

# Empirical Systems Approach for Safe Zero-Emission Transportation Systems

## Introduction

The global push for zero-emission transportation systems using hydrogen, ammonia, batteries, and methanol brings promising environmental benefits but also complex safety challenges. Current research primarily addresses individual fuel safety, leaving a gap regarding interactions between multiple alternative fuels operating simultaneously. This project addresses this gap by developing an empirical, integrated safety analysis approach using STPA and risk assessment methodologies.

## Objectives

- Collect and analyze accident data involving alternative-fuel vessels and vehicles.
- Perform detailed interaction analysis using STPA and Dynamic Risk Assessment methods.
- Develop practical safety protocols and guidelines based on identified risks.

## Systems Theoretic Process Analysis (STPA)

STPA is a safety analysis methodology developed to identify potential hazards and assess risks in complex systems.

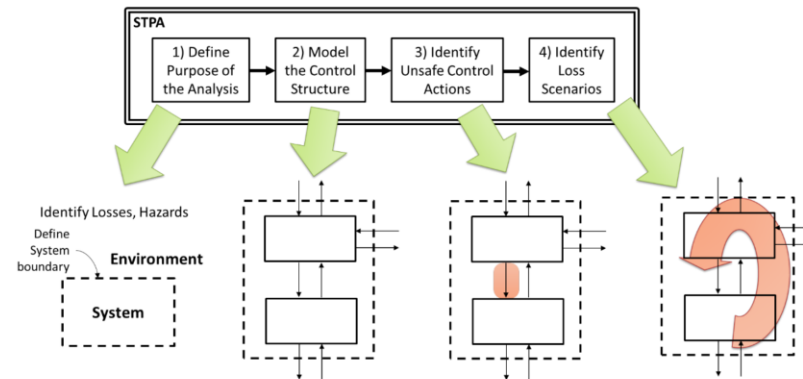
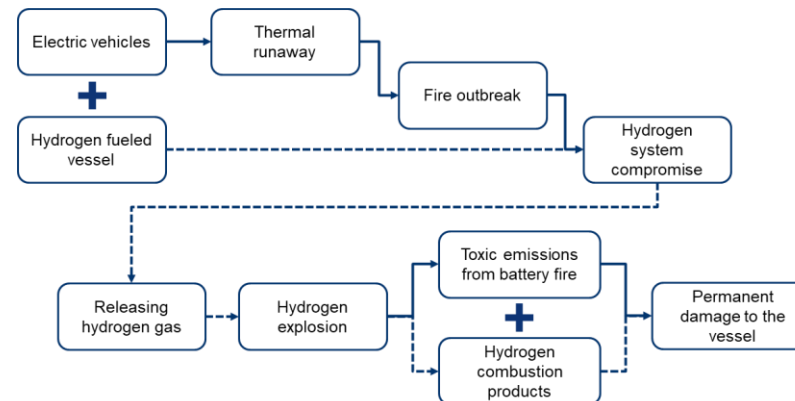


Figure 2.1: Overview of the basic STPA Method



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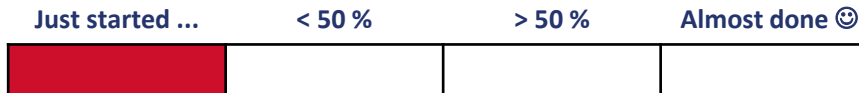
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## Estimated progress of the PhD project:



## Publications

- A Study on Multi-ship Avoidance System for Unmanned Surface Vehicles Using the Quaternion Ship Domain and Collision Risk Index, 2025, Journal of Ocean Engineering and Technology
- Human Reliability Analysis for Fishing Vessels in Korea Using Cognitive Reliability and Error Analysis Method (CREAM), 2024, Sustainability

