

Developed by

Hazel Sivori

Assessing the human and system operational paradigm within ship auto-navigation

Findings from analysis of the critical tasks in ship navigation under different states of automation

Dr Eddie Blanco-Davis *BSc MSc PgCert PhD CMarEng CEng FIMarEST*

Reader in Marine Engineering, School of Engineering

Liverpool John Moores University

Europe-Korea Conference on Science and Technology, Marseille, July 2022



Contents

* Cover
* Contents
* Research Questions
* Theoretical Lenses
* Introduction
* Statistics
* Participant Info
* Observation Photos
* Results
* Themes
* Key Findings
* Roles and Functions
* Ship Auto-Navigation
* Functional Paradigm
* Model Task Diagram
* System of Systems

Research Questions

What are the **most critical** ship **operations**?

How might we **measure** operator **performance** with ship **autonomous systems**?

How do **human** operators **interact** with **automation** in ship **operations**?

How can **training** be **enhanced** for **complex** socio-technical **systems** in **maritime**?

(Young et al., 2014)

(Flin, 2019)

(Zhao and Smidts, 2019)

(Fairclough et al., 2019)

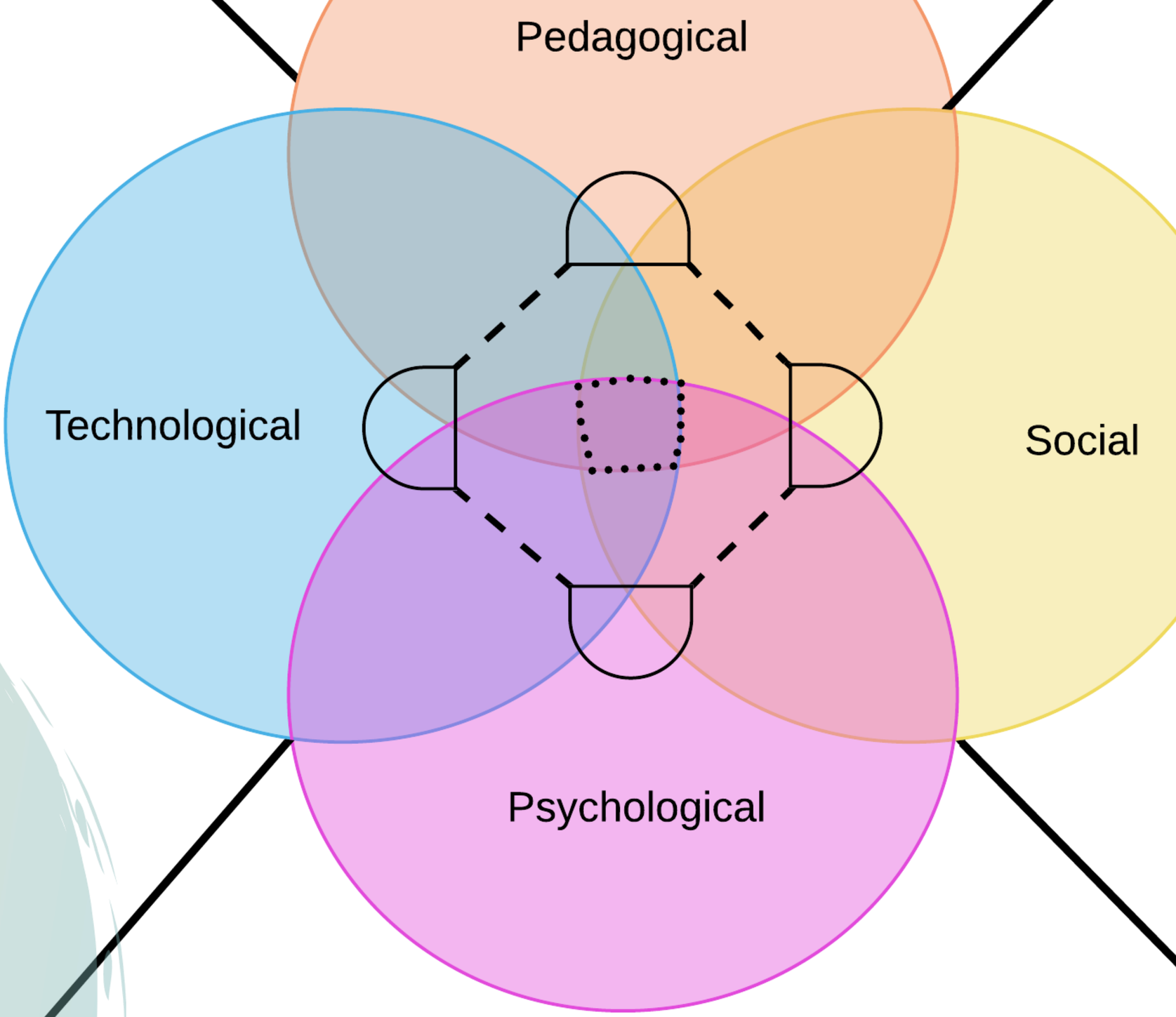
(McLeod, 2015)

