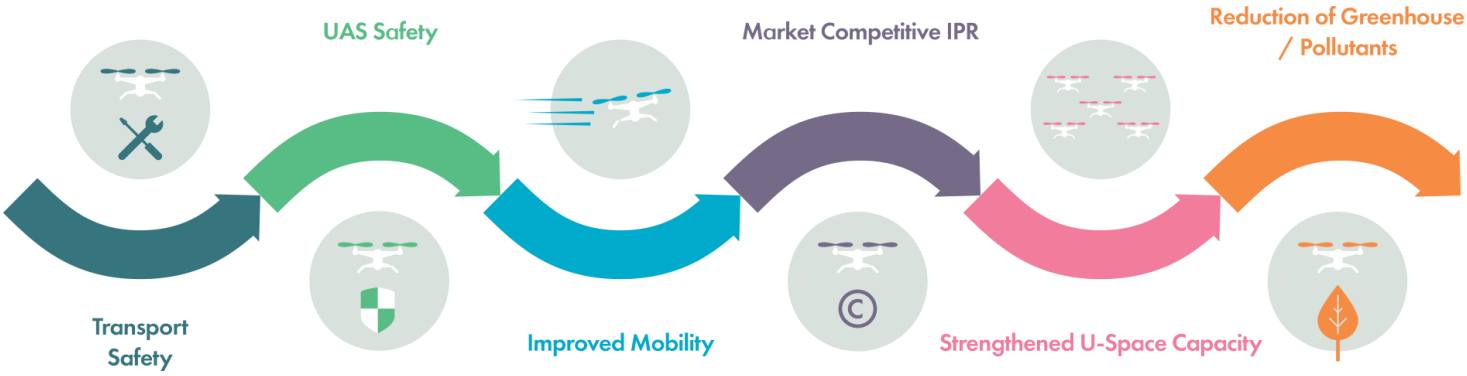
D1.2

Use case design specification

12 October 2020



The Rapid project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°861211

Document Context

Project Acronym:	**RAPID**
Grant Agreement number:	**861211**
Project title:	**Risk Aware Port Inspection Drones**
Funding agency:	**H2020**
Call:	**H2020-MG-2019-TwoStages**
Type of action:	**Research and Innovation**
Start date of project:	**01/06/2020**
Duration:	**36 Months**
Project website:	

Project Summary
RAPID will save lives by delivering an early warning system that will detect critical deterioration in transport system infrastructure, while also minimising system disruption and delays to critical supply chains. It will achieve this goal by combining and extending state-of-the-art drone technology to deliver a fully automated and safety assured maintenance-inspection (MI) service for bridge inspection, ship hull surveys and more. By combining self-sailing unmanned surface vehicles (USV) with swarms of autonomous unmanned aerial systems (UAS), RAPID will dramatically cut the time and cost of structural condition monitoring. RAPID-enabled MI services will increase efficiency and competitiveness for maritime transport stakeholders – such as ports, shipping companies, and landside transport authorities – and will deliver the safe and seamless operation of supply chain and mobility infrastructures – such as material handling equipment, cargo and passenger ships, and bridges. It encourages prioritisation of safer transport infrastructure where the technology seeks to improve environmental impact. The attractive return on investment will enable RAPID to gain market traction and incentivise commercial proliferation, bringing RAPID into widespread use for the overall benefit of society. By 2028, a newly formed company will generate €124 million and save in the order of 100 lives per year (reaching c. 20% share of the serviceable addressable maritime transport market through strategic partnership with 50 ports). RAPID brings together interdisciplinary partners with the expertise and capacity required to develop and validate this unique service model. The project will develop the consolidated maritime and aviation regulation standard for safe USV / UAS operations and the business model to scale the pilot service. RAPID will validate the high level of digitalisation, automation, and regulation required to support safe, beneficial, and scalable access to U-Space.

Deliverable number:		1.2			
Deliverable title:		RAPID feasible market opportunities			
Work package:		1			
Type:	**R**	**Delivery date**	3	**Version:**	**1.0**
Dissemination level:					
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Survey and conception with project partners

The two development methods, Business Model Canvas and SIPOC, were used both in the partner survey and in the external stakeholder survey.

In the context of the partner survey, the aim was to ensure that there was a common understanding of the design of the process steps within the use case environment. In addition, the process steps were compared with the project goals defined in the project scope to identify any missing responsibilitiesand to determine if relevant changes have occurred in the general perspective or for the accomplishment of the individual tasks and generally existing market needs.

In the next step, the identified and defined results were used in the external stakeholder survey to check their correctness and completeness from their point of view. They were asked to evaluate them in the context of each use case environment description and to supplement them with relevant requirements.

Furthermore, both partners and stakeholders were asked a variety of questions to develop a general understanding of their needs in the context of the use case environments and service requirements.

In both cases, this was carried out in several phases. The partner survey was prepared in the form of a questionnaire and then processed by the individual partners. The results were summarised in a central document and sent to the partners again for checking for completeness.

The survey of external stakeholders was carried out by sending a questionnaire agreed with the partners. Finally, the results were reviewed individually in a workshop with each stakeholder. This was to ensure that each need and information was correctly understood before it became a basis for the project

This document presents the aggregated results from the elicitation process, and the agreed-upon definition of the RAPID Use Cases.

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1. RAPID Use Case Environments

The project has defined the following four use cases in which the technology will be validated.

1) Ship emission monitoring

2) Bridge inspection

3) Remote ship hull survey

4) Collision accident response

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2. Understanding the value proposition

The sections on value proposition are taken as a subset to the Business Model Canvas[1]. The Business model canvas is widely used to document business propositions, and to convey the value of information technology-based endeavours.

We have taken a subset of the proposed canvas, which we explain in the following table:

<table>
<tr>
<td rowspan="2">Key Partnership needed for Demonstration in Hamburg Port

This section looks at relevant stakeholders within the port of Hamburg. These stakeholders can be enablers or deterrents to the Use Case. They can (and usually are) identified in the Suppliers portion of the SIPOC</td>
<td>Key Activities

This section provides a high-level overview of the Use Case Activities.

There is a relationship between the Key activities and the Process elements in the SIPOC (the last one is usually documented at a lower level of abstraction)</td>
<td rowspan="2">Value Proposition

This is a statement that conveys why (and where) the use case adds value.</td>
</tr>
<tr>
<td>Key Resources

This section intends to identify the Key resources (persons, roles, systems, authorisations, etc) that are needed to execute the key activities.</td>
</tr>
</table>

[1] Osterwalder, A., Pigneur, Y., Clark, T. & Smith, A. (2010). Business model generation : a handbook for visionaries, game changers, and challengers. Hoboken, New Jersey: Wiley.

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3. Value proposition of each use case

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Use Case 1 – Ship emission monitoring

Purpose: To increase the accuracy of ship emission monitoring.

Preconditions: There is a ship that has been targeted for ship emission monitoring within the Hamburg Port area of interest.

<table>
<tr>
<td rowspan="2">Key Partnership needed for Demonstration in Hamburg Port

For mission approval

Air traffic control
Harbour master
Legal permissions
Environmental Agency

For mission execution

Shipping companies

</td>
<td>Key Activities

SORA Mission Planning and Approval
USV carries the UAV near the mission area.
UAV Autonomous navigation to target Ship.
UAV/USV complete monitoring Mission
Mission report generation
</td>
<td rowspan="2">Value Proposition

Use Case 1 will deliver an increased accuracy of ship emission monitoring. Enabling the investigation of the contribution of emissions of identified and individual ships as well as the overall emission monitoring in maritime environments.</td>
</tr>
<tr>
<td>Key Resources

Ship traffic information
Ground interest
Air traffic control
Environmental authorities
</td>
</tr>
</table>

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Use Case 2 – Bridge Inspection

Purpose: To reduce inspection costs and develop a predictive maintenance service.

Preconditions: There is a target critical infrastructure (Bridge) for a required maintenance inspection (MI) service.

<table>
<tr>
<td rowspan="2">Key Partnership needed for Demonstration in Hamburg Port

• For mission approval
  ○ Airspace authorities
  ○ Harbour master
  ○ Legal permissions
• For mission execution
  ○ Building inspection Unit
  ○ City and infrastructure authority</td>
<td>Key Activities

• SORA Mission Planning and Approval
• USV carries the UAV near the mission area.
• UAV Autonomous navigation to target infrastructure.
• UAV/USV complete inspection Mission
  ○ Swarm UAV coordinated inspection mission.
• Mission report generation
  ○ Report of sensor Data
  ○ Report of historical comparison of the current mission against history in digital Twin</td>
<td rowspan="2">Value Proposition

Automate the maintenance/inspection process for critical infrastructure, whilst delivering cost savings and removing personnel from hazardous situations.</td>
</tr>
<tr>
<td>Key Resources

• Building inspection Unit Inspector
• Hydrography – Dept. waterside infrastructure
• Harbour master to coordinate waterway traffic
• Air traffic control</td>
</tr>
</table>

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Use Case 3 – Ship hull inspection

Purpose: To reduce downtimes, ship inspection costs and develop a predictive maintenance service.

Preconditions: There is a target Ship for a required maintenance inspection (MI) service.

<table>
<tr>
<td rowspan="2">Key Partnership needed for Demonstration in Hamburg Port

• For mission approval
  ○ Airspace authorities
  ○ Harbour master
  ○ Legal permissions
• For mission execution
  ○ Shipping Companies
  ○ Terminal operation companies</td>
<td>Key Activities

• SORA Mission Planning and Approval
• USV carries the UAV near the mission area.
• UAV Autonomous navigation to target infrastructure.
• UAV/USV complete inspection Mission
• Mission report generation
  ○ Report of sensor Data
  ○ Report of Historical comparison of the current mission against history in digital Twin</td>
<td rowspan="2">Value Proposition

Automate the maintenance/inspection process for remote ship monitoring, delivering added value (reducing downtimes) to shipping companies and terminal companies.</td>
</tr>
<tr>
<td>Key Resources

• Building inspection Unit Inspector
• Hydrography – Dept. waterside infrastructure
• Harbour master to coordinate waterway traffic
• Airfield controller</td>
</tr>
</table>

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USE Case 4 – Collision / Disaster response

Purpose: Fast tactical situation image of accidents.

Preconditions: There is an accident, or an incident occurs. In order to assess the situation, a picture of the situation is needed immediately so that the necessary response operations can be planned efficiently.

