

Remote Material Handling and Manipulation – Detailed Requirements

1. Out-reach to all industries

Although this market exploration survey concerns handling and manipulation of explosives, the UK Government is looking for solutions from across industry - from both inside and outside the explosives community. The UK Government believes that technology may exist that has been developed for the explosives industry (including explosive ordinance disposal), or for industries other than the explosives industry that could offer solutions to one, several, or all of the requirements described in this survey.

Responders to this survey do not require any prior knowledge of the properties/hazards of explosives. In order to respond to this survey it is sufficient to know that any external stimuli to the explosive (impact, friction, temperature, electrostatic discharge) should be as low as reasonably practicable (ALARP) to minimise the chance of an explosive event.

2. Introduction to the requirement

As defined in the UK's Strategy for Countering Terrorism ([CONTEST](#)), the UK Government has a requirement to protect UK citizens and infrastructure against the threat from explosives. Collaboration is necessary across government; and with industry and academia in order to deliver this requirement. For a wide range of explosive materials and improvised explosive devices (IEDs): the properties must be characterised and the development of detection and security screening equipment is required.

The hazards of highly sensitive explosives and the associated health and safety concerns mean that manual handling of significant masses is undesirable. Therefore, a remote handling and manipulation capability is essential for the UK to allow the required work with sensitive explosives to be safely undertaken. In this way, the UK Government can drive: the improved characterisation of these explosives and IEDs; the development of and the improvement of security screening equipment; and to develop the required training, evaluation and certification tests and standards.

The remote handling capability is required to enable the safe transport and manipulation of explosives between various storage, test and disposal locations within an existing UK Government facility.

The UK Government believes that there are many diverse aspects to this requirement and therefore this survey document presents the requirement broken down into a number of sub-requirements which are shown in Figure 1. The UK Government wishes to understand whether solution(s) exist to meet these sub-requirements and respondents are invited to propose solutions to one, several or all of these sub-requirements.

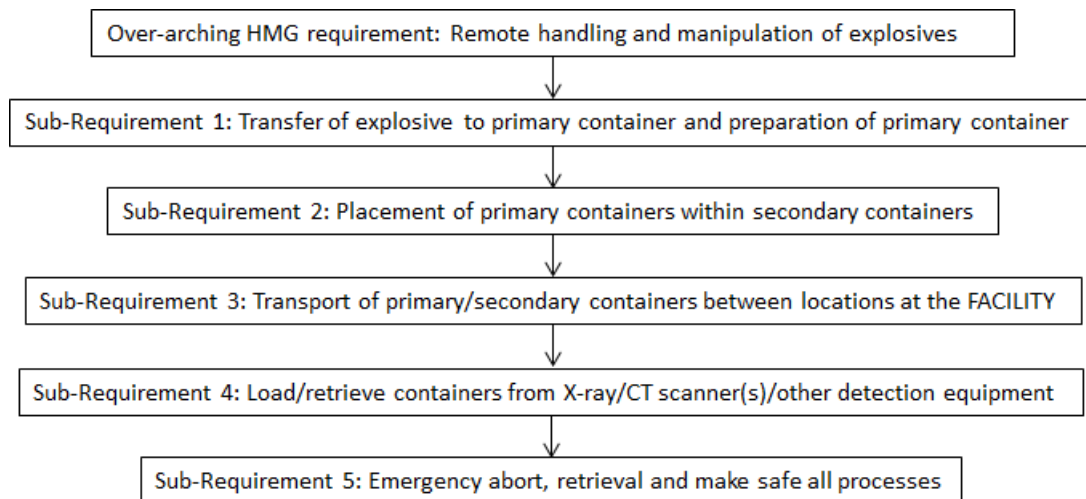


Figure 1. Breakdown of the UK Government requirement into sub-requirements. Solution(s) are sought to deliver one, several, or all these sub-requirements.

3. UK Government protection of intellectual property (IP)

All replies to this survey will be treated as Commercial-in-Confidence by the UK Government. All intellectual property (IP) belonging to the responding company that is contained in a reply will be protected by the UK Government and will not be disclosed outside of the UK Government.

