Fraunhofer CML

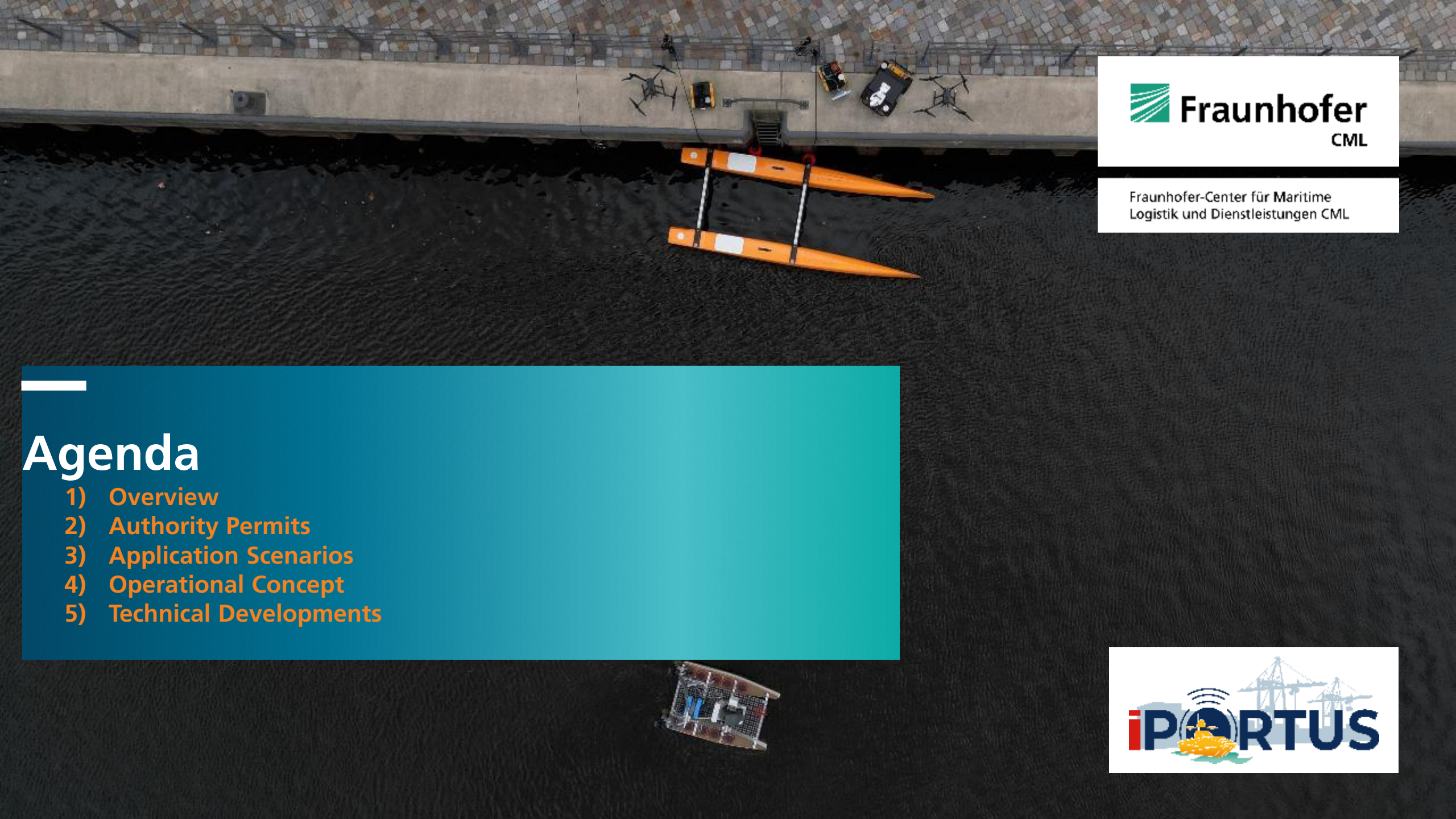
Fraunhofer-Center für Maritime Logistik und Dienstleistungen CML

