NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

SAFETY 4.0: AI-Driven Ship Safety Management System

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What is Safety 4.0?

- A new generation of workplace safety and health management systems deploying Industry 4.0 technologies

- Proactive, predictive approach by using technologies to identify risks and create a safe and healthy work environment

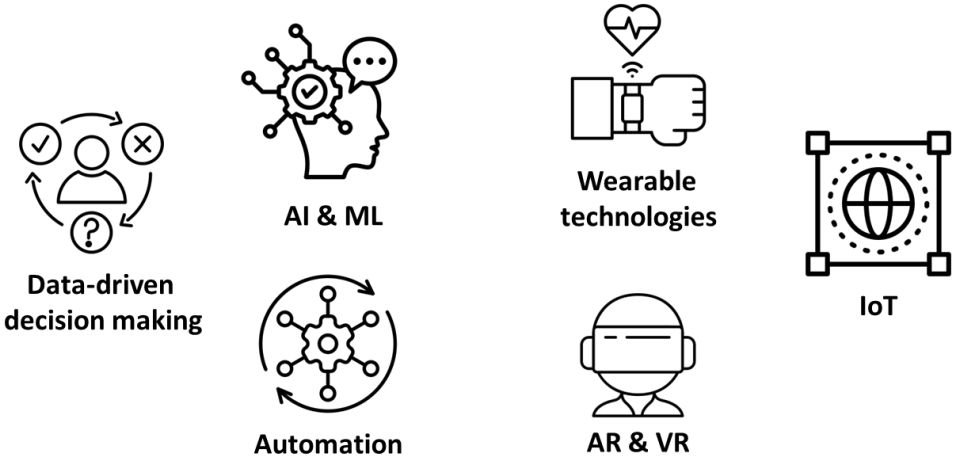
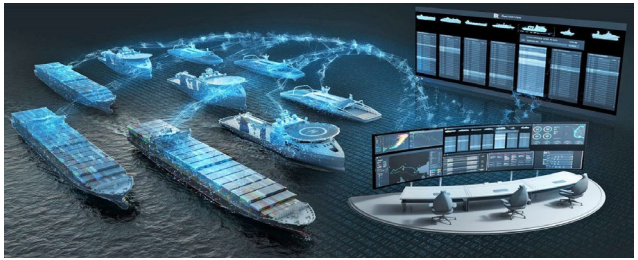


Figure 1. Principles of Safety 4.0

What is Safety 4.0?

- Developing Safety 4.0 technologies for ***shipboard operations*** is now feasible with the following enablers:

