NuSec UK-US Research Collaboration Grant Application Form

Completed Funding Application Forms should be returned to info@nusec.uk no later than the published deadline. Late applications will not be accepted. Please see our Research Collaboration Grant Guidance Notes for advice on filling in this form.

The grants support UK researchers working in areas of nuclear security and non-proliferation, for collaborative projects with US researchers who are part of the NNSA ETI, MTV and NSSC consortia or DoD/DTRA University Research Alliance.

Section 1: Applicant Details

Name of Host University:	Lancaster University
Applicant Details:	
Title:	Prof
Surname:	Joyce
First name:	Malcolm
Address:	School of Engineering, Lancaster University, Bailrigg, LA1 4BE, UK
Email Address:	m.joyce@lancaster.ac.uk

Section 2: Project Outline

Project Title

Application of compact gamma-ray detectors on robotic platforms for locating radionuclides in confined spaces	
Start Date: 01/07/2024	End Date:30/04/2025
Staffing Costs:	£ 45526.14
Student Project Costs:	£N/A
Travel & Subsistence Costs:	£4000
Total Project Costs:	£51526.14

What type of funding are you applying for: (tick all that apply)

☒ PDRA Research Project (max. project value £50k) – go to Section 3

☐ Undergraduate Internship/Summer Project (max. project value £2.9k) – go to Section 4

☒ Travel Grant (for research visit/conference/training max. project value £10k) – go to Section 5

Section 3: PDRA Research Project

Research Description

Describe the scientific aims and methodology of the work, describing what you hope to achieve. Explain the novelty of the work and its potential impact in the area of Nuclear Security (max 1000 words).

Research Vision and Aims

The vision for this research is to develop a radiation monitoring technology compatible with small robots for the inspection of contaminated, complex pipework and related confined spaces to enable the safe decommissioning of the UK's retired nuclear submarines. It is important to understand the nature and extent of radioactive contamination in these systems to be able to plan their dismantling and to ensure the security of hazardous materials generated.

This research brings together a collaboration in radiometric instrumentation, robotic systems, and nuclear decommissioning across three organisations: Lancaster University (LU), University of Liverpool (UoL), and H3D Inc. (H3D, US). We aim to:

- Design a compact radiation localisation system utilising low-volume, high-efficiency gamma-ray detectors from LU's existing instrumentation inventory.
- Integrate the detector setup with miniaturised robots designed by UoL specifically for navigating complex, multi-path pipework.
- Demonstrate and test the system on simulated pipework arrangements using a range of sealed-source radioactivity.
- Address a significant and international nuclear security and decommissioning issue that costs the UK taxpayer £30 million per-year in just the safe storage of the retired submarine fleet alone.

Background and Research Challenge

In 2024, the UK re-started decommissioning operations of its retired nuclear submarine fleet[1]. Each of the 20 boats houses a reactor pressure vessel (RPV) and ancillary systems, including the pressuriser, and primary and secondary reactor cooling circuits. For decommissioning to be carried out, these parts must first be removed from the boats.

Over their >20-year service life the materials of the steel RPV, pipework, and surrounding structures were prone to neutron activation due to their proximity to the RPV and the potential for radioactive contamination from primary circuit coolant. For example, neutron activation of steel creates several, relatively long-lived radioactive isotopes, primarily ^{60}Co, ^{110m}Ag, and ^{124}Sb[2]. Given the limited access to RPVs and coolant-circuits, the isotopic composition, amount, and location of the radioactive activation and other contamination is uncertain. Not only is this potentially a substantial decommissioning challenge and radiological hazard, but it is also security concern given the potential for there to be quantities of uncatalogued radioactive material vulnerable to illicit use or accidental dispersion in the environment (marine or air).

[1] https://www.naval-technology.com/news/uk-to-restart-nuclear-submarine-reactor-dismantling-this-year/

[2] Primary circuit contamination in nuclear power plants: contribution to occupational exposure, H. Provens, European IRPA Congress 2002

As such, there is a need to explore, localise, and identify accurately radioactive sources and contamination within the large pipe network and the RPV whilst these are still confined within the submarines to allow radioactive substances and materials to be catalogued and tracked to support accurate planning and budgets decommissioning activities.

