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

Title of Requirement	Redacted under FOI Exemption _Tri-band GPS data analysis for the CIRCE satellite mission, mandated for first–ever UK space launch in 2022.
Requisition No.	Redacted under FOI Exemption
Purchase Order Number.	Redacted under FOI Exemption
Contract Purchase Agreement.	Redacted under FOI Exemption
SoR Version	**0.1**

1.	Statement of Requirements
1.1	**Summary and Background Information**
	This iCASE will support ongoing relations for an existing collaboration in ionospheric physics and space weather. This builds directly on relationships established whilst Redacted under FOI Exemption Redacted un worked together to deliver the technical scenario for the Government Chief Scientific Advisor's extreme space weather table-top exercise in 2015. The Redacted Space Environment project has continued to work closely with the Redacted under FOI Exemption has held a visiting research fellow in the Department of Electronic & Electrical Engineering. The University staff provide world-class subject matter expertise to both Redacted under FOI Exemption The Space Environment Principal Advisor, Space Weather Chief, and Redacted under FOI Exemption supervisor contribute to the Space Environment Impacts Expert Group (an independent group formed to provide advice to government regarding the Severe Space Weather risk on the national risk register). In 2019 the Department of Electronic & Electrical Engineering rapidly designed, built, and tested two cutting-edge triple frequency GPS receiver payloads Redacted under FOI Exemption , which form part of Redacted under contribution to the Coordinated Ionospheric Reconstruction Cubesat Experiment (CIRCE), a two-satellite mission being delivered in partnership with the Redacted under FOI Exemption y. This iCASE is sought to facilitate data analysis from the Redacted under FOI Exe payloads, and will constitute a new PhD research effort. This iCASE proposal is timely because Redacted under FO is mandated for the first-ever satellite launch from the Redacted under FOI Exemption, enabled by the Redacted under FOI Exemption, later in 2022. In 2019 the Department of Electronic & Electrical Engineering rapidly designed, built, and tested two cutting-edge triple frequency GPS receiver payloads (known as Redacted under FOI Exe: Redacted under FOI Exemption contribution to the Coordinated Ionospheric Reconstruction Cubesat Experiment (CIRCE), a two-satellite mission being delivered in partnership with the Redacted under FOI Exemption . This iCASE is sought to facilitate data analysis from the Redacted under FOI Exe payloads, and will constitute a new PhD research effort. This iCASE proposal is timely because Redacted under FO is mandated for the first-

	ever satellite launch from the [redacted] enabled by the [redacted], later in 2022. [redacted]
1.2	**Requirement**
	Technology Challenges: The [redacted] mission satellite payloads, and associated data analysis, are relevant to both the engineering and physics aspects of the EPSRC remit. Two new tri-band GPS receiver payloads, [redacted] ionosphere and plasmasphere Computer Assisted Tomography [redacted] will allow remote measurement of electron densities between low earth orbit satellites and GPS satellites to improve the vertical resolution of current ionospheric imaging. [redacted] will operate at the GPS L1 band (centre frequency 1575.42 MHz), L2 band (centre frequency 1227.60 MHz), and new L5 band (centre frequency 1176.45 MHz), at 1 Hz standard, with a high data rate of 10Hz. Ionospheric total electron content (TEC) tomography utilises the integral of the number of free electrons between satellite and receiver, measured by radio signals propagating through the medium. For GPS-based tomography, TEC measurements are derived from the differential phase of dual-frequency transmissions of GPS satellites. The final TEC allows four-dimensional (4-D – i.e. 3-D spatial and time evolving) mapping of the ionosphere. Assimilating TEC data into existing sophisticated now-cast and forecasting ionospheric models is usually derived from centralised GNSS and ground-based ionosonde data repositories. Exploiting the GPS (and therefore, TEC) data derived from CIRCE is a new challenge, and one that is anticipated to bring fresh insights into demonstrating how the regional fidelity of the TEC picture can be increased by using this type of in-situ data. Technical Approach: This iCASE PhD's focus will be on making the first analysis of the [redacted]T science data returned from the CIRCE satellite mission. To our knowledge, [redacted] will enable the first space-based derivation of total electron content measurements which exploit all three of the available GPS frequency bands, in rapid succession. The rapidity of sampling the same region of space is enabled by the relatively small separation of the two CIRCE satellites (250km - 500km).

The technical approach will involve developing a simulation of the end-end process for the [redacted] observations and the subsequent inversion to test the approach to measure the ionospheric code delay and phase advance across the radio frequencies. The merits of use in combination with other CIRCE instrumentation will also be explored.

In particular, CIRCE also carries optical ultraviolet photometer payloads provided by the [redacted] which are also focused on deriving the two-dimensional distribution of electrons. Cross-correlation between the [redacted] and Tri-TIP payloads is of specific scientific interest, though the [redacted] data also contributes to data interpretation from two other [redacted]-provided payloads, namely a radiation monitor supplied by Surrey Satellite Technology Ltd, and a mass spectrometer from [redacted]

Potential Benefits:

The CIRCE satellite mission is specifically highlighted in the [redacted] "The Coordinated Ionospheric Reconstruction Cubesat Experiment (CIRCE) mission, a collaboration between world-leading UK scientists and the [redacted] will deliver unprecedented understanding of Space Weather. This will help us develop advanced Space capabilities and protect them from the harsh space environment."

