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

Master/Bachelor/Semester's Thesis – Hazard analysis of autonomous collision avoidance systems and operations

Context

At the Chair of Space Mobility and Propulsion, we are deeply engaged in advancing the safety, reliability, and operational efficiency of space systems. As the scope of space operations expands, autonomous systems, particularly in the area of collision avoidance, have become increasingly important. These systems are critical for preventing in-orbit collisions with other spacecraft, space debris, and celestial bodies, thereby ensuring the success and sustainability of space missions.

Historically, collision avoidance has been managed through ground-controlled systems, where decisions are made by human operators and executed by spacecraft. However, the move towards autonomous systems has introduced a new level of complexity. These systems must process large volumes of data in real-time, make independent decisions, and execute maneuvers without human intervention. This shift necessitates rigorous risk analysis to ensure that these systems operate safely, reliably, and within the bounds of their design parameters.

Traditional hazard analysis methods, such as Failure Modes and Effects Analysis (FMEA), Fault Tree Analysis (FTA), and Hazard and Operability Study (HAZOP), provide structured approaches to identifying and mitigating risks in complex systems. These methods, when applied to autonomous collision avoidance systems, can help uncover potential hazards and failure modes, thereby contributing to the development of safer and more reliable systems.

For this thesis, you will select and apply a traditional hazard analysis method to explore and address the safety challenges inherent in autonomous collision avoidance systems and operations.

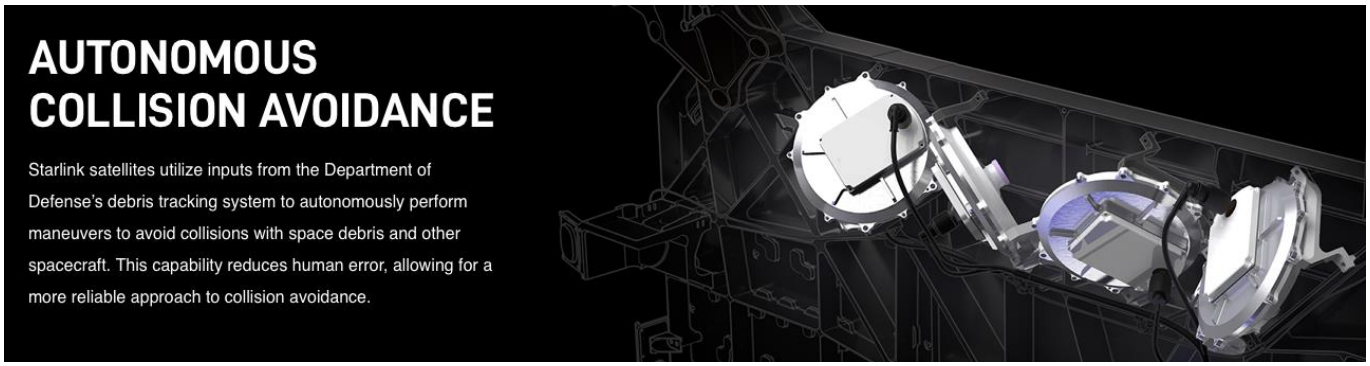

Figure: Starlink Autonomous Collision Avoidance Systems.
Credit: SpaceX.

Your Tasks

- Familiarization with traditional hazard analysis methods and with collision avoidance systems and operations.
- Select a traditional hazard analysis method based on its suitability for analyzing the complexities of autonomous collision avoidance systems.
- Conduct literature reviews on the selected hazard analysis method and on autonomous space collision avoidance systems and operations.
- Identify safety and mission-critical subsystems in collision avoidance systems whose failure could lead to significant risks or operational issues, focusing on risks introduced by autonomy and real-time decision-making.
- Apply the chosen hazard analysis method to assess potential hazards and failure modes impacting the safety, reliability, and performance of autonomous collision avoidance systems and operations.
- Investigate causal factors and mechanisms leading to identified hazards and analyze how different system components and conditions contribute to these hazards.
- Develop mitigation strategies and propose design improvements based on the hazard analysis to enhance safety and reliability.
- Formulate safety recommendations, document the hazard analysis process, and present findings to contribute to the development of safer and more reliable autonomous collision avoidance systems.

Your Profile

- Mechanical Engineering, Aerospace Engineering or MSE Student.
- Knowledge of space systems/operations 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 collision avoidance experts.
- The possibility to contribute to advancements in autonomous collision avoidance technology.

Contact

Antonio Vinicius Diniz Merladet, M.Sc.
+34 614182020
diniz.merladet@tum.de