Key Partnership needed for Demonstration in Hamburg Port	**Key Activities**	**Value Proposition**

• *For mission approval*
  ○ *Airspace authorities*
  ○ *Harbour master*
  ○ *Legal permissions*
  ○ *Waterway Police (GER Strompolizei)*
• *For mission execution*
  ○ *Police Authority*
  ○ *Port Disaster management (HASTA)*
  ○ *Fire Department*
  ○ *Harbour Master / Waterway Police (GER Strompolizei)*
	• *Provide a fast-first response vehicle that can provide information for quick diagnostics of the situation.*
	• *the USV/UAV must not interfere with other manned emergency response vehicles.*
	
	Key activities in Demonstrator
	
	• *Provide the service (signal) within 30 min.*
	• *Involve relevant authorities and their systems*
		Creation of an emergency service which, for example in the event of a collision between two ships, provides all parties involved with a fast and high-resolution situation picture.This will enable stakeholders to plan the necessary aid processes faster, more efficiently and in a more targeted manner and to monitor the overall process.

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	Key Resources • *Building inspection Unit Inspector* • *Hydrography – Dept. waterside infrastructure* • *Harbour master / Waterway Police (GER Strompolizei) to coordinate waterway traffic* • *Airfield controller*	

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4. Understanding the process steps

The sections of Use Case descriptions are based on the SIPOC method[2]. SIPOC stands for Suppliers, Inputs, Process, Outputs and Customers. It is used in product development to identify process elements before starting development work.

The elements of SIPOC are explained in the following table:

Process **Stakeholders**	Information **input** or product needs	**Process** Steps	Information or product **outputs**	Process **Customers**
Actors/organizations or entities that are needed, or that need to be informed of the activities executed in the project. Stakeholders also include the Actors/organizations or entities whose information is needed or that need to be informed of activities of the process.	Information (including physical or logical products) that will be needed to perform any activity of the process.	An ordered list of activities that are executed in the process.	Outputs are defined as any information or physical or logical product that is the results of any activity of the process.	Stakeholders (as defined in the first column) that will consume any of the outputs (usually a sub set of the first column, though new Stakeholders can be identified here). Usually the distinction between stakeholder and Customers is that the stakeholders are considered to be upstream from the process (similar the input/output) distinction.

[2] https://www.isixsigma.com/tools-templates/sipoc-copis/sipoc-diagram/

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5. SIPOC for each Use case

The process description using the SIPOC method was drawn up for each use case and compared with the partners to identify any gaps in the responsibility of the project partners for the individual process steps.

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Use Case 1 – Ship emission monitoring

Process **Stakeholders**	Information **input** or product needs	**Process** Steps	Information product **outputs**	Process **Customers**
RAPID Service Provider Port Authority Harbour Master Air traffic control Shipping Companies Ship Crew	Regulatory Framework (UOD) Location of mission Shading map of the harbour Ship traffic information to plan transit to location. Up to date navigation charts Real-time shipping movements for safe passage. real-time access to UTM data and ADS-B data Communication links and computing requirements on-board	Mission Planning in the Software layer / infrastructure (CML) Assure mission planning abides by regulatory framework (UOD) USV transports the UAV to the target Location (XO, CML) Automatic take off from USV landing platform (XO, CML) Flight from the USV platform, through the Ships emissions, while detecting and avoiding hazardous situations (UL, THALES) Monitor gas concentration as the UAV flies through the ships emission (CML) Fly back to the USV location (UL) Automatic landing in USV (UL) landing platform (XO, CML) USV Transport the UAV back to base (XO, CML) USV Transmit the information to the Software Infrastructure Software UI and infrastructure produces mission report within 15 minutes (UWS, CML)	Mission Report with emission monitoring of ship	Port Authority Port Strategy Port Affairs Shipping Companies (the stakeholder Schulte Group deleted this customer) Authority for Environment, Climate, Energy and Agriculture NGOs NABU WWF Climate Analytics WIN

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Use Case 2 – Bridge Inspection

Process **Stakeholders**	Information **input** or product needs	**Process** Steps	Information or product **outputs**	**Process** Customers
Port Authority Harbour Master Building Inspection Air traffic control (RAPID Service Provider)	Location for mission Targets for mission Up to date navigation charts up-to-date digital terrain map of area of operations Shading map of the harbour Georeferencing information Real-time movement of shipping real-time access to UTM data and ADS-B data Approvals for the flight	Mission Planning in the Software layer / infrastructure (CML, UL) Assure mission planning abides by regulatory framework (UOD) USV transports the UAV to the target location (XO, CML) Automatic take off from USV landing platform (XO, CML) Sense and avoid system (UL) Inspection with selected sensors (XO, UWS) – automatically (UWS, UL), interaction with crack detection system (UL) based on AI (THALES) Monitor results (CML, UL) Battery hot swap (CML, XO) Battery charging after hot swop (XO) Decision taking in swarm of drones (THALES) Fly back to the USV (UL) Automatic landing on USV (UL) landing platform (XO, CML) USV transports the UAV back to base (XO, ML) USV Transmit the information to the Software Infrastructure (UL/XO) 3D reconstruction of infrastructure asset (UL) Software UI and infrastructure produces mission report within 15 minutes (UWS, CML)	Mission Report with crack identification of infrastructure	Hamburg Port Authority Building Inspection Port Authorities Public building inspection Authority for City Development and Living Construction companies Engineering companies Infrastructure Companies Hamburger Hochbahn Hamburg Wasser

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Use Case 3 – Ship hull inspection

Process **Stakeholders**	Information **input** or product needs	**Process** Steps	Information or product **outputs**	**Process** Customers
Port Authority Harbour Master Fleet mana-ge-ment Air traffic control Shipping Companies (RAPID Service Provider)	Up to date navigation charts up-to-date digital terrain map of area of operations Shading map of the harbour Approvals for the flight Ship traffic information Real-time movement of shipping real-time access to UTM data and ADS-B data	Mission Planning in the Software layer / infrastructure (CML, UL) Assure mission planning abides by regulatory framework (UOD) USV transports the UAV to the target Location (OX / CML) Automatic take off from USV landing platform (XO) Sense and avoid system (UL) Automatic inspection (UL) with selected sensors Monitor results (CML, UL) Decision taking in swarm of drones (THALES) Battery hot swap (CML) Battery charging after hot swap (CML) Fly back to the USV (UL) Automatic landing system (UL), landing platform (XO, CML) USV Transport the UAV back to base (CML) USV Transmit the information to the Software Infrastructure 3D reconstruction of infrastructure asset (UL) Software UI and infrastructure produces mission report within 15 minutes (UWS, CML)	Mission Report with crack identification of infrastructure	Hamburg Port Authority Shipping Companies Fleet management Companies Terminal Operation Companies Shipyard Companies

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USE Case 4 – Collision / Disaster response

Process **Stakeholers**	Information **input** or product needs	**Process** Steps	Information or product **outputs**	Process **Customers**
Hamburg Port Authority HASTA (Disaster Mgmt) Federal Security Authorities Fire Dept Police Dept Port Auth-orities Air traffic control (RAPID Service Provider	Location of mission Targets of mission Up to date navigation charts Shading map of the harbour up-to-date digital terrain map of area of operations Approvals for the flight Ship traffic information Real-time movement of shipping real-time access to UTM data and ADS-B data Communication links to command centre or first responder site	Mission Planning in the Software layer / infrastructure (CML, UL) Assure mission planning abides by regulatory framework (UOD) USV transports the UAV to the target Location (XO) Automatic take off from USV landing platform (XO) Sense and avoid system (UL) Inspection with selected sensors (XO) – automatically (UL) Monitor results (CML, UL) Battery hot swap (CML) Battery charging after hot swap Decision taking in swarm of drones (THALES) Fly back to the USV (UL) Automatic landing in USV (UL) landing platform (XO) USV Transport the UAV back to base Relay of video stream to command centre (UL)	Mission Report with images of accident	Hamburg Port Authority HASTA (Disaster Mgmt) Harbour Master / Waterway Police (GER Strompolizei) Federal Security Authorities Fire Department Police Department Port Authorities Shipping Companies Insurance Companies

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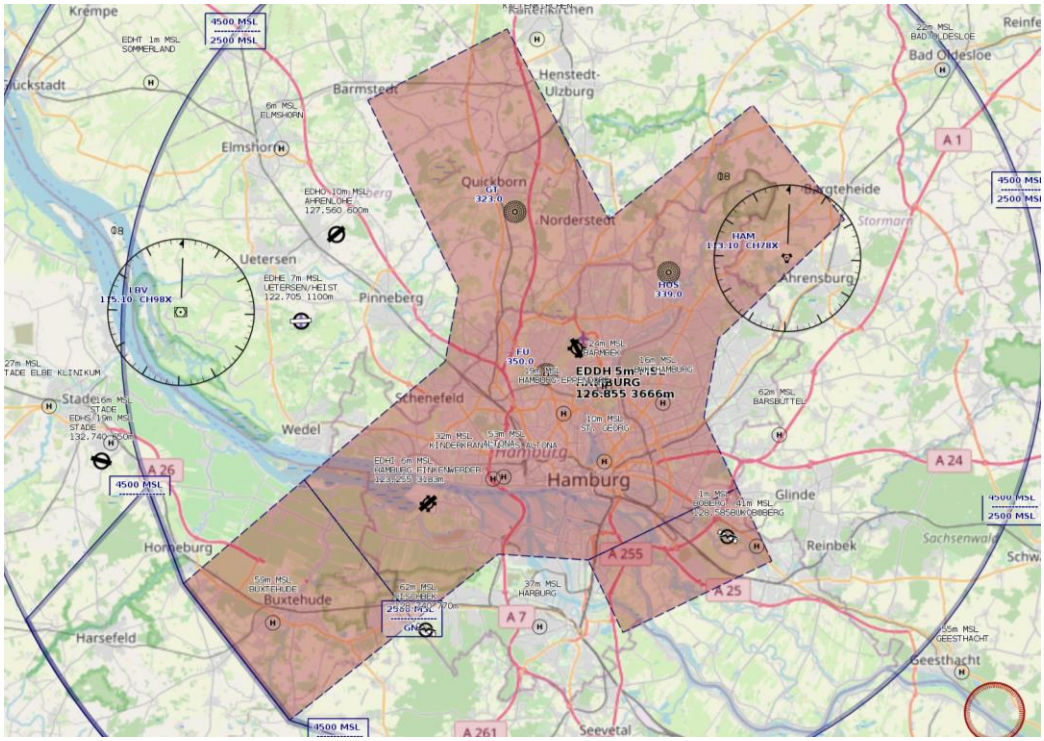
6. Needs & Requirements from the Port of Hamburg perspective

One of the HPA's main interests in the RAPID project is to achieve results in the field of autonomus maintenance inspection services and how to integrate and control them in complex infrastructures such as in the port of Hamburg. The HPA is convinced that autonomous platform systems will be able to take over various activities in the entire port area in the future. In the future, they will take over automated routines in the port and promise to do so in a more cost-efficient and targeted manner compared to existing solutions, e.g. with helicopters or using ships.

