Document Details: Clarification Q&A in response to the call for proposals

Challenge: cooling In High Power Battlefield Comms

Deadline for questions: 20/07/26

	Question	Answer
1.	The project scope refers to heat dissipation methods and a versatile heat transfer method. Would solutions that reduce the quantity of waste heat generated at source, for example through improved transmit-chain power efficiency, be considered within scope, either as a standalone approach or in combination with a heat dissipation method, provided all essential requirements are met?	Solution providers should not look at improved transmit-chain power efficiency as the radio type, manufacturer and technologies will inevitably be different and would require extensive effort to address each possible solution. The thermal management approach should be a single solution that can work with different radio technologies. ○ **Additional info**. The radio type can be diverse, from multiple manufacturers and differing technologies. The main thermal sources will be the power amplifier and FPGA units: however, these can be radically different depending on the scenario and manufacturer.

2.	Should the requirement to minimise the thermal signature be interpreted primarily as reducing peak external surface temperature contrast, as reducing the total thermal energy emitted over a mission period, or both? Relatedly, is there a preferred measurement method or test scenario that will be applied during independent testing of the prototype?	Reducing the peak external surface temperature should be the primary requirement when minimising the thermal signature for two reasons: transmitting at high power will alert the adversary to the transmitter location through RF direction finding, a bright thermal source will independently confirm this position; reducing the peak temperatures will have a beneficial effect on the radio electronic components as they are placed under less thermal stress. This will improve radio frequency stability and component lifetimes. ○ **Additional info**. Regarding the radio thermal signature, the radio will start and complete the mission at ambient temperature. All generated heat during the transmit phase will be radiated from the radio during both the transmit phase and the remainder of the mission. •

3.	What is the pattern of heat generators around the system?	There are three main sources of heat within the radio: 1. Heat generated from the FPGA within the SDR. This heat will be generated whenever the radio is active and running an application. This includes operation in both receive and transmit modes. 2. Heat generated from the PA when transmitting only. 3. Heat generated from the SMPS. This will be directly related to the power consumption of both the FPGA and PA. Both the SDR and PA are usually COTS/GOTS supplied components. In exceptional cases, the SDR and/or PA may be designed in-house. The component designers will have considered (at length) the thermal management and have provided thermally conductive paths from the FPGA/Power transistors to the outside of the individual component. The radio designer will have thermally routed the heat from the outside of the SDR/PA to the outside of the radio enclosure, where a thermal heat sink, fins or fans are attached to radiate this generated heat into the atmosphere.

4.	What are the temperatures reached at full power?	We think this is better answered by looking at the thermal sources radiating within the radio enclosure. Worst-case rating: SDR Input Power = 30W, all dissipated as heat within the radio. 100W PA at 0.3 Power Added Efficiency = 333W, all dissipated as heat within the radio. SMPS @ 95% efficiency providing 363W = 49W, all dissipated as heat within the radio. The actual temperatures reached will be dependent on the operational time and thermal conductivity to environment, usually modelled using a multi-stage second order differential equation, modelling each heat source, heat sink, thermal conductivity, and layer temperature, or using a thermal modelling CAD tool such as SolidWorks or COMSOL. It's important to note that there will be multiple temperature limits: maximum silicon temperature, thermal paste temperature, rubber pressure bushes, and thermal gaskets, alongside the external enclosure temperature which could burn the operator.
5.	Is a retrofit allowed to open up the radio and attach anything to components	Yes, retrofit is allowed, and preferrable to an external thermal management solution. We could extend this in that the SDR, PA components could be disassembled to gain better access (and thus less thermal resistance) directly to the sources of heat. Ultimately, a thermal solution could be mandated at design stage as user requirements to SDR/PA companies.

