

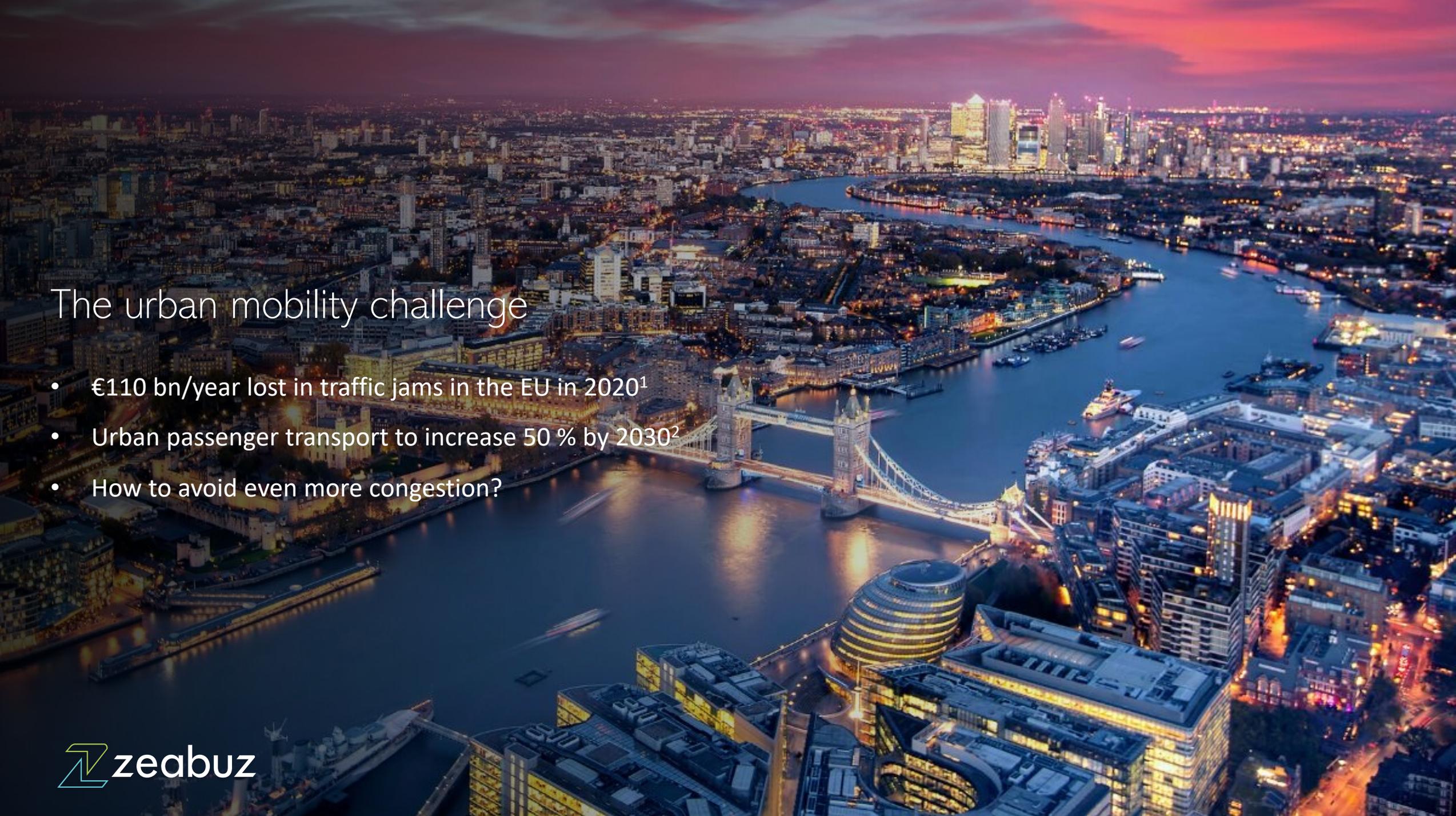
# HFC Forum 2023-04-26: AutoreMOTE operation of urban passenger ferries – combining autonomous operation with human oversight



 **zeabuz**

Enabling sustainable waterborne mobility for all

 <p>9 INDUSTRY, INNOVATION AND INFRASTRUCTURE</p>	 <p>11 SUSTAINABLE CITIES AND COMMUNITIES</p>	 <p>13 CLIMATE ACTION</p>
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An aerial night view of London, showing the River Thames winding through the city. The Tower Bridge is illuminated and spans the river. The city lights are visible in the background, and the sky is a mix of dark blue and purple from the twilight.