In the field of system control, the approach of a central control centre is also of great interest to the HPA. Especially the combination of different systems (ROV, ASV & UAV) centralised in one application promises great potential from the user's point of view.

In addition to the technical approach of the overall solution, the legal issues and security-related topics are also of great interest. Thus, it will be a great challenge to introduce a new mode of transport into the complex and high-frequency port infrastructure. Topics such as automated collision avoidance or the required approval procedures are of particular interest to the HPA.

The legal aspects in this project are very complex. For example, when using air drones, it must be taken into account that the port of Hamburg is mostly located in the controlled airspace of two airports. This means that special conditions have to be taken into account.



Map of controlled airspace

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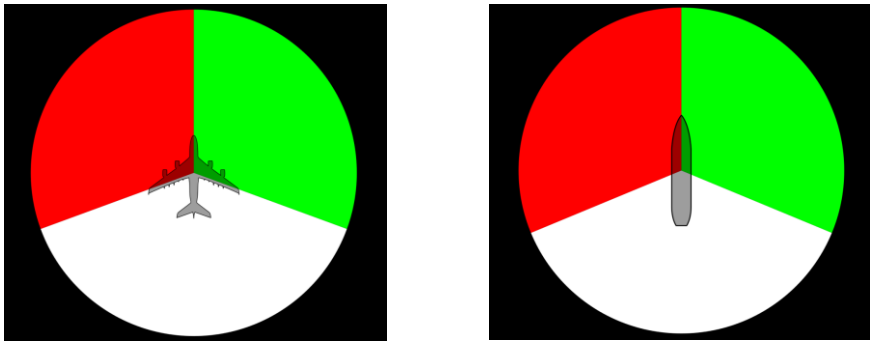
In order to establish visibility in the control centres of the port and the air traffic control tower in the first step, both the ASV should be equipped with an AIS tracker and the drones (UAV) with a transponder (ADS-B or LTE). In addition, it is important to ensure that the systems are equipped with appropriate position lights in accordance with the applicable regulations (SERA & SeeSchStrO).



Simplified presentation of position lights of a plane and a ship (source: wikipedia)

In addition to the visual and digital identification, the process of communication with the instances involved should also be considered here.

From the HPA's point of view, it is also desirable to be in constant exchange with the project partners in the field of technical architecture. This would ensure that positive effects can be achieved with a view to a later use of the project results in the port of Hamburg.

In addition, all drones operating in the port of Hamburg, especially when operating autonomously out of sight, must have remote identification, a parachute and air situation identification (ADS-B, FLAM , LTE).

The HPA is responsible for traffic control on water, road and rail in the port of Hamburg. There is a responsible control centre for each traffic environment to ensure that all coordinations are managed safely and centrally.

- *Nautical control centre - responsible for water-side control*
- *Port Road Management centre - responsible for traffic control of the roads in the port*
- *ASE Tower - responsible for rail transport in the port*

The concentration and density of the different modes of traffic in the port of Hamburg make traffic control a complex matter. For this reason, early cooperation should be sought in order to enable the safe and efficient service introduction of autonomous systems. This refers equally to the process and communication level as well as to a bilateral data exchange for visibility of the systems.

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7. Use Case Design for each Use Case Environment

The detailed refinement of the processes and the parameterisation of the technology are based on the four RAPID Use Cases. They provide a framework for both the demonstrators and the services to be developed.

The use cases were defined in close cooperation between the project partners and the participating stakeholders and are outlined below. The consultation with the stakeholders is ongoing so that the design of the use case environments will be adapted during the course of the project to reflect the growing knowledge gained in the project and to react to changes in the market or external development impacts.

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Use Case 1 – Ship emission monitoring

General information

The main applications and technical approaches to determining emission levels vary slightly depending on the perspective of the individual user or profiteer.

Shipowners and managers do not directly measure ship emissions. Instead they calculate them based on the type and amount of fuel used (CO2 and SOX) as well as the engine design characteristics (NOX). This procedure takes account of the current legal situation. Nevertheless, shipowners or ship managers could use the data as an early detection of non-compliance, that allows a notification to the vessel and make the crew take necessary action.

Thus, from the Hamburg Port Authority's point of view, the main focus is more on generating air monitoring data at different heights at previously determined points to create a picture of emission all over the port and than on determining the individual emissions of a ship. Based on the use case focus described in the project proposal, the HPA considers it desirable to extend the field of application a little bit in order to be able to meet both interests.

The value from a direct ship measurement lies in a verification, i.e. to ensure that ships operate within environmental protection margins and in compliance with current regulations. This way, the police, governments or environmental organisations could use the technique to collect evidence of non-compliance in case of need or suspicion.

Key Interests	
Emission monitoring	CO2
Provide the results	NOX
Display of the overall situation in the digital twin	SOX
Creation of an overall situation	Noice emission
	Leaks
	Oil

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Use Case & demonstrator description

Typ: 1. Ship emission monitoring

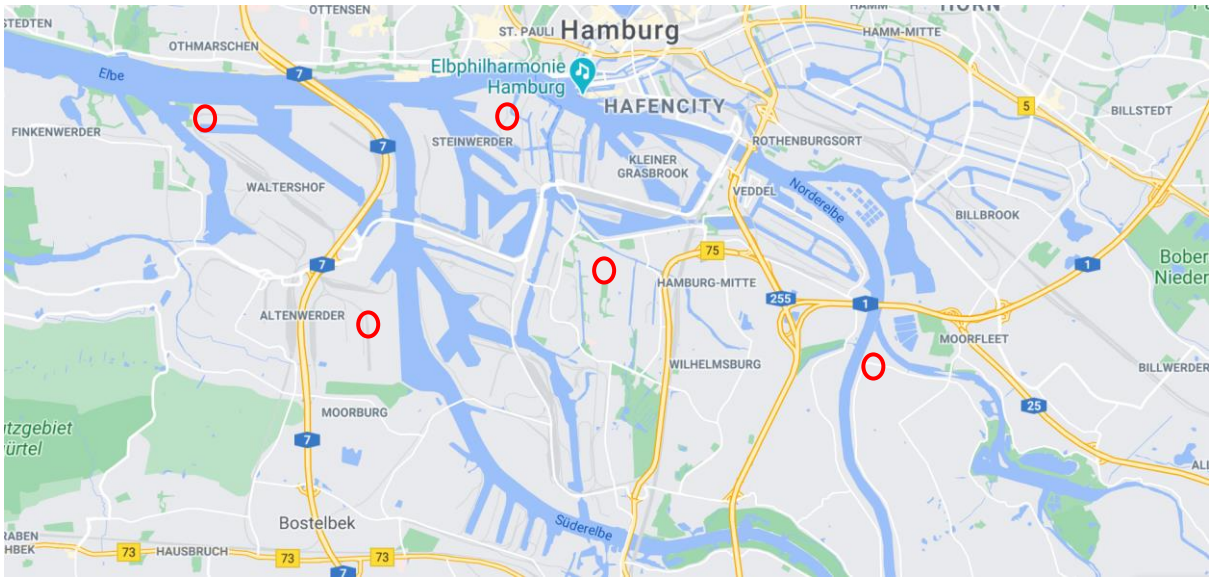
2. Emission monitoring in the port area

Task:

- *Fly to a ship and measure the emissions.*
- *display the results within the digital (port) twin*

- *Fly to different positions in the harbour and measure the emissions*
- *display the results within the digital (port) twin*

Location: - needs to be defined within the port of Hamburg –



Possible deployments:

- *Container Ships (Schulte Group)*
- *Ships (smaller) HPA Fleet*
- *Approvals (provided the drones and the area comply with the technical specifications and restrictions)*
- *AIS data service*
- *Provision of a closed test area*
- *Process information and procedures of the Traffic control center (Nautische Zentrale)*

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Use case 2 bridge inspection

As already described, bulding inspection units already deal with the use of ROVs to support and extend the ongoing inspection services.

In this context, they focus on the following key objectives:

- *Reduction of the risks for the inspection personnel as far as possible.*
- *Making non-inspectable areas testable*
- *Increasing the efficiency of inspections*
- *Minimisation of downtimes of heavily used traffic lines*

Nevertheless, visual inspection methods, regardless of whether they have been generated by drones or otherwise, are not yet permissible at the current state of testing standards. Direct comparability is therefore difficult to achieve, although the aim is not to create an alternative to the existing procedure, but rather to optimise individual sub-processes of the entire test procedure.

As shown, the main focus is on recording the condition of a building as comprehensively as possible in order to obtain an initial statement on the condition:

1. *Stability*
2. *Durability*
3. *Operational safety*

In order to create more acceptance of new technologies within the framework of the specified test bench, real best practice examples are required, on the basis of which new process technologies can be approved.

The following test environment has been defined in purely technical terms and does not presuppose legal acceptance at the present time.

The focus is on a fast acquisition of the entire object. In addition, the potential of image-based systems and their data processing will be tested. Ideally, for example, cracks (from 0.2 mm) and structural shifts (from 1 mm) should be automatically detected. The systems must be able to deliver these accuracies with a high hit rate.

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Bridge damages

Point clouds are particularly interesting for the damage progression, but if structural conditions change due to external influences, these can be better captured in these three-dimensional models. When standing in the building, the building inspector in person does not have a view of the entire building but only a momentary section, models can help here. The point cloud should be able to show significant changes (from about 2cm).

In addition, the building inspection has a considerable interest in the course of damage and a correspondingly clear and detailed presentation platform. A three-dimensional damage monitor, which provides information about the occurrence of damage and relevant influencing factors, defines a future basis for planning maintenance and inspection procedures.