6.	? If yes, is there "free air" space inside the system? Ideally please could you give a value in mm for space above electronics	There is some free space around the radio components. This free space will primarily be used for cabling and connector voids. Note that existing radios will not have free space near to the heat sources, as this would insulate the thermal heat sources within each component from the radio cooling mechanism.
7.	Does the radio already have some form of cooling mechanism or heatsink?	Current radios use a combination (usually both) of external cooling fins and fan-based forced air.
8.	Is the radio operated within the 50L carry container, or is it taken out so that heat is lost to the surroundings?	Ideally, it should be operated within the container - however this is not currently the case. Currently the equipment is removed from the case and is mounted in free air.
9.	Can the solution yield any waste eg. solid or liquid?	No
10.	Can the solution use a consumable?	No
11.	The challenge documentation refers to solutions that can be retrofitted into existing hardware without creating a system that is overly large or complex. Would you consider a different approach by focusing on the radio carrier system (e.g., the backpack) rather than modifying the radio hardware itself.	No. Creating a solution that is reliant upon a radio carrier system will reduce the usability to only those units that are able to carry the equipment in that specific system. It is expected that the solution be integrated into the radio equipment to enable it to be transported by a variety of transit cases including different backpacks and hardened cases.

12.	Space envelope: “radio system fits within a 50-litre portable container”. But are there any specific space constraints for the thermal solution? For example, maximum allowable heatsink size	There are no hard constraints for the thermal solution. However, these radios are carried by dismounted soldiers within bergens, so the solution must minimise any size and weight increase. it should still be able to fit within the Bergen, and not add too much additional weight to carry over long distances
13.	Thermal load: the pdf says “high-power transmission at 20W”. But depending on the radio/transmitter efficiency, the heat load may be different. What is the heat load to be handled by the thermal solution	The challenge specifies an RF amplifier with 20W RF output power. A ballpark efficiency value of 35% would mean a thermal heat source of 37W radiated internally. The maximum operating temperature is 85 DegC on the surface of the RF amplifier component.
14.	Thermal performance target: is the solution expected to interface directly with the radio’s primary heat generating components (e.g., PA, FPGA, CPU), and what is the target thermal performance of the thermal path from such components to ambient? This could be expressed for example as maximum thermal resistance (°C/W), or maximum temperature rise (°C), or by specifying maximum ambient temperature together with maximum component case temperature or heat sink max temperature.	A solution may interface directly to the CPU/FPGA/CPU casing, attach/integrate into the SDR/PA thermal casing, or attach to the external radio casing. We have specifically NOT specified the mechanical interface or mounting position. The (indicative) absolute limits are as follows: The maximum ambient temperature shall be +58DegC (DEF STAN 00-035 Part 04 Issue 6 Para. 3.6, A3), Maximum accessible metal surface temperature +55DegC (10s contact time) BS EN ISO 13732-1:2008, Component surface +85DegC (representative datasheet). These limits shall be enforced by a segregated safety monitoring system which shall monitor die, case and ambient temperature and shutdown the system when any one limit is exceeded.

15.	Orientation constraints: we are considering certain types of heat pipes that transfer heat only upward (i.e., the heat generating component must be positioned below the heat sink). Would this be acceptable, or must the solution operate in any orientation?	We are explicitly not specifying the solution technology: heat pipes may be one of the many solutions proposed. The radio should operate in all orientations for ease of use. It must operate in at least 2 orthogonal planes (e.g. resting on base, and standing end on, side on).
16.	Heat exchange with ambient: is an air grille permitted to exchange air with the external environment, or is the transit case sealed to a specific IP rating?	The radios currently in use usually have an IP67 rating. Thermal pipes (implemented as either specific copper bars or extended aluminium extrusion) are used to transfer the heat to externally mounted heatsinks, equipped with fans. It is not usual to operate the radio within the transit case as the transit case is designed to withstand transportation vibration, shock and impact and thus is full of anti-vibration foam. Also note that a transit case is usually a Pelicase suitcase and is a separate entity to a bergen backpack.

