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Review

System driven technology selection for future European launch systems

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ABSTRACT

In the framework of the next generation launcher activity at ESA, a top-down approach and a bottom-up approach have been performed for the identification of promising technologies and alternative conception of future European launch vehicles. The top-down approach consists in looking for system-driven design solutions and the bottom-up approach features design solutions leading to substantial advantages for the system. The main investigations have been focused on the future launch vehicle technologies. Preliminary specifications have been used in order to permit sub-system design to find the major benefit for the overall launch system.

The development cost, non-recurring and recurring cost, industrialization and operational aspects have been considered as competitiveness factors for the identification and down-selection of the most interesting technologies. The recurring cost per unit payload mass has been evaluated. The TRL/IRL has been assessed and a preliminary development plan has been traced for the most promising technologies.

The potentially applicable launch systems are Ariane and VEGA evolution. The main FLPP technologies aim at reducing overall structural mass, increasing structural margins for robustness, metallic and composite containment of cryogenic hydrogen and oxygen propellants, propellant management subsystems, elements significantly reducing fabrication and operational costs, avionics, pyrotechnics, etc. to derive performing upper and booster stages.

Application of the system driven approach allows creating performing technology demonstrators in terms of need, demonstration objective, size and cost. This paper

Abbreviations: AFP, Automatic Fiber Placement; AoA, Angle of Attack; AVD, Anti-Vortex Device; CFRP, Carbon Fiber Reinforced Polymer; COTS, commercial off-the-shelf; CX, LOX/LCH4 1st stage; DEC, Double Engine Centaur; ELV, Expendable Launch Vehicle; EMA, Electro Mechanical Actuator; EMC, Electro Magnetic Compatibility; ETF, Engine Thrust Frame; FLPP, Future Launchers Preparatory Program; FSW, Friction Steer Welding; GNC, Guidance Navigation and Control; GNSS, Galileo Navigation System; GTO, Geostationary Transfer Orbit; HMS, Health Monitoring System; HH, Two LOX/LH2 stages launch vehicle; HX, LOX/LH2 1st stage; HY, LOX/LH2 upper stage; IRL, Integration Readiness Level; ISS, InterStage Structure; ITS, InterTank Structure; LEO, Low Earth Orbit; LV, launch vehicle; MEMS, Micro-Electro Mechanical System; MDHB, Modular Data Handling Block; NDI, Non Destructive Inspection; NRC, Non-Recurring Cost; OTS, On-The-Shelf; PDR, Preliminary Design Review; PL, Pay Load; PLC, Power Line Communication; PX, Solid propellant 1st stage; PI, Solid propellant 2nd stage; RC, recurring cost; RoM, Rough order of Magnitude; RT, Research and Technology; SEC, Single Engine Centaur; SRM, solid rocket motor; S/S, subsystem; SW, SoftWare; TDVP, Technology Development and Verification Plan; TIG, Transient Inert Gas; TPS, Thermal Protection System; TRL, Technology Readiness Level; TSP, Time and Space Partitioning; US, upper stage; VPPA, Variable Polarity Plasma Arc; WRT, with respect to

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outlines the process of technology down selection using a system driven approach, the accomplishments already achieved in the various technology fields up to now, as well as the potential associated benefit in terms of competitiveness factors.
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Contents

1. Introduction

Advances in technology have been implemented in launch vehicles improvement or new launch vehicle design. The latter case applies to Falcon 9 for what concerns large use of Al–Li alloys to improve stages performance, non-pyrotechnic systems, advances in Merlin design etc. In case of European LV, improvement on flying launch systems and advances in new ones can be obtained by use of suitable technology, either innovative, either off-the-shelf, applicable to launch systems. In any case the crucial key for any technology to be taken onboard is its benefit in terms of payload mass and cost, while preserving/improving reliability and allow growth potential.

In the frame of the FLPP program, a special focus has been given to the upper stage “efficiency”, which will permit to limit the lower compound size (using the same technologies) and a better overall performance [1].

In order to make the new launch systems profit of new technologies and modern design, a top-down, bottom-up approach has been used. This paper shows how this approach has been used for the conception of the NGL main structures. The optimized design of these structures is essential for minimization of mass and cost of the overall system.

There are two main goals in the FLPP technology activity:

- Maturing technology for decision key points required by any future launcher's development.
- Acquiring new launcher technologies and associated system integration capabilities, an essential condition for the proper preparation of the future. Such technology developments allow reducing risks and time to market of the possible new developments, and are crucial for reducing cost and enhancing the long term competitiveness of European industry. Furthermore, they may also benefit possible evolutions of the current launchers.

2. High level requirements

In the frame of FLPP program, system investigations have been performed by AIRBUS-DS and ELV for the establishment of future European launch systems.

For the purpose of this paper, a launch system having its first qualification flight in 2025 or before has been considered. The envisaged performance in GTO permits to cover both institutional and commercial market by launching single payloads.

One of the main drivers for the launch system design is the recurring cost at a given launch rate and given time after the qualification flight. The recurring cost constraint is one main aspect of the top-down, bottom-up approach used for the next European launcher design. Other requirements are related to operational aspects, development cost and reliability.

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