## The urban mobility challenge

- €110 bn/year lost in traffic jams in the EU in 2020<sup>1</sup>
- Urban passenger transport to increase 50 % by 2030<sup>2</sup>
- How to avoid even more congestion?

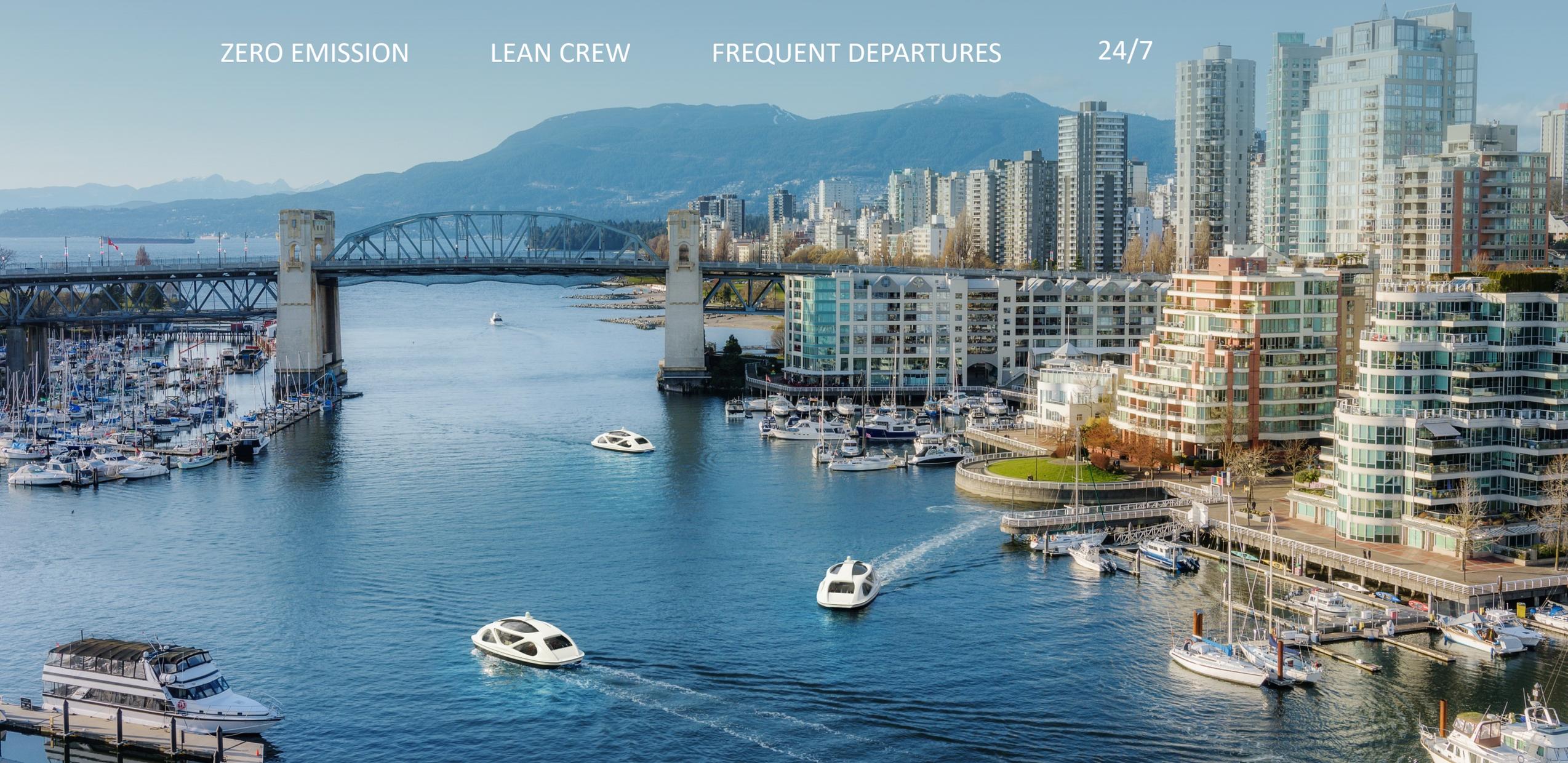
# Waterborne mobility made scalable with autonomy

