

## CHALLENGE STATEMENT

### **Request for Proposal Call for Submissions: *Quantum Technology applications in the future operating environment* (including demonstration at Army Quantum Technologies Exploration Day 2021 (AQTED21))**

Challenge Owner: Head Land Capability

#### **Call for Submissions**

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**Due Date: 14 December 2020**

**Call for Submissions (CFS) 16388**

#### **Aim**

This document outlines the purpose and technical aspects of the Quantum Technology Applications Challenge, including a list of the Challenge sub-themes for applicants to address. The Call for Submissions (CFS) process is governed by this Challenge Statement, the CFS Terms and Deed of Participation.

Quantum technologies exploit the fundamental laws of nature to reach the ultimate limits of sensing, imaging, communications and computing; in short, enabling technology to conduct incredibly complex tasks in faster times and in more detail. They are diverse, complex, and generally early in technical readiness and demand new ways of thinking about the employment and exploitation of technology. Their true capabilities, limitations and most disruptive applications are still being discovered. This combination of disruptive potential, ambiguity and complexity presents both strategic risks and opportunities to land forces. As a result, the Australian Army finds itself in an accelerating global competition to understand, co-develop and exploit quantum technologies in land operations.

The emergence of quantum technology is part of a larger transformation of warfare, where geopolitics, demographics and technology are driving changes in the character of warfare at a rate faster than which many of Army's processes, concepts, capabilities and structures are designed. Army has termed this change [Accelerated Warfare](#) and has mounted the strategic response: [Army in Motion](#). Army has identified that the emergence of quantum technologies will impact two of the major technological drivers of Accelerated Warfare: robotics and autonomous systems, and cyber and information warfare.

Army is seeking to leverage Australia's national strategic strength in quantum technology research, its emerging quantum industry and cooperation with aligned nations, to gain and retain an early quantum advantage. The first objectives are to:

- catalyse an innovation ecosystem that is focussed on the development and application of quantum technologies in land operations
- rapidly identify the most disruptive and advantageous applications of quantum technologies in the land domain before competitors.

Army's approach to these initial objectives is to initiate a series of regular Army Quantum Technology Exploration Days (AQTEDs).

The AQTEDs are designed to enable Army to:

- issue challenges that test specific hypotheses of quantum technology applications in land operations

- provide forums for the generation of new ideas and critical discussion of quantum technology applications in land operations
- establish networks and mutual understanding with Australia's quantum technology research and industry community
- assess the abilities of participating teams and their suitability for future Army quantum technology projects.

The outcomes of AQTEDs will inform future projects that aim to develop the highest value applications, capability and demonstrate how they support advantageous future Army operating concepts.

The Department of Defence via the Australian Army and the Land Capability Division (**Defence**) is seeking proposals that will demonstrate solutions to The Challenge (defined below) at the first Army Quantum Technology Exploration Day (AQTED21), to be held on **20 April 2021** at the Brisbane Exhibition Centre.

### **Overview of CFS Process**

Important: Please note that this is an overview only. Full details of the CFS process are set out in the CFS Terms and Deed of Participation.

The CFS competitive selection process is as follows:

- Applicants are to submit a short written proposal using the format dictated in Annex A. Proposals that do not adhere to this format may not be considered.
- After assessing the written proposals, Defence may select a shortlist of applicants to progress to interview.
- In the interview, applicants will pitch their proposal and discuss it with Defence representatives. An indication of how the interviews will be conducted is contained in Annex B. Applicants who are not available for interview during the nominated period may not be considered further.
- Following the interviews:
  - Defence may select approximately four proposals and invite them to enter into a simple contract arrangement to enable the selected applicants to demonstrate their solution and deliver a solution report and presentation at AQTED21 on a funded basis. The requirements of the demonstration, report and presentation are detailed in Annex C and the Deed of Participation..
  - In addition to selecting funded applicants as outlined above, Defence may also invite applicants to pitch at AQTED21 on a self-funded basis. Self-funded applicants pitching to a wider Defence audience are to comply with the format detailed at Annex D and the Deed of Participation.
- For both contracted and self-funded demonstrations, Defence acknowledges the low technical readiness of some quantum technologies, and is therefore amenable to demonstrations that primarily use simulation and/or early prototype devices in simulated environments.

Potential applicants are encouraged to respond to this CFS only if their solution can reasonably be expected to be ready for demonstration at AQTED21. Where this is not the case, an innovation submission can be made through the Defence Innovation Hub (DIH) portal as an unsolicited innovation proposal - Priority Innovation Notice at the following link:

<https://www.innovationhub.defence.gov.au/call-for-submissions/>. Proposals submitted through this method at the DIH are less time constrained than time sensitive AQTED21 submissions.

## Closing Time

You must submit a response to this CFS using CFS 16388 on AusTender by **12:00 noon (local time in the Australian Capital Territory) on Monday 14 December 2020 (Closing Time)**.