Method and Approach

Gamma-ray spectroscopy is an industry-standard means of measuring, quantifying, and localising radioactive contamination in a range of different environments. In prior research, we have designed and developed strontium iodide, $SrI_2(Eu)$, gamma-ray detector systems specifically for uranium enrichment[3], high efficiency sodium iodide counters for analysing naturally occurring radioactive material[4], and demonstrated the use of a robot-based cerium bromide ($CeBr_3$) scintillators to image and map an operating nuclear reactor[5]. We will build on this work and combine a pair of low-volume (<45 cm^3) scintillators ($SrI_2(Eu)$ or $CeBr_3$) with an advanced collimator arrangement that will allow the position of radioactive sources placed within, and around, a steel pipe network to be determined.

We will integrate the eventual collimated-detector arrangement with the robotic platforms, designed by UoL, shown in **Error! Reference source not found.**, capable of manoeuvring through confined multi-path and non-planar pipe sections, varying in size (<200 mm Ø), shape and material. These specialised robots track the path through the pipe network they traverse. Combining position tracking with the radiometric data will generate a detailed map of radioactive nuclides present.

To achieve this, we will:

- Utilise Monte Carlo simulations (i.e., GEANT4) to investigate optimal detector position and collimator arrangements on the robotic platforms. This will include determining suitable detector geometries and collimator properties for detecting and localising ^{60}Co, ^{110m}Ag, ^{124}Sb and other isotopes in steel where significant backscatter and Compton scattering interactions will affect measurements.
- Design and adapt detectors from the existing LU instrumentation inventory to produce a prototype detection instrument, informed by simulation results. The prototype will be tested in series of static laboratory experiments at Lancaster's ADRIANA NNUF facility using sealed radioactive sources.
- Integrate the radiometric system with UoL's robotic platforms and position tracking software. The resulting system will be tested on steel pipework arrangements representative of real-world submarine coolant circuits.
- Visit and collaborate with our US partner (H3D) to assess the viability of interfacing their world leading, state-of-the-art CZT semiconductor detector systems for similar applications.

Novelty and Impact

The research is novel because there are few commercial means to locate and quantify radioactivity in pipe networks consistent with submarine reactor coolant circuits. This is because these environments contain multi-path and non-planar sections, varying in size, shape, and material, and hence cannot be inspected by

[3] Enrichment measurement by passive γ-ray spectrometry of uranium dioxide fuel pellets using a europium-doped, strontium iodide scintillator, A.J. Parker *et al., (2024) Nucl Instrum Meth A, 1062*

[4] A thalium-doped sodium iodide well counter for radioactive tracer applications with naturally-abundant 40K, A.J. Parker *et al., (2013), Nucl Instrum Meth A, 722*

[5] Simultaneous, robot-compatible γ-ray spectroscopy and imaging of an operating nuclear reactor, I. Tsitsimpelis *et al.*, (2021), *IEEE Sensors 21(4)*

standard pipeline inspection gauge devices. It is an active field of research in pipeline robots with UoL's articulated magnetic tracked vehicle and pneumatic crawling mechanism designs at the forefront.

This research will be impactful because the UK has 20 out-of-service nuclear submarines to decommission and dismantle that contain relatively large quantities of radioactive material and therefore an unknown and uncatalogued volume of intermediate and low-level radioactive waste.

Financially, their storage alone costs the UK taxpayer £30 million per-year and £500 million in total since the first boat was removed from service (HMS Dreadnought) in 1980. Additionally, the MoD has budgeted £300 million to fund the Submarine Decommissioning Project[6] and £3 billion for the total decommissioning over 25 years. A programme of such length potentially exacerbates the nuclear safeguards and security risks associated with storing and managing the incumbent radioactivity. Current estimates by Babcock International identify that even a 2% improvement in radioactive contamination identification will lead to a cost saving of >£400,000 per boat and a significant reduction in worker radiation exposure.

From an international perspective, project partner H3D form part of the defence consortia and has access to potential applications in the US. Like the UK, the US Navy has nuclear-powered fleet to decommission, albeit much larger and a wider variety of platforms.

Research Team

Describe the team which will carry out the work, and your track record in this area. Give details of the PDRA who will be in post, if known (max 1000 words).

