Digitalization of Maritime: Technology Innovation Transforming Operational Safety and Risk

AIMU Marine Insurance Day, New York

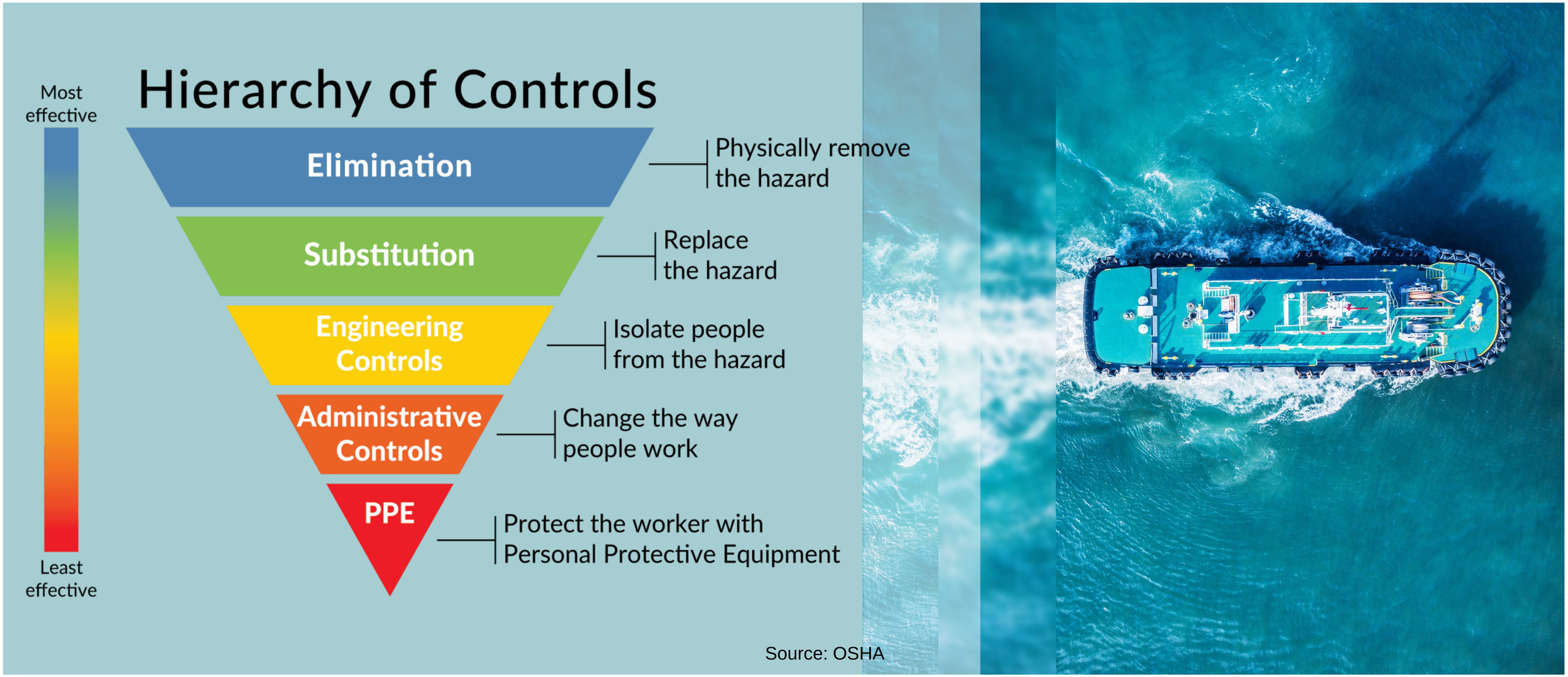
May 8, 2025

Agenda

1. Hierarchy of Operational Hazard Controls
2. Case Study 1: Remotely Operated Vehicles in Mid-River Cargo Operations
3. Case Study 2: AI-Based Machinery Predictive Failure
4. Case Study 3: The Digital Twin
5. Case Study 4: AI-Capable Navigational Safety Decision Support
6. Case Study 5: AI-Based IMDG Cargo Misdeclaration Detection
7. Case Study 6: AI-Based Fraudulent Carrier Vetting
8. Final Thoughts: Vessel Efficiency, Voyage Optimization and Next Generation Green Fuels

Operational Hazard Control Hierarchy

Where do digitization and innovative technology fit in?