(Long, 2001)

(Ayaz and Dehais, 2018)

Enhancing human performance in complex socio-technical systems

Intersection of theoretical lenses



Introduction

A hybrid **top-down bottom-up** approach to analysis of **critical tasks** influencing **ship auto-navigation**:

Organisational research

- accident data and reports, international guidelines

Workshop - semi-structured interviews

- Online survey (screening purposes)
- Individual Group Plenary (IGP) Method

Workplace study -

- **2 ships, 4 crossings,**
- 2 days o**bserving onboard** as passenger, also and **around quayside**

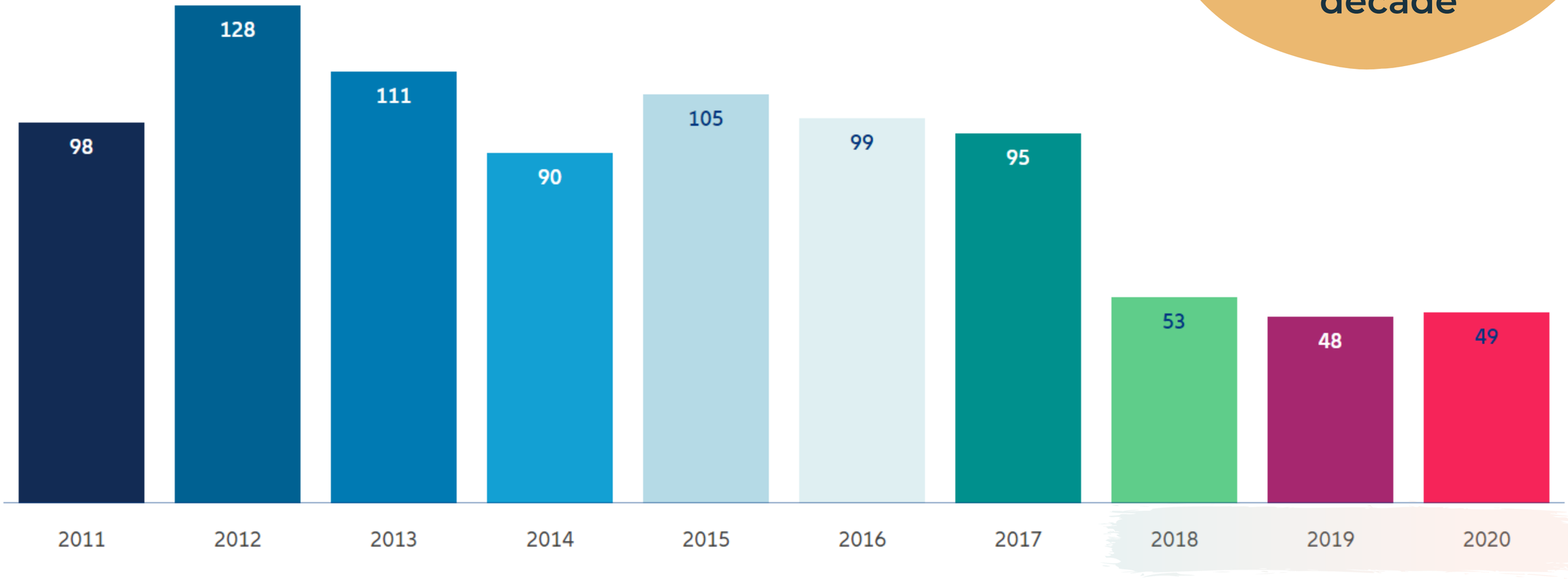
Approach to task analysis



(876 total losses from 2011-2020)

