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## HIGH-PERFORMANCE, PARTIALLY REUSABLE LAUNCHERS FOR EUROPE

**Abstract**

RLV configurations with partial reusability of 1st or booster stages are in focus of ongoing system studies. Several tandem launchers for different return and recovery modes, as well as propulsion options have been under investigation in DLR. These designed as TSTO for a GTO-reference mission turned out to be feasible, however, reaching significant size of up to 80 m length [1].

Approaching or even exceeding the payload performance expected for Ariane 6 in GTO or Lunar exploration missions would require extremely tall launcher configurations in case of tandem-staged TSTO with reusable first stage. Therefore, for this class of RLV a parallel stage arrangement is preferable: a winged stage is connected to an expendable upper segment with potentially various internal architectures. Reference [2] has demonstrated that a payload range between 12 to 15 tons GTO-class with multiple payload capability can be achieved by 3-stage architecture while still remaining at relatively compact size. Less demanding missions to different LEO can be served as TSTO.

The promising results of the configurations described in [2] have since motivated the refinement of the reusable and expendable stages' preliminary sizing. While up to now the main propulsion system was based on LOX-LH2 staged combustion cycle, this paper considers also the option of an advanced gas generator engine similar to the current PROMETHEUS development program. The two fuel options methane and hydrogen are looked at and architecture implications are discussed.

All the RLV-stages considered should implement the innovative method for the recovery of reusable stages, "in-air-capturing" [3]. One of the winged stages described in the paper serves as the full-scale reference concept for the ongoing European Horizon2020 research project FALCon focused on progressing "in-air-capturing by early flight testing.

The paper summarizes major results of the preliminary technical design process. The overall shape and aerodynamic configuration, the propulsion and feed system, the architecture and structural lay-out of the stages will be described and different technical solutions will be compared. An overview on the latest status of the FALCon-project will also be included in the paper.

[1] Stappert, S. et al: European Next Reusable Ariane (ENTRAIN): A Multidisciplinary Study on a VTVL and a VTHL Booster Stage, IAC-19-D2.4.2, 70th IAC2019

[2] Sippel, M. et al: Powerful Flexible Future Launchers in 2- or 3-stage Configuration, IAC-19-D2.4.8, 70th IAC2019

[3] Sippel, M. et al: Highly Efficient RLV-Return Mode "In-Air-Capturing" Progressing by Preparation of Subscale Flight Tests, 8th EUCASS, Madrid 2019