## The Challenge

In this Challenge, Defence wishes to test if:

- quantum sensors can deliver enhanced detection and imaging of gravitational and magnetic anomalies
- quantum computers can deliver enhanced decision making in operational planning
- there are effective countermeasures to quantum communications.

The following three sub-themes define specific examples of the above in land operations. These examples have been chosen because they are both sufficiently specific and tangible for respondents to make appropriate assumptions and produce meaningful results, whilst also being generalisable to other situations and tasks in land operations.

Proposals **must** directly address one of the sub-themes.

### Sub-theme 1: detection and imaging of subterranean structures and matériel

Scenario: It is suspected that opposing forces are storing and moving military matériel through concealed subterranean structures, voids and tunnels. Defence needs to determine where these structures are, their capacity for the moving materiel (volume/speed etc) in order to maintain situational awareness of the operational environment and adversarial actions.

Task: Your objective is to employ quantum sensors to detect and image the structures and/ or matériel. With reasonable assumptions about composition of the force elements/resources/ throughput of the voids, what is the smallest structure or amount of matériel that you can detect? What determines the spatial and temporal resolution of your images? What advantages do the quantum sensors offer over existing technologies?

### Sub-theme 2: optimisation of last-mile resupply by a squad of autonomous ground vehicles

Scenario: A squad of autonomous systems are being used to take supply from a distribution point to forward force elements engaged in battle. The squad contains  $N$  vehicles that can each carry up to  $L$  packages. There are  $F$  force elements. The  $f^{\text{th}}$  force element requires  $x_{f,s}$  packages of the  $s^{\text{th}}$  type of supply (water, ammunition etc). There is a total of  $S$  different types of supply. The routes between the distribution point and the force elements, and between the force elements, have been each assigned costs  $c_{0,f}$  and  $c_{f,f'}$ , respectively, based upon their relative duration and risk of each route.

Task: Your objective is to utilise quantum algorithms (or a combination of quantum and classical algorithms) to identify the best pathway to minimise the total cost of the resupply task, thereby maximising the speed and likelihood of successfully resupplying the force elements. The total cost being defined as  $C = \sum_f n_{0,f}c_{0,f} + \sum_{f'>f} n_{f,f'}c_{f,f'}$ , where  $n_{0,f}$  and  $n_{f,f'}$  are the total number of times each route is taken by a vehicle. For what space of the problem dimensions  $N$ ,  $L$ ,  $F$  and  $S$  is your technique advantageous over a purely classical algorithm? What are the quantum/ classical hardware requirements/ constraints to achieve this advantage?

### Sub-theme 3: disruption of satellite-mediated quantum communications

Scenario: An opposing force is securing communications between two of its major headquarters (located on land) by performing quantum key distribution using a satellite-mediated optical channel.

Defence needs to disrupt and interfere with this communication link in order to achieve freedom of action against the adversarial actions.

Task: Your objective is to non-destructively disrupt the quantum key distribution for  $T$  hours from a location on land without access to the communications equipment of the headquarters. Within reasonable assumptions, you are to maximise the duration  $T$  and the degree of disruption (i.e. reduction in key generation rate).

### Timeline

Stage	Estimated Date	Milestone
Call for Submissions	17-Nov-20	CFS Opens
(CFS)	14-Dec-20	CFS Closing Time
	18-Dec-20	Applicants notified of outcome of CFS
AQTED21	20 Apr 21	Display of submissions

### Technical Readiness Levels

Defence may consider proposals based on technologies that are immature i.e. at Technology Readiness Level (TRL) 3-4, or mature technologies which are applied in new initiatives through quantum. Proposals based upon technologies above TRL 5 will not be assessed in accordance with Clause 3.4(k) of the CFS Terms. Defence is particularly seeking proposals based upon technologies that, with appropriate funding, can be progressed to TRL 5-6 within 12 to 15 months following the AQTED21. However, this is not a requirement for application.

### Army Quantum Technologies Exploration Day 2021

AQTED21 will be **held** at the Brisbane Exhibition Centre on **20 April 2021** in conjunction with the Chief of Army Symposium 2021, which begins the day prior. The AQTED21 program will include: demonstrations and presentations from contracted Applicants, pitches from invited Applicants, and opportunities for both groups of Applicants to discuss and receive feedback from Defence personnel. The event will be promoted through Defence media channels and provides an excellent opportunity to build networks within Defence. The Deed of Participation terms (within these CFS Terms) will govern the Applicants' participation at AQTED21.

AQTED21 is open to Defence personnel, Defence contractors, invited guests, the media. Invitations will be extended to the senior representatives from across technology and innovation groups within Defence.