Total losses by year = Drop by 50% over the last decade

*Vessels over 100GT only

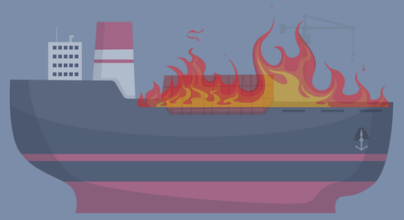


Source: Lloyd's List Intelligence Casualty Statistics

Analysis: Allianz Global Corporate & Specialty

Key Figures for 2014 - 2020

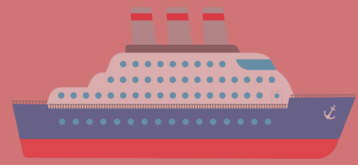
22532
Occurrences



571
Very serious ship casualties



24772
Ships involved



550
Fatalities



6921
Persons injured



966
Investigations launched



"The number of shipping incidents is UP, (2,815)

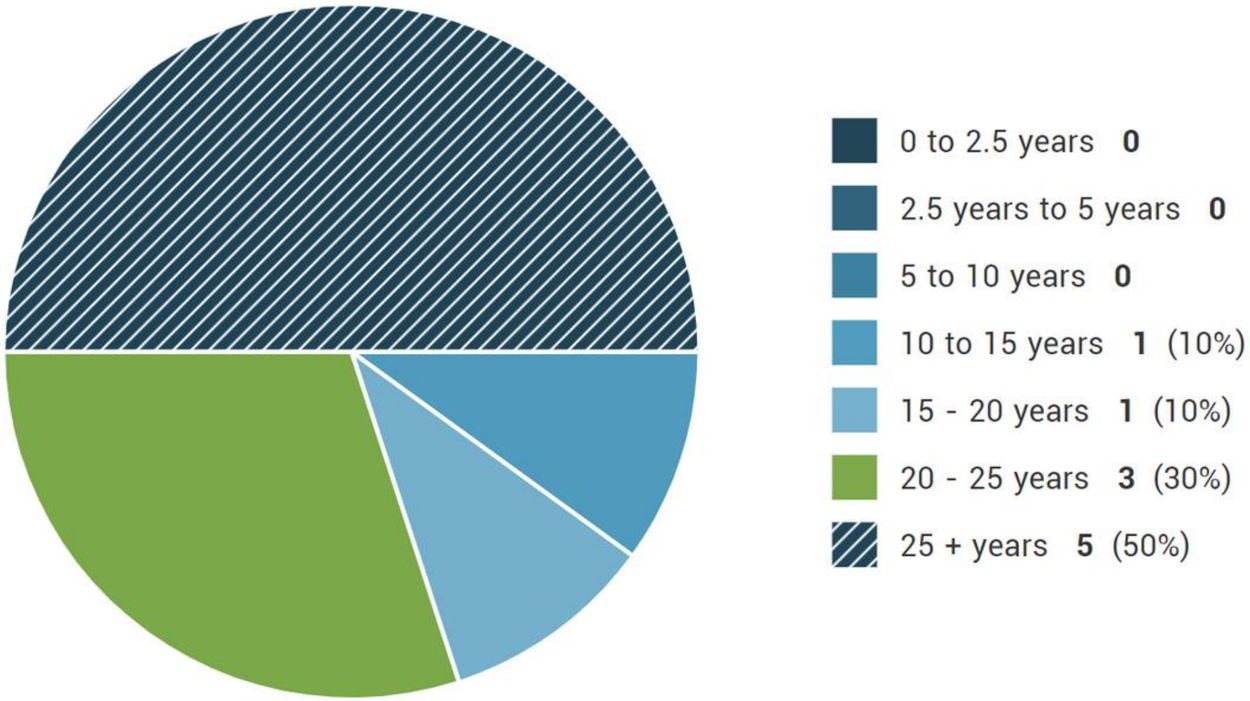
RO-RO vessel safety is a growing concern."

