

Risk management of Remote pilotage operation

Prof. Osiris A. Valdez Banda, M.Sc. Sunil Basnet

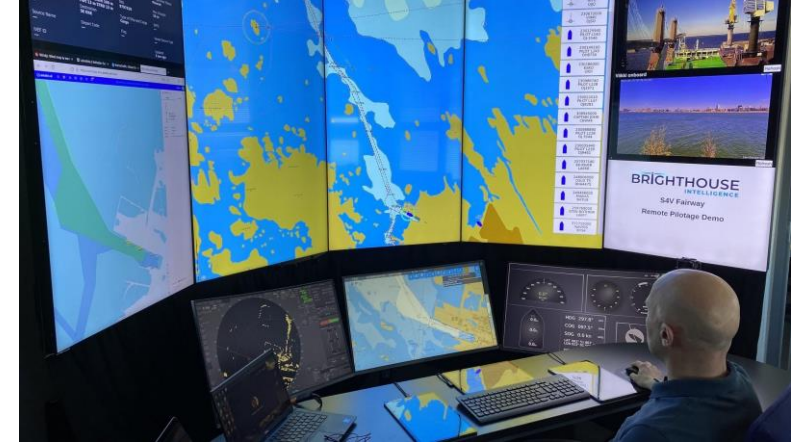
Aalto University

School of Engineering

Research Group on Safety and Efficient Marine and Ship Systems

Remote pilotage background

Supporting the vessel crew in ship manoeuvring remotely from shore



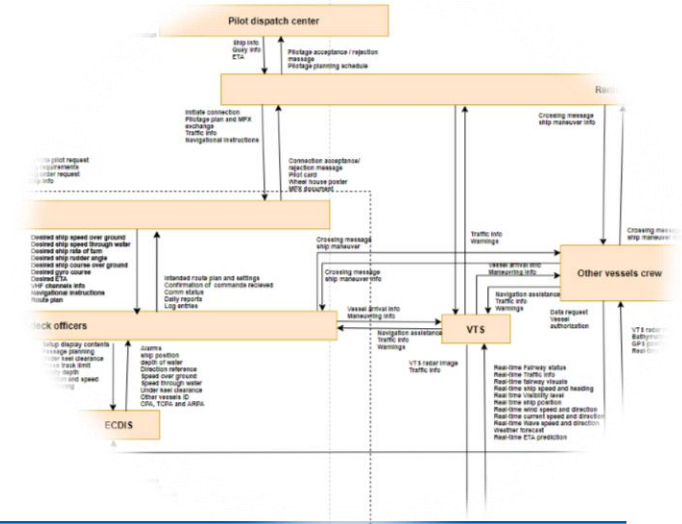
Challenges:

- Embedded software and advanced new technology
- High number of components and functions
- High interactions between components

State-of-the-art:

- Necessity to integrate advanced safety engineering methods that can handle the increasing complexity
- Limited risk management studies related to remote pilotage operation

Source: Dimecco



AIM

- Develop a description of the system (concept of operation) to understand what are the system components and how it functions
- Conduct risk management of Remote pilotage operation using Formal Safety Assessment Framework
- Integrate suitable methods for executing each step of the FSA

Initial Formal Safety Assessment

Scope: Intelligent fairway and remote piloting operations

Step 1
System
description

System requirements
System components
System design solution
Hazard identification