ZERO EMISSION

LEAN CREW

FREQUENT DEPARTURES

24/7



*September 2022:*

*World's first autonomous  
urban passenger ferry*

- Zeabuz autonomy inside
- 3 weeks
- 1500 passengers
- 400 crossings



# June 2023: Urban shortcut premiere in Stockholm



Autonomy system  
Mobility concept

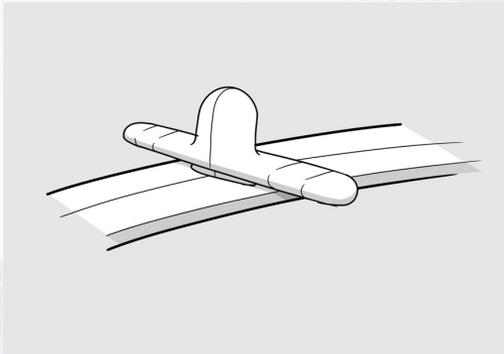


# Autonomy building blocks

## Zeabuz autonomy platform

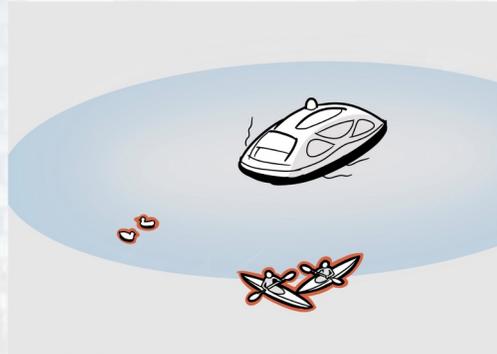
## Automation

### Sense



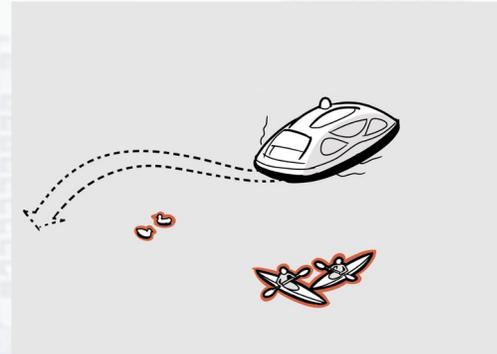
Perception sensors

### Comprehend



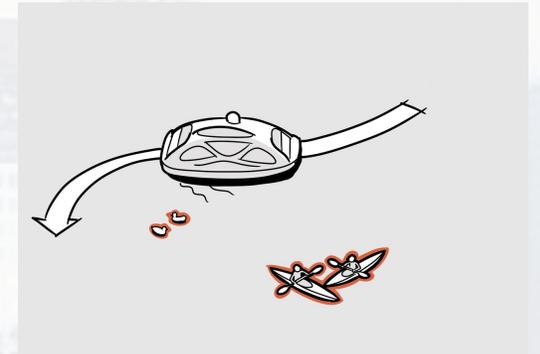
Situational awareness

### Plan



Motion planning

### Act



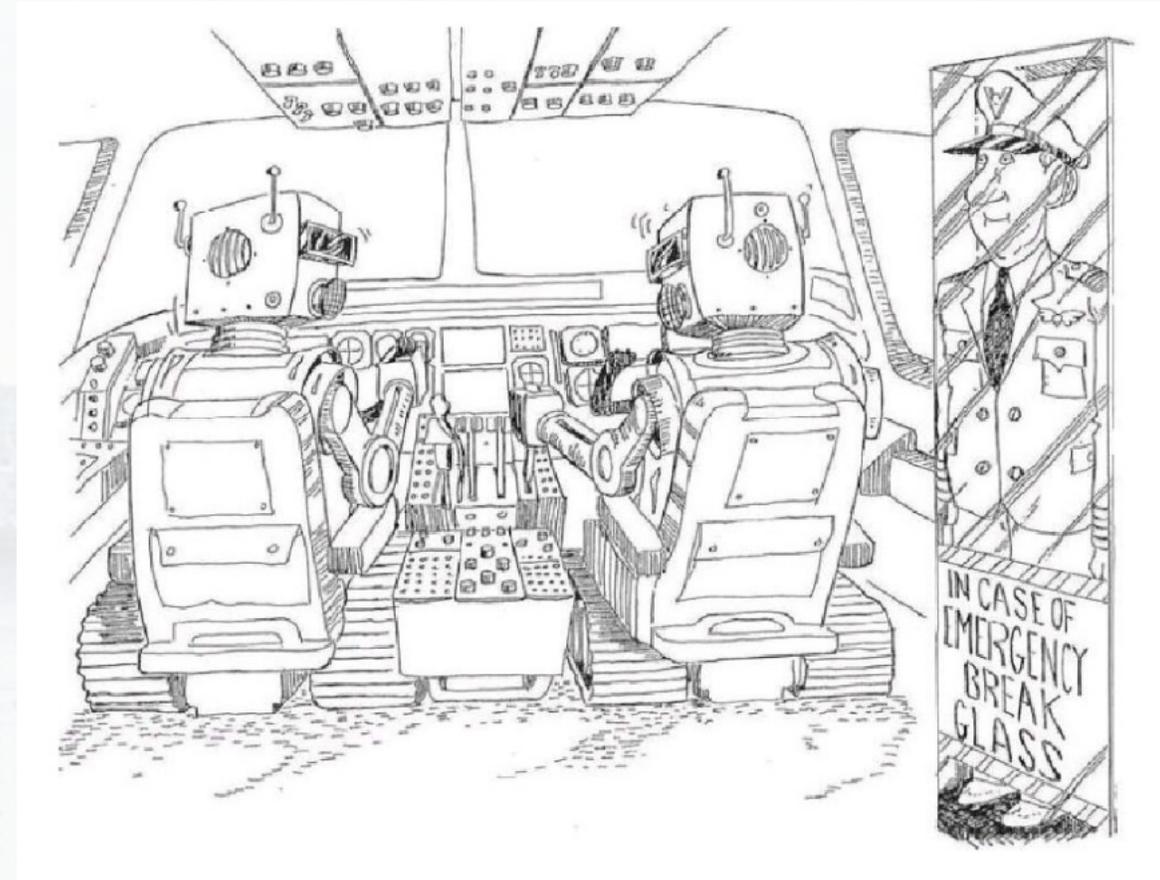
Motion control



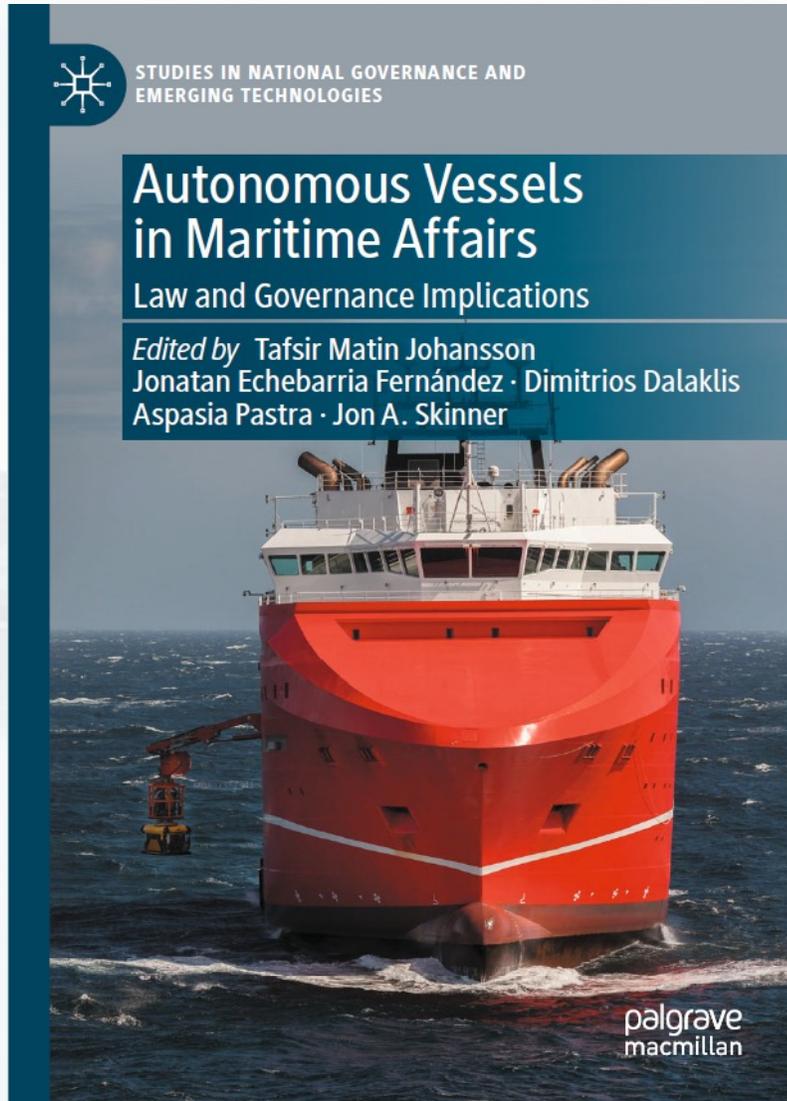
Remote support

# What is autonomy? Really?

- Autonomous - Automatic - Unmanned - Remotely Operated
- Too many different taxonomies and definitions...
- Let's rather talk about what the system really does
  - What actions does it take?
  - Which responsibilities does it have?
  - What are the fall-back functions?
  - Where and how is the human in the loop?



... but how do we regulate it?



## Chapter 10

Autonomous Urban  
Passenger Ferries—A  
New Mobility Mode in  
Need of Appropriate  
Regulation

# Generic functional overview

## Navigational functions

- Look-out
- Situational awareness
- Motion planning
- Collision avoidance
- Motion control
  - Dynamic Positioning
  - Autopilot
  - Auto-tracking
  - Auto-docking
  - ...
- Steering & propulsion

## Engineering functions

- Machinery system
- Electric power system
- Battery management
- Charging system
- Mooring system
- Hatches etc
- Anchoring
- Bilge systems
- Ballasting
- Watertight integrity
- Fire safety
- HVAC
- Cargo handling
- Maintenance
- ...

