SMILE (Solar wind Magnetosphere Ionosphere Link Explorer)

Overview

- SMILE will use a new scientific technique to provide a fuller understanding of the Sun-Earth connection. It will deliver global 3D imaging of the Earth's magnetosphere for the first time and investigate its dynamic response to the impact of solar wind
- UK is providing the core scientific instrument, the Soft X-ray Imager (SXI), and co-leads the mission's scientific consortium
- The mission is the first full scale collaboration between the European Space Agency (ESA) and the Chinese Academy of Sciences (CAS)

The Earth's magnetosphere is the strongest of all the rocky planets in our Solar System and is thought to have played an important role in the Earth's habitability. Scientists believe that a key reason Mars lost most of its atmosphere and surface water was because it lost its magnetosphere.

SMILE is expected to answer three questions:

1. What are the fundamental modes of the dayside solar wind/magnetosphere interaction?
2. What defines the substorm cycle?
3. How do Coronal Mass Ejections-driven storms arise, and what is their relationship to substorms?

In order to answer these questions, SMILE will provide scientists with data and information on the location and shape of the outer magnetospheric boundaries (i.e., the magnetopause, the bow shock, and the magnetospheric cusps) and of the auroras, and how solar wind behaves next to these.

UK involvement

Leadership of the overall mission science and the SXI instrument enables the UK teams to shape its scientific data in line with their requirements and areas of expertise. In-depth instrument knowledge will mean that the UK research base is well placed to understand and exploit the data in the post-launch research and discovery phase.

Areas in which the UK is world leading — planetary science (Earth and beyond), solar physics, space plasma and astrophysics — are all served by the science explored by SMILE.

SMILE data will also provide real-world benefits by helping to improve scientific models used to forecast space weather.

Extreme space weather could disrupt modern technology by causing geomagnetic storms affecting satellite navigation, shortwave communications, and power

grids. A recent ESA study estimated the potential socio-economic impact in Europe from a single, extreme space weather event could reach €15 billion. Much of this disruption could be avoided through accurate forecasting.

The UK SMILE team has already carried out preliminary work with the Met Office Space Weather Operations Centre in view of supporting their work with SMILE data.

Teledyne e2v, based in Chelmsford, are supplying the SXI CCD detector devices under an approx. £1.5M contract to ESA. Joint academic-industry knowledge exchange with Open University on the CCD development programme will improve space radiation hardiness of the devices, maintaining this key UK technology for commercial sales and export opportunities.

UK company Photex Ltd has also been contracted to assemble the camera for the UVI instrument.

Further socioeconomic impact will be realised through:

- Technology development in X-ray detection instrumentation; the SXI detectors devices are the largest ever flown for X-ray detection
- Skills development in the academic institutes and the industrial supply chain
- Maintaining UK reputation and world leading status in SMILE science, leading to follow on projects, further funding
- New and strengthened international partnerships with China, Canada, and European consortium UK funding and roles

UK Space Agency funding of up to £10.5 million is agreed to support the UK roles below up to mission launch in 2023, with post launch support subject to further review.

Overall mission Co-Principal Investigator: Prof Graziella Branduardi-Raymont, UCL-MSSL. Leads mission level science development alongside Chinese counterpart Prof Chi Wang (Director of National Space Science Center, Chinese Academy of Sciences).

SXI instrument Principal Investigator: Dr Steven Sembay (University of Leicester). Leads European consortium building SXI instrument, with hardware and design contributions from international partners including Spain, Norway, Switzerland, US. Leicester led the overall telescope optics using innovative 'lobster-eye' micropore technology.

UCL-MSSL also provide SXI front end electronics (FEE), and Co-Investigator support role on Chinese led Light Ion Analyser instrument.

SXI Co-Investigator: Prof Andrew Holland (Open University). Testing and characterising performance of SXI instrument's CCD (Charged Couple Device) detectors.

SXI CCD detectors provided by Teledyne e2v (Chelmsford, UK) under separate contract to ESA.

Current status & next steps

- UK-China joint proposal selected by ESA and CAS in 2015
- Phase B1 study, and all instrument and mission level System Requirements Reviews, completed in 2018
- ESA Member States voted to formally adopt SMILE in March 2019
- SXI Preliminary Design Review complete in 2020
- SXI flight instrument delivery scheduled for mid-2023
- Launch date end of 2024