Step 2
Risk analysis

Risk criteria
Risk estimation
Risk evaluation

Step 3
Risk control
options

Risk mitigation actions
Feasibility study
Initial selection of RCOs

Step 4
CBA

Implementation cost
Economical benefit
Evaluation of mitigation
capability

Step 5
SRMS

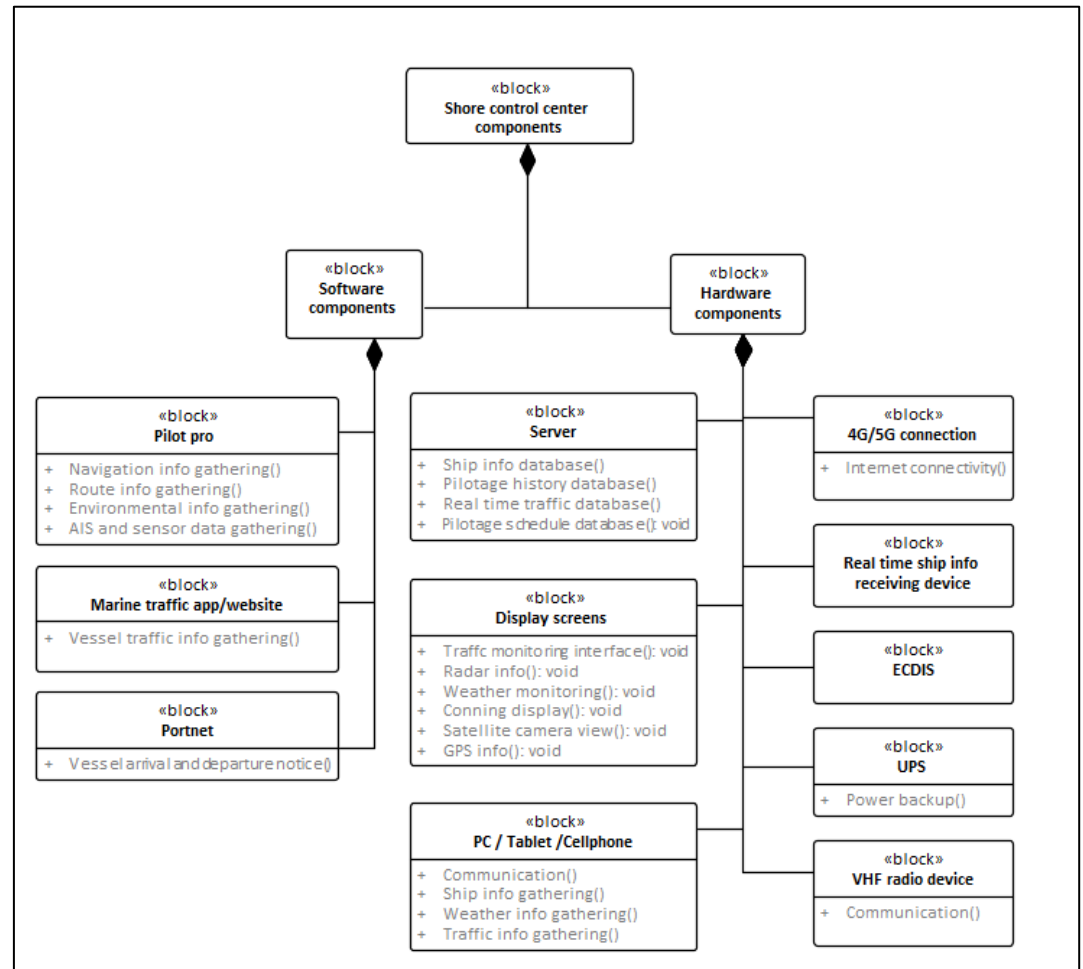
Management strategy
Stakeholder roles and
responsibilities
Documentation