LSSTF26 | 25.06.2026 | Johannes Oeffner

iPORTUS

Integrating USVs in busy ports: Operations, Permitting, and Technical Insights from the iPORTUS Project

iPORTUS



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Agenda

1) Overview
2) Authority Permits
3) Application Scenarios
4) Operational Concept
5) Technical Developments

iPORTUS

iPORTUS Project

Intelligent and safe Port Operations based on Resilient Technology for Autonomous and Uncrewed Surface Vehicles

Partner

Hamburg Port Authority (HPA)

The Hamburg Port Authority **coordinates** the project and contributes its **operational** and **regulatory expertise**. It defines requirements for autonomous watercraft, creates **test conditions** in the port, oversees approval processes, and **validates** the technologies during ongoing operations. Furthermore, it promotes their integration into port processes and acts as a **central interface** between authorities, industry, and research.

Fraunhofer-Center für Maritime Logistik und Dienstleistungen CML

Fraunhofer CML **develops key technologies for autonomy and safety**, including AI-based obstacle detection, collision avoidance, and GNSS-independent navigation. It also creates a **remote operation center** for monitoring multiple vehicles and supports the **transfer of technologies into approved applications**. Additionally, data-driven analysis and evaluation tools are developed to optimize operations.

Kongsberg Defence and Aerospace Germany

Kongsberg Defence & Aerospace Germany contributes its expertise in **maritime technology integratio**n, focusing on safely integrating autonomous systems into complex port environments, especially regarding **visibility** and **detectability**. The company also helps develop **approved operational concepts** and supports the design and validation of the remote operation center for safe autonomous fleet operations.

Associated Partner

Facts

- Duration: 12/25 – 11/28
- Budget: 1,67m Euro

This project is funded by the German Federal Ministry for Digital and Transport (BMDV) as part of the IHATEC (Innovation Programme for Logistics and Maritime Transport Technologies) funding program

  Public information

Overview
Problem definition

Challenges for ports

Ports are under pressure to implement decarbonization, digitalization and increased efficiency, while ensuring safety and resilience. USV market is rising rapidly

USV standards currently missing

Standardized approval and risk assessment procedures, solutions for cyber risks, as well as secure integration into conventional shipping traffic are lacking for autonomous or uncrewed surface vessels

Overview

Targets

Integration of ASVs into complex port environments

iPORTUS develops and tests the integration of semi-autonomous, unoccupied, environmentally friendly watercraft into complex port environments

Compliant operating concept

Developments in navigation, autonomy and cybersecurity are intended to create an operating concept and recommendations for action for technology, regulation and economic efficiency

Overview
Goals

Testing ASVs with different specifications

- Under real conditions in the port
- Different sizes and features
- Three extensive test and demonstration campaigns

Technical developments

- Sensor fusion (radar, lidar, cameras, AIS) for situational picture and action
- SLAM navigation
- VR control for remote operations
- Cyber risk assessment

Overview
Intended Results

Technical results

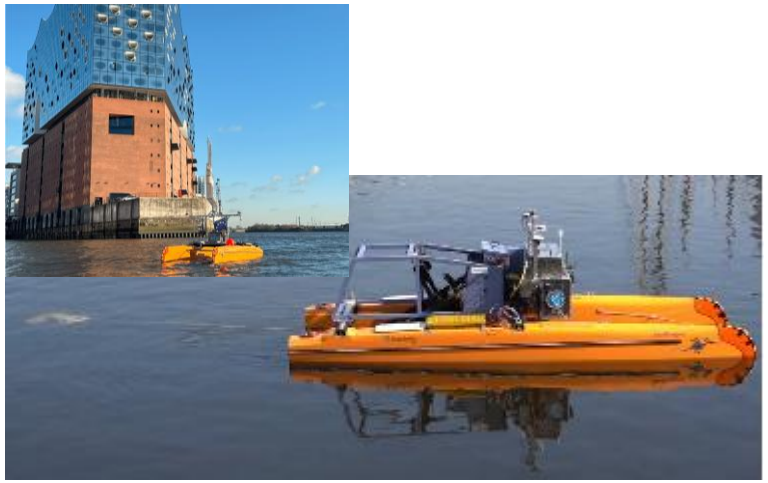
- Approvable operating concept
- Remote Operation Center
- Security Architecture in the Context of Critical Infrastructure