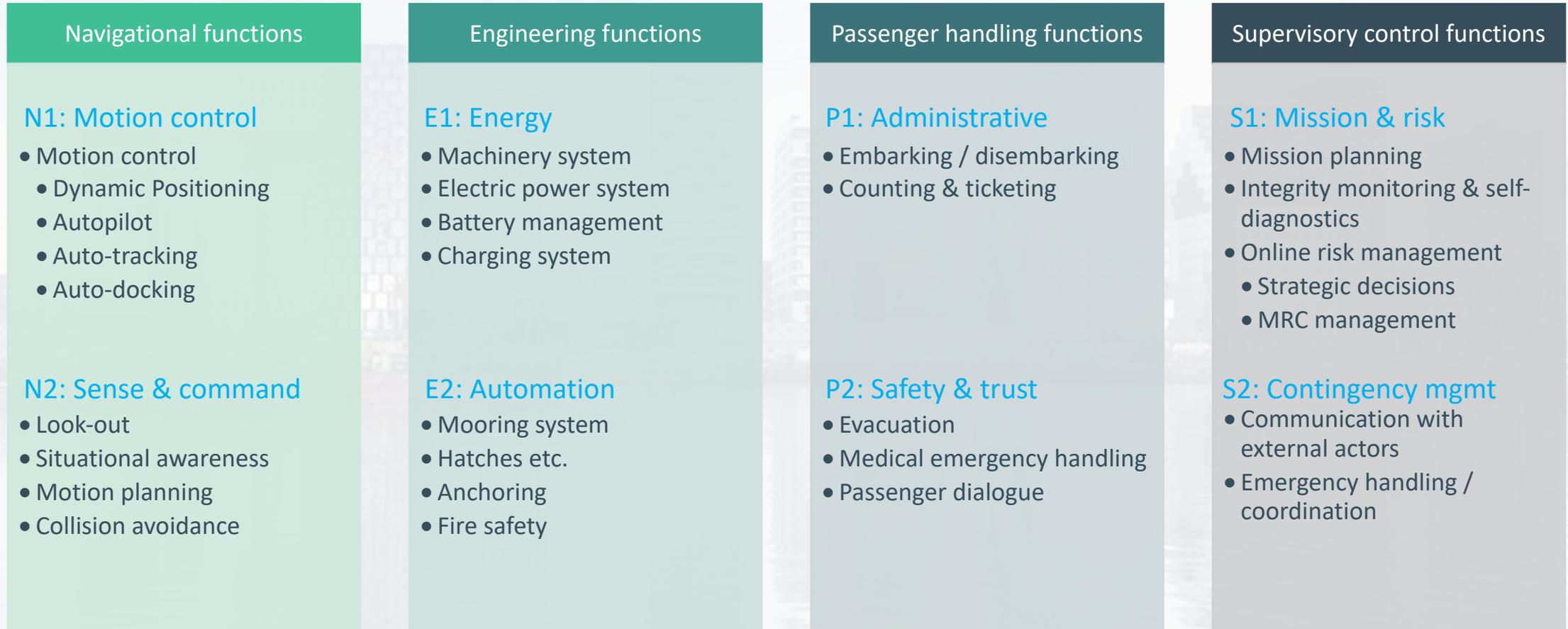
## Passenger handling functions

- Evacuation
- Medical emergency handling
- Passenger dialogue
- Embarking / disembarking
- Counting & ticketing

## Supervisory control functions

- Mission planning
- Integrity monitoring & self-diagnostics
- Online risk management
  - Strategic decisions
  - MRC management
- Communication with external actors
- Emergency handling / coordination