Automation, wearable technologies & digitalisation



Extensive maritime safety & health data in digital format

Advancement in AI methodologies & risk analytics

Technology Scan of Safety 4.0 Tools

Automation

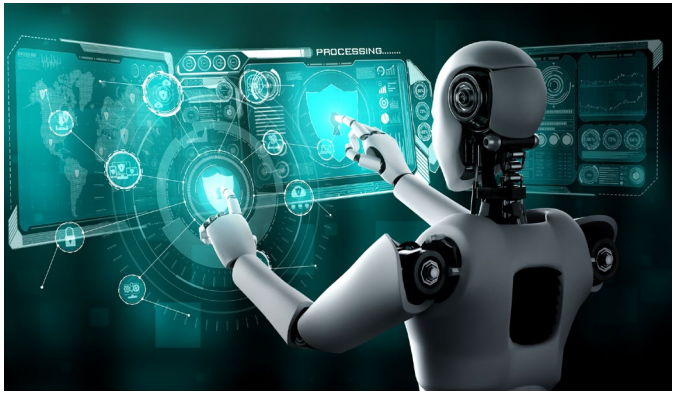
Wearable technologies

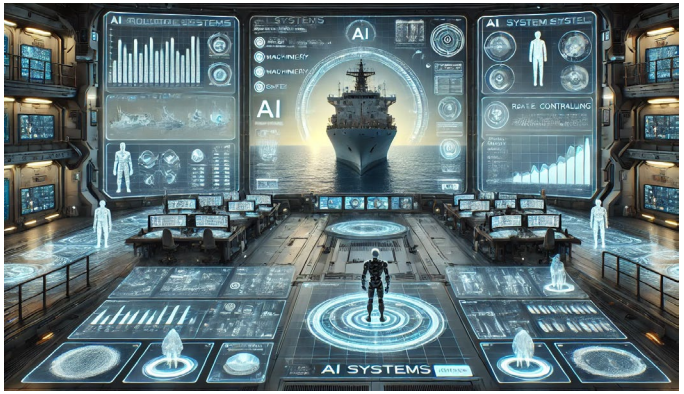
IoT

State-of-the-art Digital Safety Management System (SOL-X by MagellanX)

Project Goal

- Support decision-making by integrating AI capabilities into digital safety management systems to (1) identify, monitor and assess safety and health risks in real-time and (2) recommend suitable risk control measures





Illustrations of AI managing risks in shipboard operations

Conditions for AI Implementation

1. **Defined Goals & Use Case:** What *should* AI monitor and control?
    - *Risk Identification*: What key risks are currently faced by the ship and each seafarer?
    - *Risk Assessment*: What is the combined likelihood and consequence of each identified risk?
    - *Risk Control*: What measures can be implemented to manage high-risk events?
2. **Overcoming Constraints:** What *can* AI monitor and control?
    - *Data Availability & Quality*: Are there relevant and useful data supporting the monitoring, identification, and assessment of risks? If not, are there proxies for these data?
    - *Ethical and Regulatory Considerations*: Are the AI-generated recommendations fair, unbiased, and compliant with existing regulatory frameworks?
    - *System Integration & User Centric Design*: Can AI integrate smoothly with existing data infrastructure and workflows? Is the interface user-friendly and transparent?

A Hybrid Decision Support System

- A hybrid decision support system (DSS) is designed by (1) developing a predefined set of expert rules (i.e., logic-based algorithms) and (2) learning from historical data (i.e., data-driven algorithms)

Rule-based DSS

- **Knowledge based**: Relies on domain knowledge from occupational health and safety experts to specify risks
- **Rule-based logic**: Mimics human decision-making process using '*if-then*' rules to diagnose or predict risks
- **Predefined scenarios**: Limited by the rules preestablished by experts; incapable of adapting to new scenarios

Learning-based DSS

- **Data-driven**: Relies on datasets from incident and accident records, risk probabilities, medical history and meta-analysis to specify risks
- **Predictive analytics**: Assesses and predicts risks based on learned patterns through supervised and unsupervised learning
- **Data availability and ambiguity**: Limited by availability and quality of data, and challenges with black boxes

A Hybrid Decision Support System

1. Risk Identification:

Ship Safety Index

Crew Wellbeing Index

Primary Indicators:

