



Mission DragON

Eden Abeselom Habteslasie, Geovian Tadzi Stower, Vanessa Del Rio Ortiz, Chang Min Lee, Jan Tschakaloff, Florian Wehr, Kim Pia Schneider, Shri Hari Satheeskumar, Michael O'Donohue, Siya Patil, Bianca Weber, Felix Löser, Heba Gaballa, Janoah Dietrich, Enes Besli, Moritz Läßle, Taek-Hyun Kim, Vasileios Kolloiopoulos, Valasia Palaiothodorou

Team Green, Satellite Design Workshop (SDW) 2025

The Satellite Design Workshop is hosted by the Collaborative Research Centre 1667 "Advancing Technologies of Very Low Altitude Satellites" (ATLAS) at the University of Stuttgart, which is funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – Project-ID 516238647 – SFB 1667

The DragON satellite, developed at the Satellite Design Workshop 2025 is a proposed small satellite mission designed to push the boundaries of Very Low Earth Orbit (VLEO) operations. Scheduled for launch in 2034, DragON's two main objectives are to demonstrate Air-Breathing Electric Propulsion (ABEP) as a sustainable method of drag compensation and to test a Quantum Communication System (QCS) for secure data transmission in space. By combining cutting-edge propulsion and communications with proven spacecraft technologies, DragON aims to show that extended missions in the dense thermospheric environment are both possible and practical.

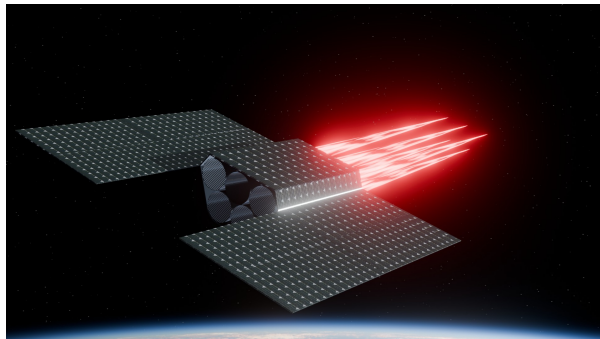


Figure 1: A render of DragON orbiting in VLEO.

Mission Phases

- 1. Launch and Commissioning:** Injection into a 400 km Sun-synchronous orbit by Isar Aerospace's *Spectrum*, followed by subsystem checks and deployment.
- 2. Controlled Descent:** Gradual lowering to 210 km while beginning early atmospheric measurements and quantum communication tests.
- 3. Nominal Operations:** Continuous ABEP drag compensation at 210 km, combined with QCS demonstration and science payload operations.
- 4. Extended Operations:** Descent below 210 km to test the ABEP in a denser atmosphere and assess system performance.

- 5. Deorbit and Disposal:** Controlled re-entry to meet debris mitigation guidelines.

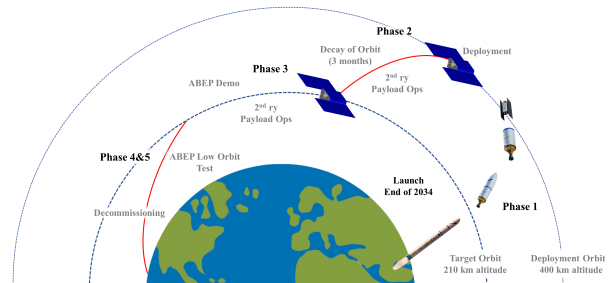


Figure 2: Concept of Operation.

KEY DESIGN DRIVERS

Operating at altitudes as low as 210 km presents a unique set of challenges. At these heights, atmospheric drag is significant, thermal conditions are highly variable, and continuous propulsion is required to maintain orbit. These constraints shaped the design trade-offs, with special emphasis on propulsion and the attitude and orbit control system (AOCS). Both subsystems directly influence the satellite's ability to remain stable, point payloads accurately, and fulfill mission goals

MAJOR SUBSYSTEMS DESIGNS

Mission Analysis

The DragON mission employs a circular Sun-synchronous dusk-dawn orbit at an altitude of 210 km. This orbit minimizes eclipse periods, providing nearly continuous solar power to support both propulsion and payload systems. It also offers an optimal atmospheric density for the air-breathing electric propulsion system, ensuring that drag is sufficient for propulsion testing while remaining manageable for power and thrust requirements.

