ABSTRACT

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Subject : Day-of-launch wind biasing trajectory optimization impact on launch vehicles pre-dimensioning methodologies

In Reference 1, a first impact study of wind biasing methods on trajectory optimization for European launchers was presented. Such methods, commonly applied on other launch systems (especially US launchers), had never been envisioned in Europe, probably due to the relatively low level of altitude winds velocity in French Guiana, compared to higher latitudes.

Two different approaches have been studied : the use of a seasonal mean wind to bias the trajectory optimization, and the use of a wind measurement performed as close as possible to the flight time.

It has been demonstrated that the use of a wind measured during launch chronology (typically 3 hours before launch) to bias the trajectory optimization, and consequently atmospheric phase attitude commands computation, could allow to reduce the Q.α parameter of at least 50% (where Q is the dynamic pressure and α is the angle of attack). This parameter is the main driver of the lateral loads which are applied to the structure of the launch vehicle during the atmospheric flight.

A reduction of about 25% of the maximum commanded deflection to the TVC actuators of launch vehicle was also observed.

Such reductions probably depend on the launch vehicle benchmark characteristics, but are so significant that, if such methodology (called *day-of launch wind biasing*) was considered at the beginning of a launch vehicle development, a significant gain could be expected on structures and subsystems design. In a second step costs and mass savings can be expected.

This paper presents a tentative adaptation of the launch vehicle pre-dimensioning methodologies to take into account the positive impact of the day-of-launch wind biasing. This adaptation concerns the so-called "phase 1" methodologies for both TVC control and general loads rough dimensioning.

The first methodology aims at dimensioning the maximum needed deflection and deflection rate of nozzles, and consequently the TVC subsystem characteristics. For Solid Rocket Motors it also drives the characteristics of the flexible joint, and for liquid propellant engines, the gimbal design.

The second methodology aims at dimensioning the loads applied to the structural parts of the launcher (stages, skirts, booster attachments, etc.) through a first computation of a sizing Q.α gauge and mechanical fluxes.

Both these methodologies use simplifying assumptions and computations to ensure conservativeness in front of large set of unknowns at a preliminary step of development.

Proposed adaptations are first presented, and then validated on the same launch vehicle benchmark as considered in Reference 1, to ensure consistency with the expected impact on a developed launcher. Objective is to show that the statistical impact observed on the LV state parameters in a fully representative set of 6 dof simulations can be faithfully be obtained on the results of the "phase 1" methodologies applied to the same launch vehicle.

Once this validation performed, the adapted tools have been applied to an ARIANE 6 case study, and interest for structures and TVC subsystem assessed.

Reference 1 : LOADS ALLEVIATION ON EUROPEAN LAUNCHERS USING WIND BIASED TRAJECTORY OPTIMIZATION
Benjamin Carpentier, Pierre-Emmanuel Haensler, Benoit Mazellier and Amaya Espinosa-Ramos
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