Secondary Indicators: **12** **31**

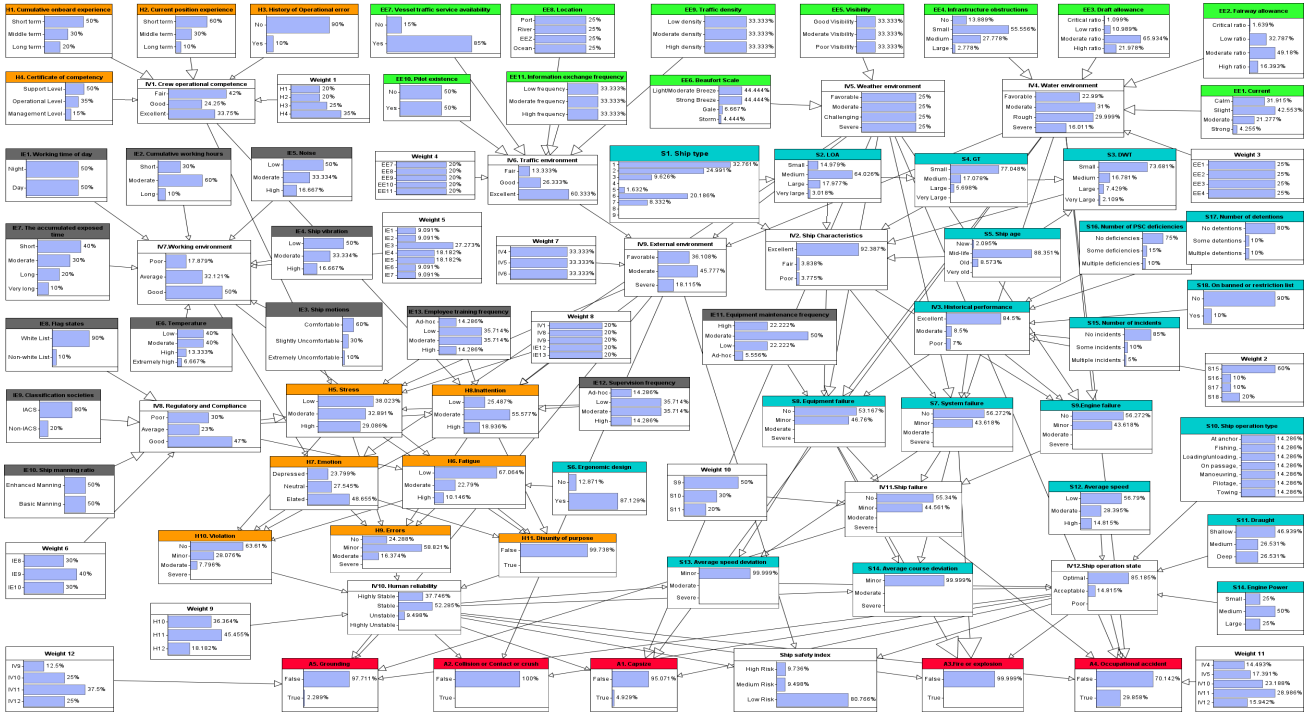
Tertiary Indicators: **51** **-**

Static & Dynamic

Lagging & Leading

A Hybrid Decision Support System

2. Risk Assessment and Scoring:



Bayesian Network Model for Ship Safety

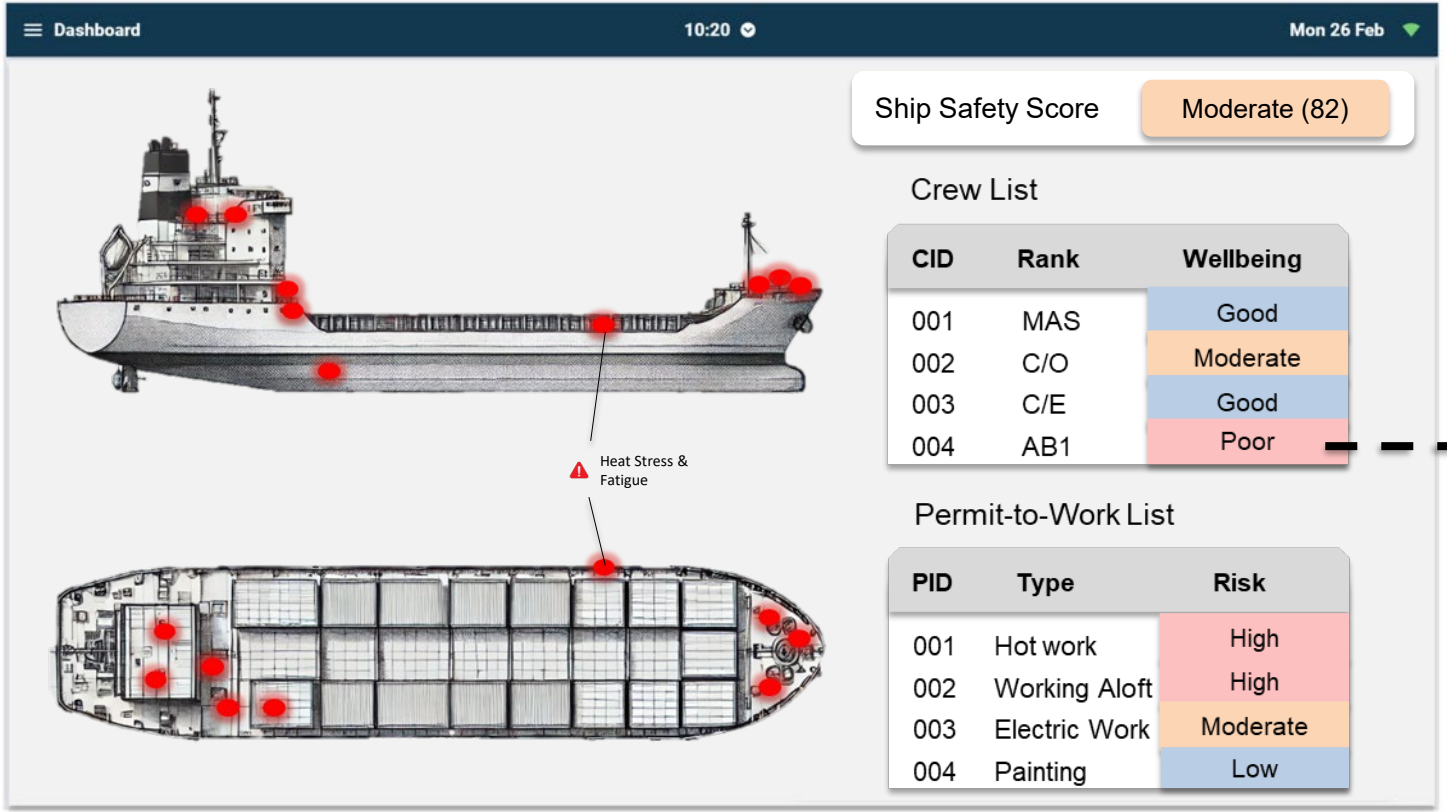
A Hybrid Decision Support System

3. Immediate Risk Control & Long-term Continuous Improvement:

- Real time scoring and identification of critical nodes (i.e., risk indicators) that contribute to *immediate* risk
    - Identify and simulate interventions that can control immediate, critical risk
    - Send prompts and interventions to users

- Recommend best practices to management and operations to address persistent, long-term risk to improve ship safety score

A Hybrid Decision Support System



Immediate Risk Detection and Intervention (Illustration)

A Hybrid Decision Support System

Immediate Risk Detection and Intervention (Illustration)

A Hybrid Decision Support System

Dashboard 10:20 Mon 26 Feb

Location	Malacca Channel
Speed	10.5
Heading	5
Draught	8.6
Lon	127.944961
Lat	34.226205

Ship-to-Ship Collision Monitor ON

⚠ *High near-miss collision risk is detected!*

ID	MMSI	Distance	Near-miss risk level
1	311906000	0.2	High
2	325913002	0.3	Medium high
3	301943520	2.1	Medium

Ship-to-Facility Collision Monitor ON

Port approached, monitor activated:

⚠ *Collision warning!*

Facility type	Location	Distance	Time-to-Collision
Harbor wall	Singapore port	0.02	3 min

Casualty-Cum-Pollution Monitor OFF

This monitor will be activated when a casualty occurs.

Immediate Risk Detection and Intervention (Illustration)

Outcomes

- ***Enhanced safety and well-being:*** Real-time risk assessment and prediction of hazards and risks
- ***Cost savings***: Risk management models help avoid incidents that could result in costly repairs, downtime, loss of cargo
- ***Increased crew confidence***: Real-time risk assessment tools can increase crew confidence in their own safety and the safety of the ship
- ***Scalability***: Solution has potential applications on other industries or sectors (e.g., oil and gas, tunnelling, construction or mining)

Collaborators

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Thank You