Life cycle risk dynamics for marine systems: A description of a bio-inspired framework for risk fluctuations throughout the life cycle

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The world is experiencing change

- The necessary measures for dealing with the COVID-19 pandemic has disrupted many “normal” functionalities
- The maritime industry is faced with the related Crew Change Crisis

Source: ITF Seafarers
The world is experiencing change

• Start rethinking what is the best way for “doing business”?  
• Maybe autonomous ship concepts will be a viable/sustainable way forward…

In this context of uncertainty, we would like to share our thoughts on how we believe risks should be managed in the future!
What is this presentation about?

A descriptive framework for risk fluctuations throughout the life cycle of marine systems

(see also Ventikos and Louzis, 2018; 2019)

**Objective**

Describe **risk fluctuations** under the influence of human-organizational and technical issues

**Inspiration**

**Biological immune system** mechanisms for adaptive identification and response to threats in a dynamic environment with varying capacity for response (i.e., immune deficiencies/degradation)
Problem Statement

How does risk, related to a marine system, fluctuate throughout its life cycle phases?

Adapted from Leveson (2015)
Risk assessment for conventional/autonomous ships

- We have a large “knowledge library” of what can go wrong with conventional ships and what are the consequences → We can prescribe recipes for averting disasters

- Autonomous ship concepts have only been tested in small scale
- We don’t know what will happen exactly
  - New interactions that may result in new hazards (unmanned ship in relation to RCS – imagine what could happen with a ship with advanced AI!)
  - New interactions between manned and unmanned ships (mixed traffic)

We must guess, and produce ways to prove these complex systems will be at least as safe as the existing systems!
Adapted Life-Cycle Model for marine systems

The relationship between self and nonself is different during each phase of the life cycle.

<table>
<thead>
<tr>
<th>DESIGN</th>
<th>SHIPBUILD.</th>
<th>OPERATION &amp; MAINTENANCE</th>
<th>LIFE EXTENSION</th>
<th>End of Life (EoL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designed ability to control risks</td>
<td>Testing &amp; Verification of designed ability</td>
<td>Susceptibility to unknown risks</td>
<td>Gradual learning, improved efficiency of response</td>
<td>Change in system components and goal</td>
</tr>
</tbody>
</table>

**Risk control effectiveness varies**

**The operational envelope may change**

<table>
<thead>
<tr>
<th>EMERGENCY</th>
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<tr>
<td>(change of system goal – e.g. from delivering cargo to saving pax)</td>
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Typical Life-Cycle Model (see also Ayyub, 2000)
Towards a descriptive framework

Assessing risk fluctuations – Example from the navigation system

- **Scenario**: Newbuilt ship with inexperienced crew operates in heavy traffic and visibility conditions they had never experienced before
- **Life Cycle Phase**: Operation & Maintenance → Growth

\[ R_{tn} = \begin{cases} 
\text{Speed} = \text{Service} \\
\text{Nav. Eq. status} = \text{Operational} \\
\text{Situation awareness} = \text{High}, \text{Low probability of nav. accident} \\
\text{Competence} = \text{Adequate} 
\end{cases} \]

\[ R_{tn+1} = \begin{cases} 
\text{Speed} > \text{Service} \\
\text{Nav. Eq. status} = \text{Operational} \\
\text{Situation awareness} = \text{Low}, \text{High probability of nav. accident} \\
\text{Competence} = \text{Adequate} 
\end{cases} \]

\[ R_{tn+1} > R_{tn} \rightarrow \text{Risk control needed} \]

Symptom identified by state detector
Instead of conclusions

Through this research, we hope to

build a **risk framework** – equally applicable to conventional and autonomous ships - that can thrive on **unknown unknowns**

develop system **antifragility** through controlled exposure to unsafe states - improved recognition, faster response
Sneak Preview…

Benefit from the efficiency of a new immune–like paradigm for dealing with emerging and unknown threats.

An evolving artificial immune system within the digital twin of the vessel.
MOSES Project Overview

MOSES Facts

- **Project Title:** AutoMated Vessels and Supply Chain Optimisation for Sustainable Short Sea Shipping
- **Call identifier:** H2020-MG-2.6-2019
- **Topic:** “Moving freight by Water: Sustainable infrastructure and Innovative Vessels”
- **Duration:** 01.07.2020 - 30.06.2023 (36 months)
- **Funding scheme:** RIA – Research and Innovation Action
- **EU contribution:** EUR 8 122 150
- **Coordinated by:** National Technical University of Athens (NTUA), Greece

This project has received funding from the European Union’s horizon 2020 research and innovation programme under grant agreement No. 861678.
MOSES Vision

The aim of MOSES project is to **enhance the Short Sea Shipping (SSS) component** of the European supply chain by **addressing the vulnerabilities** and **strains** related to the operation of large containerships.

**A two-fold strategy**

**SSS feeder services**
- Ship design for sustainable services – no infrastructure required
- Logistics solution for balancing demand-supply

**DSS ports efficiency**
- Technological solutions for improving DSS ports inefficiencies – reduce berthing time, improve safety
MOSES Innovations:
1. MOSES AutoDock (MOSES Autonomous tugboats + AutoMoor)
2. MOSES Recharging Station
3. Innovative Feeder Vessel
4. Robotic container-handling system
5. MOSES matchmaking platform
AutoMated Vessels and Supply Chain Optimisation for Sustainable Short SEa Shipping

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Thank you for your kind attention!