Principal Investigator (PI) – Prof Malcolm Joyce – School of Engineering, Lancaster University

Malcolm is Distinguished Professor of Nuclear Engineering at Lancaster University and interim Pro Vice Chancellor for Research and Enterprise. He is Principal Investigator on >£7.8 million of funded projects, works with international industrial collaborators (e.g., BAE SYSTEMS, Westinghouse, Sellafield etc.,) and a co-founder of the Nuclear Lancaster Research Centre at Lancaster University.

Malcolm is author on > 350 articles and was awarded the James Watt medal by the Institution of Civil Engineers (ICE, 2014) and a Royal Society Wolfson Research Merit award (2016). He serves on the UK Government's Nuclear Industry Research Advisory Board (NIRAB), the Committee on Radioactive Waste Management (CoRWM), the UKAEA Programme Advisory Committee and is co-chair of the National Nuclear User Facility (NNUF). He was independent observer on project ISOLUS which explored the options for dismantling the UK's laid-up nuclear submarines and has an international profile in the research of applied radiation detector systems: for example, his group was the first to image the neutron and gamma-ray distribution from an operating nuclear reactor.

Co-PI & Project PDRA – Dr Andrew Parker – School of Engineering, Lancaster University

[6] https://www.gov.uk/guidance/submarine-dismantling-project

Andrew's research is focused on applied gamma-ray detection and its use in nuclear decommissioning applications, environmental radionuclide monitoring, and radiation detection and characterisation. His research has been published in leading international journals and his work on the decontamination of plutonium from brickwork was awarded *Paper of Note* at Waste Management 2022, Phoenix, USA. Andrew's current role is a senior researcher on the Autonomous Inspection for Responsive Sustainable Nuclear Fuel Manufacture (AIRS-NFM, EP/V051059/1, £1.9M) working with Westinghouse Springfields Nuclear Fuels, and the National Nuclear Laboratory (NNL) to develop gamma-ray detection techniques to measure uranium enrichment in nuclear fuels.

Andrew led a successful application to National Nuclear Users Facility's Access Call in 2023. The project, entitled 'the Fast non-destructive characterisation of nuclear fuel pellets via hyperspectral imaging (National Nuclear Users Facility, £17k), aims to assess the viability of using hyperspectral cameras in post-irradiation examination. He is Co-Investigator on the successful bid to setup the Centre for Innovative Nuclear Decommissioning (CINDe, £250k), a Doctoral scheme embedding research students at NNL Workington

Co-Investigator (Co-I) – Dr Ioannis Tsitsimpelis – School of Engineering, Lancaster University

Ioannis Tsitsimpelis is a Senior Research Associate at the Nuclear Engineering group, working on the ALACANDRA project (Advancing Location Accuracy via Collimated Nuclear Assay for Decommissioning Robotic Applications). His research interests include Modelling and Control, Radiation detection instrumentation, AI methods, and Robotics.

Ioannis has extensive experience in the field of nuclear robotics and has previously been a key contributor in the successful completion of relevant EPSRC-funded projects, including TORONE (Total Characterisation by Remote Observation of Nuclear Environments, Lancaster), RAIN (Robotics and AI in Nuclear, Lancaster), and RNE (Robotics in Nuclear Environments, Bristol Robotics Laboratory). His expertise lies in developing radiation detection instrumentation and integrating them on robotic platforms to enable mapping, localisation and path-planning functionalities. He has led several mock-up and real-world deployments, including the successful characterisation of an operational research reactor facility (TRIGA Mark II, at the Jožef Stefan Institute, Slovenia).

Co-I – Dr Mario Gianni – Department of Computer Science, University of Liverpool

Mario is a Senior Lecturer of Robotics and Autonomous Systems at the Computer Science Department, University of Liverpool. His knowledge and expertise mainly focus on the design and development of models and methods combining AI, Machine Learning, Control Theory and Optimization to solve complex problems is real-world robotic applications.

Mario has been PI of projects granted by EPSRC and Innovate UK to enhance automation and situational awareness of robotic systems for radiological mapping of nuclear sites, explosive ordinance disposal and long-term blade inspections in offshore wind farms. He was also among six winners from Epson Europe's first ever Win-A-Robot contest.