Source: Safety and Shipping Review 2020

Source: *European annual overview of marine casualties and incidents report 2021*

Workshop Participants

Experience in the Maritime Industry



23 years Average **length of experience** per participant

70% Maritime **Simulation Training**

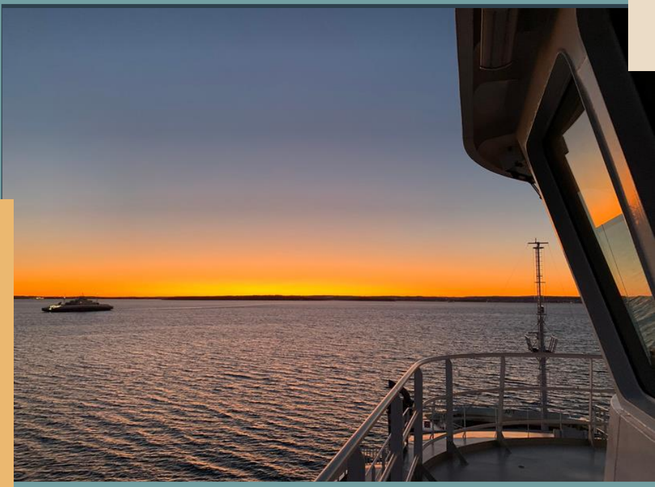
100% **Coastal** Navigation & **Deep Sea** Navigation Experience


EXTERNAL LIGHTING
AFT
FWD
Not ready
Horten - Moss
Skift 1 og Skift 3; bruker HPU-Pumpe 1
Skift 2 og Skift 4; Bruker HPU-Pumpe 2






POWER
NORSELIGHT
FOCUS
LAMP
ON

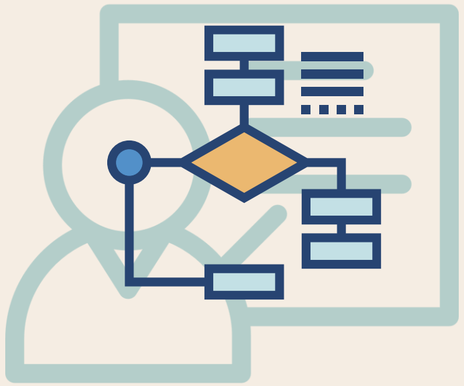


Results



Codebook

Analysed with **thematic analysis** using an **inductive approach**



Task Diagrams

A **model task diagram** that has been independently **verified by SMEs**



Auto-Navigation Workflow

An **end-to-end** process for **ship navigation** with **automation**

System

Operations

Safety

Human

Non-Technical Skills

Limitations, Conditions, Elements

Themes

6 Groups of themes were identified.

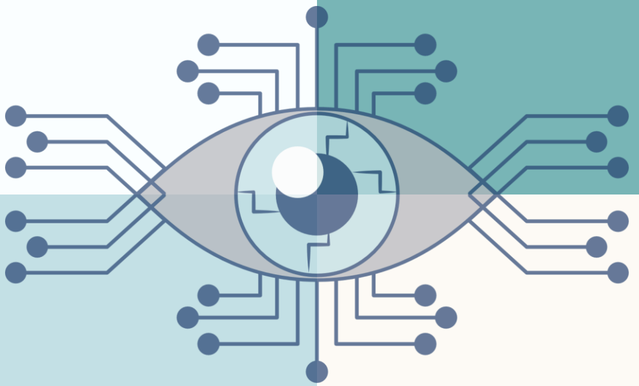
Sub-themes were also identified.

The **relationship** between each theme warrants **further investigation.**

The **human** and **system** themes highlighted the **overlapping issue** of **control.**

Key findings

In loop communication and shared **mental model**

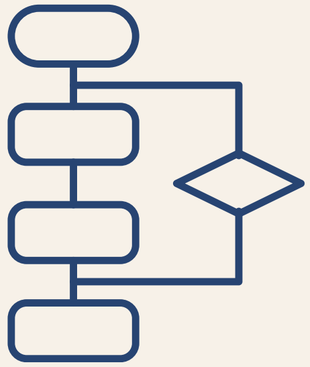


Humans are not good at **monitoring technology**

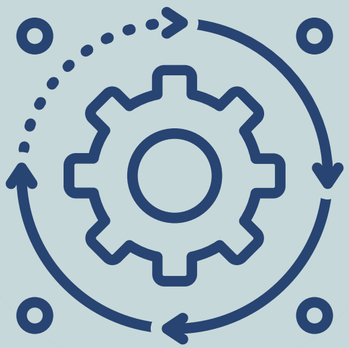
Fidelity and **sea-sense** (aka seamanship)

