SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Future Space Transportation Systems (4)

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# CONCEPTUAL DESIGN AND OPERATIONS OF A CREWED REUSABLE SPACE TRANSPORTATION SYSTEM

**Abstract**

The paper deals with the design and operational concept of future Earth-to-orbit and suborbital transportation systems. The paper addresses the process, methodology and tools that have first led to the generation of a wide range of alternative solutions and then to the selection of a small number of feasible options. The paper then focuses on the analysis of the selected feasible options, in terms of architecture and mission operations. The selected concepts are described and the design methodology, as well as the tools that have been used within the methodology itself, is presented. Starting from specific top level stakeholders requirements, this paper describes the process that has first led to the generation of a wide range of alternative solutions, taking into account different launch options (expendable launcher to lift-off the spacecraft, reusable "mother-ship" to air-drop the spacecraft, spacecraft with autonomous lift-off capabilities), development timeline and budget, staging strategies, crew's needs, propulsion strategies, aerodynamics and take-off and landing modes. In order to meet stakeholder expectations, priority has been given to spacecraft's concepts able to perform vertical take-off and landing. The capability of landing on the same take-off site has also been evaluated. Through a thorough trade-off analysis, a small number of feasible system options has been selected out of the initial wide range of alternative solutions in terms of architecture and mission operations. These feasible options include a maneuverable capsule launched by an expendable launcher, a lifting body launched by an expendable launcher and a lifting body with autonomous lift-off capabilities. The selected remaining feasible alternatives have been detailed in terms of architecture and operations, through the development of the functional analysis and the concept of operations, as well as through a dedicated mission simulation program to estimate major mission drivers (mass, heat loads, maneuverability, Earth visibility and volumetric efficiency). Other crucial mission drivers, like complexity, innovation level and safety have been evaluated through other appropriate analyses. Eventually one concept has been selected as the closest to the mission drivers previously identified and the associated challenges and constraints have been elucidated. The few remaining options

have been presented as alternative solutions and possible compromises to achieve flexibility towards future development. Further considerations on future market trends for the selected concepts of space vehicle will also be developed.