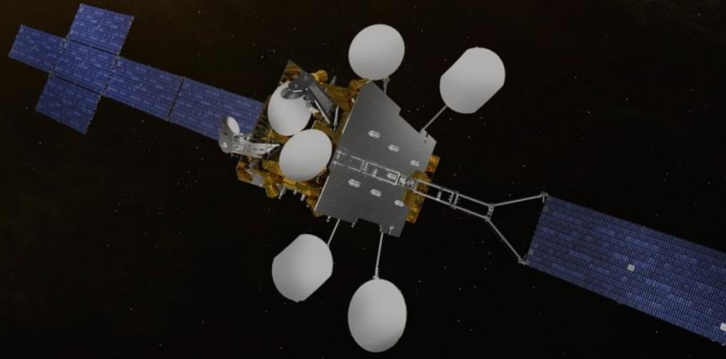
EDDA

EUROPEAN DIRECT-DRIVE ARCHITECTURE



The project has received funding from the European Union's Horizon 2020 Space Research Program under Grand Agreement N°870470

EDDA in a nutshell

EDDA

EUROPEAN DIRECT-DRIVE ARCHITECTURE

6 partners

02 years

40 delivrables

1M funding

H2020 EDDA will enable a transversal architecture compatible with various electric thrusters available on the market, allowing to enhance the global efficiency from solar array to thruster

Architecture benefit

- large telecom satellite with electric propulsion for orbit raising
- In-orbit service mission
- Interplanetary transportation

Partners

THALES ALENIA SPACE – France & Belgium

Leader in space telecommunications, navigation, Earth observation, exploration and orbital infrastructures

SITAEL – Italy

Design, Development and Production of Small Satellites, Advanced Propulsion Systems, Instruments and Avionics

THALES – Germany

Designs and manufactures Traveling-Wave Tubes, space amplifiers and ion thrusters

UC3M – Spain

Plasmas and Space Propulsion Team – Modeling, simulation and testing of plasma thruster technologies

EFFICIENT INNOVATION – France

Innovation Funding Consulting Company

Contacts

THALES ALENIA SPACE (coordinator)

Gilles BOUHOURS (FR)
Gilles.bouhours@thalesaleniaspace.com

Benjamin SPITAELS (BE)
benjamin.spitaels@thalesaleniaspace.com

SITAEL

Tommaso ANDREUSSI
tommaso.andreussi@sitael.com

THALES

Stefan WEIS
Stefan.WEIS@thalesgroup.com

UC3M

Eduardo AHEDO
eduardo.ahedo@uc3m.es

EFFICIENT INNOVATION

Matthieu FRANC
matthieu.franc@inextenso-innovation.fr

https://edda-h2020.eu/

Power Architecture

Two electrical architectures compatible with direct-drive have been defined for space applications during the project.

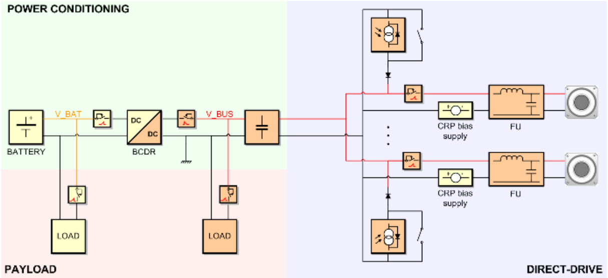


Figure 1: Solar array sections and the thrusters directly connected on the power bus.

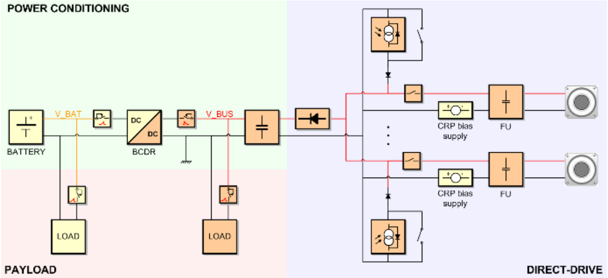
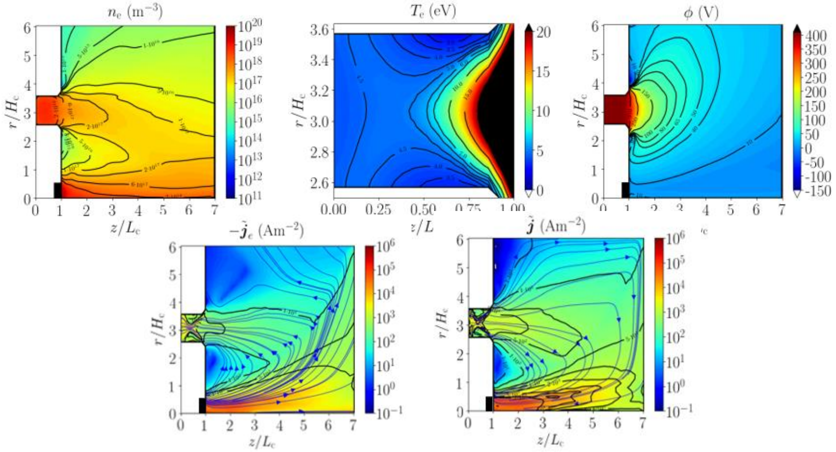


Figure 2: Solar array sections and the thrusters isolated from the power bus with a diode.