Propulsion System

The propulsion system is the heart of DragON’s innovation. It uses five ABEP thrusters with specular intakes, four of which are fitted with grids for improved efficiency and one ungridded thruster serving as a technology demonstrator. Key parameters can be found in Table 1 and the thruster is illustrated in Fig. 3.

Table 1: System parameters for ABEP configuration.

Parameter	Value
Thruster Type	AFVEN ABEP thruster
Thruster Length × Diameter	90 × 180 mm
Intake Length × Diameter	311 × 1080 mm
Intake Grid	15 mm (Honeycomb)
Min. Ignition Pressure	0.1 Pa
Intake Efficiency η_C (EOL)	0.43
Thruster Efficiency η_T	0.32
Thrust / Thruster	3.6 mN
Power Consumption / Thruster	220 W

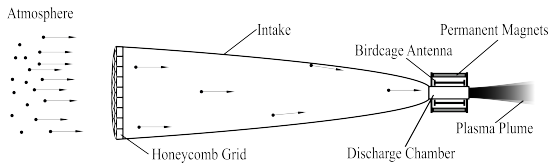


Figure 3: Schematic of one of the AFVEN ABEP propulsion systems used in the DragON mission.

Payload System

The payload configuration serves both scientific and technology demonstration goals. The ABEP performance is evaluated by an accelerometer to measure thrust and drag, retro-reflectors to track orbital decay, a FIPEX sensor for atomic oxygen density, and an ion and neutral mass spectrometer (INMS) for atmospheric composition, particle flow velocity, and density of the gas entering the ABEP intakes. By integrating FIPEX and INMS data, the mission achieves enhanced atmospheric characterization and more robust measurement reliability for VLEO research. The QCS is used to test quantum key distribution (QKD) during eclipse periods, using Ekert 91 protocol with 1550 nm wavelength for gathering scientific data on the feasibility of secure communication in VLEO for future quantum networks and quantum internet.

Electrical Power System

DragON uses world-leading quadruple-junction solar cells from Azur Space on deployable wings for efficient power generation at minimal aerodynamic drag. Energy is stored in a custom Li-Ion battery pack to supply the thrusters during eclipse.

Attitude and Orbit Control System

DragON’s AOCS aims to ensure a stable high precision orientation in VLEO, both highly critical for the ABEP and QCS operations. A 3-D axis momentum control is designed using reaction wheels and maintained by securing momentum dumping using magnetorquers. This arrangement ensures stable pointing and robust momentum management.

Thermal Control System

Thermal balance is a major challenge in VLEO. DragON uses a hybrid approach, combining passive systems—multilayer insulation, heat pipes, and reflective coatings—with active cooling provided by thermoelectric coolers and heaters. Such a balance ensures that sensitive instruments like the QCS remain within the operational temperature ranges.

Communication System

The payload suite supports both scientific and technological goals. The communications system uses S-band and X-band to provide reliable TM/TC and payload data transmission.

Table 2: Link Margin(End to End)

Link Type	Worst Case (dB)	Best Case (dB)
Uplink(S-Band)	7.53	39.26
Downlink(S-Band)	12.4	28
Downlink(X-Band)	10.92	26.94

CAD Design / Structure

The spacecraft adopts a compact bus structure with thrusters arranged in a honeycomb-like configuration to maximize intake area while reducing frontal drag. Deployable solar arrays fold neatly for launch and unfold once in orbit. A preliminary modal analysis resulted in low eigen-frequencies, further structural design is required to comply with launcher requirements.

BUDGETS

Table 3: Power and mass budget by subsystem.

Subsystem	Power [W]	Mass [kg]	Cost [﻿\$M]
ACS	379.0	44.70	15.370
COMS	28.3	1.39	0.137
Propulsion	1200	79.90	0.092
EPS	–	45.00	1.520
TCS	27.3	3.40	0.044
Payload	188.4	30.70	3.640
Structure	–	40.70	0.049
Additional	–	–	6.140
Total	1822.48	242.89	35