Case Study 1: Human Risk Elimination

Remotely Operated Vehicles – ROV Dry Bulk Cargo Operations

Human Risk Exposure Profile:

- Shore to vessel (ship and barge) transfer of floating crane barge crew/personnel
- Use of ship's gangway ladders, cargo hold access ladders and barge hopper access ladders
- Use of deck edge walkways on hopper barge and floating crane barge
- Lifting cargo handling equipment (bobcats and loaders) into/out of ship's cargo holds and barge hoppers

Human Risk Hazards

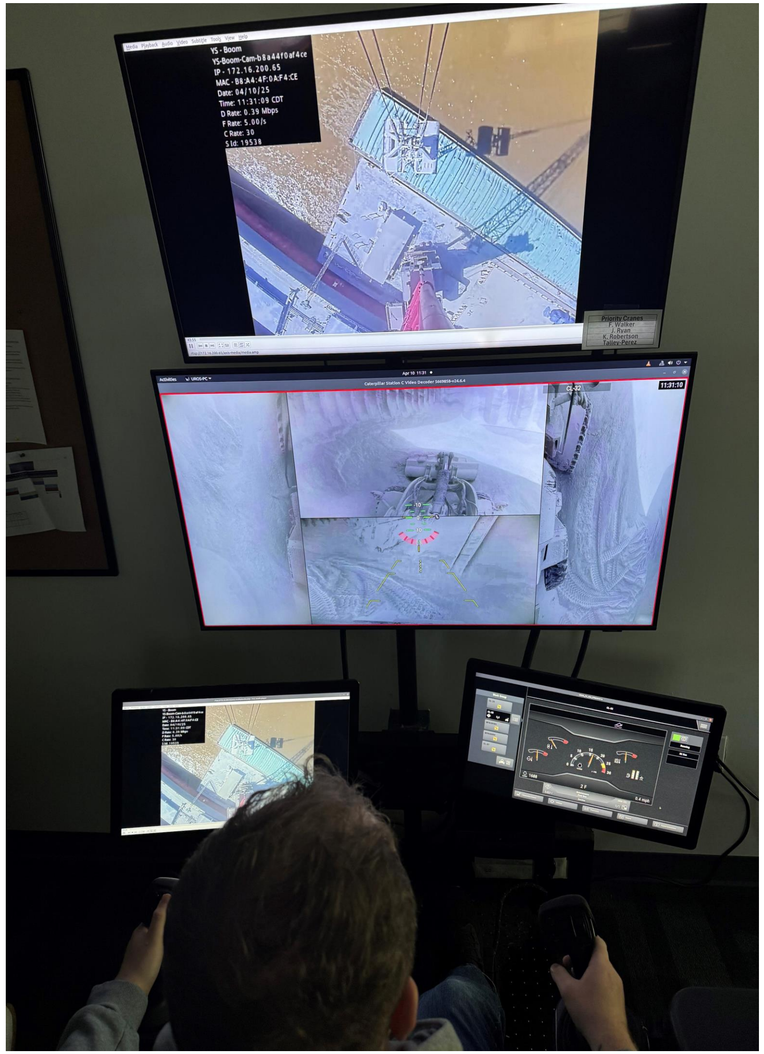
- Slip, trip and fall - multiple vessel transfers
- Large crane bucket overhead live loads
- Operation of cargo handling equipment
- Deck edge, FOB potential (flowing water)
- Exposure to environmental conditions – heat, cold (Jan 2025!), humidity, rain, noise etc.

