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SPACE SYSTEMS SYMPOSIUM (D1)
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FLYING BACK TO EARTH: A ROTORCAPSULE CONCEPT ANALYSIS

Abstract

This project aims to study the viability of installing a rotor blade in a space capsule in order to reach the Earth surface without damages during the re-entry. This rotor system is intended to provide enough stability and control to the capsule in order to perform a soft landing, just as a helicopter does.

Nevertheless this technology has never been used in spacecraft before. This rotor system would replace the parachutes systems that are used nowadays in most of the capsules for the re-entry. It is expected to provide more controllability, safety and flexibility than the parachutes.

In this case, rather than in the normal operation of a helicopter, the rotor is not powered. Instead, a phenomenon called autorotation is used. This procedure allows the blades of the rotor to turn while the capsule is descending thanks to the relative wind velocity that the blades see. So, basically, the gravitational potential energy of the capsule is transformed into kinetic energy for its rotor blade as it goes down and at the end all the remaining kinetic energy of the rotor is used for producing enough lift force to perform a stable and controlled landing.

So as to implement this innovative system, the Apollo 11 spaceflight is taken as reference mission. Particularly, the Command Module, which was called Columbia, is the considered capsule, as it is the only module that reentered and landed back on Earth containing the cabin for the three astronauts inside.

Regarding the layout of this project, it includes two different areas of study. The first one consists in the study of the rotor blade aerodynamic. Here, an analytical model of the rotor's aerodynamic behavior is stated in order to separately analyze the contribution of each parameter of the rotor during the re-entry. The second main section covers the structural study of both the space capsule and the rotor blade itself. In this, the purpose is to design the technology needed for carrying out the autorotation and withstanding the thermal and mechanical stresses during the re-entry and landing phase. A CAD (Computer Aided Design) model is created with the aim of dealing with the Columbia architectural constraints.

The obtained results mainly propose an initial sizing for the aerodynamic parameters of the rotor blade and a technological solution for the system and its deployment, which allows not having to reevaluate the docking system for lunar orbit rendezvous.