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BUILDING REUSABLE HYPERSONIC SPACEPLANES: TECHNICAL FOUNDATIONS AND DEVELOPMENT ROADMAP

Abstract

Reusable spaceplanes are a revolution in the space transportation industry in the sense of possessing a cost-effective, versatile, and high-performance alternative compared to conventional vertical launch architectures. POLARIS Raumflugzeuge GmbH is at the forefront of the revolution, and its intended trajectory is to continuously develop aerospace vehicles to the pinnacle of the ultimate objective of a hypersonic-operational spaceplane. This paper first explains the technical principles and significant advances concerning POLARIS spaceplanes, before chronicling the developmental trajectory of the company with a perspective of attaining orbital capability.

Furthermore, the author discusses how POLARIS integrates rocketry – i.e. linear aerospike engine development - and aviation technologies to aid in the development of fully reusable spaceplanes with horizontal take-off and landing capabilities. As integration significantly reduces operating costs, enhances flexibility in missions, and decreases the production of space debris. An example of such technological development is the design of linear aerospike rocket engines, which can be up to 30The paper then showcases the roadmap to orbit, following a phased development strategy step by step. Starting with subsonic and supersonic unmanned aerial vehicles, future developments entail an increase in performance, going from hypersonic test vehicles, to finish with a reusable spaceplane with 1,000 kg payload capacity to orbit. Among the reached milestones sit MIRA-II flight tests, marking the first in-flight demonstration of a linear aerospike engine. This is largely possible due to the iterative design-build-test cycle followed at Polaris that drives a rapid validation of technological development. As a result, a total of ca. 140 flight tests were conducted in 2024 alone in a 260 km dedicated flight test range located in Peenemünde.

Lastly, the paper discusses wider uses of reusable spaceplanes outside of commercial satellite launch, such as dual-use aerospace technology applications like hypersonic defense, suborbital research, and space logistics. By examining the intersection of enabling technology, market pull, and strategic investment he paper offers an understanding of the use of spaceplanes to close the aviation-spaceflight divide.

Keywords: Reusable Spaceplanes, Hypersonic Flight, Linear Aerospike Engines, Space Transportation, Dual-Use Aerospace Technologies