RCloud Tasking Form – Part B: Statement of Requirement (SoR)

Title of Requirement	Ground-Penetrating Synthetic Aperture Radar (GPSAR) Development
Requisition No.	**1000164420**
SoR Version	**0.1**

1.	**Statement of Requirements**
1.1	**Summary and Background Information**
	The concept of ground-penetrating synthetic aperture radar (GPSAR) mounted on an unmanned aerial system (UAS) has been presented in open literature as a means to detect buried landmines. Dstl seeks to explore the capabilities and limitations of the concept via field trials. To undertake such trials the design and build of a synthetic aperture radar (SAR) test-bed is required. The test-bed system shall be capable of collecting radar, positional and attitude measurements to allow the production of SAR images of the ground surface/sub-surface. The system produced under this contract does not require to be mountable to a UAS. Rather the test-bed should make use of suitable sub-system technologies and components that will ultimately support a pathway for integration with a UAS. Bids shall provide details of the work possible for an initial design study. It is intended to fund two separate designs and to down-select to a following single build phase. Of the funded designs the one that is deemed to meet the requirements to the greatest extent and offers value for money will be continued into the build phase. However, continuation is dependent on this design sufficiently meeting the defined requirements. The assessment will be judged by Dstl subject matter experts. The design phase fee should be up to a limit of £70k ex VAT. Additional funding to commence the test-bed build is available this financial year up to a limit of £95k ex VAT. Subsequent build activities to complete the system will be dependent on monies yet to be secured for financial year 2022-2023, and is hereby identified as an option.
1.2	**Requirement**
	The overarching requirement is for the design and build of a GPSAR test-bed. The system shall be capable of collecting radar data when mounted to a standard road vehicle, e.g. on a roof-rack. The radar is to look sideways and scan a swath of ground adjacent to the vehicle as it is driven along a road/track. The data collected as the vehicle moves shall enable the generation of synthetic aperture images. The radar should be integrated with positional and attitude systems to allow the production of the SAR imagery. REDACTED MILITARY SENSITIVE INFORMATION **Field Trials Setup for GPSAR Test-Bed Assessment**

Figure 1 shows how the GPSAR test-bed is intended to be used during field trials, however this is for illustrative purposes only and is not meant to imply the specific design required.