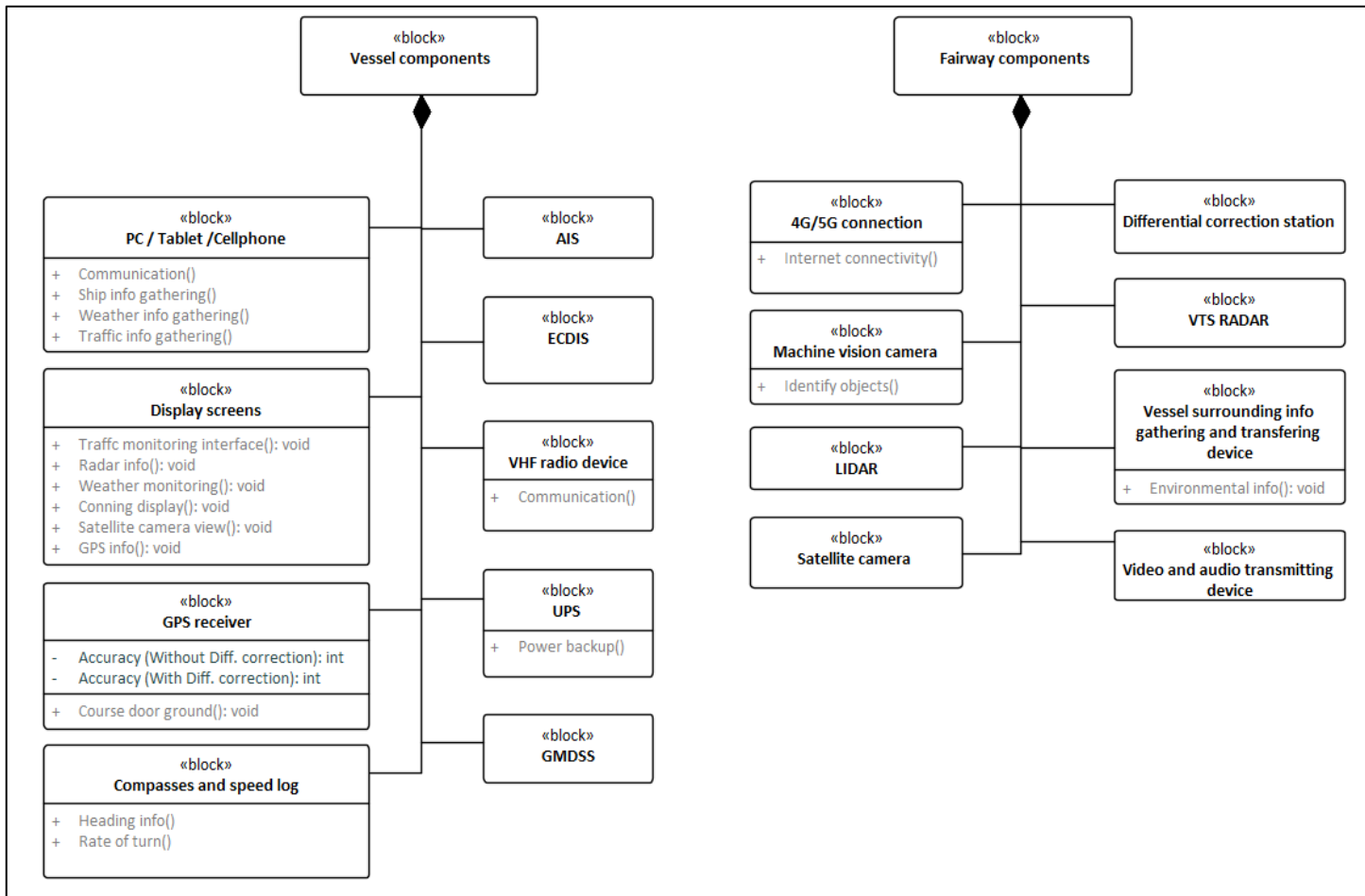
Step 1

Remote pilotage system description

RP component

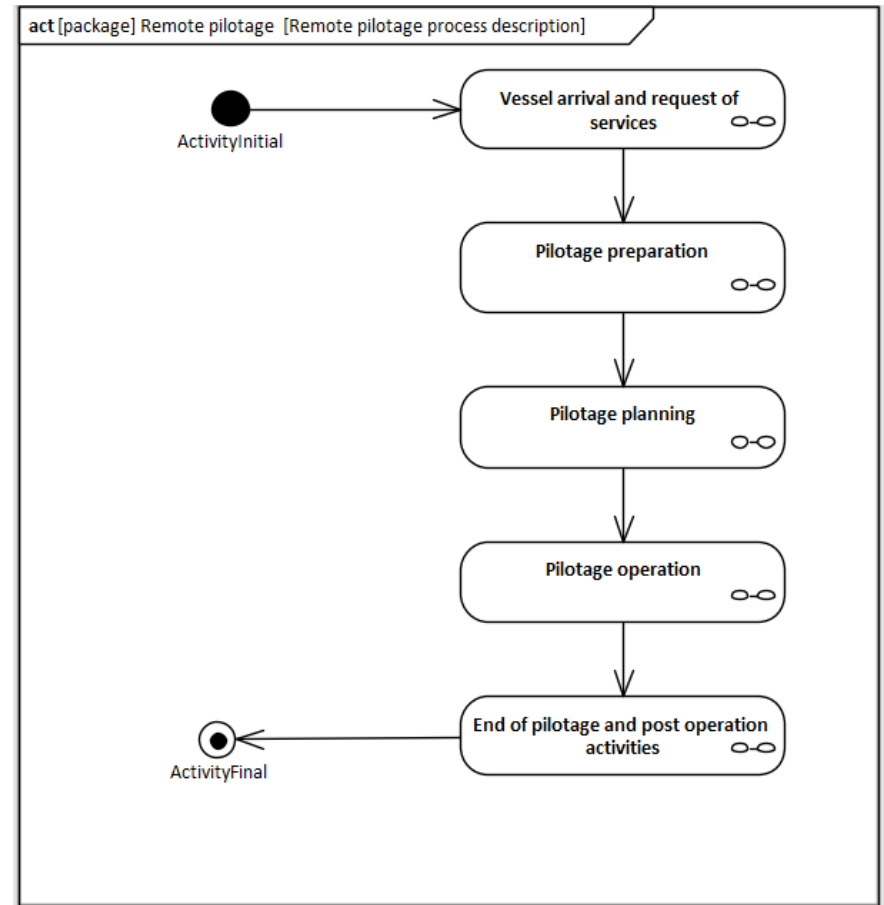
- Potential Remote pilotage components in the Shore control center, Vessel and Fairway.
- Executable models using System Modelling Language (SysML), which can be used to conduct system analysis such as power requirements, cost analysis etc in future.

