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Insuring Quality and Safety in a Cost Constrained Environment: Which Trade-Off? (1)

Author: Mr. Alexander Golikov
Central AeroHydrodynamic Institute(TsAGI), Russian Federation, agorgy@yandex.ru

INTEGRATED OPTIMIZATION AS A MEAN TO SOLVE A TRADE-OFF BETWEEN A QUALITY
AND SAFETY OF A SPACE LAUNCHER

Abstract

The problem to solve a trade-off between an increase in lift capability and safety of a space launcher is discussed. The reserves of a rise in launcher efficiency, which are latent at the border of aerospace disciplines in the current framework of design technology, are revealed on the basis of objective approach: the integrated optimization with the use of the experience in design of Russian launchers such as Energia-Buran, Angara, MRKS.

In order to simplify the interaction of specialists the safety requirements are usually set in enough general form at launcher designing. For example, in a practice of launcher ballistic analysis the constraints on flight regimes and control defined by structural strength requirements are taken into account, as a rule, as constraints on the maximum of a dynamic pressure, an angle of attack, a product of an angle of attack and dynamic pressure drag, g-load, etc. Thus the maximum allowed loads are really reached in the neighborhood of one or several points on the injection trajectory so the structure appears "underloaded" on a majority of the path. It results in underestimation of a launcher efficiency as compared with potentially accessible one.

In this paper the method to form the constraints on structure loading is offered on the basis of in-depth study in a series of points on the defined flight trajectory. Constraints are presented as the relations reflecting a change of permissible control and flight regimes along the path. Such approach allows to reveal additional reserves of increase in a launcher efficiency. The method is based on the use of thorough control optimization with the help of Pontryagin maximum principle.

It is instanced the optimization of launcher payload in view of limitations defined by conditions of structure loading during the flight in disturbed atmosphere. The optimization provided the increase in the payload of 4%, by means of control only at the thorough estimation of launcher loads.