In the last five years, Mario has worked with Babcock International Group on a project, in partnership with the National Centre for Nuclear Robotics and the National Nuclear User Facility, to commercialise a non-destructive solution for the inspection of the interior of circuit pipework of the Royal Navy's nuclear submarines. For this purpose, he and his research team has built and tested two robotic platforms capable of monitoring radioactivity under secure communication within pipes and ventilation systems. This technology can enable significant cost efficiency and better decision making in the decommissioning of laid up submarines and civil nuclear plant safety.

Co-I – Dr Willy Kaye – H3D – Member of Defence Threat Reduction Agency University Research Alliance

Willy cofounded H3D in 2011 and currently serves as CEO. Willy also cofounded a medical imaging-based spinoff company called M3D in 2022. Willy earned his PhD from the University of Michigan working on readout hardware and software for 3D position sensitive room temperature semiconductor detectors. Willy designed the real time user interface software and routed the circuit boards for most H3D products. Willy is responsible for product management on the M400 product that would be used in this collaborative effort and will be able to provide integration support.

Research Plan

Describe the planned schedule for the research and the expected outputs, listing any key dates and milestones. Identify any particular risks and describe how these could be mitigated (max 1000 words).

Activities and Timeline

The proposed research has been divided into two overarching work packages, A) Research Activities and B) Project Management. Each of these is further subdivided into activities, which are scheduled in Figure 1.

		Year	2024						2025			
		Month #	1	2	3	4	5	6	7	8	9	10
		Month	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Work Package	#	Task										
A: Research Activities	1	Review										
	2	Simulations										
	3	Experiments										
	4	Research Visit and Follow-up										
B: Project Management	M	Milestone						M1		M2		M3
	D	Deliverable								D1		D2

Figure 1. Proposed research timeline, activities, milestones, and deliverables.

M1 represents the completion and validation of a representative GEANT4 simulation model, M2 represents completion of the experimentation and data collection, M3 signifies the completion of the research visit to H3D. D1 is the production of the final experimental data set, and D2 is the final project report and technology demonstration event.

Details of the research activities are as follows:

1. Project initiation and collaborator meetings will begin the proposed activities. Where possible, site visits will be conducted to inform design choices in addition to a comprehensive literature review.
2. Potential detection systems and collimator arrangements will be evaluated using Monte Carlo computational models, specifically GEANT4. The simulations will assess and refine the detector and collimator geometries that will be tested and validated experimentally.
3. Experiment activities will be conducted in two stages:
   a. Static tests at Lancaster that will be independent of robotic integration. These experiments will test the ability of the designed detector system to locate, identify, and quantify a range of radioactive isotopes that are found in nuclear decommissioning environments (^{60}Co, ^{137}Cs, etc.,) inside a steel pipe. The results of these experiments will determine performance of the prototype detection system, i.e. minimal detectable activity, spatial resolution, and validate the simulation model. These parameters will be used to inform control aspects of the robotic platforms, e.g. speed, etc.
   b. Dynamic tests with the detector setup integrated onto the UoL robotic platform will be performed. and dynamically tested in simulated steel pipework, representative of nuclear submarine coolant circuits.
4. research visit to project partner H3D, Ann Arbor, USA. This will be to test potential integration of H3D detector systems and to build relationships for future collaboration.

Expected Outputs

This proposal is underpinned by a *real-world* nuclear security issue and as such we expect realistic impactful outcomes. Initially these will be centred on the technical aspects of the research, where outcomes will include:

- **Improved *in pipe* radiation detection and localisation system.** The primary outcome of this research will be the development of the detection system and its integration onto a miniaturised robotic platform. This will be evidenced by an end of project demonstration event (D2).
- **Validated simulation environment for future detector development applications**. A secondary outcome will be the Monte Carlo simulation model representative of the environment under investigation. This can be utilised for other research products in similar environments and contexts.
- **Production of a simulated and experimental datasets**. Where possible, the datasets and results of the research will be made Open Access and available to other researchers in the field. Both the simulation model and dataset outcomes will be evidenced by (D1)

Given the nature of the proposal, there may be restrictions on what aspects of the results and model can be made publicly available. We will work with collaborators and funders to create open access datasets whilst ensuring sensitive or proprietary information is withheld.

