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Lessons Learned in Space Systems: Achievements, Challenges, Best Practices, Standards. (5)

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CASE STUDY OF THE PARKER SOLAR PROBE THERMAL PROTECTION SYSTEM: DEVELOPMENT OF A SYSTEM LEVEL PROCESS FOR HIGH TEMPERATURE TECHNOLOGY ACHIEVEMENT

Abstract

NASA's Parker Solar Probe Spacecraft (PSP) built by Johns Hopkins Applied Physics Laboratory was launched in the Summer of 2018 to explore within 10 solar radii of the Sun. A mission enabling technology is the Thermal Protection System (TPS) which remains between the rest of the spacecraft and the Sun during approach. At closest approach, the carbon-carbon sandwich panel TPS has to withstand temperatures of 2500 F. While there are multiple materials that can survive and perform in this environment, the significant challenge was to develop the system that could meet all the mission requirements and environments.

Developing and testing the PSP TPS to technology readiness level 6 (TRL 6) required significant material testing and development but equally important was a system level engineering development effort beyond the obvious temperature requirements of the system. The mission trajectory drivers such as instrument accommodation, power, RF, and mass put constraints on the materials, shape and construction. These mission level requirements drove the trade space to determine the size, thickness, and surface profile. Some of the materials in the system had limited or no known thermal or structural properties. These properties were difficult and expensive to derive and often had large uncertainties. The engineering team developed processes to interpret the data and ensure design requirements were met. Similarly, the optical properties of the surfaces of the TPS could be predicted scientifically based on material properties. However, these estimates were found to be optimistic when produced on the larger scale of the system. The sun facing coating and the processes for implementing it at the large scale required the team to understand the difference between the optimistic values that are possible at the coupon scale and the realistic system properties. Equally critical was the ability to verify requirements at the system and component level on Earth before launch. Limitations of testing facilities drove the development of a verification plan combining thermal and structural testing to verify the design.

The successful development of the PSP Thermal Protection System was dependent on material testing and development coinciding with large system level engineering development. The key component of low TRL material development to TRL 6 and through launch is to consider these elements in tandem. The PSP Thermal Protection System provides a road map for how to design, develop and test these types of systems which will be mission enabling for future missions such as Interstellar Probe.