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Assessment of uncertainties propagation in a launcher structural sizing chain

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[Abstract]: Astrium Space Transportation is the sole prime contractor of the Ariane 5 system and puts many competences at stake to size launchers. This complex task gathers multiple and interacting domains such as trajectory definition, thermal loads assessment, thermal modelling and sizing, mechanical sizing and dynamic prediction. To cope with the different interactions and to simplify the chain between these disciplines, one method consists in using the worst case approach to perform the sizing. It allows, with worst case assumptions, to get at the end a system which is robust, reliable and safe. However, the drawbacks of this method are the difficulties to master the margins. Besides, the launcher performances are hard to optimize with possible and non-quantifiable oversizings, leading to an impact on the mass budget.

Another method that could tackle the mentioned drawbacks is to use uncertainties propagation. This approach consists in propagating all the uncertainties on input data, models, and digital solvers through each piece of the sizing chain. Therefore, the final output is no more a worst value (corresponding to the worst case approach) but a variable of interest with its statistical distribution function. As an example, the uncertainties on atmospheric parameters, mass of the launcher, thermal and mechanical loads are propagated through the design chain in order to obtain the function of distribution of the thermo-mechanical stress. Moreover, an advantage of this method is that the weight of each dispersed input data can be determined on the final criterion. Finally, the uncertainties propagation method combines classical space disciplines with data flow management, probability and statistic modelling.

The objective of the present paper is to provide an assessment of the propagations of the uncertainties applied on the field of launchers. The complete set of tools used to manage these uncertainties are developed and described. Besides, this method is compared to the classical worst case approach through a test case in which, for different domains, the input data are dispersed and propagated into a chain of sizing. This comparison aimed to show the benefits of the uncertainties propagation method.