# Urban shortcut functional overview

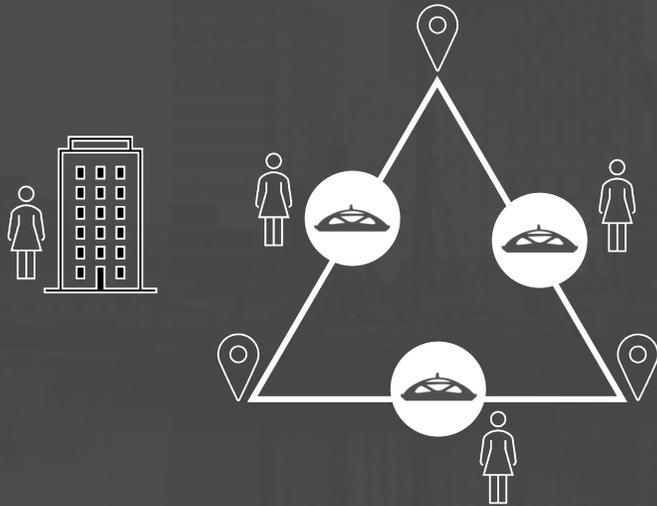


# Levels of Automation for urban shortcuts

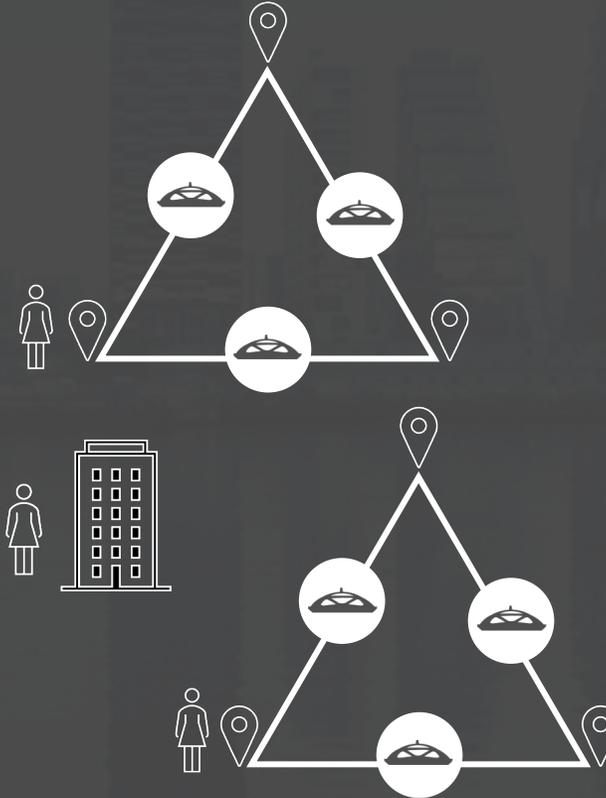
LoA 0: Manual operation

LoA 1: Automatic operation (auto-track)

