

ASTeRN

Advanced Surface Temperature Radiometer Network

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Background to Project

- Measurements of surface temperatures from satellite observations make an important contribution to long term climate data records
- To ensure the quality of these satellite data post-launch validation and in some cases recalibration against traceable 'truth' surface measurements is a fundamental element of the measurement system. This 'truth' data needs to be globally sampled across a range of surface types, ocean, inland waters, land, ice etc to maximise utility of the satellite data.
- Future missions are being developed for Land Surface Temperature (LSTM (ESA/Copernicus), TRISHNA (CNES), SBG (NASA)) and CEOS are exploring a network of radiometers to validate/calibrate the missions.
- Sea Surface Temperature measurements require enhanced capability to include measurements of the atmosphere.

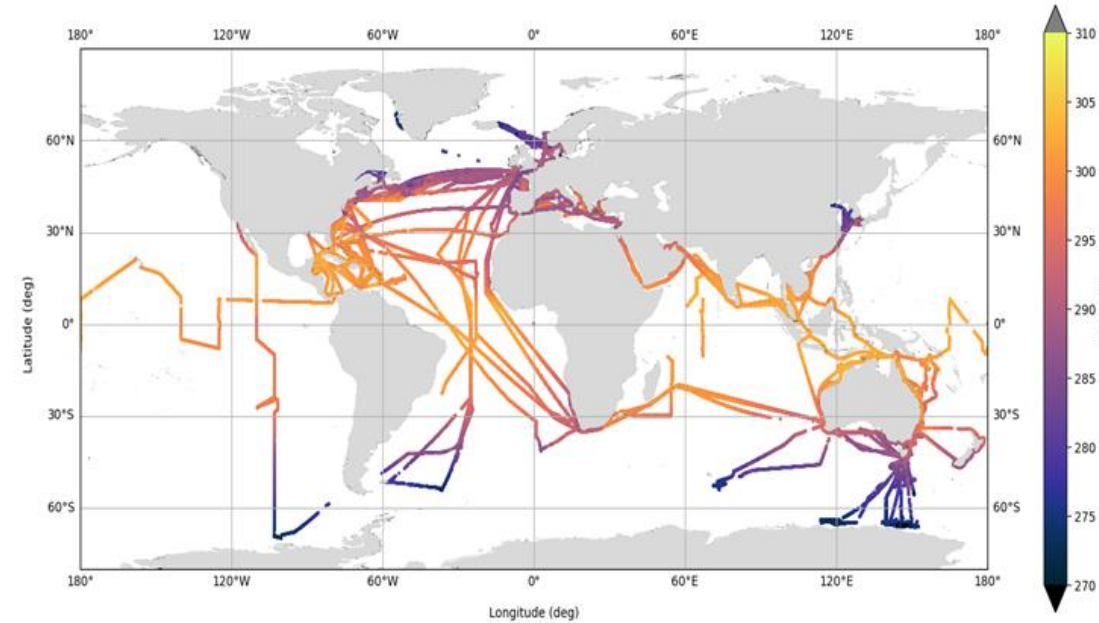
Current SST Radiometer Deployments



ISAR (UoS) >20 Deployments globally operated by different institutes



SISTeR (RAL Space)



- SST validation is supported by a number of autonomous self-calibrating ship-borne radiometers deployed by a number of institutes.
- ISARs have been deployed for LST measurements in Namibia and Greenland
- Validation of SST instruments is supported by periodic radiometer intercomparisons hosted by NPL
 - First intercomparison at Miami was initiated by IVOS

A new radiometer

- The current UK in situ radiometer designs (ISAR, SISTeR) are now 20+ years old.
- A new generation of radiometers are required to enhance and maintain capability for next decade.
 - Additional spectral channels for atmospheric characterisation
 - Extend capability for measuring Land Surface Temperatures
 - Address obsolescence issues,
 - Improve manufacturability and maintainability
- New radiometer design will be an evolution of existing designs:
 - Same basic measurement approach as existing instruments but drawing on lessons learned and incorporating modern components.
 - Ships4SST study has already defined requirements for the next generation

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- A**STeRN** = **A**dvanced **S**urface **T**emperature **R**adiometer **N**etwork
- The project is to design and manufacture radiometers with the capability for measuring **sea, land** and **ice surface temperatures** with high accuracy and precision.
- The design would be based on a recent study funded by ESA and performed by RAL and the University of Southampton.
- The radiometers will be calibrated to standards **traceable to SI** realised by NPL standards.
- Initial deployments scheduled for Q1 2025
- A**STeRN** is funded by UK Government EO Investment Plan

Participating Organisations

- Consortium is based on UK members of the Ships4SST consortium
- RAL Space
 - Consortium lead
 - Opto-electronics and calibration subsystems.
- Space ConneXions Ltd.
 - Project management support.
- Southampton University.
 - Overall mechanical and electrical design.
- Leicester University
 - Land Surface Temperature radiometer specification and deployment of a radiometer at a calibration site
 - Data analysis
- NPL
 - Calibration the radiometers at against a standard reference blackbody source.



