

Successful ESA Design Review Marks Key Milestone for Air-Breathing Electric Propulsion Development at TransMIT IQM



Project Cathodeless Electric Propulsion Thruster for Air-Breathing Electric Propulsion Systems

Gießen, March 26, 2026 – TransMIT GmbH, IQM Project division has successfully completed the **Thruster Design Review with the European Space Agency (ESA)** for their project “**Cathodeless Electric Propulsion Thruster for Air-Breathing Electric Propulsion Systems**”.

The review confirms the technical maturity and feasibility of the approach to developing a novel **air-breathing electric propulsion (ABEP) system** designed for satellites operating in **Very Low Earth Orbit (VLEO) – closer to earth than any time before**. The thruster integrates the most promising solutions for this particular target: a traditional Radio-Frequency Ion Engine with unique cathodeless functional features, eliminating the necessity

for a cathode sub-assembly, which is a critical component for ion thrusters' operation, but has shown to be borderline feasible for the ABEP concept.

The achievement represents a significant milestone in Europe's efforts to develop next-generation propulsion systems capable of enabling **sustainable satellite constellations at extremely low orbital altitudes**, utilising atmospheric particles as the thruster propellant to compensate for the drag imposed on the satellite by the very same particles.

A New Era for Satellite Propulsion

Very Low Earth Orbit — typically defined as altitudes below 200–300 km — offers compelling advantages for modern space applications. Satellites flying at these altitudes can achieve **higher-resolution Earth observation, lower communication latency, reduced launch energy requirements, and faster revisit times**.

However, VLEO also presents a fundamental challenge: the residual atmosphere exerts continuous drag that gradually slows satellites. Traditionally, spacecrafts compensate for that kind of drag (although of much lower values corresponding to much higher satellites' orbits) using onboard propellant — typically xenon in classic electric propulsion systems.

But this approach has a fundamental limitation: **satellites eventually run out of propellant**, which would happen especially fast at VLEO. Air-breathing electric propulsion offers a radically different solution. Instead of carrying propellant tanks, ABEP systems **collect the surrounding atmospheric particles, ionise them, and accelerate them to generate thrust**. The atmosphere itself becomes the propellant source.

The concept effectively enables satellites that **“breathe” the surrounding air to maintain orbit**, dramatically extending operational lifetimes and eliminating the need for onboard propellant storage. Technology also aligns with Europe's broader strategic priorities by reducing dependence on **scarce imported resources** and strengthening **European technological sovereignty in space**.

From Concept to Integrated System

Although the idea of air-breathing propulsion has existed for decades, building a **fully integrated and operational system** has proven extremely challenging. TransMIT IQM was among the few parties worldwide and the first in Europe to tackle this technology. Back in 2011, the company took part in the very first European Project Preliminary Characterisation Test Campaign of EP Technology with Non-Conventional Propellants, which aimed to confirm the potential feasibility of the ABEP concept. TransMIT IQM was responsible for testing the Radio-Frequency Engine to the requirements previously identified by ESA within the corresponding CDF. Amongst the most important achievements are the first demonstration of stable RIT (Radiofrequency Ion Thruster) operation using atmospheric gases as propellants, and the full compensation of projected drag within the offered power budget for the required altitude range. The campaign also provided essential lifetime and erosion data relevant for Very Low Earth Orbit (VLEO) missions.

Since this initial activity, TransMIT remained active in establishing a solid foundation for the physical and engineering aspects of ABEP propulsion, investigating its feasibility across all the different aspects of this very complex topic at both the system and sub-system level. A number of studies were conducted on radio-frequency ion engines, cathodes and intake designs for various sizes and potential mission target scenarios. Multiple aspects related to complex on-ground verification of the ABEP propulsion, proper identification of its performances, as well as generation of representative particle flow in the vacuum chamber to feed the ABEP system have been tackled over the past 15 years.

The current project aims to **demonstrate a cathodeless version of a radio-frequency air-breathing electric propulsion thruster**, integrating plasma generation with ion and electron acceleration in a realistic configuration suitable for small-satellite platforms without compromising already shown capability to compensate the drag.

At the heart of the system is a **novel radio-frequency (RF) ion source** developed by TransMIT.

The RF discharge operates **without electrodes inside the plasma**, reducing erosion and enabling longer operational lifetimes — a critical factor for continuous propulsion in VLEO. The grid system provides sufficient acceleration to the particles to meet the minimum feasibility needs and beyond, ensuring high efficiency and controllable thrust.

Building on extensive prior developments and internal studies, TransMIT has identified design approaches and material selections that are compatible with long-duration operation. Earlier system iterations have demonstrated the capability to reach lifetimes on the order of 60,000 hours. The present design leverages these validated solutions and does not introduce elements that are expected to degrade performance in the demanding VLEO environment.