Case Study 1: Human Risk Elimination

Remotely Operated Vehicles – ROV Bulk Cargo Operations

Technology Innovation Risk Elimination Solution:

- Leveraged cutting edge remote operation technology capability
- Equipped cargo handling equipment to be Remotely Operated Vehicles, ROVs
- Operators off-site in calm, low-distraction, controlled environment ROV room
- Provided with continuous supervisory oversight and guidance
- Eliminates 25% of physical human element exposure per “site”:
  - Vessel transfers
  - Boarding ladders/gangways
  - Cargo hold / barge hopper ladder entry/exit
  - Cargo handling equipment operation
  - Proximity to live loads
  - Exposure to environmental condition factors – heat, cold, humidity, noise, rain etc.



Case Study 2: Engineering Controls

AI Based Machinery Predictive Failure Technology

- Traditional PM (planned maintenance) based on OEM service periodicity recommendations, Class/Flag regulatory inspection regimes, experience, L/O analysis
- But many modern M/Es, A/Es and other machinery and equipment now computer controlled
- Key operational performance data outputs available for diagnostic analysis, and……
- AI technology now capable of receiving those data outputs:
  - AI algorithms “learn” normal performance parameters across variety of operational load conditions and over time
  - Enables identification of operational data points outside normal performance envelope
  - **Predicts time/hours remaining to failure of component/s**
  - **Allows proactive maintenance intervention prior to a component failure, or larger catastrophic failure**

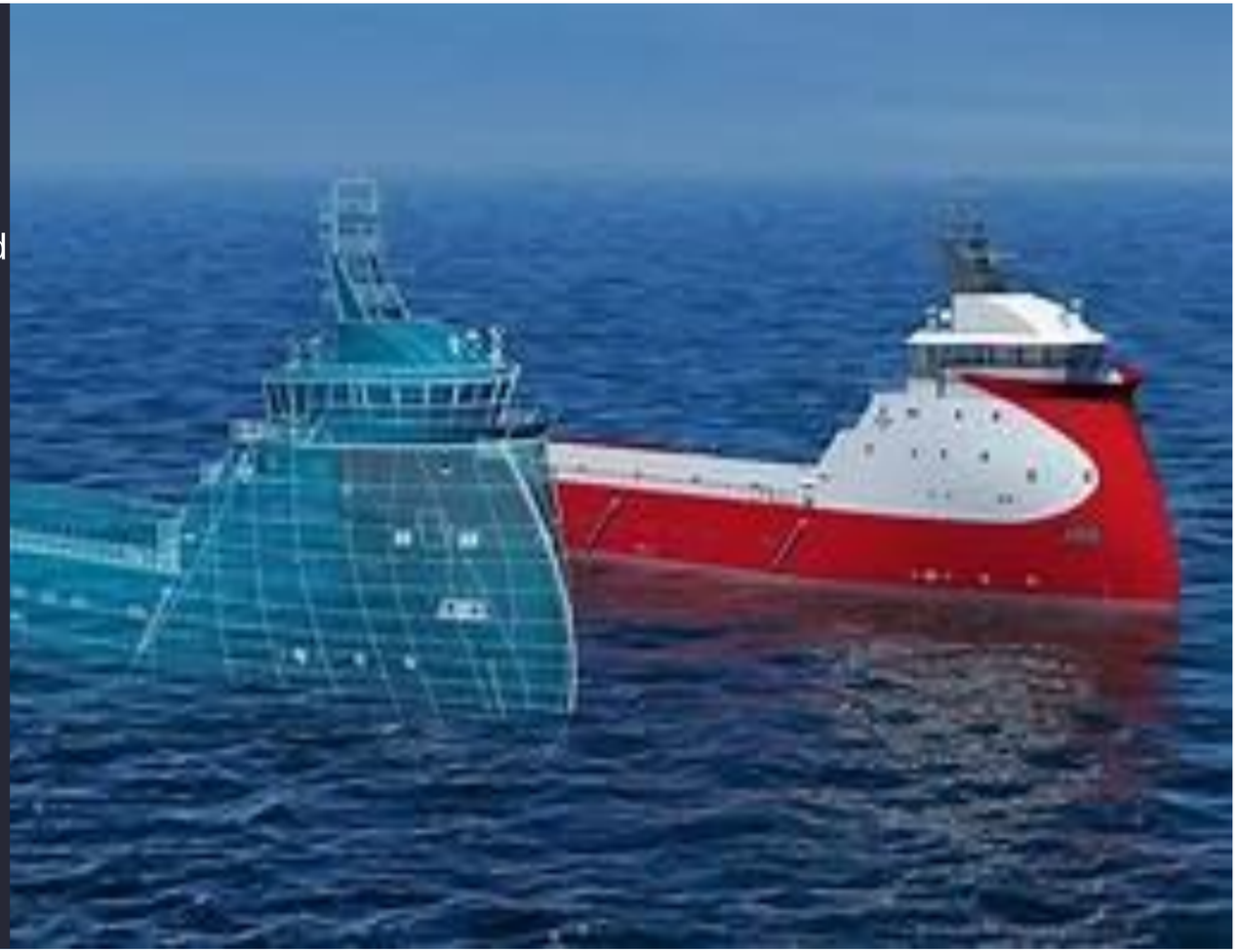
Case Study 3: Engineering & Administrative Controls

