ATLAS News

for the Collaborative Research Centre 1667

Second Issue – August 2025

Contents

What's New?

Modelled after the highly popular *Space Station Design Workshop* format, which has been conducted at the University of Stuttgart since the 1990s and, more recently, also at the Technical University Munich, the first international *Satellite Design Workshop* will take place in September 2025 and see two mutually competing teams of university students and young professionals work tirelessly on designing their own Very Low Earth Orbit (VLEO) satellite mission concept in fulfilment of a challenging set of engineering and science objectives. Throughout this intense week, the participants will receive expert guidance directly from ATLAS researchers. In preparation for this event, the doctoral researchers of the Collaborative Research Centre conducted an internal workshop in early April, testing and refining procedures and purpose-made software tools, as well as surveying the typical and most critical engineering challenges and limitations associated with VLEO-based science mission profiles.

Following its debut at the previous annual *Tag der Wissenschaft* of the University of Stuttgart in 2024 shortly after the inauguration of the CRC 1667 ATLAS, members of the team participated at this year's event on 24 May with a more refined and appealing exhibition concept. Illustrated with the help of detailed 3d-printed models depicting what a purpose-built VLEO satellite might look like, interested members of the public could learn much about the research challenges and potentials involved in this yet unconquered aerospace realm. The team further exhibited its research activities at the *Luft- und Raumfahrttag* 2025 in the *Haus der Wirtschaft* in Stuttgart on 05 June, joining forces with other representatives from the university, aerospace industry and student initiatives to engage

Figure 1: Markus Graß and Felicitas Demattio of the ATLAS team presenting the Collaborative Research Centre's activities to the public at the annual Tag der Wissenschaft*.*

with and further inspire young spaceflight enthusiasts from schools across the state of Baden-Württemberg. This event constituted the concluding event of the *Mission Zukunft: on to new horizons* school student competition held in the framework of the state's *THE aerospace LÄND* initiative.

Figure 2: Doctoral researchers of the Collaborative Research Centre 1667 ATLAS tackling complex VLEO satellite mission and system design challenges during the internal Satellite Design Workshop.

The Collaborative Research Center 1667 ATLAS is funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – Project-ID 516238647 – SFB1667

sfb1667.uni-stuttgart.de
info@atlas.uni-stuttgart.de

Figure 3: Prof. Fabian Zander (middle) amidst ATLAS team members Dr. Stefan Löhle (left) and Lasse Voigt (right). [Photo: Courtesy of M. Eberhart].

This June, Assoc. Prof. Dr. Fabian Zander joined the ATLAS team from the Institute for Advanced Engineering and Space Sciences (IAESS) at the University of Southern Queensland (USQ), Australia. Having previously conducted his post-doctoral research in the *High-Enthalpy Flow Diagnostics Group* (HEFDiG), headed by Dr. Stefan Löhle at the Institute of Space Systems (IRS), Prof. Zander returned to collaborate with the team on Project A04: *Diagnostic Tools for Atomic Oxygen*. The project benefits from bringing his extensive expertise in the field of contact-less flow diagnostic techniques to bear on the measurement of oxygen number densities, which largely dominate actual and experimentally replicated VLEO environments. Further being a renowned expert on experimental hypersonics and on the remote observation of atmospheric entries, Prof. Zander presented insights into his own research and perspectives on the Australian aerospace landscape to the ATLAS team during a special guest lecture within the ATLAS Academy framework, captivating the audience with anecdotes from his experiences in numerous airborne observation campaigns of re-entering objects.

On 23 June, the ATLAS team was fortunate to welcome another renowned guest lecturer to discuss the problem of space debris risks, awareness and mitigation. Dr. Tim Flohrer, head of the Space Debris Office of the European Space Agency in Darmstadt and valued member of the Scientific Advisory Board of the CRC 1667 ATLAS, understands the uncertainties in modelling the dynamics of the Earth's thermosphere to be a central issue in ensuring sustainable and safe spacecraft operations both in traditional LEO and VLEO, as well as a key to addressing the space debris issue as a whole. His well-received presentation was followed by a fruitful discussion on the challenges ahead in predicting and managing the highly volatile atmospheric environment in VLEO with the ATLAS team.

Spotlight: Atmosphere-Breathing Electric Propulsion

Overcoming the severely limiting effect of residual atmospheric drag on a satellite's natural lifetime arguably constitutes the most notorious challenge to the sustainable operation of satellites in VLEO. Between 2009 and 2013, ESA's Gravity Field and Steady-State Ocean Circulation Explorer (GOCE) mission had successfully demonstrated the ability of electric rocket propulsion to fully compensate aerodynamic drag at altitudes as low as 230 km. However, aside from being able to extend a mission only until depletion of a satellite's propellant, the need to bring and store such necessarily adds to its launch mass. Addressing this very issue, Atmosphere-Breathing Electric Propulsion (ABEP), often also referred to as Air-Breathing or Ram Electric Propulsion, collects the impacting atmospheric particles that exert aerodynamic drag on the satellite. The collected atmospheric residue is then compressed and either stored as propellant for later use or relayed directly to the propulsion system to continuously generate the thrust needed to offset the orbit degradation of the spacecraft.

