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

Master Thesis – Rocket engine accident investigation using Causal Analysis Based on System Theory (CAST)

Context

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

Launch vehicle propulsion systems involve sophisticated technologies and precise operations. The complexity of these systems, which includes multiple stages, turbopumps, injectors, nixing propellants, combustion chambers, and intricate control mechanisms, raises significant risks. Accidents and incidents involving these systems can have severe consequences, making it essential to understand not only the immediate technical failures but also the broader systemic issues that contribute to such events.

Traditional accident investigation techniques often focus on component failures or human errors, which can overlook the broader organizational and systemic factors at play. The Causal Analysis Based on System Theory (CAST) offers a more holistic framework for understanding these incidents. CAST examines how organizational decisions, managerial processes, and systemic interactions influence the safety and performance of launch vehicle propulsion systems. By exploring how safety constraints are enforced, how decision-making processes impact outcomes, and how feedback loops within the system may fail, CAST provides a comprehensive analysis of the underlying causes of accidents.

Applying CAST to a specific launch vehicle propulsion system accident will help identify systemic weaknesses and contributing factors. This approach will yield valuable insights into how to improve the design, operation, and safety protocols of these critical systems. The findings will not only enhance the safety measures for future launches but also contribute to the overall advancement of launch vehicle technology and mission success.

Figure: Brazilian Launch Vehicle VLS-1. All three launches experienced propulsion system accidents/incidents, resulting in the deaths of 21 operators.
Credit: Brazilian Air Force.

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Your Tasks

- Familiarization with CAST methodology, space propulsion systems/operations, system safety concepts, and space-related accidents.
- Conduct research on past space propulsion system accidents/incidents involving operations with launch vehicles and select a relevant case study for CAST analysis.
- Study the technical components and operational principles, identifying critical elements.
- Perform a literature review on the CAST methodology, on the specific accident/incident, and on the rocket engine system under analysis.
- Analyze the organizational, managerial, and operational context of the selected case study.
- Examine how safety constraints were violated and assess the role of decision-making processes in the accident/incident.
- Identify the system's intended safety goals, the hazards encountered, and the losses that occurred.
- Analyze the control structure, focusing on how decisions and actions at different levels of the organization contributed to the accident/incident.
- Investigate communication breakdowns, inadequate feedback loops, and missing controls that may have led to the unsafe state.
- Identify contributing factors, including flawed processes, human error, and design deficiencies.
- Evaluate how safety constraints were violated or inadequately enforced, leading to the event.
- Propose systemic changes and mitigation strategies to prevent future accidents in similar propulsion systems.
- Formulate safety recommendations and design improvements based on CAST findings.
- Document and present the findings, including the CAST analysis, suggested organizational improvements and proposed safety or performance enhancements for launch vehicle propulsion systems.

Your Profile

- Master’s Student in Aerospace Engineering.
- Knowledge of rocket 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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