Conducting this research in collaboration with domestic universities and international partners will generate intangible outcomes. It is expected that these will be:

- Closer research links between domestic industrial and academic partners, specifically LU, UoL, and Babcock International.
- Establishment of an international research collaboration with H3D and their consortium partners.

The success of intangible outcomes will be demonstrated through the development of future follow-on funding applications and research publications arising from these works. The development of funding applications and publications will also allow for the realisation of academic impacts. For this purpose, we have identified these funding streams, inter-disciplinary scientific publications, and international conferences:

- MoD, UKRI & Nuclear Decommissioning Authority research funding routes
- Nature Communications; Journal of Hazardous Materials; Nature Scientific Reports etc.
- IEEE Nuclear Science Symposium 2025, Waste Management 2025.

Risk Management

Our research pushes technological limits of real-time radiometric and robotic engineering. Consequently, the risk of unexpected outcomes is significant, but synonymous with research of this type. Significant risks to the work fall into two categories: experimental and collaborator based.

The primary experimental risk is associated with the influence of the large volume of steel and other high Z materials in the deployment environment (i.e., submarine primary and secondary coolant circuits). This creates two problems, 1) these materials could attenuate and mask the gamma emissions from potential contamination, 2) the same materials cause scattering of gamma-ray photons which increases the ambient radioactive background and thus minimal detectable activity.

This risk will be addressed via the use of a PDRA experienced in radiometric analysis, who will consider multiple radiometric approaches, and with close involvement with highly experienced investigators and partners to find optimal detection systems that will stand the highest chance of succeeding.

Experimental risks associated with access to detection apparatus and radioactive sources have been mitigated by utilising existing equipment at LU's ADRIANA facility. Further, we have already established compatibility between LU's radiometric instrumentation and UoL micro-robot hardware.

Realisation of developing an actualised system depends on the involvement of collaborators. If one or more of the collaborators disengages from the project, then the relevance to real-world applications and decommissioning of nuclear submarines could be impacted. This shall be mitigated through monthly progress meetings which include all project stakeholders, and regular communication.

Now proceed to Section 6.

Section 4: Undergraduate Internship/Summer Project

Student project objectives and work plan

Describe the objectives of the student project, including a summary of the planned work and a schedule (max 500 words).

N/A

Student Details

If a student has been identified for this work, please give details of their name, programme of study and any relevant experience they may bring to this project (max 500 words).

N/A

Now proceed to Section 6.

Section 5: Travel Grant

Type of Travel Grant

Select the type of travel grant you are applying for (choose just one option):

☒ Research Visit for a PhD student or PDRA (e.g., 1-4 weeks)

☐ Conference, Workshop or Training Event

☐ Staff Visit (e.g., up to 1 week)

Travel grant objectives

Describe the nature of the proposed travel, and the proposed objectives and outcomes of the travel (max 500 words).

Our proposed research trip is to the H3D offices in Ann Arbor, Michigan, USA, for a 5-night visit. The principal technical reason for the research visit is to demonstrate our radioactive contamination localisation system and investigate the potential integration of proprietary H3D technology onto the robotic systems developed by UoL and foster the relationship between collaborators.

In short, our project-specific objectives are:

- Demonstrate the UoL robotic technology and imbedded radiation detection system developed by Lancaster on-site at H3D.
- Assess technical aspects of integrating H3D detector systems with UoL robotic technology, including, power requirements, weight, etc.
- Technical discussions on related projects with focus on experience and insight gained.
- Gain a thorough understanding of the capabilities of H3D products and how they may benefit UKs nuclear security research field.

The in-person meetings and discussions proposed here will strengthen the collaboration and allow interactions that are not possible via MS Teams, etc, benefiting the project and the collaboration long-term. We will also seek to deepen our research collaboration, H3D maintain strong links to the University of Michigan (UoM) in Ann Arbor. UoM is an international centre of expertise on radiation detection instrumentation research. We will utilise the proximity of the two organisations to visit UoM. Therefore, our long-term collaborative objectives from the Research Visit are:

- Research collaboration scoping meeting and proposal development, identification of potential future funding streams.
- Techno
- Meet potential future Defense Threat Reduction Agency partners, i.e. University of Michigan visit.

