



NTNU – Trondheim
Norwegian University of
Science and Technology



NTNU AMOS
Centre for Autonomous Marine
Operations and Systems

Preliminary hazard analysis of a small harbor passenger ferry

Results, challenges and further work

Christoph A. Thieme, Chuanqi Guo, Ingrid B. Utne, Stein Haugen

14.11.2019

Paper # 49

Agenda

- **The ferry**
- Hazard analysis
- Results
- Challenges and the way forward

The ferry (1)

- 12 Passengers
- On-demand
- One minute travel
- Shore base for monitoring
- Radio communication
- Operation expected 2020



The ferry (2)

Systems and features:

- Autonomous navigation
- Autonomous docking
- Automatic passenger registration
- All electric power system
 - Charging while docking
- Maximum speed 5 knots



Photo: Kai Drageland/ NTNU

Agenda

- The ferry
- **Hazard analysis**
- Results
- Challenges and the way forward

What are hazards and risk?

- Hazard:
 - "A hazard is a potential source of harm"
 - Ferry operation or interaction with the environment
 - Damage to people, environment, property
- Risk:
 - Consequences of an event combined with the associated probabilities
 - To what extent may the ferry's hazards lead to (negative) consequences

Why hazard analysis?

- Document assumptions
- Derive requirements
- Improve design
- Demonstrate compliance with regulations
- Convince the public

Our approach

Two workshops

1. Define the goal of the meeting
2. Identify hazards and events from checklists
3. Estimate categorial frequency and consequences for the events
4. Evaluate and rank risk
5. Suggest mitigation measures

Experts

- Navigation
- Control engineering
- Sensor system engineering
- Naval architecture
- Risk engineering
- Industrial design
- Autonomy experts
- Electric propulsion

Agenda

- The ferry
- Hazard analysis
- **Results**
- Challenges and the way forward

Main results – Hazards and mitigation

- Kayaks and swimmers
- Overlooked by other boats
- Blackout
- Sensor failures
- Control system failure
- Communication
- Hacking and spoofing
- Robust detection
- Clear marking
- Redundant and robust battery
- Functional redundancy
- Robust, tested and verified system
- Encrypted, robust, redundant
- Robust cyber security design

Agenda

- The ferry
- Hazard analysis
- Results
- **Challenges and the way forward**

Hazard/ Risk analysis methods

- Difficult to assess the interactions and deviations
 - Possible methods: System-Theoretic Process Analysis or Functional Resonance Analysis Method
- Relative timing aspects not covered

Quantitative Risk analysis

- Interactions that lead to failure
 - New methods necessary
 - Few data available
- Software failure
 - Data driven modeling not possible
- Assessment of traffic in the canal
 - Influence of the ferry

Baseline and acceptable risk

- No quantitative risk level has been defined previously as baseline
- The existing rules are mainly prescriptive and do not set criteria
- Statistics by the emergency service may give an indication
 - Underreporting
- Public acceptance
 - The ferry should be significantly safer than traditional ships
- Continuous improvement

Regulations

- Several functions executed by seafarers
 - Demonstration that autonomous functions are similarly safe
 - Clear definition of performance criteria
- Certification and training requirements for the onshore operator
- Water-based firefighting
 - All electric
- Recent incidents with battery-driven ferries
 - Safety requirements

Further work

- Detailed design
- Detailed risk analysis
- Cooperation with Norwegian Maritime Authority
- Cooperation with other Stakeholders
- Share the experiences to facilitate future autonomous ships



NTNU – Trondheim
Norwegian University of
Science and Technology



NTNU AMOS

Centre for Autonomous Marine
Operations and Systems

Do you have any questions?

THANK YOU FOR YOUR ATTENTION!

The UNLOCK project: <https://www.ntnu.edu/web/imt/unlock>

References

- Eide, E. (2018). Kick-off meeting autoferry AVIT - presentation.
- Rausand, M. (2011). Risk Assessment - Theory, Methods, and Applications. Hoboken, New Jersey, USA, John Wiley & Sons.