Figure 4: Apl. Prof. Dr.-Ing. Georg Herdrich leads Project B01: Atmosphere-Breathing Electric Propulsion Technologies

Project B01 of the Collaborative Research Centre 1667 ATLAS, led by apl. Prof. Dr.-Ing. Georg Herdrich of the Institute of Space Systems (IRS) is dedicated to the development and study of such propulsion systems. The doctoral researchers Elizabeth Gutiérrez and Konstantinos Papavramidis make up the core of his ABEP research team. Their focus lies on thrusters that, unlike the well-known and routinely deployed Hall effect ion thruster, require neither exposed electrodes, grids, nor neutralizers to function. This ensures that the thruster suffers no degradation from exposure to the highly corrosive medium of the thermosphere, i.e. the desired propellant, which is dominated by the presence of atomic oxygen radicals.

Prof. Herdrich's team is no stranger to the fields of VLEO and ABEP, having previously been involved in similar research and development activities funded both by the European Space Agency and the European Commission. Most notably, this includes the Horizon 2020 DISCOVERER consortium spearheaded by the University of Manchester and leading to the development of the Radio-Frequency Helicon-based Inductive Plasma Thruster (IPT) laboratory prototype, which continues to be used as a model thruster and reference for further investigation, characterisation and developments at IRS. The IPT's most innovative feature is the so-called "birdcage" antenna design, which ensures that incoming particles are ionized efficiently. While novel to the world of electric propulsion, such antennae are well-known in the medical sector, where they are commonly used in Magnetic Resonance Imaging (MRI) technology, as well as more recently in nuclear fusion research. In the IPT, the acceleration of the charged particles is subsequently enhanced by the application of an external magnetic field generated by a solenoid. This setup

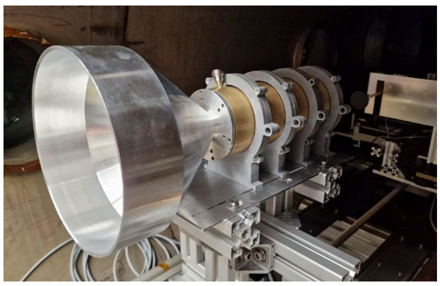

Figure 5: A laboratory prototype of an Atmosphere-Breathing Electric Propulsion (ABEP) system with intake integrated into an end-to-end experimental setup at the Institute of Space Systems (IRS).

The Collaborative Research Center 1667 ATLAS is funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – Project-ID 516238647 – SFB1667

Figure 4: Elizabeth Gutiérrez and Konstantinos Papavramidis discussing the intricacies of ABEP system engineering during internal Satellite Design Workshop.

ensures propellant exhaust velocities that exceed the speed of the spacecraft relative to Earth's atmosphere (i.e. its orbital velocity) by a comfortable margin, which is essential for a viable ABEP system.

One of the considerable challenges for the team of Project B01 within ATLAS lies in ensuring an efficient collection of the atmospheric particles to achieve the propellant densities required for the thruster to operate efficiently. A significant part of the researchers' work thus encompasses the exploration and assessment of different concepts and designs for particle collectors, i.e. intakes. A variety of designs are being investigated, with the feasibility of the most effective envisioned intakes ultimately depending much on the specifics of how the impinging particles interact with and reflect off a given surface – a question to the solution of which an entire project area of the CRC ATLAS is dedicated.

Other approaches for innovative ABEP intake designs are being studied in ATLAS Project B03, conducted by apl. Prof. Dr. rer. nat. Bernd Flemisch, Dr.-Ing. Martin Schneider, and Won Tae Lee from the Institute for Modelling Hydraulic and Environmental Systems (IWS), as well as Dr.-Ing. Marcel Pfeiffer from the Institute of Space Systems (IRS). Foreseeing the use of porous structures to trap and transport atomic oxygen or even actively augment the collected atmospheric propellant, the ATLAS researchers are developing and evaluating advanced numerical methods to upscale and efficiently assess the relevant processes on an ABEP-system-relevant macroscopic level.

As a key technology potentially defining the operational life cycle of a VLEO satellite in close interrelation with payload and mission requirements, ABEP systems are expected to constitute a major driver of VLEO spacecraft design and to essentially define its operational envelopes. Requiring careful harmonisation with the overall structure and layout, orbit and attitude control requirements, as well as electrical power generation and thermal management systems, viable ABEP-powered VLEO satellites will be particularly reliant on concurrent engineering techniques, invoking repeated iterations and trade-off analyses. For Konstantinos Papavramidis, the opportunity of addressing the engineering challenges arising from these multi-level dynamic interdependencies in a collaborative environment is one of the aspects he enjoys most about Project B01 and the Collaborative Research Centre, noting: "I find this feature of ATLAS quite fascinating and interesting, as it poses many challenging questions to be tackled in an environment that is not well-studied so far."