4. Cost range for development of capability and other considerations

This survey does not include any commitment for any procurement or contract action. However, to inform future UK Government decision making (and the potential for a future competitive tender process), the Capability Submission Form requests a cost range for each proposed solution. Also, the proposed solutions will be considered with regard to:

- assurance of safety when delivering solution(s)
- evidence for, and the likelihood that solution(s) can be delivered to meet the requirement
- time required to use the solution(s) to perform the process(es)
- inter-operability between sub-requirements (modular open architecture of solutions)
- cost of the solution(s)
- footprint of the solution
- portability of the solution

5. The requirement

5.1 ESSENTIAL or DESIRABLE

Every task under each sub-requirement is designated as ESSENTIAL (it is essential that the solution deliver these tasks) or DESIRABLE (it is not essential that the solution deliver these tasks, but it is desirable that the solution deliver these tasks).

5.2 Overview

The UK Government Facility where the remote handling capability is to be deployed is the Home Made Explosives Facility and Centre of Excellence located at Dstl, Porton Down site (subsequently referred to in this report as the FACILITY). A photograph of the Facility is given in Figure 2 with key locations indicated. These locations will be referred to in Section 6 where the sub-requirements are described.



Figure 2. The Home Made Explosives Facility and Centre of Excellence at Dstl, Porton Down – the FACILITY. Key locations are indicated where the remote handling solution(s) are to be deployed. (a) The PAD – where explosive manufacture and explosive disposal processes will be performed. Other processes may also be undertaken here (these are described in Section 4). (b) The DETECTION SUITE where equipment will be setup and to where the primary/secondary container must be delivered to /from the PAD. (c) The approximately 100m length of road with a gradual incline with a total rise height of 7m that must be traversed to transport between the PAD and the DETECTION SUITE. (d) The CONTROL ROOM where operators would be situated for any remote control of the remote handling processes.

The detailed requirements are given in Section 6, in brief:

- the remote handling and manipulation requirement is for highly sensitive liquid and solid explosives in the mass range of 0.01-5kg (ESSENTIAL) and 0.01-50kg (DESIRABLE).
- when contained within one or more containers, the total mass of explosive + container will range between 0.1 – 15kg (ESSENTIAL) and 0.1-100kg (DESIRABLE).
- remote manufacture of explosives is out of scope for this survey, this will be performed using existing UK Government equipment.
- the explosive will be provided in the manufacture container and it is ESSENTIAL to transfer it to various primary containers.
 - it is ESSENTIAL to be able to include tamping of the explosive to obtain a uniform density.
 - it is ESSENTIAL to be able to transfer sub-samples of the explosive into sample containers.

- it is DESIRABLE that spillage and explosive contamination of the primary container and any other equipment is avoided during transfer/sampling; it is ESSENTIAL that spillage/contamination is cleaned if this does occur.
- it is DESIRABLE to add additional objects to the primary container.
- it is DESIRABLE that temperature and pressure monitoring of the explosive within the primary container be possible at all times
- it is ESSENTIAL that the primary containers be placed within a variety of secondary containers
- it is ESSENTIAL that the primary/secondary containers be transported to/from various locations: on the PAD; in the DETECTION SUITE; and between the PAD and the DETECTION SUITE.
- it is ESSENTIAL that the primary/secondary containers be lifted and transferred to/from various stands or equipment at height up to 3m
- it is ESSENTIAL that the manufacture/primary/secondary containers be transported to an area on the PAD and fitted with components to enable either blast trials or destruction (Figure 1a).
- operator(s) that are operating the remote handling solution(s) by remote control will be located in the CONTROL ROOM (Figure 1d) and it is ESSENTIAL for them to have a view of all processes to perform the remote control.
- it is ESSENTIAL that all processes fail safe.
- one or many solutions may be required and each solution may meet one or more of the sub-requirements.

6. Breakdown of requirement into sub-requirements

6.1 Overarching requirements common to all sub-requirements

For all proposed solutions for all sub-requirements:

- it is ESSENTIAL that the remote handling and manipulation solution can accommodate highly sensitive liquid and solid explosives in the mass range of 0.01-5kg; and it is DESIRABLE that it can accommodate a mass range of 0.01-50kg.
- when contained within one or more containers, the total mass of explosive plus container to be accommodated by the solution will range between 0.1 – 15kg (ESSENTIAL) and 0.1-100kg (DESIRABLE).
- it is ESSENTIAL that the solution be suitable for integration within the FACILITY.
- it is DESIRABLE that the solution is able to be re-located and deployed to a different facility, if required at a later date.
- it is ESSENTIAL that the risk of harm to the operator(s) from the solution be ALARP
- it is ESSENTIAL that use of the solution allows the operator(s) to be located remotely from the explosives within an area assessed to be safe from the hazards of the explosives.
- through its use for remote handling and manipulation of explosives, it is ESSENTIAL that the solution not cause damage to the FACILITY or any equipment contained within the FACILITY