### Annexes:

- A. Format of written proposals
- B. Format of proposal pitches and interviews
- C. Successful applicants - requirements for solution demonstration, report and presentation
- D. Requirements for self-funded applicant pitches at AQTED21

## FORMAT OF WRITTEN PROPOSALS

*Your proposal is be not more than two A4 pages of 12 point Times New Roman font text and figures. Your proposal is to contain only the following the section headings (bold and capitalised). In addition to the content guidance provided below (italics), you should **refer** to the Assessment Criteria for what is expected in your proposal.*

### **1. CHALLENGE SUB-THEME**

*Identify which sub-theme you are addressing.*

### **2. SOLUTION TITLE**

*Provide a title that identifies your challenge solution in 10 words or less.*

### **3. TEAM NAME**

*Provide a name for your team that you wish to be publicly identified by at AQTED21.*

### **4. TEAM SUMMARY**

*Provide the following details of the principal members of your team: title, name, affiliation and team role. Be sure to identify a team leader.*

*Describe how the experience, expertise and structure of your team combine to give confidence that you can execute your development plan and deliver your demonstration, report and presentation as described.*

### **5. CHALLENGE SOLUTION AND DEMONSTRATION SUMMARY**

*Briefly describe your solution to the challenge including key elements of the design concepts, techniques and methods. Provide sufficient detail and references for the selection committee to understand and fairly evaluate your solution.*

*Describe exactly what you expect to demonstrate at AQTED21 and provide in your report and presentation. Identify the expected outcomes of your work and their benefits for Defence.*

### **6. DEVELOPMENT PLAN AND BUDGET**

*Describe how you plan to develop your demonstration and prepare your report and presentation (e.g. provide a roadmap that articulates the major tasks, timeline, allocation of personnel and resources).*

*Provide a budget that clearly defines the value of any contract you are requesting from Defence and how this money would be spent, as well as any cash and in-kind contributions of your organisation.*

*Comment on the feasibility of your plan and how you intend to manage the principal risks.*

## **FORMAT OF PROPOSAL PITCHES AND INTERVIEWS**

A total of 30 minutes will be allocated to your interview.

You will have the first 15 minutes to deliver your proposal pitch. This is to have a similar format and content as your written proposal.

During the latter 15 minutes, you will discuss your proposal with the Defence panel. They will ask you questions that seek to clarify their understanding of your proposal. You will have the opportunity to confirm your understanding of and any assumptions you have made about The Challenge as well as the expectations of the demonstration, report and presentation at AQTED21. You will have the opportunity to verbally make minor modifications to your proposal during the interview as a result of answers provided by the Defence panel.

## **SUCCESSFUL APPLICANTS - REQUIREMENTS OF SOLUTION DEMONSTRATION, REPORT AND PRESENTATION**

### **Demonstration**

At AQTED21, you will be required to have your demonstration setup and for you to be present to discuss your demonstration with attendees for the majority of the day. You will be assigned a demonstration space and you may request for standard items, such as desks, chairs, mains power and tv monitors, to be provided (to be discussed with Defence panel during your proposal interview). All other demonstration equipment will be your responsibility and must meet logistics and safety requirements of Defence and the AQTED21 venue (to be discussed during your proposal interview). You are encouraged to bring other items that enhance the communication and impact of your demonstration, such as flyers, brochures, posters and banners, as long as they fit within your assigned space and don't require additional fittings. Further details about AQTED21 will be provided closer to the day.

Your demonstration must demonstrate the full workflow of your solution in the most realistic environment possible. Preference will be given to demonstrations that either use prototype devices in simple simulations of the operating environment or high fidelity simulations of both the employed devices and the operating environment.

### **Report**

You are to deliver a written report of up to 5000 words that addresses each of following points:

- Your specific definition of the challenge (i.e. any assumptions you have made).
- The rationale/ motivation for choosing your approach to solving the challenge
- Technical description of your solution: the workflow, concepts, methods and techniques.
- Description of your demonstration and critical discussion of the limitations and fidelity of your prototype and/ or simulations.
- Analysis of the results and other outcomes of your demonstration and their implications for the advantages your solution offers over other quantum and classical approaches.
- A roadmap for further evaluating your solution and developing it into a fully functional defence technology. Defence is seeking a clear statement of the expected advantages offered by your solution, means to more precisely assess those advantages, the required software and hardware development milestones, and the associated timeline and risk.
- Proposal of how your team could deliver this roadmap, with particular focus on the next step of developing a prototype that enables Defence to experiment with and prove new operating concepts. Estimate the resources that you would require.

*Note that your report will be confidential and Defence is not seeking any rights over the intellectual property you generate during the contract.*

### **Presentation**

At AQTED21, you will be required to deliver a 20 min presentation, with an additional 10 minutes of discussion with a Defence panel. Your presentation is to address the same points as your report. However, your presentation will not be confidential as it will be held in a public forum. So, do not include details that should remain confidential due to intellectual property disclosure or other justifiable reasons.

**REQUIREMENTS FOR SELF-FUNDED APPLICANT PITCHES AT AQTED21**

If you are invited to pitch at AQTED21, you have been given the opportunity to pitch your solution and outline what would be required to develop the associated technology into a proof-of-concept prototype.

You will have 15 minutes to deliver your pitch and an additional 5 minutes to answer questions from a Defence panel.