Chair of Space Mobility and Propulsion (Prof. Manfletti)
TUM School of Engineering and Design
Technische Universität München

Master Thesis – System-Theoretic Process Analysis (STPA) of a Spacecraft Propulsion System

Context

At the Chair of Space Mobility and Propulsion, we are exploring innovative analysis techniques to enhance the safety, reliability, and performance of space systems and operations.

Spacecraft propulsion systems are essential for maneuvering and sustaining spacecraft in space, enabling missions ranging from low Earth orbit operations to deep space exploration. As the demand for advanced space missions increases, so does the complexity of propulsion systems, which now include a variety of technologies such as chemical, electric, and hybrid propulsion systems. Ensuring the safety and reliability of these systems is crucial to mission success and the protection of valuable assets.

Recent developments in spacecraft propulsion, such as the integration of autonomous control and advanced electric propulsion technologies, have introduced new challenges and complexities. These advancements require innovative safety analysis approaches that can handle the increased complexity and interdependencies of modern spacecraft propulsion systems. System-Theoretic Process Analysis (STPA) provides a robust framework for identifying potential hazards and unsafe control actions in complex systems, making it ideal for analyzing space systems and operations.

Figure: Starlink Propulsion Systems.

Credit: SpaceX

By applying STPA to a selected spacecraft propulsion system, this project can provide valuable insights into the safety and reliability of space propulsion technology. The findings can contribute to the development of robust propulsion system designs, ensuring safer and more efficient space missions. This analysis is useful not only for preventing mission failures or accidents but also for identifying possible improvements in spacecraft propulsion technology.

Your Tasks

- Familiarization with STPA methodology and Spacecraft Propulsion Systems.
- Conduct research on existing spacecraft propulsion engines, and select an existing propulsion system that is either currently in use or has been fully designed as the subject of the STPA application.
- Study the detailed technical components and operational principles of the selected spacecraft propulsion system, including fuel delivery, combustion processes, and thrust control.
- Identify safety and mission-critical subsystems that could result in losses.
- Literature review on STPA/STAMP approach and its applications in spacecraft systems/operations.
- Define the propulsion system's goals, safety constraints, and operational requirements.
- Identify potential system-level hazards within the spacecraft propulsion system.
- Develop a control structure model of the propulsion system, recognizing critical control actions.
- Identify unsafe control actions and possible loss scenarios through STPA.
- Investigate causal factors and mechanisms that could lead to unsafe control actions.
- Propose mitigation strategies, such as improved sensor accuracy, voltage adjustments, mixing rate modifications, redundancy in critical systems, and enhanced control algorithms.
- Formulate safety recommendations and design improvements based on STPA findings.
- Document and present the results, including the STPA process and proposed recommendations for improvement of this spacecraft propulsion system.

Your Profile

- Master's Student in Aerospace Engineering.
- Knowledge of space propulsion engines and hazard analysis techniques.
- Nice to have: background in systems engineering and/or safety analysis.
- Independent working attitude.
- Motivation to engage with interdisciplinary and highly relevant topics.

We offer

- Collaboration with an experienced and supportive team.
- Access to a broad professional network within the aerospace sector.
- Opportunities for engaging in discussions with space propulsion experts.
- The possibility to contribute to advancements in spacecraft propulsion technology.

Contact

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