These two architectures can be used with two operating modes. During the orbit raising, the Maximum Power Point of the solar array can be tracked by acting on the bus voltage to provide as much power as possible to the thrusters. And once in orbit, the bus voltage can be regulated to a fixed value, and the solar array sections can be switched to supply the current required by the satellite (or the spacecraft).

Thruster numerical modelling

An axisymmetric code was adapted to analyze the plasma discharge in the magnetically shielded (MS) HT5k thruster unit. The simulations reveal mild variations of plasma density and electric potential inside the thruster channel, with maxima close to the magnetic singular point. The MS topology also channels effectively the plasma currents out of the walls. Isolines of low electron temperature spread around the chamber walls, thus yielding low power losses to the walls and ion impact energies below typical erosion thresholds. Electrons injected through the central cathode either flow downstream to neutralize the ion beam or move towards the channel to ionize the Xe gas. Collisions with cathode-injected neutrals improve noticeably the cathode-plume electric coupling. Simulations with modulated discharge voltages at 1-100 kHz frequencies show a mild effect on performances and discharge current oscillations. The RLC filter affects marginally the discharge.



The figures show the time-averaged axisymmetric simulations of electron density and temperature, electric potential, and the meridian electron and electric current streamlines, in thruster channel and near plume, for a particular operation point.

Power and thruster hardware

The power hardware of EDDA demonstrator was divided into 5 equipments : the Battery Simulator, the Solar Array Simulator (SAS), the active load, the Power Conditioning Unit (PCU) and the CRP bias supplies.

Figure 3: Power hardware of the EDDA demonstrator, with the PCU rack on the left and the "power" rack on the right composed of the Battery Simulator, of the SAS sections and of the active load.

The test on the two HETs was carried out on two different SITAEL's 5 kW Hall thruster models with two independent cathodes, SITAEL's HC20 for the HT1 and SITAEL's HC60 for the HT2. During the test, the two thrusters were isolated from the chamber ground and were mounted on a fixture plate that simulated the satellite structure. The HEMPT (THALES-D) unit has the capability to run up to 400V/20A and was tested with different levels of voltage and current.

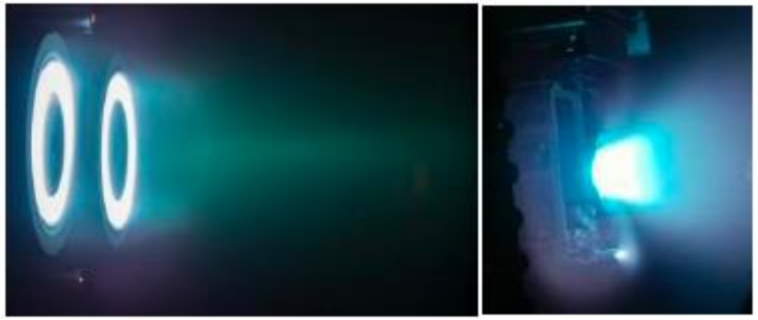


Figure 4: HT5k Hall thrusters during dual HET (left) and HEMPT (right) firing test of EDDA.

Test Results

The tests were performed with two different set ups, first with 2 HETs used simultaneously and then with a HEMPT operating individually.

The test sequence represents different operational phases for a geostationary satcom, from launch separation to telecom phase. It can be easily simplified to other types of spacecraft (Space-tug, transportation) where the main mission is electric propulsion.

In addition, some events that could happen during satellite life have been tested :

- Solar array string failure, corresponding to a 1.5A solar current decrease,
- Variation of power between the 2 thrusters, showing the capability to create a torque to change spacecraft thrust resulting orientation (HT1 min, then HT2 min),
- Variation of spacecraft platform consumption (+1200W, -1200W, +2400W, -2400W)
- Tracking maximum power from a minimum bus voltage (tracking from Vmin) or a maximum bus voltage (tracking from Vmax).

From the different runs, it was possible to verify the power regulation excellent behaviour (in MPPT or at fixed voltage) to adapt thruster power to available power. This regulation is compatible of both thruster technologies (HET and HEMPT). This architecture showed also its capability to drive two thrusters at a time, though a higher number is possible. And finally, the cathode supply limited the stray current.