Key Interests	
structural displacements (from 1mm)	automatic data processing
cracks detection (from 0.2mm)	Test of different sensory techniques
Predictiv maintenance	Rust and concrete
Digital Twin of the Object	Tracking
Display in 3D	Prediction
damage progression	

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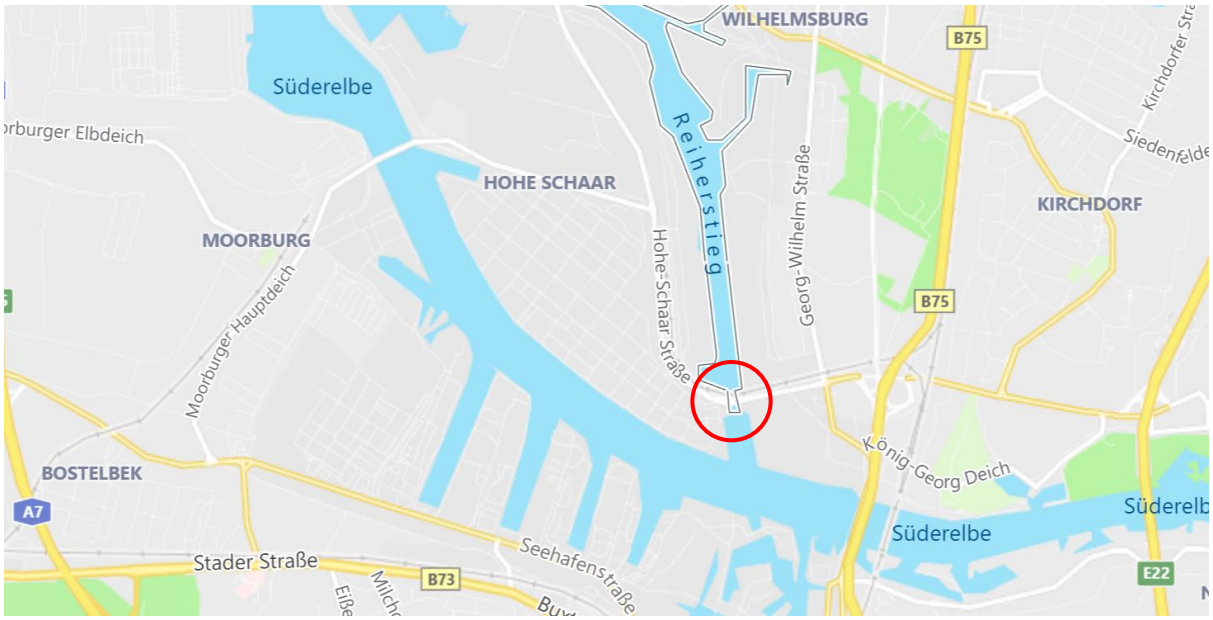
Use Case - demonstrator - design

Reiherstieg lock

Aerial image of Reiherstieg lock



Map with marker of Reiherstieg lock

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Reiherstieg lock is one of the oldest locks in Hamburg which is still active, at least one chamber is still active. Build around 1900, it survived both world wars. Due to some damages, the lock will be renewed in the next few years.

Construction: The lock chamber itself is a bulkhead construction. The Pillar of the gates are a mixed construction, part brickwork part granite masonry based on wooden piles

Location: The Lock is located in the south of Hamburg. The lock is crossed by two road bridges and a railway bridge.

Airspace:

Reiherstieg lock

The Airspace over the lock is limited due to railway tracks, powerlines and waterways. Shell is located right next to the lock which also effects UAV flights.

Right now the technical inspection unit of Hamburg Port Authority is monitoring the lock regularly to maintain traffic safety.

What can be monitored? The ground level of the lock can be monitored, we need these data regularly for two reasons:

1. *Ships need to pass the lock, therefore mud, sand and other materials need to cleared from the lock chamber.*
2. *As the bulkhead construction is very old we need to make sure we do not have any kind of fundamental break behind the bulkhead.*

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The gates of the lock are, as mentioned, of some kind of a brick construction on wooden piles which lasted against the elements for over a hundred years, They started moving, bricks fell off so it is of great interest to monitor these movements.

The Reiherstieg lock is currently not yet part of the digital port twin, but can or should be built as part of the RAPID project.

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Use Case 3 – Ship hull inspection

Both the market research and the survey of external stakeholders showed that there is a fundamental interest in automated maintenance and inspection services. In the future, these should be used for early damage detection, tracking and prediction.

It was not possible to identify a direct and comparable service to the RAPID project. Current procedures for the overall assessment of a ship's hull are mainly carried out in dry docks or by people during operation. Due to the fact that inspections above the waterline are much easier to implement than underwater hull inspections, there is a slightly higher demand for underwater inspection services.

In addition to the fact that damage above the waterline is generally much easier to identify, reach and repair, which makes it relatively easy and inexpensive to prevent intensification or consequential damage, damage below the waterline has a much more extensive impact on additional costs and necessary follow-up processes.

A frequently mentioned need in the field of "simple" underwater inspection is the detection of hull and propeller contamination. This is because too much deposit, for example from algae or smallpox, has a direct impact on a ship's fuel consumption.

In this case, precise condition assessments are helpful, because both the removal of the deposits by divers and the much more extensive clean-up in a dry dock are time and cost intensive. A further interest is an assessment of the hull damage after a ship has had contact with the seabed.

Some of the main service interests were named as follows:

- *Contaminated condition of the hull/propeller - The findings gained here allow a targeted scheduling of the cleaning intervals of hull and propeller*
- *Damage assessment after groundin*
- *Increasing safety*
- *Evaluation of the hull / condition of the hull structure*
- *Rust and corrosion detection*
- *Identification of contamination*
- *NDT of the hull structure - all detected cracks/deformations*
- *Class inspections*
- *Surfaces and paint checks*

Regardless of the specifics, there is an undisputed need for automated inspection and maintenance services. Extending a dry-docking interval alone represents a significant cost saving.

An exact budget or exact costs could not be determined exactly until now. These vary greatly and depend on the size of the ship, the urgency of an inspection and the damage to be repaired.

In addition to purely economic interests, the focus is on increasing safety across all users.

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In addition to purely economic interests, the focus is on increasing safety across all users. Particularly in the case of large ships, where employees have to abseil, for example, in order to be able to closely inspect a relevant point, there is a risk of industrial accidents. A drone based service, which enables a complete recording of the ship, analyses the recorded data and finally enables a representation of the overall situation, is versatile and urgently needed.

Key Interests	
Rust and corrosion detection	Extending dry-docking intervals
Damage assessment	Reducing down times
condition of the hull structure	Cost reduction
Prediction	High resolution images
Life cycle	Damage pattern with exact positioning on 3D model
Digital Twin	image-based reporting

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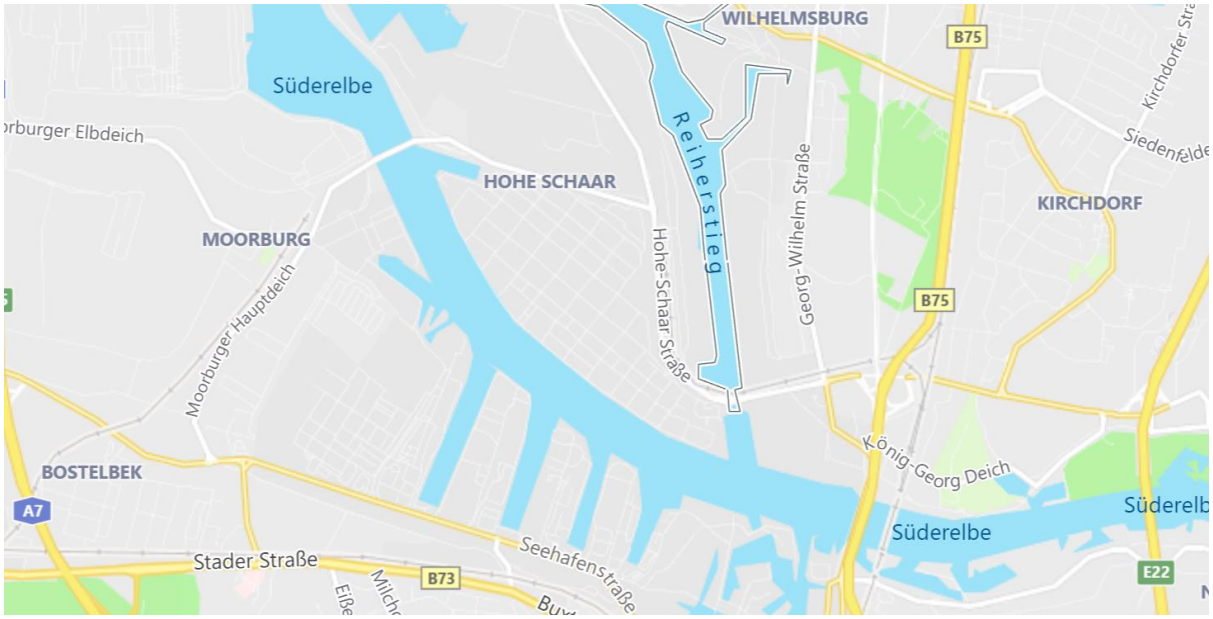
Use Case - demonstrator – design

Typ: ship hull inspection of a container ship

Task:

- *Inspection of the hull of a container ship entering the port of Hamburg.*
- *Create an image supported report*
- *display the ship and inspection results within the digital (port) twin*

Location: - needs to be defined within the port of Hamburg -



Possible deployments:

- *Container Ships (Schulte Group)*
- *Ships (smaller) HPA Fleet*
- *Approvals (provided the drones and the area comply with the technical specifications and restrictions)*
- *Access to (dry) docks*
- *AIS data service*
- *ADS-B date servie*
- *Aerial situation information Droniq system (LTE)*
- *Provision of a closed test area*
- *Process information and procedures of the Traffic control centres (Nautische Zentrale, Tower Hamburg Airport, Tower Aitport Finkenwerden (Airbus)*

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USE Case 4 – Collision / Disaster response

When a specific situation arises in the port area, a distinction is usually made between foreseeable situations (e.g. storm surge) and ad hoc situations (e.g. accident). By their nature, foreseeable situations are not time-critical and can usually be planned in advance. However, it is also possible that further time-critical situations arise in the context of non-time-critical situations, in which rapid action and thus a quickly available situation picture is necessary (e.g. a container on a ship loosens and falls into the water).

