

UK SDA Requirements for a System of Systems in Support of the UK's SDA Strategy

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The UK's first set of Space Domain Awareness (SDA) Requirements have recently been developed as a cross-government initiative, pulling in experience and knowledge from both civil and military agencies. The Requirements are aimed at shaping a system of systems which will provide for the UK's current and future SDA needs. A redacted version has been publicly released to apprise industry and academia of the UK's SDA needs so they can provide informed support as we build our system of systems. This paper discusses the Requirements, their history, as well as how they are utilized in practice, the challenges in developing them, and the future work to be done.

1. INTRODUCTION

With the stand-up of the UK Space Command in April 2021, the UK has both civil and military agencies dedicated to Space, including Space Domain Awareness. The UK government has directed these agencies to coordinate their activities, in order to develop the best possible capability, at the best value for the UK [1-4]. The National Space Strategy, published in 2021, lists SDA as a key civil and defence capability priority, and high growth area [1]. The Defence Space Strategy, published in 2022, lists SDA as a priority and a 'fundamental enabler of all other space capabilities, and critical to our ability to protect our interests in space...' [2].

The UK strives to be a responsible and safe space actor; in order to do this effectively and support future SDA procurement, research and development, and policy decision making, a cross-government SDA stakeholder working group was set up which has developed a framework of requirements for Space Domain Awareness. The working group, led by Dstl, includes members from key government agencies who have a stake in SDA; such as UK Space Agency, UK Space Command, Defence Intelligence, Civil Aviation Authority and so on.

The Cross Government Space Domain Awareness Requirements (herein Requirements) were established to inform the development of a system of systems, which includes the entire SDA chain from sensors and data processing through to readouts for policy makers. As per [5], 'The aim is to present requirements in a logical, easy to read format that clearly articulates the user and system needs'. This system of systems approach means that the Requirements can be used to underpin every piece of research, every procurement and every policy decision made by UK agencies for SDA. Recognizing that it is unnecessary to own sovereign systems to meet every SDA requirement, the UK is developing the system of systems utilizing commercially available products and collaborating with allies, industry and academia to fill any gaps in currently available solutions, while pursuing purely sovereign options only as necessary.

This paper outlines the history of the Requirements, the development of the requirements and future work still to be done. It also outlines how the requirements are being used in practice.

2. HISTORY

The Requirements were initiated under a UK Space Agency (UKSA) study, conducted by Serco, initially looking only at civil Space Surveillance and Tracking (SST) requirements. This study concluded in March 2022. The final deliverable of this study was a report on UK SST needs including an annex with civil SST requirements.

Recognizing the utility of the work that Serco had already conducted, cross-government stakeholders agreed to build upon the Serco requirements rather than start from scratch. Therefore, the initial set were then expanded by a cross-government working group led by Dstl to include requirements such as space object characterization, which sit outside SST but within the wider SDA envelope. Furthermore, the requirements were expanded to cover UK Ministry of Defence (MOD) requirements, including setting different threshold and objective Measures of Performance (MoP) for the civil and MOD organizations respectively.

Following re-development, the initial SDA Requirement set was taken through review and endorsed by UKSA on the civil side and UK Space Command on the MOD side in October 2022. However, development of the Requirements is ongoing with significant work planned to expand their scope and utility. The Requirements will remain as a living document, to be revised on an annual basis. Once work to expand the scope of them is complete this annual review

will focus on updating priorities, delivery timelines, measures of performance and checking the requirements remain valid. The next review including scope expansion is already underway. Following endorsement, the initial set have been also been redacted for public release and are now publicly available via the UK Government website [5].

3. REQUIREMENTS CONTENT

The Requirements are split into User and System (System of Systems) requirements. The user requirements are very high level, covering key capabilities, i.e., UKSDA-UR-1400: the System of Systems must ‘Enable object characterisation, including characterisation of cooperative and non-cooperative [Resident Space Objects]’ [5]. The system requirements then go into detail across a series of requirements on how the system of systems would address the user requirement, see for example UKSDA-SR-7300 and sub-requirements in [5] which directly trace back to UKSDA-UR-1400. In order to keep track of these links, the requirements are mapped with forwards and backwards traceability; such that every system requirement can be traced back to a user requirement and a user can see every system requirement that derives from each user requirement.