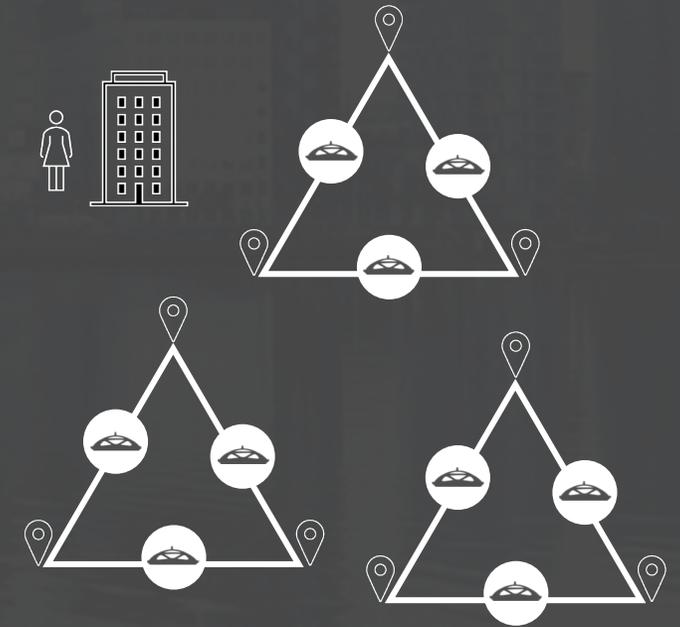
LoA 2:  
Onboard supervised autonomy



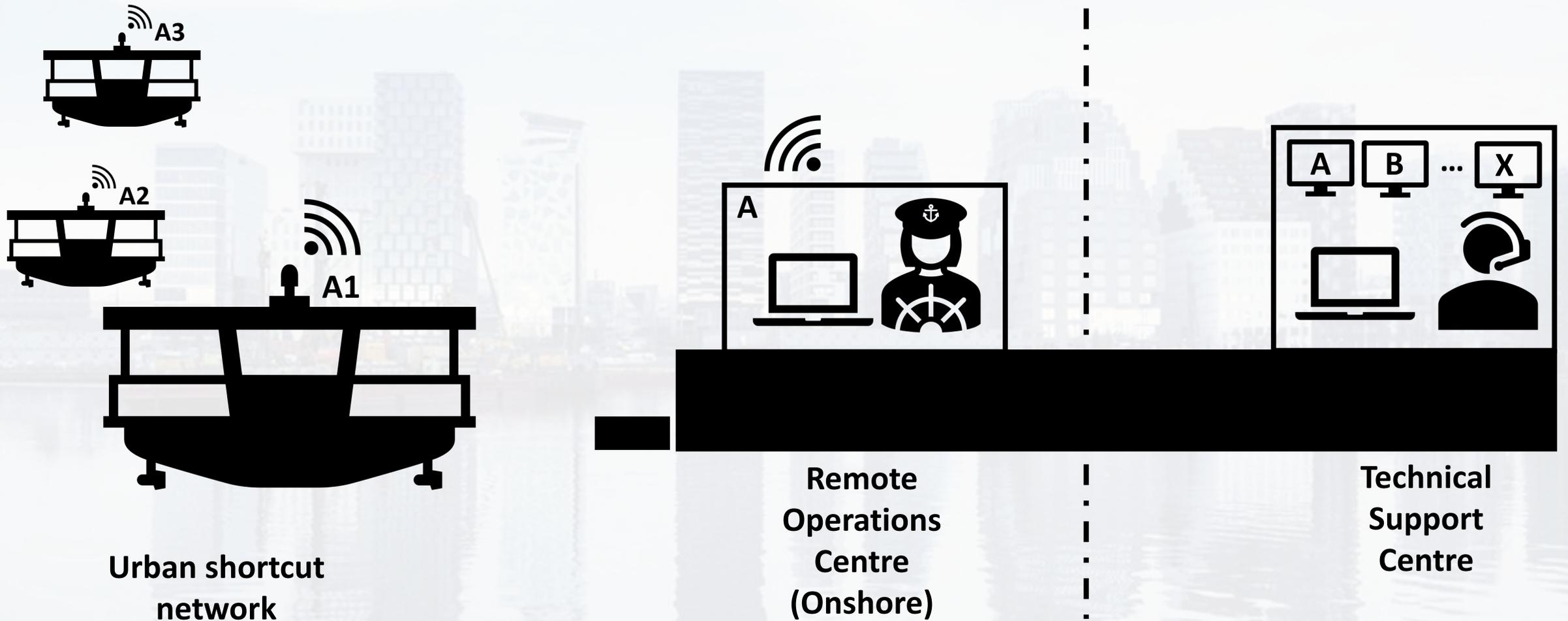
LoA 3:  
Onshore supervised autonomy



LoA 4:  
Remote supervised autonomy



# Operational setup for LoA 3: Onshore supervised autonomy



# Agents and roles

There are potentially 4 agents directly involved in the operation:

1. The autonomy system
2. The onboard supervisor
3. The onshore supervisor at the Remote Operations Centre (ROC)
4. The technical support centre (TSC)

Responsibility for operational functions are distributed among these agents:

- **Action:** Who *initiates* and *performs* the operational function?
- **Authority:** Who is *responsible* for the function?

# Levels of Autonomy – a roadmap for stepwise introduction

Level of Automation (LoA)	Functional group	Autonomy system		Onboard safety supervisor		Onshore safety supervisor (ROC)		Technical support centre (on-demand)	
<b>Level 0: Manual operation</b>	All			Action	Authority				
<b>Level 1: Automatic operation</b>	Navigation 1: Motion control Navigation 2: Sense & command Engineering 1: Energy Engineering 2: Automation Passengers 1: Administrative Passengers 2: Safety & trust Supervisory 1: Mission & risk Supervisory 2: Contingency mgmt.	Action		Action	Authority Authority Authority Authority				