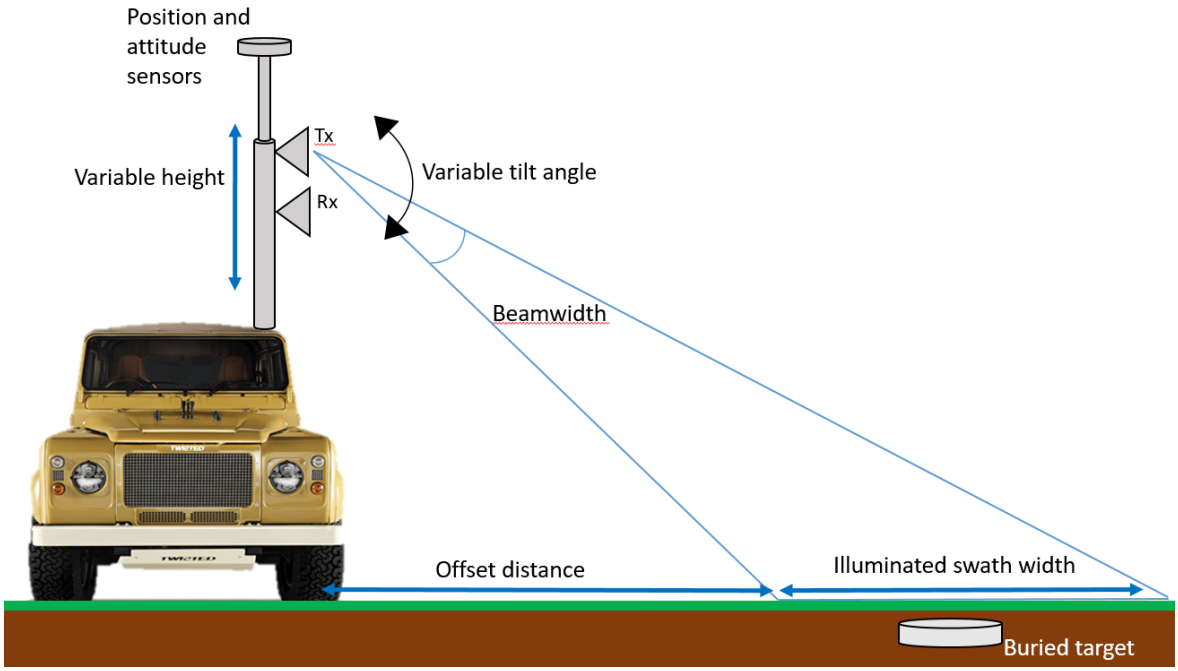

Figure 1. Field trials setup for GPSAR test-bed.

In the following sections the phrase 'along-track' refers to the direction forwards from the vehicle while the phrase 'across-track' refers to the direction perpendicular to the vehicle movement. To minimise vertical position and attitude variations as the system is carried by the vehicle, trials sites will be found where the vehicle can travel along a paved road surface, with the antennas focussed on areas of adjacent unmade ground.

GPSAR Test-Bed Hardware Component Overview

- Radar
- Antennas (Tx/Rx)
- Position system
- Attitude system
- Antennas mount
- Laptop
    - Control, data acquisition and SAR processing.

GPSAR Test-Bed Software Component Overview

- Software for radar configuration and data acquisition.
- Software to produce SAR images of the surface and of horizontal planes at variable depths into the ground.

GPSAR Test-Bed Component Specification

The following requirements list is for guidance. The intention is to convey the general performance of the GPSAR test-bed sought and reflects Dstl's understanding at the time of writing. The requirements that are strictly to be met are preceded by 'shall'. Where this prefix is not used the figures quoted may need refinement as the contracted design study, and Dstl's own research, progresses.

The requirements for the GPSAR test-bed components are as follows:

A radar with the following design and performance is required:

- The type of radar architecture is open to the bidder.
    - Justification for the chosen design shall be provided.
- A single or multi-channel Tx/Rx design is open to the bidder
    - A multi-channel full-polarimetric system is desirable providing the ability for concurrent collection of horizontal and vertical (HH, VV, HV and VH) data.
    - Justification for the chosen design shall be provided.
- The centre frequency and bandwidth needs to take into account the requirement to provide ground penetration:
    - Centre frequency shall be between 2 and 4 GHz.
        - User control within these limits is desired.
    - The minimum bandwidth shall be 3 GHz.
        - A bandwidth greater than 3 GHz is desired.
        - User control over the bandwidth is desired.

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- The radar shall have a dynamic range so that dihedral reflectors formed by building walls and the ground surface at a boresight distance of 3 m do not saturate the receiver.
    - It is desired that the dynamic range meets this requirement for highly reflective wall materials and ground types, e.g. wet concrete and wet soil.

Data acquisition and SAR processing performance:

- Software shall be provided to allow acquisition of position and attitude referenced radar data as the test-bed is moved on a vehicle:
    - All raw data (radar, position and attitude) shall be recorded and stored in a readable format to enable post processing by Dstl.
    - The data acquisition software shall indicate to the user that data collection is active.

- Data shall be sampled at a rate sufficient to collect radar range profiles, as defined in the preceding and following statements, whilst the host vehicle is continuously driving forward at a speed of 5 km/h or greater:
    - Operation at speeds greater than 5 km/h is highly desirable.
    - The maximum speed which still enables the generation of complete radar range profiles should be stated.

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    - Each individual range profile shall be sufficiently sampled to avoid aliasing.
        - This applies both to range profiles directly acquired by time domain techniques or range profiles acquired via frequency domain techniques.

