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ELECTRICAL POWER SYSTEM DESIGN ASPECTS IN THE DEVELOPMENT AND OPERATIONS OF THE EUROPEAN SERVICE MODULE

Abstract

Orion is a spacecraft built between ESA and NASA to bring astronauts back to the Moon and beyond. The Artemis programme aims at having again the means to explore the Moon and perform a variety of missions, including landing on the Moon, docking in the Gateway and the ISS. As a manned spacecraft, Orion should be extremely reliable, including a very large failure tolerance to safeguard the astronauts on board.

In classical terms, manned spacecrafts were supposed to be double failure tolerant. This is a concept that is very difficult to design, test and verify. Thus, the ESM was not built with such formal requirement but instead, was built with a very large system level failure tolerance.

This paper explains how the Orion power system was designed and built. The main features will be shown, making emphasis on the redundancy levels, protection systems and safety features. It should be noted that the development of power systems for human spacecrafts is a complicated task that faces multiple hurdles during its lifespan. The long duration of the development can significantly impact the power budget because units can implement new features that were not considered and change its power consumption.

The variable nature of the configurations in flight makes this issue even more complex. Thus, the requirements used when the design phase started could end up not representing the real flight conditions. Furthermore, the verification is usually done against the original requirements and hence, important test data about more realistic operation points might be missing.

The high redundancy levels needed to achieve the required reliability has also an important impact on the mass budget. This is because the margins taken for nominal operations are automatically multiplied several times when the redundancy for contingency situations is considered. For instance, the solar arrays produced in flight 22

The paper also addresses the operations phase of Artemis I, explaining the different events that happened in flight and how they were troubleshooted. The most significant one being the uncommanded opening of Latching Current Limiters feeding power to the Command Module.

The operations phase highlighted that telemetry and commandability are paramount aspects during flight operations and, even though they might not look like very fancy features, improvements in the telemetry availability and telemetry rates are key technologies to be implemented in future manned missions.