&D for nearly 40 years. The programme is primarily to support the IAEA as the global safeguards inspectorate (who have no R&D capability of their own), but also includes a limited amount of complementary work on subjects of more UK-specific interest. ONR Safeguards provides safeguard technical expertise to support Government (BEIS) colleagues in their oversight of this UK Safeguards Support Programme (UKSSP), and information on the UKSSP is published at gov.uk			

Cross Cutting Specialism Areas	**2020-2025**	**2025-2030**	**2030-2035**	**2035-2040**
Regulatory Improvement	Identification of novel and innovative regulatory models, including examination of both overall systemic frameworks within which ONR might operate in the future, as well as more discrete 'tools' that might be deployed.			
	'Anticipatory' regulation (predicting the future movement and demand of industry, and pre-positioning accordingly in capability and targets)			
Chemistry and Chemical Engineering	Chemistry of ANT/AMR/large scale reactors			
	Long term corrosion performance of stainless steel and cast iron exposed to potentially aggressive wastes			
	Zinc dosing in light water reactors			
		Graphite disposal		
		Chemistry implications of national plutonium strategy		
	Long-term storage behaviour of untreated raw waste			
	Chemistry, safety & detection techniques for decommissioning of legacy ponds, silos, reprocessing and other facilities			
	Production processes for the manufacture of fuels for ANT reactors such a TRISO, Sodium bonded fuel, etc., including issues related to HALEU			
Civil Engineering and External Hazards	Long term management of PCPVs including pre-stressing tendons under care and maintenance	Adaptation of smart monitoring of structures to the nuclear industry	Increased monitoring of inaccessible PCPVs (moisture content, test samples)	Demolition methods for PCPVs
	Climate Science Research			
	UK Seismic Hazard Model Developments			
		Space Weather Hazard Definitions		
	Statistical Methods for Hazard Combinations Characterisation			
		Defining the Design Basis Event for Future Pandemics		
		Civil Structure Design of Geological Disposal Facilities		
	Use of Seismic Isolation Bearings for SMRs and ANTs	High Temperature Concrete Containment Structures	Novel Material Research/Nanotechnology	
	Review of Aircraft Impact Hazard			
Cyber Security and Information Assurance/Protective Security	Physical Security	Cyber and Physical Security		
	Cyber: Secure cloud configuration			
	Cyber: Threat Intelligence Modelling			
	Cyber: Risk Assessment Methodologies			
	Cyber: OT cyber detection systems			
	Cyber: CSOC operational performance indicators			

Cross Cutting Specialism Areas	2020-2025	2025-2030	2030-2035	2035-2040
EC+I	Developments in tools and techniques to minimise the impacts of cyber security on the performance of computer based systems important to safety			
	MBSE approaches applied to safety case development			
	Intelligent control rooms			
	Smart C&I technologies (but not IoT)			
	Artificial intelligence at both the level of analytical/diagnostic tools and machine learning			
	Methodologies for substantiation of safety-critical software			
	Wireless communications in the context of use in safety-related applications			
	Nuclear robotics in the context of potential for robotic autonomy			
	Safety system diversity between computer-based solutions and those based on components that use HDL (e.g. FPGAs, CPLDs);			
	Developments in the use of formal proof and formal methods in the specification of safety systems using high integrity software			
Fault Analysis - Fault Studies	GenIV thermal hydraulic and physics modelling (inc validation)			
	Safety claims and modelling of passive systems			
	Stakeholder feedback on numerical risk targets; primarily to characterise and add granularity to recurring feedback in government and industry that the numerical targets / tolerability of risk framework fuel 'gold-plating'			
	Enhanced use of AI techniques in safety case modelling			
Fault Analysis - Fuel and Core			Additive manufacturing technologies for the construction of nuclear fuels	
	Accident Tolerant Fuel (LWR)			
Fault Analysis - PSA	Modelling of digital C&I in PSA.			
	Modelling of passive systems in PSA			
	PSA for SMRs/AMRs (including new or novel accident sequences or consequences			
	Use of PSA in security assessment			
Human and Organisational Capability	HMI and Control Room reliability			
	Efficacy of Peer Checking			
	Impact of Corporate Governance on Nuclear Safety			
	Human Behaviour and Reliability during Emergency Tasks			
	Development and Validation of a Safety Culture Model for Assessing Safety Culture within the UK Nuclear Industry			
	Use of electronic procedures			
	Enhanced decision-making			
		Human and Organisational Factors in Cyber Security		
		Human Factors in the design, substantiation and deployment of robotic systems in nuclear		
		Human Factors in the design, substantiation and deployment of artificial intelligence and machine learning in nuclear		
Mechanical Engineering	Replacement material for glovebox gauntlets & Glovebox bag welding technology	Equipment Qualification - Endurance Testing, Passive vs Dynamic	Security of diesel supply for EDGs/Phasing out of internal combustion engines	
	Use of robotics in gloveboxes e.g. POCO		Complex laminates integrity, strength and durability for nuclear applications	
	Digital engineering: (Digital twinning, Virtual Reality, Smart Components etc)			Carbide and ceramic material applications and their integrity, strength and durability for nuclear applications
	Heating ventilation and air conditioning: ageing, high strength ventilation filters, HEPA filter in-situ testing			
	Remote inspection drones	Transport: SMR transport, nuclear powered freight, battery powered electric vehicles and fire hazards		
	Asset management strategies	Mechanical engineering: pumps and valves		
	Additive manufacturing (3D Printing)			
	Nuclear crane standards (Gap analysis between BS 2573 and BS EN 13001 along with BS EN15011 & BS466)			
	Modular Construction implications on build quality assurance			
	Hot Isostatic Pressings component integrity, strength and durability for nuclear applications			
NLR	Geological Disposal Facility			
	AGR Decommissioning (cf Magnox)			
	Graphite disposal * once NDA/HMG preference is known			
	AGR spent fuel storage			
	Pu disposition* once NDA/HMG preference is known			
	Robotic autonomy (waste sorting/processing)			
	Degradation of UF6 containment			