- it is ESSENTIAL that the solution causes no appreciable (appreciable is defined as that resulting in an explosive event) stimuli to the explosive (either present within/without a container) from:
 - impact
 - friction
 - temperature
 - electrostatic discharge
- operator remote control, pre-programmed function and autonomous systems are in scope
 - wireless and command wire control of the solution are in scope
 - for operator remote control, it is ESSENTIAL that the operator be given view(s) to allow the remote control functions to be performed. It is DESIRABLE that the operator be given a 360 degree view of the remote solution, container and surrounding environment (including in low light). Note, there is no line of sight between the CONTROL ROOM (where the operator(s) would be situated) and any of the other locations at the FACILITY.
- it is DESIRABLE that temperature and pressure monitoring of the explosive (such that e.g. temperature fluctuations and evolution of gas can be monitored to assess the condition of the explosive) be possible at all times.
- it is ESSENTIAL that the solution fail-safe with:
 - there being an as-low-as-reasonably possible (ALARP) danger to operator(s) and the FACILITY infrastructure
 - no appreciable stimuli to the explosive from impact, friction, temperature or electrical discharge
- it is ESSENTIAL that the solution be recoverable from a failure at any point in any of the processes - meaning remote recovery of the primary container (with explosive within) and either re-starting the process (if possible) or transport to the disposal location for destruction.
- it is ESSENTIAL that the manufacture/primary/secondary containers are NOT dropped, knocked over or damaged in any way.
- it is ESSENTIAL that the solutions are able to function despite the fact that the primary/secondary containers may not always remain upright through some of the processes.
- it is ESSENTIAL that the solution does not tip or roll if power is lost.
- it is ESSENTIAL that the solution be suitable for use outdoors in all anticipated weather conditions, with the exception of sub-requirement 4 that will only be undertaken in the DETECTION SUITE.
- it is DESIRABLE that all solutions comply with relevant safety standards such as CE (electrical safety, electromagnetic compatibility), weatherproofing, or to follow similar principles.
- solutions that emit radio frequencies (RF) are in-scope.

Sub-Requirement 1: Transfer of explosive to primary container and preparation of primary container

Manufacture of the explosives will be undertaken on the PAD (Figure 1a) under a permanent or temporary structure giving cover from the weather. The final stage of the manufacture, and the starting point for this sub-requirement, is the explosive contained within a manufacture container. The manufacture container will be either a:

- bottle (glass or plastic) for liquid explosives
- vacuum filter funnel assembly pot (as shown in Figure 2) for solid (powder) explosives.



Figure 2. The filter funnel assembly pot used to dry solid powder explosives, the final stage in the manufacture process. Within the assembly pot (at the bottom), the solid explosive is present on filter paper.

The primary container will be provided by DstI and will vary significantly depending on the particular application. It may be made of glass, plastic, cardboard or metal. (Where sample tamping is required the primary container will be of a suitable strength.) Sizes will vary from a 6 mm diameter tube to a 300 mm diameter pot.

- it is **ESSENTIAL** that the solution transfer explosive from the manufacture container to the primary container(s).
 - for liquids, the glass/plastic bottle will be open and the liquid may be poured into the primary container.
 - the liquid could be a range of viscosities
 - for solids, the aperture diameter of the manufacture containers to be used will range from 1.3-2.5 cm;
 - in the case of the filter funnel assembly: The lid at the top of the assembly must be removed (the lid is push fit with a connector cable attached). The bottom of the filter funnel assembly is attached to a vacuum system via a tube and this tube must be removed. The pot can be transferred to another location (if required) and/or lifted upside down to transfer the explosive (if required). Note that decanting may be more difficult for wet material than for dry, with a tendency to stick or to form lumps.
 - solid explosives may be wet or dry powders; or slurries of a range of viscosities
- it is **DESIRABLE** that the solution be able to transfer several aliquots to separate primary containers.