Due to the sensitive nature of some of the information contained in the Requirements, some information has been redacted from the publicly available version [5]. The redacted copy of the Requirements has only the requirement ID, heading and description. Beyond this, the classified version of the Requirements also contains the following columns:

- Requirement Category – used to group the requirements into broad themes.
- Measures of Performance (MoP): Civil Threshold and Objective, MOD Threshold and Objective - detailing the acceptable (threshold) and desirable (objective) levels of performance.
- MoP Status (Civil and MOD) – denoting whether the threshold or objective is yet to be defined (an indicator for updates).
- Justification – reasoning for the content of the requirements and their MoPs.
- Validation Method – method to test whether the MoP has been met.
- Requirement Status – whether the requirement is candidate (unendorsed), active (endorsed), or retired (endorsed but no longer valid).
- Fulfillment Status – whether the requirement has been met or partially met, used to trigger review of MoP
- Resilience Required – whether the requirement needs to be met by redundant systems.
- Priority (Civil, MOD, Consolidated) – denotes how important the requirement is to the relevant stakeholder group.
- Delivery Timeline – indicator for how urgently the capability is needed.
- Stakeholders – indicating which organizations have a stake in the requirement, including who is the key/owner stakeholder.
- Additional Notes – any notes, or additional information that is not captured in the preceding columns.

4. REQUIREMENTS MAPPING, GAP ANALYSIS AND UTILIZATION

As previously discussed, it is unnecessary for the UK to own sovereign systems to meet the entire requirement set, therefore UK Government organizations will use the Requirements to form the basis of current and future research and procurements. Now that we have an initial set of Requirements, in order to allocate resources effectively and use available funding to buy or develop the most useful technologies that can meet the most requirements, a gap analysis of all available technologies etc. measured against the requirements is needed.

To facilitate this gap analysis a requirements mapping activity is being undertaken by Dstl, to understand how existing and future technologies, software, data etc. meet the system level requirements. The Map is likely to be generated in the form of table; an example of the expected structure is shown in Table 1. Note, due to there being differences in MoPs for civil and MOD, the Map is being created in duplicate, considering the different MoPs respectively.

Table 1. Requirement Map Example, color coding: Green = objective met; Yellow = threshold met; Orange = partial capability, but not meeting threshold; Red = no capability.

| Req. ID | Req. | MOD/Civil MoP | | Tech 1 | Tech 2 | ... | Tech X |
|---------|------------------|---------------|-----------|--------|--------|-----|--------|
| | | Threshold | Objective | | | | |
| Req. 1 | Requirement text | A km | B m | | | | |

| | | | | | | | |
|--------|------------------|--------------|--------------------|--|--|--|--|
| Req. 2 | Requirement text | C hours | D minutes | | | | |
| ... | | | | | | | |
| Req. X | Requirement text | One Location | Multiple Locations | | | | |

Beyond the table above, an estimate of the confidence in the color coded assessment will be provided, along with the evidence used to support the color coding and confidence estimate. The Map will need to be updated as the requirements change and as new technologies, data sources etc. become available. Ideally, any developing technologies will also be captured in this Map so that when gap analyses are conducted, they consider any upcoming solutions which might meet requirements.

Once the Map is complete, it can be used to generate a gap analysis, by considering which requirements are met by many technologies (or data sources etc.), but more importantly which are met by none which would indicate a capability gap. This live Map will allow UK government organizations to produce systems and solutions to meet requirements in the most efficient manner and to add the most value possible.

5. CONCLUSION & FUTURE WORK

The recent development of UK Cross-Government SDA Requirements has been discussed, along with how they will be utilized in practice. Currently, the requirements are heavily skewed towards the space segment, with some cross-over into ground and link segment, however work is ongoing to cover these areas more effectively, along with expanding the current requirements to include other areas, for example Space Control and Space Weather. Beyond expanding the requirements themselves, work is also ongoing to develop the live requirements Map.

6. REFERENCES

- [1] UK HM Government. National Space Strategy, 2021. Available at: <https://www.gov.uk/government/publications/national-space-strategy>
- [2] UK Ministry of Defence. Defence Space Strategy: Operationalising the Space Domain, 2022. Available at: <https://www.gov.uk/government/publications/defence-space-strategy-operationalising-the-space-domain>
- [3] UK House of Commons Science and Technology Committee. UK space strategy and UK satellite infrastructure, Second Report of Session 2022-23, 2022. Available at: <https://committees.parliament.uk/publications/31490/documents/176763/default/>
- [4] UK House of Commons Science and Technology Committee. Defence Space: through adversity to the stars?, Third Report of Session 2022-23, 2022. Available at: <https://committees.parliament.uk/publications/30320/documents/175331/default/>
- [5] UK Ministry of Defence and UK Space Agency. Cross Government Space Domain Awareness (SDA) Requirements Publication, 2023. Available at: <https://www.gov.uk/government/publications/space-domain-awareness-requirements>