Ship Auto-Navigation

Tasks



Functions



Processes



Goals



Control





Roles and Functions

Different **levels** and **types** of automation

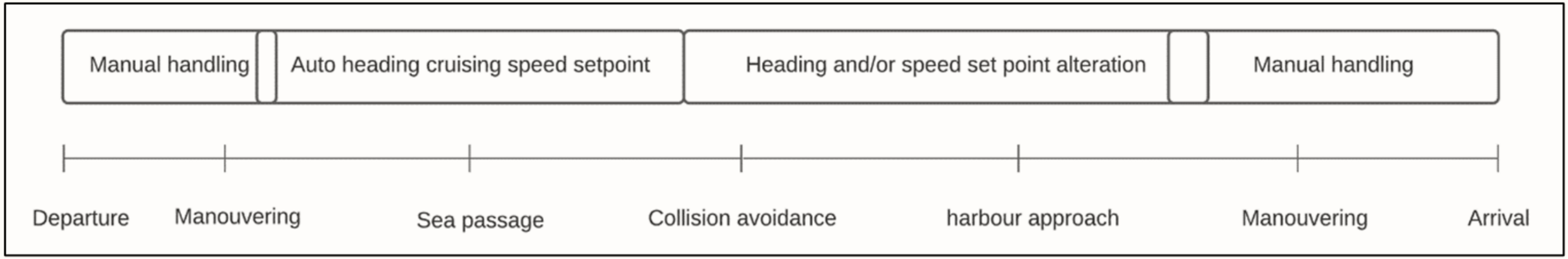
The human operators relationship with automated technology whilst watchkeeping is **often in flux**.

Throughout different phases of the navigation passage, the human may be **monitoring, supervising, manually commanding** or **evaluating** systems.

Organisational, external and internal circumstances may influence interactions between human and system.

Through observation and verification an **end-to-end navigation operation** workflow has been assembled.

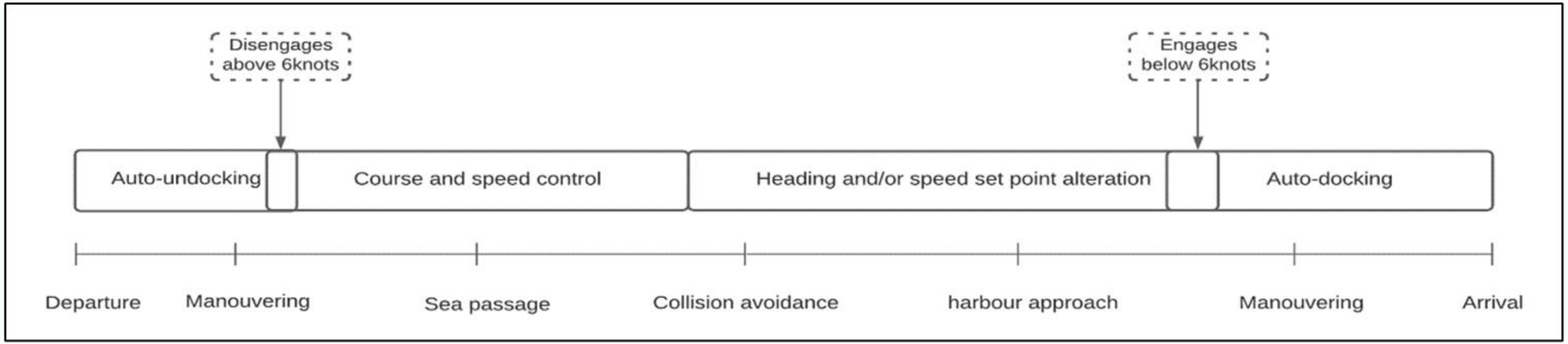
Traditional



Type 1 – function and control (lower-level automation)