- it is ESSENTIAL that the solution is able to collect a sub-sample (of approximately 1g) into a sample container (of approximately 0.8 cm diameter. This process can be undertaken before/after transfer to the primary container.
- it is DESIRABLE that the solution does not spill any explosive during transfer. If this does occur, it is ESSENTIAL that the solution is able to wash and wipe the outside surface of the container with solvent to remove any solid or liquid explosive contamination. It is DESIRABLE that there is a means to dry the outside of the container and collect any waste materials.
- it is ESSENTIAL for the solution to press the explosive into the primary container to varying densities. This may require multiple filling/pressing steps to create a uniform density in the primary container. It is DESIRABLE to be able to measure the density of the explosive.
- it is ESSENTIAL for the solution to be able to secure a lid onto the primary container by a suitable mechanism. It is ESSENTIAL for the solution to not cause any explosive contamination of the lid sealing mechanism. Throughout subsequent processes the primary container will not always remain upright and it is ESSENTIAL that the lid be sufficiently secured such that there is no spillage.
- it is ESSENTIAL for the solution to be able to rotate the primary container such that there is mixing of the explosive contained within.
- it is ESSENTIAL to be able to attach object(s) (metal, glass, plastic) or instrumentation to the outside of the primary container
- it is ESSENTIAL to be able to weigh the primary container
- it is DESIRABLE that the solution complete the sub-requirement 1 process within thirty minutes and it is ESSENTIAL to complete the process within one hour.

Sub-Requirement 2: Placement of primary containers within secondary containers

The primary container is to be placed, in turn, into many different secondary containers.

It is ESSENTIAL that the solution be able to perform this for the following secondary containers:

- bags/suitcases (of sizes ranging from approximately 0.5-1.5m²)
- boxes (ranging in sizes from 0.5 to 2 m²). These may be made from cardboard, plastic or metal.

It is DESIRABLE that the solution be able to perform this for the following secondary containers:

- shoes
- laptops
- electrical items/ domestic items
- pipes (ranging in size from 1-14 cm diameter with the length of the tube 8 times the diameter)
- furniture
- standing person sized mannequin (as a proxy for a standing person). In this case the primary container is to be attached to the mannequin not contained within it.

The secondary containers will be pre-prepared before commencing the remote tasks. The secondary containers may contain other items, but a gap will be left to allow the primary containers to be

lowered in. These processes will be required to take place on the PAD (Figure 1a) (either outside or under/within a temporary structure) and within the Detection Suite (Figure 1b).

It is ESSENTIAL that the solution be able to:

- a) lift the primary container
- b) place the primary container within an allocated section of the secondary container.
- c) close the secondary container
- d) conduct the process in reverse

It is DESIRABLE that the solution be able to zip/fasten/seal the secondary container closed.

The primary container is to be re-used in a number of different secondary containers; furthermore, several different primary containers (with explosive within) may also be required to be packed into secondary containers. It is ESSENTIAL that the solution be able to pack and remove the primary container(s) to/from a minimum of 50 secondary containers in a seven hour working day; and It is DESIRABLE that the solution be able to pack and remove the primary container(s) to/from a minimum of 100 secondary containers in a seven hour working day.

Sub-Requirement 3: Transport of primary/secondary containers between locations at the FACILITY

For this section, container is used to mean either the primary container or the secondary container with the primary container within.

Sub-requirement 3.1: Transport to/from locations on the PAD (Figure 1 a)

The PAD dimensions are approximately 100 x 50 m. The terrain is approximately flat, although the surface is not smooth. There may/may not be line of sight between all locations depending on other structures and equipment that are setup. There is not line of sight between the PAD and the CONTROL ROOM (Figure 1d) due to the earth traverse.

It is ESSENTIAL that the solution:

- be suitable for operation outside, including in the wind and rain
- lift the container
- transport the container to/from locations on the PAD
- place the container on the ground at designated locations with an accuracy of 1 cm.
- lift and place the container onto a platform at heights of up to 3 m
- collect the container from the ground/platform and move it to the next location.
- be able to place the primary/secondary container within a storage unit (on the PAD); seal and lock the storage unit; and be able to conduct this process in reverse to retrieve the primary/secondary container.

It is DESIRABLE that the solution:

- place the container on the ground at designated locations with an accuracy of 0.5 cm.

Sub Requirement 3.2: Transport between PAD and DETENTION SUITE (See Figure 1 a, b, c)

The distance between the centre of the PAD and DETECTION SUITE is approximately 200 m. The only route between the two locations is the access road shown in Figure 1c - over terrain with occasional broken tarmac; a gradual incline with a rise in height of 7m. The breadth of the access road is 3m. There is line of sight between the near side of the PAD and the top of the rise, before turning right towards the DETECTION SUITE. Entry to the DETECTION SUITE is through a 3m² door. There is not line of sight between the PAD and the DETECTION SUITE or the PAD and the CONTROL ROOM due to the earth traverse. Within the DETECTION SUITE there is a flat concrete floor.