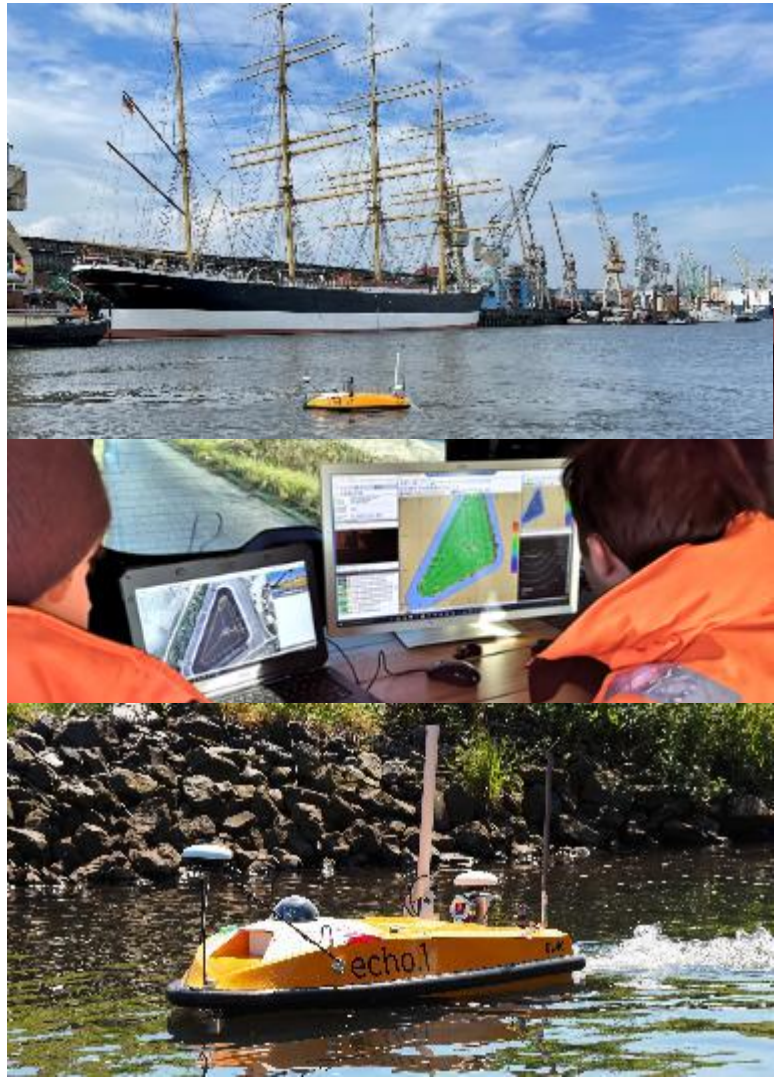
Regulatory results

- Standardised procedures for authorisation and risk assessment
- Regulatory Basis for BVLOS
- Transferable templates for ConOps (Concept of Operations) and SORA (Standard Operations Risk Assessment) for future norms