Learn More

[1] G. Herdrich, K. Papavramidis, P. Maier, J. Skalden, F. Hild, J. Beyer, M. Pfeiffer, M. Fugmann, S. Klinker, S. Fasoulas, N. Souhair, F. Ponti, M. Walther, A. Wiegand, L. Walpot, B. Duesmann, E.B. Borras, P.C.E. Roberts, N.H. Crisp (2024). System design study of a VLEO satellite platform using the IRS RF helicon-based plasma thruster, *Acta Astronautica* **215**, pp. 245-259. https://doi.org/10.1016/j.actaastro.2023.11.009

VLEO News

On March 15, the US company Albedo Space successfully launched and deployed its Clarity-1 satellite, which it considers to be the first commercial satellite designed for sustained operations in VLEO. Presently orbiting at around 450 km altitude, its designers ultimately foresee operations at around 300 km, facilitated by purposely optimized satellite bus hardware and a dedicated "Protect Mode", which foresees a high degree of operational autonomy and rapid responses to the environmental uncertainties of VLEO. From these heights, Clarity-1 intends to deliver "aerial-quality imagery" and shall operate as the cornerstone of a future 24-satellite constellation. [1]

March also saw the European Space Agency ESA announce its Strategy 2040, which outlines a total of five core goals. The first of these addresses the protection of our planet and its climate, which specifically includes taking on the growing space debris problem. While the furthering of space exploration and discovery remains another key goal, the European project is to be strengthened on various levels with regards to furthering European autonomy and resilience in space, by boosting growth and competitiveness in the space sector, and, last but not least, by inspiring the continent and its inhabitants through the fostering of a shared vision of spaceflight activities and an intensified collaboration between ESA's member states, the EU and further key stakeholders. VLEO technologies are explicitly mentioned among the roster of breakthrough performance technologies to be actively spearheaded as part of the goal to boost growth and competitiveness, alongside further technologies of immediate relevance to attaining and utilising sustainable VLEO operations. These include ultra-compact high-performance satellites as well as advanced remote sensing and next-level autonomous space systems. [2]

Complementing this development, the EU Space Act was formally proposed by the European Commission on 25 June 2025, introducing a harmonized regulatory framework for space activities across the European Union in an effort to ultimately replace thirteen existing national space laws by 2030. This proposal aims to establish a single market for space services, enabling start-ups, small and medium enterprises and large system integrators alike to operate more easily and with less red tape across all member states. The Space Act rests upon the three key pillars of safety, resilience, and sustainability, all of which constitute major motivators as well as challenges for the development of VLEO technologies and capabilities. [3]

Sources

[1] C. Oxford: "Clarity1 satellite begins VLEO mission after successful deployment", Space Daily, 18 March 2025, URL: https://www.businesswire.com/news/home/20250317584103/en/Albedos-Clarity-1-Satellite-Successfully-Launches-Establishes-First-Contact-and-

The Collaborative Research Center 1667 ATLAS is funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – Project-ID 516238647 – SFB1667

Enters-VLEO-Specific-Protect-Mode (accessed 2025-07-21).

[2] ESA – ESA Strategy 2024 The European Space Agency, URL: https://www.esa.int/About_Us/ESA_Strategy_2040 (accessed 2025-07-21).

[3] EU Space Act – European Commission. URL: https://defence-industry-space.ec.europa.eu/eu-space-act_en (accessed 2025-07-21).

What's Next?

Forty students and young professionals from Germany and around the globe have successfully applied to participate in the upcoming *Satellite Design Workshop* 2025, which is scheduled for 16-22 September. Interested members of the scientific community and the public are warmly invited to attend the final presentations of the satellite mission concepts, which are scheduled at 14:00 on Monday, 22 September 2025 at the *Raumfahrtzentrum Baden-Württemberg* (RZBW, Pfaffenwaldring 29) on the Vaihingen Campus in Stuttgart.

With approximately 40% of all relevant activities in Germany taking place within its borders, the state of Baden-Württemberg can rightfully be considered the beating heart of the German aerospace industry. The ATLAS team is thus excited to announce that planning is underway for a VLEO-themed Industry Day to be held in January 2026 in Stuttgart. This event shall bring together members of the industry, agencies and academia with a regional focus, providing a forum for delegates to learn about and exchange on state-of-the-art developments in the field of Very Low Earth Orbit technology and operations, to foster potential future collaborations and technology transfer initiatives, and to gauge the commercial and scientific interests and ideas of agencies and the regional aerospace industry. Stay tuned for further announcements!

This newsletter is brought to you by the management office of the Collaborative Research Centre 1667 ATLAS at the University of Stuttgart. The CRC 1667 is funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – Project-ID 516238647 – SFB1667.

Editors:

- Adam S. Pagan (Coordinator)
- Markus Graß (Public and Educational Outreach)

Further contributors to this issue:

- Konstantinos Papavramidis (Project B01)

Contact: info@atlas.uni-stuttgart.de