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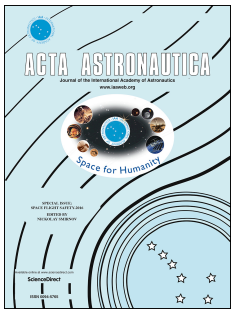

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Improving of technical characteristics of launch vehicles with liquid rocket engines using active onboard de-orbiting systems

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Abstract

In this paper, the analysis of technical requirements (TR) for the development of modern space launch vehicles (LV) with main liquid rocket engines (LRE) is fulfilled in relation to the anthropogenic impact decreasing. Factual technical characteristics on the example of a promising type of rocket "Soyuz-2.1.v." are analyzed. Meeting the TR in relation to anthropogenic impact decrease based on the conventional design approach and the content of the onboard system does not prove to be efficient and leads to depreciation of the initial technical characteristics obtained at the first design stage if these requirements are not included. In this concern, it is shown that the implementation of additional active onboard de-orbiting system (AODS) of worked-off stages (WS) into the onboard LV stages systems allows to meet the TR related to the LV environmental characteristics, including fire-explosion safety. In some cases, the orbital payload mass increases.

Key words: launch vehicle, liquid propellant residues, gasification, payload mass, impact zone, worked-off stages, active onboard de-orbiting system, re-entry.

Introduction

Main negative impacts on the environment in the LV launches are the WS and liquid propellant residues in the tanks after the main LRE turn off. Requirements to decrease anthropogenic impact on the environment are compulsory in the TR for LV design with main LRE, together with the requirement to provide the payload mass to the support orbit with the defined inclination. These requirements, being implemented to the WS, mean the minimization of the following parameters defining quantitative characteristics of the anthropogenic impact intensity:

- the orbit time of the WS on orbits in the protected zones of the near-Earth space environment after the mission implementation [1];
- the mass of liquid propellant residues in the tanks of the WS, that corresponds to the explosion safety requirement for the WS on orbits and prevention of space debris formation [2];
- areas of the WS impact zones and the fragments on the Earth surface [3].

Conventional techniques and the corresponding schemes and design decisions on decreasing anthropogenic impact on the environment of the main LV with LRE provide the following design sequence [4]:

- defining the design parameters for the LV for provision of energy and operational TR, including the insertion of the defined payload mass to the circular support orbit (the altitude of