High Level Process

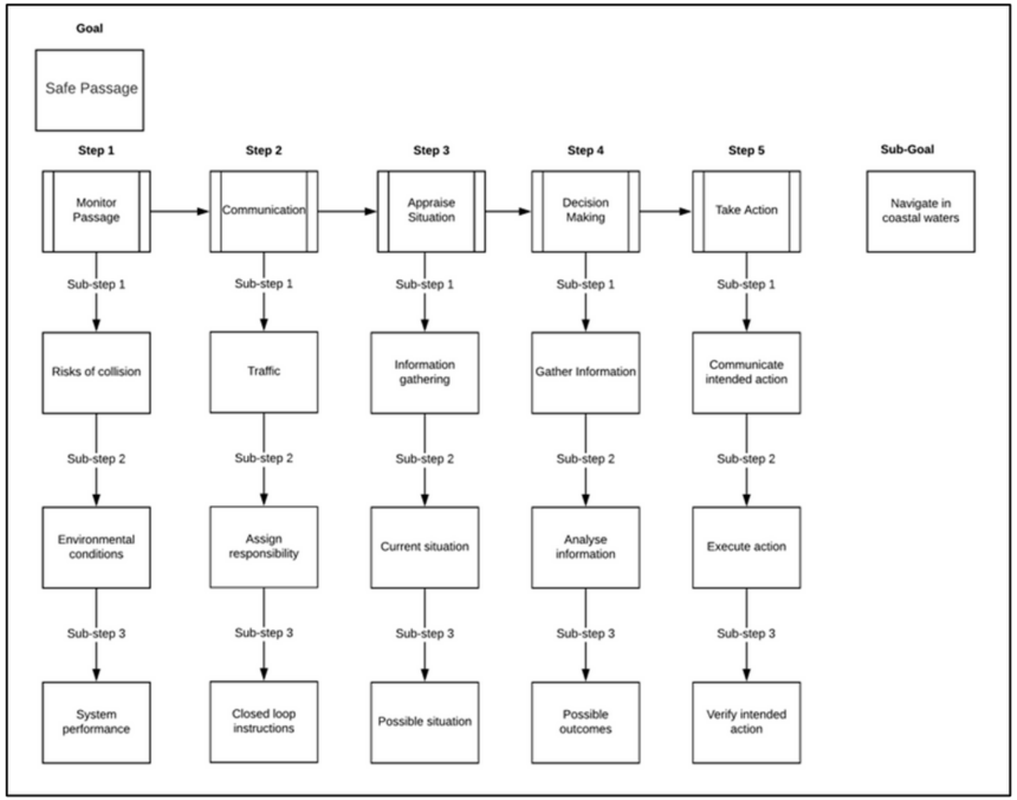
Automated



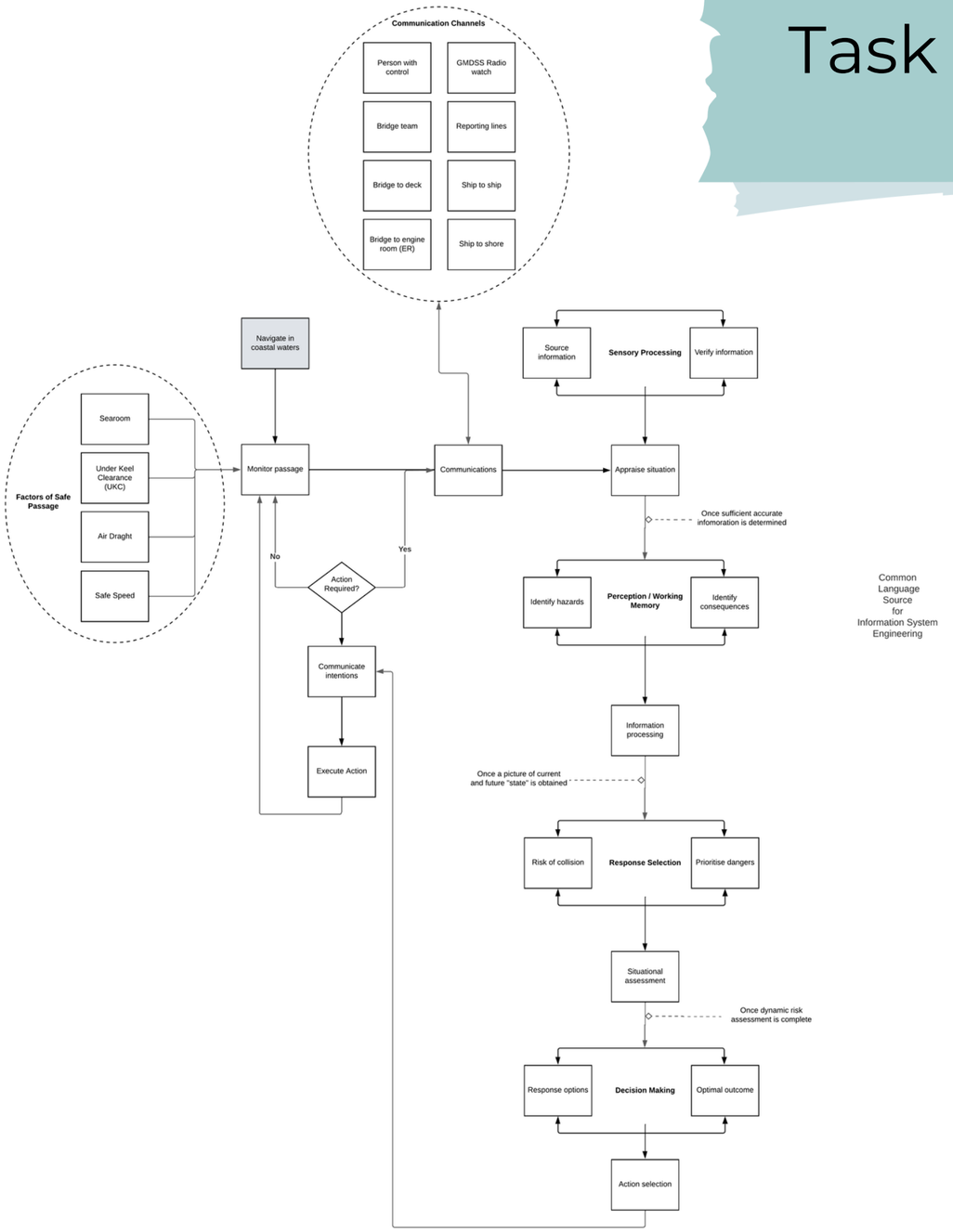
Type 2 – function and control (higher-level automation)