- Software shall be provided to allow SAR images to be formed from the data:

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    - The SAR software shall allow the processing of multiple datasets gathered at different set antenna heights to enable the generation of a 3D image volume of a scene with improved vertical resolution relative to a single pass. The generation of horizontal plane view slices at chosen depths above and below the ground surface is required.
    - It is desired that the SAR imaging software accounts for radar wave refraction into the ground, assumed to be a homogenous half-space, to faithfully reproduce sub-surface target depth and location.

- Additionally the facility to generate images from sub-sections of data is desired to confirm error-free data collection during field trials (or capability to produce a sub-section of individual radar range profiles for this same purpose)

Antennas shall meet the following specification:

- The polarisation is open to the bidder.
  - Justification for the chosen design shall be provided.

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- Beamwidth across-track shall illuminate a swath width, see Figure 1, of 4 m or greater.
- The offset distance (across-track) between the vehicle and illuminated swath (see Figure 1, is envisaged to be in the order of 3 to 10 m.
- Bandwidth and centre frequency shall be compatible with the radar requirements as described above.
- Size and weight shall allow future mounting underneath a UAS:
  - Maximum dimensions of 0.25 x 0.25 x 0.25 m – the smaller the better.
  - Maximum weight of each antenna 0.3 kg – the lighter the better.

The mount for the system shall meet the following specification:

- Enable the transmit and receive antennas to look sideways, perpendicular to direction of travel.
- Enable the transmit and receive antenna height to vary between 2 and 5 m from ground surface, independently
- Enable the mitigation of antenna cross-talk by varying separation distance and adding radar absorbent material.
- Enable the transmit and receive boresight angle to be varied from vertically downwards to horizontal.
- In the case of a single channel, linearly polarised Tx/Rx system, it shall be possible to mount each antenna in either vertical or horizontal polarisation.
- In the case of a multi-channel, linearly polarised full-polarimetric system VV, HH, HV and VH measurements shall be inherent in the configuration of the antennas.
- If a non-linear polarisation is used the mount shall enable appropriate orientation to maximise radar transmission into the ground.
- Compatible with a wide range of vehicles e.g. mountable to a roof-rack.
- Antennas mounted in a position so that radar reflections from the mount and/or vehicle are minimised.

The positional measurement system shall allow the position of the GPSAR to be measured in an appropriate coordinate framework with a resolution of 5 mm or finer.

The attitude measurement system shall allow the accuracy of the primary positional measurement system to be refined.

The power supply voltage and current limits shall be compatible with future integration with a UAS.

The GPSAR test-bed shall be designed to withstand light rainfall and to operate within a temperature range of 0 to 35 degrees Celsius.

Further Details

The test-bed should make use of sub-system technologies and techniques that will ultimately support a pathway to integration with a UK MOD Class I(c) UAS (2 to 20 kg).

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1.3	**Options or follow on work** *(if none, write 'Not applicable')*
	Options: Dstl sets out confirm that the Build Phase has been identified as an option, following completion of the Design Phase. It should be noted that the Build Phase will have be split with any activity to be performed in Financial Year 22/23 defined as an option which shall be subject to funding approval. **Potential Follow-on Work:** The details provided in Section 1.2 above relate to the build of a GPSAR test-bed for mounting to a standard road vehicle. Assuming that results from the test-bed indicate a useful capability and acceptance criteria are met, the next steps are to progress towards a UAS-mounted GPSAR demonstrator. This follow on phase would require the build of a UAS-mounted system based on the test-bed radar built under this contract. The key additional requirements would be: size, weight and power to allow mounting to a UK MOD Class I(c) UAS; compatible components with regard to EM interference; and positioning / attitude measurement system to allow focussed SAR images to be generated from a UAS. Further details of the full set of requirements will become available before commencing this later stage to develop a UAS-GPSAR system. Bidders should note that this additional requirement is not a guarantee of future work.
1.4	**Contract Management Activities**
1.5	**Health & Safety, Environmental, Social, Ethical, Regulatory or Legislative aspects of the requirement**
	The design study shall consider radiation hazards and provide calculations of safe working distances, as set by the Health and Safety Executive, from the transmitting antenna(s). The test-bed system shall be provided with measurement results to validate the safe working distances. The system shall meet the relevant electrical safety standards. The following quality requirements have been identified as applicable to this requirement: • ISO9001 – Quality Management Systems, • ISO12207 – Systems and software engineering – software life cycle, and • TickITPlus – Integrated approach to software and IT Development