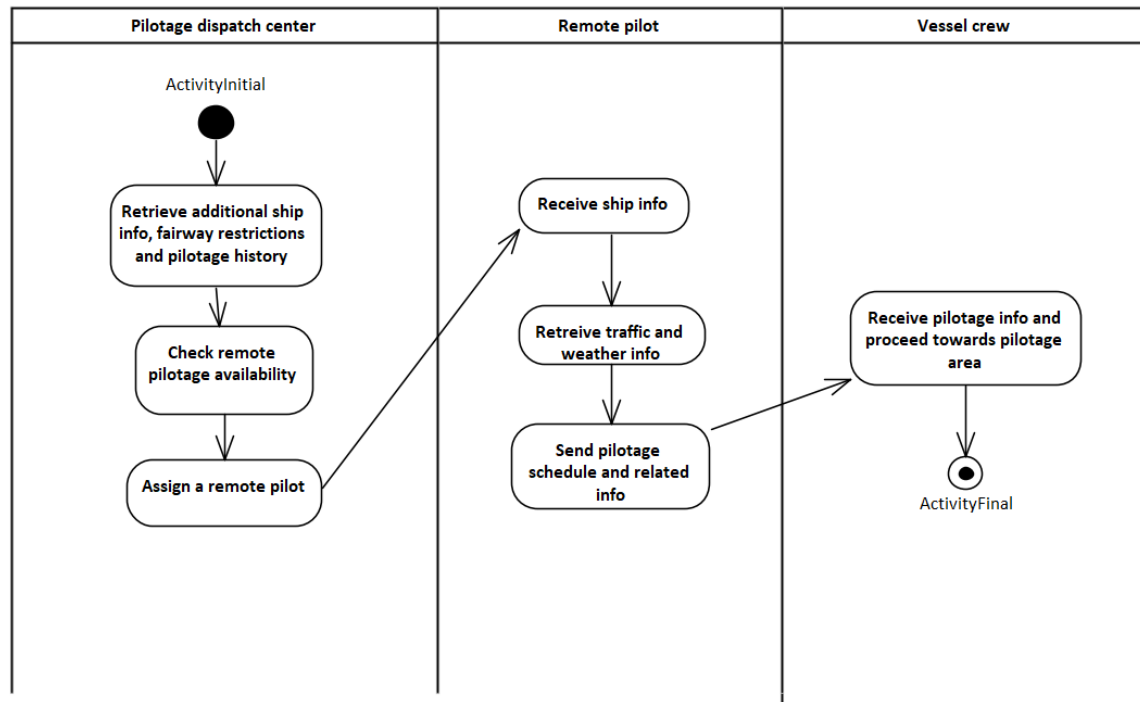
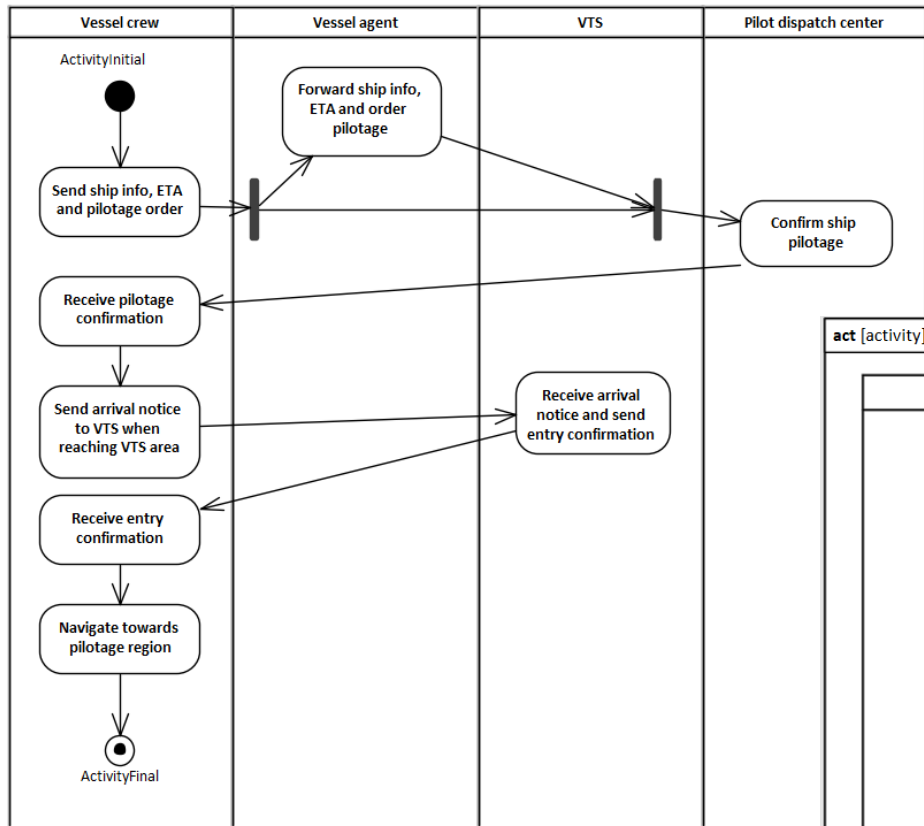