Ships4SST radiometer intercomparison at Wraysbury reservoir

Key Requirements

- The instrument shall be capable of measuring radiances / brightness temperatures suitable for the calculation of:
 - SST for all combinations of sea and atmospheric temperatures
 - LST for most (T) / all (G) combinations of land and atmospheric temperatures
 - IST for a limited range of ice and atmospheric temperatures
- SST in the range $-2\text{ }^{\circ}\text{C}$ to $35\text{ }^{\circ}\text{C}$
- LST $-30\text{ }^{\circ}\text{C}$ to $50\text{ }^{\circ}\text{C}$.
- NE Δ T 50 mK (T) / 25 mK (G)
- BT systematic uncertainty (1σ) of 70 mK (T) / 40 mK (G) near to ambient temperature
- Skin SST measurements with a systematic uncertainty (1σ) of 100 mK (T) / 50 mK (G).

Key Requirements

• Self Calibrating

- Thermal InfraRed (TIR) radiometer containing **two blackbodies** placed at the end of the detector optical chain. I.e. calibrates full optical chain.
- One blackbody operated at the ambient temperature of the instrument and one black body operated at an elevated temperature
- Provides **traceability to SI**

• Multi View

- Views to an external scene in a range extending at least $\pm 90^\circ$ from local **nadir** to **zenith**.
- Allows measurement of surface at different view angles and air temperatures

• Autonomous Operation and Data Transfer

• Transportability

- Mass < 20kg
- Dimensions able to be handled by single person

Spectral Characteristics

Band Centre	Band Width	Application	Source
8.6 μm	0.24 μm	LST, Emissivity	LSTM
8.9 μm	0.24 μm	LST, Emissivity	LSTM
9.2 μm	0.24 μm	LST, Emissivity	LSTM
10.8 μm	0.9 μm	SST, LST	SLSTR
12 μm	1.0 μm	SST, LST	SLSTR
14.6 μm *	0.5 μm *	Air Temperature	-