Support through a situation picture service is especially interesting in ad-hoc situations. Ad-hoc situations are all time-critical events that require quick action. For example in the case of a major collision.

In the context of time-critical events, there is also a differentiation with regard to the respective responsibility. This is because civil protection does not automatically come together in every situation. Depending on the severity of the situation and the threat to life and limb, other local authorities may also take responsibility. For example, smaller fires are usually not supported by a crisis management team, but rather by a " normal" fire fighting unit. A crisis team is only set up after a level 3 or 4 fire, in which several emergency vehicles of the professional and voluntary fire fighters are on duty. This also counts for collisions, for example.

If the disaster team is called up, it is active and ready for action in reduced form after only about 45 minutes. The operational readiness of the entire disaster team, consisting of 20 persons, takes about 1 ½ hours.

In the event of a ship accident, the fire brigade and police are present within 10-40 minutes after the radio message, depending on the location of the incident, and take over the initial emergency response. Especially the immediate time after an incident decides on the extent and consequences. Accordingly, a fast and detailed service represents the greatest added value for the assessment of the overall situation and the subsequent management response.

Key Interests	
Fast and detailed	Reaction within 15 – 30 minutes
High resolution images	Heat map / thermal image
Support for time-critical situations	Continous transmission for at least 1 - 2 h
Real time information	3 D localisation of the incident
Aerial view	

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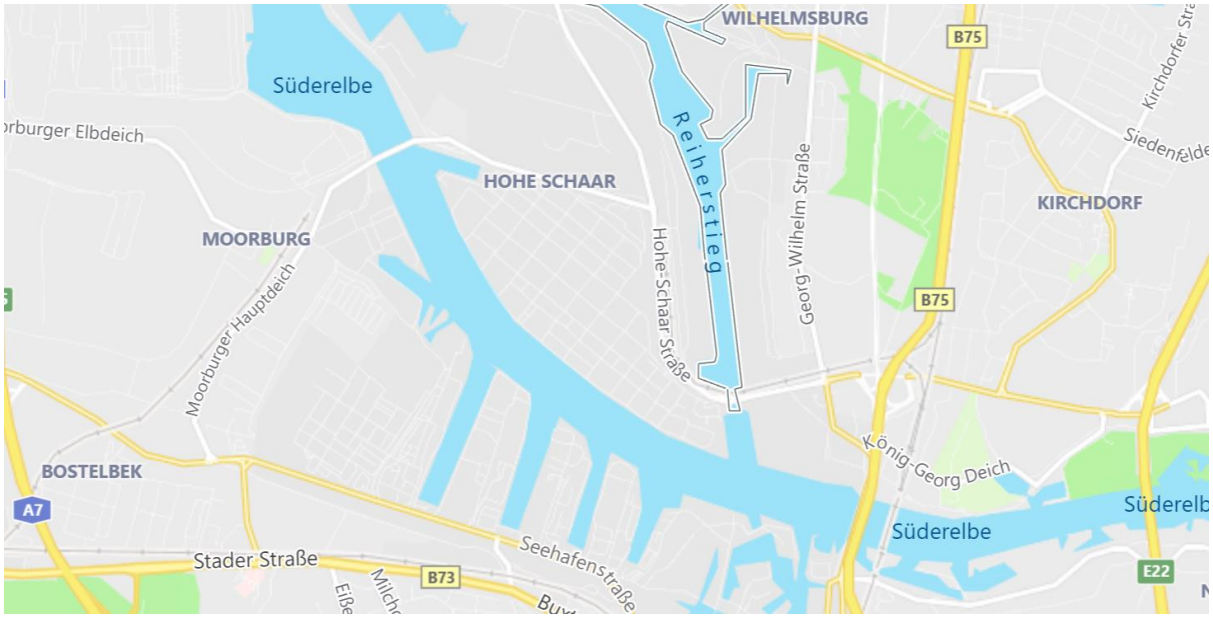
Use Case - demonstrator – design

Typ: ad hoc situations

Incedent: accident of two ships

Task: Provide a live image within 15 – 30 minutes after the report

Location: Hohe-Schaar Straße, 21107 Hamburg



Map with marker of Reiherstieg lock

Possible deployments:

- *Ships*
- *BVLOS approval (provided the drones comply with the technical specifications)*
- *Process information and procedures of a crisis management team*
- *AIS data service*
- *ADS-B date servie*
- *Aerial situation information Droniq system (LTE)*
- *Provision of a closed test area*
- *Process information and procedures of the Traffic control centres (nautische Zentrale, ASE Tower, Tower Hamburg Airport, Tower Aitport Finkenwerden (Airbus), Port raod management center*

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Ideas:

- *Autonomous routing - after the accident call, the GPS position is sent directly to the control centre and the drone*
- *Transmission of the sensor data to the mobile devices of the emergency services. Obtaining information at an early stage while you are still on the road would be nice, but not absolutely necessary.*

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ANNEX I Needs & Requirements elicitation from the Partner perspective

Questions, technical requirements – detailed results from the questionnaire

Use Case 1

What data, information or service relevant to the use case do you need to implement your development?

CML	• *Information on UAV-interfaces for custom payloads* • *Data transmission options and protocols* • *Output data format of environment sensor system (CML internal)* • *Design and assembly specifications of equipment required for automatic landing and take-off*
SINTEF	Shading map of the harbour
~~UNIDUN~~	~~None.~~
XOCEAN	• *Location of mission* • *Ship traffic information to plan transit to location.* • *Up to date navigation charts* • *Real-time shipping movements for safe passage.* • *Communication links and computing requirements on-board*
UL	• *Details on mission planning and approvals for flight* • *Communication links from USV to UAS with access to navigation/IMU streams.* • *Location and targets for mission, up-to-date digital terrain map of area of operations* • *Real-time movement of shipping, real-time access to UTM data and ADS-B data* • *Information and design of USV landing platform* • *Information and design of onboard gas sensing system*
THALES	Precise characteristics of objects to be avoided during the flight path by the onboard “detect & avoid” system.

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Use Case 2

What data, information or service relevant to the use case do you need to implement your development?

CML	For mission planning the mission structure and all possible mission parameters need to be known. To display/deliver the results the relevant sensors and their outputs need to be known.
SINTEF	Shading map of the harbour.
UNIDUN	None.
XOCEAN	• *Expected data formats for sensor data* • *Up to date navigation charts* • *Communication links and computing requirements on-board* • *Georeferencing information*
UL	• *Details on mission planning and approvals for flight* • *Location and targets for mission, up-to-date digital terrain map of area of operations* • *Communication links from USV to UAS with access to navigation/IMU streams.* • *Communication links with automated crack detection system and data relating to detected regions.* • *Real-time movement of shipping, real-time access to UTM data and ADS-B data* • *Information and design of ML crack detection system.* • *Information and design of USV landing platform*
THALES	The neural network will be trained with datasets constituted of sample images brought and labelled by HPA and augmented with image databases from Thales in Task 5.1. The databases of images comprise images of cracks of different shapes and other artefacts for the neural network to be able to discriminate between cracks and artefacts looking like cracks (false positives). Thus, Thales needs labelled crack images Dataset provided by HPA.

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Use Case 3

What data, information or service relevant to the use case do you need to implement your development?

CML	For mission planning the mission structure and all possible mission parameters need to be known. To display/deliver the results the relevant sensors and their outputs need to be known.
SINTEF	Shading map of the harbour
UNIDUN	None.
XOCEAN	• *Location of mission* • *Up to date navigation charts* • *Ship traffic information to plan transit to location.* • *Real-time shipping movements for safe passage.* • *Communication links and computing requirements on-board*
UL	• *Details on mission planning and approvals for flight* • *Location and targets for mission, up-to-date digital terrain map of area of operations* • *Communication links from USV to UAS with access to navigation/IMU streams.* • *Real-time movement of shipping, real-time access to UTM data and ADS-B data* • *Information and design of USV landing platform*
THALES	The neural network will be trained with datasets constituted of sample images brought and labelled by HPA and augmented with image databases from Thales in Task 5.1. The databases of images comprise images of cracks of different shapes and other artefacts for the neural network to be able to discriminate between cracks and artefacts looking like cracks (false positives). Thus, Thales needs labelled crack images Dataset provided by HPA.

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Use Case 4

What data, information or service relevant to the use case do you need to implement your development?

CML	For mission planning the mission structure and all possible mission parameters need to be known. To display/deliver the results the relevant sensors and their outputs need to be known.
SINTEF	Shading map of the harbour
UNIDUN	None.
XOCEAN	• *Location of mission* • *Up to date navigation charts* • *Ship traffic information to plan transit to location.* • *Real-time shipping movements for safe passage.* • *Communication links and computing requirements on-board*
UL	• *Details on mission planning and approvals for flight* • *Location and targets for mission, up-to-date digital terrain map of area of operations* • *Communication links from USV to UAS with access to navigation/IMU streams.* • *Real-time movement of shipping, real-time access to UTM data and ADS-B data* • *Communication links to command centre or first responder site* • *Information and design of USV landing platform*
THALES	Precise characteristics of objects to be avoided during the flight path by the onboard “detect & avoid” system.

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ANNEX II Value proposition elicitation from the External Stakeholders

HPA Internal

- *Building inspection*
- *Harbour Master Dept.*
- *Port Affairs*
- *“Fleet” (We operate our own fleet and are responsible for the police boats, fire boats, barges and other special ships for various port operations)*
- *Environment strategy (After reviewing the stakeholder survey and re-evaluating the RAPID project objectives – in particular use case 4, this department sees no mutual added value in cooperation)*

External

- *Bernhard Schulte Group (Innoport)*
- *BWI (Authority for Economy and Innovation) - The regional air traffic control is located there*
- *Droniq - DFS (German air traffic control)*

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ANNEX III - Needs & Requirements elicitation from the stakeholder perspective

Feedback on use case 2 from HPA building inspection

<table>
<tr>
<td rowspan="2">Key Partnership needed for Demonstration in

Hamburg Port

For mission approval
Airspace authorities
Harbour master

Legal permissions

For mission execution
Building inspection Unit
City and infrastructure authority

</td>
<td>Key Activities

SORA Mission Planning and Approval
USV carries the UAV near the mission area.
UAV Autonomous navigation to target infrastructure.
UAV/USV complete inspection Mission

Swarm UAV coordinated inspection mission.