The Digital Twin –Maintenance Optimization and New Systems Integration

- **Vessel condition inspection and planned maintenance traditionally held at set intervals:**
  - OEM recommended based on years of use, testing, experience, data and limited observation e.g. L/O analysis
  - Class / Flag prescribed e.g., annual, intermediate and special survey - probability-based approach to wear, tear and condition deterioration
  - Not “actual” condition.

- **And New (Safety) Systems Integrated On Board:**
  - Installed based on “spec” compatibility - then tested integrated and optimized. Not always successful.

- **Digital Twin – Complete Virtual Vessel**
  - Continuous monitoring – real condition data
  - Modeled in digital twin of the physical vessel/asset
  - Extend or pull forward maintenance intervals
  - Machinery management and vessel navigation software integration trials – virtually install, test and optimize prior to onboard installation



Case Study 4: Engineering & Administrative Controls

AI-Capable Navigational Decision Safety Support

- **Human error cited as primary cause of approx., 60-85%* of marine accidents** (*various sources)

- **”The Deadly Dozen” of human factors (UK MCA, MGN 520):**
  - Teamwork
  - Fatigue
  - Fitness for Duty
  - Distraction
  - Pressure
  - Capability
  - Local practices
  - Situational awareness
  - Alerting
  - Culture
  - Complacency
  - Communications

M/V Vega Sagittarius

Case Study 4: Engineering & Administrative Controls

AI-Capable Navigational Safety Decision Support

- **AI-based analysis of bridge (and E/R) data outputs: radar, AIS, ECDIS, engine and helm setting in conjunction with integrated camera systems:**
  - Continual monitoring, detection and identification of vessels/objects and navigation hazards
  - Assess navigational risk to vessel relative to course, heading, speed and voyage route plan
  - Identify risks to bridge watch – prompt acknowledgement and/or response
  - Can provide recommended navigation actions/responses to maintain safe passage
  - Support and augment crew bridge watch – perform “fatigue-inducing tasks”
  - Real-time data-supported navigational decision making rather than pure human situational assessment-based decision

M/V Rena

Case Study 5: Administrative Controls

AI-Based IMDG Cargo Misdeclaration Detection

- **Container vessel fires – several attributed to mis-declared IMDG/HAZMAT cargo. The issues:**
  - Unsuitable stowage location – ambient conditions (e.g. proximity to heated tanks, engine room)
  - Proximity to accommodation house and air/vent systems
  - Proximity to detection, alarm and FFF systems
  - Incompatibility of adjacent stowed cargo
  - Insufficient internal lashing/securing
  - Difficult to detect from cargo booking processes

- **AI capable software that integrates into cargo booking system:**
  - Learns “red flags” in booking declaration; description, spelling, abbreviations, weight v product, against established rules, historical data bases and regulatory rules libraries
  - Identifies risk % likelihood of mis-declared IMDG/HAZMAT prior to loading
  - Allows container to be pulled/survey required prior to acceptance