Every operational activity that [redacted] decides to undertake in/through the space domain must contend with this environment, so ensuring that the UK possesses a world-class understanding of it is critical to [redacted] success in many other areas (these span all domains: Land, Littoral, Maritime, and Air, in addition to the more obvious Space applications). Environmental dominance (i.e. the ability to mitigate or exploit the battlespace environment for operational advantage) requires a timely, accurate and global recognised environmental picture. Specifically, the part of the space environment known as the ionosphere can reflect and refract radio waves which enables operation of our beyond-line-of-sight systems, as well as communication paths with satellites. The ionosphere is critically important for a broad range of defence and civil applications and impacts global navigation satellite system (GNSS), communications and sensing technology. Being able to correctly attribute physical features of the space environment to either natural or man-made processes is becoming a more pressing requirement. Having as accurate as possible a picture of the expected natural environment, and exploiting this information via data assimilation into existing now and forecast models, will support this endeavour.

This iCASE PhD will enable the [redacted] from the [redacted], in a very cost-effective and accessible manner. Technical partnering of the [redacted] data analysis provides an ideal opportunity for a more junior member of the [redacted] to work alongside the academic experts and PhD student at the [redacted], which will in turn enable SQEP development of our internal staff. Developing deep subject matter expertise and enhancing academic engagement is an explicit requirement articulated in the mandate of the Space Science Project.

CIRCE directly addresses the objectives of the [redacted] Specifically, [redacted] pushes boundaries in growing the UK as a space nation, directly supports international collaboration in this field, and contributes to developing the UK as a S&T superpower. This is especially relevant in this field of space weather, for which the UK is regarded as a world-leader. [redacted]

operationalise the Space domain. Data from the [redacted] payload is anticipated to specifically enhance both [redacted] ionospheric modelling capabilities, enabling enhancements in both accuracy and resilience in the operation of both defence and civil space capabilities and services spanning detection, positioning and sensing systems. In response to Severe Space Weather on the National Risk Register, the UK Severe Space Weather Preparedness Strategy (published 2021) sets out a five-year vision for enhancing our resilience to the risk of a severe space weather event. Data from [redacted] will enhance [redacted] and the UK's capability directly in the first two pillars of this strategy (assess, prepare) and will contribute to improving our ability to respond & recover (pillar three).

Capabilities and Skills Developed:

Engineering understanding of cutting-edge GPS receiver technologies, particularly the specific alterations that make it possible for use on-board a satellite platform.

Scientific understanding of the Space Environment, specifically the ionosphere.

Strengthens [redacted] technical relationship with the world-leading and highly respected academic department of Electronic & Electrical Engineering at the [redacted]

Working closely with the experts at the [redacted] significantly strengthens the UK's contribution to the CIRCE satellite mission, facilitating in-depth technical exchange with our US partners at the [redacted]

[redacted] is both a government department sponsor, and a beneficiary, of [redacted] Space Weather Instrumentation, Measurement, Modelling and Risk (SWIMMR) programme. This is a ~[redacted] programme running until end March 2025, which is focused on transitioning cutting-edge UK academic space weather modelling and measurement capabilities, through to operations at the [redacted] From here information products are passed to [redacted] at [redacted] The [redacted] is interested in taking a feed of some [redacted] data, which could include information derived from the [redacted] payload, if initial analysis (enabled by this iCASE) demonstrates there is scope for this to directly enhance the [redacted] capability. This will benefit both [redacted]. The timeframes for this iCASE PhD, the transition to operations phase of the [redacted] programme, and the initial monitoring phase following delivery are well-aligned, and would mean that [redacted] data can potentially demonstrate value to a very broad spectrum of users.

This iCASE will develop expertise by investing in a new resource for the highly sought-after, and niche, field of ionospheric physics. UK Government have declared space weather as a priority for the nation, and this iCASE will directly support this positioning. It anticipated that research undertaken by this iCASE will be exploited in support of enabling [redacted] to adequately respond to actions placed on the department in the UK's 5-year Space Weather Preparedness Strategy (published 2021).

Payment Plan

Progress payment 1 : end of PhD Year 1 [redacted]

Progress payment 2 : end of PhD Year 2 [redacted]

Progress payment 3 : end of PhD Year 3 [redacted]

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	Progress payment 4 : end of PhD Year 4 Redacted under FOI Exemption Redacted under FOI Exemption
1.3	**Options or follow on work** *(if none, write 'Not applicable')*
	future work will be identified during the course of the project.
1.4	**Contract Management Activities**
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1.5	**Health & Safety, Environmental, Social, Ethical, Regulatory or Legislative aspects of the requirement**

	N/A

1.6	Deliverables & Intellectual Property Rights (IPR)				
Ref.	**Title**	**Due by**	**Format**	**Expected classification** (subject to change)	**What information is required**
D – 1	Monthly updates	T0+1 Month	Word Doc	[redacted]	Top level update on progress r
D - 2	Quarterly Progress and Technical Reviews	T0+3 Months	Presentation (.pptx)	[redacted]	Presentation pack to include b • Update on technical progress • Review of risk management p • Risks/issues. • Proposed work plan for next c

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1.7	Deliverable Acceptance Criteria
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2	Evaluation Criteria
2.1	Method Explanation
	Evaluation is based on technical compliance and affordability.
2.2	Technical Evaluation Criteria
	Technical Evaluation already predetermined through internal process
2.3	Commercial Evaluation Criteria
	Redacted under FOI Exemption [redacted]