Authority Permits

ASVs in Hamburg since 2017



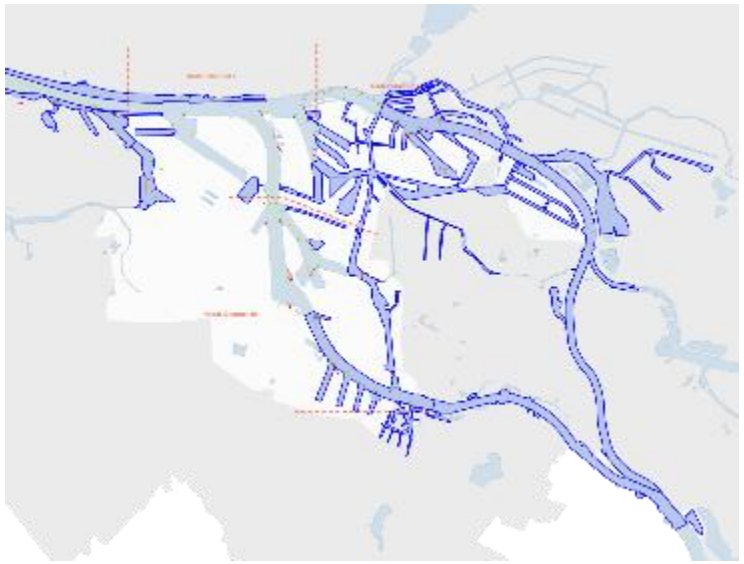


Authority Permits

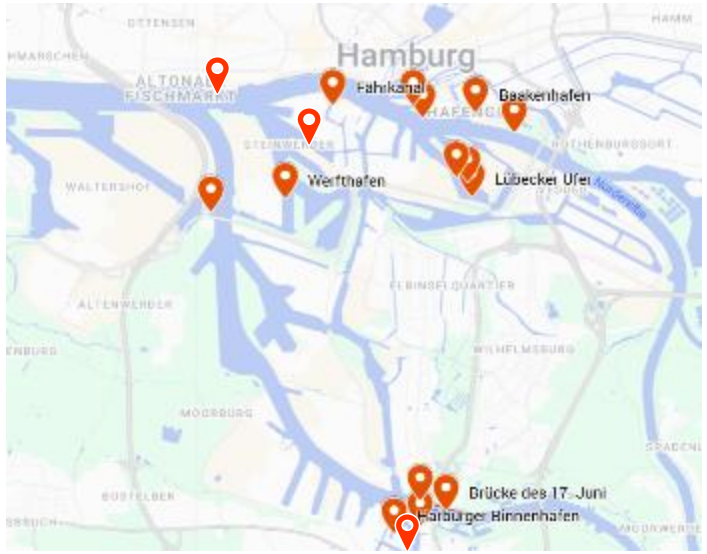
Applications at Harbor Master's Office

Echo.1 since 2020 in Regular operation

Port areas approved for echo.1



Other internal and external applicants for ASV use since 2020



Authority Permits

Approval situation in German Waters

Inland area = inland vessel (GDWS / ZSUK)

- Policy (EU) 2016/1629 (Frame)
- ES-TRIN (Technical)
- ES-QIN (Technical)
- BinnenSchStrO (Traffic rules)
- BinSchUO (Implementation ES-TRIN)

val class for
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s and pilot

Sea Ports (z.B. Hamburg)

Transitional area with superimposition of inland and maritime law

- HVSchG (Basis for HVO)
- HfVerkO / HVO (§42 – Perr
  Prohibitions)

Sea and coastal areas = seagoing vessel (BG Verkehr / BSH / GDWS)

- SOLAS (Ship Safety)
- COLREGs (Navigation rules)
- STCW (Crew)
- UNCLOS (Law of the Sea)
- MASS-Code (unverbindl. ab 1.7.26)
- SeeAufgG (Basis)