M/V Yantian Express

Case Study 6: Administrative Controls

AI-Based Fraudulent Carrier Vetting – Cargo Theft Prevention

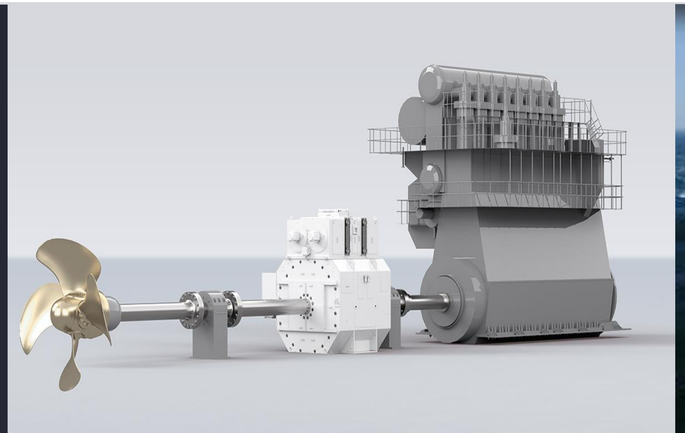
- **Cargo theft in the US up approx. 50% 2023 to 2024, and approx. 600% since 2021.**
- **“Fraudulent” theft up approx. 1,000% 2021 to 2024, and up from approx. 5-10% to 35-40% of all theft. The issues:**
  - Theft by deception – historically “fictitious pick up”
  - Has evolved in sophistication…assumed identities: carrier, tractor/trailer, drivers
  - Double brokering of loads
  - Cyber methods - hacking freight booking systems, and load boards to manipulate of BoLs changing carriers/drivers, delivery address, quantities
  - Social engineering – phishing, smishing, vishing
- **AI backed carrier vetting:**
  - Against operational information – FMCSA DoT history, mileage, fleet size/type
  - Against “bad actor” database
  - ID red flag potential fraud indicators
  - Prompt further verification or recommend do not use
  - Perform real-time ID verification checking if carrier, tractor/trailer/driver change at origin pick up
  - Verify as legitimate or identify as fraud risk “do not load”

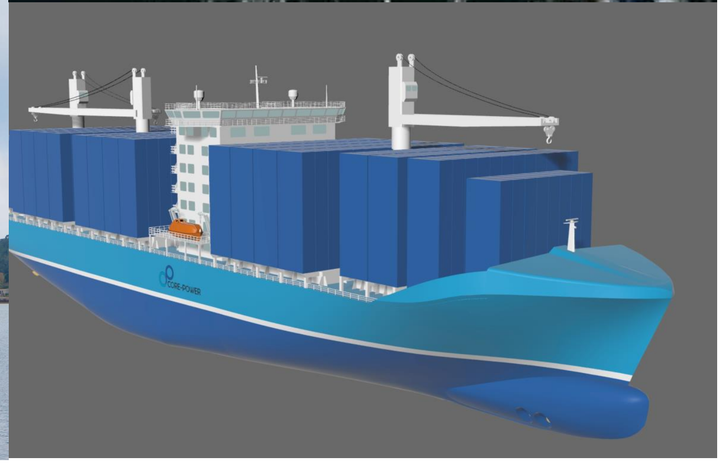
Final thoughts on Innovation and Technology Integration in Maritime

Vessel Efficiency, Voyage Optimization, and Next Generation Green Fuels

Innovation and new technologies are deeply embedded in future greening of marine:

- **AI-based vessel and voyage big data analysis for vessel and voyage optimization:**
  - Continually changing load condition – cargo, ballast, fuel, deadweight
  - Sea state and currents on intended route
  - Needed port arrival date
  - CII index considerations
  - Optimize engine/vessel speed, trim/ballast
- **Vessel Propulsive Efficiency:**
  - Hull form
  - Wind Assisted Propulsion, WAPs
  - Shaft generation
  - Waste heat recovery
- **“Green fuels”:**
  - New nuclear for maritime – propulsion / FNPP
  - Hydrogen, ammonia, methanol, biofuels





Thank you.
Questions?

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