It is ESSENTIAL that the solution:

- be suitable for operation outside
- lift and transport the primary/secondary container from the PAD to the DETECTION SUITE
- must not be more than approximately 1 m width (if a permanent infrastructure solution), to ensure sufficient space remains for other vehicles to pass on the access road (Figure 1c).
- position the container on a location on the ground or onto a stand/table etc. (with an accuracy of 1 cm); and at heights up to a maximum of 2 m.
- collect the container and return it to a location on the PAD.

It is DESIRABLE that the solution:

- position the container on a location on the ground or onto a stand/table etc. (with an accuracy of 0.5 cm)

Sub-Requirement 4: Load/retrieve containers from X-ray/CT scanner(s)/other detection equipment

The processes for this sub-requirement will be undertaken in the DETECTION SUITE, the dimensions of which are 25 m by 15 m. Within the centre of the DETECTION SUITE there is an approximate 2 m² piece of infrastructure and this space cannot be used.

- the container is either the primary container, or the secondary container with the primary container within.
- more than one primary container may be used
- the container(s) are to be scanned by one or more X-ray/CT scanners/other detection equipment (referred to as scanners in the following section) in turn.

It is ESSENTIAL that the solution:

- provide a conveyor belt mechanism to pass the container through between one and six scanners in turn.
- allow sufficient access to the work area for engineers to install/remove up to six scanners
- allow sufficient access to all scanners for 'sub-requirement 6: Emergency abort' to be fulfilled.
- place the container within a tray (supplied by UK Government, compatible with cabin and hold baggage scanners, of sizes up to 100 x 180 cm) on the throughput mechanism.

- be able to manipulate the tray such that it is always centred on the conveyor belt of each scanner before it is passed into the scanner – thus ensuring no container becomes jammed within a scanner.
- prevent any container falling to the ground from the mechanism or the scanner conveyor belts
- prevent more than one container entering a scanner at any time
- be able to pass the container through the scanner(s) a second or third time in the following orientations: 90 and 180 degrees relative to the starting orientation
- retrieve the container once all required scans have been completed and return it to a secondary container loading location in the DETECTION SUITE.
- at the secondary container loading location, remove primary container from secondary container 1 and place within secondary container 2.
- close lid of secondary container 2 and repeat above steps to pass secondary container 2 through the scanner(s)
- repeat the above steps for multiple secondary containers
- remove primary container from final secondary container and place on loading platform.
- be able to retrieve the primary container (or the secondary container with primary container within) and return it to the secondary container loading platform in the event of an issue with any of the scanners that prevents scanning/data collection
- perform the above steps for the following secondary containers: suitcases, bags and boxes.

It is DESIRABLE that the solution:

- perform the above steps for the following secondary containers: shoes, laptops, other electrical/domestic items.
- be able to unzip/unfasten secondary containers if the solution had zipped/fastened these containers
- be able to isolate any scanner(s) that are not functioning as required and continue to scan the containers with the other X-ray scanners.
- allow multiple containers to be scanned at once, i.e. at any one time, one container is being scanned by each scanner.
- allow different sections of the 'throughput mechanism' to be operated independently to help facilitate effective scanning of multiple containers.
- be able to capture the time each bag is scanned by each of the scanners.

For remote control of detection equipment that cannot inherently be operated remotely, or if remote control functionality of that equipment has been lost.

It is ESSENTIAL that the solution:

- press a button that is prominent on the hardware, or turn a key, to start the detection equipment such that it will analyse each container in turn;
- press this button/turn the key as many times as is required to analyse each container
- not damage the detection equipment.

It is DESIRABLE that the solution be able to activate a software control (e.g. press a mouse or press a pressure sensitive screen) to start the detection equipment and perform this function as many times as required to scan all items.

It is ESSENTIAL that the combination of the solutions for primary container packing (into secondary containers) and passing the containers through the scanners achieve scanning of a minimum 20 containers, it is DESIRABLE that the solution achieve a minimum of 200 containers in a seven hour working day.

Sub-Requirement 5: Emergency abort, retrieval and make safe all processes

This requirement underpins all the preceding requirements.

It is ESSENTIAL that the solution:

- be able to stop and make safe all remote operations at any point in any of the processes corresponding to the sub-requirements described in this document
- be able to return the primary container, or primary container within a secondary container, to the storage or disposal location in a safe and controlled manner.

It is DESIRABLE that the solution is able to fix and re-start the failed process if this is deemed safe to do so by an operator.