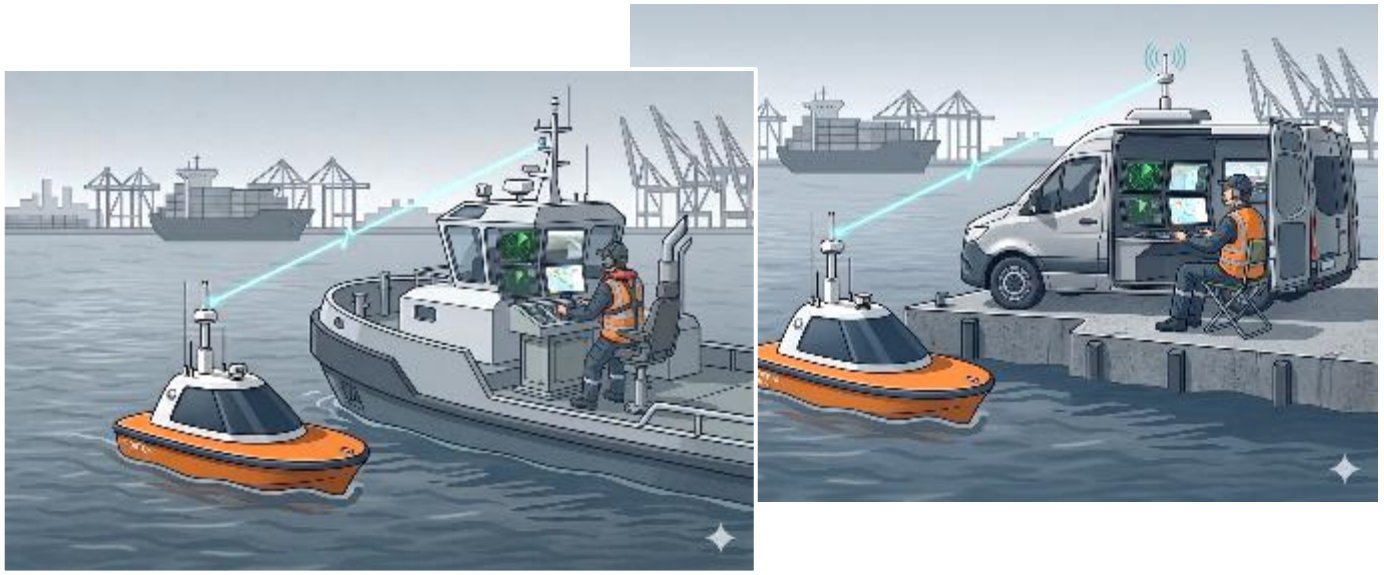
Application Scenarios

Visual Line of Sight (VLOS)

Scenario 1 - VLOS

Current Operation

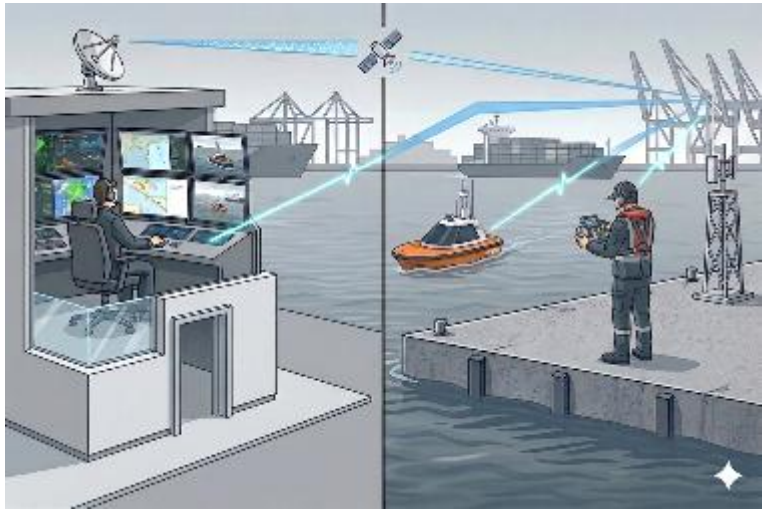
- Operator in sight (on board / ashore)
- Local Operations Center in sight
- Manual transfer possible at any time
- Low degree of autonomy



Scenario 2 – VLOS

Current Operation

- Operator in sight (on board / ashore)
- Remote Operations Center (ROC) out of sight
- Communication between Operator & ROC
- Manual transfer possible at any time
- Low degree of autonomy



Application Scenarios

Beyond Visual Line of Sight (VLOS)

Szenario 3 - EVLOS

Based on flying drones

- Spotter in sight
- ROC out of sight
- Manual takeover/control from ROC
- Higher degree of autonomy
- Fallback solutions & fail/safe measures

Szenario 4 - BVLOS

- ROC out of sight
- Manual takeover/control from ROC
- High degree of autonomy
- Fallback solutions & fail/safe measures
- High requirements for redundancy

Szenario 5 - Fully Autonomous

Out of scope in iPORTUS

- ROC for BVLOS monitoring only
- No manual takeover/control from ROC
- Highest degree of autonomy
- Highest requirements for resilience, redundancy and fail/safe measures