RP Process

- Process diagrams of remote pilotage operations
- Executable models – Can be simulated to see the process sequence



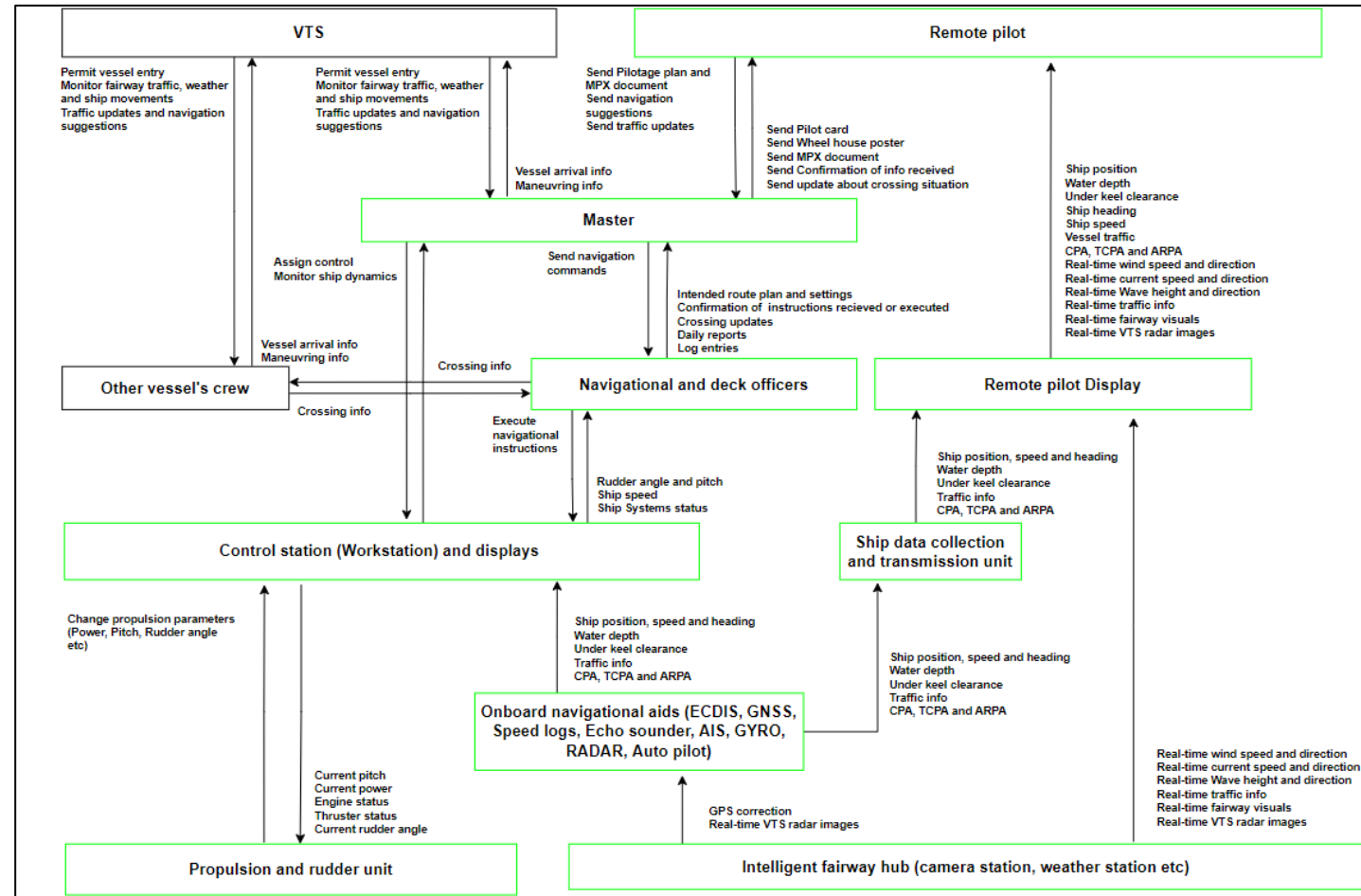


Step 2-4

Remote pilotage risk management

STPA hazard analysis

- Advanced hazard analysis method for complex socio-technical systems, which considers safety a dynamic control problem rather than a failure prevention problem.
- Analyze all interactions in RPO to identify unsafe situations