European Expertise Driving Innovation

The project combines complementary capabilities from industry and academia through the collaboration between TransMIT GmbH and the Bundeswehr University Munich.

TransMIT brings extensive experience in developing RF ion thrusters and plasma sources, supported by established vacuum testing capabilities. The Department of Plasma Technology and Fundamentals of Electrical Engineering at the Bundeswehr University Munich provides advanced know-how in plasma diagnostics, vacuum experimentation, and modelling of gas–surface interactions in VLEO — a key factor for reliable performance and lifetime prediction.

The division of responsibilities reflects this synergy: TransMIT leads the thruster development and experimental validation, while the University focuses on orbital analysis and air intake design. This integrated approach enables a comprehensive system-level understanding of atmosphere-breathing propulsion.

Together, the partners aim to deliver one of the few experimentally validated end-to-end air-breathing propulsion systems worldwide. The work is driven by a strong research focus, targeting higher technology readiness and paving the way toward practical implementation.

Enabling the Next Generation of VLEO Missions

Following the successful ESA Design Review, the project now moves forward toward **hardware development, integration, and experimental testing** of the downscaled prototype.

The results will provide valuable experimental data for future development steps and contribute to establishing a **technology roadmap toward operational air-breathing propulsion systems for satellite constellations**.

By enabling satellites that effectively **“breathe” the surrounding atmosphere**, the technology could open the door to a new class of **high-performance, sustainable, and cost-efficient space missions** in very low Earth orbit.

About the Project

The activity **“Cathodeless Electric Propulsion Thruster for Air-Breathing Electric Propulsion Systems”** is conducted by TransMIT GmbH and supported by the Bundeswehr University Munich and funded by the **European Space Agency (ESA) under the ARTES Advanced Technology (AT) programme [Contract No. 400014759125UKAL] Cathodeless Electric Propulsion Thruster**.

The project focuses on the **experimental characterisation of a Cathodeless Electric Propulsion Thruster for ABEP**, paving the way toward future commercial VLEO satellite constellations.

More information:

<https://iqm.transmit.de/en/research-and-development/ongoing-projects/cathodeless-electric-propulsion-thruster>

Notiz für die Redaktion

Die TransMIT GmbH erschließt und vermarktet im Schnittfeld von Wissenschaft und Wirtschaft seit 1996 mit rund 150 Angestellten das Innovations-Potenzial zahlreicher Wissenschaftler aus mehreren Forschungseinrichtungen in und außerhalb Hessens. Direkt aus den drei Gesellschafterhochschulen der TransMIT GmbH (Justus-Liebig-Universität Gießen, Technische Hochschule Mittelhessen und Philipps-Universität Marburg) bieten mehr als 170 TransMIT-Zentren unter professioneller wissenschaftlicher Leitung innovative Produkte, Technologien, Dienstleistungen sowie Weiterbildungsveranstaltungen aus nahezu allen Fachrichtungen an. Der Geschäftsbereich Patentverwertung identifiziert und bewertet im Kundenauftrag Produktideen und Forschungsergebnisse und bietet diese international für Lizenzierung oder Kauf an. Das betreute Portfolio umfasst dabei alle Technologiefelder deutscher Hochschulen. Ergänzt wird dieses Angebot durch Leistungen für das komplette Innovationsmanagement von der Idee bis zum marktreifen Produkt im Geschäftsbereich Managed Innovation Services (MIS), insbesondere Fördermittelberatung und Projektmanagement für kleine und mittelständische Unternehmen. Darüber hinaus initiiert und betreut das Geschäftssegment Kooperationsnetzwerke & Neue Märkte Netzwerke zwischen KMU, die sich proaktiv weiterentwickeln wollen. Die TransMIT GmbH hat bei mehreren Rankings im Auftrag verschiedener Bundesministerien jeweils den 1. Platz unter den 21 größeren Technologietransfer-Unternehmen in Deutschland erreicht und ist autorisierter Partner des BMWi-Programms „go-Inno“ sowie der Innovationsberatung des BAFA. Referenzprojekte sind u. a. das Museum „mathematikum“, das Clustermanagement für die Medizinwirtschaft „timm“ und die BMWi-Projekte „SIGNO KMU-Patentaktion“ und „Erfinderfachauskunft“ sowie „WIPANO Unternehmen“. Die TransMIT GmbH war federführender Partner der Horizont2020-EU-Initiative KETBIO (Key Enabling Technologies in Biotechnology), baut aktuell über das Projekt GO-Bio initial den Transfererfolg in den Lebenswissenschaften aus und unterstützt GründerInnen im Rahmen der Förderinitiative EXIST. Gemeinsam mit StudiumPlus, Philipps-Universität Marburg und Regionalmanagement Mittelhessen betreibt die TransMIT derzeit mit TeamMit das Transformationsnetzwerk der Automobilindustrie in Mittelhessen.

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