SPACE SYSTEMS SYMPOSIUM (D1)
Interactive Presentations (IP)

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NEW TOPOLOGY OF DEBRIS IMPACT POINTS DISPERSION

Abstract

A random dispersion of debris that are typical for separated parts (SP) of space launchers and their fragments after destruction in atmosphere is considered. Consequences of the debris fall are environmental pollution, property damage, and threat to human health and life. Therefore the problem of the debris ground impact area minimization is the priority one for a space launcher design and analysis of hazards.

The complexity of simulation of the motion that is characterized by multi-scaled processes and difficulty of prediction of SP destruction is aggravated with a variety of characteristics of considered objects (boosters with remaining fuel, structure fragments, etc.) and flight regimes (a circular range of angles of attack and slip, supersonic and subsonic speed, etc.).

The traditional approach to the estimation of probable ground impact areas of the debris is reduced to the analysis of ballistic trajectories with small random disturbances. At such approach the random dispersion of impact points has the form of “a dispersion ellipse” (DE).

However, the space launchers operation shows that some falling elements are found out far from the predictable dispersion ellipse. It happens, unfortunately, not so seldom that it can be possible to explain by statistical deviations with a low probability.

The theoretical explanation of these facts has been given firstly in Doklady Physics, 2010. vol. 55. No. 12. pp. 597-601, and Paper IAC-10.D2.3.12. Calculations with the developed comprehensive computational model confirm that the impact point dispersion area can exceed a conventional DE dimensions in orders. But more importantly, the physical reasons of the “abnormal” dispersion cause the qualitatively new topology of such areas. In particular, the multiply connected dispersion areas with the maximum probability density, which have a type of a ring or semilunar and locate far from the traditional DE, are really more expected.

At problem parameters variation the random trajectories flow and dispersion areas change with bifurcations. The “explosive” growth of the dispersion area in orders passing the critical parameter values is verified by results of comprehensive statistical simulation.

To provide adequate modeling and be able to detect features above the appropriate requirements for the simulation technique are formulated. As a result, the technique is more complicated in comparison with the actual ballistic analysis practice, but due to the noted synergetic effects, it has a significant impact on space launching hazard estimation.