Daedalus: ESA’s Earth Explorer 10 mission candidate for lower thermosphere-ionosphere studies

Alex Hoffmann1,∗, Arnaud Lecuyot3, Theodoros Sarris2 for the Daedalus Teams3
1 European Space Agency, Noordwijk, The Netherlands, 2 Democritus University of Thrace, Xanthi, Greece, see below
∗ Contact: alex.hoffmann@esa.int (ESA/ESTEC Earth Observation Mission Science Division)

Context: the Living Planet Programme

ESA’s Living Planet Programme was originally conceived as an Earth Observation strategy to develop our knowledge of the Earth, to preserve the Earth and its environment, and to manage life on Earth in a more efficient way. Since its inception in 1998, the original strategy has been periodically updated, revising the key challenges in Earth system science across five Earth science disciplines: atmosphere, cryosphere, land surface, solid Earth and oceans (ESA SP-12330, 2015) and introducing interdisciplinary elements and advances accounting for interactions and interdependencies between disciplines and Earth system components.

Framework: the Earth Explorers

The Earth Explorer (EE) missions respond to the Science & Research element of the Living Planet Programme. Where the original 6 Explorers, E1 to E6, were launched between 1999 and 2017, the new generation of 6 Earth Explorers, E7 to E12, is currently in planning stage (Q3-4/2022). The 10th mission candidate, Daedalus, is one amongst 21 proposals retained for E10 Phase-0 studies up until the 2027 call for mission ideas, alongside Harmony, measuring surface deformation with bistatic SAR, and Hydrophorum, monitoring the glacial water cycle over Africa and Europe with geopositioned SAR.

Exploring the atmosphere-space transition region

Daedalus is a lower thermosphere-ionosphere mission concept, targeting the region between 120 and 200 km and above with a suite of instruments for comprehensive plasma and neutral atmosphere measurements on an elliptical orbit, to quantify key electrodynamic and Sun-Earth coupling processes. The original mission objectives were to:

1) Determine the energy balance and quantify heating processes in the T-I region, notably dealing with the geomagnetic meridian.
2) Investigate the causes of variations in the spatial and temporal temperature and composition structure of the T-I region.

Pathway to mission selection

Earth Explorer candidates are selected for preparation (Phase-0 and -A) or implementation (end of Phase-A) based on criteria of 1) relevance to the ESA research objectives for EO (science strategy, including major societal issues), 2) needs, usefulness and excellence, 3) uniqueness and complementarity, 4) degree of innovation and advancement of European EO capabilities, 5) feasibility and maturity, 6) timeliness, and 7) programmatics (schedule, cost, risks, synergies).

Phase-0 activities shall substantiate the above through separate scientific (1-4) and 2 parallel system/industrial (5-6) contract studies to:

1) Consolidate the science case and the mission requirements (MRD)
2) Assess the scientific feasibility and performance (Science Readiness Level), ultimately through E2E performance simulations (SRL-5 to end of Phase-A), tested and validated in realistic conditions/scenarios
3) Evaluate the mission’s potential scientific and/or societal impact
4) Support and improve the scientific maturity (SRL) with observational campaigns to test and consolidate the mission or measurement concept, the observing technique, and/or requirements; typically by deploying instrument demonstrations, prove sensitivity to the geophysical parameters (SRL-4) and later to “simulate” representative measurements (SRL-5) with error budgets, which can be also used to properly compare results to model simulations
5) Establish the technical requirements (SRD), feasibility, mission concept and architectural baseline, and evaluate preliminary trade-offs
6) Support the technical maturity (Technical Readiness Level) through technology pre-developments or risk eliminations (TRL-5 by end of Phase B1: breadboard component validated in relevant environment) whilst ensuring full traceability from the missions’ overarching scientific objectives (in MRD) down to technical requirements expressed in the SRD.

The scientific mission definition is overseen and endorsed by the Mission Advisory Group (MAG), an appointed group of independent experts from the scientific community.

Questions for CESAR:

• What are community requirements of T-I spaceborne or in situ measurements for model parameterization and development assessment/verification, as well as data driven exploitation and assimilation?
• What are community thoughts on major open T-I science questions (also from an Earth system science perspective), on coupling to the lower atmosphere and magnetosphere, and synergies with current efforts?
• What are the best models for science generation and OSSIE?

* imaging (K, L, S radio, optical, UV)
* science consortia
* industry consortia and other contributors

Member of:
• ESA Core/Advisory/Steering Committee
• T-I/Space Weather/Space Physics
• ESA European Space Agency

References