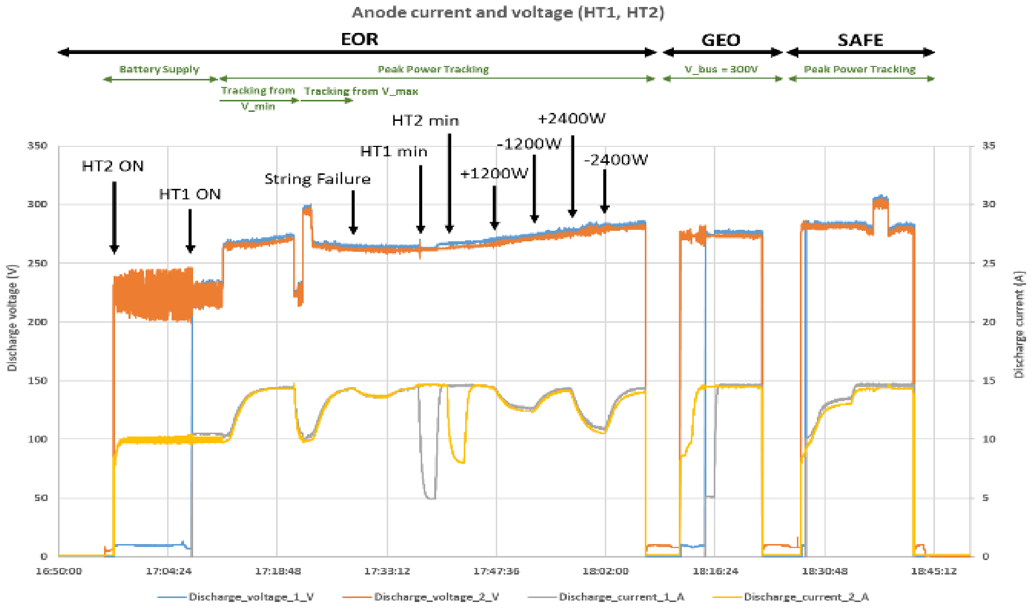


Figure 5: Current and voltage of each of the two HETs at 16A, 300V with a common CRP bias supply

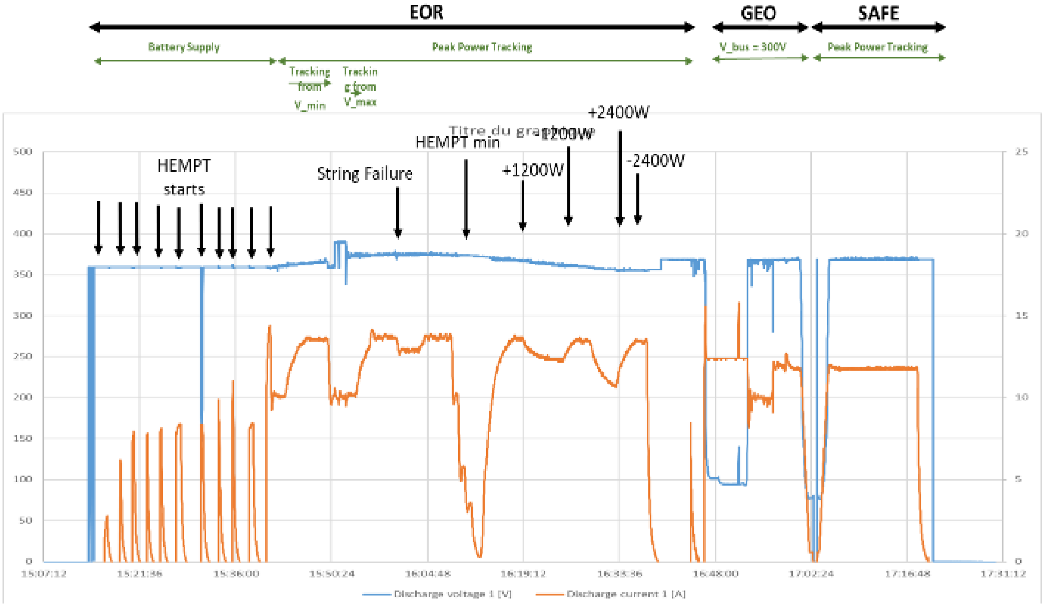


Figure 6: Current and voltage of the HEMPT at 16A, 300V

Conclusion

All EDDA's objectives were achieved, as evidenced below :

- Checked quality of the bus in direct drive
- Simulated the different operational phases of the spacecraft mission
- Confirmed feasibility of direct drive with several thrusters' technologies and operating in parallel
- Confirmed the concept of CRP supply for direct drive application
- Confirmed 2 regulation modes for direct drive

EDDA has been a great study to increase the TRL up to 4. Based on its successful results, further activities must be planned to go to TRL 8 or 9.In Orbit Demonstration is one of the ways to achieve it and is planned for 2024.