1.6	Deliverables & Intellectual Property Rights (IPR)					
Ref.	**Title**	**Due by**	**Format**	**Expected classification (subject to change)**	**What information is required in the deliverable**	**IPR Condition**

GPSAR-1	GPSAR Test-Bed Design	T0 + 5 Months	Documentation as listed herein, and a Presentation (.pptx)	OFFICIAL	• Design report
					  ○ Work breakdown structure
					  ▪ Science and technology challenges and dependencies
					  ▪ Timescales and Gantt chart
					  ▪ Risks/issues
					  • S&T and delivery
					  ▪ Overall cost and breakdown
					  ○ Proposed specification
					  ▪ Hardware and software
					  ○ Radiation hazards and electrical safety
					  ○ Commercial aspects
					• Presentation
					Summary of the above aspects
						Default RCloud Agreement Terms and Conditions shall apply
						Full Rights Version

GPSAR-2	OPTION GPSAR Test-Bed Build	To be defined by the Output of deliverables GPSAR-1 – Test Bed Design Phase	GPSAR Test-Bed System hardware and Software	OFFICIAL	• Performance evidence data and interim reports of tests carried out during the Build Phase. • GPSAR test-bed system hardware and control software as defined by Design Phase • SAR imaging software as defined by Design Phase • Demonstration of the system at a site chosen by Dstl prior to delivery to confirm functioning of hardware and software components. • Training on the use of the system and software. • Documentation of technical specification. User manual.	Default RCloud Agreement Terms and Conditions shall apply Full Rights Version

1.7	**Deliverable Acceptance Criteria**

The acceptance criteria in regards to the deliverables of Section 1.6 shall be met as outlined below. Continuation to the 'Phase 2 – Build' is dependent on successfully meeting these design acceptance criteria. Within the outlined deliverables evidence is to be provided to show that the requirements in Section 1.4 preceded with 'shall' have been met.

Phase 1 – Design

- Design report
    - Work breakdown structure (WBS)
        - Science and technology challenges and dependencies
            - The requirements of Section 1.4 should be addressed
            - Modelled results and/or calculations shall be provided to give evidence of positive target detection performance against the requirements.
        - Timescales
            - Timing estimates and Gantt chart for the WBS with indication of margin of error.
        - Risks and issues
            - Provision of S&T and delivery risks and issues.
    - Proposed technical specification
        - Hardware
            - System design diagram
        - Software
            - Evidence shall be provided to show the current holding, or ability to produce or source, test-bed control software.
            - Evidence shall be provided to show the current holding, or ability to produce or source, SAR imaging software.
            - Details of the SAR imaging algorithm shall be provided.
    - Radiation Hazards and Electrical Safety
        - Evidence to show the design meets radiation and electrical safety standards.
    - Commercial aspects
        - Background IP shall be stated.
    - Costing.
        - The overall and breakdown of costs
- Presentation
    - Summary of the above delivered as a presentation and slides (.pptx) provided.

	Break point – Continue or cease development dependent on the Design Phase fulfilling the acceptance criteria.
	
