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Design and Manufacturing Status of Advanced Structures for Reusable Launch Systems Demonstrators with Retro Propulsion Assisted Landing Technologies (RETALT)

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Abstract

To foster the competitiveness of the European industry on the global launcher market there is not only an urgent need of building up the necessary know-how on state-of-the-art Vertical Take-Off Vertical Landing (VTVL) Two Stage To Orbit (TSTO) concepts, but also to go beyond this approach. Historically, many concepts of Reusable Launch Vehicle (RLV) are based on Single Stage To Orbit (SSTO) designs, e.g. the VentureStar, the DC-X and the Russian CORONA. In the EU Horizon 2020 project RETALT (RETro propulsion Assisted Landing Technologies) the VTVL approach is also investigated for SSTO RLV. In this way, the concept of vertical landing with retro propulsion is investigated in a more general way and has the potential to be applied to more concepts of future RLV.

The vertical landing of an RLV applying retro propulsion is a complex multidisciplinary task. The investigation for both reference configurations will be performed in the areas of aerodynamics, aerothermodynamics and flight dynamics and GNC as well as advanced structural parts and materials, health monitoring systems and advanced propulsion assisted landing systems.

The focus of the contribution of MT Aerospace lies on design and manufacturing of hardware for aerodynamic and aerothermal experiments as well as demonstrators of structures and mechanisms of aerodynamic control surfaces and landing structures. Therefore, TRL 5 will be reached during the project.

This paper presents an outlook on the upcoming activities.

Keywords: reusable launcher, structures, landing leg, control surface

Acronyms/Abbreviations

Vertical take-off vertical landing (VTVL), single stage to orbit (SSTO), two stage to orbit (TSTO), reusable launch vehicle (RLV),

1. Introduction

This paper shows the planned work of MT Aerospace in the Project RETALT, which is funded by the European Union, is described in [1] and started March 2019.

The two main scientific and technological objectives of the RETALT project are:

- To investigate the Launch system reusability technology of VTVL TSTO RLV applying retro propulsion combined with aerodynamic control surfaces that is currently dominating the global market.
- To investigate the Launch system reusability technology of VTVL SSTO RLV applying retro propulsion for future space transportation systems.

To meet these two main project objectives of the project, described above, two reference launch vehicle configurations will be defined:

- A configuration similar to the SpaceX rocket “Falcon 9” that will be the reference for the state-of-the-art TSTO RLV (see Fig. 1).
- A configuration similar to the DC-X that will serve as a reference for a VTVL SSTO (see Fig. 2).

Fig. 1. Conceptual sketch of the RETALT1 spacecraft. Configurations from left to right: launch, stage separation, first stage descent, first stage landing.

Fig. 2. Conceptual sketch of the RETALT2 spacecraft. Configurations from left to right: launch, descent and landing.

A novel approach will be applied which is reusing the interstage and the fairing as aerodynamic control surfaces. This has the potential to further reduce the costs of future European launchers. From the main project objectives the following technical objectives are derived, which concern structures of the launcher which are MT Aerospace´s involvement in the project:

- To develop new structural concepts and mechanisms for landing legs and control surfaces and manufacture ground demonstrators and test them.
- To provide an estimation of the necessary investment and time schedule needed to reach TRL 8/9 of the technologies developed in the RETALT project.

2. Structures for RLVs

In the frame of this project, the objective is to develop low-cost, light weight and reliable structures and mechanisms for the aerodynamic control surfaces and the landing structures. For the structures and mechanisms loads and thermal loads have to be considered. The corresponding mechanisms will be developed by the project partner ALMATECH in close collaboration with the development of structures by MT Aerospace. The Thermal Protection System will be developed by the project partner AMORIM Cork Composites.

The challenge for the structures within this project will be to find solutions that are lightweight and, depending on the selected mechanism incorporate shock absorbing features. One way this may be achieved is to go away from massive single piece sandwich constructions to tubular frameworks made from composite materials. In order to obtain an optimum system weight, composite materials will be considered for the landing legs due to their good performance to weight ratio. Control surfaces may require metallic solutions to handle the high temperatures during re-entry. In particular when using the fairing or interstage structure as control surfaces, these will have to sustain significant aerodynamic and thermal loading, yet retain low mass. It can therefore be necessary to seek composite solutions for these structures as well with the appropriate heat shielding.

After the solution trade-off phase, the most promising concept for the aerodynamic control surface and the landing structure will be developed, designed and manufactured at a representative scale. Proof tests will be performed to validate the functionalities of the mechanisms and the structural behaviour of the systems (Landing leg and control surfaces).

Examples for potential structures and mechanisms for the two launcher configurations are shown in figures 3 to 7.