Application Scenarios

Test Vehicles & Demonstration Campaigns

SL40 | 1,6m | 25kg Payload

SeaLion | 2,2m | 100kg Payload

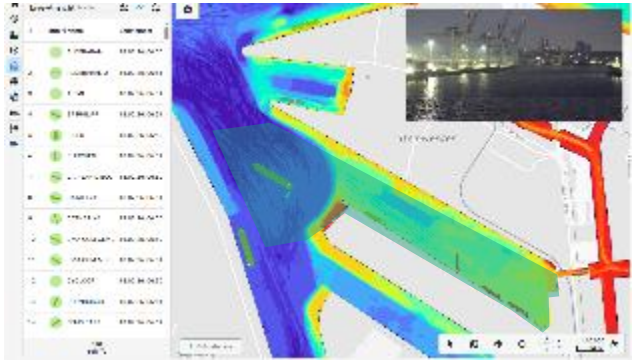
DUS V3000 | 3,0m | 150kg Payload

Otter X | 4,6m | 250kg Payload

SeaDragon | 5,5m | 350kg Payload

Test area Fraunhofer CML

Harburg inland port



Port of Hamburg harbour basin

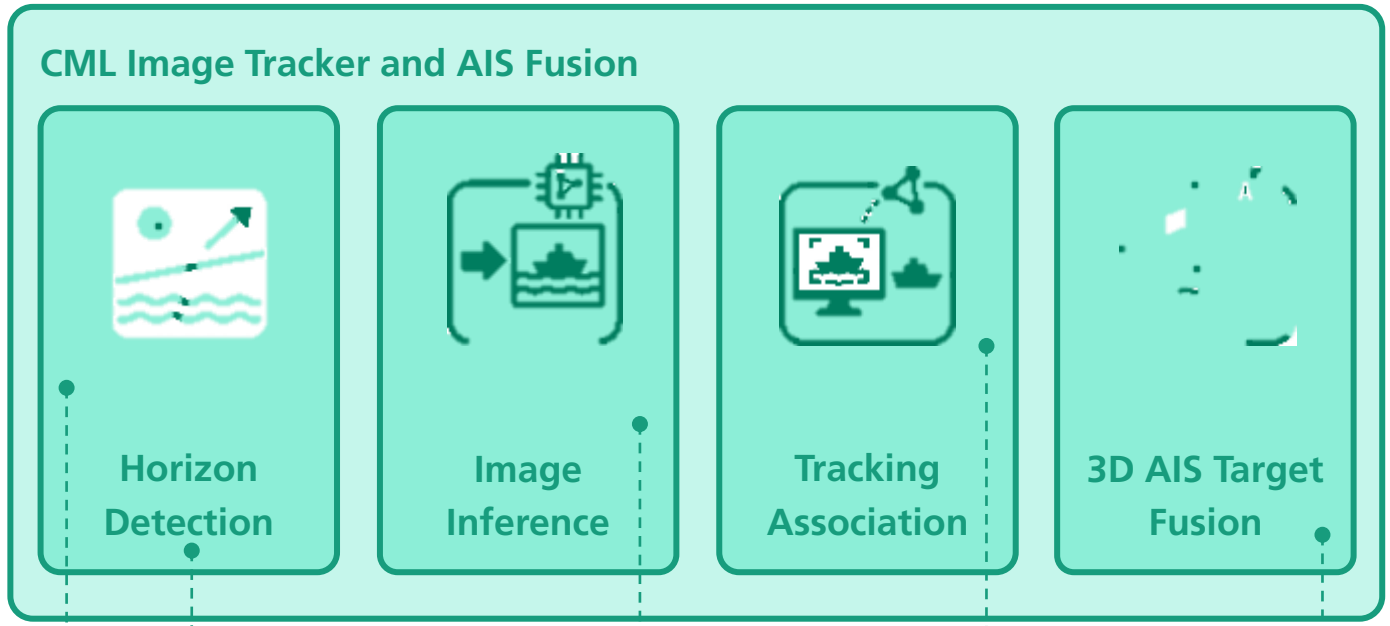
Operational Concept

Vehicle classes (Size vs. Technology readiness)

E. M. de Andrade, J. S. Sales Jr., and A. C. Fernandes,"Operative Unmanned Surface Vessels (USVs): A Review of Market-Ready Solutions,"Automation, vol. 6, no. 2, p. 17, Apr. 2025, doi: 10.3390/automation6020017.

