Challenge: Stand-Off Alpha Radiation Detection Under Daylight Conditions

The AWE plc (the Atomic Weapons Establishment) and National Nuclear Laboratory (NNL) are seeking game changing solutions that could enable the remote (e.g. several metres distant) detection and identification of radiologically hazardous sources of alpha radiation and provide an accurate assessment of their location. As a time critical component of emergency responses, there is a need to more accurately and rapidly map radiological contamination. Commercial off-the-shelf (COTS) hand-held alpha radiation monitoring equipment requires close proximity sweeps of the surfaces of potential source materials. This is time consuming, labour intensive and may not even be possible in some situations due to safety restrictions. Novel systems are sought that can operate from a distance of up to several metres under a range of illuminated conditions, including daylight.

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Introduction

Alpha radiation is a decay product of heavy elements that is usually only present in activities undertaken within civil and defence nuclear sectors.

The detection of alpha radiation and identification of its sources and their locations, provides crucial information that is vital for:

- The prevention of terrorist attacks using radiologically hazardous materials.
- Management of the immediate consequences of accidental or deliberate contamination by radiologically hazardous materials and the subsequent forensic investigations into such incidents.
- Management of the potential hazards of alpha radiation to health and the environment.

Potential applications in the civil nuclear industry, where organisations such as NNL require alpha monitoring, include limiting the spread of radioactive contamination during decommissioning and the remote assessment of the condition of nuclear waste packages. The latter activity involves extremely restricted access in terms of both the packages themselves and facilities within which they are stored.

In the defence sector, organisations such as AWE utilise hand-held devices to scan the surfaces of materials in order to detect alpha radiation in suspected contamination incidents, counter terrorism, emergency responses and forensic investigation. However, the detection of surface deposits of alpha emitting materials using current technology is particularly challenging due to the extremely short (~mm) range of travel of alpha particles in the air.

Hand-scanning over large areas is laborious and time consuming. Personnel who perform this task require extensive training and the use of personal protective equipment (PPE) in order to work effectively and remain safe. This is assuming that safety restrictions even allow human ingress into the affected area.

For instance, in the case of the poisoning of Alexander Litvinenko with polonium-210 in 2006, one method deployed was the use of COTS handheld scanners to detect the characteristic alpha radiation of the source. When the results of this were combined with other forensic evidence, it was possible to map the movement of the radioactive source throughout a building over several days. In this case highly detailed assessment and mapping utilising alpha radiation monitoring was undertaken in a wide variety of environments and illumination conditions, both indoors and outdoors. However, it did illustrate the deficiencies of current COTS technology and its particularly restricted deployment.

Current practice

Whilst real chemical, biological, radiological, nuclear and explosives (CBRNE) incidents are rare, the capability to deal with such events is required permanently and exercised on a regular basis.

Alpha radiation monitoring is typically undertaken by trained personnel with appropriate health physics expertise and suitable PPE. They can use COTS hand-held alpha monitors. The probes on these monitors are typically 0.5 to 2kg in weight with a detector head area of a few tens of cm^2 which must be placed within a few millimetres of the surface under examination.

In another example, training in the use and deployment of such equipment is undertaken by AWE personnel as well as the military and police responders, using simulated but life-sized situations and real equipment to ensure operatives are suitably qualified and experienced.

Challenge aims

As described above, current COTS alpha radiation monitoring is time consuming, labour intensive and requires personnel to be near potential radiological contamination. To improve on this situation, AWE and NNL would benefit from the ability to detect alpha radiation from contamination on surfaces from a distance of 2 metres or greater whilst under daylight conditions.

The primary aims of this challenge are:

- Detection of alpha radiation from contaminated surfaces under daylight illumination conditions from a distance of 2 metres or greater.
- Precise identification of the location of areas of alpha contamination above 50 kBq per m^2

Although not a primary aim of this challenge, it would be beneficial to be able to:

- Quantify the level of alpha activity on a surface.
- Be able to identify ('finger-print') the source material.

Please refer to the Functional Requirements section for further details.

Benefits to AWE and NNL's security and non-proliferation focus area

A viable solution to this challenge would be of key interest to several UK organisations and agencies, to provide additional capability to existing equipment. It could aid nuclear site clean-up operations and enhance the speed and efficacy with which potential radiological threats could be detected. It would also enable rapid trace of radiological materials to enhance police and military operations.

In the UK there is an estimated market for tens of units required on an ongoing annual basis and a much larger potential market overseas. AWE and NNL are seeking a solution capable of live deployment as soon as practicably possible and is therefore willing to invest in supporting viable solutions through development and prototyping for a marketable product.

In addition to commercial benefits, solutions to this challenge could reduce the radiological risks to personnel involved in alpha monitoring operations and the risks to the public from radiological contamination incidents.

Constraints

The need to preserve the forensic integrity of the potentially contaminated surfaces under examination dictates that systems that involve destructive processes are not suitable for this purpose.

Any detection device or system must be versatile in order accommodate a wide variety of search and detection scenarios and environments. These include:

- Scanning irregular objects such as items of clothing or furniture
- Confined and complicated spaces such as the interiors of vehicles
- Extensive, large areas both indoors and outdoors
- Outdoor spaces in all weathers
- Illumination levels of the operating environment could include total darkness through to full daylight and artificial lighting
- In the nuclear setting: waste and product stores with limited access for remote monitoring; areas undergoing decommissioning; and laboratories

Functional Requirements

ESSENTIAL

Any detection system or device must:

- Be sensitive to localised sources of alpha-emitting radionuclides such as polonium-210 or americium-241 with activities of 250 kBq or greater.
- Be sensitive to surface contamination of alpha-emitting radionuclides such as polonium-210 or americium-241 with activities of 50 kBq per m^2 or greater.
- Give a precise location, with centimetre precision, of areas of alpha contamination with an activity of 50 kBq per m^2.
- Detect the levels of alpha radiation specified above from a distance of 2 metres in daylight conditions.
- Have components that are person-portable and deployable by a single operator.
- Be able to fully monitor a typical office space in minutes, including set-up time.
- Provide real-time data for the detection system operator and ideally transmit data to an ex-situ recording device.

DESIRABLE

- Be sensitive to localised sources of alpha-emitting radionuclides such as polonium-210 or americium-241 with activities of 50 kBq or greater.
- Be sensitive to surface contamination of alpha-emitting radionuclides such as polonium-210 or americium-241 with activities of 1 kBq per m^2 or greater.
- Give a precise location, with centimetre precision, of areas of alpha contamination with an activity of 1 kBq per m^2.
- Detect the levels of alpha radiation specified above from a distance greater than 2 metres in daylight conditions.
- Detector systems that are straight forward to operate, with minimal operator training required.
- Detector designs intended to be handheld should fit into a volume of 2 litres or less and have a mass of 2kg or less [ref. Home Office Standards].
- Provide a self-contained solution that can be powered by batteries with all system features operating for a minimum period of 1 hour.
- A detector that can give reliable results for wet surfaces would be beneficial, but not essential.

What Next?

Game Changers are hosting a workshop for this challenge where delegates will have the opportunity to meet the challenge owners. Details are available on the Game Changers website www.gamechangers.technology

If you have new ideas or innovations which can be applied to address this challenge, we invite you to join us.

If you'd like more information about the funding available through the Game Changers programme, please visit our Funding Process (gamechangers.technology)

The deadline for applications to this challenge is **18th November 2021 at 12 noon**

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