A Probabilistic Design Analysis Approach in Reducing the Overall Risk of a Fusion Propulsion Spacecraft

Natalie Walker
Department Chair: Jason Cassibry

Overview

The Probabilistic Design Analysis (PDA) approach uses a physics-based model to describe the system behavior and response for a given failure scenario. Each driving parameter in the model is treated as a random variable with a distribution function. Monte Carlo simulation is used to perform probabilistic calculations to statistically obtain the failure probability. Sensitivity analyses are performed to show how input parameters affect the predicted failure probability, providing insight for potential design improvements to mitigate the risk.

Key Findings

Because a Fusion spacecraft system is still so new, many interfaces have yet to be explored and analyzed. Designing a fusion spacecraft with a high degree of both reliability and safety requires a significant assessment of risk beginning in the conceptual phase of the vehicle design and continuing throughout the life of the vehicle. The failure probability data that were obtained from the PDA are more design and system specific because the actual vehicle design and operational data were used in the physics-based model. The PDA technique takes into account the variability of the design parameters through the use of "random" values of input parameters in the model. As a vehicle design matures, a greater understanding of the system characteristics is attained, and more design and testing data are available for use in the PDA. This provides better failure probability data to ultimately obtain better LOM and LOC estimates.

Impact

PDA in general:

- Complements other system safety, reliability, and risk assessment tools.
- Supports the estimates of loss of mission (LOM) and loss of crew (LOC) in an integrated vehicle probabilistic risk assessment (PRA).
- Performs in the early phase of the launch vehicle program.
- Update PDA’s periodically as the program and design mature.
- Is part of NASA’s Continued Risk Management process for the program.

By applying this approach to a Fusion Propulsion spacecraft, it could essentially ease the fears of both the astronaut crew as well the designers of the spacecraft.

Explanation

This research is important to the AAS because the overall reliability of the system is crucial in meeting NASA’s safety requirements for a manned Fusion Propulsion Spacecraft. This enables a Fusion Spacecraft to become a more viable option by furthering man’s need to explore space.

Acknowledgements

I would like to acknowledge Ann Shih and Yohon Lo help with the development of the overall PDA process and for being great co-workers too.