Summary of RPO Hazard analysis

-Six types of losses considered

L-1: Loss of life or injury to people
L-2: Loss of or damage of own ship and cargo
L-3: Loss of or damage of external objects
L-4: Loss of mission
L-5: Loss of environment
L-6: Loss of customer satisfaction

-Five System-level hazards considered

H-1: Ship violate minimum separation standards in route (L-1, L-2, L-3, L-4, L-5, L-6)
H-2: Ship does not maintain safe under keel clearance (L-2, L-4, L-5, L-6)
H-3: Ship leaves designated route (L-1, L-2, L-3, L-4, L-5, L-6)
H-4: Lack of communication initiation between remote pilotage stakeholders during remote pilotage (L-4, L-6)
H-5: Lack of information sharing between remote pilotage stakeholders during remote pilotage (L-1, L-2, L-3, L-4, L-5, L-6)

-More than 150 Unsafe actions identified

UCA1: Remote pilot does not initiate the communication with master prior to the pilotage. (H-4, H-5)
UCA12: Remote pilot provides wrong, unclear or missing info in pilotage plan and is followed by the vessel crew (H-1, H-2, H-3)
UCA103: Navigational crew provides rudder angle too late during pilotage operation (H-1, H-3)
UCA104: Navigational crew provides rudder angle via AP without providing correct settings to AP during pilotage (H-1, H3)

...

Summary of RPO Hazard analysis

- **800+ unsafe scenarios were identified, which was categorized into 3 major categories and 50+ sub-categories:**

Category 1 (C1) : Issues related to Hardware and Software

C1.1 - VHF failure

C1.2 – Cellphone /Tablet

Category 2 (C2): Issues related to Human factors

C2.1- Distraction

C2.2- Lack of skills/competence

Category 3 (C3): Issues related to incomplete, incorrect, unclear or lack of data

C3.1- Issues with data related to ship info

C3.3- Issues with data related to ship dynamics

UCA1: Remote pilot does not initiate the communication with master prior to the pilotage. (H-4, H-5)

Causal Scenario 1 (S1): The remote pilot does not initiate the communication because he doesn't receive the required ship information to initiate the communication from pilot dispatch center (C3)

Causal Scenario 2 (S2): The remote pilot does not initiate the communication because of fatigue due to work overload (C2)

...

Safety related to equipment

GYRO	RADAR	AIS	GPS
Engines	Fairway infrastructures	Lights onboard	Cloud services
Displays	Sound signaling device	Integrated alarm system	Communication device
Autopilot device	ECHO sounder	ECDIS	Rudder and helm
Data transmission unit	Networking equipment	Thruster and propulsion unit	



© Canstockphoto

Safety/Security related to information exchange

Ship dynamic data	Ship info	Fairway traffic info
Ship systems info	Weather info	Water depth info
Communications info	Quay info	Tugboat info
Crossing info		



© istock



© freepik

Safety related to human factors

Lack of skills /competence	Fatigue	Stress	Distraction
High level of task complexity	Lack of trust	Lack of checklists/ guidelines	Lack of standard phrases
Lack of seamanship	Language barrier	Wrong assumption	Poor situational awareness



© dreamstime



© shutterstock

Safety related to human factors

Lack of skills /competence	Fatigue	Stress	Distraction
High level of task complexity	Lack of trust	Lack of checklists/ guidelines	Lack of standard phrases
Lack of seamanship	Language barrier	Wrong assumption	Poor situational awareness

Skills related to remote pilot : Navigational suggestions, pilotage planning, establishing connection and sending info, suggesting emergency procedures, communication skills, situational awareness, handling new equipment e.t.c.