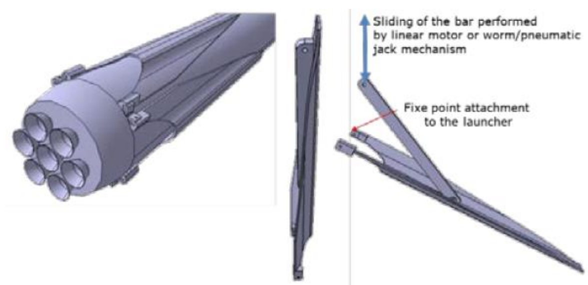

Fig. 3. RETALT1: linear actuator attachet to silidng bar

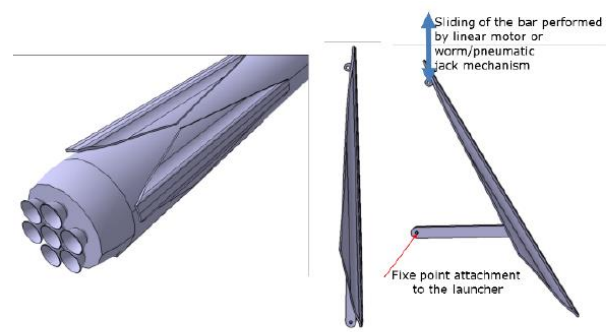

Fig. 4. RETALT1: leg structure attached to actuator

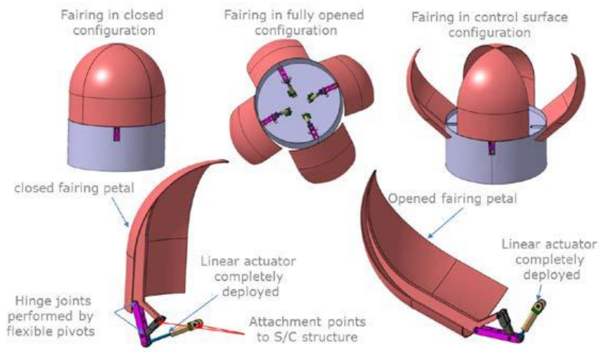

Fig. 5. Concept of aerodynamic control surface mechanism for RETALT 2

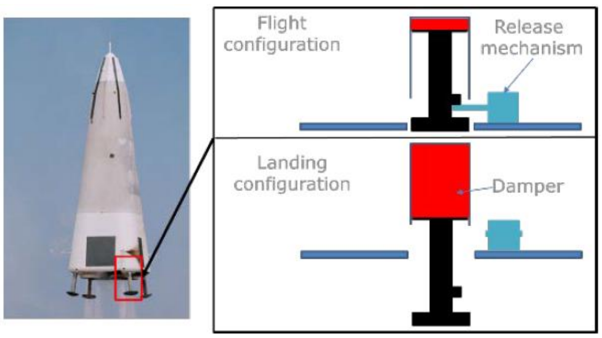

Fig. 6. RETALT 2: pneumatic cylinder

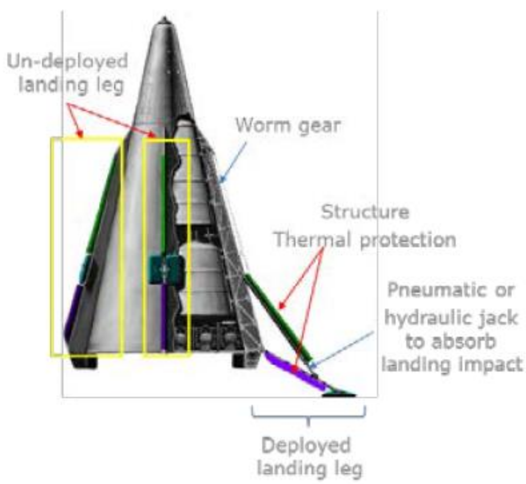

Fig. 7. RETALT 2: deployment kinematics

The challenge in developing reusable landing leg structures is in achieving a good balance between high strength and robustness on one hand and the structures being as light as possible on the other hand. During touch-down the legs are subjected to very large forces from the inertia of the launcher itself and the aerodynamic forces of the retro-burn. SpaceX has achieved a solution that uses a carbon fibre reinforced composite to produce their landing legs. The impact of the touch-down is absorbed within the actuators, thus the landing legs can be kept structurally simple. Clearly, the solution from SpaceX is simple, therefore the challenge within this proposal will be to find a structural solution that is lighter and, depending on the selected mechanism incorporate shock absorbing features for example tubular frameworks made from composites.

6. Conclusions

The project started in March 2019. The work on structures and mechanisms will start in September 2019, so there were no results achieved until now. The scope of this paper is to show the planned activities of MT Aerospace within RETALT.

Acknowledgements

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References

[1] A. Gülhan, A. Marwege, J. Klevanski, J. Riehmer, D. Kirchheck; “Retro Propulsion Assisted Landing Technologies (RETALT): Current Status and Outlook of the EU Funded Project on Reusable Launch Vehicles” IAC-19,D2,4,5,x49370, 70th International Astronautical Congress, Washington D.C., USA, 2019, 21 – 25 October.