Technical Insights

Object Detection: Optical



Dynamically adjust vessel rolling

Inbuilt tracking stabilization

Context-aware model selection and multi-inference

Custom tracking across all situations for consistent visualization of identified targets

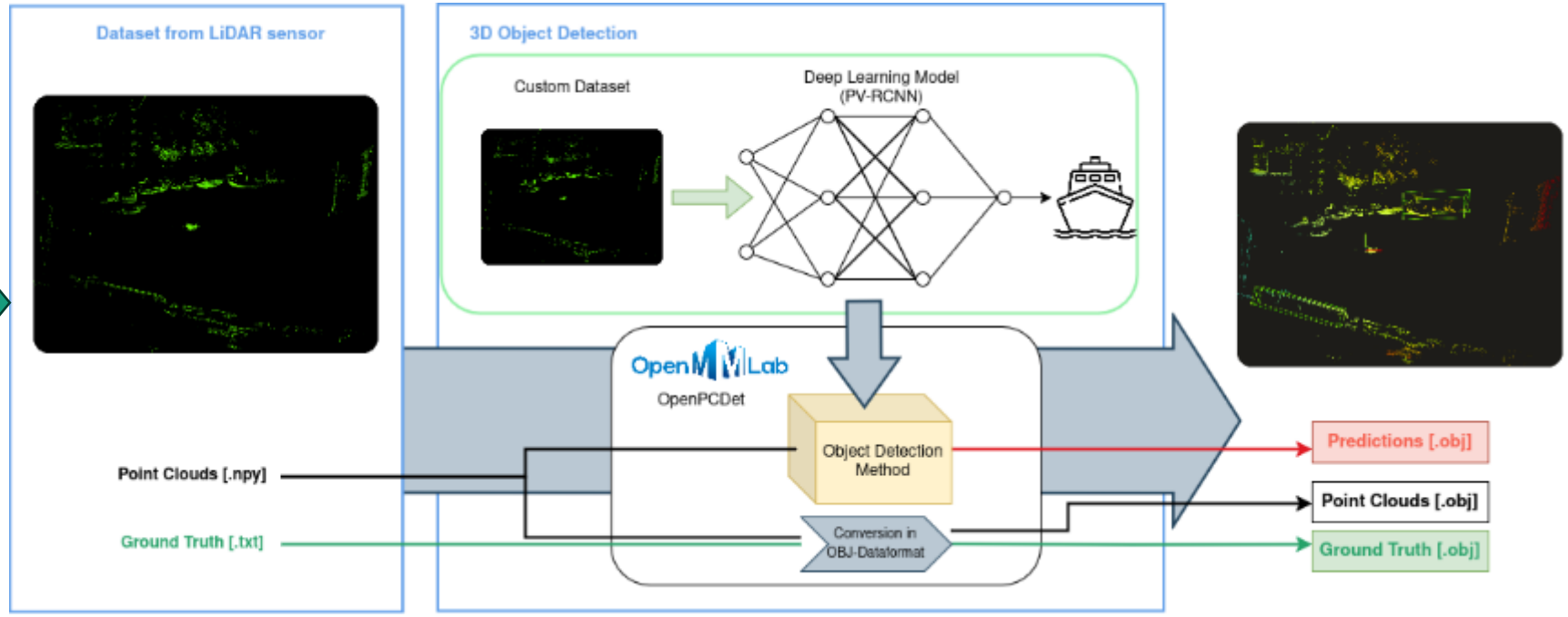
3D reconstruction of image plane to associate targets, even if occluded

Technical Insights

Object Detection: LiDAR

LiDAR-Pipeline: ML-based Vessel Detector

LiDar (Ouster OS1) onboard SeaDragon USV



LiDAR-Pipeline

Get in touch

https://www.cml.fraunhofer.de/de/forschungsprojekte1/iPORTUS.html

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