

## 16th IAA SYMPOSIUM ON SPACE DEBRIS (A6)

Mitigation and Standards: status, lessons learnt and future with smallsats and constellations (4)

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ZENITH” LV UPPER STAGE PASSIVATION FOR SPACE DEBRIS MITIGATION MODERN  
REQUIREMENTS COMPLIANCE

**Abstract**

Unforeseen break-ups of explosive nature of the LV wasted stages are one of the basic sources of space debris formation. In the light of current international requirements and standard documents, modern experience of some LVs propellant systems passivation as effective method for space debris mitigation, quantitatively reducing their number by minimum twice is summarized. Passivation of propellant systems in the form a set of special and interlinked measures with introduction of some new devices and subsystems into LV pneudraulic system structure is presented. Complex physical, heat-mass exchange, - gas – dynamic processes, as well as the phase transformations occurring with the outflow of pressurization gases, vapors and remaining liquid propellant into vacuum are analyses in detail. Their features, boundary conditions of potential self-freezing and propellants hazardous and explosive situations are revealed. Taking into account a propellant type, inherent features of the propellant tank structure and orbital parameters, specific design solutions and features of their implementation are shown. Some new experimental – theoretical dependencies and ratios for calculation and definition of effecting factors are established. The methods of ground development tests minimizing expenditures are developed. Analysis results of succesful application of passivation system during “Zenith” LV flight are considered. Correctness of the accepted technical solutions and passivation system designing techniques is confirmed.