Cross Cutting Specialism Areas	2020-2025	2025-2030	2030-2035	2035-2040
Nuclear Internal Hazards & Site Safety	Characterisation of internal hazards: Experimental research, modelling and methodologies for nuclear safety analysis			
	Characterisation of hazards associated with novel approaches and materials in advanced nuclear technologies (ANTs) e.g. • Consideration of fire initiation mechanisms, explosion hazards, hazard combinations etc. • Models incl. new and bespoke approaches specific to ANTs			
	Hazards related to decommissioning activities e.g. management of contaminated asbestos			
Regulatory Oversight & Regulatory Intelligence	Measuring Safety Performance: review current practices for measuring safety performance to identify good practices			
RP Criticality EP+R	Comparison of Gaussian Plume and Lagrangian model for target 9	Artificial Intelligence in criticality and shielding calculations		
	Treatment of Rainfall in Off-site Deterministic Radiological Consequence Analysis			
	Radiation Shielding good practice in UK			
	Assessment of dutyholders' criticality / shielding capabilities measured against hypothetical scenarios supplied by ONR.			
	Comparison of calculated to measured dose values for transport packages (end to end testing)			
	Dose conversion factors due to Groundshine for non-adult age groups			
	Excess risk (off-site) to non-adults and females from accidents			
	Public dose info for RIFE report (food standards agency) (methodology for dose rates / habits)			
Structural Integrity	Environmentally assisted degradation			
	Irradiation assisted degradation			
	Non-destructive examination			
	The effect of new manufacturing methods on structural integrity eg additive manufacturing; hot isostatic pressing; electron beam welding; cladding			
	Quantitative probabilistic approaches to structural integrity safety cases			
	High temperature degradation mechanisms for advanced nuclear reactor designs			

Office for Nuclear Regulation

Glossary

AGR	Advanced Gas Reactor
AMR	Advanced Modular Reactor
ANT	Advanced Nuclear Technology
BEIS	Department for Business, Energy and Industrial Strategy
C+I	Control and Instrumentation
CFD	Computational Fluid Dynamics
CPLD	Complex Programmable Logic Device
CSOC	Cyber Security Operations Center
DFW	Decommissioning Fuel and Waste
EC+I	Electrical Control and Instrumentation
EDG	Emergency Diesel Generators
FPGA	Field Programmable Gate Array
GDF	Geological Disposal Facility
GEN IV	Generation 4 Reactors
HDL	Hardware Description Language
HMG	Her Majesty's Government
HMI	Human Machine Interface
IAEA	International Atomic Energy Agency
IoT	Internet of Things
LWR	Light Water Reactor
MBSE	Model based system engineering
NDA	Nuclear Decommissioning Authority
OT	Operational Technology
PCPV	Pre-stressed Concrete reactor Pressure Vessel
POCO	Post Operational Clean Out
PSA	Probablistic Safety Assessment
Pu	Plutonium
R+D	Research and Development
RIFE	Radioactivity in food and the environment
RPV	Reactor Pressure Vessel
SMR	Small Modular Reactor
SS	Stainless Steel
TSC	Technical Support Contract
UKSSP	UK Safeguards Support Programme