High Level Process

Task Diagram

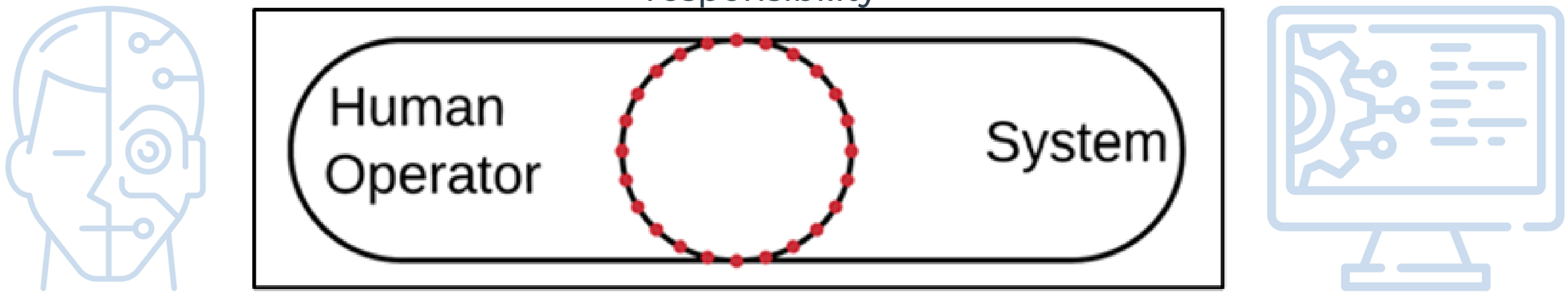


Steps and Sub-steps



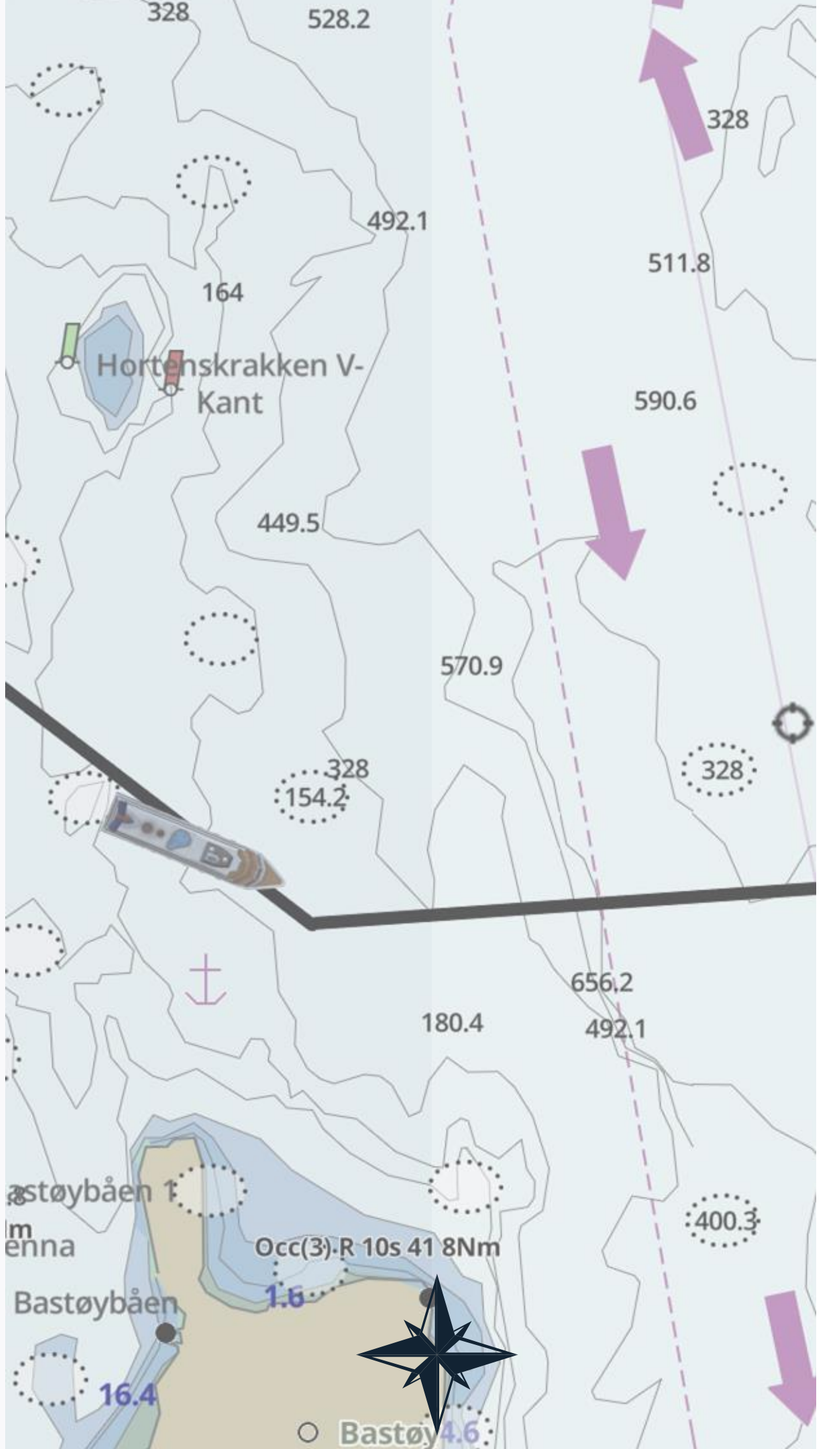
Functional paradigm

Allocation of **functional responsibility** between the **human and system**.



This changes with **vessel design** and **equipment available, preferences of teams,** and even comes down to **individual watchkeeper* skill and experience**.

*human operator



System of Systems

Human operators whether supervising the **safe passage of a ship**, be that:

- on the **navigational bridge**,
- on ship but in a **remote location**, or
- off ship **in a shore control location**,

require training and experience of new **operational paradigms**.

Ships are complex socio-technical systems

What's next?

Ships have evolved from **simple** into **complex systems.**