Travel details

Give details of the dates and places of the proposed travel, including any additional names of those travelling (max 500 words).

The proposal includes two research staff visits, one from each of LU and UoL.

Names of Travellers; Dr Andrew Parker, PDRA (LU), Dr Mario Gianni (UoL).

Dates: Depending on commitments, we have initial schedule the visit on the week commencing 25th March 2025. Dates chosen at end of project schedule but avoid Easter holiday to reduce cost.

Duration: 5-night stay, allowing four full days.

Destination – Ann Arbor, Michigan, USA.

Places of visit(s): H3D inc. Offices and facilities. University of Michigan Nuclear Engineering and Radiological Sciences programme.

Activities will include:

- H3D Facility tour
- Demonstration of robotic system and current radiation detection systems
- Demonstration of H3D detection systems and equipment, inc case studies
- Collaboration building meetings
- Technical discussions, assessing integration of H3D systems onto Robots, potential testing of system
- Visit to University of Michigan.

Section 6: Financial Details

Only complete the sections that are relevant to your application. Refer to the guidance notes for details about eligible costs.

Staffing FEC costing for PDRA Research Grant

Gross Salary *Give the value of the gross annual salary and the salary grade/level*	£44765.90	
Time Allocated *Give the overall FTE and the duration (e.g., 100% FTE for 3 months, or 50% FTE for 2 months)*	0.4 FTE for 10 Months - £19748.90	
Salary Cost *Enter the value of the salary paid to the researcher.*		£15658.00
Salary Employer Contributions *Enter the value of the employer salary costs, e.g., employer USS and NI contributions. Indirect and Estates costs are not permitted.*		£4090.90
Total Staff Costs (DI)	A	£19748.90
Investigators Costs (DA)	B	£ 260.24
Estates Costs (DA)	C	£6503.00
Other Directly Allocated Costs (DA)	D	£206.00
Indirect Costs	E	£18308.00
Total Staffing Costs	Sum of A-E	£45026.14

Financial details for Student Internship/Summer Project

Student stipend *State the level of the monthly stipend, and the number of months/weeks required. Refer to the guidance notes for the expected value of the student stipend.*	*Details…*	£
Research Costs *Itemise any laboratory consumables or related research costs. Refer to the guidance notes for the maximum value which can be claimed.*		£
Total Student Costs		£

Financial details for Travel Grant

Air Travel *Give brief details and a breakdown of air travel costs. State the destination and dates of each journey.*	*Costs based on* *Return flights from Manchester to Detroit (USA) in April 2025*	£1000
Other Transport *Give brief details and a breakdown of non-airline travel costs. State the destination and dates of each journey.*	Costs based on 5 day hire of *compact class* car from Detroit International Airport Return Train from Lancaster to Manchester Airport	£200 £35
Accommodation *Give brief details and a breakdown of accommodation costs, including dates and the number of nights claimed.*	Costs, based on 5 nights in Microtel Inn & Suites by Wyndham Ann Arbor	£425
Subsistence *State an estimate for the total amount of your subsistence costs*	*Estimate the value based on the number of days multiplied by the standard subsistence rate (see application guidance)* *Based on £75 per day x 5 days*	£375
Total Travel Costs	*Costs x 2 for two attendees*	£2000x2 = £4000

Enter the total amounts on page 1 of the application.

Section 7: US Collaboration Information

Is your grant application in collaboration with a US NNSA or DTRA consortium?

NuSec actively supports collaboration with Nuclear Security US researchers within the NNSA or DTRA consortia. Collaboration with the US is not mandatory for this grant call, and applicants may apply for projects based solely in the UK.

☐ YES, this application is in collaboration with US NNSA/DTRA researchers.
Please complete Section 7.

Which NNSA/DTRA consortium do you plan to collaborate with?

Please indicate the consortium which you propose to collaborate with. This will be used to select a US reviewer for your project, if applicable.

NNSA Consortia:		DTRA URA:	
	☐ ETI		☒ IIRM
	☐ MTV		☒ MSEE
	☐ NSSC		

Nature of the US collaboration

Describe the nature of the proposed US collaboration, including any existing connections you have with the proposed collaborators. How will the proposed project research/travel/training develop, or deepen, collaboration with the US partners? (max 1000 words).