*Subject to change

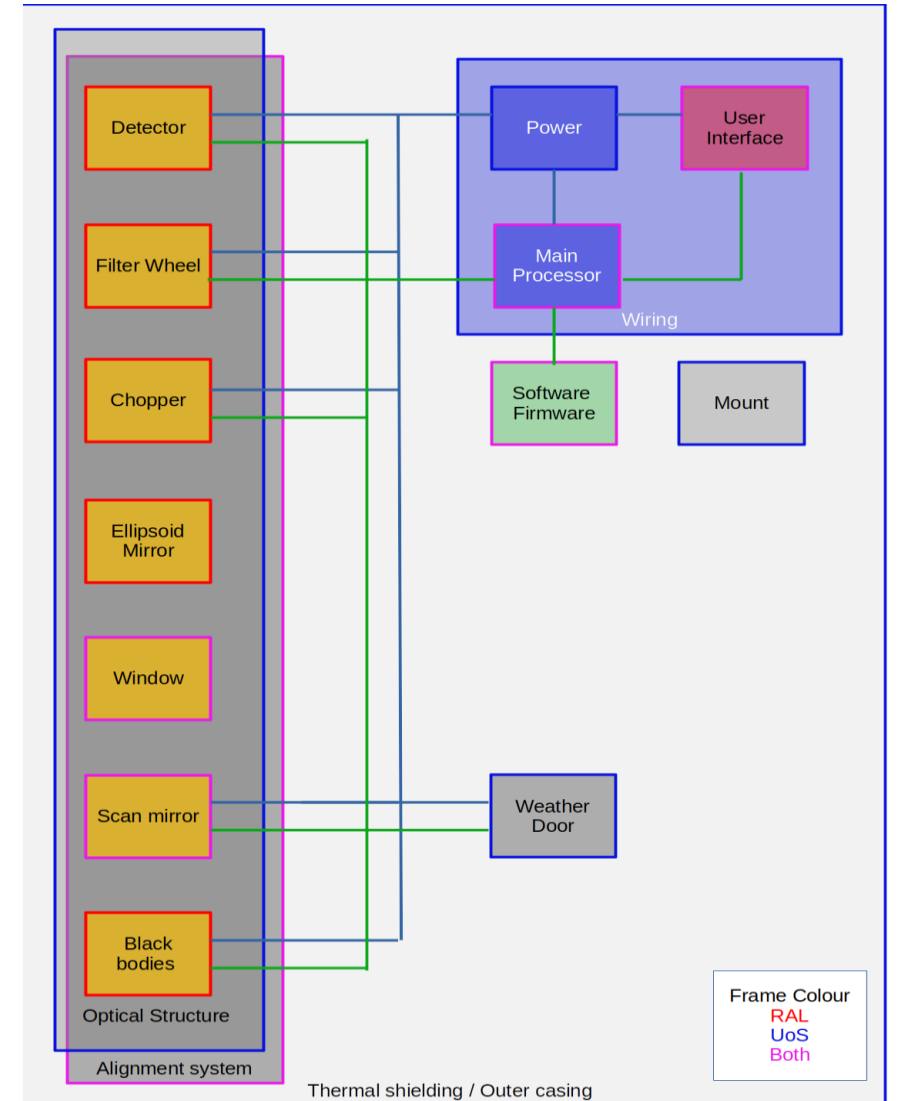
System Architecture

RAL Space

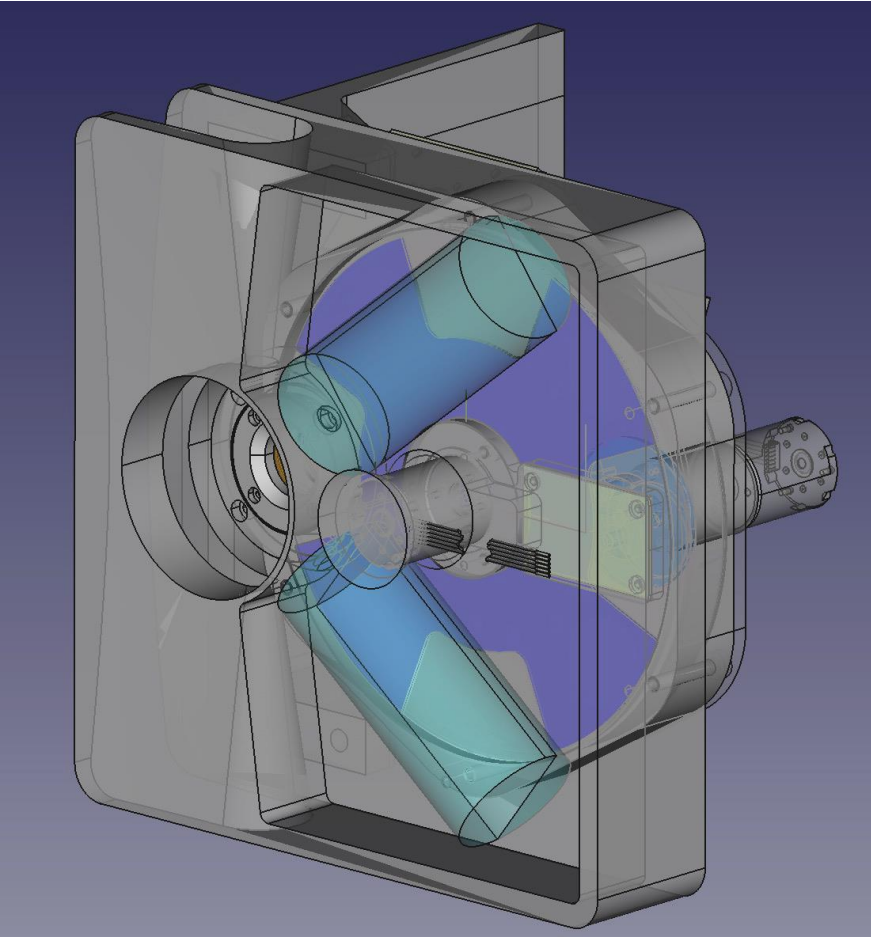
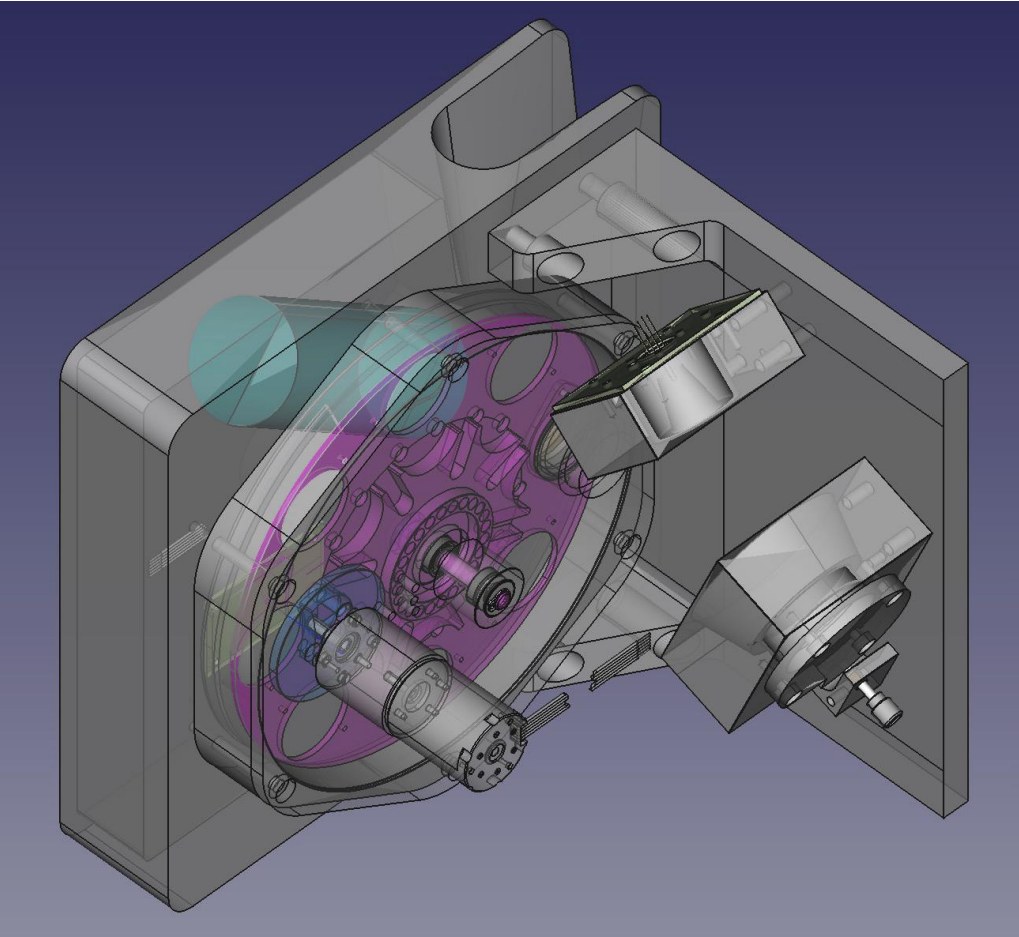
- ◇ Detection Chain
- ◇ Optical Bench Layout
- ◇ Blackbody Sources
- ◇ Electronics for opto-electronics

