

SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Upper Stages, Space Transfer, Entry and Landing Systems (3)

Author: Dr. Farid Gamgami
OHB System AG-Bremen, Germany, Farid.Gamgami@ohb-system.de

Dr. Martin Sippel
Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Germany, Martin.Sippel@dlr.de
Mr. Arnold van Foreest
Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Germany, arnold.vanforeest@dlr.de

USING MONTE CARLO SIMULATION FOR DESIGN ROBUSTNESS ASSESSMENTS OF WINGED
RE-ENTRY VEHICLES.**Abstract**

Winged re-entry vehicles often have to fulfill contradicting requirements in respect of the mission scenario:

- high safety standards and high flexibility,
and the system architecture:
- versatility and robustness of the design.

The higher the flexibility of the mission and the versatility of the vehicle, the higher is the complexity of the total design. A measure of the complexity of a system is the non-linearity of the describing mathematical model. The intention of the paper is to investigate these factors using the example of the SpaceLiner¹ (a winged re-entry passenger vehicle) in order to determine the tolerable margins of the design and its inherent complexity.

In its first part, the paper describes the technological concept of the SpaceLiner and its major features. This includes the mission analysis (i.e. the flight trajectory) and the system architecture (i.e. configuration, propulsion, aerodynamics and thermal protection). In its second part, the paper analysis and identifies, based on the SpaceLiner, the mission requirements, like minimal landing ellipse, maneuverability, maximal loads in order to derive the system requirements, like GNC² and aerodynamic performance (i.e. lift over drag).

A common way to characterize a non-linear dynamic system is by using statistical methods. This is done in the third part via Monte Carlo Simulations. Strong non-linear coupling of two properties can be illustrated by the skewness of the resulting probability distribution. The propagation of uncertainties and errors throughout the system will be focused.

Based on the results of the second and third part, a risk analysis shall be performed. The impact of the above discussed requirements on the risk assessment shall be highlighted. The robustness of the design especially to off-nominal conditions shall be discussed.

¹Martin Sippel, Arnold van Foreest: *Progress in Research on the SpaceLiner High-Speed Passenger Transportation Concept*, IAC-07-D2.7.07, September 2007 India, Hyderabad

²Guidance Navigation and Control