Skills related to Master and navigation crew: Vessel navigation, communication skills, executing emergency procedures e.t.c

Risk control measures:

- Selection of ship and fairway
- Simulation practices for remote pilotage
- Experienced and skilled pilots / crew
- Half-Duplex or Duplex communication
- Certification of Remote pilots and its validity
- Training for remote pilots and ship crew.
- Emergency procedures for remote pilotage (changing to conventional pilotage in case of major issues)
- Increased situational awareness (Installation of more camera stations in fairway, assess other technologies)
-

Risk matrix

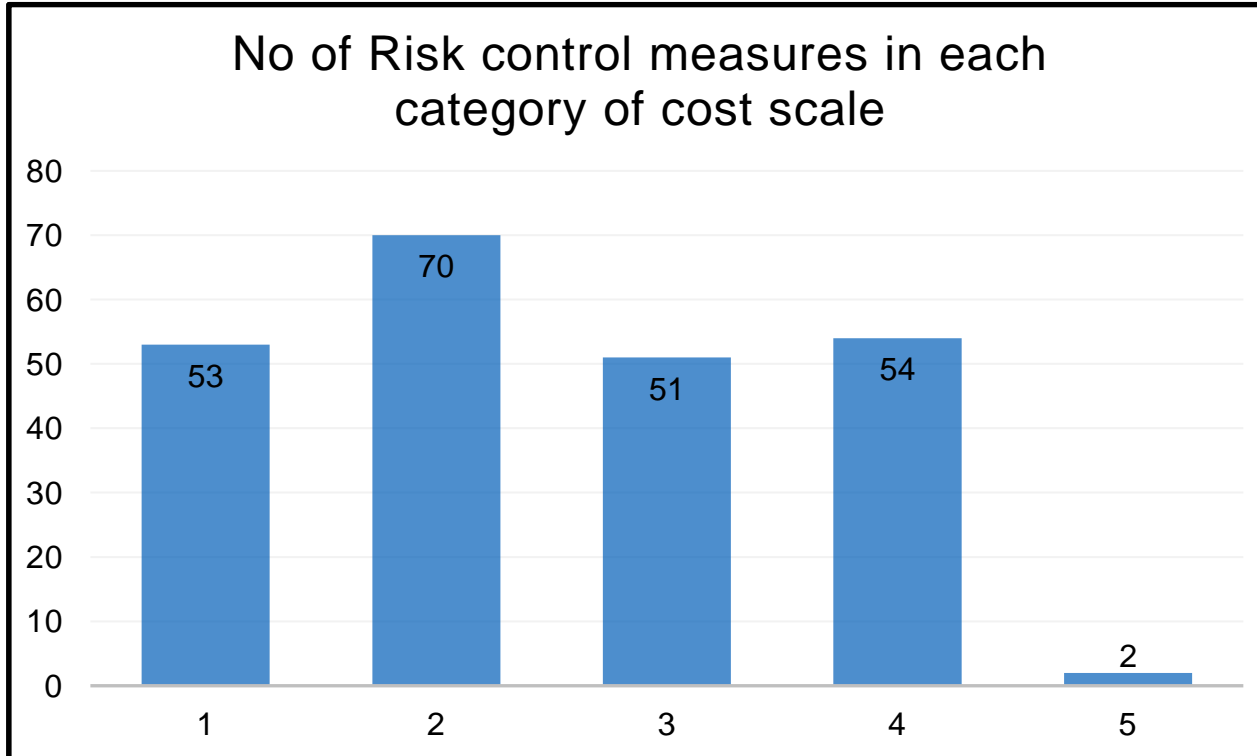
Risk matrix		Severity 			
		Minor	Significant	Severe	Catastrophic
Frequency 	Extremely remote	0	1	0	2
	Remote	6	10	7	2
	Reasonably probable	1	0	13	2
	Frequent	0	1	3	1

Estimated risk levels

Low risk level – 18 categories
Medium risk level – 9 categories
High risk level – 22 categories

- The estimated risk levels are before the implementation of risk control measures
- The successful implementation of risk control measures is expected to lower the risk levels

