

Improving the Brazilian Satellite Launch Vehicle

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Abstract

Two attempts have been made with the aim to launch the Brazilian satellite launch vehicle VLS. Unfortunately both launches were failed due to problems related to the first and second stage motors, which together build the low part of the vehicle.

The first vehicle of *Cruzeiro do Sul* program family, the VLS Alfa, will make use of the lower part of the first Brazilian satellite launch vehicle VLS, which is composed by solid propellant motors as first and second stages. Nevertheless the configuration of VLS Alfa will make use of a liquid engine as third stage, in replacement of the third and fourth solid propellant stages of VLS.

Comparing both vehicles with their typical configurations, as stated before, VLS Alfa simply doubles the payload capability of VLS for small satellites into LEO orbits. In a previous study the low part of VLS has been replaced by an only solid propellant motor with the same total propulsive energy amount. The obtained results have shown a very representative gain in performance due to the slender design of the resulting configuration.

In a first evaluation the gains were only related to a better aerodynamic configuration of the concept. Presently this study has been continued with the scope to consider also the use of the launch site infrastructure already developed and built for VLS at the *Alcantara Launch Space Centre* in Brazil.

With these new requirements the diameter of the new solid propellant motor of the first stage has to be increased in order to shorten the vehicle length so that the complete vehicle should be accommodate in the already built Mobile Integration Tower at the launch site. This modification leads to the need of increasing the motor diameter from the actual 2 meters to 3 meters.

Due to the fact that the upper stage is based on a liquid propellant motor of 2 meters diameter, a conical inter-stage segment between both stages becomes necessary. This certainly will impose some aerodynamic losses related to the geometry changes, resulting in velocity losses which could be minimized establishing a new strategy for the low stage separation, i.e. designing the inter-stage to allow a hot separation of the stage.

The VLS Alfa should be designed to accomplish all Brazilian space missions already planned in the PNAE (Brazilian National Program for Space Activities), concerning the transport of small satellites to equatorial as also to sun synchronous orbits from *Alcantara Launch Space Centre* in Brazil.

The study firstly concerns the mission analysis and system requirements for VLS Alfa with the aim to prove its capability in attending the basic missions, e.g. insertion of small satellites into low earth orbits.

Furthermore, and in order to make VLS Alfa more attractive for governmental and private investors, an attempt is made to improve its performance and capability of transporting small satellites into sun synchronous orbits.

So, some new requirements are imposed regarding trajectory optimisation, aerodynamics, mass reduction through use of lighter materials, optimisation of staging events, eventually use of an apogee motor, reduction or simplification of on board subsystems or devices, etc.

The paper describes in detail the proposed vehicle, its actual performance and mission capability. Furthermore, a detailed discussion is presented, showing strategically the impact of one or other modification on the performance improvement of the vehicle.

The study is concluded with the proposition of an optimised configuration, and a trajectory and launch event strategy in order to attend all the actually defined Brazilian space missions.