17.	Must show a working prototype, delivering this to sponsors for independent testing': what testing is likely to be performed on the working prototype? Is there a test plan created and is it possible to identify what aspects will be tested? For example mechanical / shock, and thermal. Is the purpose of the testing to verify against what the project said it would deliver or against a set of criteria? If so, what is the criteria?	The test plan will be written by the sponsors and evaluated alongside a suitable trial and demonstration to senior leaders. The specific test serials have not yet been devised but will likely include: Documentation - Pack Review- Hazardous material content - User Manual - Safety Manual. Build - minimum order quantity - maximum rate of production - tooling time, cost, resources - production lead times - component sourcing availability, volatility & suitability - Unit cost: @ quantities 1, 10, 100, 1000). Installation - time- training - ease of fitment, human factors- required tooling- PPE. Commissioning - time - training - verification- required tooling. Operation - How much does it increase radio transmit time for the specified use case? (Primary key requirement). Operation - Does the improvement unlock additional use cases? - How does it affect the thermal signature? - How does it affect the accessible surface temperature? - Does it degrade the system lifetime? Maintenance - time - training - required tooling - fault detection/determination- PPE. Disposal - time- training- required tooling- PPE- waste management routes- Environmental Consideration

18.	Develop a roadmap to a low-cost solution': what is the order of magnitude of a low-cost solution? Cost would be dependant on volumes, are there any anticipated volume of both new and retrofit solutions? These would help with selection of manufacturing processes. Cost reduction can take engineering time, investment in tooling, and equipment. Is there likely to be further investment to cover development and NRE costs or is this more likely to be driven on commercials. What are the likely steps in the future to qualifying a solution? Because cost is mentioned is this likely to be a compromise solution for cost-benefit ratio, i.e. the solution may not be perfect but is low cost.	A road-map to a low-cost solution should be presented as a set of worked through scenarios. If the proposal/solution provides a major improvement in transmission time, then there would be high likelihood of further investment to realise a low-cost, mass production run.
19.	Could be applicable to maritime and air domains': are there any specific differences required from land based to the other domains? It would be helpful to understand the differences prior to making a work plan. For example, shock/vibration or G-force or IP protection levels (in the instance of the retrofit) ?	There are specific differences for land and maritime domains as described in DEF STAN 00-035. However, for the purposes of this challenge, and reflecting the specified TRL level, we should consider a generic solution which is mechanically robust for outdoors use. The focus should be on a technical solution for thermal management, rather than meeting specific environmental requirements. (For background INFORMATION ONLY, this would be specified as Environmental: DEF STAN 00-035 Part 04 A3/B4/C0/M0 (UK operating environment)), Vibration DEF STAN 00-035 Part 05 Chapter 2 - Transportation, Chapter 3 – Handling And Storage, Chapter 4 - Man Mounted And Portable.)

20.	Viability' - commercial exploitation routes will be limited – the most immediate is the 'retrofit' opportunity and current manufacturers of this equipment and related technology. Will the body be supporting exploitation by ensuring that the specifications of equipment changes to meet the needs of the users, and recommending / providing information of work already undertaken such as Phase 1 to the supplier of equipment? Will a future Phase have sufficient budget to incorporate engagement from equipment suppliers to test or verify the thermal solutions within their equipment?	The opportunities for commercial exploitation will vary wildly dependant on the technological approach taken. For example, if a solution is to improve cooling by incremental change to a specific radio architecture, then the available market space will be limited to that radio architecture. If, however, a novel technology is proposed that can be applied to all new SDR's, then we could mandate that technology and the adoption will be widespread across HMG and further afield.
21.	What is the the approximate amount of waste heat in kWh released during the day	70W in continuous transmission, which equates to 6MW per day! This is clearly not the case. The radios do not usually continuously transmit but transmit in bursts (i.e.: tx/rx transactions or a block transmission). Also, they are usually powered off batteries, so the mission duration is limited to the battery capacity. Some basic calculations are below Also see question 13
22.	Can our solution be located inside or should it be attached to the outside of an existing 50L transport case	All thermal management components should be contained within the 50L bergen.