Southampton University

- ◇ Mechanical design and manufacture
- ◇ Main structure
- ◇ Rain gauge
- ◇ Door and shutter
- ◇ Main Electronics incl. processor and firmware.
- ◇ End-to-end checkout



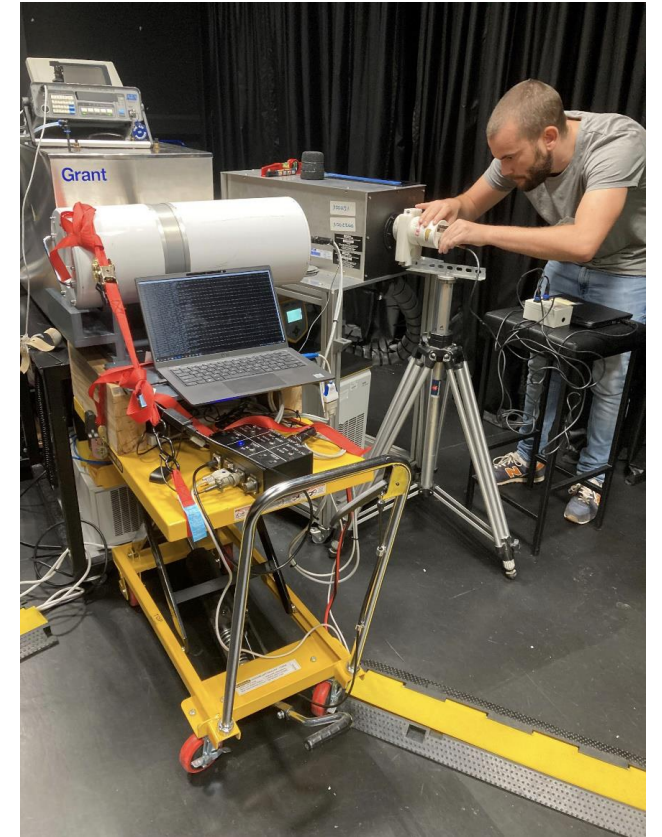
Optical Design



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Calibration and Deployment

- Calibration of radiometers will be against reference blackbody source at **NPL** as per Ships4SST intercomparison protocol.
- Transport and install SST Radiometers on ships (e.g. QM2, Pride of Bilbao)
 - Mechanical mounting
 - Electrical Checkout
 - Verify Transmission of Data
- Transport and install LST Radiometer at land site
 - Mechanical mounting
 - Electrical Checkout
 - Verify Transmission of Data
 - Install existing stock of LST radiometers to increase the geographic coverage for LST validation
 - Ensure common format for all datalogger outputs
 - Site operations



Radiometer Measurement against reference BB source at NPL during June- 2022 Radiometer Intercomparisons.
Ref: FRM4SST-CRICR-NPL-002_ISSUE-1