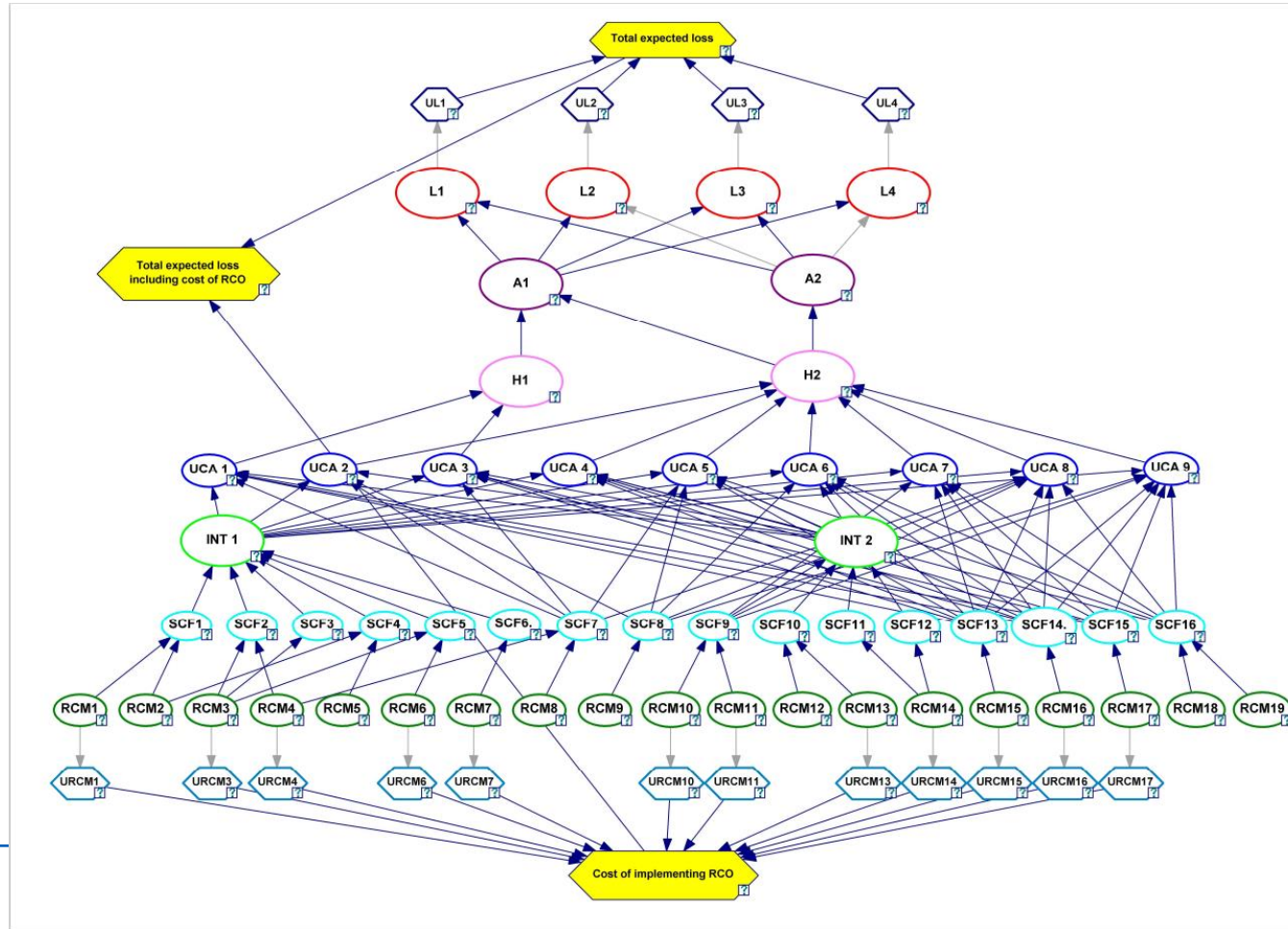
Preliminary Cost-benefit analysis of Risk Control measures



Scale for effectiveness of Risk Control Options	
Effectiveness	Reduction
1- Minimal effectiveness	0-20%
2- Low effectiveness	20-49%
3- Medium effectiveness	50-69%
4- High effectiveness	70-99%
5- Very high effectiveness	100%

Cost-benefit analysis of RPO using Influence diagrams

- An Influence diagram of RPO has been developed to assist the decision-makers on the selection of Risk Control Options
- The diagram is focused on critical risk nodes and can estimate the total expected benefit by calculating the benefit due to risk reduction and the cost of implementation



Step 5

Defining the basis for the Risk and Safety Management Strategy of Remote Pilotage

Work concluded and “potential” next steps

- 50+ loss causal factors were identified in RPO risk analysis requiring risk control options.
- The risk management strategy defined with the RCOs should be used as the foundations for the definition of a structured management system during the remote pilotage service life-cycle.
- The output of this work supports the definition of safety requirements related to remote pilotage (preliminary abstract level requirements exist already in the pilotage act)
- For the next iterations, the scope of the analysis should be expanded to a higher level (management and authorities).
- The defined processes and the collected information should be accompanied by the operational and simulation data as available in future.

Thank you!



Task 4.1 Risks, safety and security (Research Team)

For more information please contact:
Osiris A. Valdez Banda (osiris.valdez.banda@aalto.fi)
Sunil Basnet (sunil.basnet@aalto.fi)