<b>Level 2: Onboard Supervised Autonomy</b>	Navigation 1: Motion control Navigation 2: Sense & command Engineering 1: Energy Engineering 2: Automation Passengers 1: Administrative Passengers 2: Safety & trust Supervisory 1: Mission & risk Supervisory 2: Contingency mgmt.	Action Action Action Action		Action Action Action	Authority Authority Authority Authority			(Action) (Action) (Action)	(Authority) (Authority) (Authority)
<b>Level 3: Onshore Supervised Autonomy</b>	Navigation 1: Motion control Navigation 2: Sense & command Engineering 1: Energy Engineering 2: Automation Passengers 1: Administrative Passengers 2: Safety & trust Supervisory 1: Mission & risk Supervisory 2: Contingency mgmt.	Action Action Action Action Action	Authority Authority Authority Authority			Action Action	Authority Authority	(Action) (Action)	(Authority) (Authority)
<b>Level 4: Remote Supervised Autonomy</b>	Navigation 1: Motion control Navigation 2: Sense & command Engineering 1: Energy Engineering 2: Automation Passengers 1: Administrative Passengers 2: Safety & trust Supervisory 1: Mission & risk Supervisory 2: Contingency mgmt.	Action Action Action Action Action	Authority Authority Authority Authority					Action Action Action	Authority Authority Authority



# Summing up

- Urban electric passenger ferries are a sustainable and compelling solution to growing congestion and emissions in cities across the world
- Cost of crew, increasing crew shortages and old business models inhibits the scaling potential
- Autonomy is the key enabler for widespread waterborne mobility, but will need appropriate regulation and societal acceptance
- **Solution:** Smart and stepwise introduction of autonomy with human supervision