Mission report generation

Report of sensor Data
Report of Historical comparison of current mission against history in digital Twin

</td>
<td rowspan="2">Value Proposition

Automate the maintenance/inspection process for critical infrastructure, whilst delivering cost savings and removing personnel from hazardous situations.

AI based damage monitoring
</td>
</tr>
<tr>
<td>Key Resources

Building inspection Unit Inspector
Hydrography – Dept. waterside infrastructure
Harbour master to coordinate water way traffic
Air traffic control

</td>
</tr>
</table>

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Process Steps of Use Case 2

Process **Stakeholders**	Information **input** or product needs	**Process** Steps	Information or product **outputs**	Process **Customers**
Port Authority Harbour Master Building Inspection Air traffic control (RAPID Service Provider)	Location for mission Targets for mission Up to date navigation charts up-to-date digital terrain map of area of operations Shading map of the harbour Georeferencing information Real-time movement of shipping (e.g. trains or cars) real-time access to UTM data and ADS-B data Approvals for the flight	Mission Planning in the Software layer / infrastructure Assure mission planning abides by regulatory framework USV transports the UAV to the target location Automatic take off from USV (CML) landing platform Sense and avoid system Inspection with selected sensors – automatically, interaction with crack detection system based on AI Monitor results Battery hot swap	Mission Report with crack / damage identification of infrastructure (It should not only be cracks, paint defects or other defects should be monitored as well)	Hamburg Port Authority Building Inspection Port Authorities Public building inspection Authority for City Development and Living Construction companies Engineering companies Infrastructure Companies Hamburger Hochbahn Hamburg Wasser

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		Battery charging after hot swap Decision taking in swarm of drones Fly back to the USV Automatic landing on USV landing platform USV transports the UAV back to base USV Transmit the information to the Software Infrastructure 3D reconstruction of infrastructure asset Software UI and infrastructure produces mission report within 15 minutes		

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Technical requirement	Value
Automatic crack detection	Cracks ≥ 0.2mm
Automatic structural displacement detection	Displacement ≥ 1.0mm
Show significant changes in building constructions (3D point cloud)	≥ 40.0mm

Describe how you would take value from this RAPID service.

The Service gives us the opportunity to monitor critical Bridges and other objects within the HPA on a more regular basis. This would provide us a more detailed overview of the object.

As a result the next hands on inspection can be more focused on critical areas

Are you already using a comparable service? If so, can you describe it?

Note: If you answered yes, can you share what is your current budget for this service?

We are currently using VLOS UAS to support our inspections in areas which are hard to reach, or where we need special equipment. With the UAS we try to get a good overview of those areas to reduce the time we need with special equipment.

We got a budget of around 20'000€ per anno

If the provided date is accurate and reliable, we would spend ¼ of the budget for a regular building inspection for such a service (due to the rules of the building inspection we are not allowed to only rely on this data)

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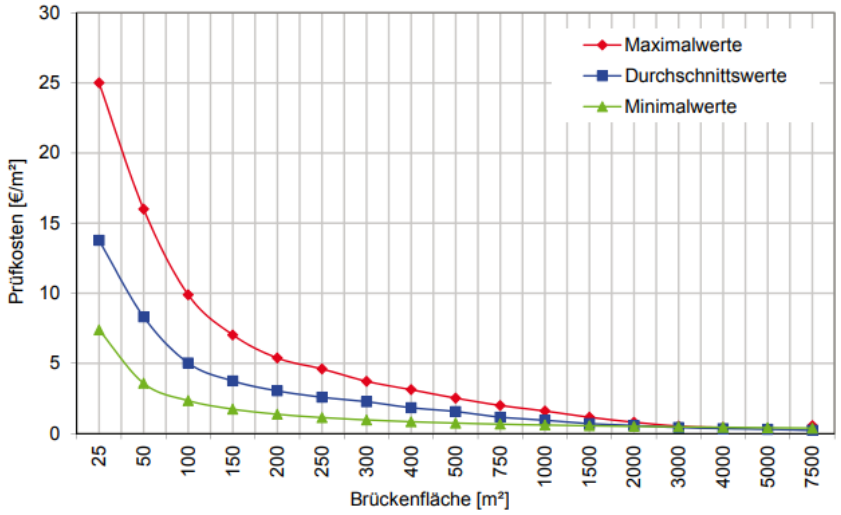

Bild 44: Kosten für Brückenprüfungen nach Leistungsbild E

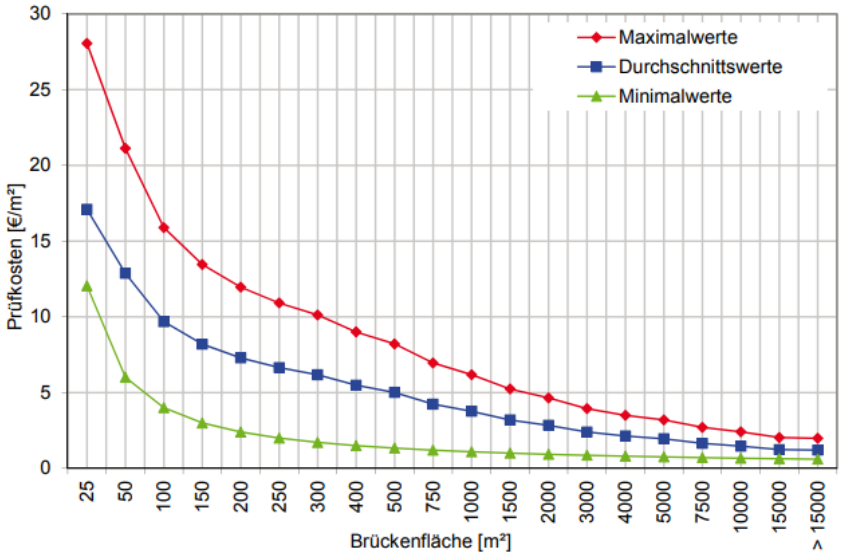

Bild 45: Kosten für Brückenprüfungen nach Leistungsbild H, H1 und H2

Legend:

- *Vertical: costs [€/m²]*
- *Horizontal: bridge area [m²]*
- *Red: maximum values*
- *Blue: average value*
- *Green: minimum value*

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What information do you think the report from this output should include? If you have added outputs, please answer the question for each of them.

Think about:

- ***What kind of emission type needs to be measured?***
- ***What other information can be measured in the process?***

The output should provide some sort of 3D Model (pointcloud etc) where the detected damages can be located. For each detected damage we need Information such as dimensions and the percentage of the effected area compared to the overall area

How do you envision the shape of the output? (Or how do you think it would be useful for you to consume the information in the output).

The best output would be a combination of a 3D model and a report (excel etc) where each damage and its dimensions are listed and linked to its location within the pointcloud / 3D model Also it would be a great advantage if the program is able to compare each acquisition.

What data, information or interfaces relevant to use case do you provide?

We need jpeg's to create 3D Models (therefore they need to be taken with a front an side overlap of at least 80% and in various angles for example 45°, 70°, 90°) We need High quality raw images for visual Inspections In future the results of the AI defect detection should be IFC compatible so that they can be transferred to other BIM Software. Best would be a direct import possibility to SIB Bauwerke 2.0. Scans should use the .LAS format.and xyz 3D Models should be provides as obj

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How often do you need measurement data on ship emissions?

If the Service is easy to use it would be a good way to monitor every critical object once a year

Would you use this RAPID Service? (Please give reasons for your answer)

Yes, because as with modern buildings the technical inspection will get more complex and therefore you need more information of the building an how a crack etc is developing over time

What effect would the service have on your daily business?

If the provided data is reliable, each hands on inspection can be more focused. On top we might be able to reduce the risk for the personel by excluding certain areas from the inspection

The following questions refer to the entire RAPID Service and not to individual use cases.

In which environment do you see the greatest potential for the RAPID service?

I see the biggest potential within the technical inspection of infrastructure. The regulations in this sector are quickly changing and therefore we are looking for options to optimize the inspections.

What can you contribute to a real RAPID service demonstration? (for example: ship, permits, infrastructure etc)

Infrastructure an UAV know how

How would you like to see the RAPID Service demonstration?

A live BVLOS demonstration with AI based data processing

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What demands do you have on the demonstration environment?

The demonstration should be taking place in a complex environment with little to no gps coverage

What are your top 5 criteria that need to be considered today in order to use the RAPID service productively in 2023?

1. *The UAV should be able to operate safely within the Hamburg Air Space, so it has to follow the common law*
2. *Defect Detection should work with little to no tolerance*
3. *Mission planning should be simple to use*
4. *…*
5. *…*

Prioritise the following Requirements and Services (using the MoSCoW method)	• *M (Must have)* • *S (Should have)* • *C (Could have)* • *W (Won't have)*
The Drone control within the RAPID Service need to be done VLOS?	**S**
The Drone control within the RAPID Service need to be done eVLOS?	**C**
The Drone control within the RAPID Service need to be done BVLOS?	**M**
The integration of the RAPID Service in your own infrastructure?	**M**
Using the RAPID Service as a bookable product?	**C**

At what intervals and in what way would you like to be informed about project developments?