	Phase 2 – Build
	• Performance evidence.
	  ○ Copies of all test-bed performance evidence shall be made available to Dstl as and when it is generated during the Build Phase.
	  ○ The final build is to meet the 'shall' requirements as defined in Section 1.4 with consideration also given to the 'desired' aspects. Documentation that records the system demonstrates these requirements is to be delivered on completion of the build.
	• GPSAR test-bed system hardware and control software as defined by Design Phase
	  ○ System hardware and control software shall be demonstrated by the supplier during a pre-delivery test at the supplier's premises.
	  ○ On contract completion delivery of the system in suitable field-deployable packing cases.
	• SAR imaging software as defined by Design Phase
	  ○ SAR imaging software shall be demonstrated by the supplier during the pre-delivery test at the supplier's premises using data collected on the day..
	• Training on the use of the system and software.
	  ○ Following the system demonstration a day of training on system control, data collection and SAR imaging shall be provided.
	• Documentation to be provided on delivery of test-bed system.
	  ○ Test performance results showing that the 'shall' requirements of Section 1.4 are met.
	  ○ Technical specification.
	  ○ User manual.
	System operation and SAR processing guide including troubleshooting.

2	**Evaluation Criteria**
2.1	Method Explanation
	The evaluation shall be conducted using a Value for Money (VfM) Index. This approach divides the total score of the non-cost (quality) criteria by the tender cost. It ranks tenders on the quality (represented by the non-cost score) for each £ (or £k or £m) of cost. If more than one proposal receives the same VfM Index score, preference shall be given to the proposal that scored the higher non-cost (quality) score.
2.2	Technical Evaluation Criteria
	The technical team will evaluate the technical aspects of the bids.

A total technical score will be calculated using a sum of marks awarded for each of the 8 questions, resulting in a maximum achievable score of 70.

Solutions will be deemed to fall short of the Authority's technical requirement and therefore be technically non-compliant in the following cases:

- A score of 0 is achieved for any of the criteria
- A score of 3 is achieved for two or more criteria

ID	Criteria	score
1	The proposal provides strong evidence that the Contractor has the expertise and knowledge to successfully complete this work package to Dstl satisfaction.	0-10
2	The proposal demonstrates that staff working on the project have a good track record, and experience, of working on similar projects.	0-10
3	The proposal demonstrates that the Contractor has access to the necessary facilities and assets to successfully undertake the concept study and any further de-risking work.	0-10
4	The proposal demonstrates that the Contractor has a clear plan and approach to enable successful completion of the work package within the required timescales.	0-10
5	The proposal demonstrates that the Contractor takes a flexible approach and is keen to help Dstl shape its requirement and provide the best possible solution within the given budget.	0-10
6	The proposal clearly demonstrates and provides evidence that it has addressed all of the outline technical requirements and added additional requirements where relevant.	0-10
7	The bidder has provided information on the technical extent of Background IP which will be critical to the success of the proposed solution and the impact of any Background IP on Dstl's freedom to use the Foreground Information. The bidder has also provided a mechanism by which Dstl can secure the necessary user rights in any Background IP to enable the successful completion of the project as a whole. If the proposed solution does not include any Background IP and states this in the proposal the bidder will be awarded a score of 7 - Good.	0-10

The following scoring guide will be used to evaluate against each criteria:

Score	Definition
10	**Excellent:** The response addresses all elements of the requirement, and provides a comprehensive, unambiguous and thorough explanation of how the requirement will be fulfilled.
7	**Good:** The response addresses all of the elements of the requirement and provides sufficient detail and explanation of how the requirement will be fulfilled.
3	**Adequate:** The response addresses the majority of elements of the requirement but is weak in some areas and does not fully detail or explain how the requirement will be fulfilled.

	0	**Inadequate:** The response does not address or explain how the requirement will be fulfilled and fails to demonstrate the ability to meet the requirement.
2.3	Commercial Evaluation Criteria	
	The following Commercial evaluation criteria shall be assessed as Pass / Fail: 1. Has the bidder submitted One (1) Full technical proposal excluding any price data, and has submitted One (1) full Commercial proposal, including all price detail. 2. Has the proposal been submitted as a firm price 3. Has the bidder uploaded a response (Supplier Assurance Questionnaire (SAQ)) in response to the cyber risk assessment 4. Has the bidder uploaded a completed Part C Task Response Form	