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23.	Are there any constraints on form factor during deployed use? (Ie not the packaged volume)	We will employ Human Factors Engineers to evaluate the usability of each proposed solution. Prosaically, it should be able to be carried alongside the radio in the rucksack, easy to setup and use, provide a minimum of additional hazards with low severity, and requires no special tooling or training.
24.	Do you want us to do the maximum development within the £60k or show a threshold level of development to show sufficient feasibility for a lower price?	The challenge shall provide £60K to promote innovation in novel radio thermal management systems. We would suggest that, if you have an existing thermal mangement system which would meet the above criteria, then use the time and budget to exploit this technology, either through novel application, cost reduction, thermal signature management etc..
25.	You say you want cooling solution to meet the temperature profile/signature to match the environment - what is that. Are you thinking a human body, 37c, or are you thinking ambient operating environment (i.e say from a -10c to +40c operating environment)	Plan against expectations for an operating environment where the UK military could be active.
26.	Can a radio or a CAD model of it be provided so that a prototype solution can be modelled	The radio for this initial challenge shall fit a form factor of a SFF standard 5.25" half-height PC drive, 34 x 171 x 145 mm. The radio has internal heat dissipation to present the entirety of one of the largest faces as an interface for a heatsink (normally the upwards-facing 'top' face). As a stretch objective, a desirable future direction would be to provide cooling as the mounting rails of a 3U VPX

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		card as defined in UK MOD STICS and US DOD CMOSS/SOSA standards specifications (2 faces each, left and right facing, of 170.6 x 20.83 mm). Neither the 5.25" drive nor 3U VPX form factor have significant hot spots.
27.	Can the solution be external to the radio system (while still addressing the size and weight constraints). i.e. are we talking about an internal modification or could it be something external that helps dissipate the heat.	As per essential requirement: must be small enough to integrate with person-portable, field-deployable military equipment
28.	What is the maximum mass burden that would be tolerated	Military Judgement Panel for comparable equipment has previously identified a maximum weight of 16kg for the equipment. The radio system is likely to comprise 5-8kg of this, meaning the acceptable mass for a cooling solution can be 8-11kg if required. Less mass is better, but also 11kg is not an absolute limit if innovative solutions can be demonstrated in slightly more weight.
29.	Is this radio used in a backpack	The use case to plan from is that the radio will be unpacked from its transport container and set up on the ground. You may provide options for use while in a rucksack, but this must be in addition to the primary use case.

30.	Because of the varied electronics that may be cooled (different manufacturers etc) - are we better to look at cooling this standardized "50l container", rather than specific cooling of say cpu/chipsets on hardware itself? - that would be easier and quicker to implement	Cooling the container is not a suitable approach.
31.	what is the limit for electromagnetic interference from the thermal solution	Very low. The radio is specifically designed to capture extremely weak signals from far away transmitters. A ballpark figure would be -130 dBm across 50MHz - 5GHz. Any poorly designed SMPS, BLDC motor, CPU would likely exceed this threshold limit.
32.	Is the priority reducing thermal signature (i.e., spread out/slowly dissipate heat), or keeping electronic components cool (extracting heat from components)? Or are they equally important?	The Priority is keeping electronic components cool.
33.	Are you looking for a solution that can be attached to current radios or is a solution that requires radio case/internal structure redesign be possible	Both external attachment and internal modification solutions may be acceptable, however the challenge scoring shall take into account the amount of rework required to modify existing radios. That said, if the solution provides significantly greater performance, then it is possible to take a more strategic, longer term view and start to mandate this for new component builds
34.	Is the antenna fully external ie if anything attached to the side of the case, is it assumed that it would not interfere with the signals as the antenna is not covered	The radios usually have an N type RF coaxial chassis connection. The antenna could be mounted directly to the N type connector, or using a short coaxial cable. The solution should provide access to the radio connections,

		indicators, controls and displays. These are usually mounted on one panel.
35.	In the final demo will we have access to the radio, or will it be demonstrated on a subtle analogue for the radio	TBC, but likely analogue for radio
36.	Will the solution be used for a limited cooling period or continually used	We think it's important to distinguish the two radio use cases: There is a significant difference in the thermal management system for SDR's used for continuous (a) or burst (b) transmission. In use case (a), the thermal management system must be able to dissipate heat from radio continuously, allowing the mission to specify higher continuous power outputs. In use case (b), the radio will be switched on and left in receive mode for an extended period of time. When complete, it shall then transmit a large burst of data. The radio will then be switched off. The thermal management system will be able to store the waste heat during the burst transmission phase, allowing for more data to be transmitted. The underlying limitation in both cases is the maximum silicon die temperature threshold, which is raised due to transmit inefficiencies. Solutions should prioritise planning against use case (b) and see use case (a) as a stretch target.