Via Mail every 6 months

Sample of a review report:

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BWI-Nord
HPA - Hamburg Porth Autority
Bewegliche Infrastruktur / Anlagenmanagment Bewegliche Infrastruktur
Sperrwerk Billwerder Bucht Objekt-ID.:2310323402

Prüfbericht

Sperrwerk Billwerder Bucht

Berichtsnummer:	2018-08-20
Inspektionsjahr:	2018
Baujahr:	2002
Teilnoten:	
Konstruktion	2,2
Stahlbau	2,2
Ausrüstung	1,9
Sonstiges	1
Korrosionsschutz	1
Bauwerksprüfer/-in:	Florian Steffens
Bauwerksprüfung vom:	20.08.2018 bis 31.08.2018
Inspektionsrichtung:	Nord Süd

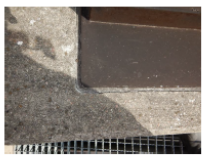
Prüfnote: 2,2

(Schäden an Bauteilen der Kategorie Korrosionsschutz sind nicht Bestandteil der Prüfnote)

BWI-Nord
HPA - Hamburg Porth Autority
Bewegliche Infrastruktur / Anlagenmanagment Bewegliche Infrastruktur
Sperrwerk Billwerder Bucht Objekt-ID.:2310323402

Nr.	Ort	Schadensbeschreibung	SK
1 N	**Bauwerk** Massivbau, Nord-Ost Drempel	Stahlbeton, Hindernisse, bereichsweise, Der Drempel ist von Norden nach 5 Metern und von Süden nach 3 Metern bedingt durch Schlickablagerungen nicht mehr verfolgbar. [78]	1
2 N	**Bauwerk** Massivbau, Nord-Ost Aufbauten	Stahlbeton, Längsriss***, stellenweise, Dieser Schaden steht stellvertretend für alle Aufbauten. Im Bereich der Durchgänge tritt überall das gleiche Schadensbild auf. [86]	1

3 N	**Bauwerk** Massivbau, Nord-Ost Lagerkonstruktion	Sonstiges, abgerissen, umlaufend, Die Dehnungsfuge um sämtliche Lagerkosntruktionen ist Betonseitig abgerissen. Dieser Schaden steht stellvertretend für alle Schäden, da dieser Schaden bei allen Aufbauten auftritt. [90]	1



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Feedback on use case 1 from Schulte Group

<table>
<tr>
<td rowspan="2">Key Partnership needed for Demonstration in Hamburg Port

For mission approval

Air traffic control
Harbour master
Legal permissions
(Environmental Agency…)

For mission execution

Shipping companies

</td>
<td>Key Activities

SORA Mission Planning and Approval
USV carries the UAV near the mission area.
UAV Autonomous navigation to target Ship.
UAV/USV complete monitoring Mission
Mission report generation
</td>
<td rowspan="2">Value Proposition

Use Case 1 will deliver an increased accuracy of ship emission monitoring. Enabling the investigation of the contribution of emissions of identified and individual ships as well as the overall emission monitoring in maritime environments.</td>
</tr>
<tr>
<td>Key Resources

Ship traffic information
Ground interest
Air traffic control
Environmental authorities
</td>
</tr>
</table>

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Process Steps of Use Case 1

Process Stakeholders	Information input or product needs	Process Steps	Information or product outputs	Process Customers
RAPID Service Provider Port Authority Harbour Master Air traffic control Shipping Companies Ship Crew	Regulatory Framework Location of mission Shading map of the harbour Ship traffic information to plan transit to location. Up to date navigation charts Real-time shipping movements for safe passage real-time access to UTM data and ADS-B data Communication links and computing resources on-board	Mission Planning in the Software layer / infrastructure Assure mission planning abides by regulatory framework USV transports the UAV to the target Location Automatic take off from USV landing platform Flight from the USV platform, through the Ships emissions, while detecting and avoiding hazardous situations Monitor particle & gas concentration as the UAV flies through the ship emission Fly back to the USV location Automatic landing on USV landing platform USV Transport the UAV back to base	Mission Report with emission monitoring of ship	Port Authority Port Strategy Port Affairs Shipping Companies Authority for Environment, Climate, Energy and Agriculture NGOs NABU WWF Climate Analytics WIN

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		USV Transmit the information to the Software Infrastructure Software UI and infrastructure produces mission report within 15 minutes		

The Rapid project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°861211

Describe how you would take value from this RAPID service.

Comments from Group Technical Management:

- *Provide evidence that the vessel is in compliance with regulation -> supporting CSR reports.*
- *Early detection of non-compliance, allows a notification to the vessel and they can take necessary action.*
- *Governments can use the technology to collect evidence of non-compliance. Inform law enforcement to visit the vessel.*
- *Check EMSA, they have started a project already in September 2020, starting from CROSS*

Comments from Group HSEQ:

- *Value lies in verification, i.e. ensuring that ships operate within environmental protection margins.*

Comments from Group Fleet Performance Management:

This is not a service of value for shipowners or ship managers. The main customers would be Port Authorities since they are currently limited to indirect sample checking based on physical attendances of inspectors onboard. RAPID would allow them to instead directly sample emissions from multiple ships in a single flight and at a fraction of the cost.

Are you already using a comparable service? If so, can you describe it?

Note: If you answered yes, can you share what is your current budget for this service?

No.

What information do you think the report from this output should include?

Think about:

- ***What kind of emission type needs to be measured?***
- ***What other information can be measured in the process?***

Comments from Group Technical Management:

- *Sulphur concentration in the exhaust gas.*

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Comments from Group Fleet Performance Management:

- *SOX, PM and airborne noise*
- *Visual check for signs of water pollution*

Comments from Group HSEQ:

Information on whether ships are within environmental protection margins (traffic light).

How do you envision the shape of the output? (Or how do you think it would be useful for you to consume the information in the output).

Comments from Group Technical Management:

Use the information in the output for the company's CSR report.

Comments from Group HSEQ:

Email that measurement has taken place with download notification of report

Comments from Group Fleet Performance Management:

SOX, PM and airborne noise would have to be presented as measured values against expected/mandated benchmark.

What data, information or interfaces relevant to use case do you provide?

N/A

How often do you need measurement data on ship emissions?

Comments from Group Technical Management:

- *There is no regulatory requirement for measuring emission if you are using compliant fuel.*

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- *Exhaust gas cleaning equipment have a build in sensor system,*
- *We measure fuel oil consumption and calculate emission. EU MRV / IMO DCS*

Comments from Group HSEQ:

Case by case.

Comments from Group Fleet Performance Management:

As shipowners and managers we do not directly measure ship emissions. Instead we calculate them based on the type and amount of fuel used (CO2 and SOX) as well as the engine design characteristics (NOX).

Would you use this RAPID Service? (Please give reasons for your answer)

No, there is no regulatory requirement for measuring emission if you are using compliant fuel.

What effect would the service have on your daily business?

None, unless a Port Authority finds one of the ships under our management violating emission regulations.

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Feedback on use case 3 from Schulte Group

<table>
<tr>
<td rowspan="2">Key Partnership needed for Demonstration in Hamburg Port

• For mission approval
  ○ Airspace authorities
  ○ Harbour master
  ○ Legal permissions
• For mission execution
  ○ Shipping Companies
  ○ Terminal operation companies</td>
<td>Key Activities

• SORA Mission Planning and Approval
• USV carries the UAV near the mission area.
• UAV Autonomous navigation to target infrastructure.
• UAV/USV complete inspection Mission
• Mission report generation
  ○ Report of sensor Data
  ○ Report of Historical comparison of current mission against history in digital Twin</td>
<td rowspan="2">Value Proposition

Automate the maintenance/inspection process for remote ship monitoring, delivering added value (reducing downtimes) to shipping companies and terminal companies.</td>
</tr>
<tr>
<td>Key Resources

• Building inspection Unit Inspector
• Hydrography – Dept. waterside infrastructure
• Harbour master to coordinate water way traffic
• Airfield controller</td>
</tr>
</table>

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Process Steps of Use Case 3

Process **Stakeholders**	Information **input** or product needs	**Process** Steps	Information or product **outputs**	Process **Customers**
Port Authority Harbour Master Fleet Management Air traffic control Shipping Companies (RAPID Service Provider)	Up to date navigation charts up-to-date digital terrain map of area of operations Shading map of the harbour Approvals for the flight Ship traffic information Real-time movement of shipping real-time access to UTM data and ADS-B data	Mission Planning in the Software layer / infrastructure Assure mission planning abides by regulatory framework USV transports the UAV to the target Location Automatic take off from USV landing platform Sense and avoid system Automatic inspection with selected sensors Monitor results Decision taking in swarm of drones Battery hot swap Battery charging after hot swop	Mission Report with crack identification of infrastructure	Hamburg Port Authority Shipping Companies Fleet management Companies Terminal Operation Companies Shipyard Companies

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		Fly back to the USV Automatic landing system, landing platform USV Transport the UAV back to base USV Transmit the information to the Software Infrastructure 3D reconstruction of infrastructure asset Software UI and infrastructure produces mission report within 15 minutes		

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Describe how you would take value from this RAPID service.

Comments from Group Technical Management:

- *Hull and propeller fouling evaluation*
- *NDT of Ship's hull structure – any cracks/deformations detected*
- *Class Survey Inspections*

Are you already using a comparable service? If so, can you describe it?

Note: If you answered yes, can you share what is your current budget for this service?

Comments from Group Technical Management:

- *Yes, underwater inspection to detect hull and propeller fouling.*
- *Hull and propeller cleaning*
- *Damage assessment after grounding*
- *Extension of Dry Dock interval.*
- *Hull evaluation.*

Budget really depends on vessel size as well as how urgent such inspection is.

What information do you think the report from this output should include?

Think about:

- ***What kind of emission type needs to be measured?***
- ***What other information can be measured in the process?***

Comments from Group Technical Management:

- *Fouling Condition of the Hull/Propeller*
- *Hull Structure Condition*
- *Possible to check for oil pollution from Stern tubes, bow thrusters, sewage overboard.*
- *Be aware of the water flow into the vessel (sea chest). Vessel must be aware if somebody is moving around the vessel*

How do you envision the shape of the output? (Or how do you think it would be useful for you to consume the information in the output).

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Comments from Group Technical Management:

- *Output should be in the form of an inspection report assessing the different areas of the hull with photo evidence.*
- *Ideally this report can be accessed online with a 3D mapping of the vessel's hull, indicating the pictures of fouling, maybe even hull condition when clicking on particular areas.*
- *Early detection of hull and propeller fouling, -> initiate cleaning -> reduce fuel consumption*

What data, information or interfaces relevant to use case do you provide?

Comments from Group Technical Management:

No regulatory requirements for collecting live data

How often do you need measurement data on ship emissions?

Comments from Group Technical Management:

We measure fuel oil consumption and calculate emission. EU MRV / IMO DCS

Would you use this RAPID Service? (Please give reasons for your answer)

Yes. This is a service which would allow us to increase performance of our vessels by regularly getting the latest information on the degree of marine fouling on the hull.

Ideally this can be combined with autonomous hull cleaning and propeller polishing services.

What effect would the service have on your daily business?

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Regular insight into the actual degree of fouling would allow us to save cost on hull cleaning as well as reduce fuel consumption of vessels.

AI to detect degree of ouling, type of ouling (e.g.algae, slime, barnacles etc.)

