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EDITORIAL

Retro propulsion assisted landing technologies: the RETALT project

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In the last years, significant progress in industrial technologies and digital communication caused remarkable changes in daily life of societies concerning their needs for space-based services. As a result, the number of global players that joined the competition for the development and operation of space transportation systems has been growing. A further important change is the increasing need for launches of satellite constellations, which require a different payload management because of the large number of satellites with small sizes and masses. The Launch Vehicle market is therefore under constant pressure to reduce the costs, while at the same time improving versatility. This ambitious goal of low cost, reliable and versatile high-performance launchers is unlikely to be achieved by evolutionary modifications to existing Expandable Launch Vehicles (ELV) systems alone. Major development steps are necessary to be competitive in the new market.

Due to the impressive success of SpaceX in terms of launch costs and reliability by using reusable launcher technologies, the reusability became one of the main game changers in the modern global market of launchers. For a while, Reusable Launch Vehicles (RLV) were considered not to be more efficient than ELVs. This common opinion was mainly based on NASA's experiences with the Space Shuttle Program (STS—Space Transportation System) where the boosters and the Space Shuttle Orbiter were reusable. Due to extremely high maintenance and refurbishment costs and long turn-around times, the launch of a STS was more expensive than the launch of comparable ELV at that time, e.g., the Ariane 5 or the Soyuz. However, new RLV developments by SpaceX and other US companies are changing this paradigm.

The key of the success of SpaceX is the focus on partial reusability, with the recovery of the first stage of the Two Stage To Orbit (TSTO) "Falcon 9" launcher configuration as starting point. Another very important feature of this launcher is its Vertical Takeoff Vertical Landing (VTVL) operation mode. Compared to Vertical Takeoff Horizontal Landing (VTHL) configurations, the architecture of the Falcon 9 and the landing site infrastructure are less complex. But the need for additional propellant for the retro assisted deceleration and landing is one of the drawbacks of this concept. The descent of the first stage during return flight is performed with the main engines supported by aerodynamic control surfaces. Using retro propulsion for the landing approach keeps the number of additional parts needed for this phase small and the design of the rocket simple. This makes the concept very cost-efficient and keeps the risk entailed with the development of such a system relatively small.

Complementary to the on-going ESA future launcher activities, the European Union (EU) "Horizon 2020" and "Horizon Europe" research and innovation funding framework programs include calls to reinforce the European capability of securing an independent access to space. Due to limited knowledge and expertise on reusability of launchers, both framework programs identified this topic as one of the key future technologies for competitive future European launchers. Following the spirit of the Horizon 2020 call, the German Aerospace Center (DLR) and the companies DEIMOS Space (Spain), MT Aerospace (Germany), Amorim Cork Composites (Portugal), CFS Engineering (Switzerland), and Almatech (Switzerland) formed a team and submitted the RETALT proposal with a focus on a VTVL launcher configuration with retro propulsion assisted descent and landing capabilities. The RETALT idea became a project after its successful evaluation in 2018.

Constraints in funding and the limited project duration of 3.5 years forced the RETALT team to focus on the development of selected technologies that are key to enable

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reusability and could be applied to a future reusable European launcher. Selected launcher configurations are preliminarily developed to be used as full-scale representative "test benches", or study cases, to assess the applicability of the technologies developed. The main configuration studied in the RETALT project is a reusable Two Stage To Orbit (TSTO) launcher with retro propulsion assisted descent and landing features. A Falcon 9 like flight configuration based on European technologies is used as baseline. A second configuration in RETALT covers the retro assisted VTVL approach for a Single Stage To Orbit (SSTO) RLV, as historically, many concepts of RLV are based on SSTO designs, e.g., the VentureStar, the DC-X and the Russian CORONA. Due to its higher relevance for the European launcher market in the short and medium term, the TSTO configuration was studied in greater detail than the SSTO configuration.

The 10 papers presented in this special issue cover the extensive range in research carried out in the RETALT project, and the results obtained. The first paper provides an introduction to the RETALT project, and it discusses the project objectives and initial design choices. Aerodynamic and aerothermal design including aerodynamic database (AEDB) and aerothermal database (ATDB) of the reference launcher with retro assisted descent and landing in combination with aerodynamic control surfaces is one of the selected research topics of RETALT. This includes unique aerothermodynamic tests including retro hot plume interaction tests in the wind tunnel, and CFD simulations of ground and full-scale flight experiments. The results of these studies are discussed in papers 2 to 5. Papers 6 and 7 are devoted to the mission analysis and the investigation of flying qualities along the complete trajectory, and the development of a GNC concept. A remarkable effort has been devoted to the development of new structural concepts (paper 8) and mechanisms (paper 9) for landing legs and control surfaces resulting in the manufacturing and testing of ground demonstrators. Development of a trowelable Thermal Protection System (TPS) for the base areas of RLV configurations with retro propulsion is another research topic of RETALT and is presented in paper 10.

The achievements of the RETALT project after 3.5 years of research and development activities are considered remarkable. Key challenges of a reusable retro propulsion assisted VTVL launcher configuration are believed to be understood very well and solutions for selected technologies have been developed. The RETALT team achieved a credible scientific acceptance worldwide and is meanwhile partner of the ArianeGroup consortium for the development of a new generation of European launchers.

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