Automated technologies have changed the way a ship's crew work. Hence, an **altered operational relationship** has emerged.

This research observed how a **human operator** and **autonomous technology** interact.
The critical tasks identified from many sources make up **a model task** for further study.

What's more, this data has informed the **development of ship navigation scenarios**.

Now, we are refining cognitive performance assessment experiments using these ship simulation scenarios.





fNIRS and human-based design

- Usage of fNIRS equipment to estimate hemodynamic activity in relation to neural activity and cognitive performance and demand.
- Human-based design in enhancement of ship bridge design.

Functional near-infrared spectroscopy

Part of the team



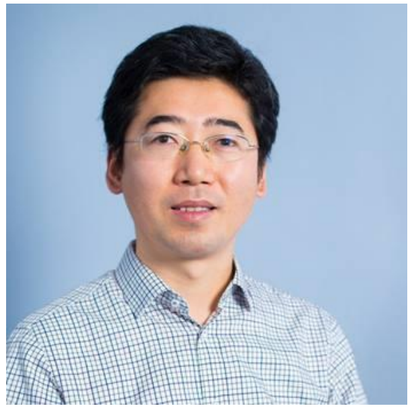
Dr E. Blanco-Davis



Prof Stephen Fairclough



Hazel Sivori



Prof Zaili Yang

Dr Alan Bury

Dr Shiqi Fan

Dr Stephen Symes