How safe do we need to be?

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Navigating the Future of European Waters with Autonomous Innovation

7 November 2023, Rotterdam

These projects have received funding from the European Union's Horizon 2020 research and innovation programme under grant agreements N° 815012, 859992, 861678.

How much «safety» is enough?

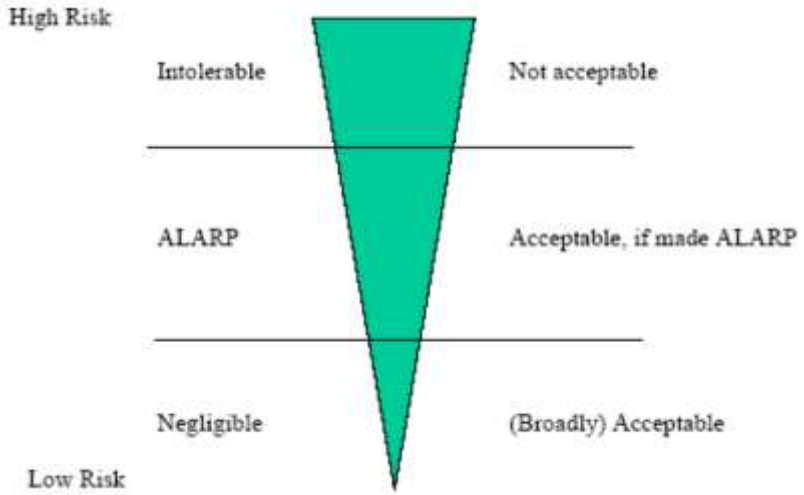
The absence of accidents
(see e.g. Tench, 1985 Hollnagel, 2014; Leveson, 2016)

Acceptable risk
(see e.g. Lowrance, 1976; Rausand, 2011; Aven et al., 2015)

Safety is related to the amount of risk we are willing to accept and, ultimately, risk acceptance is a societal problem.

Different stakeholders may have different perspectives:

- Regulators and authorities
- Owners and operators
- The public



IMO FSA guidelines (2018)

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How much «safety» is enough?

Perceived safety is one of the most significant concerns and is inversely proportional to autonomy levels!

Survey for autonomous urban ferries

(Goerlandt and Pulsifer, 2022)

"Impact of automation to the tugboat industry" survey (2022)

Would you trust and feel safe onboard a fully autonomous tugboat?

90% would moderately trust the system or not at all

How would you make the autonomous operation of the "tugboat swarm" more efficient in realistic conditions?

"There should be a crew of at least two people onboard"

"More emphasis should be placed on safety and emergency cases"

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How safe do we think we need to be?

Since we don’t want to end up with a worse situation...

Autonomous ships need to be **at least as** safe as conventional, manned ships

(see, e.g., Jalonen, 2017)

This is just to get things started but…

Is the current safety level acceptable?
Should the maritime transport system not get safer?

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How much safety do we expect?

We have **X number of accidents** now,
autonomous ships will **reduce accidents by Y%** due to [...],
therefore with autonomous ships we will have **Z number of accidents**.

58% (EMSA, 2018) **to 75%** (Allianz, 2017) of marine accidents are caused by human error.

Assuming that:

1) lost lives will be reduced due to less crew onboard,
2) autonomous ships will reduce navigation-related accidents

de Vos et al. (2021) support that the largest benefit is from reducing the risk exposure of humans.

Scenario	Impact (lives lost)	Max Impact (nav. accidents)
Small (< 120m) cargo ships unmanned	-47.4%	-14.2% ships lost -12.8% lives lost
All cargo ships unmanned	-69.5%	-20.8% ships lost -15.7% lives lost

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Autonomous ships
will need to be SAFER
than conventional ships

Why do we need to be safer?

Making autonomous ships safer would also make them more attractive to stakeholders!

COST

Potentially higher **generalized costs**
(e.g. advanced automation, shore control centres, less personnel but more expensive, loss of reputation in case of an accident)

UNCERTAIN

BENEFIT

Generalized benefits should also increase (incl. SAFETY)

PARADOX:

Why are we expecting so much more from automation than what we expect from humans?

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What will it take to be safer?

Address the uncertainties

- Will reduced or eliminated risks be outweighed by **new risks introduced by automation** (Porathe et al., 2018; Ventikos and Louzis 2019)?
- How much will not having the **mitigative potential** of the human element affect the overall safety level?
  - In an implementation of STPA on a theoretical autonomous ship, we identified **less measures for "mitigating the consequences"** with higher autonomy (Ventikos et al., 2020)
- How can we convincingly **verify and validate** the expected safety level (digital twins?)
- Address **system fragility** potentially introduced by ultra-efficient automation

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What will it take to be safer?

