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Title

Further Progress in Aerodynamic Studies for CALLISTO - Reusable VTVL Launcher First Stage Demonstrator

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Abstract

DLR, CNES and JAXA jointly continue the developing of the a vertical take-off and landing (VTVL) reusable subscaled first stage demonstrator CALLISTO, which has to show the capability to launch, land and relaunch a vehicle under conditions representative for the first stage of an operational launch vehicle in the several demo-flights. Furthermore, during CALLISTO demonstration flights, data will be gathered to improve knowledge on the operation of a reusable vehicle which will help to optimize the reusability capabilities of future launch systems [1-2]. The key challenge is to create an extensive aerodynamic data base covering all the flight configurations and conditions which than can be used for 6-DoF flight dynamics simulation, considering the complex aerodynamic shape of the demonstrator with limited computing resources. Indeed, the aerodynamic performance plays a central role in the global performance of CALLISTO. In the period of 2020-2022 the extensive aerodynamic database (AEDB) with uncertainties and aerothermodynamic database (ATDB) based on the numerous CFD-simulations and wind tunnel measurement campaigns were created. The AEDB and ATDB are extensively used for the GNC design and tuning and 6DoF flight simulations (including Monte-Carlo). The actual AEDB and ATDB relate to the detailed layout of CALLISTO corresponding to the state of 2019-2020 called aeroshape CAL1C. At the same time, in the process of design development, significant changes and details were made to the layout of the demonstrator, resulting in a new aerodynamic shape called CAL1D (state 2022). The limited computing resources and time plan do not allow repeating all CFD-simulations and wind tunnel test campaigns performed for CAL1C. The paper will discuss the concept and methodology called "delta-aerodynamics" which allows applying the existing database for the new aeroshape CAL1D with only minimal necessary corrections.

References

- [1] Dumont, Etienne et. al. (2022) *CALLISTO: A Prototype Paving the Way for Reusable Launch Vehicles in Europe and Japan*. 73rd International Astronautical Congress (IAC), 18-22 September 2022, Paris, Frankreich.
- [2] Klevanski, Josef and Reimann, Bodo and Krummen, Sven and Ertl, Moritz and Ecker, Tobias and Riehmer, Johannes and Dumont, Etienne. (2022) *Progress in Aerodynamic Studies for CALLISTO - Reusable VTVL Launcher First Stage Demonstrator*. EUCASS 2022, 27.Jun. - 01. Jul. 2022, Lille, Frankreich.
- [3] Ecker, Tobias and Ertl, Moritz and Klevanski, Josef and Krummen, Sven and Dumont, Etienne (2022) *Aerothermal characterization of the CALLISTO vehicle during descent*. EUCASS 2022, 27.Jun. - 01. Jul. 2022, Lille, Frankreich.
- [4] Ertl, Moritz and Ecker, Tobias and Klevanski, Josef and Dumont, Etienne and Krummen, Sven (2022) *Aerothermal analysis of plume interaction with deployed landing legs of the CALLISTO vehicle*. EUCASS 2022, 27. Jun. - 01. Jul. 2022, Lille, Frankreich.
- [5] Riehmer, Johannes and Kapteijn, Kees and Klevanski, Josef, and Reimann, Bodo and Krummen, Sven and Gülhan, Ali and Dumont, Etienne. (2022) *Wind Tunnel Experiments of the CALLISTO VTVL Launcher in the TMK and HST Wind Tunnels*. EUCASS 2022, 27.Jun. - 01. Jul. 2022, Lille, Frankreich.
- [6] Dumont, E. et. al. (2021) *CALLISTO: A Demonstrator for Reusable Launcher Key Technologies*. Transactions of the Japan Society for Aeronautical and Space Sciences, Aerospace Technology Japan, JSASS 19 (1), pp. 106-115, 2021, DOI: [10.2322/tastj.19.106](https://doi.org/10.2322/tastj.19.106).
- [7] Guedron, S. et. al. (2020) *CALLISTO DEMONSTRATOR: Focus on system aspects*. 71th International Astronautical Congress, 12.-14. October 2020, online. URL: <https://elib.dlr.de/138808/>
- [8] Klevanski, J. and Ecker, T., Riehmer, J. and Reimann, B., Dumont, E., and Chavagnac, C. (2018) *Aerodynamic Studies in Preparation for CALLISTO - Reusable VTVL Launcher First Stage Demonstrator*. 69th International Astronautical Congress (IAC), 1-5 October 2018, Bremen, Germany. URL: <https://elib.dlr.de/122062/>
- [9] Marwege, A., Riehmer, J., Klevanski, J., Gülhan, A., Ecker, T., Reimann, B. and Dumont, E. (2019) *First Wind Tunnel Data of CALLISTO - Reusable VTVL Launcher First Stage Demonstrator*. EUCASS 2019, 1-4 July 2019, Madrid, Spain. URL: <https://elib.dlr.de/128629/>
- [10] Marwege, A., Riehmer, J., Klevanski, J., Gülhan, A. and Dumont, E. (2019) *Wind Tunnel investigations in CALLISTO - Reusable VTVL Launcher First Stage Demonstrator*. 70th International Astronautical Congress (IAC), 21-25 October 2019, Washington D.C., United States. URL: <https://elib.dlr.de/132566/>
- [11] Riehmer, J., Marwege, A., Klevanski, J., Gülhan, A. and Dumont, E. (2019) *Subsonic and Supersonic Ground Experiments for the CALLISTO VTVL Launcher Demonstrator*. International Conference on Flight Vehicles, Aerothermodynamics and Re-entry Missions & Engineering, 30 September – 3 October 2019, Monopoli, Italy. URL: <https://elib.dlr.de/137501/>