Nature of proposed collaboration

Our collaborator, H3D, inc. are based in Ann Arbor, Michigan. They a commercial organisation and part of the Department of Defense - Defense Threat Reduction Agency (DoD/DTRA) University Research Alliance. This collaborative project will build on the existing relationship between the School of Engineering (LU) and H3D and establish a strong international relationship in the field of applied nuclear security radiation instrumentation across the three organisations (LU, UoL, and H3D).

To foster collaboration, we have identified and developed this proposal because it addresses a real and significant nuclear security issue relevant to both the UK and the USA. All parties have expertise and experience relevant to this area of research; applied gamma-spectroscopy (LU), micro-robotic systems (UoL), and development of high-performance gamma-ray detection and imaging systems (H3D). The collaboration on this proposal is mutually beneficial as:

- Lancaster has a unique opportunity to apply its knowledge in radiation detection and localisation systems and gain experience with state-of-the-art technology.
- Liverpool obtains access to international capability in gamma-ray spectroscopy which will improve the functionality and performance of their current and future radiation-mapping, robotic platforms.

- H3D develops a route to having its technology deployed in new research areas and real-world radiation detection challenges with significant commercial opportunities and new international customers.

The collaborator

H3D design and manufacture world-leading gamma-ray detection and imaging systems. They are a spin-out of the internationally recognised University of Michigan Nuclear Engineering and Radiological Sciences programme and are a member of the DoD/DTRA research consortia.

The commercial systems H3D develop are based on cadmium zinc telluride (CdZnTe or CZT) room temperature semiconductor devices. CZT offers high resolution gamma spectroscopy without the requirement for detector cooling necessary in other high-resolution detection systems (e.g. HPGe). In addition, CZT crystals are also typically low-volume (<2 cm^3) and lightweight (<12 g), allowing the devices to be integrated into small detector systems, robotic platforms, and aerial drones.

Because of this and H3D's engineering capability, their products are now used in <70% of US nuclear power plants and shipped to nuclear power plants and research labs around the world, including the International Atomic Energy Agency. They are also utilised in CBRN and nuclear security contexts, radioactive waste management, and medical imaging applications.

H3D also have extensive experience working with external research organisations and universities, including projects using remote drone and robot-based imaging platforms. Their experience using imaging and detection systems to identify mercury contamination in submarine pipework will be invaluable in optimising the detection systems proposed here and recognizing potential engineering challenges or difficulties early.

Existing links

The Nuclear Lancaster Research Centre at Lancaster have existing links with H3D through their association with the University of Michigan. Both LU and Michigan are internationally recognised centres of nuclear engineering research

Your US Collaborator

Please give the name of your US collaborator if you have one. If not, leave this box blank

H3D Inc.

Letter of Support

A letter of support is required for all grant applications that are collaborative with US partners, except for Conference/Workshop travel grants. The letter of support should be supplied either by your US collaborator, or from the relevant NNSA/DTRA consortium principle investigator.

Please confirm if you are submitting a letter of support from your US collaborator, and email your letter info@nusec,uk

☒ I confirm that I will email a letter of support to NuSec

☐ I am not providing a letter of support (e.g. for a conference/workshop grant)

Section 8: Financial Contact

Give details of the person responsible for approval and signature of this award in your finance/research office. If an award is made they will be contacted directly with the contract details, and they should have the necessary authorisation to approve and sign the contract.

Contract Office contact person

Title:	Mr
Surname:	Lloyd
First name:	Peter
Address:	Lancaster University, Research Services, Bowland Main, Bailrigg, LA1 4YR
Email Address:	p.lloyd@lancaster.ac.uk
Contact Telephone Number:	0152465201

Section 9: Declaration

Please sign below to confirm that you have read and agree to the terms and conditions for this grant scheme.

You also acknowledge that any award and subsequent payments will be made at 80% of the requested budget, and that the host university is responsible for sourcing the remaining 20% of the project costs.

Name:	Signature:	Date:
Prof Malcolm Joyce		25th April 2024

Please submit your completed application form to info@nusec.uk