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Feedback on use case 4 from Schulte Group

<table>
<tr>
<td rowspan="3">Key Partnership needed for Demonstration in Hamburg Port

• For mission approval
  ○ Airspace authorities
  ○ Harbour master
  ○ Legal permissions
• For mission execution
  ○ Police Authority
  ○ Port Disaster management (HASTA)
  ○ Fire Department</td>
<td>Key Activities

Clarify/Validate that the USV/UAV does not interfere with other manned emergency response vehicles.</td>
<td rowspan="3">Value Proposition

Creation of an emergency service which, for example in the event of a collision between two ships, provides all parties involved with a fast and high-resolution situation picture. This will enable everyone involved to plan the necessary aid processes faster, more efficiently and in a more targeted manner and to monitor the overall process.</td>
</tr>
<tr>
<td>Key activities in Demonstrator</td>
</tr>
<tr>
<td>Key Resources

Building inspection Unit Inspector

• Hydrography – Dept. waterside infrastructure
• Harbour master to coordinate water way traffic
• Airfield controller
• SAR, Coast guard respondents, MRCs</td>
</tr>
</table>

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Process Steps of Use Case 4

Process **Stakeholders**	Information **input** or product needs	**Process** Steps	Information or product **outputs**	Process **Customers**
Hamburg Port Authority HASTA (Disaster Management) Federal Security Authorities Fire Department Police Department Port Authorities SAR Air traffic control (RAPID Service Provider)	Location of incident Targets of mission Up to date navigation charts Shading map of the harbour up-to-date digital terrain map of area of operations (Approvals (BOS) for the flight) Ship traffic information Real-time movement of shipping	Mission Planning in the Software layer / infrastructure Assure mission planning abides by regulatory framework USV transports the UAV to the target Location Automatic take off from USV landing platform Sense and avoid system Inspection with selected sensors – automatically Monitor results	Realtime images Different sensor data Mission Report with images of accident Situational updates	Hamburg Port Authority HASTA (Disaster Management) Federal Security Authorities Fire Department Police Department Port Authorities Shipping Companies Insurance Companies Salvage companies / tug operators

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	real-time access to UTM data and ADS-B data Communication links to command centre or first responder site	Battery hot swap Battery charging after hot swop Decision taking in swarm of drones Fly back to the USV Automatic landing on USV landing platform USV Transport the UAV back to base Relay of video stream to command centre		

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Describe how you would take value from this RAPID service.

Comments from Group HSEQ:

Continuous update on the situation.

Are you already using a comparable service? If so, can you describe it?

Note: If you answered yes, can you share what is your current budget for this service?

No.

What information do you think the report from this output should include?

Think about:

- ***What kind of emission type needs to be measured?***
- ***What other information can be measured in the process?***

Comments from Group HSEQ:

Data measurement (e.g. measure toxic gases in air), live video feed, warning of other participants in nearby maritime traffic

Comments from Group Technical Management:

- *Oil spill and oil drifting*
- *Fire / Smoke*
- *Search for missing persons*

How do you envision the shape of the output? (Or how do you think it would be useful for you to consume the information in the output).

Output should be in the form of live feeds during operation as well as email / pdf after the job is completed.

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What data, information or interfaces relevant to use case do you provide?

Browser-based / desktop client with live feed.

How often do you need measurement data on ship emissions?

N/A

Would you use this RAPID Service? (Please give reasons for your answer)

Yes, but on on request.

What effect would the service have on your daily business?

Comments by Group Technical Management / HSEQ:

Efficiency improvement in emergency response activities by aassisting with crisis management.

The following questions refer to the entire RAPID Service and not to individual use cases.

In which environment do you see the greatest potential for the RAPID service?

We see the greatest potential for the service in

What can you contribute to a real RAPID service demonstration? (for example: ship, permits, infrastructure etc)

We can contribute ships and their respective crews.

How would you like to see the RAPID Service demonstration?

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We would like to be physically present during the RAPID service demonstration.

What demands do you have on the demonstration environment?

To be discussed.

Hence, the respective authorities need to make sure that provision of the service is allowed. In case of any accident caused as part of the demonstration or damage caused to the respective vessel we provide, it needs to be clear who bears the cost.

What are your top 5 criteria that need to be considered today in order to use the RAPID service productively in 2023?

1.
2.
3.
4.
5.

Prioritise the following Requirements and Services (using the MoSCoW method)	• *M (Must have)* • *S (Should have)* • *C (Could have)* • *W (Won't have)*
The Drone control within the RAPID Service need to be done VLOS?	**C**
The Drone control within the RAPID Service need to be done eVLOS?	**C**
The Drone control within the RAPID Service need to be done BVLOS?	**C**
The integration of the RAPID Service in your own infrastructure?	**S**
Using the RAPID Service as a bookable product?	**M**

At what intervals and in what way would you like to be informed about project developments?

We would like to be regularly informed about the project's progress. The intervals could be monthly and we would like to be update through (video-) conference calls and written reports.

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Feedback on use case 4 from HPA Port Affairs PA 23

<table>
<tr>
<td rowspan="3">Key Partnership needed for Demonstration in Hamburg Port

• For mission approval
  ○ Airspace authorities
  ○ Harbour master
  ○ Legal permissions
  ○ Strompolizei
• For mission execution
  ○ Police Authority
  ○ Port Disaster management (HASTA)
  ○ Fire Department
  ○ HM / Strompolizei</td>
<td>Key Activities

Clarify/Validate that the USV/UAV does not interfere with other manned emergency response vehicles.</td>
<td rowspan="3">Value Proposition

Creation of an emergency service which, for example in the event of a collision between two ships, provides all parties involved with a fast and high-resolution situation picture. This will enable everyone involved to plan the necessary aid processes faster, more efficiently and in a more targeted manner and to monitor the overall process.</td>
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<td>Key activities in Demonstrator</td>
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<tr>
<td>Key Resources

• Building inspection Unit Inspector
• Hydrography – Dept. waterside infrastructure
• Harbour master/Strompolizei to coordinate water way traffic
• Airfield controller</td>
</tr>
</table>

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Process Steps of Use Case 4

Process **Stakeholders**	Information **input** or product needs	**Process** Steps	Information or product **outputs**	Process **Customers**
Hamburg Port Authority HASTA (Disaster Management) Federal Security Authorities Fire Department Police Department Port Authorities Air traffic control (RAPID Service Provider)	Location of incident Targets of mission Up to date navigation charts Shading map of the harbour up-to-date digital terrain map of area of operations (Approvals (BOS) for the flight) Ship traffic information Real-time movement of shipping	Mission Planning in the Software layer / infrastructure Assure mission planning abides by regulatory framework USV transports the UAV to the target Location Automatic take off from USV landing platform Sense and avoid system Inspection with selected sensors – automatically Monitor results	Realtime images Different sensor data Mission Report with images of accident	Hamburg Port Authority HASTA (Disaster Management) HM/Strompolizei Federal Security Authorities Fire Department Police Department Port Authorities Shipping Companies

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	real-time access to UTM data and ADS-B data Communication links to command centre or first responder site Authorizations of waterside buildings and structures	Battery hot swap Battery charging after hot swop Decision taking in swarm of drones Fly back to the USV Automatic landing on USV landing platform USV Transport the UAV back to base Relay of video stream to command centre		Insurance Companies

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Describe how you would take value from this RAPID service.

- *Coordinate water way traffic, rescue of the accidented vehicles and operations to stop the spreading of pollution (Oil, Parts etc.) with the help of the images provided from the RAPID service.*
- *Standard inspection of buildings and other authorised structures.*
- *Optimisation of the subsequent process control*
- *Water surface (floating debris or persons) inspection*
- *Incident monitoring (cargo falls into the water, person overboard, leakage*

Are you already using a comparable service? If so, can you describe it?

Note: If you answered yes, can you share what is your current budget for this service?

no

What information do you think the report from this output should include?

Think about:

- ***What kind of emission type needs to be measured?***
- ***What other information can be measured in the process?***

An overall view of the collision place or the inspected area

3D model of the entire site

How do you envision the shape of the output? (Or how do you think it would be useful for you to consume the information in the output).

- *Pictures/films with the coordinates of defined areas and the area content*
- *heat maps*

What data, information or interfaces relevant to use case do you provide?

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Authorizations of waterside buildings and structures

How often do you need measurement data on ship emissions?

- *Accidents / incidents: when they occur (maybe ones a month or two)*
- *Standard inspections: ones a week or two*

Would you use this RAPID Service? (Please give reasons for your answer)

Yes, as already described in the value task.

What effect would the service have on your daily business?

It would have an effect on the standard inspections and collision coordination and would offer another, new, viewpoint on the tasks, that would surely make our business more precise and easier.

The following questions refer to the entire RAPID Service and not to individual use cases.

In which environment do you see the greatest potential for the RAPID service?

Waterside and landside port environment

What can you contribute to a real RAPID service demonstration? (for example: ship, permits, infrastructure etc)

Authorizations of waterside buildings and structures

How would you like to see the RAPID Service demonstration?

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?

What demands do you have on the demonstration environment?

To be similar to the environment in later use

What are your top 5 criteria that need to be considered today in order to use the RAPID service productively in 2023?

1.
2.
3.
4.
5.

Prioritise the following Requirements and Services (using the MoSCoW method)	• *M (Must have)* • *S (Should have)* • *C (Could have)* • *W (Won't have)*
The Drone control within the RAPID Service need to be done VLOS?	
The Drone control within the RAPID Service need to be done eVLOS?	
The Drone control within the RAPID Service need to be done BVLOS?	
The integration of the RAPID Service in your own infrastructure?	**S**
Using the RAPID Service as a bookable product?	**C**

At what intervals and in what way would you like to be informed about project developments?

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Version history

Version	Changes	Responsible	Reviewed by
31/10/2020	First Version	HPA, UWS	XO

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Risk-aware Automated Port Inspection Drone(s) – RAPID

RAPID will save lives by delivering an early warning system that will detect critical deterioration in transport system infrastructure, while also minimising system disruption and delays to critical supply chains.

RAPID will save lives, minimise system disruption and delays to critical supply chains.

What is RAPID - Risk-aware Automated Port Inspection Drone(s)?

The EU-funded RAPID project will combine and extend drone technology to deliver a fully automated and safety-assured maintenance inspection service for bridges, ship hull surveys, and more. Specifically, the service will combine self-sailing unmanned surface vehicles with autonomous unmanned aerial systems. The aim is to reduce the time and cost of structural condition monitoring of maritime transport infrastructures such as material-handling equipment, cargo and passenger ships, and bridges. RAPID's new system will also facilitate the prioritisation of safer transport infrastructure.

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