Choose a strategy

Option 1: Humans stay in the loop

Constrained autonomy – the ship solves all “standard” problems, an operator solves the complex problems (Porathe et al., 2018)

STPA for the MOSES autonomous tugboat swarm operation: for most identified loss scenarios, **remote-control or direct control from a tugboat captain** was considered the most appropriate action to get to a Minimum Risk Condition (MRC)

Option 2: Autonomous ships become more “autonomous”

Deal with a lot more different situations on their own (depends on autonomy level)

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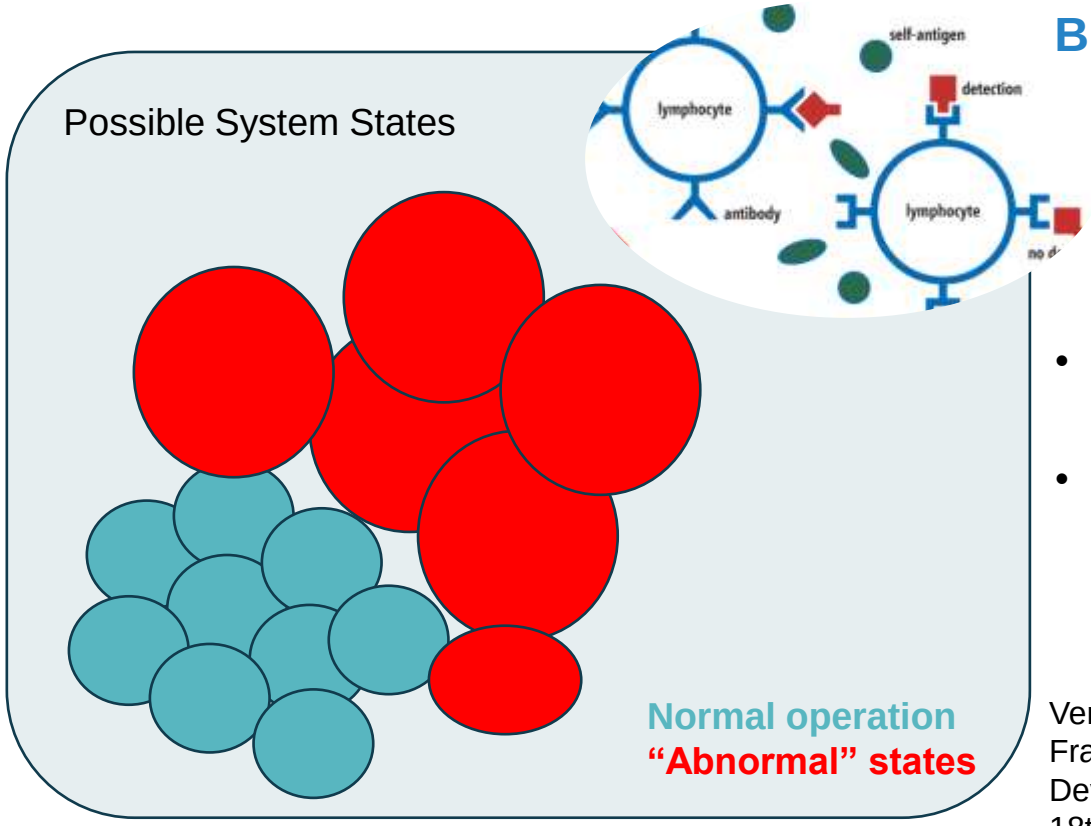
Another way to look at safety?

We cannot only rely on trying to identify scenarios
for accidents that have not yet happened!



Bio-inspired safety

What if, by knowing what is "normal",
the autonomous ship could understand what is "abnormal"?

- An autonomous ship can be viewed as an "organism" with integrated processes for regulating its "health".
- Our research at NTUA is trying to implement this perspective for risk assessment in the different ship life-cycle phases.

Ventikos, N.P., Louzis, K., 2019. Introducing a bio-inspired Life-Cycle Framework for emerging risks in the maritime industry. Sustainable Development and Innovations in Marine Technologies: Proceedings of the 18th International Congress of the Maritime Association of the Mediterranean (IMAM 2019). Varna, Bulgaria. CRC Press, pp 527 - 536.

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Thank you

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