U.S. NAVAL RESEARCH LABORATORY

# CIRCE

*Coordinated Ionospheric Reconstruction Cubesat Experiment*

## AT A GLANCE

### What is it?

CIRCE comprises twin 6U CubeSats flying at 600 km in a lead/trail formation 300-500 km apart in the same orbit plane to measure Earth's ionosphere and particle radiation environment. The payload includes five low size, weight, and power *in-situ* and remote space environment sensors from the Department of the Navy (US) and Ministry of Defense (UK).

### How does it work?

Naturally-occurring ionospheric airglow is mapped in the ultraviolet to reveal its horizontal structure below the spacecraft. GPS signals are monitored as GPS satellites rise or set below the horizon to provide vertical electron densities and topside electron content. A particle radiation sensor measures energetic charged particles, and a compact mass spectrometer measures ion and neutral density and composition near the two spacecraft. Combining these simultaneous vertical and horizontal measurements will yield regional 2-D tomographic maps of ionospheric structures.

### What will it accomplish?

These low-cost, compact space sensors demonstrate advanced methods to characterize ionospheric structure and particle energy deposition on regional scales, highly relevant to operational systems, including communications and radar.

### Point of Contact

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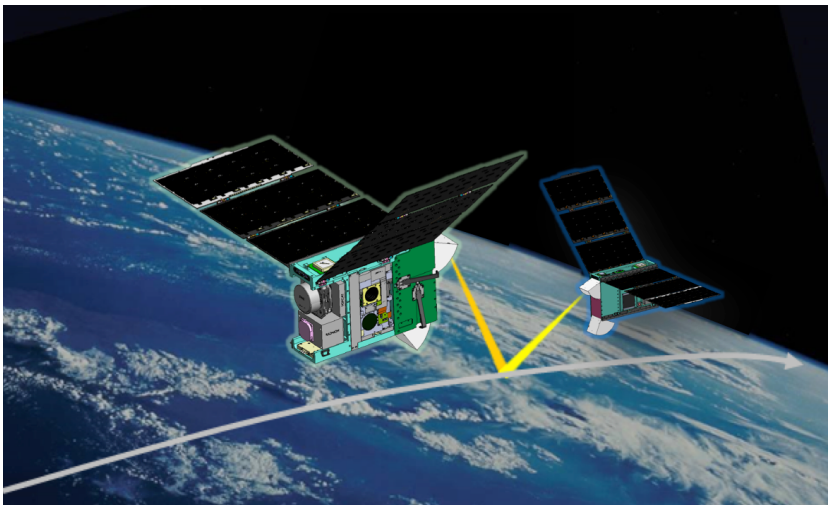


*CIRCE dual CubeSats will fly in tandem in low Earth orbit to characterize ionospheric 2-dimensional structure (vertical and horizontal) using advanced UV and radio remote sensors and tomographic methods. Miniaturized in-situ sensors provide key insights to the radiation environment and density and composition in the spacecraft environment.*

## Objective

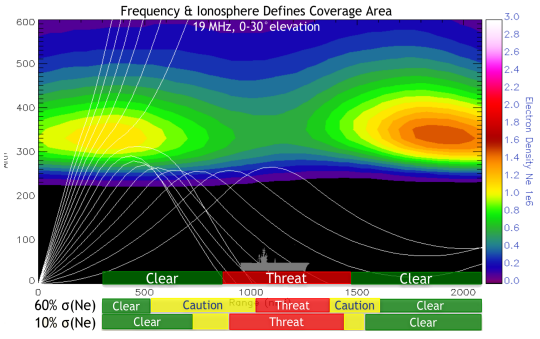
- Demonstrate passive remote UV and radio sensing with in situ particle detection aboard tandem CubeSats to specify the ionosphere and radiation environment from multiple viewing angles and locations with low-latency data return.

## Approach

- CIRCE remotely senses the ionosphere passively to characterize both its vertical structure and the horizontal gradients in the orbital plane.
  - Two GPS receivers derive vertical electron density and scintillation from GPS satellite occultations and topside measurements.
  - Four high-sensitivity 135.6 nm ultraviolet photometers measure in-track horizontal ionospheric gradients between the spacecraft
  - Local ion and neutral densities and charged particle radiation are measured at satellite altitude
- Tomography and data assimilation methods combine horizontal & vertical and remote & in-situ data to produce 2-D ionosphere maps in the orbital plane, focusing on the F-region ionosphere, relevant to DoD and Navy applications.
- Radar reflectors on one spacecraft provide opportunites for ground monitoring as the CubeSats operate in formation, maintained by differential satellite drag.

## Payoffs

- CIRCE provides risk reduction for advanced ionospheric sensing techniques planned for future mission concepts, including Persistent Volumetric Ionospheric Sensing of Targeted Areas (Persistent VISTA). CIRCE can also provide low-latency space weather data suitable for use in operational model.




*Signal propagation depends on the structure and density of the ionosphere.*

Ministry of Defence [dstl]